BEFORE THE

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D. C.

PETITION OF RADIO CORPORATION OF AMERICA AND NATIONAL BROADCASTING COMPANY, INC. FOR APPROVAL OF COLOR STANDARDS FOR THE RCA COLOR TELEVISION SYSTEM

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1. Radio Corporation of America and National Broadcasting Company, Inc. (hereinafter referred to as "Petitioners") petition the Commission to institute rule-making proceedings for the purpose of adopting new technical signal specifications as standards for commercial color television broadcasting. A copy of the technical signal specifications proposed for adoption as color standards is attached as Exhibit 1.

2. Petitioners have developed the RCA color television system which operates on the color standards proposed in this Petition. These standards have been approved by the NTSC. The RCA color television system is a compatible color system and programs broadcast using the RCA system can be received in natural color on color receivers and in high definition black and white on the more than 24,000,000 black and white receivers already in the hands of the American public without changing these black and white receivers or adding to them in any way.

3. The RCA color television system satisfies all of the criteria for a color television system specified by the Commission in its Public Notice 65008 of June 11, 1951. Technical and field test data supporting this conclusion are contained in the attached statement of Dr. C. B. Jolliffe, Vice President and Technical Director of Radio Corporation of America, and in the Exhibits and Appendixes attached to and made a part of this Petition.

4. The color standards proposed in this Petition are technical signal specifications approved February 2, 1953, by outstanding engineers and scientists of the radio and television industry, including members of Petitioners' staffs, through the National Television System Committee (NTSC). Petitioners know of no responsible engineer or scientist in the radio and television field who proposes adoption of any other color standards.

5. The high standards adopted by the Commission in 1941 for black and white television broadcasting have made possible the miraculous growth and development of the present black and white television service to the American public. Petitioners submit that the Commission should now take a similar stand in respect of adoption of standards for color television and adopt new standards for color television broadcasting which will encourage rapid growth and development of color television as a service to the American public.

6. Petitioners have already expended almost twenty-one and a half million dollars in research and development work on and field testing of the RCA color television system and the proposed color standards. On the basis of this research and development work and field testing, Petitioners believe adoption of the proposed color standards by the Commission would serve the public interest by affording the public the advantage of color television now and not interfering with or diminishing the present monochrome service to the more than 24,000,000 black and white television set owners.

7. If the Commission approves the proposed color television standards:

Petitioner Radio Corporation of America will expedite production of color receivers, tricolor tubes and broadcasting and studio equipment for sale to the public, to television manufacturers and to broadcasters. As was the case with the introduction of black and white television apparatus, mass production and experience in the television industry will result in improved apparatus and lower prices. The sooner compatible color standards are approved and the actual start of production can be made the sooner the factors of mass production and experience will assert themselves throughout the industry.

Petitioner National Broadcasting Company, Inc., will commence broadcasting compatible color television programs which it will offer to commercial sponsors and its affiliated stations throughout the United States. Forty-one NBC affiliated television stations have already amended their network affiliation agreements to provide that they will, on approval of the proposed standards, make the relatively minor modifications to their transmitting apparatus to enable them promptly to commence broadcasting networked color television programs.

8. Petitioners believe that the present field sequential color television standards based upon an incompatible color television system are sterile and that their continuance is not in the public interest.

First, the more than 24,000,000 black and white television receivers now in the hands of the American public, representing an investment by the public of billions of dollars, would be "blind" to incompatible color broadcasts.

Second, the present incompatible color system is unsatisfactory from a technical, engineering and commercial standpoint. This is demonstrated by the fact that in the face of undoubted public demand for color television, Petitioners know of no television broadcaster who is broadcasting or plans to broadcast any incompatible color television programs and of no television receiver manufacturer who is now manufacturing or plans to manufacture receivers designed to receive incompatible color television broadcasts.

9. The Commission's Public Notice 65008 of June 11, 1951 would require Petitioners to put a color signal on the air in Washington, D. C., for the purpose of demonstrating Petitioners' color television system. Petitioners request that the Commission waive this requirement for the following reasons:

(a) There is no studio in Washington equipped to demonstrate the RCA color television system. Moving the equipment in Petitioners' New York color television studios to Washington, and installing this equipment in Petitioners' Washington facilities, would delay Commission consideration of this Petition, would delay Petitioners' preparation for commercial color broadcasting and would require Petitioners to make substantial expenditures.

(b) Networking a color signal originating in Petitioners' New York color television studios to Washington, and there putting it on the air, would result in a signal which could be affected by the quality of intercity network facilities, a condition over which Petitioners have no control. Networking a color signal to Washington would also require Petitioners to make substantial expenditures for radio relay or coaxial cable, which it would be necessary for Petitioners to lease from the Telephone Company, for every transmission from New York to Washington. These expenditures, and the existing commercial schedules of Petitioners' Washington station, would make it costly and impractical to broadcast a regular series of experimental color television programs in Washington.

(c) Petitioner National Broadcasting Company, Inc., under authorization granted by the Commission, is now remodeling its Washington monochrome transmitting facilities by raising the height of its antenna and installing additional equipment to give improved service to the Washington area. During this construction period it would not be practical to adjust and use the Washington transmitter to broadcast color television test programs nor would test programs broadcast under such conditions furnish accurate data on the performance of the RCA color television system or the proposed color standards.

10. Petitioners believe that only in New York are full facilities available for Commission study of all aspects of the RCA color television system and the proposed color standards:

(a) Petitioner, National Broadcasting Company, Inc., maintains studios in New York fully equipped with apparatus to demonstrate and test the RCA color television system. Petitioner knows of no other studios which are fully equipped to demonstrate and test the RCA color television system or the proposed color standards.

(b) The transmitting facilities of Station WNBT, Channel 4, New York, owned and operated by Petitioner National Broadcasting Company, Inc., with antenna located on the Empire State Building, New York, are equipped to broadcast RCA color television signals using the proposed color standards.

(c) The transmitting facilities of Station WPIX, Channel 11, New York, owned and operated by WPIX, Inc., and affiliated with the New York Daily News, with antenna located on the Empire State Building, New York, are now being equipped to broadcast RCA color television signals. Thus, New York City will be the only city in which comparative tests of the RCA color television system and the proposed color standards can be made off the air on more than one television channel.

(d) Petitioners maintain a laboratory for color television test purposes in Astoria, Long Island, 2.8 miles from Petitioners' New York Channel 4 antenna. Petitioners also maintain a polyethylene cable connection between their New York color television studio facilities and their Astoria laboratory which is used to make test signals available to color receivers in the laboratory when Petitioners' New York transmitter is pre-empted by commercial commitments and at other times. If at any time the Commission, or members of the Commission staff, should desire tests to be made over typical coaxial cable or radio relay transmission facilities, Petitioners would arrange to make available Telephone Company looped circuits from New York to Washington, or other cities, so that observers at Petitioners' Astoria laboratory would be able to test the RCA color television system and the proposed color standards both at the transmitting end and at the receiving end of the looped circuits.

(e) Petitioners offer to make their laboratory, studios, transmitter, test equipment and other facilities, freely available to the Commission and to members of the Commission staff for testing the RCA color television system and the proposed color standards.

11. In compliance with the Commission's Public Notice 65008, Petitioners will deliver representative receiver apparatus to the Commission's laboratory at Laurel, Maryland.

WHEREFORE, Petitioners request that the within Petition be granted and that the Commission adopt the technical signal specifications for compatible color television contained in Exhibit 1 as standards for commercial color television broadcasting.

Respectfully submitted,

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June 25, 1953.

STATEMENT BY DR. C. B. JOLLIFFE, VICE PRESIDENT AND TECHNICAL DIRECTOR OF RADIO CORPORATION OF AMERICA

RCA and NBC have built, operated and tested the RCA color television system which uses the signal specifications contained in Exhibit 1.[1] This system satisfies the criteria established by the Commission for a color television system.[2]

The signal specifications used in the RCA color television system are identical with the signal specifications approved for publication by the National Television System Committee on February 2, 1953.

The RCA color television system is a compatible system (Exhibits 4, 7, 10). Compatibility is of extreme importance. As the Commission stated in 1950:

> The Commission is of the opinion that if a satisfactory compatible system were available, it would certainly be desirable to adopt such a system. Compatibility would facilitate for the broadcaster the transition from black and white broadcasting to color broadcasting and would reduce to a minimum the obsolescence problem of present receivers.[3]

The RCA color television system, which operates on the signal specifications proposed as standards, is a satisfactory compatible system and is available.

The signal specifications contained in Exhibit 1 have been extensively field tested by RCA and NBC and they are suitable for adoption as standards by the Commission.

RCA and NBC have the know-how to broadcast color programs, to build equipment for color broadcasting and to build sets that will receive these color programs. In addition, RCA and NBC have a nucleus of trained personnel ready to do the job.

If the Commission approves the proposed color television standards, NBC will commence broadcasting compatible color television programs and will offer these programs to commercial sponsors and NBC affiliated stations throughout the United States.

RCA is already manufacturing prototype compatible color television receivers, tricolor tubes and studio equipment. If the Commission authorizes standards for commercial color television broadcasting on the basis of the

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[1] Exhibits referred to are those attached to and made a part of the Petition.

[2] FCC Public Notice 65008, June 11, 1951.

[3] First Report of Commission (Color Television Issues), par. 123, adopted September 1, 1950, FCC 50-1064.

signal specifications contained in Exhibit 1, RCA will manufacture and sell this apparatus to the public, to broadcasters and to other manufacturers.

The RCA color television system meets all of the criteria established by the Commission for a satisfactory color television system.

Criterion 1

The Commission's first criterion for a satisfactory color television system is:[4]

> It must be capable of operating within a 6-megacycle channel allocation structure.

The signal specifications contained in Exhibit 1 are identical with those used for standard monochrome television except that a color subcarrier has been added. Measurements of interference between adjacent channels establish that the RCA color television system operates within the Commission's six-megacycle channel allocation structure (Exhibit 8).

There have been many hours of on-the-air color television transmissions, using the signal specifications contained in Exhibit 1, while standard monochrome television stations were broadcasting on adjacent channels. No reports of interference on adjacent channels have been received and no interference has been observed by trained observers (Exhibit 4).

Criterion 2

The Commission's second criterion for a satisfactory color television system is:

> It must be capable of producing a color picture which has a high quality of color fidelity, has adequate apparent definition, has good picture texture, and is not marred by such defects as misregistration, line crawl, jitter or unduly prominent dot or other structure.

It has been established by public reaction tests, theoretical analyses and engineering observations that the RCA color television system produces a color picture which has a high quality of color fidelity (Exhibits 2, 4, 7).

Color fidelity in a color television system is not necessarily a purely scientific or engineering matter. The objective is to produce in the mind of the viewer a pleasing and satisfying sensation of color. Public reaction tests conducted by RCA and NBC under the direction of the Opinion Research Corporation show that the RCA color television system achieves this objective (Exhibit 2).

Engineering observations have resulted in favorable conclusions as to the color fidelity of the pictures produced by the RCA color television system (Exhibit 7). The choice of receiver primaries is determined essentially

[4] The criteria are quoted from FCC Public Notice 65008, June 11, 1951.

by purely colorimetric considerations such as spectral response and efficiency of the phosphors used in the color reproducer.[5] In the present apparatus the gamut of colors that it is possible to produce with the RCA receiver primaries compares very favorably with that possible with the best processes of color reproduction and is much superior to most commercial processes (Exhibit 4).

Suitably chosen camera spectral characteristics are good approximations to those theoretically required, and analysis shows that good color reproduction may be obtained with the camera spectral characteristics presently used in the RCA color television system (Exhibit 4).

It has been established by public reaction tests, engineering observations and theoretical analyses that the RCA color television system produces color pictures which have adequate apparent definition and good picture texture and are not marred by such defects as misregistration, line crawl, jitter or unduly prominent dot or other structure (Exhibits 2, 4, 7).

Public reaction to the clearness of detail and the overall quality of RCA color television pictures was overwhelmingly favorable (Exhibit 2).

Picture definition is directly related to the resolution provided by the system. The resolution capabilities of the RCA color television system are theoretically the same as those of the standard monochrome system. All of the fine detail information is conveyed by the luminance channel which has the same bandwidth as monochrome television (Exhibit 4). Accordingly. any differences in horizontal and vertical resolution which may now exist in the RCA color television system, as compared to the standard monochrome system, are due to current apparatus limitations (Exhibit 7). However, as the public reaction tests demonstrated, the color pictures produced at the present time by the RCA color television system have adequate apparent definition (Exhibit 2).

There are a number of factors that enter into the broad classification of picture texture. In the RCA color television system there are the same number of lines in the picture as in standard monochrome television and the line structure is the same. Since this line structure has been satisfactory in the present commercial monochrome television service, there is no reason to believe that it will not be satisfactory for color television. The diameter of an individual dot in the RCA 16-inch envelope tricolor kinescope is about 70 per cent of the thickness of a scanning line (Exhibit 7). Since lines are not usually visible at normal viewing distances, the individual red, green and blue phosphor dots are even less visible.

There is no objectionable dot pattern in RCA color pictures resulting from color.

Such minor misregistration as may, from time to time, be perceptible in present RCA color television apparatus does not interfere with enjoyment of the color pictures and is not a system limitation (Exhibits 2, 7).

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[5] Research work continues on the development of new and better phosphors. As they are perfected, they can be incorporated into tricolor kinescopes without alteration of the proposed standards.

Neither line crawl nor dot crawl in RCA color television pictures was seen by technical observers (Exhibit 7).

Technical observers, as well as the public, were favorably impressed with the overall quality of the RCA color television pictures (Exhibits 2, 7).

RCA has made extensive field test transmissions of color television during regular program hours to test compatibility and to get opinions as to the quality of black and white pictures reproduced from color transmissions. An overwhelming majority of those who sent in comments reported good picture quality. Many stated that the black and white pictures produced on standard receivers were better than pictures produced from standard black and white transmissions (Exhibits 4, 7, 10). Observers at tests and demonstrations held by RCA and NBC have made similar comments.

Criterion 3

The Commission's third criterion for a satisfactory color television system is as follows:

> The color picture must be sufficiently bright so as to permit an adequate contrast range and so as to be capable of being viewed under normal home conditions without objectionable flicker.

It has been established by public reaction tests, engineering observations and analyses that the RCA color television pictures are sufficiently bright so as to permit an adequate contrast range and to be capable of being viewed under normal home conditions without objectionable flicker (Exhibits 2, 7).

Flicker may be present in any cyclic process which depends upon the rapid presentation of a sequence of pictures for conveying the impression of continuity. The question is not whether flicker is present but rather whether, at the repetition rates and picture brightness levels employed, the flicker is noticeable or objectionable with the particular viewing device used.

As a practical matter, the RCA color television system is free of noticeable flicker. The field and frame rates and interlacing, which determine flicker, are the same in the RCA color television system as in standard monochrome television. As a result, flicker is no more of a problem in the RCA color system than it is in the standard monochrome system. Despite considerable increase in kinescope brightness over the past years, commercial monochrome television is, as a practical matter, free of noticeable flicker. The same is true of the RCA color television system. Engineering tests in this connection included observations on an RCA color television receiver operating at a highlight brightness of approximately 40 foot lamberts. None of the technical observers noticed any objectionable flicker (Exhibit 7).

Measurements and technical observations establish that RCA color television pictures are sufficiently bright so as to permit an adequate contrast range. The contrast range in RCA color television pictures has been found adequate (Exhibits 2, 7).

Criterion 4

The Commission's fourth criterion for a satisfactory color television system is as follows:

> It must be capable of operating through receiver apparatus that is simple to operate in the home, does not have critical registration or color controls, and is cheap enough in price to be available to the great mass of the American purchasing public.

In testing the RCA color television system, color signals have been transmitted for thousands of hours (Exhibit 10). As part of all of these tests, the transmissions were viewed on RCA color television receivers (Exhibit 6). This extensive testing has shown the high standards of performance of RCA color receivers.

The RCA color television system is capable of operating through receiver apparatus that is simple to operate in the home and does not have critical registration or color controls. The viewer controls on RCA color television receivers (Model No. 3A) are precisely the same as on standard monochrome receivers with the addition of one color control knob—chroma (Exhibit 6). The usual viewer controls on monochrome receivers as compared with this color receiver are tabulated below.

Viewer Controls	*Monochrome Receiver*	*Color Receiver*	*Viewer Operations*
Station Selector	Yes	Yes	Same
Fine Tuning	Yes	Yes	Same
On-Off	Yes	Yes	Same
Sound	Yes	Yes	Same
Tone	Yes	Yes	Same
Contrast	Yes	Yes	Same
Brightness	Yes	Yes	Same
Horizontal Sync	Yes	Yes	Same
Vertical Sync	Yes	Yes	Same
Color	No	Yes	New

Thus, the only additional viewer control on this color receiver is the chroma control. This control is not critical and is simple to operate. The knob for this control turns from left to right. At the extreme left position color is taken out of the picture. As the knob is turned to the right, the color first appears and, when the knob is turned all the way to the right, the colors are most fully saturated. Viewers differ as to the degree of color saturation they desire and it is a simple matter to adjust this knob to the desired degree of color saturation. Accordingly, this control raises no problems for home viewers. Other viewer controls on RCA color receivers are the same as those on standard monochrome receivers. As in black and white receivers, service controls are built into the chassis of this color receiver.

RCA has had extensive experience in designing and manufacturing millions of monochrome receivers now in use in the home. A major consideration in design of these receivers has been the ease with which the average home viewer may operate the sets. The fact that there are now more than twenty-four million standard black and white receivers giving service in American homes shows that the viewer controls on television receivers are simple to operate in the home. No more rigorous testing of controls is possible than that which has already been undergone by these millions of receivers.

Development work is now nearing completion on another pre-production model color television receiver identified as Model No. 4 and described in Exhibit 6. This model approximates the design of the receiver which would be put into production if the Commission approves the proposed color standards. In Model No. 4, conforming with recent trends in design of black and white receivers, several customer and service controls have been relocated under the control cover and for experimental work all of these have been equipped with knurled shafts. In a production model the service controls would be screw-driver adjustments and thus would not normally be used by the viewer. The color hue control will probably be included in the production model under the control cover as a viewer control. Experience has shown this may be desirable. The color hue control permits a viewer to make minor adjustments in the hue of the picture to satisfy his own personal liking. Thus, in this receiver the viewer has control over both chroma and hue of the color. These controls are not critical and are simple to operate. They require only occasional adjustment. Model No. 4 has been changed from Model No. 3A in other respects as well in order to improve performance, to facilitate manufacturing and to reduce costs.

The RCA color television system is capable of operating through receiving apparatus that is cheap enough in price to be available to the great mass of the American purchasing public. It is estimated that the introductory price of the first RCA color television receivers, using the 16-inch envelope tricolor tube (which has the same picture size as a 14-inch black and white tube), will be between $800 and $1000.

Since the quantity of color receivers produced initially will be small, it is of interest to compare the price of the first black and white receivers produced at the beginning of monochrome television in 1939. In making this comparison, it is necessary to take into account the change in price levels based on the Bureau of Labor Statistics Price Index.[6]

In 1939 a 12-inch kinescope black and white console with sound radio had a list price of $598. Allowing for the elimination of the sound radio, the adjusted price would be approximately $560. Adjusting for the change in the value of the dollar, this list price in terms of 1953 dollars would be approximately $1,050.

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[6] The 1939 average for the Bureau of Labor Statistics *Consumers' Price Index* (Old Series) was 99.4. On March 15, 1953 the same index stood at 188.8.

Another comparison can be made with the first console black and white television receiver using a 16-inch kinescope introduced by RCA on January 1, 1949. The average price of three models was $575 (or $635 if adjusted to 1953 dollar levels in accordance with the Bureau of Labor Statistics Price Index). The 1953 price of a comparable 17-inch kinescope console receiver is $270, less than one-half of the 1949 price.

A major item in the price of a color television receiver is the tricolor kinescope (Exhibit 5). It is estimated that, for the relatively small quantities in which the tricolor tube will be produced initially, the tube will sell to receiver manufacturers for a price of between $175 and $200. The design characteristics of a larger tricolor kinescope have not been finally determined; consequently, a price for such a tube cannot be definitely estimated at this time.

The cost of any kinescope is a complex function of cost of material, labor, automatic machinery, engineering development and other factors. The number of tubes produced has a major effect on the price of any type of vacuum tube.

The price and size history of black and white kinescopes will be followed in color kinescopes. Prices will be reduced and sizes and quality increased as quantity production is attained by manufacturers of kinescopes.

An illustration of the effect of quantity production on the price of kinescopes is shown by the manufacturers' price history of the 16-inch (later increased to 17-inch) kinescope.[7] The first 16-inch round kinescopes were introduced in the middle of 1948. RCA made approximately 250,000 tubes of this type in 1949. At the end of 1949, a new type of 16-inch tube, which was shorter, was introduced. The price then was approximately two-thirds of the original price. In 1950, RCA produced about 1,250,000 tubes of this type. During that year the price was reduced to approximately one-half of the original price.

By the end of 1951, the 17-inch rectangular tube almost supplanted the 16-inch round type in new receivers. During 1951 nearly 900,000 17-inch rectangular tubes were produced by RCA.

The price of the newer 17-inch rectangular tube at the end of 1951 was approximately one-third the original price of the 16-inch round tube.

RCA has built millions of monochrome receivers and millions of tubes of different designs. On the basis of this extensive experience in manufacturing techniques and the design and use of automatic production machinery, RCA believes that its price estimates with respect to tricolor kinescopes and color television receivers are realistic and that reductions in such prices will follow the pattern of comparable monochrome television equipment.

If standards for commercial broadcasting of compatible color television are adopted by the Commission thus enabling compatible color receivers to

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[7] In this discussion of kinescope prices, no account is taken of changes in the Bureau of Labor Statistics Price Index or the introduction of a 10 per cent Federal excise tax in 1950.

be manufactured on a mass production basis, experience and competition will inevitably result in bringing about substantial reductions in the price of color receivers (Exhibits 5, 6).

As to the future trend of color receiver prices, Dr. Elmer W. Engstrom, Vice President in Charge of the RCA Laboratories Division of RCA, stated, in answer to a question as to the difference between the cost of a black and white and a color receiver, in testimony on March 24, 1953 before the Committee on Interstate and Foreign Commerce of the House of Representatives:

> I indicated during the [FCC color] hearings that I thought that when we got into mass operations on color television that we could expect that a color set would cost approximately 50 per cent more than a black and white set and that that would reduce, be reduced, as we go along and might some day get as close as not more than 25 per cent; but I cannot see any possibility of them being the same, because one must do more in order to have color.[8]

I agree with Dr. Engstrom's estimate.

Criterion 5

The Commission's fifth criterion for a satisfactory color television system is as follows:

> It must be capable of operating through apparatus at the station that is technically within the competence of the type of trained personnel hired by a station owner who does not have an extensive research or engineering staff at his disposal and the costs of purchase, operation, and maintenance of such equipment must not be so high as unduly to restrict the class of persons who can afford to operate a television station.

Extensive experience in testing and transmitting color television has established that the RCA color television system is capable of operating through apparatus at the station that is technically within the competence of the type of trained personnel hired by a station owner who does not have an extensive research or engineering staff at his disposal (Exhibit 10).

The operation of color television studio equipment is more complicated than the operation of black and white television equipment because the signal to be transmitted carries more information. Extensive testing of the RCA color television system has been carried on in the NBC studios by technical personnel recruited from monochrome operations and excellent pictures have been produced (Exhibits 2, 10). Additional training of technical personnel to acquaint them with the special problems of color television operation will be necessary, but the situation is like that which existed during

[8] Transcript of the Hearings on Color Television before the Committee on Interstate and Foreign Commerce of the House of Representatives, March 24, 1953, p. 81.

the rapid growth of monochrome television when technical personnel, previously trained for sound broadcasting, successfully adapted themselves to the operation of television equipment.

The cost of purchasing station apparatus for the RCA color television system is not so high as unduly to restrict the class of persons who can afford to operate a television station.

A television station does not need to equip color studios in order to broadcast network color programs. The station can take color programs from the network by making relatively minor expenditures for equipment and standard stock items. plus in most cases certain additional sums for test equipment[9] (Exhibit 9). The station operator may expand his operations by adding a color slide camera, color film equipment and color cameras if he desires to provide programs from local sources. The amount and total cost of such equipment will depend on the kind and extent of local color program material the broadcast station owner elects to provide. Prices based on probable steps that may be taken by a typical station owner in equipping his station for color are given in Exhibit 9.

The present prices are preliminary estimates based on existing conditions, present equipment designs and limited production. Provided other conditions remain the same, it is anticipated that substantial price reductions will be made when commercial product designs are finalized and the production of color equipment increases.

The extensive testing of the RCA color television system by NBC shows that the cost of operating and maintaining station equipment for the RCA color television system is not so high as unduly to restrict the class of persons who can afford to operate a television station.

At the transmitter no additional personnel is required for color operation or maintenance. Also, the transmission of slides and motion pictures requires no additional technical personnel.

The operation of television studio equipment for originating live programs, whether monochrome or color, depends to a great extent upon the nature and amount of the program material being telecast. NBC's extensive color broadcasting experience has shown that, if a station owner wishes to originate live color television shows, the normal technical crew for color television studio operations contains the same number of technical persons as are assigned to a monochrome operation, except perhaps for the video control position (Exhibit 10). In monochrome television the video control technician usually handles two or three television cameras. However, in the present state of development activities in color television, NBC has found it expedient to assign a video control technician to each color television camera, due primarily to the added complications of this function. It is expected that future developments will bring about a modification of this

[9] The amount of equipment necessary will vary in individual stations depending on amount and type of test equipment already on hand and other factors.

practice (Exhibit 10). This additional operating cost will not unduly restrict the class of persons who can afford to operate a television station.

Maintenance of color television equipment used for a studio plant is more complicated than for a comparable monochrome studio plant due to the fact that color television requires additional components. The complications in any electronic equipment are usually a function of the amount of information being transmitted and considerably more information is transmitted in a color television system than in a monochrome system.

The additional maintenance costs associated with broadcasting live programs using the RCA color television system will not unduly restrict the class of persons who can afford to operate a television station (Exhibit 10). If it is the practice of the station owner to take his local color program origination from slides and motion pictures and his live color shows from a network, there should be no substantial additional operating or maintenance costs due to color except for the added cost of color film as compared with black and white film.

Criterion 6

The Commission's sixth criterion for a satisfactory color television system is as follows:

> It must not be unduly susceptible to interference as compared with the present monochrome system.

Extensive tests were conducted by RCA which determined that the RCA color television system is not unduly susceptible to interference as compared to the present monochrome system (Exhibit 8).

With regard to co-channel interference, color and monochrome are substantially equally susceptible. Concerning lower adjacent channel interference, color and monochrome are substantially similar. In the case of upper adjacent channel interference, color is somewhat more susceptible than monochrome. However, the ratio of desired carrier to interfering carrier for tolerable interference is well above the ratio set by the Commission's allocation structure. With regard to random noise, color is only slightly more susceptible than monochrome. Color is more susceptible than monochrome to sine wave interference but only in the vicinity of the color subcarrier. In so far as multipath is concerned, color is only slightly more susceptible than monochrome, and with respect to impulse noise, color and monochrome are substantially equally susceptible (Exhibit 8).

Criterion 7

The Commission's seventh criterion for a satisfactory color television system is as follows:

> It must be capable of transmitting color programs over intercity relay facilities presently in existence or which may be developed in the foreseeable future.

A series of test transmissions of the RCA color television system over present networking facilities has established that the system is capable of transmitting color programs over intercity relay facilities now in existence or which may be developed in the foreseeable future (Exhibit 11).

The American Telephone and Telegraph Company provides two types of intercity television facilities; the microwave relay and the coaxial cable. The microwave circuits have a bandwidth of somewhat more than 4 megacycles and are capable of transmitting good quality color television pictures produced by the RCA color television system (Exhibits 2, 11). Since it may be anticipated that coaxial cables having a bandwidth of only 2.7 megacycles may continue to serve certain areas for some time, it was necessary to devise equipment for networking the RCA system in color over such cables. This equipment has been developed and extensively and successfully tested (Exhibit 11). Public reaction to RCA color pictures networked by microwave relay facilities and by coaxial cable has been very favorable (Exhibit 2).

The RCA Color Television System Satisfies the Commission's Criteria

The foregoing review with respect to the Commission's criteria for a color television system shows that the RCA color television system operating on the basis of the signal specifications contained in Exhibit 1 fully satisfies in all respects the criteria set by the Commission. Further, the RCA color television system has been extensively field tested (Exhibits 2, 4, 7, 8, 10, 11).

Signal Specifications Proposed as Standards

The color television signal specifications which RCA and NBC are petitioning the Commission to adopt as standards for commercial color television broadcasting are identical with those previously approved by the National Television System Committee (Exhibit 1).

RCA and NBC engineers and scientists have worked with the NTSC in developing the recommended technical signal specifications and in field testing these specifications. RCA and NBC have furnished many color television transmissions and the use of their facilities for NTSC field tests (Exhibit 10). RCA and NBC have cooperated with the NTSC and furnished information obtained in their research and field testing to the NTSC.

Future Developments

RCA and NBC believe that in an industry as dynamic as the television industry, any set of signal specifications adopted as standards for color television should be so constituted that future improvements in equipment may be incorporated within their framework. The proposed technical signal specifications make provision for future improvements. By setting sufficiently high standards and not limiting the standards to the capabilities of existing equipment, the fruits of research and invention in the coming years can result in better equipment at both transmitter and receiver giving better performance and better pictures without requiring a change in standards or obsoleting receivers in the hands of the public.

For example, RCA has under development, and has already demonstrated, tricolor kinescopes having greatly increased brightness. As such tubes are developed to the point of commercial practicability, they can be incorporated in the RCA color television system without necessitating any change in the proposed standards.

RCA has also developed and demonstrated a single tricolor camera tube. This camera tube is being further tested and when it reaches the commercial stage, it likewise can be incorporated in the RCA color television system with no change in the proposed standards.

Work is also in progress on developing larger picture tubes and improved projection methods. Both larger picture tubes and a projection receiver have been demonstrated and they can later be incorporated in the RCA color television system without any change in the proposed standards.

Color Telecasting Plans

Upon adoption by the Commission of the signal specifications contained in Exhibit 1 as standards for commercial color television broadcasting, NBC would put into effect the plans and policies contained in Exhibit 3. NBC would commence broadcasting compatible color television programs and would offer such programs to commercial sponsors and NBC affiliated stations throughout the United States.

NBC has already equipped two studios for color television (Exhibit 10). Demonstrations have shown that these existing studios permit the production of color television programs comparable to monochrome productions (Exhibits 2, 10).

NBC has ordered additional color television studio equipment. When such equipment is delivered and if the proposed standards have been authorized for color television broadcasting on a commercial basis, NBC will expand its studio operations and increase color programming.

RCA's Manufacturing Plans

RCA has established a pilot plant for the production of RCA tricolor kinescopes within its tube plant at Lancaster, Pennsylvania (Exhibit 5). Within a few months, this pilot operation can attain a production rate of 2,000 tubes per month.

In response to demand for more tricolor kinescopes than can be produced in the pilot production unit, operations can be expanded into existing black and white kinescope production facilities with suitable modification of such facilities and the addition of the specialized items needed for tricolor kinescope production (Exhibit 5).

If the signal specifications contained in Exhibit 1 are approved by the Commission as standards for commercial color television broadcasting, RCA will take steps immediately to institute production of color television receivers similar in basic respects to the latest model receiver described in Exhibit 6. The final production model will make provision for both UHF and VHF reception.

Factory space for producing RCA color television receivers is available and necessary test equipment has been determined. Manufacturing personnel have examined the engineering samples of model RCA color television receivers and are agreed that no unusual manufacturing problems are involved. While a substantially increased number of component parts are required for a color television receiver as compared with a black and white receiver, and circuits require a greater degree of testing and adjustment, manufacturing techniques will be basically the same as for black and white television receivers.

If the Commission approves the proposed standards by the end of the Summer of 1953, engineering schedules call for engineering sign-off on a production model in the Fall of 1953. It is estimated that, on this schedule, pilot production of color receivers can start during the Spring of 1954 (Exhibit 6).

If the Commission approves the proposed standards by the end of the Summer of 1953, RCA would plan for the production of substantial quantities of color television receivers during 1954.

RCA plans to produce and offer for sale the RCA color television equipment needed by broadcast stations if the Commission adopts the proposed color standards. In order to facilitate the introduction of commercial color television broadcasting, RCA's initial plans are to produce appropriate broadcast equipment on a custom basis. This will enable broadcasters to proceed with color television early in 1954. Meanwhile, RCA will continue its development and design activities leading toward a regular commercial production program (Exhibit 9).

It is expected that color television will conform to the general pattern of all revolutionary new products or developments in the electronics field. Developments that result in better service take place continuously as commercial equipment is designed, built and used by the broadcasters and the public. New methods of doing things are devised and incorporated in new equipment as it is produced. Rapid progress in improving manufacturing techniques after production is commenced, mounting production volume, and subsequent engineering development, will all combine to reduce cost and improve the product.

The natural forces of American enterprise and competition result in better service at less cost in any product. Color television will not be an exception. The sooner the actual start of production can be made, the sooner the factors of mass production and experience will assert themselves, resulting in better color television equipment at lower prices.

INDEX TO EXHIBITS

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EXHIBIT 9

EXHIBIT 10

EXHIBIT 11

In general, each of the Exhibits and Appendixes which follow represents work by a number of people in the RCA and NBC organizations.

Although it is not feasible to list the names of all in the RCA and NBC organizations who made any contribution to each Exhibit and Appendix, major contributions were made by the following:

RCA LABORATORIES DIVISION

E. W. Engstrom
G. H. Brown
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A. J. Torre
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Y. W. Uyeda
J. W. Wentworth
J. F. Wilhelm

NATIONAL BROADCASTING COMPANY, INC.

S. L. Weaver, Jr.
O. B. Hanson
R. E. Shelby
A. L. Hammerschmidt
E. D. Goodale
E. P. Bertero
R. R. Davis
J. R. De Baun
H. Gronberg
H. M. Gurin
A. V. Hallack
R. A. Monfort
A. A. Walsh

EXHIBIT 1

TECHNICAL SIGNAL SPECIFICATIONS PROPOSED AS STANDARDS FOR COLOR TELEVISION.

EXHIBIT 1

TECHNICAL SIGNAL SPECIFICATIONS PROPOSED AS STANDARDS FOR COLOR TELEVISION.*

TEST SPECIFICATIONS — GROUP I

1. The image is scanned at uniform velocities from left to right and from top to bottom with 525 lines per frame and nominally 60 fields per second, interlaced 2-to-1.

2. The aspect ratio of the image is 4 units horizontally and 3 units vertically.

3. The blanking level is fixed at 75 per cent (± 2.5 per cent) of the peak amplitude of the carrier envelope. The maximum white (luminance) level is not more than 15 per cent nor less than 10 per cent of the peak carrier amplitude.

4. The horizontal and vertical synchronizing pulses are those specified in Section 3.682 of Subpart E of Part 3 of the FCC Rules Governing Radio Broadcast Services (as amended April 11, 1952, effective June 2, 1952), modified to provide the color synchronizing signal described in Specification 21 (Group II of these Specifications).

5. An increase in initial light intensity corresponds to a decrease in the amplitude of the carrier envelope (negative modulation).

6. The television channel occupies a total width of 6 mc. Vestigial-sideband amplitude modulation transmission is used for the picture signal in accordance with the FCC Rules cited in Specification 4, above.

7. The sound transmission is by frequency modulation, with maximum deviation ± 25 kilocycles, and with pre-emphasis in accordance with a 75-microsecond time constant. The frequency of the unmodulated sound carrier is 4.5 mc ± 1000 cycles above the frequency of the main picture carrier actually in use at the transmitter.

8. The radiated signals are horizontally polarized.

9. The power of the aural signal transmitter is not less than 50 per cent nor more than 70 per cent of the peak power of the visual signal transmitter.

TEST SPECIFICATIONS — GROUP II

10. The color picture signal has the following composition:

$$E_m = E_Y' + \{E_Q' \sin(\omega t + 33^\circ) + E_I' \cos(\omega t + 33^\circ)\}$$

where

$$E_Q' = 0.41\ (E_B' - E_Y') + 0.48\ (E_R' - E_Y')$$

$$E_I' = -0.27\ (E_B' - E_Y') + 0.74\ (E_R' - E_Y')$$

$$E_Y' = 0.30\ E_R' + 0.59\ E_G' + 0.11\ E_B'.$$

* These signal specifications are identical with the signal specifications approved for publication by the National Television System Committee on February 2, 1953.

The phase of the color burst is sin ($\omega t + 180°$).

Notes: For color-difference frequencies below 500 kc, the signal can be represented by

$$E_m = E_Y' + \left\{ \frac{1}{1.14} \left[\frac{1}{1.78} (E_B' - E_Y') \sin \omega t + (E_R' - E_Y') \cos \omega t \right] \right\}$$

In these expressions the symbols have the following significance:

E_m is the total video voltage, corresponding to the scanning of a particular picture element, applied to the modulator of the picture transmitter.

E_Y' is the gamma-corrected voltage of the monochrome (black and white) portion of the color picture signal, corresponding to the given picture element.

E_R', E_G', and E_B' are the gamma-corrected voltages corresponding to the red, green, and blue signals intended for the color picture tube, during the scanning of the given picture element.

E_Q' and E_I' are the two gamma-corrected orthogonal components of the chrominance signal corresponding respectively to the narrowband and wideband axes.

ω is 2π times the frequency of the chrominance subcarrier. The phase reference of this frequency is the color synchronizing signal (see Specification 21 below) which corresponds to amplitude modulation of a continuous sine wave of the form $\sin(\omega t + 180°)$ where t is the time.

The portion of each expression between brackets represents the chrominance subcarrier signal which carries the chrominance information.

It is recommended that field test receivers incorporate a reserve of 10 db gain in the chrominance channel over the gain required by the above expressions.

11. The primary colors referred to by E_R', E_G', and E_B' have the following chromaticities in the CIE system of specification:

	x	y
Red (R)	0.67	0.33
Green (G)	0.21	0.71
Blue (B)	0.14	0.08

12. The color signal is so proportioned that when the chrominance subcarrier vanishes, the chromaticity reproduced corresponds to Illuminant C ($x = 0.310$, $y = 0.316$).

13. Gamma correction is such that the desired pictorial result shall be obtained on a display device having a transfer gradient (gamma exponent) of 2.75. The equipment used shall be capable of an overall transfer gradient of unity with a display device having a transfer gradient of 2.75. The voltages E_Y', E_R', E_G', E_B', E_Q', and E_I' in the expression of Specification 10, above, refer to the gamma-corrected signals.

14. The color subcarrier frequency is 3.579545 mc ± 0.0003% with a maximum rate of change not to exceed 1/10 cycle per second per second.

15. The horizontal scanning frequency is 2/455 times the color subcarrier frequency. This corresponds nominally to 15,750 cycles per second (the actual value is 15,734.264 ± 0.047 cycles per second).

16. The bandwidth assigned to the monochrome signal E_Y' is in accordance with the FCC standard for black and white transmissions, as noted in Specification 6 above.

17. The bandwidth assigned prior to modulation to the color-difference signals E_Q' and E_I' is given by Table I.

Table I

Q-channel bandwidth

at 400 kc less than 2 db down
at 500 kc less than 6 db down
at 600 kc at least 6 db down

I-channel bandwidth

at 1.3 mc less than 2 db down
at 3.6 mc at least 20 db down

18. E_Y', E_R', E_G', E_B', E_Q', and E_I' are all matched to each other in time to within ± 0.05 microseconds. This is a tentative tolerance to be established definitely later.

19. The overall transmission bandwidth assigned to the modulated chrominance subcarrier shall extend to at least 1.5 mc below the chrominance subcarrier frequency and to at least 0.6 mc above the chrominance subcarrier frequency, at an attenuation of 2 db.

20. A sine wave, introduced at those terminals of the transmitter which are normally fed the color picture signal, shall produce a radiated signal having an envelope time delay, relative to 0.1 mc, of zero microseconds up to a frequency of 2.5 mc; and then linearly decreasing to 4.3 mc so as to be equal to —0.26 microseconds at 3.579545 mc. The tolerance on all these delays shall be ± 0.05 microseconds relative to the delay at 0.1 mc.

21. The color synchronizing signal is that specified in Figure 1.

22. The field strength measured at any frequency beyond the limits of the assigned channel shall be at least 60 db below the peak carrier level.

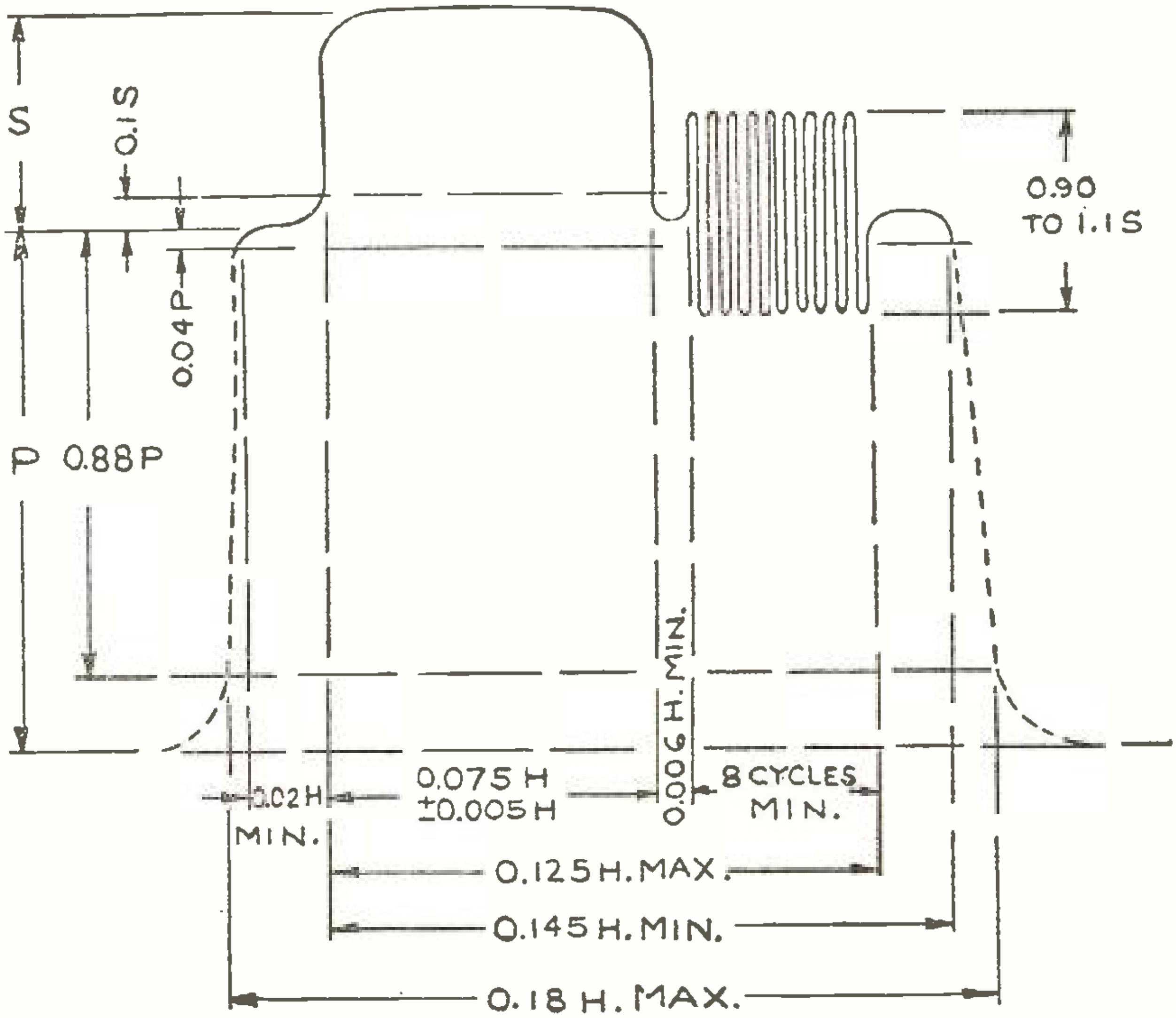


Fig. 1 — Specifications.

NOTES

1. The radiated signal envelope shall correspond to the modulating signal of the above figure, as modified by the transmission characteristics of Specification 6.
2. The burst frequency shall be the frequency specified for the chrominance subcarrier. The tolerance on the frequency shall be ±0.0003% with a maximum rate of change of frequency not to exceed 1/10 cycle per second per second.
3. The horizontal scanning frequency shall be $\frac{2}{455}$ times the burst frequency.
4. Burst follows each horizontal pulse, but is omitted following the equalizing pulses and during the broad vertical pulses.
5. Vertical blanking 0.07 to 0.08v.
6. The dimensions specified for the burst determine the times of starting and stopping the burst, but not its phase.
7. Dimension "P" represents the peak-to-peak excursion of the luminance signal, but does not include the chrominance signal.

EXHIBIT 2

A SURVEY OF AUDIENCE REACTION TO RCA COLOR TELEVISION

CONDUCTED IN NEW YORK CITY

June, 1953

FOR

RADIO CORPORATION OF AMERICA

BY

OPINION RESEARCH CORPORATION

Princeton, New Jersey

June 8, 1953

A SURVEY OF AUDIENCE REACTION TO RCA COLOR TELEVISION

Index

Appendixes

EXHIBIT 2

A SURVEY OF AUDIENCE REACTION TO RCA COLOR TELEVISION

Foreword

THIS report presents the findings of a survey conducted in connection with field tests of the RCA color television system which were made during the period June 2-5, 1953. The purpose of the survey was to obtain public reaction to RCA color television. Results are based on questionnaires from 763 persons.

The survey was conducted in the Lounge of the Center Theatre, West 49th Street and Avenue of the Americas, New York City. The audience was composed of members of the public from NBC tour groups.

Viewers filled out their own questionnaires after instructions from a representative of Opinion Research Corporation.

The same program was presented three times a day (11:00 A.M., 2:00 P.M. and 3:30 P.M.) on each of the four days during which the survey was conducted. Total duration of the program, which consisted of musical numbers and performances by a magician and a ventriloquist, was approximately twenty minutes. All test programs originated in the NBC Colonial Theatre at 62nd Street and Broadway, New York City.

Survey procedures are described in detail in this report. A copy of the questionnaire is attached (Appendix D).

PART I

Survey Procedures

A. The Viewing Situation

The Center Theatre Lounge contains six "booths." (A detailed diagram of the Lounge is attached as Appendix A.)

Four of these booths (Booths 1, 2, 3 and 4) are identical in size, shape and seating arrangements. Each of these contains four rows of five seats, the second, third and fourth rows being higher than the preceding row. Booth 5, the capacity of which is about 26, has a level floor. Booth 6 has 28 seats, arranged in four tiered rows.

The vast majority of the audience witnessed the tests in the four identical booths (1, 2, 3 and 4). The other two booths were used only once each in connection with the survey. On June 4, thirteen people saw the 3:30 P.M. show in Booth 5; and on June 5, six people saw the 11:00 A.M. show in Booth 6.

The television receivers in each booth were on platforms eighteen inches high.

B. Test Conditions (Description Supplied by NBC)

For ten of the twelve tests programs, color signals were transmitted from the theatre studio over a New York Telephone Company circuit to the RCA Building, and from there by cable to a miniature transmitter located in the Center Theatre Building. The output of the miniature transmitter was fed by cable to the color receivers.

Conditions for the other two test programs were as follows:

> *June 4, 2:00 P.M.:* Color signals were transmitted over the American Telephone and Telegraph system on microwave relay to Garden City, Virginia (just outside of Washington, D.C.), back to the RCA Building and thence to the miniature transmitter in the Center Theatre Building. These intercity facilities have a nominal bandwidth of 4 megacycles.
>
> *June 5, 2:00 P.M.:* The procedure above was followed except that transmission was to Washington, D.C., and back by AT&T coaxial cable. In this case, the nominal bandwidth was 2.7 megacycles, and the special heterodyne terminal equipment developed by RCA for this purpose was used.

C. Remarks by NBC Representative

Immediately prior to the beginning of each show, a representative of NBC made these remarks to the audience in the Center Theatre Lounge:

> "Ladies and Gentlemen: On behalf of the National Broadcasting Company, it is a pleasure to welcome you here today to view one of the Radio Corporation of America's color television field tests in the New York area.
>
> "This program, actually performed while you view it, will originate in the NBC Colonial Theatre at 62nd Street and Broadway. The color signals are transmitted from the theatre studio over a cable* to the RCA Building across the street, and thence to a miniature television transmitter located in this building.
>
> "On the stage in front of you is an experimental RCA color set which will receive these color signals. These receivers house RCA tricolor picture tubes.
>
> "And now it is my pleasure to introduce Mr. .... of the Opinion Research Corporation of Princeton, who has a few words to say to you before the show. Mr. ...."

---

* The words "over a cable" were omitted in the case of "network" shows (Part I, B).

D. Remarks by Opinion Research Corporation Representative

Following the introduction an Opinion Research Corporation representative said:

"Thank you.

"Ladies and gentlemen, we will greatly appreciate it if after the show is over you will remain in your seats for a few minutes. We would like to have a word with you at that time.

"And now, sit back, relax and enjoy the show."

At the end of each show, the Opinion Research Corporation representative said:

"Ladies and gentlemen, Opinion Research Corporation has been asked by RCA and NBC to conduct a survey of public reaction to the color television test you have just seen.

"A brief questionnaire will be handed you on which we would like you to express your frank opinions. It will take only a few minutes to complete this questionnaire, and we shall be very grateful for your cooperation.

"On most of the questions, you indicate your answer by placing an 'X' in the *one* box that comes closest to your opinion. Be sure to check just *one* box for each question. On a few questions, we ask you to write in your comments in your own words.

"When you have finished, please check over your questionnaire, making sure you have answered the questions on *both* sides of the sheet. Then, please turn in your questionnaire, writing board and pencil to the attendant at your booth. The attendants will give the questionnaires to us, and we shall tabulate the results in our office in Princeton, New Jersey.

"We want to assure you that your name will not be used in any way. Again, we would like to thank you for giving us your opinions."

E. The Balloting

An NBC page was assigned to each booth to serve as usher and to distribute and collect questionnaires, writing boards and pencils. Immediately after the completion of the balloting at each showing, the pages handed the completed questionnaires to an Opinion Research Corporation representative.

Pages and other RCA and NBC personnel were instructed to refer to members of the survey organization any questions from the audience dealing with the survey and the questionnaire.

F. Characteristics of the Audience

The audience was composed of members of the general public from NBC tour groups.

As a means of identifying any persons connected with the radio and television industry who might be present at the tests, the following question was included in the questionnaire:

> "Are you, or is anyone in your immediate family, connected in any way with the manufacture, sale, servicing, or broadcasting of radio or television?"

Of the 763 persons taking part in the survey, 92 answered this question in the affirmative. For purposes of tabulation and analysis, two classifications were established:

Audience (nonindustry): The 671 persons whose questionnaire had a negative answer to the question quoted above (644) or no answer at all (27).

Audience (industry-connected): The 92 who answered this question in the affirmative.

The table below gives characteristics of these two audiences:

	Audience (Nonindustry) Number	Per Cent	Audience (Industry-Connected) Number	Per Cent
Total	671	100%	92	100%
Sex:				
Men	301	45%	65	71%
Women	365	54%	27	29%
Not reported	5	1%	0	0%
Age:				
Under 20 years	156	23%	17	19%
20 - 29	155	23%	36	39%
30 - 39	121	18%	19	21%
40 or over	228	34%	16	17%
Not reported	11	2%	4	4%
Education:				
Incomplete grammar school	37	6%	2	2%
Completed grammar school	43	6%	2	2%
Incomplete high school	76	11%	11	12%
Completed high school	205	31%	30	33%
Incomplete college	136	20%	25	27%
Completed college	74	11%	16	17%
Postgraduate college	63	9%	5	6%
Not reported	37	6%	1	1%
Previous Television Exposure:				
Own a TV set	498	74%	70	76%
Do not own a set but had seen TV in preceding month	126	19%	20	22%
All others	47	7%	2	2%

The following table gives audience distribution according to home location:

	Audience (Nonindustry)	Audience (Industry-Connected)
Total	*671*	*92*
Alabama	3	0
Arkansas	4	0
California	16	6
Colorado	7	1
Connecticut	12	0
Delaware	2	0
Florida	8	2
Georgia	8	0
Illinois	15	3
Indiana	13	1
Iowa	9	0
Kansas	10	0
Kentucky	10	2
Louisiana	3	1
Maine	2	0
Maryland	13	2
Massachusetts	30	5
Michigan	9	2
Minnesota	13	1
Mississippi	3	2
Missouri	14	1
Nebraska	6	0
New Hampshire	3	0
New Jersey	28	6
New York City	161	23
Other New York State	41	10
North Carolina	7	3
North Dakota	2	0
Ohio	46	2
Oklahoma	2	0
Oregon	3	0
Pennsylvania	70	4
Rhode Island	3	0
South Carolina	3	0
Tennessee	8	0
Texas	24	8
Utah	1	0
Vermont	2	0
Virginia	15	2
Washington	1	0

Home Locations (*cont.*):	Audience (Nonindustry)	Audience (Industry-Connected)
Washington, D. C.	7	0
Wisconsin	8	1
Canada	9	3
Ireland	1	0
Scotland	3	0
Not reported	13	1

It is of course not possible to say to what extent viewers who witnessed these tests are representative of the national general public.

G. Receiver Monitoring

Each receiver was monitored by an engineer, who submitted a brief report (sample form attached as Appendix B) on receiver performance for each showing.

A total of 196 members of the nonindustry audience viewed the program on receivers that the reports described as being other than normal in one or more respects. In the Detailed Tables, the opinions of this group are shown separately.

Reports covering 35 of these 196 viewers referred only to the audio and stated that the condition was corrected during the showing. In many other cases, the reports indicated that irregularities were minor in character or were of only momentary duration.

H. The Receivers (Description Supplied by RCA)

The receivers used during the tests were RCA color television receivers Model No. 3A. These were designed to receive both the RCA color television signals and standard monochrome signals. Each receiver was equipped with the 16-inch envelope RCA tricolor kinescope and was housed in a cabinet having the following over-all dimensions: height, 40½ inches; width, 26¾ inches; and depth, 26 inches. The receivers had one additional operating control as compared with the number of controls found on most conventional monochrome receivers. This served to control the color saturation of the picture.

I. The Program

The program, a musical variety starring Nanette Fabray, was the same throughout the tests and lasted about twenty minutes. (The program script is attached as Appendix C.)

Following is the opening announcement:

"The Radio Corporation of America and the National Broadcasting Company present Color Television!

"Ladies and gentlemen, this is Ben Grauer speaking. (Bob Courtleigh substituted for Ben Grauer on the three June 2 showings.) It is my pleasure to welcome you to this special demonstration of RCA's compatible all-electronic color television system. By 'compatible' we mean that when the RCA color system is broadcast, all owners of existing television sets have the opportunity to see the same performance in black and white.

"You are seeing this program on a color receiver equipped with the RCA direct-view tricolor tube, and before we actually start with our show, let me give you a quick illustration of the effectiveness of color and the ease of change from black and white to color. Just look at these lovely and natural flowers in black and white. (A bouquet was shown in black and white for several seconds.) Now look at them in color!"

A brief outline of the program:

Singing and dancing: "That's What Makes Paris, Paree."

Magician: A series of tricks involving a piece of multicolored paper and accompanied by humorous commentary.

Song: "I'm a Little Bit in Love."

Ventriloquist: Imitation of a fox hunt.

Dancing with choral background: "Wait Till You See Her."

The closing announcement:

"You have been witnessing a special demonstration of RCA's all-electronic compatible color television system. And now for the Radio Corporation of America and the National Broadcasting Company, this is Ben Grauer (Bob Courtleigh on June 2) bidding you good (morning) (afternoon)."

PART II

Findings in Brief

The findings reported in this section are based on the 671 cases making up the nonindustry audience.

1. *Opinion was virtually unanimous that RCA color television is more enjoyable than regular black and white.*

"Which do you think is *more enjoyable*—color or regular black and white television that you have seen before today?"

		References to Detailed Tables
Color much more enjoyable	85%	
Color somewhat more enjoyable	13%	
Both about the same	1%	
Black and white somewhat more enjoyable	*%	
Black and white much more enjoyable	*%	A-1
Have never seen black and white	0%	
No answer	1%	

Note: On this question, 17 (3%) of the nonindustry audience marked "color much more enjoyable" *and* "color somewhat more enjoyable." These were classified in the less favorable of the two categories.

2. *There was widespread approval of the over-all quality of the RCA color television pictures.*

"How do you feel about the *over-all quality of the color television pictures* you have seen?"

Excellent	50%	
Very good	37%	
Good	11%	A-2
Only fair	2%	
Poor	0%	
No answer	*%	

3. *There was widespread approval of the clearness of detail of the RCA color pictures.*

"How would you rate the *clearness of detail* in the color television pictures?"

Excellent	46%	
Very good	39%	
Good	12%	A-3
Only fair	2%	
Poor	*%	
No answer	1%	

* Less than ½%.

4. *There was widespread approval of the trueness-to-life of the colors.*

"How would you rate the *trueness-to-life of the colors* in the pictures you saw?"

		References to Detailed Tables
Excellent	39%	
Very good	38%	
Good	18%	A-4
Only fair	3%	
Poor	1%	
No answer	1%	

5. *Almost seven in ten said there was a wide variety of colors.*

"What is your opinion about the *variety of colors* you saw?"

There was a limited variety	13%	
There was a wide variety	69%	
Somewhere in between	15%	A-5
No answer	3%	

6. *Better than seven in ten (73%) felt that the colors were about right in regard to vividness.*

"What is your opinion about the *vividness of the colors* you saw?"

Colors too vivid (too strong)	25%	
About right	73%	
Colors not vivid enough (too weak)	2%	A-6
No answer	*%	

7. *Better than seven in ten (76%) thought that, apart from the colors themselves, the over-all brightness of the screen was about right.*

"Apart from the colors themselves, how would you rate the *over-all brightness of the screen?*"

Much too bright	2%	
A little too bright	17%	
Just about right	76%	A-7
A little too dim	4%	
Much too dim	0%	
No answer	1%	

* Less than ½%.

8. *There was widespread approval of the quality of pictures in scenes with considerable action.*

"How would you rate the quality of pictures in the scenes with a *lot of action?*"

		References to Detailed Tables
Excellent	34%	
Very good	44%	
Good	18%	A-8
Only fair	3%	
Poor	*%	
No answer	1%	

9. *About one fourth (24%) of the nonindustry audience said there were defects in the pictures.*

A major part of this group, however, indicated that the defects they noted interfered only a little with their enjoyment of the pictures.

"Were there any defects, or anything wrong, in the color television pictures you saw, which interfered with your enjoyment of them?"

"How much did these defects interfere with your enjoyment of the pictures?"

Of the 24% who said there were defects— A-9

- 1% said these defects interfered a great deal with their enjoyment of the pictures A-10
- 6% said they interfered somewhat with their enjoyment
- 15% said they interfered a little
- 2% didn't express an opinion

These 24% did not give concentrated mention to any single defect. The most frequent comments made dealt with:

Colors not being true to life (5%)
Running of color (3%) A-11
Colors being too vivid (3%)
Blurred picture (3%)

* Less than ½%.

10. *In answer to an open question asking for any other comments about the color television pictures—*

References to Detailed Tables

41%	gave favorable comments	
10%	gave unfavorable comments	A-12
4%	gave both favorable and unfavorable comments	
4%	gave other comments or asked questions	
42%	gave no comments	

(These percentages add to more than 100 because a few viewers gave favorable or unfavorable comments and also asked a question.)

Among those who gave favorable comments, remarks made most often (by 25%) were along these lines:

Color TV is wonderful — A-13

Other principal favorable comments:

I want color TV now (6%)
Color makes television more enjoyable (5%) — A-13
Color is less tiring on the eyes than black and white (4%)

Among those who made unfavorable comments, these were the most frequent criticisms:

The colors weren't true to life (2%)
The colors were too vivid (2%) — A-14
The production or program content was poor (2%)

Here are some sample verbatim comments:

Favorable

"The color pictures were wonderful in every way. May RCA color TV come very soon!"

"Beautiful, especially the muted colors. Please make this available to the public without further delay."

"The eighth wonder of the world. The movies are on their way out with the coming of color television."

"It would be wonderful if we could now have both color and black and white so that if we wanted color, we could turn it on; and if not, we could turn to black and white."

"I hope it is available in the immediate future."

"It would be nice if they could speed up the distribution of the color tubes for TV sets."

"I would like to see it released for general use in the near future."

"I think we are missing a lot with just black and white pictures."

"According to what I have seen, I think color television is perfected well enough for home use."

"The quality of the picture was marvelous and the colors were true to life, not too vivid, and just about perfect. We have a lot to look forward to."

"I feel that color television is definitely a step in the right direction. It is far easier on the eyes. It adds a truer conception of what is being presented."

"Wonderful and easier on the eyes. In fact it was gorgeous."

"I especially enjoyed color TV with musical and dance numbers. Color scenes do add so much to the movements and settings."

"I did not expect to see such a fine demonstration. Color usually hurts my eyes, but your picture was more restful than black and white television."

"Perfect. Thoroughly enjoyable and we anxiously await the time when everyone can experience the same pleasure in the home."

"Since seeing the color TV I will not be satisfied with our own set. It is much more appealing and restful for the eyes. Detail was very good in the close-ups."

"The demonstration gave a wide variety of types of color. That is, loud, muted, deep-shadowed, etc. I enjoyed it very much and hope to get a set as soon as it comes out."

"Terrific. I was very much impressed and enjoyed every minute of it. Color TV marks a new era in an already outstanding field. I think it should be developed to the point where all sets will be in color."

"When color television like this is available to the public, I would like to have a television set. One hundred per cent better than black and white, I think."

"I liked it very much. In fact I will wait until color TV is on the market before purchasing TV."

"Very pleasantly surprised by their good quality in color and clarity."

"Excellent entertainment, but even a news broadcast would be more interesting in color. This is my first view of color TV and from what I saw I prefer it to black and white. I would buy a set now."

"I think the RCA system is very good. The colors were perfect in almost all cases."

"This particular showing was beautiful and breathtaking in quality. I would like to have a color TV set."

Unfavorable

"The lips are not true color. Close-ups of the mouth showed a false flesh tone on lips, tongues and gums."

"I noticed a red fuzziness about hands and arms."

"Human skin had a certain blueness."

"The colors were too vivid."

"The colors were too bright."

"The stage settings and musical numbers were not the best."

11. *The detailed tables that follow do not show many marked differences in the attitudes of subgroups.*

Where differences occur, they are chiefly in the degree of approval that is expressed.

With some exceptions, these broad generalizations can be made:

Age: Persons over forty were slightly more favorable than were those between twenty and 39. Those under twenty tended to be in an intermediate position.

Test conditions: As a rule, persons who saw the microwave relay showing tended to vote less favorably than did those who viewed the coaxial cable showing. The main exception here is that the reverse is true on the comparison of the enjoyableness of color television with that of black and white. By and large, closed-circuit viewers were more favorable than those who saw either of the two network showings. As is the case with most subgroup differences, however, differences in the attitudes of closed-circuit and network viewers are largely in the degree of *favorable* opinion expressed.

All differences among subgroups should be interpreted with caution, particularly where the differences are small and where the subgroups themselves are small.

PART III

Detailed Tables

The tables in this section present the detailed findings of the survey. The order of the tables is the same as that in which the questions appear in the survey questionnaire.

Persons taking part in the survey have been divided into two broad classifications according to whether or not their questionnaires indicated a connection with the radio or television industry (Part I, F).

Total tabulations only are shown for the 92 members of the industry-connected audience. Survey questions have been tabulated in detail for the non-industry audience (671 of the 763 persons taking part) in terms of personal characteristics and factors directly connected with the survey situation, as follows:

Personal Characteristics

Previous television exposure: television set owners; those who do not own a set but saw a television program in the month preceding the tests; all others

Sex

Age

Survey Factors

Date attended

Time of show attended

Test conditions: closed circuit; microwave relay; coaxial cable (Part I, B)

Booth

Receiver performance: Under "reception normal" are included all viewers covered by engineer monitor reports which showed no irregularity in receiver performance. Under "reception irregular" are shown those covered by reports indicating irregular receiver performance in any respect (including audio) of even momentary duration. (See Part I, G.)

Five members of the nonindustry audience did not indicate their sex, and eleven did not indicate their age. These cases are included in the nonindustry audience totals but not in the subgroups for which information is lacking.

On the first question (Table A-1), seventeen members of the nonindustry audience marked "color much more enjoyable than black and white" *and* "color somewhat more enjoyable than black and white." These cases have been shown only in the second (less favorable) of these two categories.

On tables giving results to comment questions, some percentages add to more than 100 on the totals shown because of multiple answers.

Question 1: *A-1*

WHICH DO YOU THINK IS *MORE ENJOYABLE*—COLOR OR REGULAR BLACK AND WHITE TELEVISION THAT YOU HAVE SEEN BEFORE TODAY?

(Table reads across.)

	Total	Color Much More Enjoyable than Black and White	Color Somewhat More Enjoyable	Both About the Same	Black and White Somewhat More Enjoyable	Black and White Much More Enjoyable	Have Never Seen Black and White	No Answer
AUDIENCE (nonindustry)	671	85%	13%	1%	*%	*%	0%	1%
TV owners	498	83%	15%	1%	*%	*%	0%	1%
Nonowners, viewers	126	91%	8%	0%	0%	0%	0%	1%
All others	47	87%	9%	2%	0%	0%	0%	2%
Men	301	84%	14%	1%	0%	*%	0%	1%
Women	365	87%	12%	*%	*%	0%	0%	1%
Under 20 years	156	90%	8%	1%	0%	0%	0%	1%
20-29 years	155	86%	14%	0%	0%	0%	0%	0%
30-39 years	121	86%	11%	2%	0%	0%	0%	1%
40 years or over	228	81%	16%	1%	*%	*%	0%	2%
June 2 (Tuesday)	186	83%	13%	*%	0%	1%	0%	3%
June 3 (Wednesday)	164	86%	13%	0%	0%	0%	0%	1%
June 4 (Thursday)	181	89%	9%	1%	0%	0%	0%	1%
June 5 (Friday)	140	80%	18%	1%	1%	0%	0%	0%
11:00 A.M. show	236	87%	10%	1%	0%	0%	0%	2%
2:00 P.M. show	217	80%	17%	1%	*%	1%	0%	1%
3:30 P.M. show	218	87%	12%	0%	0%	0%	0%	1%
Closed circuit	565	86%	12%	*%	0%	*%	0%	2%
Microwave relay	59	90%	8%	0%	0%	0%	0%	2%
Coaxial cable	47	68%	26%	4%	2%	0%	0%	0%
Booth 1	157	87%	11%	0%	0%	1%	0%	1%
Booth 2	164	85%	14%	1%	0%	0%	0%	*%
Booth 3	173	81%	15%	2%	1%	0%	0%	1%
Booth 4	160	87%	10%	0%	0%	0%	0%	3%
Booth 5	13**							
Booth 6	4**							
Reception normal	475	86%	12%	*%	0%	*%	0%	2%
Reception irregular	196	81%	16%	1%	1%	0%	0%	1%
AUDIENCE (industry-connected)	92	83%	13%	1%	0%	0%	0%	3%

* Less than ½%.
** Cases too few for analysis.

HOW DO YOU FEEL ABOUT THE *OVER-ALL QUALITY OF THE COLOR TELEVISION PICTURES* YOU HAVE SEEN?

(Table reads across.)

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer
AUDIENCE (nonindustry) ...	671	50%	37%	11%	2%	0%	*%
TV owners	493	49%	38%	12%	1%	0%	0%
Nonowners, viewers	126	51%	38%	9%	1%	0%	1%
All others	47	58%	32%	6%	4%	0%	0%
Men	301	51%	35%	12%	2%	0%	*%
Women	365	49%	39%	11%	1%	0%	0%
Under 20 years	156	41%	50%	8%	1%	0%	0%
20-29 years	155	39%	42%	16%	3%	0%	0%
30-39 years	121	53%	29%	16%	1%	0%	1%
40 years or over	228	62%	30%	7%	1%	0%	0%
June 2 (Tuesday)	186	52%	38%	10%	0%	0%	0%
June 3 (Wednesday)	164	53%	38%	7%	2%	0%	*%
June 4 (Thursday)	181	42%	43%	13%	2%	0%	0%
June 5 (Friday)	140	54%	28%	15%	3%	0%	0%
11:00 A.M. show	236	58%	33%	7%	2%	0%	0%
2:00 P.M. show	217	40%	43%	16%	*%	0%	1%
3:30 P.M. show	218	51%	36%	11%	2%	0%	0%
Closed circuit	565	53%	36%	9%	2%	0%	*%
Microwave relay	59	27%	52%	19%	2%	0%	0%
Coaxial cable	47	43%	34%	23%	0%	0%	0%
Booth 1	157	51%	33%	15%	1%	0%	0%
Booth 2	164	43%	45%	10%	2%	0%	0%
Booth 3	173	50%	34%	13%	2%	0%	1%
Booth 4	160	55%	37%	7%	1%	0%	0%
Booth 5	13**						
Booth 6	4**						
Reception normal	475	54%	34%	11%	1%	0%	*%
Reception irregular	196	41%	44%	12%	3%	0%	0%
AUDIENCE (industry-connected) ...	92	37%	48%	11%	3%	1%	0%

* Less than ½%.

** Cases too few for analysis.

HOW WOULD YOU RATE THE *CLEARNESS OF DETAIL* IN THE COLOR TELEVISION PICTURES?

(Table reads across.)

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer
AUDIENCE (nonindustry) ...	671	46%	39%	12%	2%	*%	1%
TV owners	498	46%	38%	13%	2%	*%	1%
Nonowners, viewers	126	48%	41%	9%	1%	0%	1%
All others	47	40%	47%	9%	0%	0%	4%
Men	301	46%	40%	12%	1%	*%	1%
Women	365	47%	38%	12%	2%	0%	1%
Under 20 years	156	47%	39%	12%	2%	0%	0%
20-29 years	155	36%	44%	17%	3%	0%	0%
30-39 years	121	46%	37%	15%	1%	1%	0%
40 years or over	228	55%	36%	6%	*%	0%	3%
June 2 (Tuesday)	186	50%	37%	9%	2%	0%	2%
June 3 (Wednesday)	164	42%	43%	11%	2%	0%	2%
June 4 (Thursday)	181	46%	39%	13%	2%	0%	*%
June 5 (Friday)	140	47%	35%	15%	1%	1%	1%
11:00 A.M. show	236	51%	40%	8%	*%	0%	1%
2:00 P.M. show	217	42%	41%	13%	2%	*%	2%
3:30 P.M. show	218	47%	37%	14%	2%	0%	*%
Closed circuit	565	48%	38%	11%	1%	0%	2%
Microwave relay	59	41%	40%	17%	2%	0%	0%
Coaxial cable	47	34%	45%	17%	2%	2%	0%
Booth 1	157	47%	36%	14%	2%	0%	1%
Booth 2	164	46%	42%	8%	2%	1%	1%
Booth 3	173	43%	42%	13%	1%	0%	1%
Booth 4	160	52%	34%	11%	1%	0%	2%
Booth 5	13**						
Booth 6	4**						
Reception normal	475	49%	37%	11%	1%	0%	2%
Reception irregular	196	41%	42%	14%	2%	1%	*%
AUDIENCE (industry-connected) ...	92	39%	39%	15%	5%	2%	0%

* Less than ½%.

** Cases too few for analysis.

Question 4: *A-4*

HOW WOULD YOU RATE THE *TRUENESS-TO-LIFE* OF *THE COLORS* IN THE PICTURES YOU SAW?

(Table reads across.)

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer
AUDIENCE (nonindustry) . . .	671	39%	38%	18%	3%	1%	1%
TV owners	498	39%	38%	18%	4%	*%	1%
Nonowners, viewers	126	39%	40%	18%	1%	1%	1%
All others	47	43%	36%	11%	4%	2%	4%
Men	301	40%	34%	20%	4%	1%	1%
Women	365	39%	41%	16%	3%	*%	1%
Under 20 years	156	40%	37%	19%	4%	0%	0%
20-29 years	155	28%	41%	24%	5%	2%	0%
30-39 years	121	32%	47%	16%	4%	0%	1%
40 years or over	228	50%	33%	13%	1%	0%	3%
June 2 (Tuesday)	186	46%	35%	15%	2%	1%	1%
June 3 (Wednesday)	164	42%	42%	13%	1%	0%	2%
June 4 (Thursday)	181	29%	41%	22%	6%	1%	1%
June 5 (Friday)	140	39%	34%	20%	5%	0%	2%
11:00 A.M. show	236	45%	36%	15%	2%	1%	1%
2:00 P.M. show	217	34%	36%	22%	4%	1%	3%
3:30 P.M. show	218	38%	42%	16%	4%	*%	*%
Closed circuit	565	42%	38%	15%	3%	1%	1%
Microwave relay	59	22%	41%	30%	7%	0%	0%
Coaxial cable	47	30%	36%	24%	6%	0%	4%
Booth 1	157	46%	36%	15%	2%	0%	1%
Booth 2	164	36%	39%	20%	2%	2%	1%
Booth 3	173	37%	38%	18%	5%	1%	1%
Booth 4	160	40%	39%	16%	3%	0%	2%
Booth 5	13**						
Booth 6	4**						
Reception normal	475	41%	38%	17%	3%	*%	1%
Reception irregular	196	34%	39%	19%	5%	1%	2%
AUDIENCE (industry-connected) . . .	92	31%	41%	16%	10%	1%	1%

* Less than ½%.

** Cases too few for analysis.

Question 5: *A-5*

WHAT IS YOUR OPINION ABOUT THE *VARIETY OF COLORS* YOU SAW?

(Table reads across.)

	Total	A Limited Variety of Colors	A Wide Variety of Colors	Somewhere in Between	No Answer
AUDIENCE (nonindustry)	671	13%	69%	15%	3%
TV owners	498	13%	71%	14%	2%
Nonowners, viewers	126	15%	64%	19%	2%
All others	47	13%	62%	15%	10%
Men	301	13%	67%	19%	1%
Women	365	13%	71%	13%	3%
Under 20 years	156	9%	75%	16%	0%
20-29 years	155	12%	65%	23%	0%
30-39 years	121	15%	67%	16%	2%
40 years or over	228	16%	70%	10%	4%
June 2 (Tuesday)	186	13%	68%	16%	3%
June 3 (Wednesday)	164	12%	70%	15%	3%
June 4 (Thursday)	181	13%	70%	15%	2%
June 5 (Friday)	140	14%	68%	16%	2%
11:00 A.M. show	236	13%	69%	15%	3%
2:00 P.M. show	217	12%	69%	17%	2%
3:30 P.M. show	218	14%	69%	15%	2%
Closed circuit	565	14%	68%	15%	3%
Microwave relay	59	10%	75%	15%	0%
Coaxial cable	47	9%	74%	17%	0%
Booth 1	157	11%	69%	17%	3%
Booth 2	164	10%	75%	11%	4%
Booth 3	173	16%	67%	16%	1%
Booth 4	160	12%	70%	16%	2%
Booth 5	13**				
Booth 6	4**				
Reception normal	475	13%	70%	14%	3%
Reception irregular	196	13%	66%	19%	2%
AUDIENCE (industry-connected)	92	14%	75%	9%	2%

** Cases too few for analysis.

Question 6:

WHAT IS YOUR OPINION ABOUT THE *VIVIDNESS OF THE COLORS* YOU SAW?

(Table reads across.)

	Total	Colors Too Vivid (Too Strong)	About Right	Colors Not Vivid Enough (Too Weak)	No Answer
AUDIENCE (nonindustry)	671	25%	73%	2%	*%
TV owners	498	26%	71%	3%	*%
Nonowners, viewers	126	25%	74%	1%	0%
All others	47	15%	83%	0%	2%
Men	301	24%	72%	4%	0%
Women	365	26%	73%	1%	*%
Under 20 years	156	24%	75%	1%	0%
20-29 years	155	36%	61%	3%	0%
30-39 years	121	27%	68%	5%	0%
40 years or over	228	16%	83%	1%	*%
June 2 (Tuesday)	186	18%	78%	3%	1%
June 3 (Wednesday)	164	28%	71%	1%	0%
June 4 (Thursday)	181	30%	69%	1%	0%
June 5 (Friday)	140	23%	73%	3%	1%
11:00 A.M. show	236	23%	74%	3%	*%
2:00 P.M. show	217	27%	70%	2%	1%
3:30 P.M. show	218	24%	74%	2%	0%
Closed circuit	565	24%	73%	2%	1%
Microwave relay	59	25%	73%	2%	0%
Coaxial cable	47	30%	70%	0%	0%
Booth 1	157	18%	78%	3%	1%
Booth 2	164	28%	71%	1%	0%
Booth 3	173	27%	69%	3%	1%
Booth 4	160	26%	72%	2%	0%
Booth 5	13**				
Booth 6	4**				
Reception normal	475	25%	72%	2%	1%
Reception irregular	196	23%	75%	2%	0%
AUDIENCE (industry-connected)	92	22%	73%	5%	0%

* Less than ½%.
** Cases too few for analysis

APART FROM THE COLORS THEMSELVES, HOW WOULD YOU RATE THE *OVER-ALL BRIGHTNESS* OF THE SCREEN?

(Table reads across.)

	Total	Much Too Bright	A Little Too Bright	Just About Right	A Little Too Dim	Much Too Dim	No Answer
AUDIENCE (nonindustry) . . .	671	2%	17%	76%	4%	0%	1%
TV owners	498	2%	19%	75%	4%	0%	*%
Nonowners, viewers	126	1%	16%	78%	4%	0%	1%
All others	47	4%	11%	77%	4%	0%	4%
Men	301	2%	14%	77%	7%	0%	*%
Women	365	2%	20%	76%	2%	0%	*%
Under 20 years	153	2%	25%	69%	4%	0%	0%
20-29 years	155	1%	23%	70%	6%	0%	0%
30-39 years	121	2%	13%	78%	6%	0%	1%
40 years or over	228	1%	11%	86%	1%	0%	1%
June 2 (Tuesday)	186	1%	15%	77%	6%	0%	1%
June 3 (Wednesday)	164	1%	24%	72%	2%	0%	1%
June 4 (Thursday)	181	2%	18%	76%	4%	0%	0%
June 5 (Friday)	140	2%	13%	80%	4%	0%	1%
11:00 A.M. show	236	1%	13%	80%	5%	0%	1%
2:00 P.M. show	217	2%	24%	69%	4%	0%	1%
3:30 P.M. show	218	2%	16%	79%	3%	0%	0%
Closed circuit	565	2%	16%	77%	4%	0%	1%
Microwave relay	59	2%	27%	63%	8%	0%	0%
Coaxial cable	47	0%	19%	79%	2%	0%	0%
Booth 1	157	3%	17%	74%	5%	0%	1%
Booth 2	164	2%	20%	76%	2%	0%	0%
Booth 3	173	0%	19%	76%	3%	0%	2%
Booth 4	160	1%	17%	76%	6%	0%	0%
Booth 5	13**						
Booth 6	4**						
Reception normal	475	2%	18%	75%	4%	0%	1%
Reception irregular	196	1%	16%	79%	4%	0%	0%
AUDIENCE (industry - connected)	92	0%	21%	69%	9%	1%	0%

*Less than ½%.
**Cases too few for analysis.

Question 8: *A-8*

HOW WOULD YOU RATE THE QUALITY OF PICTURES IN THE SCENES WITH A *LOT OF ACTION?*

(Table reads across.)

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer
AUDIENCE (nonindustry) ...	671	34%	44%	18%	3%	*%	1%
TV owners	498	36%	42%	17%	3%	*%	2%
Nonowners, viewers	126	26%	55%	17%	1%	0%	1%
All others	47	32%	41%	21%	4%	0%	2%
Men	301	33%	44%	17%	4%	0%	2%
Women	365	35%	45%	18%	2%	*%	*%
Under 20 years	156	34%	46%	15%	4%	0%	1%
20-29 years	155	27%	46%	23%	2%	1%	1%
30-39 years	121	28%	48%	21%	2%	0%	1%
40 years or over	228	43%	39%	14%	2%	0%	2%
June 2 (Tuesday)	186	35%	43%	18%	2%	0%	2%
June 3 (Wednesday)	164	34%	46%	14%	4%	1%	1%
June 4 (Thursday)	181	29%	47%	21%	2%	0%	1%
June 5 (Friday)	140	39%	39%	16%	4%	0%	2%
11:00 A.M. show..........	236	38%	44%	14%	3%	0%	1%
2:00 P.M. show...........	217	32%	43%	21%	2%	*%	2%
3:30 P.M. show...........	218	32%	45%	18%	4%	0%	1%
Closed circuit	565	36%	43%	17%	3%	*%	1%
Microwave relay	59	15%	56%	26%	3%	0%	0%
Coaxial cable	47	36%	39%	21%	0%	0%	4%
Booth 1	157	36%	38%	20%	4%	0%	2%
Booth 2	164	22%	52%	19%	5%	0%	2%
Booth 3	173	39%	44%	14%	2%	0%	1%
Booth 4	160	38%	41%	18%	1%	1%	1%
Booth 5	13**						
Booth 6	4**						
Reception normal	475	35%	44%	16%	3%	*%	2%
Reception irregular	196	32%	43%	22%	2%	0%	1%
AUDIENCE (industry - connected)	92	27%	46%	17%	7%	2%	1%

*Less than ½%.
**Cases too few for analysis.

Question 9a: *A-9*

WERE THERE ANY DEFECTS, OR ANYTHING WRONG, IN THE COLOR TELEVISION PICTURES YOU SAW, WHICH INTERFERED WITH YOUR ENJOYMENT OF THEM?

(Table reads across.)

	Total	Yes	No	No Answer
AUDIENCE (nonindustry)	671	24%	75%	1%
TV owners	498	28%	71%	1%
Nonowners, viewers	126	14%	86%	0%
All others	47	6%	92%	2%
Men	301	25%	75%	*%
Women	365	23%	76%	1%
Under 20 years	156	24%	75%	1%
20-29 years	155	35%	65%	0%
30-39 years	121	30%	69%	1%
40 years or over	228	12%	87%	1%
June 2 (Tuesday)	186	21%	77%	2%
June 3 (Wednesday)	164	24%	76%	0%
June 4 (Thursday)	181	28%	70%	2%
June 5 (Friday)	140	22%	77%	1%
11:00 A.M. show	236	23%	77%	*%
2:00 P.M. show	217	26%	72%	2%
3:30 P.M. show	218	23%	76%	1%
Closed circuit	565	23%	76%	1%
Microwave relay	59	27%	70%	3%
Coaxial cable	47	26%	74%	0%
Booth 1	157	27%	71%	2%
Booth 2	164	25%	74%	1%
Booth 3	173	18%	81%	1%
Booth 4	160	27%	72%	1%
Booth 5	13**			
Booth 6	4**			
Reception normal	475	23%	76%	1%
Reception irregular	196	26%	73%	1%
AUDIENCE (industry-connected)	92	35%	63%	2%

* Less than ½%.
** Cases too few for analysis.

HOW MUCH DID THESE DEFECTS INTERFERE WITH YOUR ENJOYMENT OF THE PICTURES? (Asked only of those who said there were defects in the color television pictures they saw.)

(Table reads across.)

	Total Respondents	Those Who Said There Were Defects (Per Cent of Total)	A Great Deal	Somewhat	A Little	No Answer
AUDIENCE (nonindustry)	671	24%	1%	6%	15%	2%
TV owners	498	28%	1%	7%	18%	2%
Nonowners, viewers	126	14%	1%	2%	9%	2%
All others	47	6%	0%	0%	4%	2%
Men	301	25%	2%	6%	15%	2%
Women	365	23%	*%	6%	16%	1%
Under 20 years	156	24%	1%	3%	19%	1%
20-29 years	155	35%	1%	10%	22%	2%
30-39 years	121	30%	1%	9%	16%	4%
40 years or over	228	12%	1%	3%	7%	1%
June 2 (Tuesday)	186	21%	0%	5%	15%	1%
June 3 (Wednesday)	164	24%	2%	2%	18%	2%
June 4 (Thursday)	181	28%	1%	8%	16%	3%
June 5 (Friday)	140	22%	1%	7%	13%	1%
11:00 A.M. show	236	23%	2%	6%	12%	3%
2:00 P.M. show	217	26%	*%	7%	17%	2%
3:30 P.M. show	218	23%	*%	4%	18%	1%
Closed circuit	565	23%	1%	5%	15%	2%
Microwave relay	59	27%	2%	8%	14%	3%
Coaxial cable	47	26%	0%	13%	13%	0%
Booth 1	157	27%	0%	9%	17%	1%
Booth 2	164	25%	1%	7%	16%	1%
Booth 3	173	18%	1%	5%	10%	2%
Booth 4	160	27%	1%	4%	19%	3%
Booth 5	13**					
Booth 6	4**					
Reception normal	475	23%	1%	4%	16%	2%
Reception irregular	196	26%	*%	10%	15%	1%
AUDIENCE (industry-connected)	92	35%	0%	6%	26%	3%

* Less than ½%.
** Cases too few for analysis.

WOULD YOU PLEASE WRITE IN BELOW WHAT DEFECTS YOU NOTICED? (Asked only of those who said there were defects in the color television pictures they saw.)

(Table reads down.)

	Audience	
	Non-industry	Industry-connected
Total respondents	671	92
Those who said there were defects (per cent of total)	24%	35%
Color Factors:		
COLORS NOT TRUE TO LIFE: teeth looked funny; teeth outlined in black; mouth cavity blacked out; complexion of most seemed too pink; the lip coloring on the announcer seemed unnatural; colors were not natural enough; too much like technicolor; skin tones were blue; did not like the color of the teeth; the color of the hair was not natural-looking; flesh tones unnatural; purplish cast to flesh; hands looked dirty	5%	5%
RUNNING OF COLOR: colors blur; in some places the colors overlapped; on close-ups colors blurred; a nonrelated color glow about the faces; a few of the colors ran a little with a green background; there were some colors reflected in the skin of the performers	3%	8%
CRITICISM OF BACKGROUND: dim background; a quiver in the background when magician was on; background color didn't blend properly; reflection of dim light in back	1%	3%
ENTIRE PICTURE TINGED: there seemed to be a dark filter in front of the viewing screen which tinted everything purple; too much blue tone in picture; much of the picture seemed to be blue	1%	2%
COLORS WRONG: the green color did not seem right; the white seemed bluish in the man's white shirt; there were no true whites	1%	1%
COLOR VARIATION: hands turned blue when raised up to face	1%	0%

Question 9c (continued):

(Table reads down.)

	Audience Non-industry	Audience Industry-connected
POOR COLOR IN ACTION SHOTS: during action scenes colors were not clear but dull and confusing; as a dancer with black hair turned, it looked as if her hair were red	*%	3%
Definition Factors:		
PICTURE BLURRED: the faces, particularly the eyes of the performers, were hazy; face was not clear; very slight blurring; blurred when getting closer; a little blurry in the features a few times; occasionally it seemed blurred; some of the pictures seemed a little smudged or blurred	3%	3%
PICTURE BLURRED IN ACTION SCENES: a bit of haze in the quick action shots; quick action close to camera made unclear picture; blurred picture during the entrance and exit of the actors; motion of people was somewhat blurred	2%	3%
UNCOMPLIMENTARY TO ACTORS: the faces looked older; man who opened program seemed to to have no teeth; shows too clearly the small faults like a girl's hair or teeth; one of the men looked like he needed a shave	1%	0%
FOCUS IN LONG SHOTS: full stage pictures were dim; not too clear on distance; lines of contrast not distinct when object is distant from camera	*%	2%
Production and Program:		
SELECTION OF COLOR IN COSTUMES AND STAGING: too few colors; the use of one color in repetition; too much black used; Nanette's dress was too dark; no white; blue shirts with black formal attire; too much blue; I noticed there was no white used	2%	2%
TECHNICAL AND PRODUCTION: reflection lights on faces; mikes were showing; lighting occasionally too bright; audio reproduction too prominent; camera range	1%	5%

* Less than ½%.

Question 9c (continued):

(Table reads down.)

	Audience Non-industry	Audience Industry-connected
MAKE-UP POOR: make-up could be improved; Nanette's cosmetics were too pronounced; lipstick on Nanette; make-up on actors seemed a little too obvious; too much make-up on the men	1%	2%
Brightness Factors:		
COLORS TOO VIVID: colors too vivid and bright; colors much too strong; the colors were too vivid to be compressed into such a small area; the effect was almost blinding; the bright colors, red and bright blue, were too bright in comparison with background or lighter colors; overloaded color values	3%	2%
COLORS NOT VIVID ENOUGH: some of the colors were a little too dull; colors were too flat with inadequate color change in shadows	*%	1%
PICTURE BRIGHTNESS: too bright sometimes	*%	1%
Receiver Characteristics:		
DIFFERENCE OF COLOR AT EDGE OF SCREEN: when light colors are on screen there is a red color around the edges; purple streak on the right side of the screen; a violet line at the lower edge of the screen	1%	3%
SCREEN TOO SMALL: picture too small; screen a little small considering my distance from it	*%	1%
PICTURE FADE-OUT	*%	0%
Other Factors:		
COLORS TIRE THE EYES: a little too strong for my eyes	1%	1%
Miscellaneous	*%	0%
No comment	1%	1%

* Less than ½%.

PLEASE WRITE BELOW ANY OTHER COMMENTS YOU WOULD LIKE TO MAKE ABOUT THE COLOR TELEVISION PICTURES YOU SAW.

(Table reads down.)

	Audience	
	Non-industry	Industry-connected
Respondents	671	92
TYPE OF COMMENT		
Favorable	41%	34%
Unfavorable	10%	10%
Both favorable and unfavorable	4%	13%
Questions	2%	3%
Qualified	2%	0%
No answer	42%	43%

A total of nineteen people from both audience groups asked questions. These were the most frequent subjects of inquiry:

Five persons wanted to know about the clearness of color pictures on larger screens; for example:

"Will the clearness of detail be lost as the size of the screen is increased?"
"Can you produce the same color on large screens?"

Four asked when would color television be available to the public; for example:

"When are the color tubes going to be for sale?"
"When will it be possible to have color sets at home?"

Three inquired if color television would cause eyestrain.

Two wanted to know whether or not the men had on blue shirts.

Most of the fourteen comments classified as qualified expressed approval with reservations; for example:

"RCA color is a great novelty and will be a huge commercial success *but* quality of programs will be the primary concern if TV is to continue to be the Number 1 segment of the entertainment industry."

"I believe that color television would be appreciated more than black and white by everyone if just perfected a little more."

"I think it is very good and with a few more improvements it will become excellent."

(Table reads down.)

	Audience Non-industry	Industry-connected
Favorable Comments	41%	34%
COLOR TV WONDERFUL: enjoyed it very much; terrific; most enjoyable; think color TV is excellent; satisfactory; very good; color pictures were wonderful in every way; it is wonderful; wonderful new type of entertainment; lovely; beautiful; better than I expected	25%	16%
WANT COLOR TV NOW: hope these color sets will be available soon; hope RCA color TV comes out real soon; can't wait until it is nationwide; hope it is in the immediate future; will wait for color before buying TV	6%	3%
COLOR MAKES TELEVISION MORE ENJOYABLE: think color TV is much more enjoyable; more entertaining; color added much to the enjoyment	5%	4%
COLOR LESS TIRING ON THE EYES THAN BLACK AND WHITE: very easy on the eyes; easier on the eyes; doesn't seem to be so hard on the eyes	4%	2%
GENERALLY MUCH BETTER THAN BLACK AND WHITE TV: I think we are missing a lot with just black and white pictures; I think it is much better than black and white	3%	3%
PICTURE CLEAR: was very surprised at high quality of the picture; the clarity was amazing; not much smear noted; distinct; clarity of detail	3%	2%
LIKE THE COLORS: the colors were lovely; I especially enjoyed the subdued shades and colorings; the reds and blues were lovely; very colorful; I liked the variety of colors; the colors were very exciting	3%	2%
FINE PROGRESS, GOOD ADVANCEMENT, A STEP FORWARD, ETC.: greatest improvement in TV yet; a modern improvement; color TV is definitely a step in the right direction; a great step forward in the color TV field	2%	7%

Question 10 (continued):

(Table reads down.)

	Audience Non-industry	Audience Industry-connected
COLORS TRUE TO LIFE: thought faces were very good for coloring; very realistic; when they showed the flowers they looked true to life; life-like; makes pictures seem alive and real; very natural	2%	1%
AS GOOD AS, OR BETTER THAN, TECHNICOLOR: better than movie technicolor; at this stage color TV is far out in front of colored movies	2%	1%
DETAILS AND TEXTURES CLEARER IN COLOR THAN IN BLACK AND WHITE: much more clear than black and white; more true to life than black and white	2%	0%
SHOULD BE IN PRODUCTION: it should be put on the market; I think it is perfected to a remarkable point and quite ready for home use	1%	2%
LIKE THE PROGRAM: show itself was enjoyable; program was very good; well arranged and nicely executed; staging very good; entertainment was delightful; well produced; on the whole, the program was excellent	1%	0%
BEST COLOR SYSTEM I HAVE SEEN UP TO NOW: much better than the Columbia system; CBS was not as clear to the eye; better color than the CBS color demonstration I saw	*%	1%
LIKE THE COMPATIBILITY FEATURE	0%	2%
Other favorable answers	1%	3%

A-14

Unfavorable Comments	10%	10%
COLORS NOT TRUE TO LIFE: the lips were not true color; false flesh tones; colors seemed somewhat artificial; some colors were not quite realistic	2%	1%
COLORS TOO VIVID: colors were too strong; color was a little too bright; toned down a bit they'd be terrific	2%	1%

* Less than ½%.

Question 10 (continued):

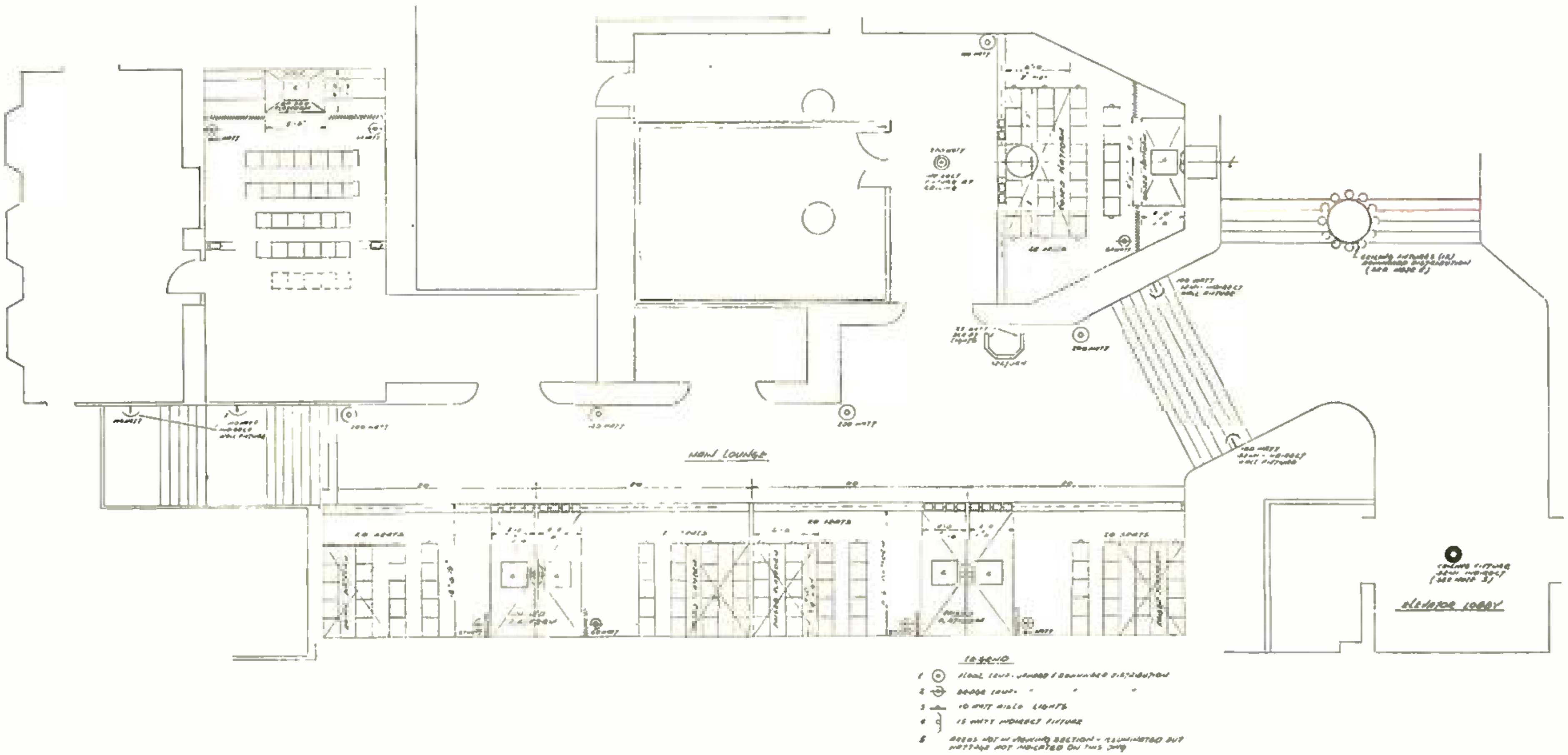
(Table reads down.)

	Audience Non-industry	Audience Industry-connected
THE PRODUCTION OR PROGRAM CONTENT POOR: too much dancing; no white color and very few pastels; too many colors; colors used were too many and too bright	2%	0%
SCREEN TOO SMALL: would like a larger screen; a larger screen should be used	1%	2%
MAKE-UP POOR: face make-up seemed rather heavy; the make-up could be toned down a bit	1%	1%
PREDOMINANCE OF CERTAIN COLORS: a few colors kept showing up too much; there were more blues and purples than any other colors	1%	1%
PICTURES BLURRED: the sharpness of the picture wasn't too good	*%	1%
RUNNING OF COLORS: one color running into another	*%	1%
BLURRING IN ACTION SHOTS	*%	0%
COLORS WRONG: white seemed to be blue	*%	0%
COLOR TIRED THE EYES	*%	0%
Other unfavorable answers	1%	3%

* Less than ½%.

APPENDIX A

DIAGRAM OF CENTER THEATRE LOUNGE



APPENDIX B

ENGINEERING MONITOR REPORT FORM

Filled out for Each Receiver at Each Showing

Time .... Date ....

Receiver # .... Booth ....

Resolution ....

Registration ....

Brightness ....

Color Fidelity ....

Contrast Range ....

Sound ....

Comments ....

....

....

....

....

Checked by ....

The above items should be checked (√) when normal. If not normal, indicate in what regard under Comments.

APPENDIX C

PROGRAM SCRIPT

Opening for Public Reaction Tests

AUDIO *VIDEO*

GRAUER:*

The Radio Corporation of America and the National Broadcasting Company present Color Television!

FANFARE: (UP, SUSTAIN AND OUT)

Ladies and gentlemen, this is Ben Grauer speaking. It is my pleasure to welcome you to this special demonstration of RCA's compatible, all-electronic color television system. By "compatible" we mean that when the RCA color system is broadcast, all owners of existing television sets have the opportunity to see the same performance in black and white. You are seeing this program on a color receiver equipped with the RCA direct-view tricolor tube, and before we actually start with our show, let me give you a quick illustration of the effectiveness of color and the ease of change from black and white to color.

(CELESTE NOODLING IN BG)

Just look at these lovely and natural flowers in black and white. Now, look at them in color!

GRAUER (Cont.)

Let's set this portrait in motion with the Hit Parade Dancers and our star, Nanette Fabray.

* Bob Courtleigh substituted for Ben Grauer on the three June 2 showings.

INTO "THAT'S WHAT MAKES PARIS, PAREE"

AUDIO *VIDEO*

"THAT'S WHAT MAKES PARIS, PAREE"

X INTRODUCTION

VERSE

CHOIR:

A You can keep the Empire State,
It's very tall but that is all.

B You can keep your old New York,
It's not for me, give me Paree!

GIRL:

C My New York may have its faults
Just as you say
But your Paris has some, too,
Please step this way

D 6 BARS ORCHESTRAL INTERLUDE

CHORUS

GIRL:

E From your hotel
The view is swell,
But here's the rub,
There is no tub;

F The plumbing's 1883
That's what makes Paris, Paree!

G You try to grab
A taxi cab,
The light is red,
He goes ahead

H And knocks you down
Quite cheerfully
That's what makes Paris, Paree.

CHOIR:

I The Can-Can girls

GIRL: The Eiffel Tower

CHOIR: The flower girl

GIRL: The Eiffel Tower

AUDIO *VIDEO*

J

CHOIR: The priceless art

GIRL: The Eiffel Tower

BOTH: The Eiffel, Eiffel,
Awful, awful Eiffel Tower.

GIRL:

K The clothes are chic
The hats unique
It's such a thrill
Then comes the bill

L And you're undressed financially
That's what we call, "C'est la vie"

M That's what makes Paris, Paree
But New York is home to me.

FASHION — MODELS

CHOIR:

N Garcon regrets,
No crepe suzettes,
The lady pales,
He's serving snails;

O They'll both get heartburn,
Wait and see.
That's what makes Paris, Paree!

P Each man is geared
To sport a beard,
Who are those guys?
They're ex-G.I's.

Q To look correct,
Wear a goatee,
That's what makes Paris, Paree!

R The horse-drawn cart
The Eiffel Tower
The butchers mart,
The Eiffel Tower

S The search for art,
The Eiffel Tower
The Eiffel, Eiffel,
Awful, Awful, Eiffel Tower

AUDIO *VIDEO*

T You're half a-live,
You're eighty-five,
There's no "Tou-jours"
To your l'amours.

U Then all at once you're twenty-three.
That's what we call "C'est la vie!"

V That's what makes Paris, Paree.

W

CHOIR: The gay cafés,

GIRL: The Eiffel Tower,

CHOIR: The mayonnaise,

GIRL: The Eiffel Tower,

X

CHOIR: La Marseillaise,

GIRL: The Eiffel Tower,

GIRL: The awe inspiring,
But so tiring, Eiffel Tower.

Y

CHOIR: I've seen it all

GIRL: The Beaux Arts Ball

CHOIR: The Rue de la Paix

GIRL: Well, it's O.K.

Z

GIRL: Just twist my arm
And I'll agree,
Paris is getting to mean

Al

CHOIR: The priceless art,

GIRL: The peddlers cart,

CHOIR: The clothes so chic,

GIRL: The pipes that leak,

GIRL: That's what makes Paris

CHOIR: That's what makes Paris

BOTH: That's what makes Paris, Paree!

AUDIO *VIDEO*

GRAUER:

Magic in color with Jay Marshall.

INTO MARSHALL ROUTINE

GRAUER:

Subdued Color—the working pallet
for everyday—broken light and
patterns of light—Nanette Fabray.

INTO NUMBER

"A LITTLE BIT IN LOVE"

Mmm——
I'm a little bit in love
Never felt this way before
Mmm——
Just a little bit in love
Or perhaps a little bit more
When he looks at me,
Everything's hazy and all out of focus
When he touches me
I'm in the spell of a strange hocus
  pocus
It's so, I don't know
I'm so, I don't know
I don't know, but I know if it's love
  then it's lovely
Mmm——
It's nice to be alive
When you meet someone who bewitches you
Will he be my all
Or did I just fall
A little bit
A little bit in love?
I've met a guy
My kind of guy
Wonderful guy, he's so appealing
Marvelous guy
Nice looking guy
This time I'm sure
Sure it's the real thing
I feel I'm on a vacation
Now that I feel this sensation
Mmm——

AUDIO VIDEO

When he looks at me,
Everything's hazy and all out of focus
When he touches me
I'm in the spell of a strange hocus
pocus
It's so, I don't know
I'm so, I don't know
I don't know, but I know if it's love
then it's lovely
Mmm——
It's so nice to be alive
When you meet someone who bewitches you
Will he be my all
Or did I just fall
A little bit
A little bit in love?
GRAUER:
The colorful antics of Clifford Guest
and his friend Lester

INTO GUEST ROUTINE

"WAIT TILL YOU SEE HER"

GRAUER:

Translucent color.

INTRO: MUSIC 8 BARS

Mood in low key
Extreme depth
Shafts of light and silhouette

I INTRO 8 BARS

II INTRO 10 BARS

DANCE

"WAIT TILL YOU SEE HER"

DANCE WITH BACKGROUND CHOIR

CLOSING FOR PUBLIC REACTION TESTS

NANETTE:
Ladies and gentlemen, thank you for
being with us today. Now I would
like to reverse the usual and give
you our bouquet of color.

AUDIO	*VIDEO*
GRAUER: You have been witnessing a special demonstration of RCA's all-electronic compatible color television system. And now for the Radio Corporation of America and the National Broadcasting Company, this is Ben Grauer bidding you good (morning) (afternoon).	

APPENDIX D

THE SURVEY QUESTIONNAIRE

COLOR TELEVISION SURVEY

Based on your own experience in the color television demonstration you have just seen, would you please answer *each* of the following questions as completely as possible? For each question, please check one box.

1. Which do you think is *more enjoyable* — color or regular black and white television that you have seen before today?
   - ☐ Color *much more* enjoyable than black and white
   - ☐ Color *somewhat more* enjoyable than black and white
   - ☐ Both *about the same*
   - ☐ Black and white *somewhat more* enjoyable than color
   - ☐ Black and white *much more* enjoyable than color
   - ☐ Have never seen black and white television

2. How do you feel about the *over-all quality of the color television pictures* you have seen?
   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

3. How would you rate the *clearness of detail* in the color television pictures?
   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

4. How would you rate the *trueness-to-life of the colors* in the pictures you saw?
   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

5. What is your opinion about the *variety of colors* you saw?
   - ☐ There was a *limited* variety of colors
   - ☐ There was a *wide* variety of colors
   - ☐ Somewhere in between

6. What is your opinion about the *vividness of the colors* you saw?
   - ☐ Colors too vivid (too strong)
   - ☐ About right
   - ☐ Colors not vivid enough (too weak)

7. Apart from the colors themselves, how would you rate the *over-all brightness of the screen?*
   - ☐ Much too bright
   - ☐ A little too bright
   - ☐ Just about right
   - ☐ A little too dim
   - ☐ Much too dim

8. How would you rate the quality of pictures in the scenes with a *lot of action*?

☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

9a. Were there any defects, or anything wrong, in the color television pictures you saw, which interfered with your enjoyment of them?

☐ Yes
☐ No

(IF "YES" TO 9a)

9b. How much did these defects interfere with your enjoyment of the pictures?

☐ A great deal
☐ Somewhat
☐ A little

(IF "YES" TO 9a)

9c. Would you please write in below what defects you noticed?

....

....

....

10. Please write below any other comments you would like to make about the color television pictures you saw.

....

....

....

....

And now, just a few facts about yourself—

11. Sex: ☐ Male ☐ Female

12. Age: ☐ Under 20 ☐ 20 - 29 ☐ 30 - 39 ☐ 40 and over

13. Please circle the last year in school that you attended.

Grammar School	High School	College
1 2 3 4 5 6 7 8	1 2 3 4	1 2 3 4 5 6

14a. Do you have a television set in your home?

☐ Yes
☐ No

(IF "NO" TO 14a)

14b. Have you seen any regularly broadcast television programs in the last month or so?

☐ Yes
☐ No

15. Are you, or is anyone in your immediate family, connected in any way with the manufacture, sale, servicing, or broadcasting of radio or television?

☐ Yes
☐ No

Your name: ....

Address: ....

That's all. Many thanks for your cooperation!

Opinion Research Corporation
Princeton, New Jersey

Booth .... Time .... Date ....

EXHIBIT 3

NBC COLOR TELEVISION PROGRAMMING PLANS AND POLICIES

EXHIBIT 3

NBC COLOR TELEVISION PROGRAMMING PLANS AND POLICIES

THIS statement outlines the plans and policies of the National Broadcasting Company which will be put into effect if the Federal Communications Commission approves the signal specifications in Exhibit 1 as standards for color television.

The first immediate proposal of NBC consists of starting "an introductory year", in the course of which all the engineering and programming groups of NBC will have a chance to get direct experience in colorcasting, because they will produce their present black and white television shows in color premieres. This step and its desirability are outlined below.

The next step is in the actual transition to a color broadcasting schedule within the black and white service, and includes many factors which cannot be described precisely until more experience is gained during the introductory year. Included are such matters as time rates, telephone line charges, production charges, staging services to be offered, color film televising policies and program control to insure continuing excellence of the black and white service during color shows. It also depends upon when the Commission takes action with respect to the proposed technical signal specifications in Exhibit 1.

All possible patterns of action that we could devise were considered by us before we determined on the superiority of an introductory year as the opening color broadcasting network activity. We believe that it will most truly serve the public interest, and the interests of our industry, our art, and our country.

Let us outline the plan for the introductory year.

We have now worked out a rough schedule of colorcasts from the Colonial Theatre in New York, and 3H in our Radio City studios, which are the two present color-equipped studios of the National Broadcasting Company. This schedule calls for us to meet with the interested parties on each show in our schedule, and get agreement to broadcast a color premiere of that show, with possible additional color broadcasts to follow at intervals.

We expect to average two shows a week from the Colonial, and the two shows will average an hour together. 3H will be reserved for continued technical experiment, with only sporadic use for program colorcasting at the beginning of color service.

After we have met with the interested parties, we will begin the planning of each individual show working with the groups concerned with that show and its series in all aspects. To illustrate the complexity of this, the groups involved on a network show usually include the series' producer, the show producer, the writers, the director, the technical director, the program crew (which includes the assistant director, stage manager, and others), the technical crew (which includes camera men, boom men, video and audio controls, etc.), the production crew (which includes those concerned with staging services, the staging coordinator, stagehands, make-up men, costumer, dressers, designers, carpenters, electricians, painters, etc.), the advertising agency that represents the client who pays the bill, the agent (management company) who represents the major talent, the talent (particularly the stars), and the client.

This list does not include the servicing divisions of the network, which are usually involved in any show or series, the program services, such as casting, script procurement, continuity acceptance, basic program supervision; the financial division with its cost accounting procedures, its billing procedures, its payroll activities; the sales department services, such as promotion and research on the series, advertising of it and advertising on it.

These and many more activities are affected by the introductory year, for the impact of color on each activity will be felt, although, of course, in varying degree. The principal elements above, however, are affected vitally. They must make their adjustment to color. In some areas color can mean as much to the working individuals as the coming of sound meant to working individuals in silent motion pictures, or the coming of television to radio broadcasters.

We, therefore, believe that a plan which will enable most of those affected to get immediate experience in color, and to begin at once to meet the problems, and be stimulated into new creative thinking, is a sound plan.

We do not believe in a policy of narrowing the color experience to a small elite team which would televise a certain set number of hours per week in color. Since the shows would come from the Colonial, to meet the time-on-the-air specifications, it would be necessary to streamline operations, just indeed as it would in black and white, and to do shows which lend themselves to quantity production. Few of the shows of NBC are of the type which would lend themselves to quantity production, and fewer of the shows of this type are great audience draws.

Hence, if any such minimum hour policy were adopted, not only would we restrict color experience by increasing the number of hours on the air to a fixed standard, and reducing the quality and variety of the entertainment offered, but we would be transmitting series which would serve neither the trade in showing a range of color experiment in all show types, in all production techniques, in all time periods; nor would it offer the public any inducement to become attracted to color. Today our great stars are working in black and white. Our best creative staffs are now working to do the best shows they can devise, using a large plant with many facilities which have been developed over a number of years of experimenting in black and white. These shows, or some of them, in color, or variations on these shows, as color programming techniques are learned — these are the shows the American public will want to see in color.

If during our introductory year, we find that we can move into the second step, substantial commercial color programming itself on a regular basis, we will do so. The real obstacle to speed in evaluating the prospect of this is, first, the delivery and installation of color equipment we have already ordered and, second, the complexity of the problem.

We have on order twenty color cameras, twenty color camera chains, and remote equipment. This is enough to broadcast from five additional studios. It would enable us to make the great sound stage in Brooklyn that we purchased from Warner Brothers into a huge color studio, to equip or build new color studios in Hollywood, to equip theaters and studios in New York, depending on what we learn about color programming technology.

As we go into this introductory year, we do so because the more than twenty million dollars already spent in color development by RCA has so far been largely the development of technical art, the technology of color television, the tools whereby programs can be rendered in color. The real possibilities of the great art of color production have yet to be learned.

We do not believe that we should wait until we have mass audiences to watch us experiment in programming techniques in color. Under our plans, by the time the manufacturers have tooled up for mass distribution of color receivers, and a large audience watches our programming work, we will have learned the program technology just as our engineers have learned the proper use of their new tools. Meanwhile, between us, the art of entertainment and the presentation of reality, in color, will have progressed far, before many have seen our work except those in the trade.

Under our plan for an introductory year in color, we will schedule the color premieres, out of the Colonial Theatre, on a rotational basis of all our black and white attractions, so that each show is seen in color at least once, in a specially-devised color show, which will still be great in black and white, but we hope superb in color. We include the NBC opera in English, Toscanini, Great Conversations, and other occasional as well as regular shows. We believe that no one should decide ahead of color experience what shows are good for color.

We believe that every creative group should study and experiment in the color problem for the show in question. Each group will prepare, far in advance, a special color show. This show obviously will be highly publicized as the color premiere. The reaction of the audience, which will view the final product in black and white, will be of great importance. But the reaction of those few hundred first color set owners, station men, advertisers, public officials, critics and talent, will be of high importance as well.

We know from seeing shows live, in person, how much color means to our great revues and extravaganzas. But — we expect surprises. The advantages that color may offer a panel show, or a simple modern drama, or a news pick-up . . . well, we expect surprises!

When the great shows and the regular shows of NBC are offered in their color premieres at the average rate of two a week from the Colonial, the advertiser will offer his advertising in color with the show. In the case of multiple sponsors, we hope to offer all advertisers the same opportunity. A show like Howdy Doody or Kate Smith, for instance, may be repeated more often, and the advertisers rotated to get an equal chance at colorcasting.

With remote gear, we hope to include color pick-ups on Today and Kate Smith, so that local events and exhibits and celebrations can all be covered in color. When important enough, we would hope to use our remote equipment to bring the scene on a special event pick-up basis. Thus not only the Flower Show on the Kate Smith Program, and a Fashion Show, and the flowering of the Washington cherry blossoms on Today, but the Tournament of Roses from Pasadena or the Mardi Gras from New Orleans will be special event shows. Also, football, baseball, in color, and, of course, Niagara Falls, the Grand Canyon, and the submarine gardens of Santa Catalina, in color and live.

When the creative and engineering groups at NBC have the color premieres on their regular series, they will be working with our color corps to do the regular show in color.

We also expect that the color discussions and press comments will continually add to our knowledge and shape our plans.

Color will become a conversation piece of the Country during this introductory year. Meanwhile, we will be building a wide base of know-how and experience in the field, will be continually testing and improving techniques for color production, modifying equipment to meet production needs as discovered from wide ranging color experiment.

The public, knowing that Your Show of Shows, Your Hit Parade, the Comedy Hour — all their favorite shows are now being broadcast in color — will begin to wish for color more sharply. Followers of Fred Coe or Robert Montgomery will be impatient to see the color values that are offered in drama. And when Dinah Shore, and Dennis Day, and Bob Hope, and Martin and Lewis, and other Hollywood stars have their color premieres, we are going to generate the same excitement we had in early television.

Color will make many present shows infinitely more appealing, will stimulate imagination and experiment among the creative people, will suggest new forms which can be created as color shows, modified into all-set circulation shows, and produced. There is everything to be gained from a wide range of color programming experiment, rather than a schedule of hours per week, in which essentially we continue technical rather than programming experiment.

We stated above that our introductory year will provide us with an opportunity to learn programming in color as our engineers have learned televising in color. In black and white, the vast amounts of money spent in television development by the RCA-NBC scientific and technical groups was followed by a vast amount of money spent by the company to develop programming techniques and skills, to find the proper use of showmanship in this new medium.

Our plan to repeat this formula in color will cost additional sums. We are prepared to finance this undertaking; as we make progress, we may find ways to distribute this burden equitably.

We believe that a schedule of two or so well publicized shows a week, already known in type and quality to the trade, will be easier to follow, and be more productive of an informed opinion about color progress, than would the broadcasting of new color shows on a prescribed number of hours a week.

If compatible color standards are approved, we would proceed into our introductory year, the manufacturers would begin tooling up to make color sets, and we would start finalizing policies in our color commercial schedule planning.

The extra value that color can offer advertisers will be quickly recognized and the new value that color will offer to many industries not now using television, or using it in minor ways, will also be quickly recognized. This will provide revenue to change the American television industry to a color industry, but with the compatible features of the RCA color system, the present service will not decline in strength. This is because the increased revenue will enable the broadcasters to improve the overall service, to give more and fuller coverage, to find new and more stimulating programming innovations, etc. Every one of these innovations will be seen on all present monochrome sets. And each set owner has had an infinitely better program service as years have passed since his original investment.

The policies of NBC have stemmed from a belief that primarily television is a communications invention, that it takes people from their homes to places, rather than brings pictures into their homes. We have, therefore, tried to take people to those places where the finest in the various categories of entertainment could be found, and let them attend those entertainments. Similarly, when the conventions, or the inauguration, or the sporting event, or the symphony, or the celebrations were taking place, we have tried to use television as the instrument that let the viewer attend the event.

Today, we must view color as we viewed the ever larger screen. It makes better what we have. It must be pressed to insure that its particular values do not obscure the true overall service pattern of television, which is to present the whole range of information and entertainment services to the public.

As we take up this new financial burden, it is important to realize that under the RCA compatible color system, the average station will have only minimum expense, in light of its black and white investment, to modify its facilities to broadcast color programs it receives over the network.

The substantial capital costs will be in studio equipment for networks now and stations in due time. It is right that the preliminary expenditures and experience be undertaken by the network, so that station commitments can be made after more experience is gained.

With this in mind, during the introductory year NBC will set up procedures to give technical and program people from our affiliated stations, and our owned and operated stations, experience in color broadcasting and color problems.

At a meeting of its affiliates held at the David Sarnoff Research Center on May 26, NBC outlined its introductory one year plan and gave representatives of its affiliates a demonstration of the RCA color television system.

Affiliates were offered a color television supplement to their existing affiliation contract. A copy of this color television supplement is contained in Appendix A.

These NBC affiliates have already signed this color television supplement:

WBRE-TV	Wilkes Barre	WTMJ-TV	Milwaukee
WSYR-TV	Syracuse	WWJ-TV	Detroit
WJAC-TV	Johnstown	WCOV-TV	Montgomery
WLW-T	Cincinnati	WFMJ-TV	Youngstown
WLW-D	Dayton	KTYL-TV	Mesa-Phoenix
KSTP-TV	Minneapolis-St. Paul	KGNC-TV	Amarillo
WJAR-TV	Providence	KEDD-TV	Wichita
KPTV	Portland, Ore.	WBEN-TV	Buffalo
WBAL-TV	Baltimore	KFEL-TV	Denver
WOAI-TV	San Antonio	WFAA-TV	Dallas
WTTV	Bloomington	KTSM-TV	El Paso
KCBD-TV	Lubbock	WOOD-TV	Grand Rapids
WDSU-TV	New Orleans	WEEU-TV	Reading
KPRC-TV	Houston	WSB-TV	Atlanta
WLW-C	Columbus	KSD-TV	St. Louis
WKY-TV	Oklahoma City	KOTV	Tulsa
WSAZ-TV	Huntington	WDAF-TV	Kansas City
WJIM-TV	Lansing	WALA-TV	Mobile
WBAP-TV	Fort Worth	KTBC-TV	Austin
WNHC-TV	New Haven	WBTV	Charlotte
WKTV	Utica		

NBC believes that all-electronic compatible color television will be a revolutionary forward step in communications and will vastly expand and improve the service to the public already given by the television broadcasting industry, and aid in making television an even greater influence for the enrichment of American life.

APPENDIX A

AFFILIATION CONTRACT—COLOR TELEVISION SUPPLEMENT

GENTLEMEN:

The agreement between us for affiliation of your television broadcasting station (herein called "station") with the NBC Television Network is hereby supplemented as follows:

1. At such time as standards for compatible color television are approved by the FCC you agree to take such steps as may be necessary to enable your station to broadcast in color NBC Television Network programs delivered to your station in compatible color.

2. The right of first refusal contained in Paragraph 2 of the aforesaid agreement between us shall be extended to include any NBC Television Network programs delivered to your community in compatible color.

If this is in accordance with your understanding, will you please indicate your acceptance on the copy of this letter enclosed for that purpose and return that copy to NBC.

Very truly yours,

NATIONAL BROADCASTING COMPANY, INC.

By ....

Accepted:

This day of , 195

By ....

EXHIBIT 4

PRINCIPLES AND DEVELOPMENT OF COLOR TELEVISION SYSTEMS

PRINCIPLES AND DEVELOPMENT OF COLOR TELEVISION SYSTEMS

INDEX

APPENDIXES

EXHIBIT 4

PRINCIPLES AND DEVELOPMENT OF COLOR TELEVISION SYSTEMS

PART I

Introduction

A SATISFACTORY television broadcasting system must provide pictures which are pleasing to viewers. This is not the same thing as providing a completely accurate reproduction of the original subject, but the operating parameters should include a set which will approach this ideal situation, particularly when color is used. Also, color television must grow in the framework of very wide popular use of existing black and white television service. It thus seems evident that a basic requirement for a color television signal specification should be the ability to produce acceptable black and white pictures on normal unmodified black and white receivers. This property of a color television signal is called "compatibility." In view of the general scarcity of space in the radio spectrum, excessive channel width to provide color service is not tolerable.

These general principles of pleasing human sight, providing compatible service, and avoiding waste of spectrum have guided the study of color television systems in the Radio Corporation of America for many years. Certain facts regarding color vision, now to be set forth, and some basic characteristics of television systems, to be pointed out later, provide a framework in which the course of color television system development in RCA can be chronicled.

PART II

Vision

A. General

Human vision is an extremely complicated process, occurring partly in the eye and partly in the brain, which connects the stimulus of physical light output from some object to the conscious sensation experienced by a person observing that object. This duality must always be borne in mind when vision is discussed. Vision is by no means fully understood, but many facts about it have been found by experiment, and some of these are the most significant guides for color television. We perceive color, as a conscious sensation, in terms of three major attributes. Primary among these, and the only one of them exhibited by both neutral or gray (achromatic) tints and truly colored colors, is "brightness." This is a matter of overall intensity of light given out by objects seen, their physical "luminance." A second major attribute, and the one most characteristic of color, is the distinction among redness, yellowness, greenness, blueness, and so forth. This is called "hue," and among the pure colors of the physical spectrum corresponds rather directly to wavelength. Finally, distinguishing strong colors from pale ones of the same hue, as red from pink, is the attribute of "saturation" or "chroma." Saturation may be thought of as related to physical "purity," or freedom from dilution with white.

B. Large-Area Color Vision

It is well known that large-area visual sensations of every brightness and hue are reproducible by mixing lights of only three suitable "primary" colors, usually chosen as red, green, and blue. Matching by mixing three light stimuli provides, in fact, the basis of some important methods of measuring color. Full saturation in every hue, however, is not reproducible in this way with real primary lights.

Once three actual primary lights have been chosen, no two of which can match the third, any color at all can be specified fully just by stating the amount of each primary needed to match that color. The luminance of a color is equal to the sum of the luminance of the primaries required to match it. "Chromaticity," or coloredness, is fully specified by the fractional contributions of any two primaries to the total (the sum of all three such fractions must be exactly one).[1]

Standard primary colors have been chosen by international agreement, and color measurements by different observers, using different actual primaries, can all be compared by expressing them in terms of the mixing fractions that would have been found if normal observers had been measured with the standard primaries. All mixing fractions can be positive in matching all real colors only if the primaries chosen are "supersaturated" colors that are not themselves physically realizable. All three of the primary lights chosen as standards are of this unrealizable sort. Characteristics of the supersaturated green standard primary have been chosen to give it a very special property. The amount of this primary needed in a mixture to match any given color is by itself the luminance of that color.

One does not need to become an expert in colorimetry in order to understand clearly the broad features of color vision that are important guides for color television. However, some familiarity with the general form of chromaticity diagrams can be most helpful.[2] These diagrams result when colors are specified graphically in terms of mixtures of the International Committee on Illumination (CIE) standard primaries. They are plots, with axes at right angles, of mixing fractions of the CIE super-green or Y primary against those of the super-crimson or X primary. Any single color plots as one point on such a diagram; the location of this point specifies fully the chromaticity of that color, but tells nothing about its brightness.

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[1] D. W. Epstein, "Colorimetric Analysis of RCA Color Television System," to be published in June, 1953, issue of *RCA Review*, attached hereto as Appendix A.

[2] *Ibid.*

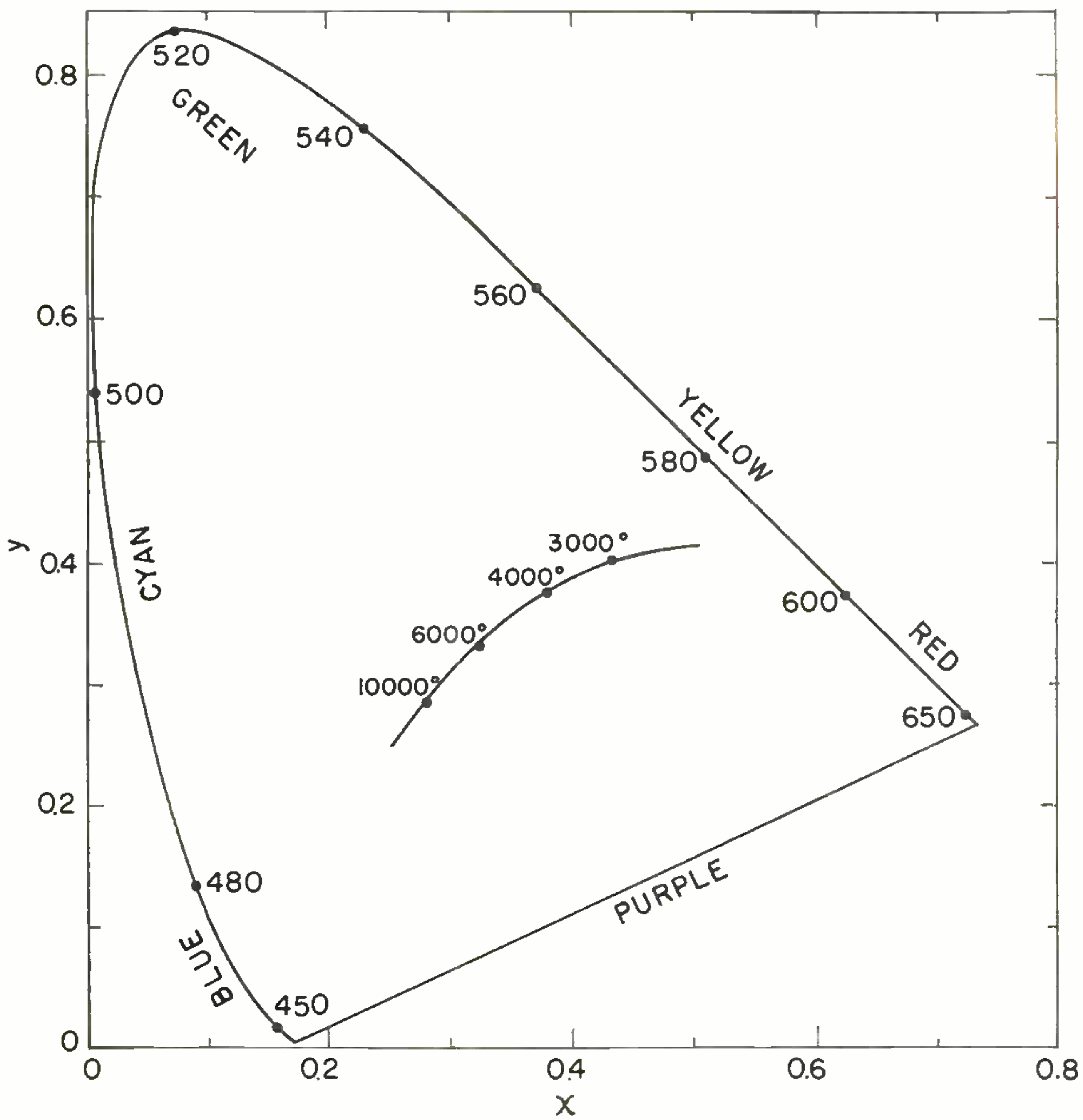

Fig. 1 — Locus of the visible spectrum and the chromaticity locus of incandescent radiators.

Figure 1 shows how the colors of all spectral lines, the most saturated of real light sources, plot as an inverted-horseshoe curve with its open end closed by the non-spectral purples. The numbers spotted along the horseshoe are wavelengths in millimicrons (billionths of a meter). Ideal incandescent radiators (black bodies) plot as an arched curve across the middle of the horseshoe, also shown in Figure 1, with some values of radiator temperature in degrees Kelvin shown by the numbers beside this curve. "White" is a general term for a light which evokes an achromatic (colorless) sensation. Points located in the central region of the chromaticity diagram, including the segment of the black body locus between 2500°K and 8000°K, are recognized as "white" depending upon particular adaptation conditions of the observer.

Given a choice of standard white, the hue of any color is related to its dominant wavelength, the angular or clock-dial position of the point representing that color on the chromaticity diagram, about the chosen white or achromatic point as a center (compared to sunlight, 12 o'clock is green, 3 o'clock an excellent red, 6 o'clock a purple, and 9 o'clock a blue-green). Similarly, the saturation sensation given by any color is related to its purity, the distance along the radius from the white point through the point representing that color, measured as a fraction of the total distance out to the spectrum locus, along that same radius. It should be noted that chromaticity is fully given by just two numbers, whether x and y or angle and fractional radius. To give any additional number conveys no further chromaticity information at all. Of course, a third number is needed to specify brightness, or rather physical luminance, but that is a separate matter. It should be noted that lines on such a diagram do not have the properties of vectors.

Given any set of real primaries, such as the phosphor colors used in reproducing color pictures by television, they can be plotted on the diagram, as indicated by the points G, R, and B on Figure 2, which are for standard reproducer primaries as chosen by the National Television System Committee. The selected achromatic point at W represents CIE Illuminant C. Any color that is representable by a point within the triangle GRB is reproducible by a real mixture of these primaries. Experience with various types of color photography, Technicolor and Kodachrome, has shown limited saturation capabilities to be practically quite acceptable. Fortunately most natural objects display unsaturated colors.

Two further facts are to be noted. One is that three strongly colored real primaries, with intensities proportioned to give a good white when mixed, appear quite different in brightness when viewed separately. The green primary then appears as something like twice as bright as the red, and perhaps five to thirty times as bright as the blue primary. The other is that the apparent visual difference between adjacent patches of different colors becomes least when they appear equally bright.

C. Small-Area Color Vision

Many new data on vision, accumulated in recent years, are very important for color television, though still fragmentary and not yet widely known. The gist of these data is that normal color vision is a decidedly simpler matter for small objects than for large ones. Everybody knows nowadays that "vision is a three-color process," but hardly anybody yet knows that this cliche by no means tells the whole story.

Willmer and Wright, in England,[3] have found that any color, in a small enough patch well centered in the field of vision, can be matched by mixing only two, and not three, "primary" colored lights. The "chromaticity

[3] E. N. Willmer and W. D. Wright, "Colour Sensitivity of the Fovea Centralis," *Nature*, Vol. 156, No. 3952, pp. 119-121 (July 28, 1945).

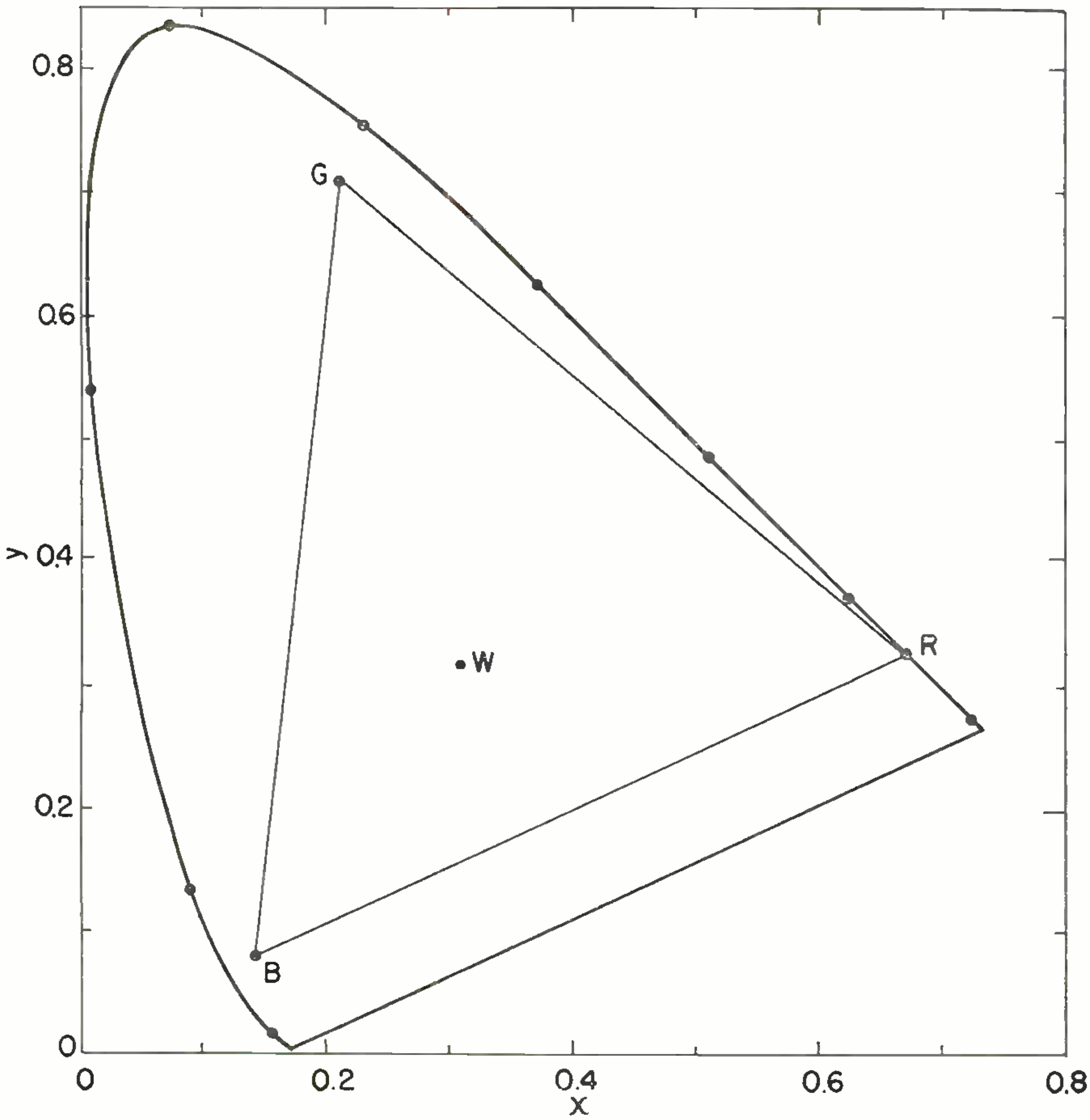

Fig. 2 — Color triangle associated with the reproducer primaries chosen by NTSC.

diagram" then becomes merely a straight line, and a single number specifies any small-object color as position along that line. Middleton and Holmes, in Canada,[4] have found independently that small patches cut from large colored sheets are not as well matched visually by the original sheets as they are by sheets of somewhat differently colored material. Figure 3 shows some of their results, the outer ring of points representing the chromaticities of the original sheets, and the inner ring those of the other sheets found by two observers to best match tiny patches (subtending about 2 minutes of arc at

[4] W. E. K. Middleton and M. C. Holmes, "The Apparent Colors of Surfaces of Small Subtense—A Preliminary Report," *Journ. Opt. Soc. of Amer.*, Vol. 39, No. 7, pp. 582-592 (July, 1949).

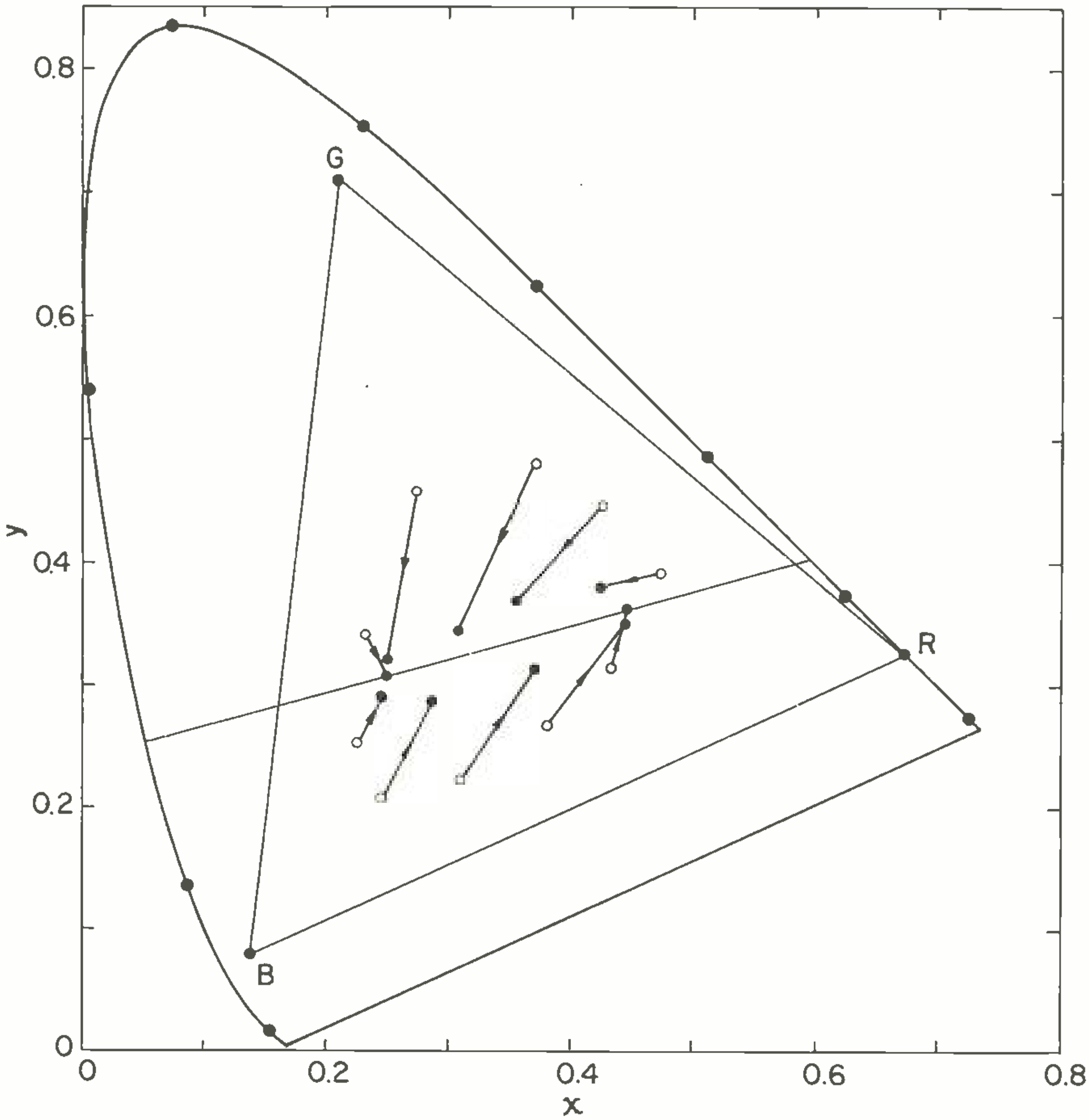

Fig. 3 — Chromaticity data of Middleton and Holmes. Color matching of tiny patches.

the eye of the observer) cut from the original sheets. The tendency of the chromaticity diagram to degenerate toward a single line for these small patches is quite evident, as is the fact that the two primaries mixed to match the color of any tiny object should be chosen as a barely orange red and a greenish blue.

Still another English worker, Dr. Hartridge,[5] has made a wide variety of investigations that differ in detail but generally corroborate the above findings. None of the three investigations cited was concerned particularly with

[5] H. Hartridge, "The Visual Perception of Fine Detail," *Phil. Trans. Roy. Soc.* (London), Ser. B, Vol. 232, No. 592, pp. 519-671 (May 15, 1947).

television. Observations of sharpness of visibility of color and brightness contrast edges, made in the RCA Laboratories Division,[6] give further corroboration. It is evident from the totality of the work cited that individual observers actually see somewhat differently from one another, and there is consequently wide disagreement as to exact numerical details, but there is full agreement on the general character of the phenomena observed.

As colored test objects are decreased in size, four things are found to happen in succession. First, blues become indistinguishable from grays of equivalent brightness and, second, yellows become indistinguishable from grays. In the size range where this happens, browns are confused (in hue but not in brightness) with crimsons, and blues with greens, but reds remain clearly distinct from blue-greens. On the whole, colors with pronounced blue lose blueness, while colors lacking in blue gain blueness; all become less saturated. Third, with still further decrease in size, reds merge with grays of equivalent brightness and, finally, blue-greens also become indistinguishable from gray. A large nearby object of the same color helps a small object to retain its chromaticity, while a nearby large area of contrasting color helps to wash out the color of a small area. Decreasing brightness, like decreasing size but in less drastic fashion, also washes out colors.

People with normal vision, then, see rather small objects in just the same way that certain color-blind people see all objects. For exceedingly small objects, normal visual sensations are devoid of all color connotation, and only perception of brightness remains. Statements made here do not put forth theoretical hypotheses, but do attempt to describe actual facts of observation. Much more research is needed to establish details firmly, but the general nature of the situation seems quite definite.

Television reproduction on a full three-color basis for all details of all objects, regardless of size, is thus seen to be a thoroughly wasteful process. However, it would seem fairly safe to estimate that about twice the information needed to produce the same picture in black and white should be entirely adequate. Color transmission should have the following properties:

1. Dominant wavelength, purity, and luminance data should all be transmitted for homogeneous color patches subtending relatively large areas at the eye.

2. Only purity (within reduced limits) and luminance information need be transmitted for quite small color detail.

3. Only luminance need be transmitted for the finest detail.

There is no single, positive "best" black and white equivalent of a colorful scene, as witness the variety of lights, films, and filters used by the black and white photographer. Of the single achromatic picture properties that might be so used, however, luminance seems as unobjectionable as any.

[6] A. V. Bedford, "Mixed Highs in Color Television," *Proc. I.R.E.*, Vol. 38, No. 9, p. 1003 (September, 1950), attached hereto as Appendix B.

D. Visual Resolution

Ability to distinguish two nearby objects as separate, called "resolution," is another characteristic of vision that is very important for picture reproduction. It is a measure of "definition," the sensation of sharpness obtained in looking at a picture. Resolving power of the eye is strongly dependent on subject contrast. There is a well known and reasonably good rule of thumb that two small objects, placed side by side against a strongly contrasting background, can just be recognized as separate by a normal observer when viewed from a distance about 3400 times their separation (at which they subtend an angle of about one minute at the eye). Visual receptors in the human retina are tiny, physically separate elements called "cones." In the *fovea centralis*, the part of the retina used for sharpest seeing, the cones are probably spaced about 0.0001 inch between centers (this seems very difficult to measure), a pair subtending about 2/3 minute of arc at the pupil. Loss of distinct red and blue-green color sensations, as described above, occurs only when isolated objects subtend at the eye an angle comparable to, or at most a few times greater than, that separating adjacent cones. Loss of blue and yellow occurs for objects considerably larger, possibly even as much as 30 cones across. Different observers disagree markedly on the exact numbers here.

When a picture 4/3 times as wide as it is high is viewed from a distance 6 times its height, perhaps 1/2 million separate cones in the retina are brought into use. This gives some idea of the maximum detail that the eye can use in a television picture. Another related item is the fact that adjacent lines of a 525-line picture can be made to subtend just about the same angle at the pupil of the eye as do adjacent foveal cones within the eye, by viewing the picture from a distance 11 times its height. Line length scanned in one microsecond subtends 8 minutes of arc, or about 12 foveal cones, when viewed at 11 times picture height. These figures are not meant to recommend any particular viewing distance, but only to show relationship of picture resolution to eye resolution.

E. Persistence

Present-day television, like motion pictures, is possible only because of the fact that seeing is not an instantaneous process, but includes a retentive feature known as "persistence of vision." This feature enables a viewer to remain conscious of what he saw in one corner of a television picture, while the rest of the picture is being sketched, a speck at a time, until the first corner is gone over again. An area that is flashing in this way may give a sensation of flicker, however, if the time between flashes, the brightness of the light, or the size of the area becomes excessive. These quantities must be so chosen that there will be no objectionable flicker in the television picture. The practical importance of size of flashing area in determining the strength of flicker sensation, other things being equal, is very great. If the pattern of flashing is complex, flicker may show as an apparent crawling of detail within the picture. Flashing from one hue to another of equal brightness gives markedly less flicker sensation than does flashing from darkness to light of that same brightness. Breakdown of persistence of vision, giving rise to flicker sensations, can set a decidedly more stringent lower limit on acceptable picture-repetition frequency than does the need to reproduce motion smoothly.

PART III

Transmission Systems for Television Signals

A. Television Signals

A complete color television system (neglecting sound), may be considered here to consist of four parts, as diagrammed in Figure 4.

1. A camera that translates visual characteristics of a scene to electrical signals,

2. A reproducer that builds up from these signals a reasonable facsimile of the original scene,

3. A transmission system that accepts the electrical signals from the camera, and

    a. processes them,

    b. transports them,

    c. again processes them, and ultimately applies them to a distant reproducer, and

4. Scan synchronizing and driving devices for both camera and reproducer.

Only a necessary minimum will be said now about properties and structure of the camera and reproducer. The latter, for color, is a device which,

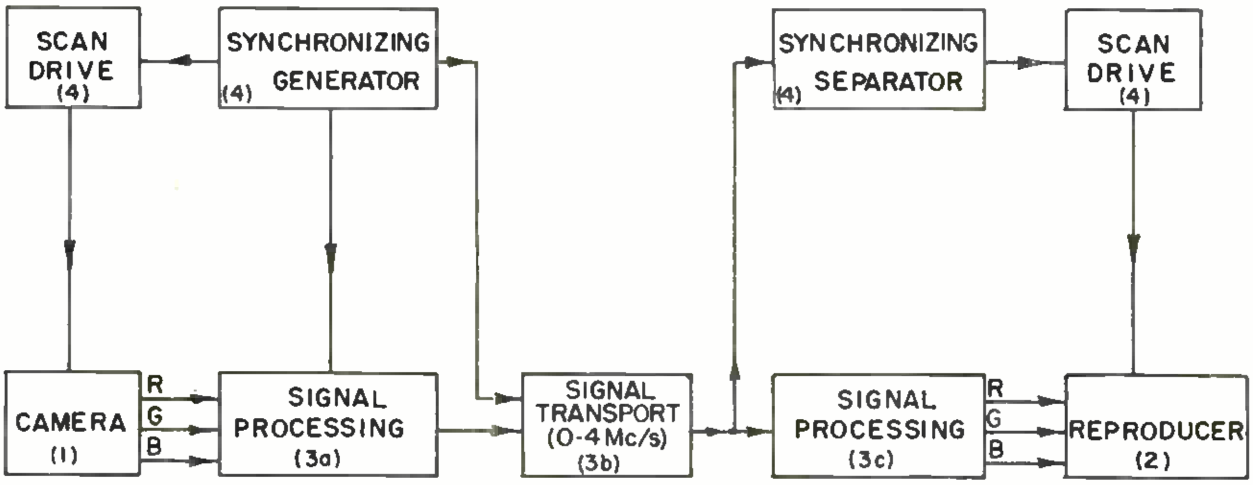

Fig. 4—A diagram of a complete color television system (neglecting sound).

when fed simultaneously with three electrical signals, proportional respectively to the amounts of three primary-colored lights required to match a portion of an original scene, emits properly mixed light in the proper location to give the observer the required visual sensation. Most simply, this reproducer may be thought of as a group of three synchronously scanned television picture tubes ("kinescopes"), each emitting light of one primary color, with their light outputs combined in register by a system of mirrors.

The camera may be thought of as performing the reproducer functions in reverse, and as resembling optically a one-shot photographic color-separation camera, with three synchronously scanned television pickup tubes in place of the three photo films. Both camera and reproducer are assumed for now to establish direct, linear proportionality between electrical and light signals.

It may be noted in passing that the camera spectral sensitivities needed to determine the subject-matching levels for the reproducer primaries are not the same as the spectral emission distributions of those reproducer primaries. Required camera characteristics may be built up electrically, even to the extent of providing regions of negative sensitivity, despite limitations of optical filters. This is a very distinct advantage possessed by television, as well as by slower electrical color-reproducing systems, over the laborious "masking" techniques of color photography.

Attention will be concentrated for the present on the signal-transmission system alone, disregarding the scan-synchronizing function. The transportation function of this system usually involves modulation, transmission, reception, and detection of a radio signal, although direct transport over wires or cables is also used. Radio interference considerations do strongly affect the requirements to be met by the modulating signal, but this is the only way the radio link concerns the present discussion. Only the video signal entering the transmitter modulator and leaving the receiver detector (presumably without suffering distortion in between) will be considered at this point. This signal will be considered with regard both to its own properties and to the way it is developed from the camera output and is processed to provide reproducer input.

The signal-processing devices emerge as the heart of the transmission system, and as the means of distinguishing among systems. A sufficiency of specific examples will appear later. For the present, signal properties and possible processing devices will be described in general terms.

B. Channel Capacity

Rules of the Federal Communications Commission, in accord with recommendations of the National Television System Committee in 1940, operate to set up rather definite boundaries for the usable video channel. Thus arises a frame within which television must live. Extending upward from an assigned radio carrier frequency, which may be taken as zero for the scale of video modulating frequencies, the picture channel is bounded by the presence of a cooperating sound channel 4.475 to 4.525 megacycles above the picture-carrier frequency (with nominal center displaced 4.500 megacycles). Sound signal must be kept out of the picture channel and vice versa. Sound signal is kept out of picture signal by providing sharp rejection filters in reproducers. The upper frequency limit of the useful video channel is actually set by the capability of these filters, in turn determined largely by the cost considered acceptable for reproducers. No exact figure can be set for this upper picture-frequency limit, but 4.0 megacycles per second is a reasonable figure for this discussion.

It is shown in standard expositions of information theory that a transmission channel can, in principle, forget what it was doing last in just one-half cycle of the highest frequency passed. That is, instantaneous transmitted-signal amplitudes through such a channel can be completely independent, momentarily, at intervals of just one-half cycle at maximum frequency. The 4-megacycle video channel can, therefore, transmit a maximum of 8 million fully independent amplitude values per second.

Video-signal amplitudes differing by as much as the statistical amplitude of the prevailing noise on the channel can be definitely recognized as separate. Information obtainable from each independent signal-amplitude element is, therefore, determined by the prevailing ratio of available signal power to noise power. The number of independent amplitude samples transmissible per second, set by channel width, and the number of distinguishable amplitude levels per sample, set by signal/noise ratio, together determine the maximum rate at which information can be passed over a given channel. In this way the nature of the physical world and the rules of the Commission cooperate to set outer limits to the transmission capabilities within which television must develop.

C. Effects of Scanning

Dissection and reproduction of the scene being televised, by a repetitive point-by-point and line-by-line scanning process, provide the transmitted picture with a highly characteristic artificial structure. The essence of compatibility among systems, which means in effect interchangeability of equipment, is that this scanning structure must not be altered in such ways as to violate its basic organization. Through the scanning process, reproducer and signal are placed in a lock-and-key relation. If the key will not enter the lock, one does not merely get reduced effectiveness of operation; he gets no operation whatever.

A little bookkeeping is in order here to compare the television picture structure with the resolution of the eye, as discussed earlier. At 8 million picture elements per second in a 4-megacycle video channel, a line scan lasting 1/15,750 second covers 508 elements. Signal blanking during the line-retrace time, however, leaves only 416 of these elements visible. Of the 525 lines per frame, 483 are left visible by field-retrace blanking. This represents 104 elements per unit length horizontally, against 161 per unit length vertically, in a picture 4 units wide and 3 units high. Because line structure may match poorly with subject structure, useful resolution may actually be nearly the same horizontally as vertically. Picture elements transmissible during the 1/30-second standard frame total 266,667.

Mertz and Gray[7] long ago pointed out that the scanning structure also represents a typical spectrum of use of the frequencies within the video channel. They found that, for most subjects, almost all signal energy is concentrated at frequencies that are whole multiples of the line-scanning frequency. Halfway between these heavily used frequency bands, that is, at odd multiples of half the line frequency, substantially unused frequency bands are usually found.

More elements of independent amplitude can be transmitted per picture the smaller the number of pictures transmitted per second, since the possible number of elements per second is limited by the assigned video-channel width. If the whole picture field is scanned in unbroken line sequence, however, the whole field flashes together at picture-repetition or frame frequency. Frame frequency must then be kept quite high to keep resulting flicker tolerable to the viewer, and this limits picture detail.

Scanning first only alternate lines, throughout the whole picture field, then returning and scanning only the lines missed the first time, breaks up the flicker pattern so that adjacent lines flash at complete-frame frequency, but with opposite timing. The smaller-area flicker due to this "interlaced" scanning is much less visible than the solid-field flicker of the simple scan. Frame frequency of complete pictures can be reduced by two to one, while still keeping as high as before the frequency of the alternate-line fields that flash as a whole. Thus, twice as many elements can be transmitted per picture in this way, and such interlacing has been adopted as standard practice.

More complicated line-interlace patterns seem tempting, but they lead to orderly progression of small, bright areas, so that any residual flicker sensation manifests itself as an impression that lines are crawling up or down the picture. Thus, triple line interlace has been found to be self-defeating.

Interlaced scanning is such a very effective channel-saving device that it should be exploited to the fullest practical degree. (Application of horizontal interlace to black and white television signals to achieve greater definition than can normally be carried in a six-megacycle channel is possible but does not seem to be justified in view of practical limitations.) If only alternate elements (or dots) of alternate lines are transmitted in a single field scan, four such fields are required to build up a complete frame. Adjacent areas, flashing at frame frequency, but in different time sequence, are then reduced to very tiny picture-dot size, and the visibility of the flicker is very much reduced. Holding the field frequency, at which large-area flicker occurs, as high as always, the frame frequency at which complete pictures are built up can be reduced to one fourth of that required for a simple once-over scanning scheme.

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[7] P. Mertz and F. Gray, "A Theory of Scanning and Its Relation to the Characteristics of the Transmitted Signal in Telegraphy and Television," *Bell Syst. Tech. Jour.*, Vol. 13 pp. 464-515 (July, 1934).

Use of dot interlace thus permits the number of elements transmissible per complete frame to be quadrupled. Residual flicker is then progressive, but is only a weak sensation, so that the very fine crawling pattern of residual dots is not annoying. (It can, in principle, be entirely eliminated, but this requires more advanced and complex techniques than are customary today.)

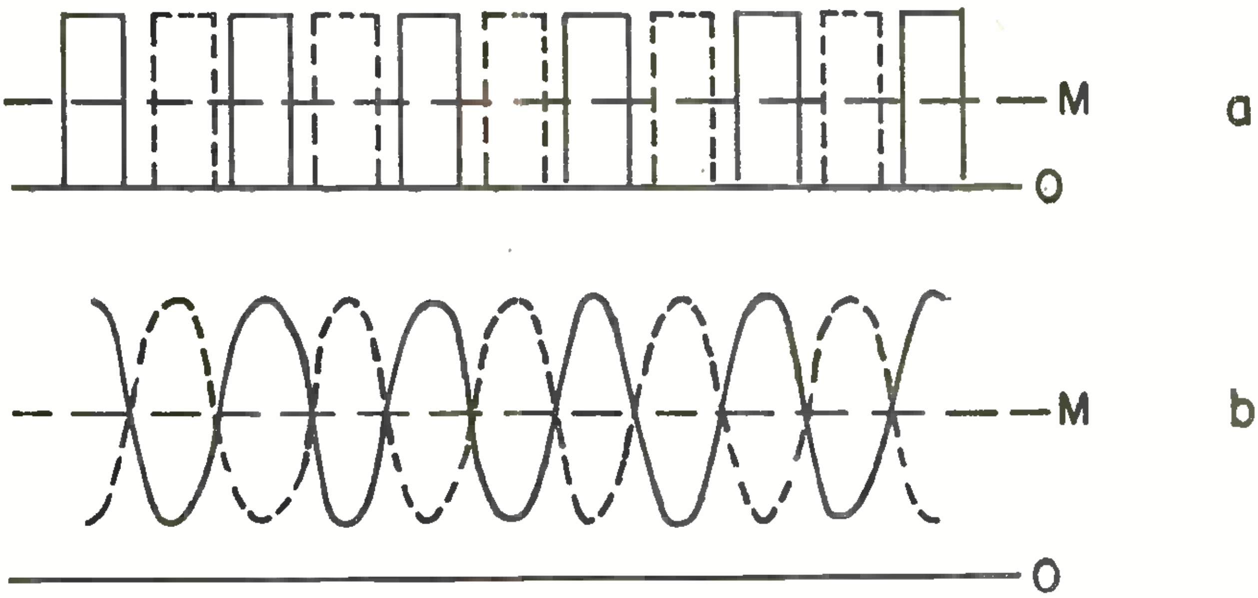

Fig. 5 — (a) An example of additive interlace.

(b) An example of cancellation interlace.

Fourfold interlace takes place in fairly obvious fashion, as described above, if individual picture dots are reproduced as sharp, separate points ot the scan. It is then clearly an additive process, as indicated for part of one line in Figure 5a, with one field scan filling in correctly one quarter of the total elements required for the complete picture, and with the remaining three quarters left blank throughout that field scan. The next three field scans simply fill in correctly the blank spaces, to complete one frame. A subtractive or cancelling type of interlace can be at least equally important for color television.

Suppose that an entirely normal black and white signal is transmitted, but that an additional, independent signal is mixed with it. This is to be done in such a way that, on any one field scan, the extra signal adds to the original one on every second picture element of each line, and subtracts from it on the other, alternate elements. On the second following field scan, the same line will be retraced, but this time the extra signal is to be arranged to subtract from the original one on those elements where it previously added, and vice versa. Time variation of the total signal, on two successive scans of the same line, is as shown in Figure 5b. Over a complete frame, comprising four field scans, the extra signal will then just average to zero on every picture element. This cancellation leaves the original black and white picture completely uncontaminated, at least to the extent that persistence of vision eliminates frame-frequency flicker. With suitable equipment, the extra signal can likewise be recovered separately, with minimum contamination by the original signal.

When studied in detail, the additive and subtractive types of interlace are recognizable as basically just two aspects of the same thing. Dot interlace of either sort can be produced merely by arranging to lock the picture-element signals firmly to the scanning pattern. This is so done that picture-element signals occur at a frequency that is exactly an odd multiple of half the line frequency. The extra signal, alternately added and subtracted to give subtractive interlace, then develops a spectrum with energy concentrated just in the middle of those unused spectrum gaps found by Mertz and Gray in the ordinary signals. Such frequency separation further substantiates the concept that the two signals can be cleanly separated from one another. Because of its spectrum properties, the subtractive aspect of dot interlace has been referred to on occasion as "frequency interlace."

D. Multiplexing

Color television requires definitely that more information be transmitted per frame than is needed for black and white pictures of equal sharpness. This additional information must be treated as independent of the black and white information. It must be transmitted along with, but be kept separable from, the latter. Sending independent messages together over one transmission system, yet keeping them separable at will, is no new problem. In the older communications art, the process is known as "multiplexing," and is widely used. Present use of multiplexing involves setting up a transmission channel wider in frequency band than is needed for one message, and then applying techniques known as:

1. Frequency division.
2. Time division.

Frequency-division multiplexing is done, as might be expected, by using electrical filters to allocate distinct portions of the overall frequency band to the separate messages being handled—letting one talk bass while another talks soprano. Shifting of messages from their original frequencies to the desired portions of the band, and back again, is usually done by modulation of appropriate subcarriers. These subcarriers must normally be synchronous at transmitter and receiver.

Time division, as also might be expected, involves the other alternative of allocating the entire channel briefly to each individual message, in a sequential manner. Synchronous switching at transmitting and receiving terminals is the mechanism used to accomplish this. Alternate transmission of the sum and the difference of two messages is one special form of time-division multiplexing. This is what is done in the cancelling type of picture-element interlace described earlier.

When modulation of a subcarrier is used, one sideband suffices for one message. If two sidebands are available, two independent messages can be handled by one subcarrier. For example, one message can produce an upper sideband only and the other a lower sideband only, as a special sort of frequency-division multiplex. Or, since the above is difficult to do, one message may amplitude modulate and the other may phase modulate the subcarrier. Or, again, two subcarriers, synchronous in frequency but differing in phase (preferably by 90 degrees), may be amplitude modulated, respectively, by the two messages, with the results added for transmission. In any of these cases, the two resulting sidebands together may be treated as a single signal in any further multiplexing. Separate recovery of two messages so treated is effected by synchronous detection with local, phase-locked subcarriers, at the receiving terminal.

Still a third type of multiplexing is possible, but has not come into use. This may be called level-division multiplexing. If the desired signal is very powerful, or the noise level very low, more signal-level gradations may be positively distinguishable, between no signal and maximum signal, than are needed to handle a given message. With sufficient excess levels, a second message may, so to speak, be "written between the lines" of the first, without using any additional frequency band.

Bandwidth economy may thus be purchased at the price of power, but the exchange rate becomes prohibitive if one seeks to accomplish very much in this way. Two on-off telegraph messages may be level multiplexed at a cost of 9 to 1 in power, but to multiplex three 20-level signals would increase required power by a factor of 177,240. Also, complexity of equipment and criticalness of its adjustment would increase beyond all reason in the latter case.

E. Crosstalk

Attempts to multiplex information beyond the capacity of the channel result in inability to separate cleanly, at the output of the transmission system, all the independent pieces of information that were fed into its input. This "crosstalk" or interference, taking place between messages while they are in the system, is the special bane of multiplex communication. Its effects correspond somewhat with those of outside noise or interference in simplex communication. Crosstalk can sometimes be made of such nature, however, that its effects are self-nullifying.

Cancelling interlace, described earlier, amounts to permitting strong instantaneous crosstalk between two picture-signal channels, and then arranging the display so that the retentivity of the observer's vision undoes the damage by averaging. The same thing can be carried a step further, with improved channel utilization, if limitations of visual resolution of the observer can be put to use. If the second signal, which was chopped into dot-size pieces of alternating polarity for removal by interlace cancellation, consists of the sum of two signals during one set of alternate picture lines, and of their difference during the interleaving set, such a result can be accomplished. When the newly added third signal is recovered, and used to make a picture, that picture will show crosstalk, which will be of opposite polarity on adjacent lines. This crosstalk will be averaged out by observer vision when viewing is under conditions such that adjacent lines are not resolved, with regard to the type of information conveyed by the third signal. A single sideband of a single subcarrier can thus be made, on the average, to carry two distinct items of picture information, as a sort of space-division multiplex.

F. Effects of Nonlinearity

Linear, or proportional, properties have so far been assumed throughout the system. This provided the basis for the cancelling interlace of Figure 5 to work out exactly. Light output from kinescopes does not, in fact, vary linearly with the electrical input, and cancellation is consequently imperfect. While the kinescope is emitting light, this can be corrected by special design of the kinescope or the amplifier driving it, which might somewhat improve cancellation. Compensation of kinescope nonlinearity by intentional nonlinearity in remote parts of the system does not necessarily operate to clean up interlace.

Signals that call for less than no light from a kinescope can occur, and it is then just not possible for the kinescope to respond. This basic nonlinearity must remain in the ordinary kinescope, and must interfere with complete cancellation, even if lesser nonlinearities are eliminated. It is called "kinescope rectification," and is the major source of imperfect interlace, with consequent visibility of dot patterns, in systems that are otherwise perfect in principle (if not yet in practice). Crosstalk cancellation by interline visual averaging, described above, aggravates this condition.

Kinescope rectification can be avoided completely, if signals can be stored electrically over the duration of a full picture frame. Negative signal elements that occur during one field can then be cancelled by overlying positive elements on a following field, before being used to control a light output. This is possible in principle, and even to some degree in practice, but picture-storage devices are still far too crude to be of real use against kinescope rectification. Nor is there present indication that the trouble is serious enough to justify future resort to this rather complicated remedy.

G. Consequences

Enough has now been said of the properties of human vision, and of television systems, so that the general form desirable for color television signals should begin to be evident, as follows:

1. A full-band signal should be present, meeting normal black and white television standards, and should represent reasonably closely the luminance variations of the subject.

2. Amplitude of an additional subcarrier, at a frequency chosen to provide subtractive dot interlace, should represent (as a weighted

fraction of the luminance signal) color purity variations in the subject, such modulation occurring at least out to half the width of the video band (in single-side-band fashion where necessary) and being capable of both positive and negative values.

3. Phase of the modulated subcarrier should vary (without affecting amplitude) to represent hue variations in the subject (as polar angles about the "white" reference of the chromaticity diagram), but such phase modulation, requiring both sidebands, need only occur out to perhaps one eighth of the total channel. When phase modulation has a zero value, subcarrier phase should represent an axis from orange-red to blue-green.

4. A subcarrier-phase reference should be provided as part of the synchronizing signal.

As an alternative to the third item above, which requires as much as ⅛ channel width available on each side of the subcarrier, a wholly single-side-band scheme is possible. This involves crosstalk between suppressed-subcarrier phase and amplitude, but by reversing the phase shaft as between alternate picture lines, visual hue averaging to correct values takes place.

It is hoped that what has been said may help to place the episodes of the following chronicle of transmission system development in proper perspective. Study of applicability to color television of known methods of multiplexing as catalogued briefly above, will be seen from what follows to have been quite extensive. It represents, indeed, a long-term program now approaching completion. As would be expected, sophistication of approach has increased markedly as the program progressed.

PART IV

System Phases of Color Television Development in RCA

A. Beginnings

Attention was given quite early by the Radio Corporation of America to the possibilities of time-division multiplexing for color television. Figure 6 shows the basic form of all purely time-division color systems. Early trials, made in 1940 and 1941, naturally had the synchronous commutators running only rather slowly, namely, at field frequency. That is, one full field was reproduced in one primary color, the next field in a second primary, and so on until both alternate-line fields of an interlaced picture had been picked up and reproduced in all three primary-colored components. Frame frequency became only ⅙ of field frequency, and field-size flashing of green, the brightest primary, occurred at only ⅓ of the field frequency. Because of the very low frequency involved, the very simple, if very crude, expedient of channel "switching" by direct mechanical interchange of optical color filters could be used.

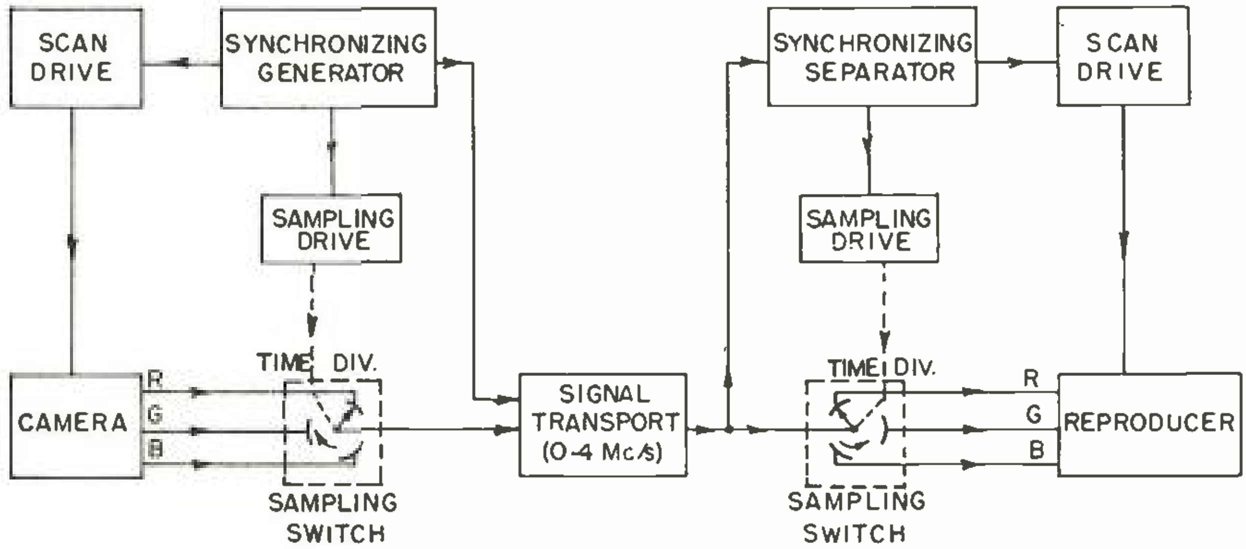

Fig. 6 — The basic form of all purely time-division color television systems.

Color pictures were readily transmissible in this field-sequential way, but its use immediately raised the horns of a basic dilemma. If standard black and white scanning rates were used, the 20-cycle green-field flashing caused wholly intolerable flicker, even at very modest brightness levels. Detail definition, to the full capability of the normal channel, then remained unimpaired in all colors. If, on the other hand, the field frequency was raised by a factor of about 3, flicker was reduced to its normal level, but the new color signal, so obtained, could produce no picture whatever on a normal black and white reproducer. The system had become completely incompatible.

Furthermore, the detail transmitted per picture was divided by about 3 at the higher scan rate, and for the same number of scanning lines, this resulted in an intolerable threefold reduction of horizontal definition. Nor did the system offer any flexibility, whereby red-green definition might be improved at the expense of the relatively imperceptible yellow-blue definition. The dilemma of bad flicker versus complete incompatibility, seemingly inherent in field-sequential multiplexing of color, remains unresolved to this day.

Other early tests made at RCA included some which employed a three-kinescope reproducer, suitable for simultaneous, three-channel transmission, using triplicate equipment. In terms of Figure 4, such transmission would involve three separate 4-megacycle low-pass filters, as well as a scan-synchronizing link, connecting camera directly to reproducer. At the time, no simultaneous-signal camera was built, so no complete-system, simultaneous-channel tests were then made.

These early tests were made at a time when black and white television service was in its inaugural period. World War II not only put a stop to the initiation of regular television service, but also enforced a moratorium on development of color television.

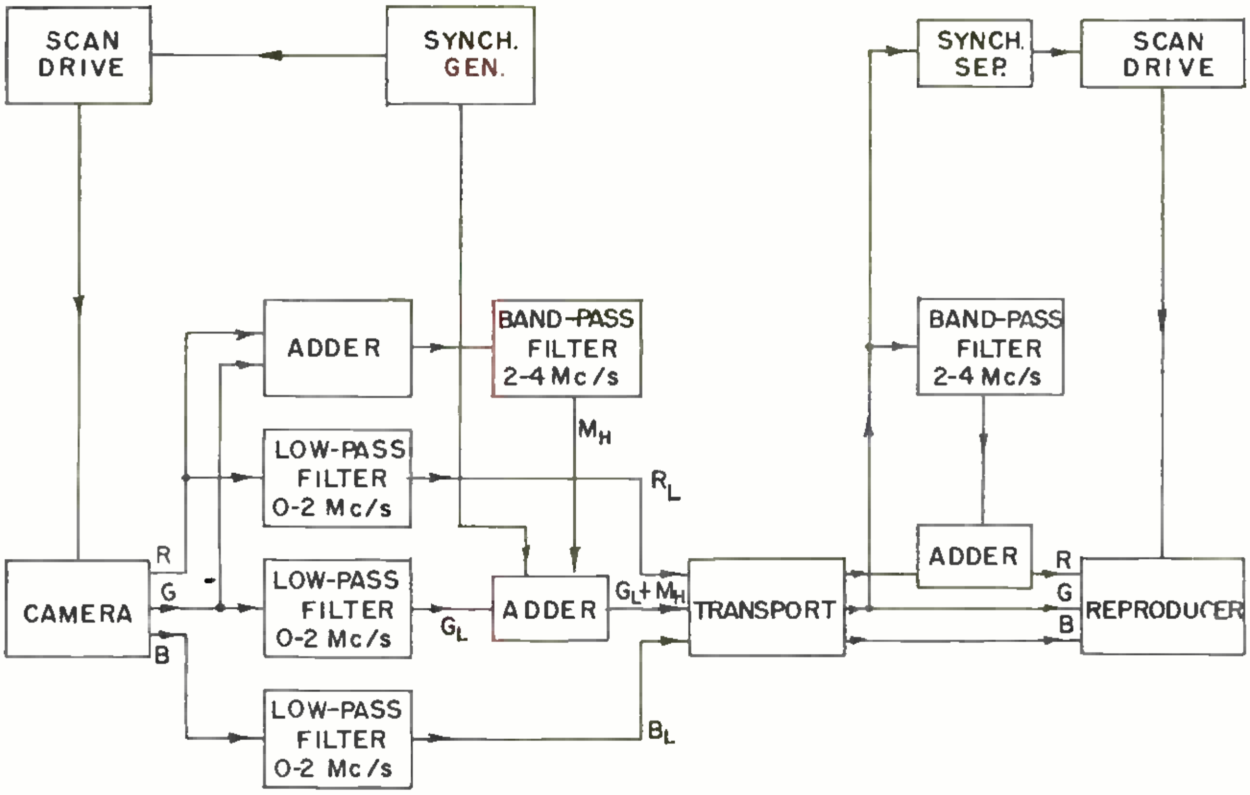

Fig. 7 — A simultaneous-transmission system using "mixed highs" for band saving.

Experiments on color television were resumed immediately after the war. Color cameras and reproducers using three full-band simultaneous channels were then built and tested successfully.[8] Use of three full radio-frequency channels, however, was recognized to be intolerably wasteful of spectrum. When the experiments of Bedford[9] made evident some of the limitations of vision, a more advanced simultaneous-transmission system, which permitted more economical frequency-division multiplexing, was tried. This was demonstrated by RCA, in 1946 and 1947, to the Federal Communications Commission and others. Figure 7 shows the system then proposed, using a technique called "mixed highs" for band saving. At frequencies above 2 megacycles, the only information transmitted was a single signal, combining green and red picture detail, sent on the "green" channel only. No blue information at all was sent in the 2 to 4-megacycle band, because the blue contribution to fine detail is hardly visible, and the blue contribution to luminance is very small.

The composite signal on the "green" channel was intended to be used alone as a monochrome signal, to render a fully compatible black and white service. Figure 8 shows the spectra of the signals in the respective channels; using one standard channel for the composite "green" or "achromatic" signal,

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[8] R. D. Kell, G. C. Sziklai, R. C. Ballard, A. C. Schroeder, K. R. Wendt, and G. L. Fredendall, "An Experimental Simultaneous Color-Television System," *Proc. I.R.E.*, Vol. 35, No. 9, pp. 861-875 (September, 1947).

[9] A. V. Bedford, "Mixed Highs in Color Television," *Proc. I.R.E.*, Vol. 38, No. 9, p. 1003 (September, 1950), attached hereto as Appendix B.

the red and blue signals could readily be frequency multiplexed on one additional channel. The system had limitations; its requirement of two regular 6-megacycle channels was excessive, while the broad-area red blindness of the composite channel was found to lead too often to rather poor tone rendition in black and white reception and caused the black and white reproduction to be rather disconcerting in the special case of broad all-red subject areas having fine detail.

Nevertheless, the system was a technically workable one, which could have been put into use in the ultra high frequency channels without disrupting black and white service, and its limitations other than extravagant channel use were easily remediable (provided two RF channels could be kept identical as to propagation vagaries).

"Mixed highs" is a term that might readily give rise to the idea that detail will be rendered in some confused fashion. This is not the case, and the concept will carry on through most of what follows, so some discussion of what really happens is in order here, even though the particular system is not presently of practical importance.

First, it is necessary to note that any signal put out by a high-pass filter can only be purely alternating, without any steady component. Consider a purely white or gray subject. The color system of Figure 7 rendered the broad areas of such a subject correctly as to luminance and absence of hue. Fine-detail information gave a purely alternating signal applied to the green and the red reproducer tubes only, so was reproduced as variations of yellow light. The broad-area average light output, on which the fine-detail variations were superimposed, was not tinted. Reduction of yellow-light component output alone in reproduction left dimmer-than-average details with a slightly bluish tint, while increase of yellow reproduced brighter-than-average details with a slight yellowish tint. These imperfections of physical light-pattern reproduction were exactly the ones found by research on vision to be least perceptible in fine detail, and did not result in any noticeable imperfection of visual sensation given by the reproduction.

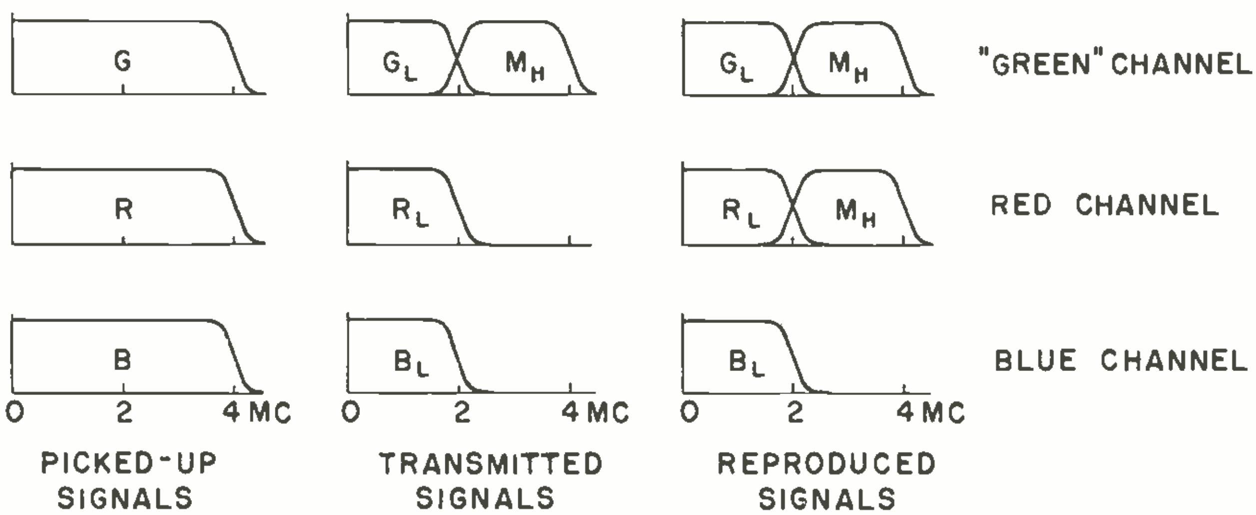

Fig. 8 — Spectra of the signals in the simultaneous-transmission system.

Yellow areas were given physically as well as visually perfect reproduction, even as to fine detail. Pure blue areas were reproduced with no fine detail at all in the particular system shown in Figure 7. Green subject areas were reproduced correctly as to green light, even down to somewhat weakened fine detail. The pure alternating signal fed across to the red reproducer for a green subject, however, suffered kinescope rectification, so that, while dimmer-than-average details were reproduced only in green, brighter-than-average details got some red light added, so were reproduced at correct luminance level, but in green with a slight yellowish cast. Likewise, in broad red subject areas, dimmer-than-average details were reproduced in pure red, with somewhat reduced dimming, while brighter-than-average details got some added green, giving correct brightness increase, but a slight orange cast. Again, these are just the right physical defects to cause no noticeable impairment of color-detail sensation.

Development effort in the actual field of color television at RCA, during the following two years, was directed toward necessary improvement of terminal equipment and study of basic concepts of compatible high performance systems capable of operating at reduced channel widths. The terminal equipment improvements included color cameras and slide scanners, with associated studio control equipment (including "masking amplifiers," or bipolar channel-mixing matrices),[10] as well as three-kinescope color reproducers. Preliminary tests were also made of some proposals for color reproducers using only a single picture tube, and proposals for the application of level-division multiplexing to color-picture transmission were put forth.

Wholly independently, development of exceptionally fast time-division multiplex was actively in progress in groups within RCA concerned with communication systems in general. The need for economy of channels was universally becoming strikingly evident. This basic work in the communications field became the practical springboard of experience for moving forward with the developing concepts for color television.

B. The Period of the 1949-1950 FCC Hearings

During the early part of 1949 RCA proceeded to narrow its research to the most promising system for color television, with the objective of maintaining high definition pictures and compatibility, while keeping within a 6-mc channel. In mid-1949 the Federal Communications Commission called for an early showing of the then existing color television art, with particular regard to channel economy and to system compatibility with existing black and white service. The notices of this hearing naturally accelerated RCA's work on defining an all electronic, compatible color television system in order that RCA might be prepared to give as comprehensive a report as possible during the course of the Commission's proceeding.

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[10] W. H. Cherry, "Colorimetry in Television," *RCA Review*, Vol. VIII, No. 3, pp. 427-459 (September, 1947).

RCA began a careful review of the status of all color television developments known to it. This included a repetition of earlier tests of field sequential methods which soon gave the old answers, either intolerable flicker or complete inability to produce any picture on any of the black and white receivers in service. The acuteness of the television channel shortage was by that time fully evident and it had already become obvious that the wide channels needed for simple simultaneous transmission were not obtainable.

RCA wholeheartedly endorsed the conditions set up by the FCC in its Notice of Hearing that transmission should be within a 6-mc channel and that the color transmissions should provide service to the existing black and white receivers. These conditions RCA considered as necessary features in any practical color television system.

Status of fast time-division multiplex development was reviewed, in the light of earlier proposals for picture-element-sequential color transmission. It was decided that the fast-multiplex art was ripe for successful application to television. Proposals for level-division multiplexing, or "quantizing," were also reviewed. The road to successful application here looked much longer. Nevertheless, experimental development of the most promising of the quantizing proposals was undertaken, as insurance against possible difficulties in applying the simpler time-division approach.

Tests were also undertaken to provide first-hand familiarity with a line-sequential color television system, at that time actively proposed by another organization. Figure 6 again applies: it was only necessary to drive the synchronous commutators (at 5250 rps) to make (and hold) one contact for each line. This switching was fast enough to require electronic means for its accomplishment, but slow enough to pose no technical difficulty. As in the field-sequential case, no flexibility to apportion color information to meet the needs of vision seemed possible. Trials were made of several line-interlace schemes, using standard black and white scanning frequencies. Results were always the same: either the line structure was very coarse, or excessive flicker appeared, manifesting itself as very annoying line jitter or line crawl. Flicker effects were not as bad, however, for line-sequential as for field-sequential transmission at the same scan frequencies.

Figure 6 is also descriptive of element-sequential time division: for that, it was only necessary to drive the synchronous switches together at, for example, 2⅔ million revolutions per second, electronically of course. This caused 8 million sharp, completely independent "samples" of the signals from the color camera to be applied per second to the 4-megacycle transmission channel, just loading that channel fully. By so driving the electronic time-division commutators that picture-dot interlace occurred (that is, at exactly an odd multiple of half the line-scan frequency), color-frame frequency could be reduced to ½ the black and white value. Color-picture detail could thus be kept up to ⅔ the value attained in normal black and white television, despite the 3-way division of channel time. Separate handling of each picture element gave flexibility for future improvement in matching color-detail transmission to the needs of human vision.

In mid-July of 1949, very creditable color pictures were produced by the above system. Confirmation of the decision that fast-multiplex methods were ripe for application to television thus came about very rapidly. Normal, unmodified black and white receivers showed a normal black and white picture on the element-sequential color signal, and unmodified element-sequential color receivers showed a normal black and white picture on the standard black and white signal. Successful operation of this fully compatible color system in a six-megacycle channel, with both black and white and color reproduction, was a major event in the history of television. That the element-sequential system required circuit techniques regarded at the time as very advanced caused little dismay; accumulating experience and development have a way of making such things easy.

Problems requiring attention in the system as first tried were: excessive dot size, making residual flicker unduly perceptible as crawling dot structure in the picture, and reduction of resolution to ⅔ that of normal black and white television. This was about the resolution usual in black and white transmission over the existing intercity coaxial cables. The first trouble was alleviated by raising the sampling frequency, the frequency of complete revolutions of the commutators of Figure 6, from 2⅔ to over 3½ million per second. For the second defect, a mixed-highs signal was bypassed around the sampling commutators at the originating terminal, as shown in Figure 9. Increased sampling frequency meant that over 10½ million samples per second were being impressed on a 4-megacycle channel, which was only capable of accepting 8 million of them without crosstalk. Resulting crosstalk, which was in the nature of color fringes at sharp, vertical color-contrast edges, was not found visually objectionable at that time, and the improved appearance resulting from the smaller dots was fairly marked. With sharp samples impressed on the reproducer, true additive dot interlace occurred in the reproduced pictures.

Synchronization of the time-division multiplexing "samplers" was initially done by way of extremely accurate timing of the trailing edge of the normal line-synchronizing pulse. This worked well in the laboratory, but did not prove rugged enough to continue working well in the face of the many sources of disturbance in field operation. An alternative method, utilizing a "burst" of several cycles of a signal at sampling frequency transmitted during the latter part of the line-retrace blanking signal, provided much firmer synchronization. Burst synchronization has, in fact, proved adequate in field use, even in the presence of strong interference.

Demonstrations were given in October, 1949, by RCA to the Federal Communications Commission and others, with the system of Figure 9, using pulse-edge synchronization and a sampling frequency of about 3.8 megacycles. Comparative tests, in November of 1949, were made with the same system, but at a sampling frequency of about 3.6 megacycles. Comparative tests in February of 1950 again used the same system, but this time with the more stable burst synchronization and at 3.583125 megacycles (455 dots per complete line). At this time, also, circuit stability had been improved by

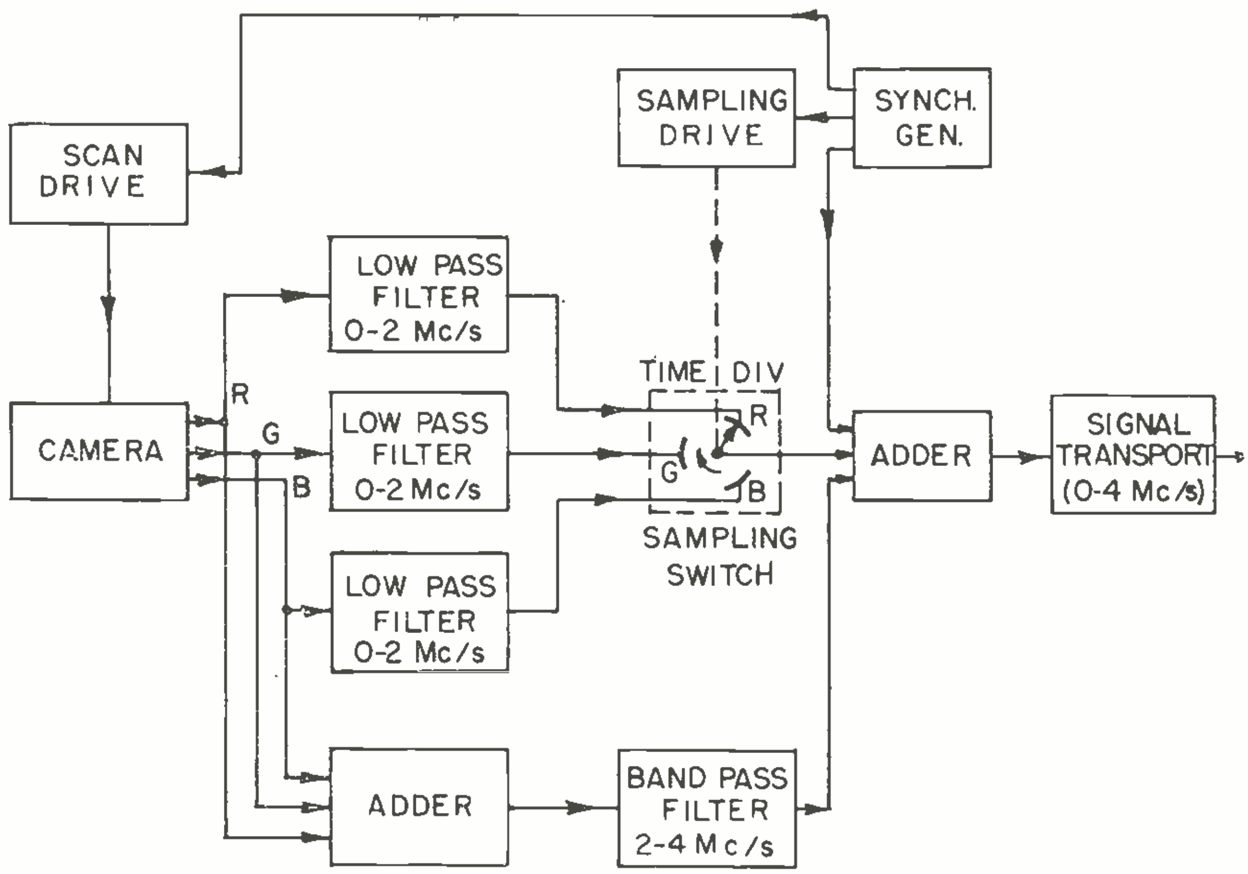

Fig. 9 — Early element-sequential transmission system.

doing the electronic multiplex switching, or signal sampling, directly at the picture tubes of the three-tube reproducer.

Microwave relays going into service in 1949 and 1950 were able to transmit the RCA color signal from city to city without trouble, and new coaxial cables were expected also to have this capability. Existing intercity coaxial cables, however, were limited in bandwidth to less than 2.7 megacycles, and were unable to pass the 3½-megacycle sampling frequency. Special signal-processing terminal equipment, which cut picture detail to ½ (as compared to almost ⅔ in coaxial handling of black and white), and employed reduced sampling frequency, proved able to pass a useful color signal over the existing cables, and to reconstitute it for normal radio use afterward. Such cable-terminal equipment was demonstrated in April 1950.

Reproducers using an assembly of three picture tubes and two mirrors were used in the RCA demonstrations of 1949 and early 1950. As soon as the practicability of a compatible transmission system was well assured, however, intensive effort on a large scale was applied to the problem of making practical a single picture-reproducing tube, capable of giving full-color pictures. Tubes using several different principles were made and tested. The story of these tubes is a very considerable one in itself,[11] but is not a part of this story of system development. One type showed promise of becoming

[11] "Direct-View Color Kinescopes," a series of eleven papers, *Proc. I.R.E.*, Vol. 39, No. 10, pp. 1177-1263 (October, 1951).

producible more rapidly than the others, so samples of two versions of this "shadow-mask" tube were built into receivers, and demonstrated by RCA to the Federal Communications Commission and others in March and April of 1950.

Extensive co-channel and adjacent channel interference tests, using radio-frequency transmission, were made on standard black and white, field-sequential color, line-sequential color, and element-sequential color systems.[12] No substantial difference was found among the various possible system combinations, from the standpoint of channel allocations.

Another activity intensified by RCA in the summer of 1949 was the analytical study and comparison of proposed systems. This soon began to reveal many possibilities of further development and refinement inherent in the original element-sequential system. For one thing, it led to study of recent literature on vision, with recognition of the two-color nature of medium-detail vision, and of extensions of the mixed-highs principle thereby implied. It also led rapidly to recognition that the transmitting sampler of Figure 9, with its filters, was the exact equivalent of a set of three ordinary balanced modulators, each having a direct video-signal bypass, and each modulating a suitably phased sinusoidal subcarrier. Either scheme could produce just the same signal in the common transmission channel, the channel-bandwidth limitation leaving no sharp dots in either case. On the other hand, if the receiving sampler were replaced by video-bypassed modulators and filters, the positive dot interlace occurring on the reproducer-tube faces with sharp sampling was found to be replaced by a negative or error-cancelling interlace. Somewhat less dotty reproduction could so be obtained.

Our study of the information content of the composite color signal quickly made it evident that two balanced modulators plus a single direct bypass channel would suffice for the entire signal-processing job, at either the originating or the reproducing terminal. Many ways of apportioning the required information among these three channels were evident. Several of these ways permitted avoiding crosstalk due to excessively frequent application of signal samples to the band-limited transmission channel. The very simple scheme of Figure 6 amounted to one symmetrical but rather inflexible choice of apportionment of information. The scheme of Figure 9 was the beginning of greater flexibility.

Results of these basic studies were not demonstrated experimentally during the period of the hearings. They did, however, lay a groundwork for much experimentation done since. Detailed studies were made of the way in which sharp sampling dissected and reconstituted the color picture, and in which excessively fast sampling led to crosstalk.[13] Results of these studies were presented to the Commission during the hearings.

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[12] RCA Laboratories Division, "A Study of Co-Channel and Adjacent-Channel Interference of Television Signals," *RCA Review*, Vol. XI, Nos. 1 and 2, pp. 99-120 and 287-295 (March and June, 1950).

[13] RCA Laboratories Division, "An Analysis of the Sampling Principle of the Dot-Sequential Color-Television System," *RCA Review*, Vol. XI, Nos. 2 and 3, pp. 255-286 and 431-445 (June and September, 1950).

C. May, 1950 through December, 1951

Presence of a physical dot structure in the fluorescent screen of the single-tube, shadow-mask color reproducer could give rise to moiré patterns in the reproduced picture when sharp-dot samples were applied to such a reproducer. This indicated a probable advantage in signal filtering and negative interlace, theretofore regarded as merely an equivalent alternative to sharp-sample time sharing. Complete separation of video bypassing from sampling was also previously considered an equivalent alternative. This had been found practically advantageous in experiments carried out independently by Hazeltine Electronics Corporation.

The system of Figure 10 was, therefore, tried by RCA soon after the close of the hearings. It may be noted that, at the originating terminal, the change from Figure 9 to Figure 10 involved only the shifting of one band-pass filter from one signal path to another. Yet this single rearrangement resulted in handling the direct mixed-video monochrome signal quite separately from the added color signal, over the entire video band. This gave new freedom of control, while still producing exactly the same composite signal for transmission as did Figure 9. Somewhat greater changes at the reproducing end gave similar freedom there, while at the same time filtering out as much of the sampling structure from the reproduced color signals as possible. This reduced shadow-mask moiré effects.

The system of Figure 10, used during the summer of 1950, was found to handle more conveniently than the earlier arrangements. Distinction between sharp sampling and subcarrier modulation, important under some circumstances in the basic element-sequential, time-division system of Figure 6, was already vestigial in the originating terminal of Figure 9. Because of the smoothing action of the filters shown, such distinction was entirely gone from both terminals in Figure 10. Choice between classical sharp-sampling commutators and sinusoidal modulators had thus become merely a matter of convenience.

Operation of modulated-subcarrier color systems is perhaps most readily understood in terms of the basic arrangement of Figure 11, in which signal paths are clearly separated. Here, the three camera signals, representing three primary-color components of the subject viewed, are mixed in appropriately chosen proportions to give three composite signals, each of which is filtered to an appropriately chosen bandwith. One composite signal, representing black and white picture information, is handled directly, as in an ordinary monochrome television system, while the other two, representing chromaticity information, are used to modulate, in balanced fashion, two suitably phased, sinusoidal subcarrier signals. After suitably filtering the two modulated-subcarrier color-mixture signals, these are added to the direct signal to form for transmission (by radio or otherwise), a single composite signal, the complete color television signal.

At the receiving terminal of Figure 11, the incoming composite signal, suitably filtered in each case, is used to modulate two suitably phased

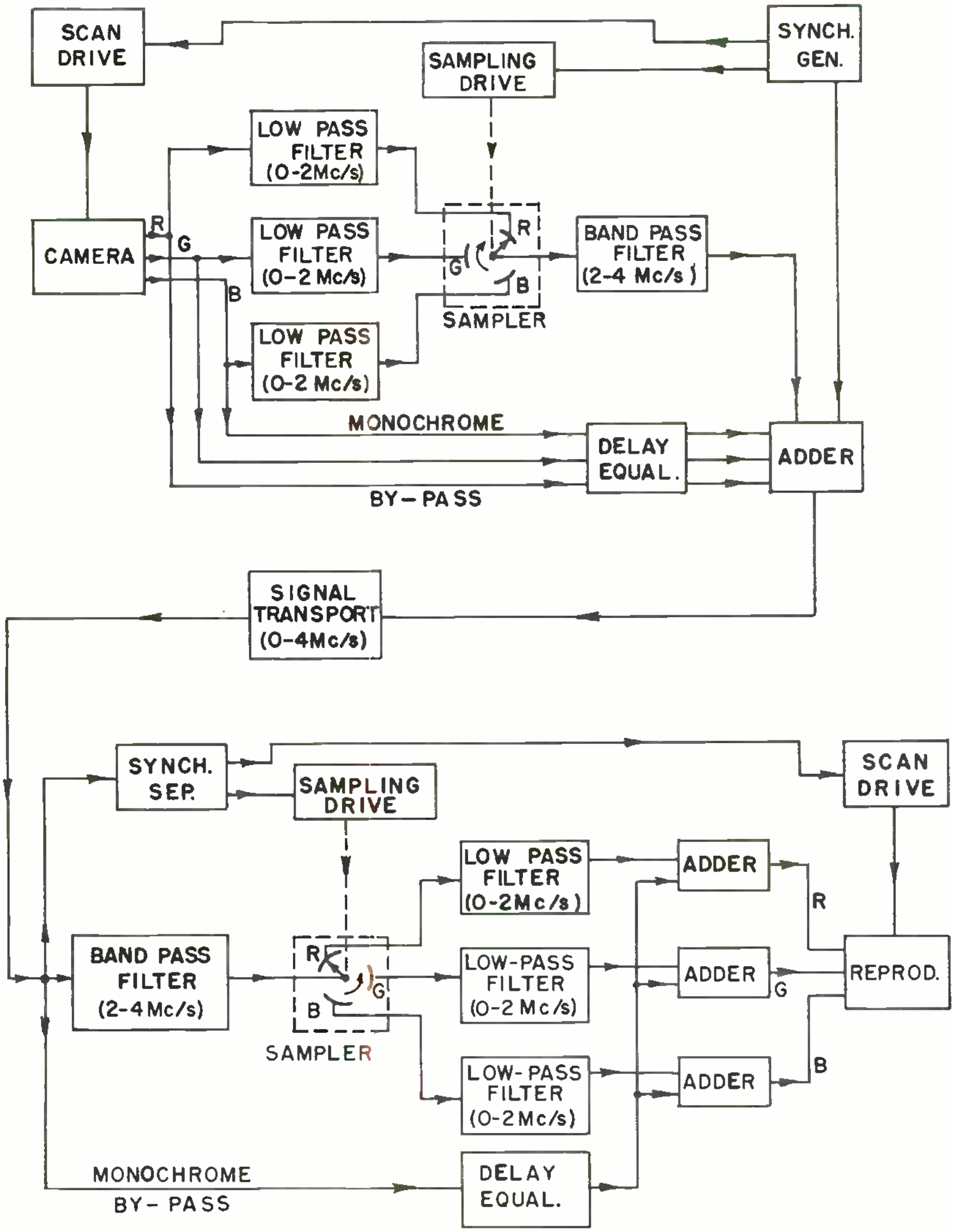

Fig. 10 — A simultaneous-transmission system using complete monochrome by-pass.

sinusoidal subcarriers, as well as being passed on directly in a monochrome channel. The two chromaticity signals recovered by this second modulation process, after filtering, are added in appropriately chosen proportions to the direct-path composite signal. Thus, three primary-color control signals are recovered, for use as reproducer inputs.

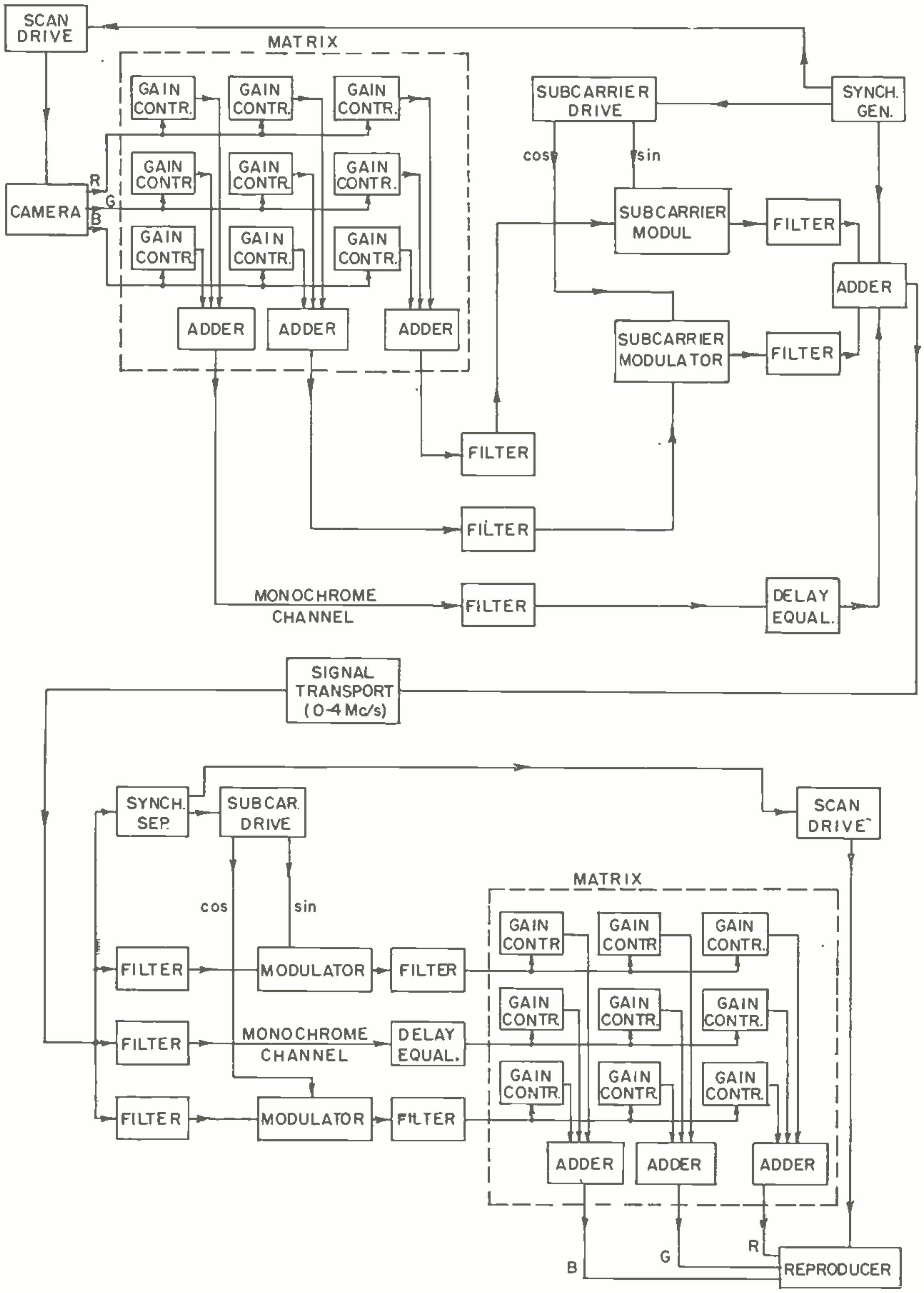

Fig. 11 — A basic modulated-subcarrier color television system.

Nine independent gain settings are involved in deriving three independent mixed-color signals from three primary-color camera outputs at the originating terminal. These gains may involve some negative values—that is, signal-polarity reversals. A similar nine-control gain matrix is involved at the receiving terminal. Camera-channel levels will be assumed hereafter to be so chosen that a white subject produces equal voltages at all three camera outputs. Similarly, reproducer-channel levels will be assumed so chosen that equal voltages applied to all three reproducer inputs result in white-light output from the reproducer. As mentioned in the earlier discussion of colorimetry, choice of a "reference white" is itself arbitrary, but once such a choice is made, the stated level relations become fully meaningful.

Each of the filters shown, in addition to its intended function of shaping the spectrum of the signal passing through it, also subjects that signal to a time delay. Filter delays must be so chosen or compensated that the signal from each camera output suffers the same delay in reaching the corresponding reproducer input, whatever path it follows through the system of Figure 11.

So far as the originating terminal is concerned, all system tests made by RCA since introduction of the mixed-high system of Figure 9, in the early fall of 1949, have been direct equivalents of choosing various gain settings, filter pass-band limits, and subcarrier phase conditions in the single basic system of Figure 11. As regards the receiving terminal, the same is true of all system tests made by RCA since introduction of the output filters of Figure 10, in the late spring of 1950.

Two modulators, as indicated in Figure 11, suffice to do all that can be done. Use of three modulators, with a single input channel feeding each one, is a particularly obvious equivalent of the three-position time-division commutator of Figure 6. Actually, however, such a three-modulator arrangement amounts to a way of taking advantage of the vector properties of polyphase modulators, to get control of two independent mixed signals by using three gain controls and three subcarrier-phase controls. This is alternative to the six gain controls feeding two modulators shown in Figure 11. Independent control of the two mixed-channel bandwidths, however, is not fully available when using three modulators, so long as each of them has only a single-camera-channel input. Both two-modulator and three-modulator forms have been tested, and the former have proved more convenient in practice.

If three single-input modulators are run symmetrically as to carrier phase, as in Figures 9 and 10, certain rather special properties result, but freedom of control of the two mixed channels resulting is then very limited. To make the composite transmitted signal and the reproducer-input signals the same in the case of Figure 11 as for Figure 10, it would only be necessary to give the originating-terminal gain matrix the settings shown in Figure 12a, and the receiving-terminal matrix the settings of Figure 12b, with filter pass bands also as shown.

Checking through the result of the settings shown in Figure 12, one finds that the signals applied to the red, green, and blue reproducer-input channels remain equal, respectively, to the signals on the red, green, and blue camera-output channels. This is true whatever those outputs may be, so long as the three channels remain free of crosstalk. Graphical representation of the modulated two- and three-phase subcarriers by rotating vectors, or phasors, which will be discussed later, can be helpful in visualizing the signal relationships between Figures 10 and 11.

Unity gain settings in Figure 12b between monochrome input to the receiving matrix and all three of its outputs should be noted. This feature has made possible the custom of applying the monochrome signal directly to all three grids of the color kinescope, with the remaining signal components applied separately to the three cathodes. Signal additions take place within the kinescope by the joint control action of grids and cathodes on the three electron beams. The external matrix actually used then comprises only the remaining six elements of Figure 12b, the ones fed by the chromaticity signals. Matrix settings for other systems, to be shown later, retain this direct-monochrome feature.

Differences between areas of various colors are least apparent when such areas look equally bright, as mentioned earlier. Workers in the laboratories of Hazeltine Electronics Corporation pointed out early in 1951 that certain adjustments of systems having the capabilities of Figure 11 permit taking advantage of the above fact. What is required is that the output of each receiving-terminal modulator shall be fed to the three reproducer inputs

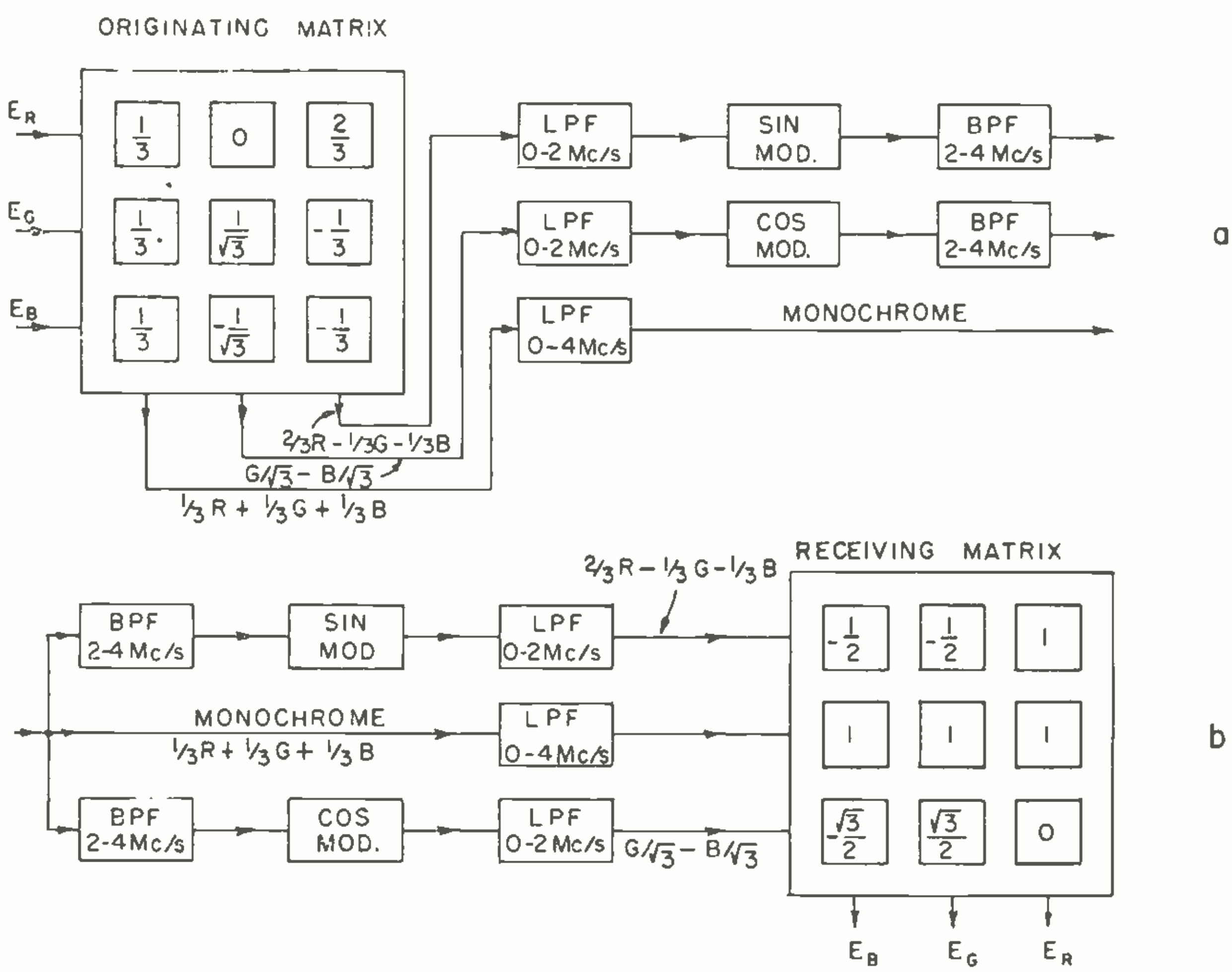

Fig. 12 — Filter pass bands and matrix gain settings which make Fig. 11 the equivalent of Fig. 10.

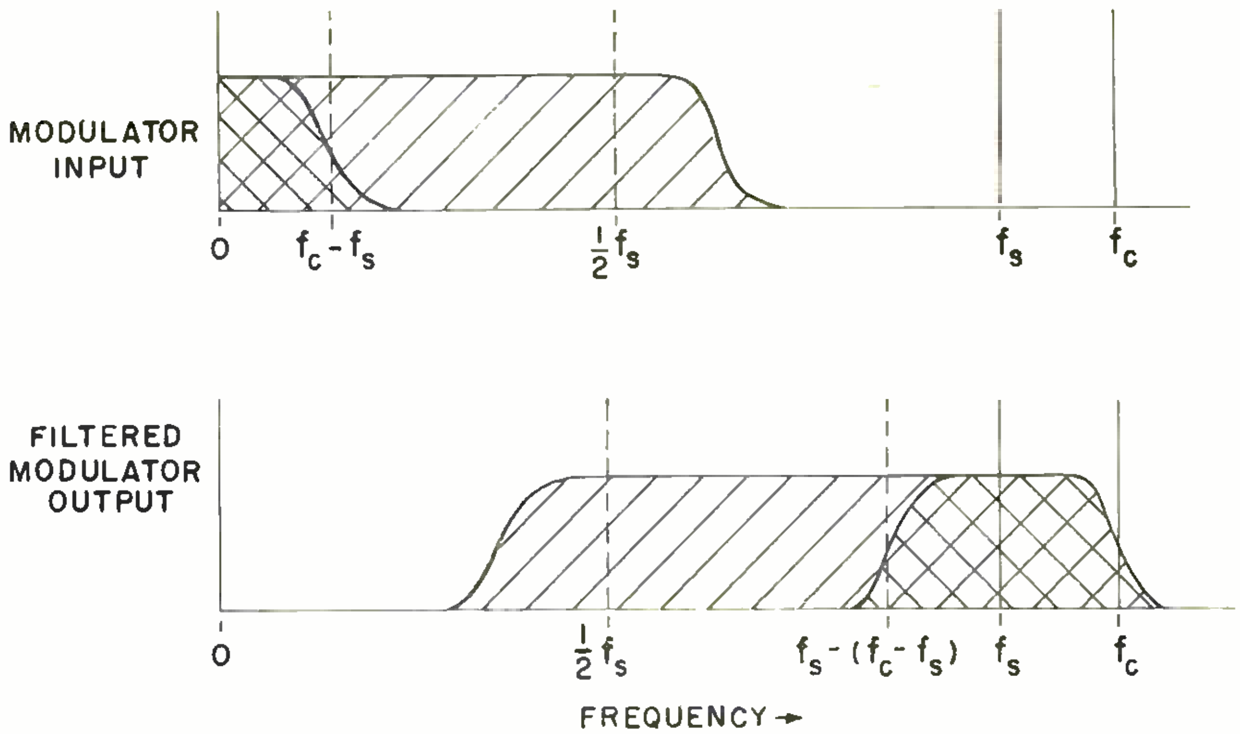

Fig. 13 — Spectra of the signals in the system of Fig. 12.

in such proportions and polarities that it cannot alter the net luminance but only the hue and purity of the total reproducer light output.

Such constant-luminance operation results in minimum visual annoyance from interfering signals which reach the receiving modulators along with the modulated-subcarrier components of the desired signal. Flicker due to removal by cancelling interlace of the monochrome signal applied to these modulators is particularly sharply reducible in this way. Appendix J shows that constant-luminance operation necessarily results if the composition of the monochrome signal is so chosen as to represent subject luminance. System amplitude nonlinearities seriously limit the practical utility of the constant-luminance principle.

Certain spectrum properties of the system, evident from Figure 11, need to be borne in mind. Call the upper cutoff frequency of the transmission channel f_c, and the subcarrier frequency f_s. Modulation of the subcarrier by picture components of frequencies from zero to $f_c - f_s$ then results in double-sideband modulator output. This is the condition for the doubly cross-hatched regions of the spectrum diagrams of Figure 13. Modulation by picture frequencies exceeding $f_c - f_s$ produces only single-sideband useful output from the modulators, since the final transmission channel does not pass any upper sideband so produced. This condition exists for the singly cross-hatched regions of Figure 13.

In the double-sideband region, two independent signals can be handled without crosstalk. This requires first that, at the originating terminal, the two subcarrier signals, modulated directly by the two mixed-video signals which are to be kept separate, shall be, respectively, sine and cosine functions of time. Second, it is required that the two subcarriers modulated, at the receiving terminal, by the combined output of the originating modulators shall follow, respectively, time functions identical to the corresponding ones at the originating terminal. The two recovered signals will then be accurate and independent reproductions of the two original signals. In single-sideband operation, input to either originating-terminal modulator results in output from both receiving-terminal modulators, whatever the subcarrier phases used. This represents crosstalk. Signal components at frequencies producing single-sideband modulation should be given twice as much gain as components which produce double-sideband modulation, to make up for attenuation due to loss of one sideband. This is a matter of properly shaping the amplitude characteristics of the filters at the outputs of the receiving-terminal modulators of Figure 11.

With f_c at about 4 megacycles and f_s about 3.6 megacycles, as they were in using the system of Figure 10, color-video components above about 0.4 megacycle produced single-sideband modulation, with resulting crosstalk. By the summer of 1950, technical system performance was otherwise good enough to make this crosstalk annoyingly perceptible, as discolored fringes following sharp, vertical color-contrast edges. Two methods of minimizing damage done by such crosstalk have been field-tested. The more complex method was tried first, and will be described first.

If the polarity of the subcarrier applied to one modulator at the originating terminal, and to the corresponding modulator at the receiving terminal, for example the cosine modulators of Figure 11, is reversed between successive picture fields, crosstalk effects will exactly reverse between adjacent, interlaced lines of the complete picture. Such breaking up of the crosstalk should enable the viewer's vision to respond only to its average, which is zero. Reversals may be made, alternatively, between successive lines of each picture field, with very similar visual averaging. Reversal of one subcarrier polarity in the two-modulator case corresponds to reversal of the order of subcarrier-phase progression in the three-modulator case.

These expedients for minimizing crosstalk damage, while still permitting crosstalk to occur, have been called "color-phase alternation," or CPA. Use of CPA should, in principle, permit full single-sideband operation. As the subcarrier frequency f_s is raised toward the main-channel cutoff frequency f_c, however, the width of the alternating-polarity vertical crosstalk bar following each sharp vertical edge must increase. CPA also has another effect. Errors in phasing of receiving-terminal subcarriers, relative to those at the transmitter, normally result in wrongly colored reproduction. CPA causes color errors of this sort to reverse periodically, so that the observer may disregard them on the average, and phase synchronization should thus be rendered less critical.

Besides a readily acceptable coarsening of vertical color detail, without loss of brightness detail, the price of reducing crosstalk damage by CPA is a modified flicker pattern. Crosstalk bars flash as solid areas at one-half of field frequency, if reversals are made between fields, or flash as line segments at one-quarter of field frequency, if reversals are made between successive lines. Phasing errors result in similar flashing of entire solidly-colored areas.

Extensive tests have been made of several system modifications using color phase alternation. Initial trials, early in 1951, involved merely some modification of the color-sampling drive in the system of Figure 10, to provide the needed reversals of color sequence. This resulted in an impressive improvement of color reproduction.

By early 1951, the National Television System Committee was actively engaged in a consideration of a signal choice for compatible color television. After extensive study of the work already done, certain panels of this committee set to work to produce system specifications for field testing. RCA has contributed heavily to the work of the NTSC, both in its initial studies and in the continuing work of its panels. A set of signal specifications for field testing was completed by NTSC late in 1951 and released for publication on November 26, 1951. These signal specifications used color phase alternation, constant luminance, and a subcarrier frequency of 3.89 megacycles. Gain settings for Figure 11, to realize the specified signal, are shown in Figure 14. The monochrome signal resulting from these settings represents subject luminance, as shown in Appendix K, assuring constant-luminance operation.

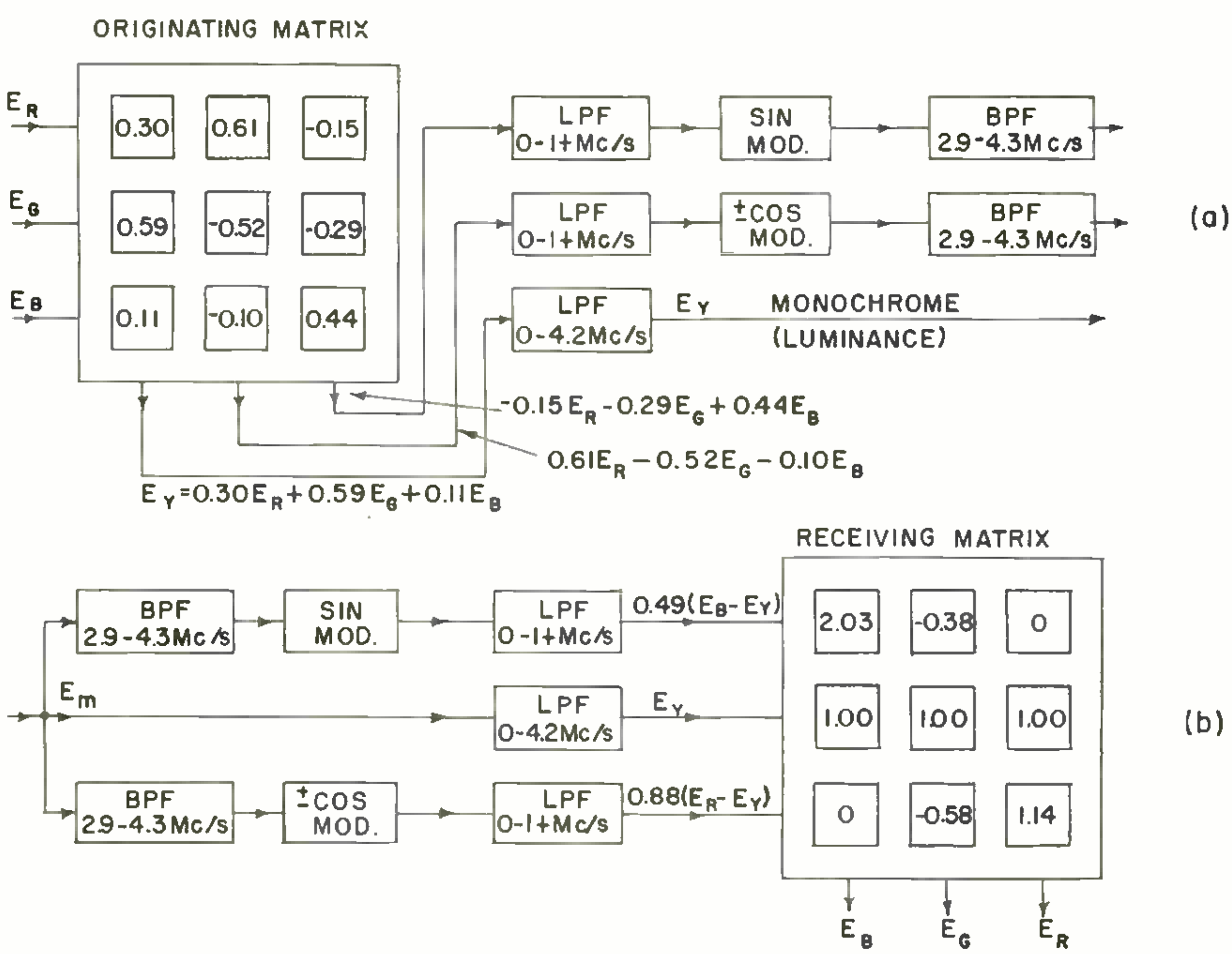

Fig. 14 — Filter pass bands and matrix gain settings for the NTSC signal specifications of November 26, 1951.

D. 1952

When the signal specifications of November 26, 1951, were adopted by the NTSC, RCA promptly began extensive field testing of the specified signal and of the equipment necessary to radiate that signal and receive it in color. During 1952, RCA carried on four parallel lines of system investigation, two of them as parts of these field tests. First, extensive field testing with color receivers indicated that a lower subcarrier frequency was likely to produce better color pictures with greater stability. Therefore, studio equipment and receivers were provided so that three separate color signals could be generated and received. These three signals were alike except for the frequency of the color subcarrier. The subcarrier frequencies used in these tests were 3.898125 megacycles, 3.740625 megacycles, and 3.583125 megacycles. Extensive observations confirmed our feeling that the lowest subcarrier frequency produced the best color pictures.

Secondly, a large amount of time was devoted to compatibility tests to assure ourselves that the many types of black and white receivers in use would perform satisfactorily on the new signal. These compatibility tests were performed in two ways, one by gathering a large number of representative receivers for observation by skilled observers and the other by broadcasting the signal and soliciting audience response. A small number of black and white receivers showed a slight disturbance in the received picture which was traced to the presence of the color-subcarrier burst in the synchronizing signals. The difficulty was overcome by a slight change in the character of the burst, involving removal of the low-frequency pedestal component that had been a part of the burst. The validity of this solution was verified by further field tests. It had also been observed that on a few black and white receiver types a beat between the color subcarrier and the sound carrier appeared as a series of wavy lines. Again, corrective measures were applied. The solution in this case was brought about by lowering the subcarrier slightly, approximately thirty-five hundred cycles, thus reducing the beat to low visibility by applying the frequency-interlace principle. Extensive on-the-air broadcasts fully justified this "offsetting" of the color subcarrier.[14]

When it became apparent that improved color reception could be obtained with a lower subcarrier, another series of compatibility tests by skilled observers and by audience response showed that no loss in compatibility was to be expected if a lower subcarrier were used.[15] Hence, two distinct series

[14] Report entitled "An Audience Survey Conducted to Evaluate the Merits of a Proposed 'Preferred' Frequency Relationship between the Sound Carrier and the Color Subcarrier in the RCA Color Television System, July, 1952," attached hereto as Appendix C; report by Opinion Research Corporation entitled "Reactions to a 'Preferred' Relationship between Sound Carrier and Color Subcarrier in Experimental Color Broadcasts, July, 1952," attached hereto as Appendix D.

[15] Report entitled "An Audience Survey Conducted to Evaluate the Influence of the Frequency of the Subcarrier as it Relates to Compatibility in the RCA Color Television System, September, 1952," attached hereto as Appendix E; reports by Opinion Research Corporation entitled "Reactions to Black and White Reception of Eight RCA Experimental Color Broadcasts, September, 1952," attached hereto as Appendix F and "Reactions to Black and White Reception of Six RCA Experimental Color Broadcasts, November, 1952," attached hereto as Appendix G.

of tests first shifted the color subcarrier from 3.898125 megacycles to 3.583125 megacycles to secure better color pictures (a relatively large change in frequency) and then shifted the subcarrier to 3.579545 megacycles to secure greater compatibility (a relatively small change in frequency).

Third, work on methods and apparatus for transmission of color signals over limited-band coaxial cables continued through 1951 and 1952. A very straightforward method of accomplishing the necessary signal conversion was found and successfully developed.[16] This involves low-pass filtering of the composite color signal, to provide a 0 to 2 megacycle monochrome signal, and band-pass selection from the composite signal of the frequency region within plus or minus 0.3 megacycle of the color subcarrier. The narrowband color signal so obtained, including the synchronizing burst, is heterodyned to center on a new subcarrier frequency, near 2.4 megacycles, which bears an exact fractional relationship to the original subcarrier frequency.

A composite color signal able to pass through 2.7 megacycle cable results from adding together the narrowed monochrome and heterodyned color components. Reversal of the heterodyning process, with appropriate filtering, reconstitutes at the far end of the cable a composite color signal entirely normal except for reduced detail. Such a system was first used in September, 1951; numerous successful demonstrations of cable transmission by improved versions of this method have been given since then.

Results of experience in the field with the NTSC signal during 1952 indicated that, in practice, effects consequent on single-sideband use of CPA rendered color reproduction less than fully satisfactory. Color-edge flicker was excessive, particularly at high reproducer luminance levels. Color-area flicker prevented CPA from markedly relaxing subcarrier-phase tolerances. At its best, the system produced very good pictures, and the technical shortcomings might have been accepted had no alternative been available.

The fourth line of investigation followed by RCA during 1952 stemmed from earlier analytical studies, centered on the problem of making the signal structure fit closely the characteristics of human vision. These studies had already indicated in the Fall of 1949 the possibility of crosstalk-free, sharp-sampling color systems. By mid-1950 further study had shown how to adapt such schemes to modulated-subcarrier use, providing an attractive alternative to CPA.

This alternative approach employs:

1. Fullband transmission of the bypassed luminance-only signal.
2. Moderately wideband, partly single-sideband transmission of a single color mixture signal distinguishing, for example, slightly orange-red from blue-green.
3. Narrowband, double-sideband transmission of an additional color-mixture signal distinguishing, for example, green from purple.

[16] J. G. Reddeck and Howard Gronberg, "Network Transmission of Color Television Signals." (Submitted to *Electronics* for publication.)

Suitable choice of gain settings and filter pass bands in the basic system of Figure 11 immediately gives just such operation. No crosstalk is generated, because no attempt is made to transmit more information than the system can handle. Application of this approach to studio and receiving equipment provides the benefits of color-phase alternation, while rendering actual alternation unnecessary. The constant-luminance property may be retained.

Considerable flexibility is inherent in the system obtained by adjusting the equipment of Figure 11 according to the above rules. So long as only frequencies below $\frac{1}{2}f_s$ are used to modulate the major or wider-band chromaticity channel, the modulator input and output filters indicated in Figure 11 can prevent any direct feed of modulator-input signals to modulator-output circuits. In principle, however, the bandwidth of the major chromaticity channel can have any value up to f_s without ill effect, in particular without crosstalk, giving increased fineness of two-color detail that might perceptibly improve color-picture reproduction. Filters alone cannot separate desired modulator output from input, for input bands between $\frac{1}{2}f_s$ and f_s, as may be seen from the spectrum overlap in Figure 13. For such operation, modulators must be balanced against the video input signal, as well as (at the originating terminal) against the subcarrier input itself.

Another sort of flexibility has been available to the receiving-terminal designer since the advent of Figure 10. By limiting the input signal to his modulators to frequencies above $\frac{1}{2}f_s$, with his bandpass filter, he has been able to keep much of the energy in the monochrome signal, normally concentrated near the lower harmonics of the line-scan frequency, from entering these modulators. This results in keeping low the spurious modulator output which has to be removed from the viewer's notice by cancelling interlace. By limiting the monochrome-channel signal, with the aid of a low-pass filter, to frequencies appreciably below subcarrier frequency, he has also been able to prevent most of the incoming chromaticity-channel signal energy, normally concentrated near the subcarrier, from being directly applied to the reproducer. This results in keeping low the subcarrier ripple that must be rendered imperceptible by subtractive interlace, as well as the moiré pattern due to beating of that ripple with reproducer-screen structure.

Thus, the receiver designer can choose for himself the extent to which he wishes to employ interlace cancellation without requiring limitation of the detail transmitted to others. He can, if he wishes, remove almost all flashing of dot-sized areas at one-fourth of field frequency, at the expense of reduction of reproduced detail. It is, in effect, possible to obtain truly simultaneous signals, in monochrome and chromaticity channels, with negligible spurious components.

The symmetrical-sampling type of signal obtained by setting the matrix controls of Figure 11 according to Figure 12 can readily be freed of crosstalk. It is only necessary to use filters passing 0 to 0.4 megacycles in association with originating and receiving cosine modulators, in place of the 0 to 2-megacycle filters indicated in Figure 12. The reproduced-chromaticity locus controlled by the monochrome and wider-band color channels only then becomes quite similar to the orange-cyan axis shown on Figure 3. The monochrome signal departs appreciably from representing subject luminance, and the system lacks the constant-luminance property. This arrangement should, nevertheless, provide decidedly good color reproduction.

A brief review of the steps leading from the original symmetrically-sampled element-sequential system of Figure 6 to the more refined system given by adjusting Figure 11 as above is of interest. Visually unproductive high frequency color-detail signals were first removed by the mixed-high bypass of Figure 9, giving more efficient channel use. A separately controllable monochrome channel was then split off by the change to Figure 10, after which the change to Figure 11 replaced three interdependent color-modulation channels by two independent modulation channels. The last increase in freedom of control permits further discarding of unproductive color detail, by proper choice of filters, to clear up crosstalk and still further increase effectiveness of channel use. Major cumulative improvement in performance has thus been possible with remarkably little change in the basic signal.

Numerous laboratory tests were made by RCA during 1952 on systems using graduated bandwidths to reduce crosstalk. These tests indicated that such systems are much less subject to technical difficulties than was the system using vestigial-sideband CPA. Matching time delays in the various filters of differing band pass proved fairly easy of accomplishment and maintenance. Reduction of green-purple contrast in small picture detail proved, as expected, to cause no readily noticeable deterioration of color reproduction. Reduction of color-screen moiré by filtering the subcarrier region out of the luminance signal applied to the color reproducer was found attractive, even at some cost in fine detail resolution. Improvement due to elimination of crosstalk was impressive, as it had been with CPA. Experiments with two different color-mixture signal compositions showed[17] better results when the major-channel signal corresponded closely with the residual color axis found by Middleton and Holmes,[18] in general agreement with Hartridge.

E. 1953 TO DATE

A crosstalk-free system, using chrominance-channel bandwidths graduated to the needs of vision, was first demonstrated by RCA to panels of NTSC in the summer of 1952. These demonstrations led to activity by NTSC which resulted in a new set of signal specifications on which a new series of field tests were based. These "Revised Specifications for Field Test

[17] R. D. Kell and A. C. Schroeder, "Optimum Utilization of the Radio Frequency Channel for Color Television," to be published in June, 1953, issue of *RCA Review*, attached hereto as Appendix H.

[18] W. E. K. Middleton and M. C. Holmes, "The Apparent Colors of Surfaces of Small Subtense — A Preliminary Report," *Journ. Opt. Soc. of Amer.*, Vol. 39, No. 7, pp. 582-592 (July, 1949).

of NTSC Compatible Color Television," released for publication on February 2, 1953, are reproduced in full as Exhibit 1.

Matrix gain settings and channel bandwidths required to realize the specified signal with the system arrangement of Figure 11 are shown in Figure 15. Again, a check of the settings given will reveal that, for low video frequencies, the red, green, and blue-channel reproducer inputs remain equal, respectively, to the corresponding camera outputs, to give true three-color reproduction. More sudden color changes, for which only single-sideband transmission is available, can be found to be reproduced as chromaticity increments approximately along the desirable orange-cyan line indicated on Figure 3. The monochrome-channel signal is again proportioned to represent approximately subject luminance.

Linearity of the transmission system has so far been assumed throughout this narration. Actually, however, kinescope light-control characteristics are quite non-linear, and allowance for this is necessary. Both sets of NTSC signal specifications make such allowance by requiring compensatory non-linear devices, or gamma-correcting amplifiers, to be interposed directly at the camera outputs of Figure 11. This arrangement gives a signal-to-noise advantage by compressing the dynamic range of the transmitted signal. Because filters and subcarrier sources are present between the gamma com-

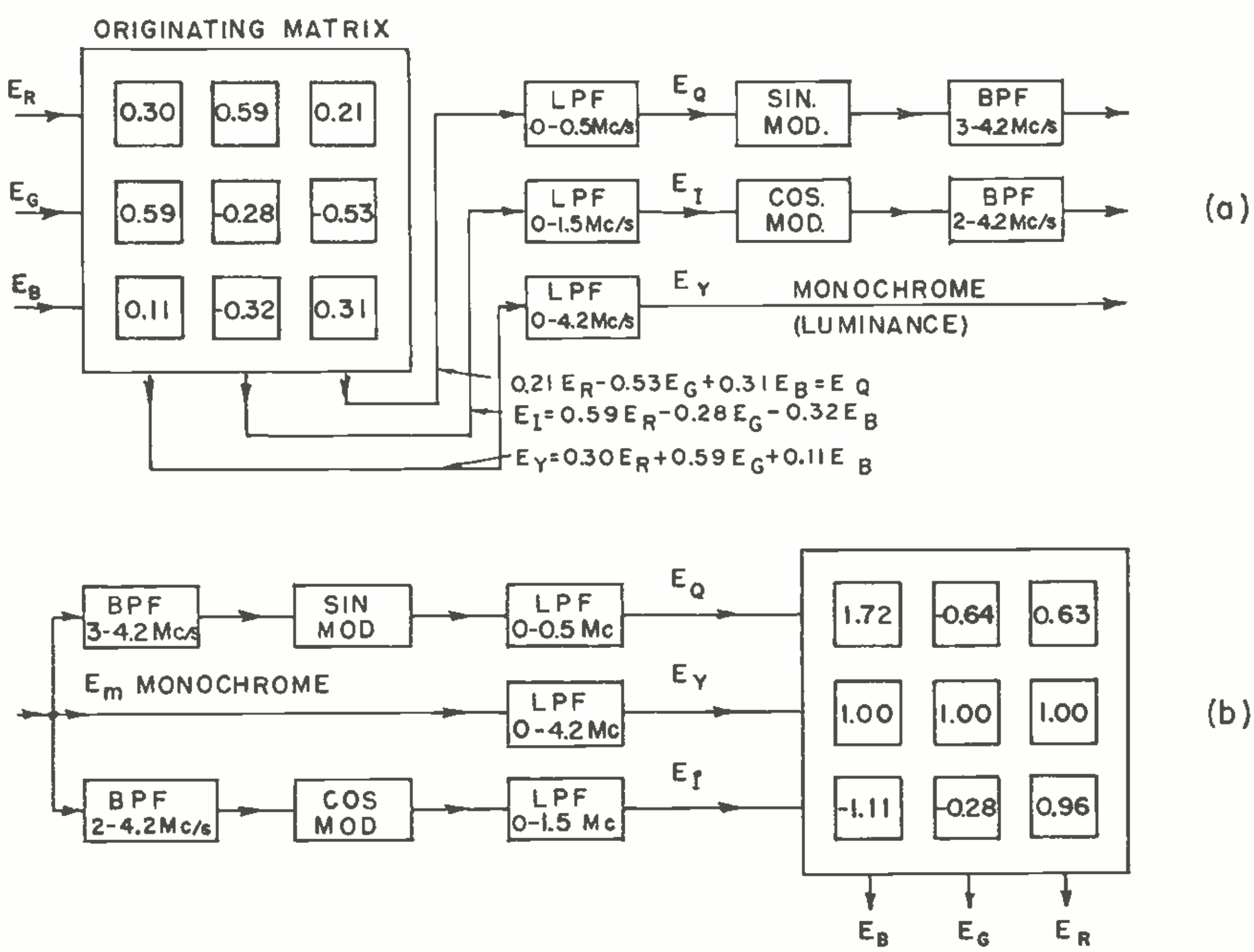

Fig. 15 — Filter pass bands and matrix gain settings for the NTSC signal specifications of February 2, 1953.

pensators and the kinescopes, however, complete compensation of kinescope nonlinearity is not possible in this way. Nor does such an arrangement give properly gamma-corrected black and white tone gradation. Freedom of the designer in applying widely different color cameras or color reproducers is somewhat restricted by this method of compensating for color-kinescope nonlinearity.

Kinescope control characteristics usually approximate a power law. Light output varies as something between the square and the cube of the applied video-signal voltage. Gamma correction therefore requires that the signal output from each gamma amplifier should vary as something between the square root and the cube root of the light input to the camera that feeds it. The overall result is then that each color-kinescope light output varies linearly with the corresponding color-camera light input. Both NTSC signal specifications assume a 2.75-power kinescope-control law, and so require a gamma compensator which will combine with the camera to provide a 0.364-power response law. Gain settings given in Figures 14 and 15 apply with these gamma compensations in place.

Test Specification 11 of NTSC (see Exhibit 1) relates to the trichromatic coefficients of the assumed receiver phosphors. These coefficients enable one to compute the theoretical spectral sensitivities required of the three portions of the color camera.[19] In the embodiment of the camera which uses three separate picture tubes, the spectral sensitivity curves shown in Figure 16 apply to the red, green, and blue tubes together with their respective filters. In practice, the negative responses may be neglected and very good reproduction may still be maintained.

The total video voltage, E_m, corresponding to the scanning of a particular picture element, and applied to the modulator of the radio transmitter, is

$$E_m = E_Y + [E_Q \sin(\omega t + 33°) + E_I \cos(\omega t + 33°)], \quad (1)$$

where

$$E_Y = 0.3\,E_R + 0.59\,E_G + 0.11\,E_B \quad (2)$$

$$E_Q = 0.41\,(E_B - E_Y) + 0.48\,(E_R - E_Y) \quad (3)$$

$$= 0.21\,E_R - 0.52\,E_G + 0.31\,E_B \quad (3a)$$

$$E_I = -\,0.27\,(E_B - E_Y) + 0.74\,(E_R - E_Y) \quad (4)$$

$$= 0.60\,E_R - 0.28\,E_G - 0.32\,E_B. \quad (4a)$$

The voltages E_G, E_R and E_B are signals derived from the green, red and blue signal outputs of the camera, with operations such as gamma-correction

[19] D. W. Epstein, "Colorimetric Analysis of RCA Color Television System," to be published in June, 1953, issue of *RCA Review*, attached hereto as Appendix A.

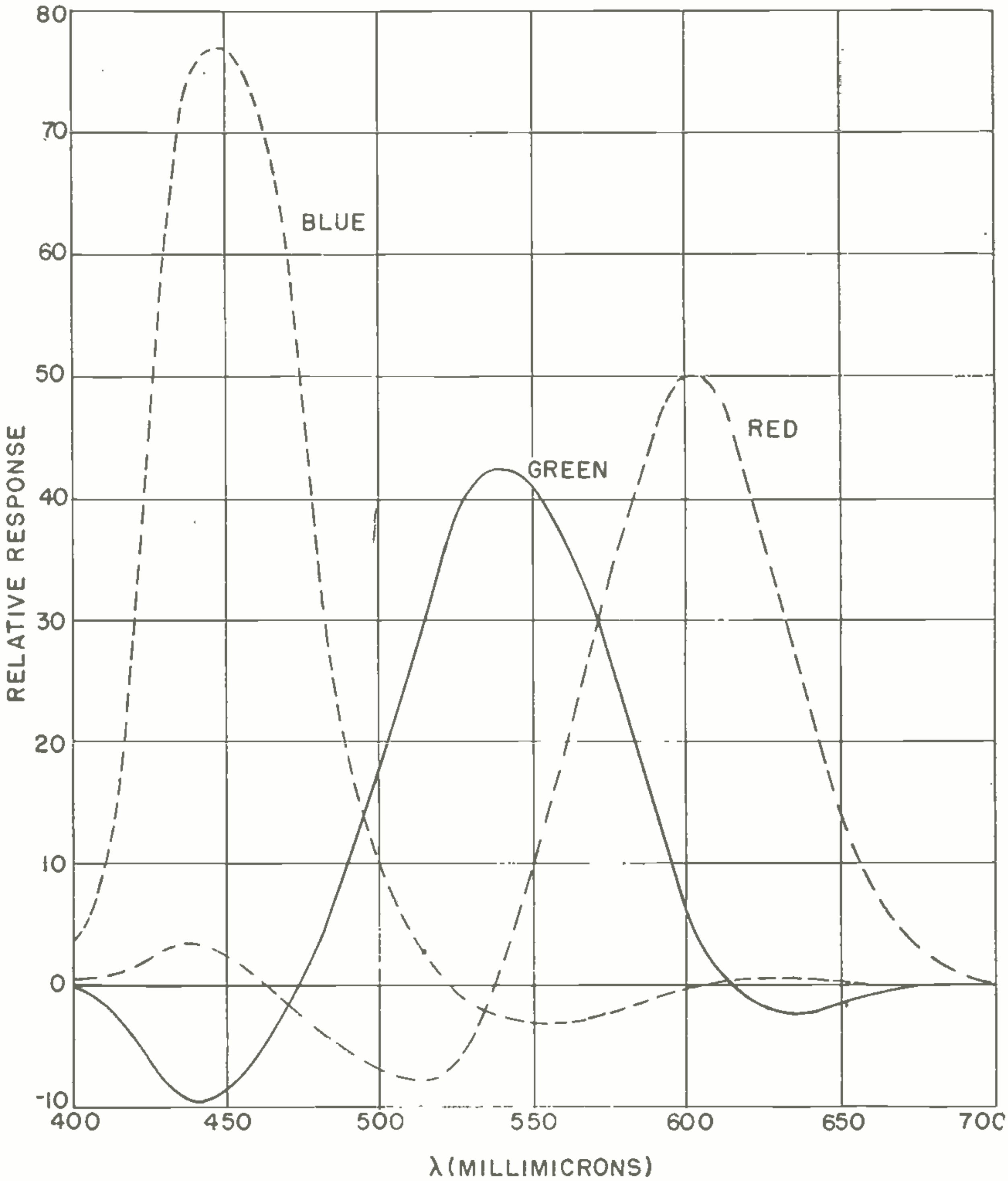

Fig. 16 — Spectral sensitivity curves of the color camera, for the receiver reproducer phosphors having the following chromaticities:

	x	*y*
Red	*0.67*	*0.33*
Green	*0.21*	*0.71*
Blue	*0.14*	*0.08*

performed on the signals before the combinations shown in Equations (1), (2), (3) and (4) are accomplished. These individual voltages may assume values between zero and unity, depending on the hue and intensity of the

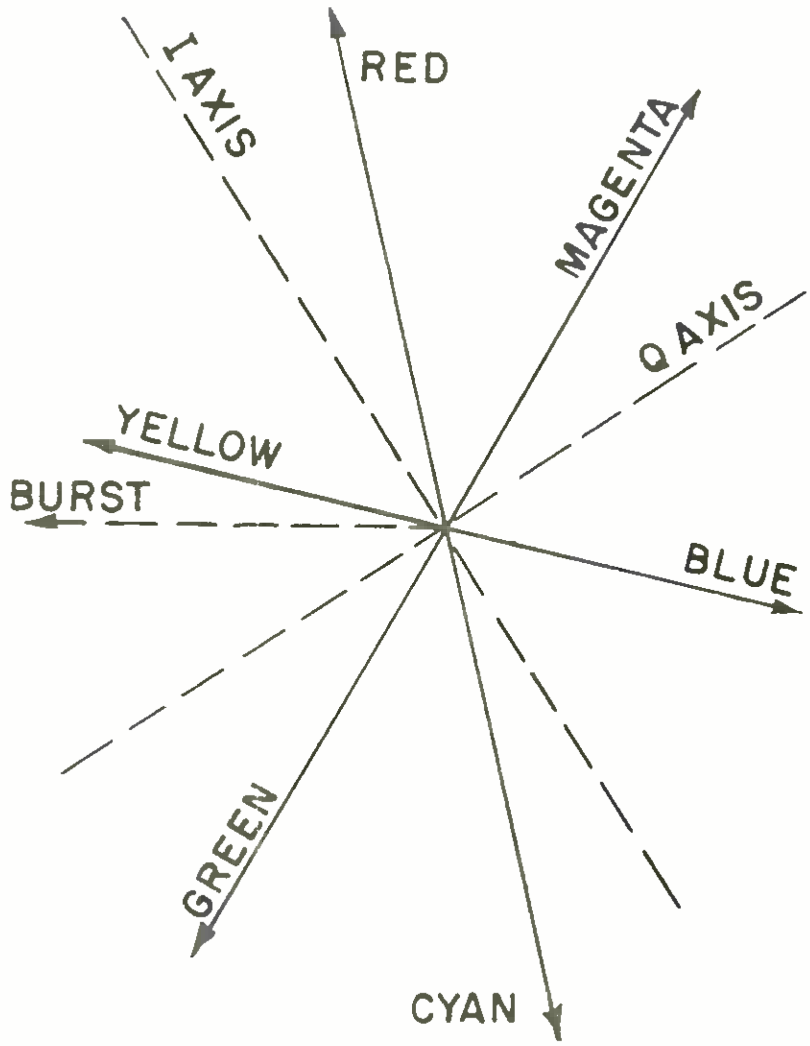

Fig. 17 — Phase and amplitude of the total subcarrier for modulating frequencies less than 500 kilocycles.

light from the area under consideration. Equations (3a) and (4a) define directly the matrix settings of Figure 15a.

Equation (1) shows that the signal contains a main video component E_Y, which Equation (2) shows to be so constructed as to convey only luminance information, and which is capable of producing an excellent black and white picture on a conventional monochrome receiver. The chrominance information is carried on a color subcarrier.

The color signals E_Q and E_I are formed from the camera signals according to Equations (3) and (4), then go through individual low-pass filters whose characteristics are given in Specification (17) before these signals are applied to the encoder to form the signal of Equation (1).

For color signals with frequencies below 500 kilocycles, we may rewrite Equation (1), making use of Equations (2), (3) and (4), and find

$$E_m = E_Y + 0.493\ (E_B - E_Y) \sin \omega t + 0.877\ (E_R - E_Y) \cos \omega t. \qquad (5)$$

Here the signal is expressed in terms of color-difference signals. Figure 17 shows the phase and amplitude of the total subcarrier for the three primary

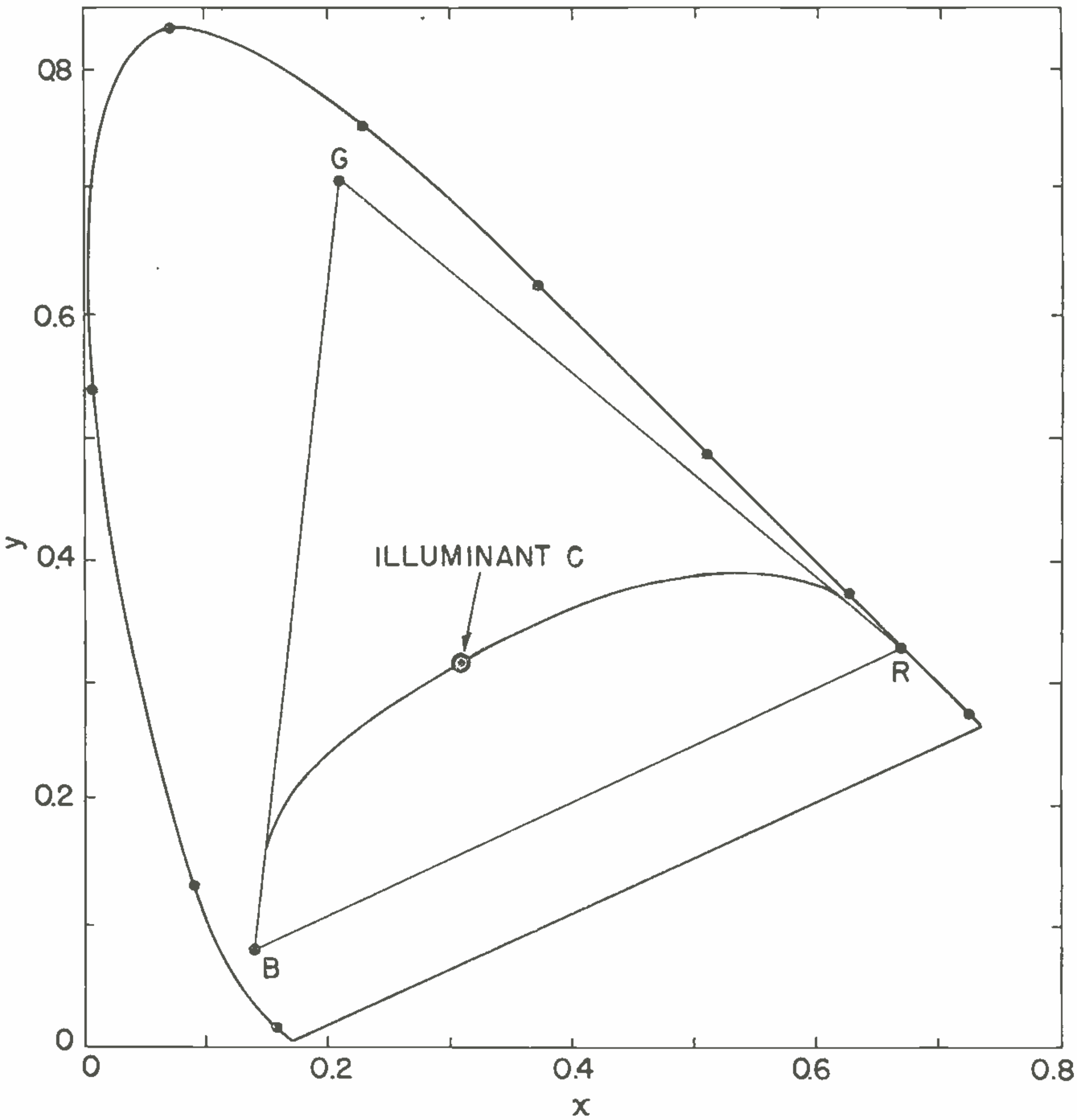

Fig. 18 — Reproduction of color detail for the system of Fig. 15.

(a) Frequencies below 500 kilocycles reproduce colors over the area of the triangle RGB.

(b) Frequencies between 500 kilocycles and 2000 kilocycles produce hues along the curved line.

(c) Color detail at frequencies greater than 2000 kilocycles reproduce in monochrome (Illuminant C).

colors, as well as their complements, where the color signals are varying at a frequency less than 500 kilocycles.

When the frequencies of the original color-video signals are well above 500 kilocycles, the first subcarrier term in Equation (1) may be dropped, and the final-term signal due to any single-frequency video component of amplitude E_i, phase ϕ and frequency f_i (angular frequency β) becomes

$$E_m = E_Y - \frac{1}{2} E_i \sin\left[(\omega - \beta)t + 33^\circ - \phi\right]. \quad (6)$$

The signal specification, making use of the *I* and *Q* filters of dissimilar bandwidths, makes possible the reproduction of color detail in three ways, illustrated by Figure 18:

1. Color detail which produces signals of frequency less than 500 kilocycles is reproduced accurately over the entire area enclosed by the triangle *RGB*.
2. Color detail which produces signals of frequency greater than 500 kilocycles and less than 2000 kilocycles is reproduced in hues which lie along the curved line shown on Figure 18. Curvature of this color locus is the result of the amplitude nonlinearity of the gamma correctors and kinescopes.
3. Color detail which produces signals of frequency greater than 2000 kilocycles is reproduced in monochrome (the point on Figure 18 representing Illuminant C), thus making use of the principle of mixed highs.

Field tests by RCA have shown that a modulated-subcarrier color system, using picture-element interlace to reduce permissible picture-repetition frequency by half, and using two different color-mixture channel bandwidths to meet fully the needs of color vision, while avoiding transmission difficulties, gives color-reproduction quality adequate to warrant adoption of such a system.

PART V

Conclusion

We have discussed RCA work which has been directed toward achieving an adequate, compatible color system and a suitable set of signal specifications. It is important that any set of specifications adopted as standards be neither circumscribed by present-day equipment limitations, nor unnecessarily restrictive, so that the fruits of research and invention may result in more stable performance, better pictures and simpler equipment both at the transmitter and receiver. That is to say, the ceiling performance of the system must be sufficiently high to insure continued equipment improvement without a collision with restrictive standards.

It is of course difficult to disengage entirely the signal specifications from equipment development, since it is the equipment available at the moment which must be used to test the concepts which bring about the growth of the system. Thus the systems engineer must be guided by practicalities which his engineering judgment tells him will not be easily overcome, perhaps for economic or physical reasons, and at the same time he must be able to envisage possible solutions to present obstacles even though the details of the solutions are not apparent at the present time.

It is believed that the signal specifications released by the NTSC on February 2, 1953, will provide a sound basis for adequate service with presently available equipment, and at the same time will allow for continued equipment development and improvement within the proposed standards.

APPENDIX A

COLORIMETRIC ANALYSIS OF RCA COLOR TELEVISION SYSTEM*

By

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Summary—The objective of color television is the reproduction on the viewing screen of the receiver of not only the relative luminances (brightness) but also the chromaticities (hues and saturations) of the details in the original scene. Colorimetry, the science of color measurement and specification, is of great importance to the color television engineer, since it is with the aid of the principles of colorimetry that he is able to determine quantitatively the characteristics of reproducton and to accumulate engineering data for the constant improvement of the reproduction.

The purpose of this paper is to present an analysis of the colorimetric capabilities of the RCA Color Television System. Since some of the readers may not be well versed in colorimetry, the first section will be devoted to an introduction to the subject. This is followed by a section describing the ideal requirements for perfect reproduction and an analysis of the fidelity of reproduction when ideal requirements are not fulfilled.

Colorimetry

The object of colorimetry is the unique quantitative specification of color. The difficulties in attaining this objective stem from the fact that color involves both physical and psychological factors. It is important to differentiate between the physical color stimulus and the psychological color sensation. Three attributes may be recognized in the color sensation. These are: (1) hue, which is described by terms red, violet, green, etc., (2) degree of saturation, which is implied by the use of such vague terms as pastel, pale, deep, etc., and (3) brightness. These psychological concepts serve to supply names to visual sensation, but since sensations are not measurable, they have very little quantitative significance. Purely physical concepts concentrate on the radiant power and its spectral distribution as the stimulus for the sensation of color. These might specify color by a spectroradiometric curve giving the watts per millimicron as a function of wavelength. It is found, however, that there is an infinite number of spectroradiometric curves for all of which the same color sensation is produced. Thus the purely physical concepts do not yield a system of colorimetry. The system of colorimetry widely used at present is based upon the relationships which have been discovered between physical stimuli and the sensory or perceptual aspects of these stimuli.

Although the normal human visual mechanism is unsuitable for measuring, it can be considered as a satisfactory null instrument. It is this property of vision that is utilized in colorimetry. Thus any color stimulus may be specified by finding a known second stimulus which is equivalent to it. In modern colorim-

* To be published in June, 1953, issue of *RCA Review*.

etry, the second stimulus is taken as a combination of three known stimuli. These three are called primary stimuli (usually taken as red, green, and blue lights), and the specification consists of giving the amounts of each primary stimulus required for matching. This is known as the *tristimulus* system of colorimetry or color specification.

Most colors can be matched by a proper additive mixture of three suitably chosen primary colors, in which case the amounts of the primaries are recorded as positive quantities and constitute the specifications of the unknown color. However, some colors cannot be matched with such an additive mixture, and it is then necessary to establish a match between a mixture of the unknown color with one of the primaries and a mixture of the other two primaries. In this case, the amount of the primary mixed with the unknown color is considered as a negative quantity. There may be some instances when it is necessary, in order to establish a match, to mix two of the primary colors with the unknown color and match this mixture with the remaining primary. In this case, the quantities of the two primaries mixed with the unknown would be considered as negative quantities. *All* colors can be matched with *any* three primaries if negative quantities are included. In practice, the three color primaries are usually chosen to minimize the occurrence of negative quantities. There is a

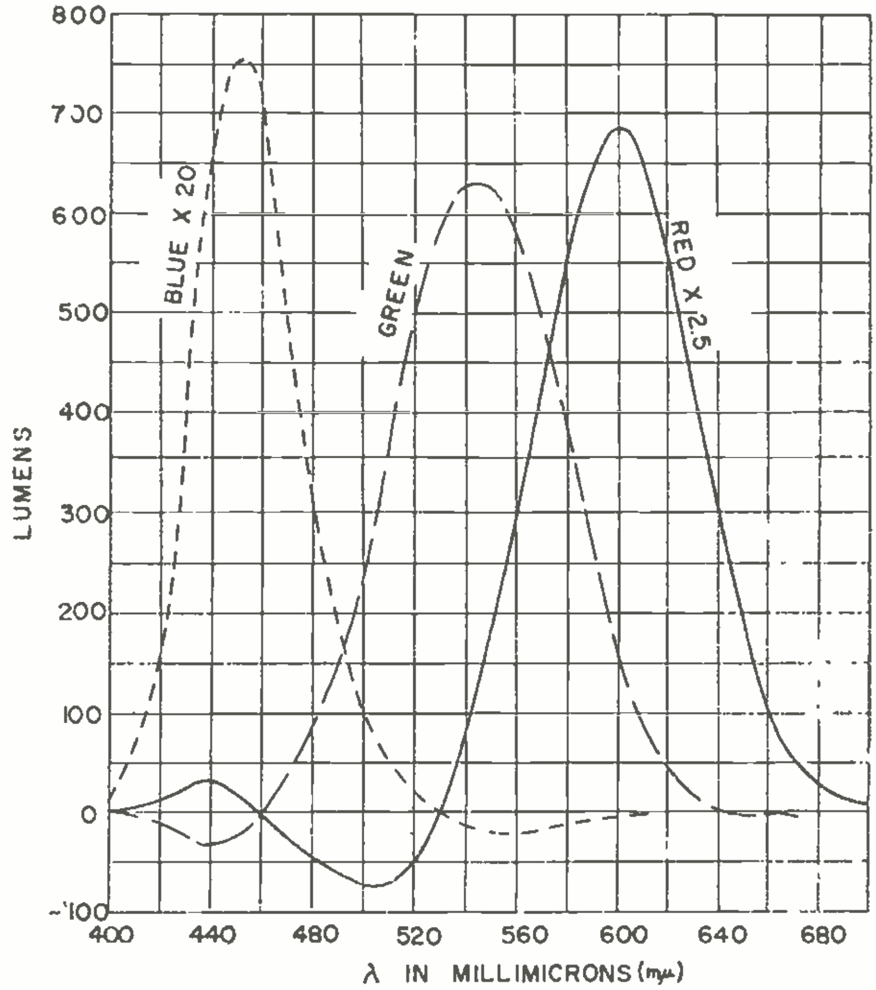

Fig. 1—Color mixture curves giving the number of lumens of three monochromatic primaries (Red—650 mμ, Green—530mμ, Blue—460mμ) required to match one watt of radiant power having indicated wavelength. Based on data obtained by W. D. Wright.[1]

[1] W. D. Wright, *Trans. Opt. Soc.*, Vol. 31, p. 201 (1929-1930).

prevalent impression that there is something unique about primary colors. Actual experiment shows, however, that an infinite number of sets of primaries can be used for color matching and the only requirements of primary stimuli are that no two primaries shall be the same and that no combination of two shall be capable of matching the third.

In the tristimulus system of colorimetry, the specification of a color stimulus made up of the sum of any number of component stimuli is obtained by merely adding together the specifications of the components. Thus, if (R_1, G_1, B_1) are the specified amounts of red, green, and blue equivalent to one color stimulus, (R_2, G_2, B_2) are the specified amounts of red, green, and blue equivalent to a second color stimulus, and (R_3, G_3, B_3) those equivalent to a third color stimulus, then the specification of the stimulus obtained by superimposing these three stimuli is $(R_1 + R_2 + R_3)$, $(G_1 + G_2 + G_3)$, $(B_1 + B_2 + B_3)$. As a result of this, it is possible to *compute* all equivalent stimuli for an observer from his tristimulus specifications of the spectrum colors (a spectrum color is the color of light comprising only a very narrow range of wavelengths) because any stimulus may be considered as the sum of a number of spectrum stimuli. A set of curves which gives tristimulus specifications of the spectrum for any observer is called color-mixture curves.

Figure 1 shows a set of curves, obtained experimentally, which represents the average color-mixture data of a number of normal observers. The color-mixture curves of Figure 1 give the amounts of three monochromatic primaries needed to match all the spectrum colors. If other primaries had been used, a different set of curves would have been obtained. Since there is nothing unique about any set of primaries, one set of curves obtained with one set of primaries must be transformable into any other set of color-mixture curves obtained with other primaries if the data is to have any general significance. This is the case, and all color-mixture curves for any observer can be computed from any one set of color-mixture curves for that observer.

The color-mixture curves corresponding to any possible set of real primaries require negative values of some wavelengths. For convenience of computation, the International Commission on Illumination (CIE) standardized in 1931 on the set of color-mixture data shown graphically in Figure 2 and tabulated in Table I. These curves can be considered as based on fictitious primaries which cannot be actually obtained, but which serve to eliminate negative values. They were derived, by a suitable transformation, from experimental color-mixture curves such as shown in Figure 1.

The observer for whom the standard mixture curves apply is called the standard observer. The use of actual observers equivalent to the standard observer for the direct visual determination of standard colorimetric specification is impractical. As a result, an indirect method of colorimetry is generally used. This consists of the computation of standard colorimetric specification from the standard color mixture data (Figure 2) and spectroradiometric data.

Specifications computed by indirect colorimetry permit the classification of ordinary colors in a manner corresponding quite closely to the appearance of the colors for over 90 per cent of the population.

The three tristimulus values of any sample of light are the relative amounts of the three CIE standard (fictitious) primaries which when added would match the sample. Two color stimuli are considered identical if they have identical tristimulus specification. The ordinates of the standard CIE color-mixture curves $\bar{x}$, $\bar{y}$, $\bar{z}$, at any wavelength give the tristimulus values of a spectrum color at that wavelength. For example, the tristimulus values of green light of wavelength 520 millimicrons are

$$\bar{x} = 0.0633,\ \bar{y} = 0.7100,\ \bar{z} = 0.0782.$$

In order to present these numbers graphically on a two-dimensional drawing, the quantities

$$x = \frac{\bar{x}}{\bar{x} + \bar{y} + \bar{z}},$$

$$y = \frac{\bar{y}}{\bar{x} + \bar{y} + \bar{z}},$$

$$z = \frac{\bar{z}}{\bar{x} + \bar{y} + \bar{z}},$$

are defined so that $x + y + z = 1$ and therefore any two of these quantities are sufficient to specify a chromaticity. Thus the chromaticity of the spectrum color just considered may be represented in a two-dimensional rectangular coordinate system by a point whose coordinates are,

$$x = \frac{0.0633}{.8515} = 0.0743,$$

$$y = \frac{0.7100}{.8515} = 0.8338.$$

If, using Figure 2, the same procedure is followed for all spectrum colors, and the values of x and y so obtained are plotted, the horseshoe-shaped curve shown in Figure 3 is obtained. The coordinates x and y are known as the *trichromatic coefficients,* the diagram is known at the *chromaticity diagram,* and the curve is known as the *spectrum locus.* The measurement of color may be divided into two general problems: (1) the measurement of luminance (brightness), and (2) the measurement of chromaticity. Each point in the chromaticity diagram of Figure 3 specifies the chromaticity of a color independent of its luminance. The complete domain of all realizable colors is within the horseshoe-shaped curve of the spectrum locus and the straight line that joins the violet and red extremities of the spectrum locus. The CIE standard primaries or stimuli are represented by the point $x = 0$, $y = 1$ for the "green" and primary, $x = 0$, $y = 0$ for the "blue" primary, and $x = 1$, $y = 0$ for the "red" primary. As may be seen

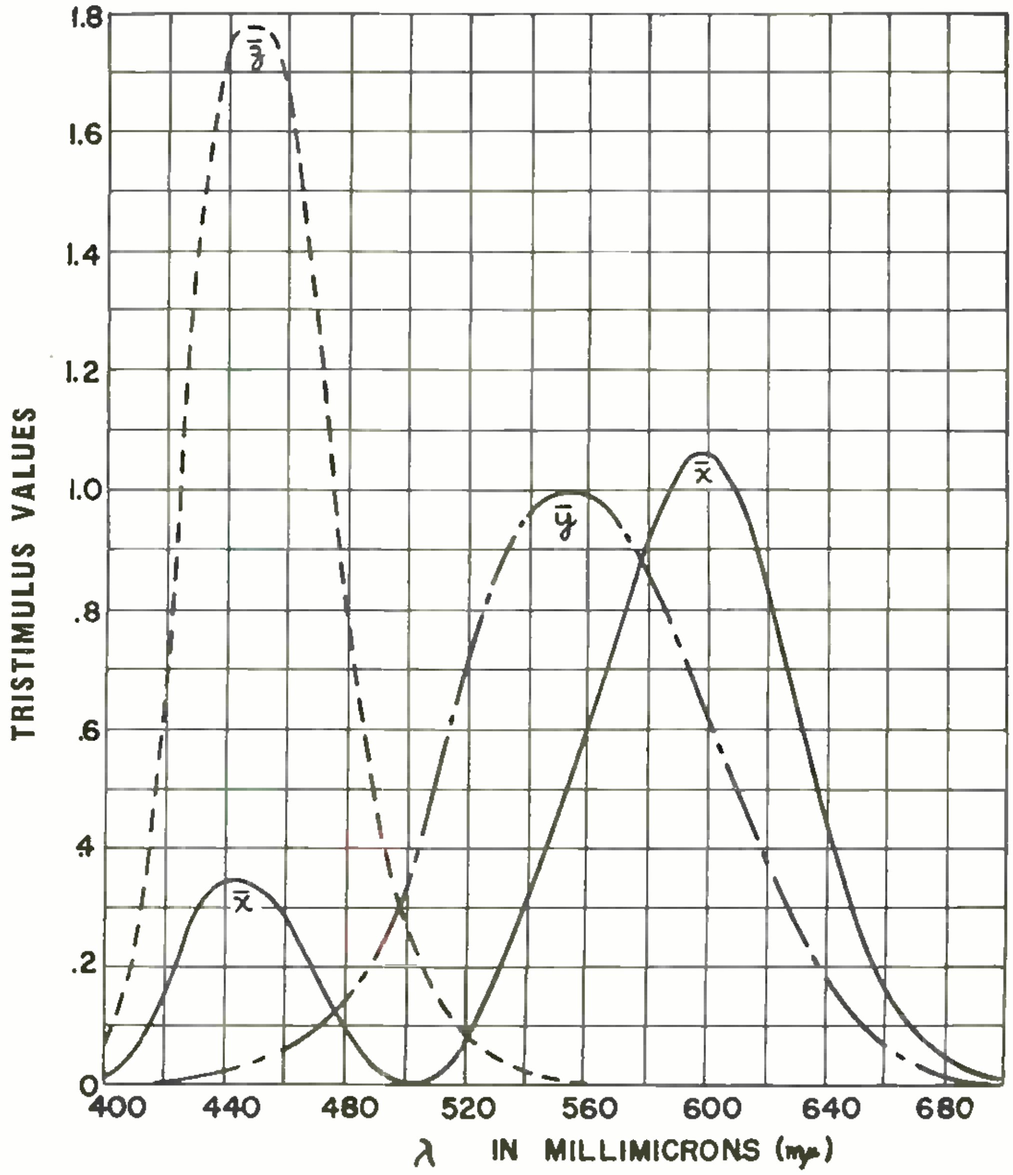

Fig. 2—Standard CIE color-mixture curves giving amounts of the three CIE primaries required to color match a unit amount of radiant power having the indicated wavelength.

from the chromaticity diagram of Figure 3, these primaries lie outside the domain of realizable colors.

The three tristimulus values of any sample of radiant energy are given by

$$X = \int_{\lambda = 380\ m\mu}^{\lambda = 780\ m\mu} \bar{x}(\lambda)\ f(\lambda)\ d\lambda,$$

$$Y = \int_{\lambda = 380\ m\mu}^{\lambda = 780\ m\mu} \bar{y}(\lambda)\ f(\lambda)\ d\lambda,$$

$$Z = \int_{\lambda = 380\ m\mu}^{\lambda = 780\ m\mu} \bar{z}(\lambda)\ f(\lambda)\ d\lambda,$$

where $f(\lambda)$ is the spectral distribution of the sample of light. The above integration is generally carried out by the ordinary methods of numerical integration such as

$$X = \sum_{\lambda = 400\, m\mu}^{\lambda = 700\, m\mu} \bar{x}(\lambda)\, f(\lambda)\Delta\lambda$$

$$= \bar{x}(\lambda_1)\, f(\lambda_1)\Delta\lambda + \bar{x}(\lambda_2)\, f(\lambda_2)\Delta\lambda + \cdots + \bar{x}(\lambda_n)\, f(\lambda_n)\Delta\lambda,$$

where $\lambda_1 = 400\, m\mu,$
$\lambda_n = 700\, m\mu,$
$\Delta\lambda = 10\, m\mu.$

The trichromatic coefficients are then obtained as,

$$x = \frac{X}{X+Y+Z},$$

$$y = \frac{Y}{X+Y+Z},$$

$$z = \frac{Z}{X+Y+Z},$$

and the coefficients x and y are then plotted on the chromaticity diagram. Thus the point representing the chromaticity of white light from a source radiating an equal amount of energy throughout the spectrum has the coordinates $x = .3333$, $y = .3333$ and is represented by the point E in Figure 3.

Because the tristimulus values of a *mixture* of several varieties of light are the sums of the corresponding tristimulus values of the components of the mixture, the point representing the chromaticity of a mixture of two components is located on the straight line connecting the points representing the chromaticities of the separate components. Similarly, the chromaticity of a mixture of three components, whose points on the chromaticity diagram are not colinear, is located at a point within the triangular area obtained by connecting the three points. It may be seen from Figure 3 that, since the domain of all realizable color is within the area of the color triangle obtained by connecting the three points representing the CIE primaries, any realizable color will be "matched" with positive amounts of the three CIE primaries. As mentioned before, this is one of the reasons why these primaries were standardized.

If the trichromatic coefficients of a color are known, the coefficients of possible combining colors capable of producing a match can be deduced by drawing a straight line of arbitrary length, within the area of real colors, in an arbitrary direction through the given point. Any point on this line to one side of the given point represents a color capable of being combined with any color represented by a point on the other side to produce a match with the original color. This leads to another procedure of specifying chromaticity of a color, i.e., by giv-

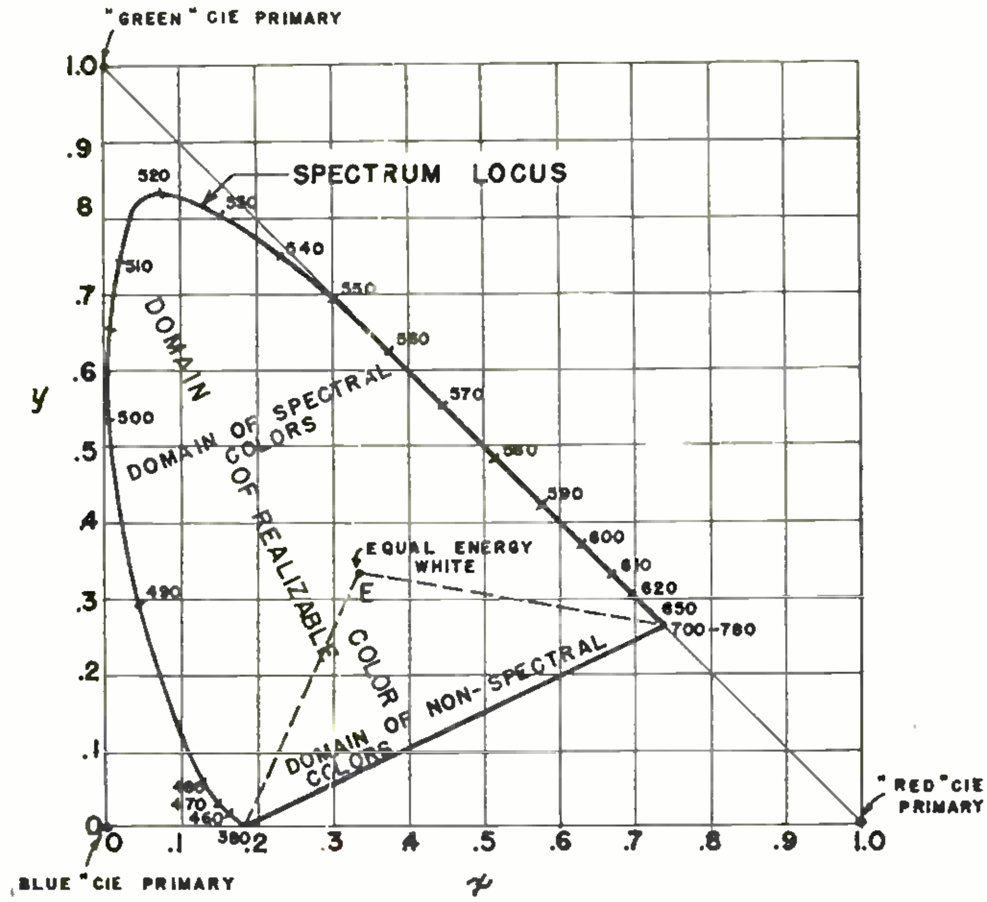

Fig. 3—CIE chromaticity diagram.

ing its dominant wavelength and purity. The dominant wavelength of a sample is the wavelength of the monochromatic light which would have to be mixed with a suitable amount of achromatic or white light in order to match the chromaticity of the sample. The purity gives the proportion of the spectrally pure component in the mixture matching the chromaticity of the sample. Dominant wavelength and purity correspond approximately to the attributes of hue and saturation respectively of the color sensation. Thus the chromaticity of a mixture of white light represented by E and the spectrum color of 520 millimicrons wavelength ($m\mu$) (see Figure 3) must be represented somewhere on the straight line between E and 520 $m\mu$. The less the proportion of the spectrum component 520 $m\mu$ present in the mixture, the closer is the chromaticity of the mixture to point E. Impure colors such as those perceived as pastel or pale are represented by points near the chromaticity representing white light. Purer colors are represented by points more remote from E, approaching the spectrum locus. Colors represented by points on the spectrum locus are called spectrum colors even though, in some cases, the stimulus is not radiant energy confined to one small wavelength interval.

It should be noted that dominant wavelength and purity, as defined above, can only be used to specify the chromaticity of those colors indicated as the domain of spectral colors in Figure 3. In the domain of nonspectral colors (the purples) chromaticity is specified by complementary wavelength and purity. The complementary wavelength is determined by extending a straight line from the sample point through the achromatic or "white" point until it intersects the spectrum locus. The purity is determined by the distance of the sample point from the "white" point.

The specification of dominant wavelength and purity depends upon the point in the chromaticity diagram considered as white. Thus it is possible for a given point on the chromaticity diagram to be specified by a dominant wavelength of 583 $m\mu$ (orange) when referred to sunlight "white" or by a dominant wavelength of 484 $m\mu$ (blue) when referred to incandescent "white".

Color Reproduction

The RCA color television system can be described from the colorimetric point of view as an additive three-color reproducing system. It is so called because the reproduced colors are the results of the addition of three colored lights emitted by the three phosphors of the picture reproducer.

It was shown in the preceding section on colorimetry that the gamut of colors that may be produced have chromaticities which lie within the color triangle whose apexes represent the receiver primaries. It can be seen from Figure 3 that it is impossible to choose three real primaries, i.e., primaries located on or within the horseshoe-shaped curve, such that the entire domain of realizable colors may be produced.

The choice of primaries in the RCA color television system is dictated essentially by the purely colorimetric considerations of phosphor spectral characteristic and efficiency, since flicker and phosphor decay characteristics play no more important roles than they do in black-and-white. This provides a wide latitude in the choice of phosphors for use as receiver primaries, and as a result a large color triangle can be obtained. The spectral distributions of a blue-emitting silicate phosphor, green-emitting silicate phosphor and red-emitting silicate phosphor are shown in Figure 4. The spectral distributon of the light output of red,

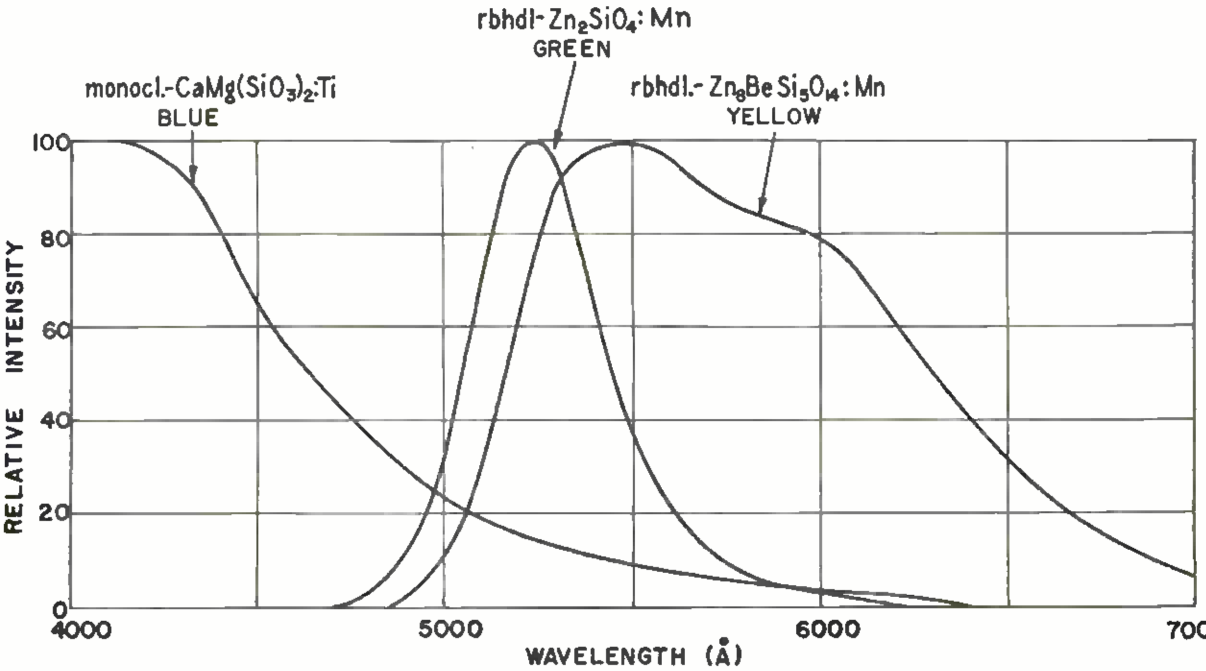

Fig. 4—Spectral characteristics of red, green, and blue silicate phosphors. At the present time (1953), ZnS:Ag is being used as the blue phosphor, and $Zn_3(PO_4)_2$:Mn as the red phosphor in tricolor kinescopes.

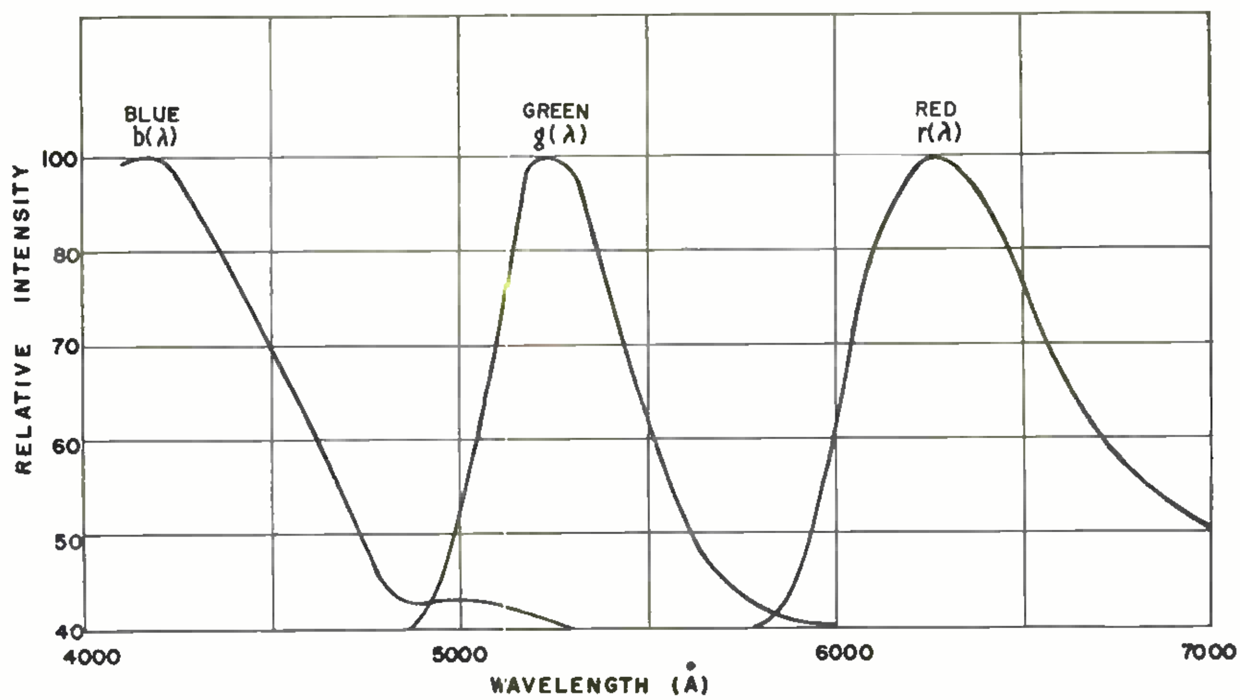

Fig. 5—Spectral characteristics of Red, Green, and Blue kinescopes (receiver primaries) plus dichroics and red filter.

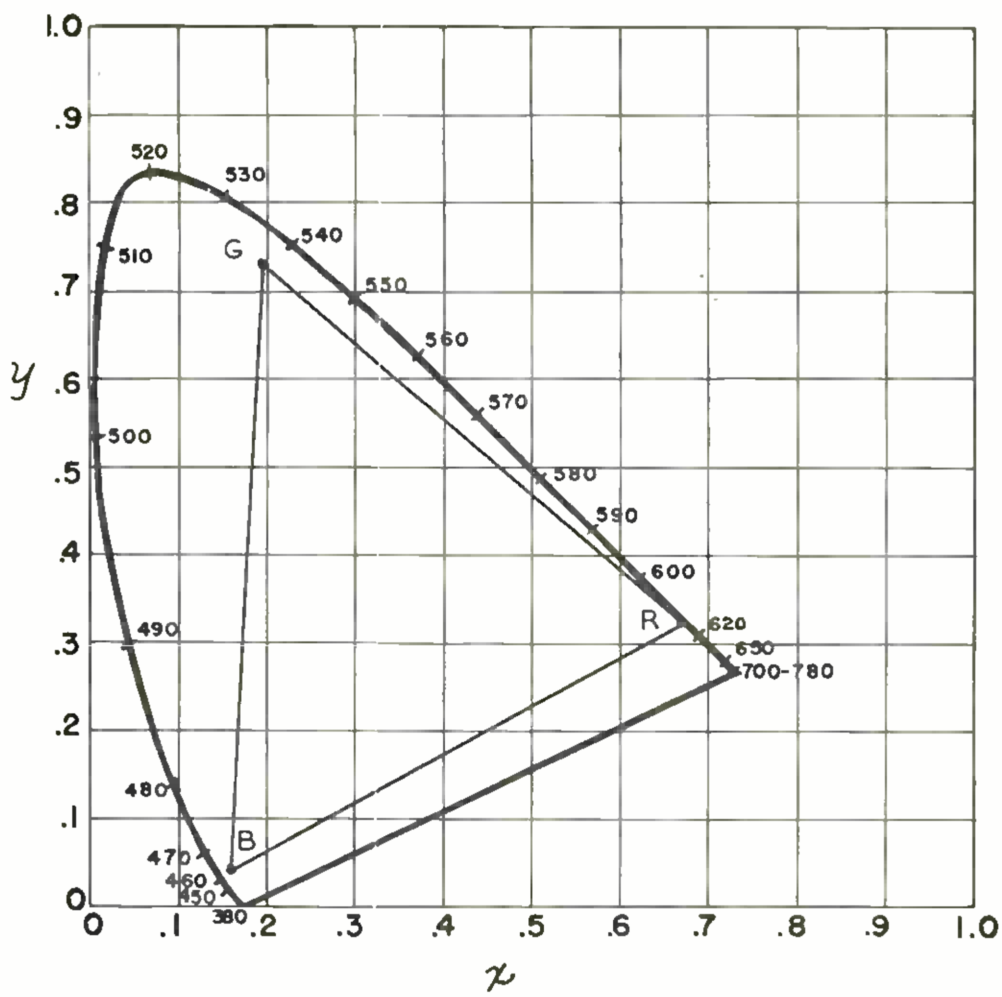

Fig. 6—CIE chromaticity diagram showing location of receiver primaries R, G, B, and color triangle of receiver. These primaries are only slightly different from those adopted by the NTSC February 2, 1953.

green and blue tubes as modified by dichroic filters and a red filter over the red tube is shown in Figure 5. These curves are the spectral distribution of the primaries at RCA direct-view color receivers used in the 1949-1950 period. The chromaticities[2] of these primaries and the color triangle which they determine are shown in Figure 6. The gamut of colors that it is possible to produce with these primaries compares very favorably with that obtained with the best processes of color reproduction, and is much superior to that which can be produced by such commercial processes as color printing.

The fact that all colors within the triangle of the receiver primaries can be *produced*, does not mean that these colors can be reproduced faithfully. For good color reproduction, it is necessary that the tristimulus values or trichromatic coefficients of the subject and reproduction be the same. In order to reproduce faithfully all those chromaticities of the original scene which lie within the color triangle of the receiver primaries, it is necessary to control properly the relative amounts of the primaries at every point of reproduction. This imposes special requirements on the three spectral sensitivity curves that are used in the camera for making the trichromatic analysis of the original scene. By imposing the condition that the tristimulus values of original and reproduced scene be identical, the theoretically correct spectral sensitivities of the camera may be deduced. The equations (derived in Attachment 2) giving the ideal camera spectral sensitivities are:

$$A_r = (y_g z_b - y_b z_g)\,\bar{x} + (x_b z_g - x_g z_b)\,\bar{y} + (x_g y_b - x_b y_g)\,\bar{z},$$

$$A_g = (y_b z_r - y_r z_b)\,\bar{x} + (x_r z_b - x_b z_r)\,\bar{y} + (x_b y_r - x_r y_b)\,\bar{z},$$

$$A_b = (y_r z_g - y_g z_r)\,\bar{x} + (x_g z_r - x_r z_g)\,\bar{y} + (x_r y_g - x_g y_r)\,\bar{z},$$

where A_r, A_g, and A_b represent the spectral sensitivities of the red, green, and blue pick-up tubes together with their respective filters, $\bar{x}$, $\bar{y}$, and $\bar{z}$ represent the color mixture functions of the CIE standard observer (Figure 2 or Table I) and (x_r, y_r, z_r), (x_g, x_g, z_g) and (x_b, y_b, z_b) represent the trichromatic coefficients of the red, green, and blue primaries of the receiver. Figure 7 shows graphically the theoretical camera sensitivities required with the receiver primaries shown in Figure 6. Figure 8 shows another set of theoretical camera sensitivities computed for primaries which form a smaller triangle. It can be seen from Figures 7 and 8 that the theoretically required camera spectral sensitivity curves have regions where the sensitivity is negative. It can also be surmised from Figures 7 and 8 that:

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[2] The tristimulus values of the primaries were determined by forming the sums

$$X_r = \sum r(\lambda)\,\bar{x}\,\Delta\lambda \qquad Y_g = \sum g(\lambda)\,\bar{y}\,\Delta\lambda \qquad Z_b = \sum b(\lambda)\,\bar{z}\,\Delta\lambda, \text{ etc.}$$

$$\Delta\lambda = 10 \text{ m}\mu$$

where $r(\lambda)$, $g(\lambda)$ and $b(\lambda)$ are shown in Figure 5, $\bar{x}$, $\bar{y}$, $\bar{z}$ are shown in Figure 2, and finally obtaining the trichromatic coefficients:

$$x_r = \frac{X_r}{X_r + Y_r + Z_r} \qquad y_r = \frac{Y_r}{X_r + Y_r + Z_r}, \text{ etc.}$$

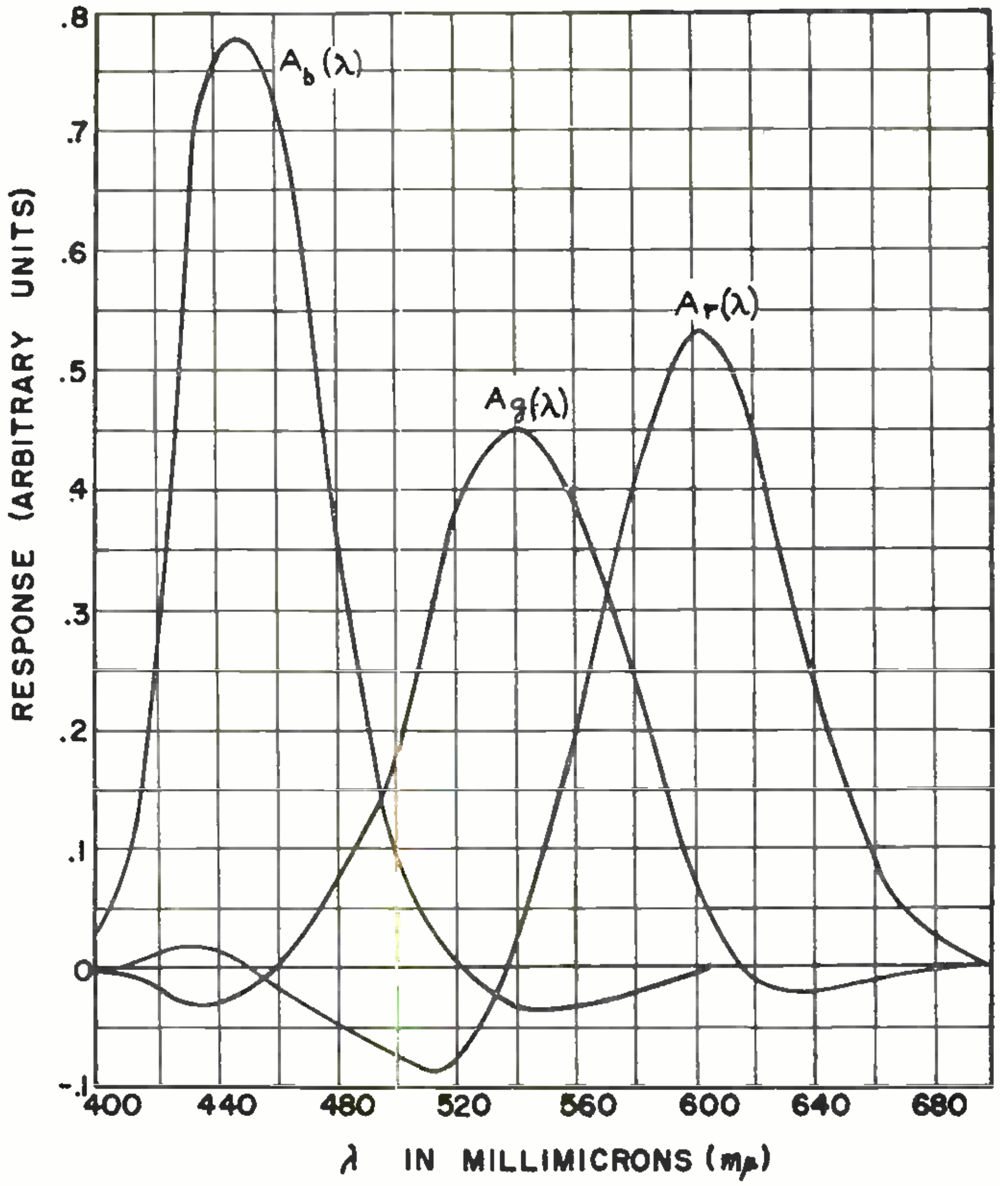

Fig. 7—Theoretical camera spectral sensitivities required with receiver of Figure 6.

(1) The negative portions of the curves depend rather critically on the choice of receiver primaries.

(2) The positive portions may vary only slightly for a wide choice of receiver primaries.

The negative portions of these sensitivity curves correspond approximately in magnitude and spectral location to the areas and locations of the portions of the chromaticity diagram lying within the spectrum locus but outside of the color triangle of the receiver. As a result, the ratio of the areas of negative response to those of positive response is smaller the larger the color triangle of the receiver. This is another reason for choosing receiver primaries which form a large triangle.

Because of the regions of negative response, the attainment, in general, of the theoretically correct camera spectral sensitivities is very difficult,* and an investigation was undertaken to determine the effect on the fidelity of reproduc-

* See Attachment 3.

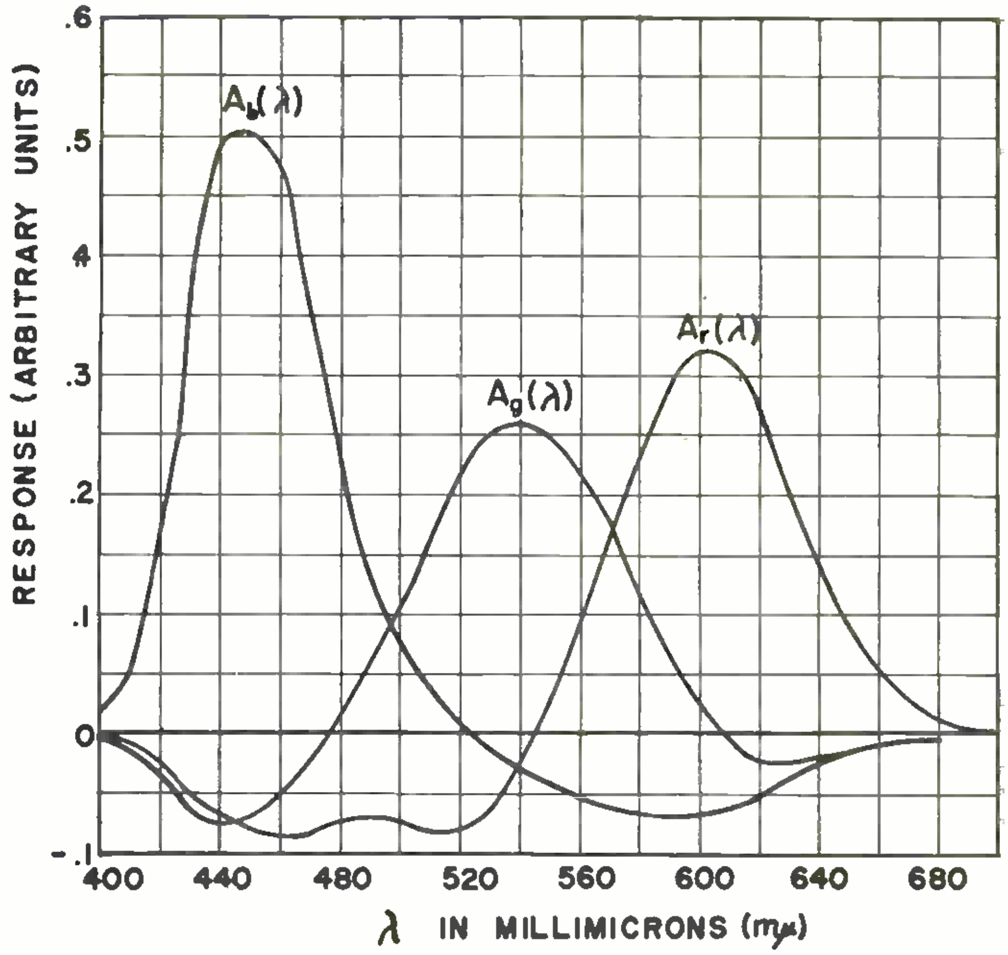

Fig. 8—Theoretical camera spectral sensitivities required with a receiver having primaries

$$x_r = .575,\ y_r = .305,\ z_r = .120,$$
$$x_g = .260,\ y_g = .650,\ z_g = .090,$$
$$x_b = .235,\ y_b = .150,\ z_b = .615.$$

tion of various camera spectral sensitivities which are positive throughout the spectrum.

Any departure from the ideal camera spectral sensitivities results in some lack of fidelity. The degree of reduction in fidelity depends upon:

(1) The receiver primaries.

(2) The degree of departure of the actual camera spectral sensitivities from the ideal.

(3) The "white" chosen to be reproduced exactly.

(4) The chromaticity and spectral distribution of the color to be reproduced.

The computations were carried out on the basis that nonlinearity, crosstalk, noise, etc. have negligible effect, and for the following set of conditions:

(1) One set of receiver primaries, shown in Figure 6.

(2) Four sets of camera spectral sensitivities shown on Figures 9, 10, 11 and 12.

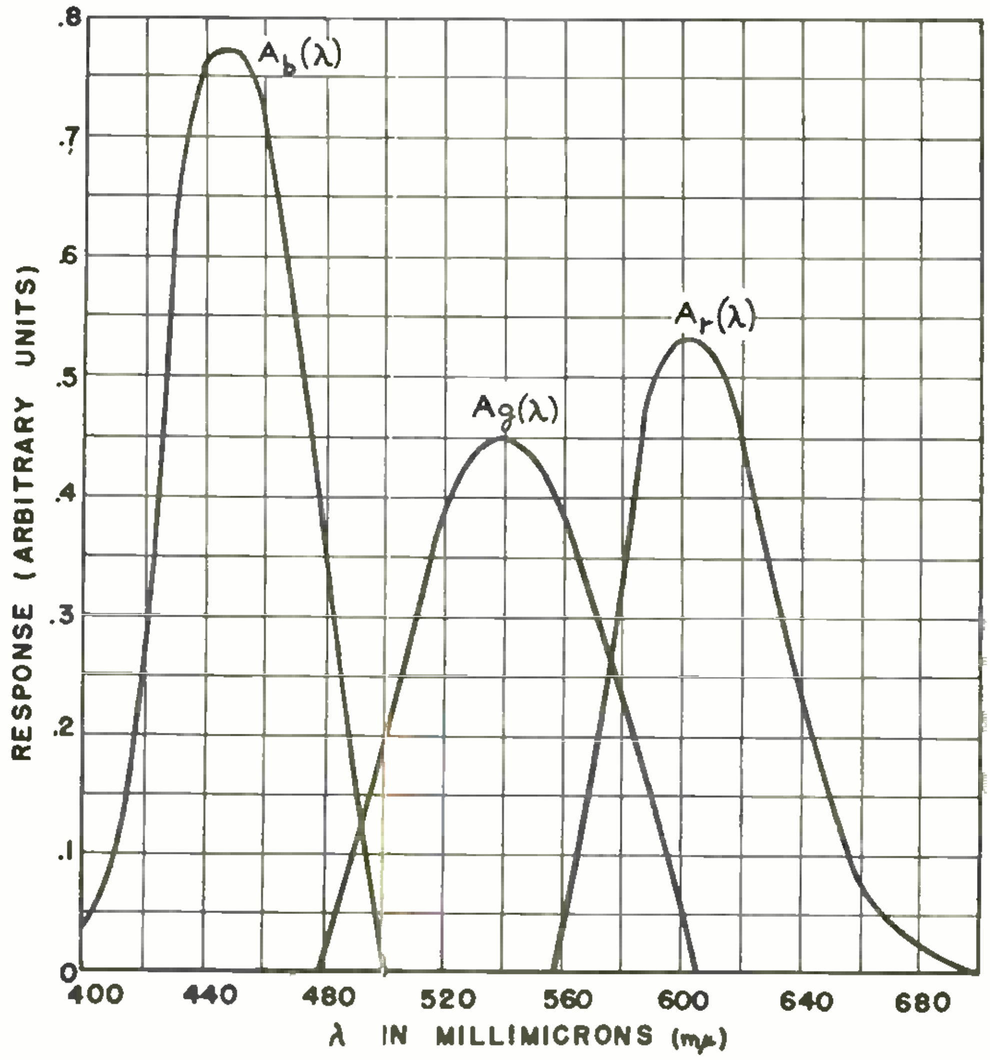

Fig. 9—Camera spectral sensitivities having only regions of positive response adjusted so that the areas under the curves are equal to those of Figure 7.

(3) Three "whites", selected for accurate reproduction—these correspond to the appearance of a white card illuminated by,

(a) Sunlight (approximated by an equal energy spectrum).

(b) Daylight fluorescent lamps.

(c) 2848° K tungsten lamps.

(4) Nine chromaticities, three sources (the receiver primaries) and six reflecting subjects representing gold, light green, light blue, light yellow, light red, and light purple.

An outline of the calculation procedure follows.

Assuming a given illuminant (studio or outdoor), the six reflecting subjects become effective sources and their trichromatic coefficients are computed. A set of camera spectral sensitivities is then selected and the system adjusted so that the "white" for the illuminant chosen is accurately reproduced. The trichromatic coefficients of the nine subjects as reproduced by the system with this adjustment are then computed. The fidelity of reproduction may then be checked by comparing the original and reproduced trichromatic coefficients of the nine

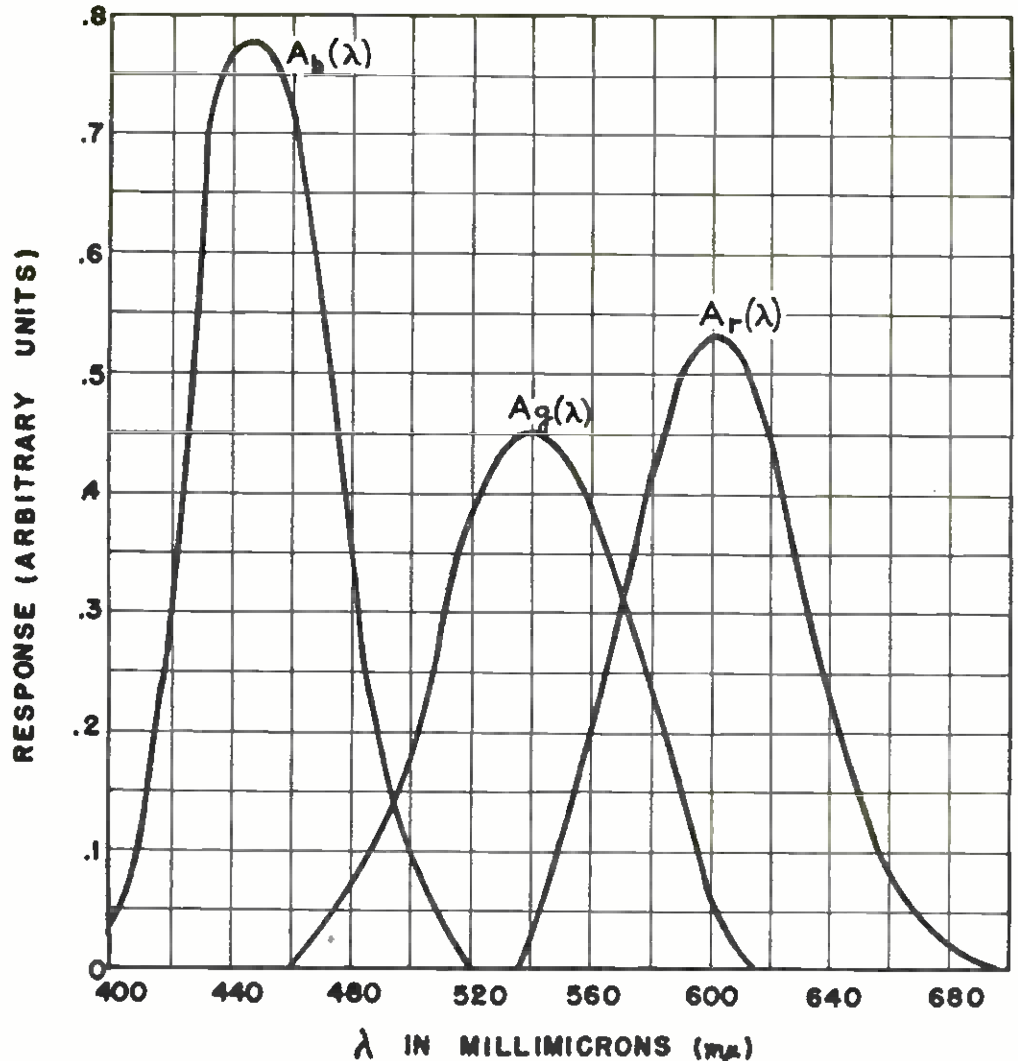

Fig. 10—Camera spectral sensitivities having only regions of positive response which are the same as those of Figure 7.

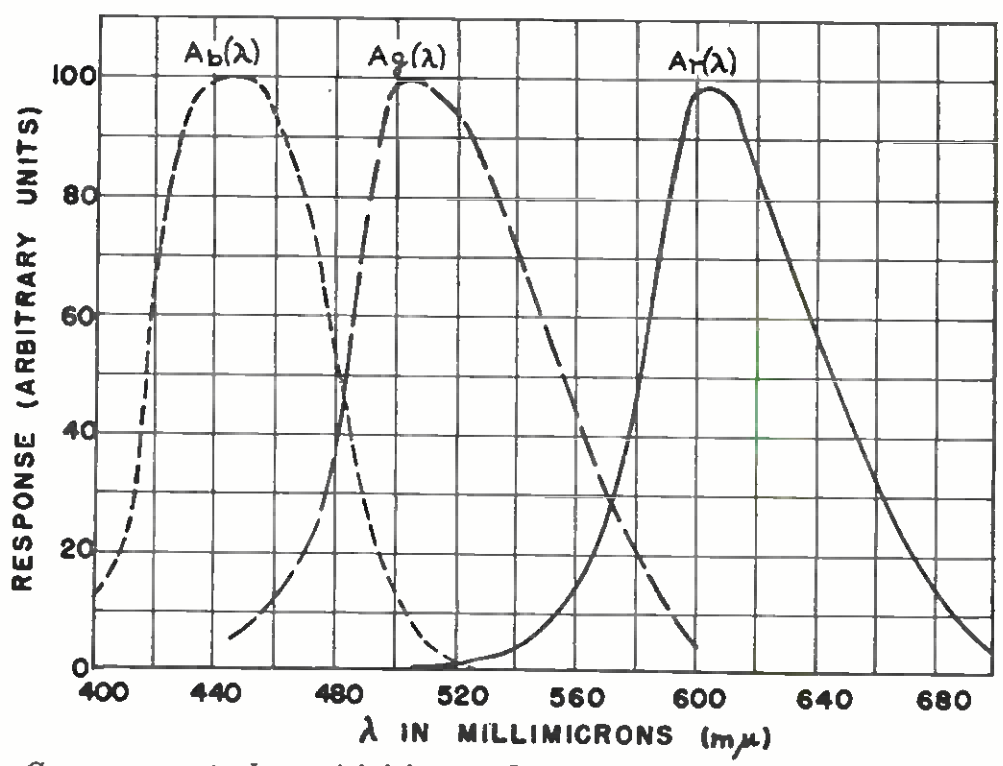

Fig. 11—Camera spectral sensitivities used during the October, 1949 demonstrations at Washington, D. C.

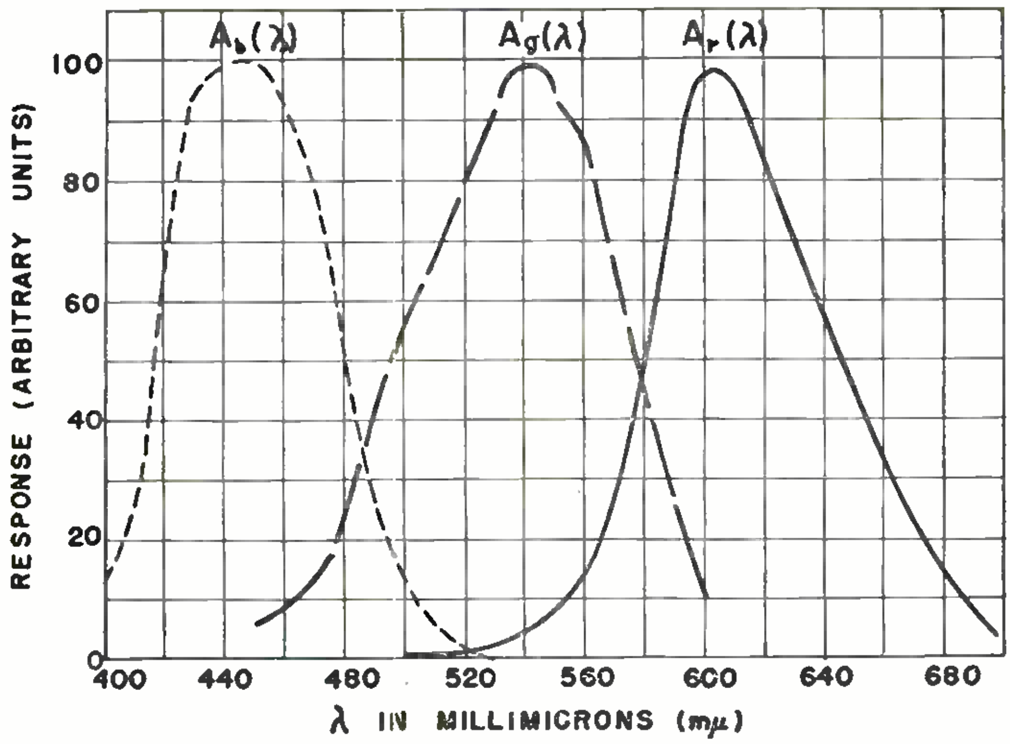

Fig. 12—Camera spectral sensitivities used during the November, 1949 comparative demonstrations at Washington, D. C.

subjects. The calculations were then repeated for most of the possible combinations of camera sensitivities and studio illuminants. The equations used for computing the chromaticity of the reproduction are developed in Attachment 1.

The CIE chromaticity diagram has the disadvantage that a fixed distance between two points on the diagram does not represent a fixed subjective difference between the two colors which these points represent. For example, a given range of orange colors extend over a much smaller area on the chromaticity diagram than does the same range of green colors. It is therefore not immediately obvious from the distance between the original and reproduced chromaticity as shown on the diagram as to how well a given color is reproduced. However, there have been published[3] three contour diagrams with the aid of which the change in chromaticness* due to a known change in the CIE trichromatic coefficients can be calculated. This computation proceeds from the square of a distance,

$$ds^2 = g_{11}dx^2 + 2g_{12}dxdy + g_{22}dy^2.$$

Here, ds is the difference in chromaticness due to a change dx in the x trichromatic coefficient and to a change dy in the y trichromatic coefficient between the original and reproduced chromaticity. The quantities g_{11}, $2g_{12}$, and g_{22} are given on the contour diagrams of Figures 13, 14, and 15. The chromaticness difference ds is the number of times that the chromaticity difference is greater than the standard deviation of the observer in MacAdam's experiment. The number com-

[3] D. L. MacAdam, "Specification of Small Chromaticity Differences," *Jour. Opt. Soc. Amer.*, Vol. 33, pp. 18-26, January, 1943.

* Chromaticness refers to the combined subjective hue and saturation attributes of color sensation, and thus represents the subjective reaction to a chromaticity.

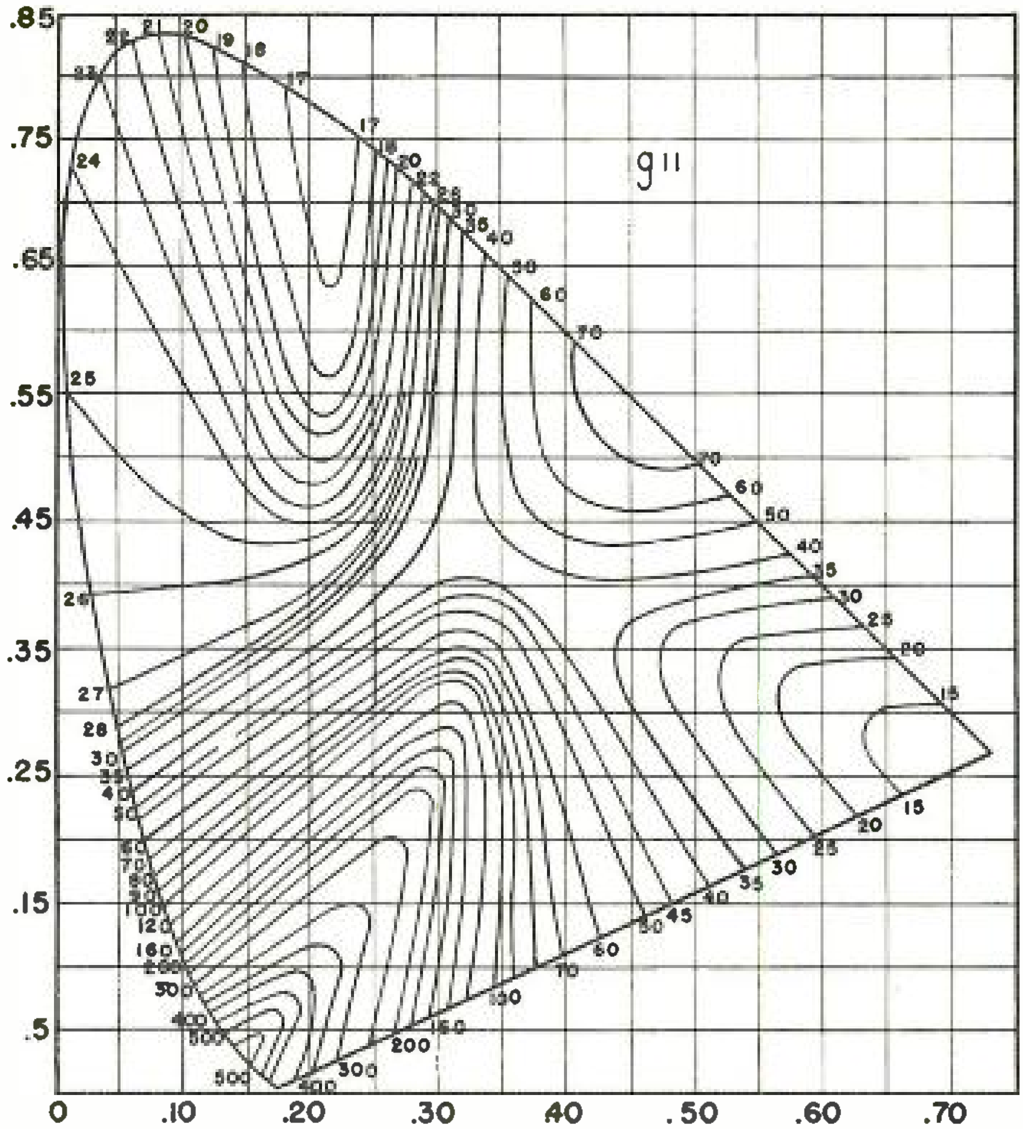

Fig. 13—Contour diagram of the values of the coefficient g_{11} (to be multiplied by 10^4) used in the determination of ds from the equation

$$ds^2 = g_{11}\Delta x^2 + 2g_{12}\Delta x\Delta y + g_{22}\Delta y^2,$$

reproduced from D. L. MacAdam.

puted for *ds* represents approximately the number of times that the difference in chromaticness is greater than the minimum color difference that a normal observer can perceive.

The evaluation of the fidelity of color reproduction (when it is not perfect) is always open to criticism, since the visual sensitivity to color differences varies considerably for different individuals or for the same individual under different conditions of observation. However, it is reasonable to assume that color differences represented by a *ds* of perhaps 10 (computed on the basis of the charts of Figures 13, 14, 15) are negligible in the case of color television reproduction. Among the reasons for this are (1) the data on which the charts are based was obtained with the aid of a trained observer under relatively ideal conditions of observation, and this is not duplicated in viewing a color television receiver, (2) the original is not available for comparison.

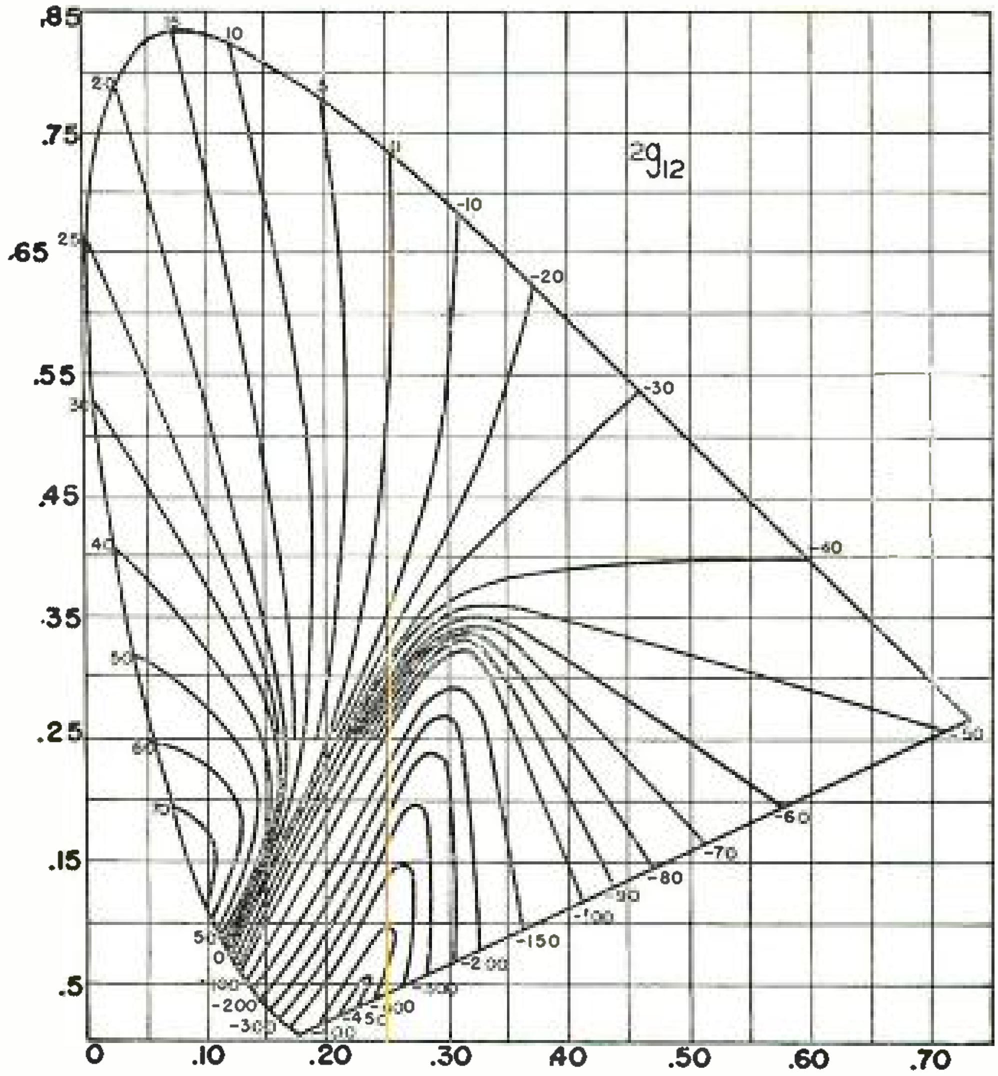

Fig. 14—Contour diagram of the values of the coefficient $2g_{12}$ (to be multiplied by 10^4) used in the determination of ds from the equation

$$ds^2 = g_{11}\Delta x^2 + 2g_{12}\Delta x\Delta y + g_{22}\Delta y^2.$$

Results

The effects of camera spectral characteristics and studio lighting on fidelity of reproduction in the RCA Color Television System have been analyzed. The results of the analysis are shown in tabular form in Tables II to XII, and graphically in Figures 17 and 18.

In the tables, the trichromatic coefficients of the original sample colors are given by x_0 and y_0, those of the reproduced colors by x_R and y_R. Figure 16 shows the location on the color triangle of all of the original sample colors. The locations of the original and reproduced chromaticities are shown graphically in Figures 17 and 18 for the cases of Tables X and III respectively. The fidelity of reproduction is evaluated in columns 8 and 9 of the tables both in forms of *ds* and in terms of the quantity

$$\sqrt{\Delta x^2 + \Delta y^2},$$

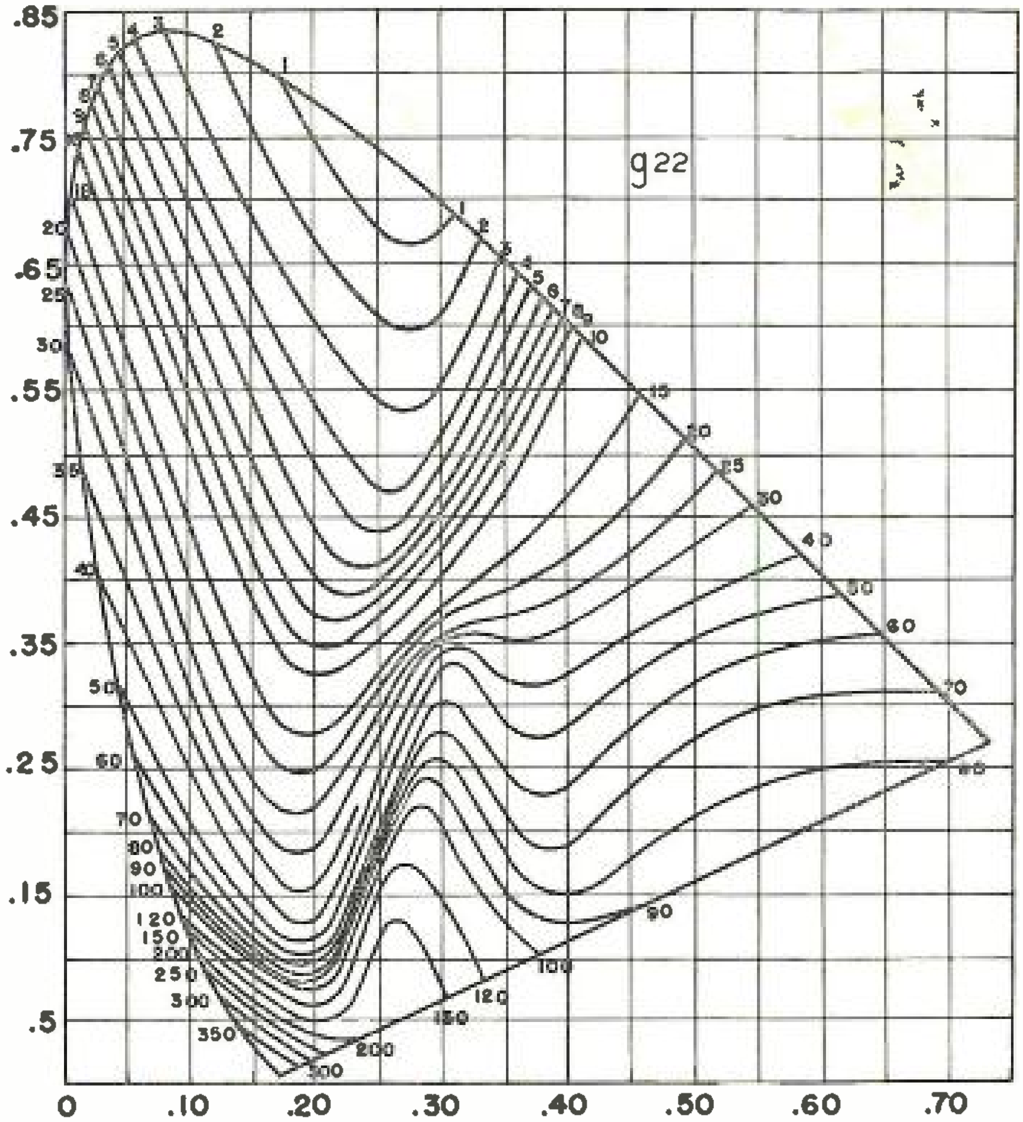

Fig. 15—Contour diagram of the values of the coefficient g_{22} (to be multiplied by 10^4) used in the determination of ds from the equation

$$ds^2 = g_{11}\Delta x^2 + 2g_{12}\Delta x\Delta y + g_{22}\Delta y^2.$$

the latter being the distance, on the CIE chromaticity diagrams, between the original and reproduced colors. The evaluation in terms of *ds* is the preferable one, because a fixed distance on the chromaticity diagram does not represent a fixed subjective difference between the two colors which these points represent, but rather depends upon the location of these colors on the diagram. Thus, it may be seen from the tables that a smaller distance,

$$\sqrt{\Delta x^2 + \Delta y^2},$$

in the blue (sample No. 3 in the tables) corresponds to a much greater value of *ds* than a larger distance in the green (sample No. 2).

In all color-reproducing systems, as a result of not having the theoretically required camera sensitivities, the fidelity of reproduction depends upon the studio

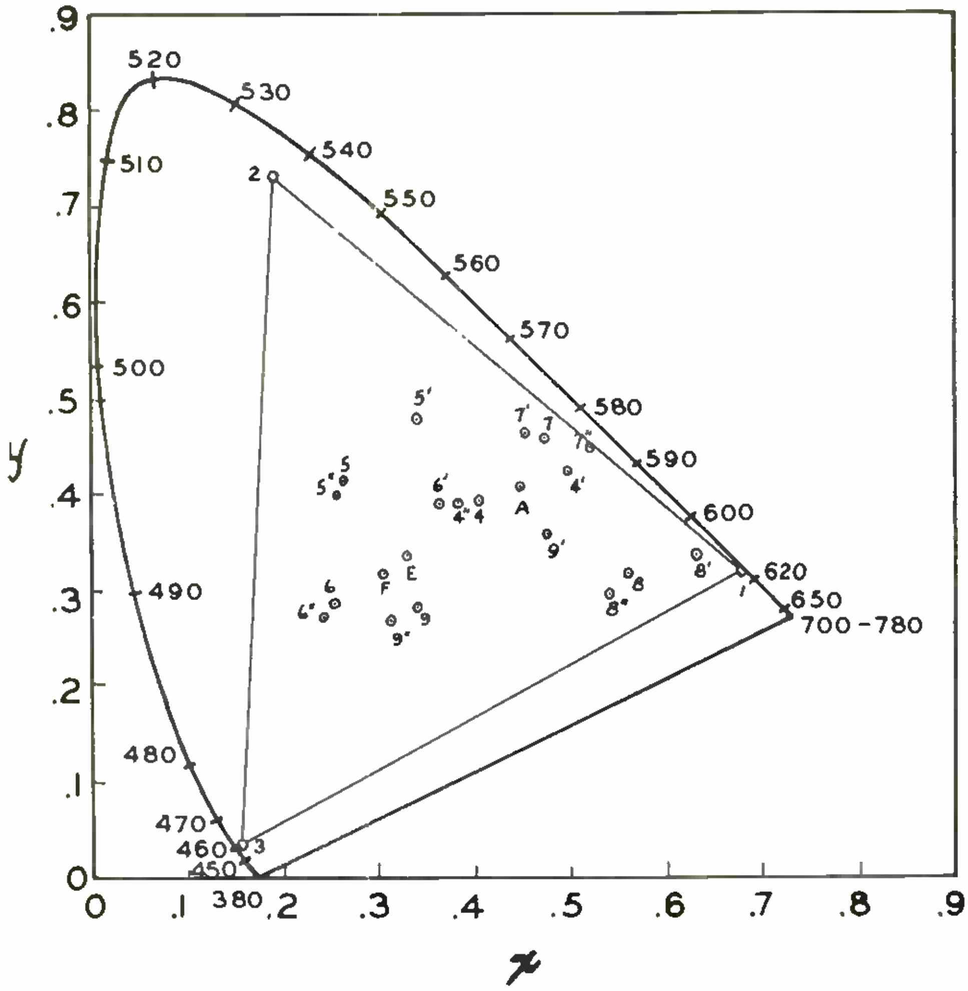

Fig. 16—Location of original test colors and working "whites" on CIE chromaticity diagram.

illuminant and, for any given illuminant, upon the chromaticity being reproduced. The computations confirm this as may be seen from the tables.

Camera spectral sensitivities which correspond to the positive sensitivity portion (Figure 10) of those theoretically required are often the objective in color reproducing systems. This has been practically attained with the characteristics of Figure 12.

It can be seen from the mean value of *ds* given in the tables that very good reproduction may be obtained by using the camera spectral sensitivities of Figure 9. Good color reproduction may be obtained with the camera spectral sensitivities shown in Figure 12.

The spectral sensitivities shown in Figures 11 and 12 were attained with readily available filters. Still further improvement in the fidelity of reproduction is in store because, as indicated in Attachment 3, it is possible with the RCA Color Television System to attain effectively the camera spectral characteristics shown in Figure 7.

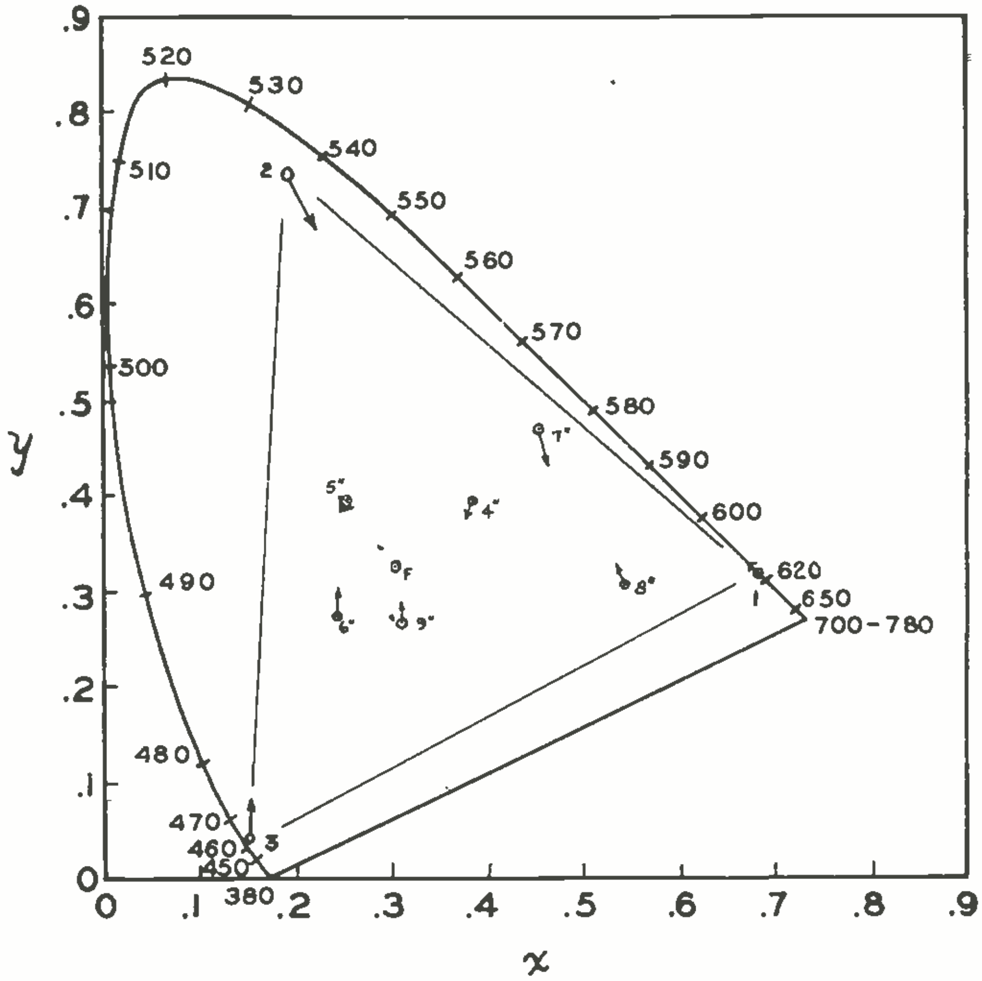

Fig. 17—Calculated chromaticity reproductions with receiver primaries of Figure 6, camera spectral sensitivities of Figure 12, and studio illuminant F (6500° K fluorescent):

⊙ = original chromaticities,
→ = reproduced chromaticities.

Data from Table X.

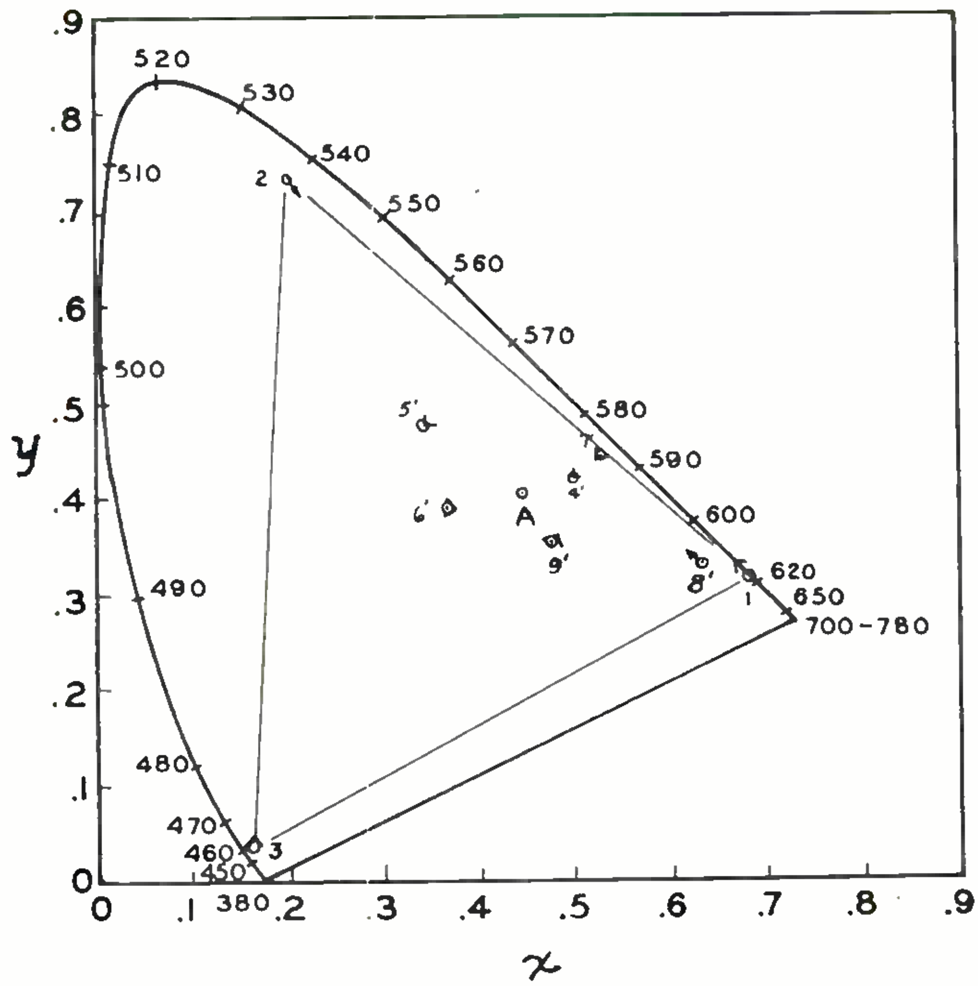

Fig. 18—Calculated chromaticity reproductions with receiver primaries of Figure 6, camera spectral sensitivities of Figure 10, and studio illuminant A (2848° K incandescent):

⦿ = *original chromaticities,*
➔ = *reproduced chromaticities.*

Data from Table III.

Table I—Monochromatic Tristimulus Values

(Plotted in Figure 2)

$\lambda (m\mu)$	$\bar{x}$	$\bar{y}$	$\bar{z}$	$\lambda (m\mu)$	$\bar{x}$	$\bar{y}$	$\bar{z}$
380	.0013	.0000	.0065	560	.5945	.9950	.0039
390	.0042	.0001	.0201	570	.7621	.9520	.0021
400	.0143	.0004	.0679	580	.9163	.8700	.0017
410	.0435	.0012	.2074	590	1.0263	.7570	.0011
420	.1344	.0040	.6456	600	1.0622	.6310	.0008
430	.2839	.0116	1.3856	610	1.0026	.5030	.0003
440	.3483	.0230	1.7471	620	.8544	.3810	.0002
450	.3362	.0380	1.7721	630	.6424	.2650	.0000
460	.2908	.0600	1.6692	640	.4479	.1750	.0000
470	.1954	.0910	1.2876	650	.2835	.1070	.0000
480	.0956	.1390	.8130	660	.1649	.0610	.0000
490	.0320	.2080	.4652	670	.0874	.0320	.0000
500	.0049	.3230	.2720	680	.0468	.0170	.0000
510	.0093	.5030	.1582	690	.0227	.0082	.0000
520	.0633	.7100	.0782	700	.0114	.0041	.0000
530	.1655	.8620	.0422	710	.0058	.0021	.0000
540	.2904	.9540	.0203	720	.0029	.0010	.0000
550	.4334	.9950	.0087				

Table II—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") E, $x_w = y_w = .3333$ and Camera Spectral Sensitivities Shown in Figure 9

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2 + \Delta y^2}$	ds
1	.6806	.3193	.6682	.3298	—.0124	.0105	.0162	12.6
2	.1969	.7311	.2132	.7118	.0163	—.0193	.0253	6.0
3	.1556	.0324	.1565	.0479	.0009	.0155	.0155	27.0
4	.4073	.3952	.4016	.3939	—.0057	—.0013	.0058	3.2
5	.2642	.4112	.2708	.4070	.0066	—.0042	.0078	4.3
6	.2584	.2877	.2668	.2880	.0084	—.0003	.0084	9.1
7	.4742	.4566	.4592	.4547	—.0150	—.0019	.0150	10.9
8	.5585	.3197	.5540	.3308	—.0045	.0111	.0119	10.3
9	.3404	.2824	.3458	.2853	.0054	—.0029	.0062	6.9
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0125	10.0

Table III—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") *A*, $x_w = .4476$, $y_w = .4075$ and Camera Spectral Sensitivities Shown in Figure 9

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6686	.3295	—.0120	.0102	.0157	12.3
2	.1969	.7311	.2137	.7112	.0168	—.0199	.0260	6.1
3	.1556	.0324	.1566	.0485	.0009	.0161	.0161	28.5
4′	.4992	.4250	.4945	.4233	—.0047	—.0017	.0050	2.7
5′	.3441	.4784	.3451	.4766	.0012	—.0018	.0021	1.3
6′	.3673	.3907	.3751	.3919	.0078	.0012	.0079	4.4
7′	.5311	.4439	.5201	.4406	—.0110	—.0033	.0115	7.0
8′	.6323	.3336	.6212	.3459	—.0111	—.0123	.0166	7.7
9′	.4751	.3610	.4804	.3648	.0053	—.0038	.0065	4.9
$\Delta x = x_R - x_o$		$\Delta y = y_R - y_o$			mean		.0119	8.3

Table IV—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") *F*, $x_w = .3064$, $y_w = .3233$ and Camera Spectral Sensitivities Shown in Figure 9

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6674	.3305	—.0132	.0112	.0173	13.5
2	.1969	.7311	.2122	.7125	.0153	—.0186	.0241	5.6
3	.1556	.0324	.1565	.0483	.0009	.0159	.0159	28.4
4″	.3849	.3911	.3715	.3934	—.0134	.0023	.0136	9.0
5″	.2569	.3992	.2570	.4006	.0001	.0014	.0014	0.4
6″	.2448	.2704	.2477	.2741	.0029	.0037	.0047	2.4
7″	.4542	.4653	.4302	.4685	—.0240	.0032	.0242	19.3
8″	.5422	.3024	.5212	.3286	—.0210	.0262	.0336	28.5
9″	.3136	.2666	.3135	.2713	—.0001	.0047	.0047	4.0
$\Delta x = x_R - x_o$		$\Delta y = y_R - y_o$			mean		.0155	12.3

Table V—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") *E*, $x_w = y_w = .3333$ and Camera Spectral Sensitivities Shown in Figure 10

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6628	.3345	—.0178	.0152	.0234	18.2
2	.1969	.7311	.2403	.6676	.0434	—.0635	.0769	14.8
3	.1556	.0324	.1565	.0531	.0009	.0207	.0207	37.0
4	.4073	.3952	.4001	.3920	—.0072	—.0032	.0079	3.7
5	.2642	.4112	.2819	.3999	.0177	—.0113	.0210	12.2
6	.2584	.2877	.2694	.2904	.0110	.0027	.0113	10.8
7	.4742	.4566	.4598	.4516	—.0144	—.0050	.0152	10.0
8	.5585	.3197	.5408	.3330	—.0177	.0133	.0221	17.1
9	.3404	.2824	.3392	.2876	—.0012	.0052	.0053	4.6
$\Delta x = x_R - x_o$		$\Delta y = y_R - y_o$			mean		.0226	14.3

Table VI—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") A, $x_w = .4476$, $y_w = .4075$ and Camera Spectral Sensitivities Shown in Figure 10

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6638	.3336	—.0163	.0143	.0221	17.1
2	.1969	.7311	.2429	.6674	.0460	—.0637	.0786	17.7
3	.1556	.0324	.1596	.0546	.0040	.0222	.0225	37.3
4′	.4992	.4250	.4932	.4229	—.0060	—.0031	.0068	3.4
5′	.3441	.4784	.3541	.4678	.0100	—.0106	.0146	9.1
6′	.3673	.3907	.3781	.3923	.0008	.0016	.0018	.6
7′	.5311	.4439	.5200	.4396	—.0111	—.0043	.0119	7.1
8′	.6323	.3336	.6146	.3496	—.0177	.0160	.0239	18.7
9′	.4751	.3610	.4741	.3682	—.0010	.0072	.0073	5.1
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0209	12.9

Table VII—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") F, $x_w = .3064$, $y_w = .3233$ and Camera Spectral Sensitivities Shown in Figure 10

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6629	.3344	—.0177	.0151	.0233	18.1
2	.1969	.7311	.2403	.6600	.0434	—.0711	.0833	16.7
3	.1556	.0324	.1568	.0517	.0012	.0193	.0193	32.8
4″	.3849	.3911	.3755	.3801	—.0094	—.0110	.0145	4.5
5″	.2569	.3992	.2708	.3796	.0139	—.0196	.0240	11.4
6″	.2448	.2704	.2520	.2649	.0072	—.0055	.0091	10.3
7″	.4542	.4653	.4398	.4550	—.0144	—.0103	.0177	9.8
8″	.5422	.3024	.5085	.3251	—.0337	.0227	.0406	31.4
9″	.3136	.2666	.3090	.2637	—.0046	—.0029	.0054	3.8
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0264	15.4

Table VIII—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") E, $x_w = y_w = .3333$ and Camera Spectral Sensitivities Shown in Figure 11

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6766	.3227	—.0040	.0034	.0055	4.1
2	.1969	.7311	.2257	.6738	.0288	—.0573	.0644	9.5
3	.1556	.0324	.1585	.0805	.0029	.0481	.0482	72.0
4	.4073	.3952	.4117	.3768	.0044	—.0184	.0189	11.5
5	.2642	.4112	.2665	.4195	.0023	.0083	.0086	2.3
6	.2584	.2877	.2646	.3128	.0062	.0251	.0258	10.9
7	.4742	.4566	.4933	.4166	.0191	—.0400	.0443	29.5
8	.5585	.3197	.5682	.3238	.0097	.0041	.0105	3.3
9	.3404	.2824	.3475	.2997	.0071	.0173	.0187	9.2
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0272	16.9

Table IX—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") A, $x_w = .4476$, $y_w = .4075$ and Camera Spectral Sensitivities Shown in Figure 11

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6764	.3228	—.0042	.0035	.0055	4.2
2	.1969	.7311	.2255	.6801	.0286	—.0510	.0585	10.3
3	.1556	.0324	.1592	.0911	.0036	.0587	.0588	80.1
4′	.4992	.4250	.5214	.4027	.0222	—.0223	.0315	23.4
5′	.3441	.4784	.3317	.4908	—.0124	.0124	.0175	10.7
6′	.3673	.3907	.3825	.4081	.0152	.0174	.0231	7.3
7′	.5311	.4439	.5602	.4058	.0291	—.0381	.0479	34.0
8′	.6323	.3336	.6377	.3364	.0054	.0028	.0061	2.0
9′	.4751	.3610	.4976	.3679	.0225	.0069	.0235	9.9
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0302	20.2

Table X—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") F, $x_w = .3064$, $y_w = .3233$ and Camera Spectral Sensitivities Shown in Figure 11

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6764	.3229	—.0042	.0036	.0055	4.3
2	.1969	.7311	.2247	.6743	.0278	—.0568	.0632	10.0
3	.1556	.0324	.1585	.0799	.0029	.0475	.0476	73.1
4″	.3849	.3911	.3798	.3748	—.0051	—.0163	.0171	6.2
5″	.2569	.3992	.2486	.3877	—.0083	—.0115	.0142	5.4
6″	.2448	.2704	.2462	.2991	.0014	.0287	.0287	13.9
7″	.4542	.4653	.4637	.4281	.0095	—.0372	.0384	22.2
8″	.5422	.3024	.5340	.3212	—.0082	.0188	.0205	18.0
9″	.3136	.2666	.3132	.2864	—.0004	.0198	.0198	16.6
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0283	18.9

Table XI—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") E, $x_w = y_w = .3333$ and Camera Spectral Sensitivities Shown in Figure 12

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6721	.3266	—.0085	.0073	.0113	8.8
2	.1969	.7311	.2271	.6709	.0302	—.0602	.0673	10.7
3	.1556	.0324	.1581	.0617	.0025	.0293	.0294	47.8
4	.4073	.3952	.4046	.3882	—.0027	—.0070	.0075	2.7
5	.2642	.4112	.2693	.4070	.0051	—.0042	.0066	3.4
6	.2584	.2877	.2672	.2962	.0088	.0085	.0122	6.8
7	.4742	.4566	.4678	.4435	—.0064	—.0131	.0146	5.7
8	.5585	.3197	.5648	.3273	.0063	.0076	.0099	5.3
9	.3404	.2824	.3502	.2916	.0098	.0092	.0134	6.7
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0190	10.9

Table XII—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") A, $x_w = .4476$, $y_w = .4075$ and Camera Spectral Sensitivities Shown in Figure 12

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6728	.3259	—.0078	.0066	.0102	12.4
2	.1969	.7311	.2304	.6713	.0335	—.0598	.0689	12.1
3	.1556	.0324	.1578	.0673	.0022	.0349	.0350	56.8
4′	.4992	.4250	.5133	.4109	.0141	—.0141	.0199	14.9
5′	.3441	.4784	.3388	.4782	—.0053	—.0002	.0053	3.5
6′	.3673	.3907	.3913	.3931	.0240	.0024	.0241	14.2
7′	.5311	.4439	.5404	.4235	.0093	—.0204	.0224	15.7
8′	.6323	.3336	.6349	.3390	.0026	.0054	.0060	3.6
9′	.4751	.3610	.5021	.3625	.0270	.0015	.0270	13.9
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0243	16.3

Table XIII—Reproduction of Test Colors with Receiver Primaries Shown in Figure 6, Studio Illuminant (Working "White") F, $x_w = .3064$, $y_w = .3233$ and Camera Spectral Sensitivities Shown in Figure 12

Sample	x_o	y_o	x_R	y_R	Δx	Δy	$\sqrt{\Delta x^2+\Delta y^2}$	ds
1	.6806	.3193	.6719	.3267	—.0087	.0074	.0114	8.9
2	.1969	.7311	.2266	.6705	—.0297	—.0606	.0675	16.1
3	.1556	.0324	.1575	.0636	.0019	.0312	.0313	49.3
4″	.3849	.3911	.3734	.3873	—.0115	—.0038	.0121	5.9
5″	.2569	.3992	.2505	.3752	—.0064	—.0240	.0248	7.1
6″	.2448	.2704	.2481	.2821	.0033	.0117	.0121	5.0
7″	.4542	.4653	.4381	.4571	—.0161	—.0082	.0181	10.9
8″	.5422	.3024	.5306	.3254	—.0116	.0230	.0276	22.6
9″	.3136	.2666	.3156	.2775	.0020	.0109	.0111	6.8
$\Delta x = x_R - x_o$			$\Delta y = y_R - y_o$			mean	.0240	14.7

Conclusions

To attain perfect color reproduction within the color triangle of the reproducer of any color television system, it is necessary that the camera spectral characteristics have regions of negative response. It is well known that such negative responses are extremely difficult to achieve in practice. Since the RCA Color Television System is essentially a simultaneous system, it is relatively easy to attain camera spectral characteristics having regions of negative response. All known color reproducing systems and processes, therefore, employ spectral characteristics for the camera or taking device which are only approximations to those theoretically required for perfect reproduction.

Because the standards under which the RCA Color Television System operates are essentially identical with those used in the black-and-white system, flicker and phosphor decay considerations play no more important roles than they do in monochrome, and the choice of receiver primaries is determined essentially by purely colorimetric considerations such as spectral response and efficiency of the phosphors used in the color reproducer. As a result, the gamut of colors that it is possible to produce with the RCA receiver primaries compares very favorably with that possible with the best processes of color reproduction and is much superior to most commercial processes.

Since the color triangle of the RCA color receivers encompasses a large gamut of colors, suitably chosen camera spectral characteristics which are positive throughout the spectrum are good approximations to those theoretically required, and the analysis shows that good color reproduction may be obtained with the camera spectral characteristics presently used.

References

(1) *Handbook of Colorimetry*, Technology Press, Cambridge, Mass., 1936.

(2) "Quantitative Data and Methods for Colorimetry," *Jour. Opt. Soc. Amer.*, Vol. 34, pp. 633-688, 1944.

(3) A. C. Hardy and F. L. Wurzburg, Jr., "The Theory of Three-Color Reproduction," *Jour. Opt. Soc. Amer.*, Vol. 27, pp. 227-240, 1937.

(4) W. H. Cherry, "Colorimetry in Television," *RCA Review*, Vol. 8, pp. 427-459, September, 1947.

Attachment 1

Computation of Chromaticity Difference Between Subject and Reproduction

Let $E(\lambda)$ be the spectral distribution of the light source illuminating a subject having a reflectivity $R(\lambda)$. The spectral distribution of the light reflected by the subject is then $S(\lambda) = E(\lambda)\ R(\lambda)$. Then if A_r, A_g, and A_b be the spectral sensitivities of the three portions of the color camera, the signal outputs of the red, green, and blue channels will be

$$\begin{aligned} V_r &= \int S(\lambda)\ A_r(\lambda)\ d\lambda, \\ V_g &= \int S(\lambda)\ A_g(\lambda)\ d\lambda, \\ V_b &= \int S(\lambda)\ A_b(\lambda)\ d\lambda. \end{aligned} \tag{1}$$

Let $X_rY_rZ_r$, $X_gY_gZ_g$, and $X_bY_bZ_b$ be the tristimulus values of unit amounts of the primaries of the receiver, then the tristimulus values of the primaries when controlled by the signal from the camera will be

$$\begin{aligned} X'_r &= k_1\, V_r\, X_r, \quad Y'_r = k_1\, V_r\, Y_r, \quad Z'_r = k_1\, V_r\, Z_r, \\ X'_g &= k_2\, V_g\, X_g, \quad Y'_g = k_2\, V_g\, Y_g, \quad Z'_g = k_2\, V_g\, Z_g, \\ X'_b &= k_3\, V_b\, X_b, \quad Y'_b = k_3\, V_b\, Y_b, \quad Z'_b = k_3\, V_b\, Z_b, \end{aligned} \tag{2}$$

where k_1, k_2, and k_3 are constants which include the gain of the red, green, and blue channels. It should be noted

$$x_r = \frac{X'_r}{X'_r + Y'_r + Z'_r} = \frac{X_r}{X_r + Y_r + Z_r}$$

and similarly for all other trichromatic coefficients of the receiver primaries. The tristimulus values of the reproduction (obtained by the addition of the lights from the three primaries) are then

$$X_R = k_1 V_r X_r + k_2 V_g X_g + k_3 V_b X_b,$$
$$Y_R = k_1 V_r Y_r + k_2 V_g Y_g + k_3 V_b Y_b, \qquad (3)$$
$$Z_R = k_1 V_r Z_r + k_2 V_g Z_g + k_3 V_b Z_b.$$

Equation (3) may be written, except for a change in the constants k in terms of the trichromatic coefficients of the receiver primaries, as

$$X_R = k_r V_r x_r + k_g V_g x_g + k_b V_b x_b,$$
$$Y_R = k_r V_r y_r + k_g V_g y_g + k_b V_b y_b, \qquad (4)$$
$$Z_R = k_r V_r z_r + k_g V_g z_g + k_b V_b z_b.$$

The proportionality constants k are determined by the condition that the receiver reproduce "white" exactly. The tristimulus values of "white" are those of the illuminant $E(\lambda)$ used in the studio (or the light reflected by a nonselective reflector, say a white card) and are given by

$$X_w = \int E(\lambda)\, \bar{x}\, d\lambda,$$
$$Y_w = \int E(\lambda)\, \bar{y}\, d\lambda, \qquad (5)$$
$$Z_w = \int E(\lambda)\, \bar{z}\, d\lambda.$$

The signal output of the red, green, and blue channels for white is

$$W_r = \int E(\lambda)\, A_r\, d\lambda,$$
$$W_g = \int E(\lambda)\, A_g\, d\lambda, \qquad (6)$$
$$W_b = \int E(\lambda)\, A_b\, d\lambda.$$

Since, for reproduction of white, it is merely necessary that the tristimulus values of white for the original are proportional to those of the reproduction, Equation (4) becomes

$$X_w = k_r W_r x_r + k_g W_g x_g + k_b W_b x_b,$$
$$Y_w = k_r W_r y_r + k_g W_g y_g + k_b W_b y_b, \qquad (7)$$
$$Z_w = k_r W_r z_r + k_g W_g z_g + k_b W_b z_b.$$

The solution of Equation (7) gives the values of k_r, k_g, and k_b as

$$k_r = [(y_g z_b - y_b z_g) x_w + (x_b z_g - x_g z_b) y_w + (x_g y_b - x_b y_g) z_w] W_g W_b,$$

$$k_g = [(y_b z_r - y_r z_b) x_w + (x_r z_b - x_b z_r) y_w + (x_b y_r - x_r y_b) z_w] W_b W_r, \quad (8)$$

$$k_b = [(y_r z_g - y_g z_r) x_w + (x_g z_r - x_r z_g) y_w + (x_r y_g - x_g y_r) z_w] W_r W_g.$$

Having the values of k_r, k_g, *and* k_b, the tristimulus values (or actual quantities proportional to the tristimulus values) of the reproduction of the subject $S(\lambda)$ are then computed from Equation (4), and the trichromatic coefficients of the reproduced chromaticity are given by

$$x_R = \frac{X_R}{X_R+Y_R+Z_R},$$

$$y_R = \frac{Y_R}{X_R+Y_R+Z_R}. \quad (9)$$

The fidelity of reproduction is then computed from the difference between the reproduced and original trichromatic coefficients. The original trichromatic coefficients are given by

$$x_O = \frac{X_O}{X_O+Y_O+Z_O},$$

$$y_O = \frac{Y_O}{X_O+Y_O+Z_O}, \quad (10)$$

where $$X_O = \int S(\lambda)\, \bar{x}\, d\lambda,$$

$$Y_O = \int S(\lambda)\, \bar{y}\, d\lambda, \quad (11)$$

$$Z_O = \int S(\lambda)\, \bar{z}\, d\lambda.$$

Attachment 2

Camera Spectral Sensitivities Required for Perfect Reproduction

For perfect reproduction it is necessary that the tristimulus values of the reproduced and original be the same (or proportional to each other) i.e.,

$$X_O = X_R, \quad Y_O = Y_R, \quad Z_O = Z_R. \quad (12)$$

From Equations (12), (11), (4), and (1),

$$\int S(\lambda)\, \bar{x}\, d\lambda = k_r x_r \int S(\lambda)\, A_r(\lambda)\, d\lambda + k_g x_g \int S(\lambda)\, A_g(\lambda)\, d\lambda + k_b x_b \int S(\lambda)\, A_b(\lambda)\, d\lambda,$$

$$\int S(\lambda)\,\bar{y}\,d\lambda = k_r\,y_r \int S(\lambda)\,A_r\,(\lambda)\,d\lambda$$
$$+ k_g\,y_g \int S(\lambda)\,A_g\,(\lambda)\,d\lambda + k_b\,y_b \int S(\lambda)\,A_b\,(\lambda)\,d\lambda,$$
$$\int S(\lambda)\,\bar{z}\,d\lambda = k_r\,z_r \int S(\lambda)\,A_r\,(\lambda)\,d\lambda$$
$$+ k_g\,z_g \int S(\lambda)\,A_g\,(\lambda)\,d\lambda + k_b\,z_b \int S(\lambda)\,A_b\,(\lambda)\,d\lambda.$$

Since all chromaticities have to be reproduced faithfully, Equation (13) must apply to all subjects regardless of the spectral distribution $S(\lambda)$. This is true only if, at every wavelength,

$$\begin{aligned} \bar{x} &= k_r\,x_r\,A_r + k_g\,x_g\,A_g + k_b\,x_b\,A_b, \\ \bar{y} &= k_r\,y_r\,A_r + k_g\,y_g\,A_g + k_b\,y_b\,A_b, \\ \bar{z} &= k_r\,z_r\,A_r + k_g\,z_g\,A_g + k_b\,z_b\,A_b. \end{aligned} \tag{13}$$

Solving equations (13) for the red, green, and blue camera spectral sensitivities, there results

$$\begin{aligned} A_r &= k_g k_b\,(y_g z_b - y_b z_g)\,\bar{x} + k_g k_b\,(x_b z_g - x_g z_b)\,\bar{y} + k_g k_b\,(x_g y_b - x_b y_g)\,\bar{z}, \\ A_g &= k_b k_r\,(y_b z_r - y_r z_b)\,\bar{x} + k_b k_r\,(x_r z_b - x_b z_r)\,\bar{y} + k_b k_r\,(x_b y_r - x_r y_b)\,\bar{z}, \\ A_b &= k_r k_g\,(y_r z_g - y_g z_r)\,\bar{x} + k_r k_g\,(x_g z_r - x_r z_g)\,\bar{y} + k_r k_g\,(x_r y_g - x_g y_r)\,\bar{z}. \end{aligned} \tag{14}$$

The proportionality constants $k_g\,k_b$, $k_b\,k_r$, and $k_r\,k_g$ are unimportant, since only relative values of the sensitivities are generally used. Equation (14) has been written above without the proportionality constants.

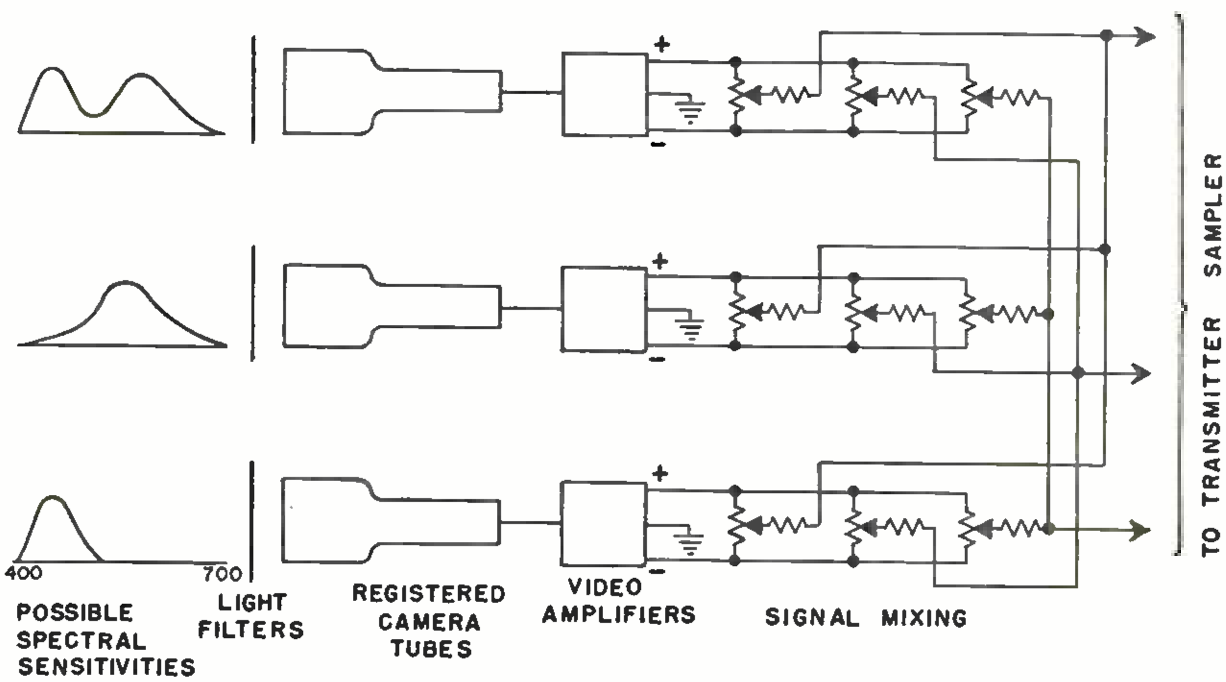

Fig. 19—Schematic arrangement for mixing camera signals in order effectively to obtain the theoretically required spectral sensitivities with regions of negative response.

ATTACHMENT 3

In any color system, in order to reproduce faithfully all those chromaticities of the original scene which lie within the color triangle of the receiver primaries, it is necessary that the camera spectral sensitivity have regions of negative response similar to those shown in Figures 7 and 8. In color photography, the procedures called "masking" are carried out in order to attain some approximation to these regions of negative response.

It is also possible effectively to attain these regions of negative response with the RCA Color Television System.[4] This can be accomplished by combining with linear networks, before sampling, the three simultaneous signals from the camera having only suitable positive spectral characteristics. The mixing of the camera signals requires some means of phase inversion. The three positive camera spectral sensitivities should be so chosen that when divided through by the spectral sensitivities of the photo-surface of the pick-up device, the resulting required filter characteristics are easily obtainable. Figure 19 shows schematically one arrangement of the signal mixing circuits which can be used to obtain exact color reproduction within the color triangle of the receiver. This has been tried in the laboratory, where it was found that with the then available apparatus, the signal-to-noise ratio was somewhat impaired by the subtraction process and that the adjustment procedure was rather complex. Therefore the use of the mixing (or "masking") amplifiers has been postponed till further development simplifies the complexity of the adjustments.

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[4] D. L. MacAdam, "Specification of Small Chromaticity Differences," *Jour. Opt. Soc. Amer.*, Vol. 33, pp. 18-26, January, 1943.

APPENDIX B

MIXED HIGHS IN COLOR TELEVISION*

A. V. BEDFORD,† FELLOW, IRE

Summary—A high-quality color television system could be made by transmitting independent red, green, and blue images of equally high quality. The bandwidth required by this method would be three times as great as that required for a black-and-white picture of equal resolution and repetition rate, regardless of whether the images are transmitted in sequence or simultaneously.

Tests made on the human eye, and reported herein, indicate that the acuity for detail residing in color differences is less than half as great as the acuity for detail residing in brightness. Therefore, if the brightness values in a color television system are transmitted with fidelity up to 4 Mc, it is adequate to transmit the individual color values up to only 2 Mc, with a corresponding saving in bandwidth. In the "mixed-highs" system described, each of the three color images uses frequencies from zero up to 2 Mc and the "mixed highs," which carry only the brightness values of the fine detail, use a video frequency band from 2 to 4 Mc. The total width of the video bands then is only 8 Mc instead of 12 which would be required for three identical bands from zero up to 4 Mc.

The bandwidth saved by the mixed-highs technique is obtained not at the expense of picture quality, but is a legitimate saving that arises by avoiding the transmission of information which the eye is unable to use. In this sense the saving could be compared to that which occurs by transmitting only the visible spectrum of colors, omitting the ultraviolet which the eye cannot see.

The brightness acuity eye tests were made with projected charts without the use of television apparatus. A new-type test pattern was used having a calibrated blurred junction which corresponds to the light values resulting from the transient response of a video amplifier with restricted bandwidth in passing from a dark area to a light area. The measurement of acuity for detail in color was made with similar blurred junctions between areas of different colors.

Though the work reported was done a number of years ago and was applied to the simultaneous system demonstrated by RCA Laboratories in 1946, the principles and techniques are equally applicable to the new RCA color system demonstrated in 1949. In the latter system the mixed highs and the dot interlace jointly provide a three-to-one bandwidth reduction that allows a high-definition compatible color television service to be operated within the 6-Mc radio-frequency channels now allocated for black-and-white television.

I. BASIC THEORY AND METHOD OF MIXED HIGHS

A proper additive mixture of three suitably chosen primary colored lights (such as red, green, and blue lights) will produce practically all the colors commonly encountered. Therefore, a high-fidelity color television system requires the transmission of only three separate color images which are superimposed at the receiver. Originally, it was assumed that the three images would be transmitted at equal repetition rates and with equal resolution. Then the total bandwidth requirement would be three times as great as for a black-and-white picture of equal resolution and repetition rate, regardless of whether the three images are transmitted simultaneously or sequentially.

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In 1940 Alfred N. Goldsmith[1] proposed that in the simultaneous system the bandwidth of the blue image could be made considerably less than that for the green and the red images without appreciably impairing the picture received. Since the human eye has less acuity for blue light than for red or for green, the nearest satisfactory viewing distance would be determined primarily by the resolution of the red and the green image components and the acuity of the eye for these colors; hence, if the blue image had resolution equal to the green or red, the eye would not appreciate the full value of this resolution and a portion of the bandwidth required to produce the blue image would be wasted. Thus, it is seen that a deficiency of the eye can be used to save bandwidth. It is noteworthy that the field-sequential and the line-sequential systems cannot readily take advantage of this saving because the same radio band is used in turn for the red, green and blue images.

In the literature[2] there is reference to "the well-known fact, first demonstrated by Aubert in 1865, that objects of small size or low intensity always appear colourless." This amounts to saying that the human eye is color-blind for small objects. The present author has indirectly confirmed Aubert's statement by tests reported herein, which show that the eye has less acuity for detail of a certain type residing in differences in color than for detail residing in differences in brightness. Then, to satisfy the eye observing a color television picture at a particular distance, it would not be necessary to transmit information regarding the *color* of certain tiny areas even though these areas are large enough to be distinguished by differences in brightness and therefore should be correctly reproduced in regard to brightness.

Accordingly, it is not necessary in scanning from area to area of the picture to be able to change from one color to another as quickly as it is necessary to change from one brightness to another. In the case of a television system transmitting three complete separate color images by identical means, the color in the received picture can change as abruptly along the scanning line as can the brightness. This system then is wasteful of bandwidth in that it transmits information which the eye is normally unable to use.

In the "mixed-highs" simultaneous system proposed by the author several years ago, this waste is avoided by transmitting the low-frequency components of the three color images separately and a fourth signal produced by mixing or adding the high-frequency components of the green and the red signals to form a single mixed high-frequency signal for transmission. At the receiver the mixed-highs component is added to the green or to the green and the red low-frequency signals for application to the respective color picture reproducers.

One version of the system is shown in Figure 1. In Figure 1(a) is shown the transmitter apparatus which receives the three separate simultaneous green, red, and blue signals, indicated as *G*, *R*, and *B*, from the camera, not shown. These signals are of full video bandwidth extending from 60 cycles or lower up to 4 Mc as shown in Figure 1(c). The low-pass filters *LP* at the transmitter pass only

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[1] Alfred N. Goldsmith, U. S. Patent No. 2,335,180; November 23, 1943.

[2] Ragnar Granit, "Sensory Mechanisms of the Retina," Oxford University Press, London, England, p. 321; 1947.

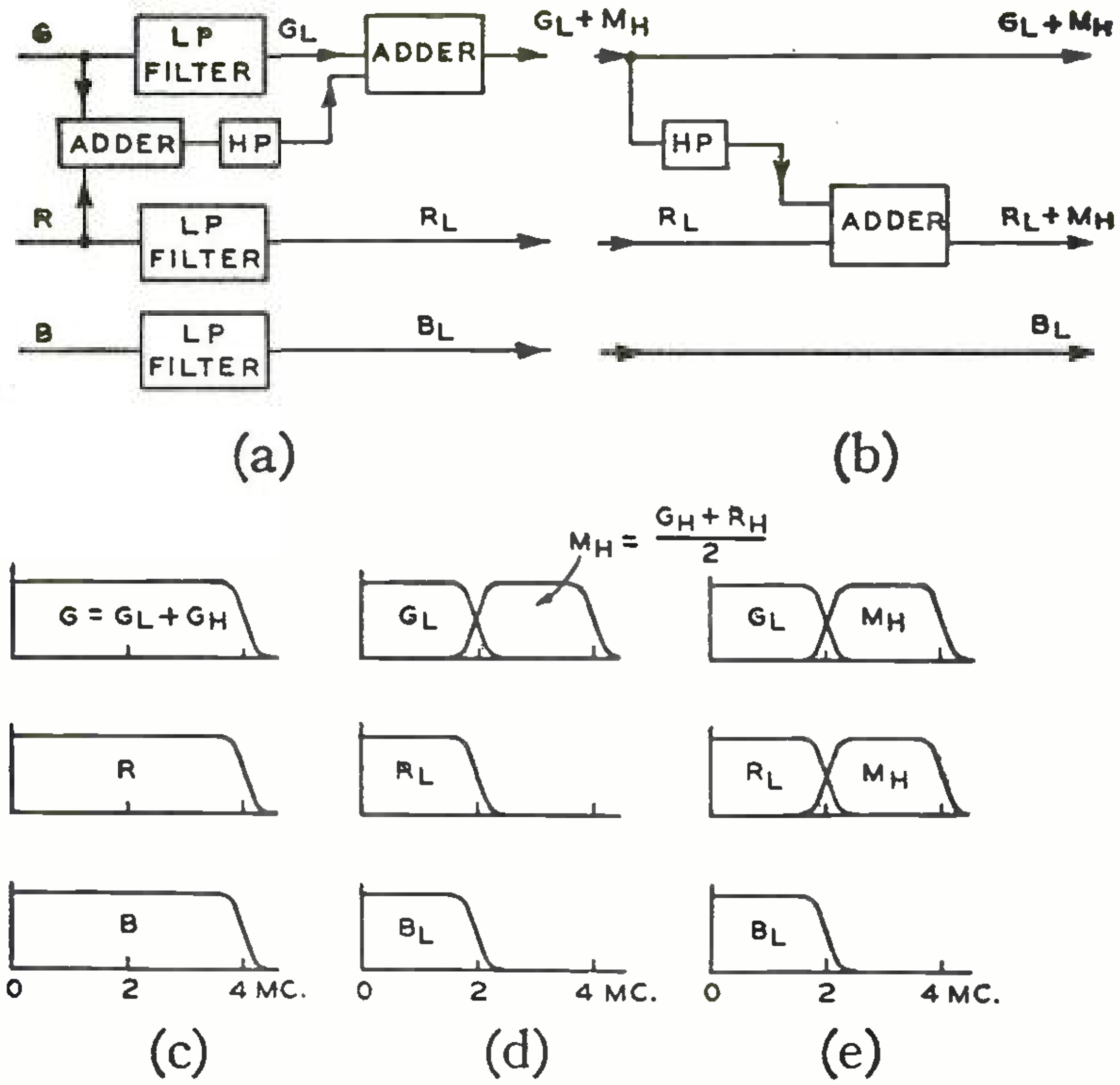


Fig. 1—Color television system with mixed highs. (a) Transmitter. (b) Receiver. (c) Pickup signals. (d) Transmitted signals. (e) Reproduced signals.

the lower 2 Mc of each of these signals. The low frequency components are indicated as G_L, R_L, and B_L respectively, in the figure. The green and the red original signals are added in the adder and a mixture of higher-frequency components of both signals together are passed by the high-pass filter *HP*, no use being made of the blue highs. The mixed high-frequency components M_H so obtained are added to the low-frequency green components G_L to form the combined signal $G_L + M_H$ which is transmitted as a single signal. It is important that this combined signal may be used directly to operate a black-and-white receiver.

The low-frequency components of the red and the blue images, R_L and B_L, respectively, are separately transmitted as shown in Figure 1(d). The color receiver as shown in Figure 1(b) applies the green low frequencies and the mixed highs $G_L + M_H$ to the green kinescope directly. The signal for the red kinescope similarly is the red low-frequency signal and the mixed highs which are obtained by a suitable high-pass filter and adder as shown.[3]

[3] This system was publicly demonstrated in October, 1946, and was described in testimony before the Federal Communications Commission presented in behalf of Radio Corporation of America in December, 1946 (Docket No. 7896), and in September, 1948 (Docket No. 8976).

The three diagrams in Figure 1(e) show the signals applied respectively to the three kinescopes. The mixed-highs part of the signal applied to the green and the red kinescope are the same as the high-frequency components which would be produced by a panchromatic camera for picking up a conventional black-and-white signal except that the unimportant blue highs are absent. If such a panchromatic camera had suitable sensitivity for the various colors, the signal would contain information for reproducing correctly all useful brightness values of the original subject in detail corresponding to 4 Mc. Therefore, so far as brightness only is concerned, the color picture would have full 4-Mc resolution. However, since both the green and the red kinescopes receive the same signal above 2 Mc, it is evident that the resolution in terms of different colors (which can be called "color resolution" as compared to "brightness resolution") extends only up to 2 Mc. It thus appears that the system described would accomplish the objective of saving bandwidth by avoiding the transmission of information which the eye cannot use.

The special measurements of the eye which will be reported below showed that the acuity for blue light alone is considerably less than the acuity for changes from red to green. Therefore, no advantage would be obtained in modifying the arrangement of Figure 1 to use the blue highs as a component of the mixed highs. Neither would there be any advantage in applying the mixed-highs signal to the kinescope which reproduces the blue image.

Later it will be found that the circuit of Figure 1 should be modified because of the cutoff characteristics of the kinescope. In the meantime, the tests of the eye will be presented.

II. Measurements of Acuity for Different Single Colors on Black

In a television system the scanning spot sweeps over the picture at a very high speed. When it passes abruptly from a dark area to a light area the signal generated is a steep step wave. If the scanning spot is small enough that it does not appreciably limit the picture detail, the generated wave may be considered to be a Heaviside unit function for all practical purposes. If the video channel is uniform in amplitude and phase response up to the cutoff frequency, the time of rise of the transmitted step wave will be inversely proportional to the bandwidth of the video channel. A narrow bandwidth which causes a relatively long time of rise manifests itself in the reproduced picture as a gradual transition in brightness or color in going in a horizontal direction along the picture screen from one brightness or color to another. The junction between the two areas would be "blurred" instead of sharp and the picture would be said to have low resolution.

In the proposed mixed-highs system, the junctions between areas of different colors would be reproduced with wider blurs than would the junctions between areas of different brightnesses of the same color. The eyes have less acuity for differences in color than for differences in brightness. Then, when the minimum viewing distance for the picture is determined as that at which the blurs of the brightness transitions are not visible, the wider blurs of the color transitions also would be invisible.

In order to determine the frequency above which the highs can be mixed without degrading the picture, it is necessary to measure the relative acuity of the eye for detail residing in differences of color and for detail residing in differences of brightness. For this purpose, the author devised a special test pattern in which the observer attempts to detect a calibrated blurred transition when compared directly with other adjacent transitions which are extremely sharp. The basic test pattern as drawn is shown in Figure 2. Films for both

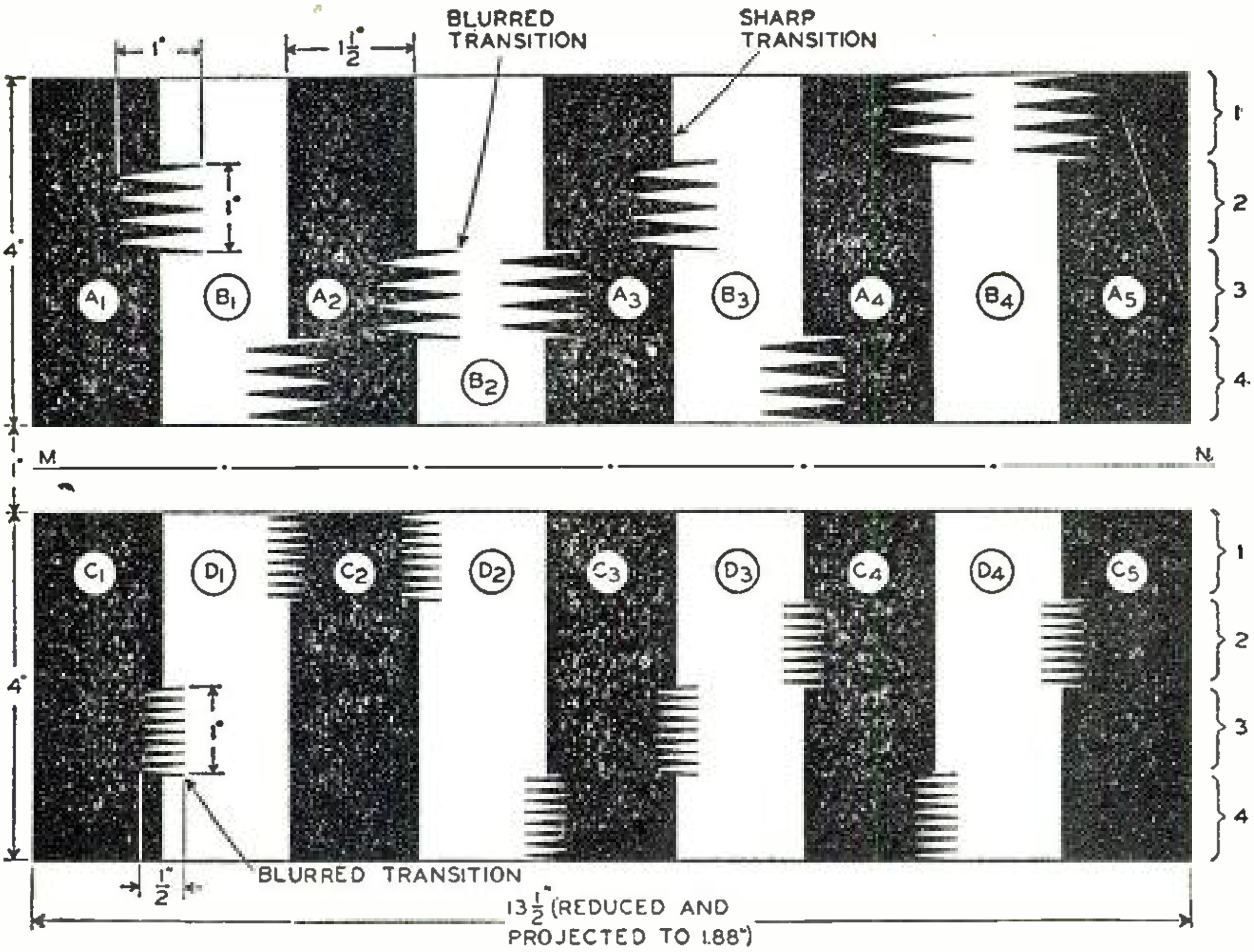


Fig. 2—Test pattern without surround, before reduction.

positive and negative lantern slides were made of this pattern. These films were then cut in two along the horizontal line *MN* and reassembled into three slides as follows:

Slide No. 1—Positive of upper part; positive of lower part.

Slide No. 2—Negative of upper part; positive of lower part.

Slide No. 3—Opaque mask on upper part; positive of lower part.

Three 300-watt Society-for-Visual-Education slide projectors *R*, *B*, and *G* and half-silvered mirrors were arranged to project the three slides in registration upon a translucent screen 1.88 inches wide, as shown in Figure 3. This translucent screen was surrounded by a large opaque apertured screen illuminated by white light from a fourth projector *W* having a transparent slide with a small opaque rectangle in its center for keeping light off the translucent screen. An observer positioned before the screen as shown in the figure saw a small reproduction of the basic test pattern surrounded by a large, uniformly

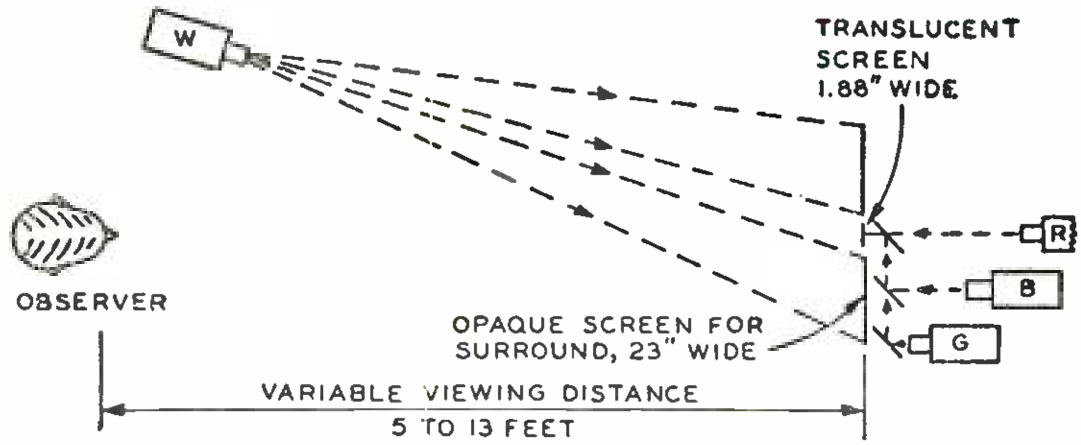


Fig. 3—Plan of eye-test apparatus.

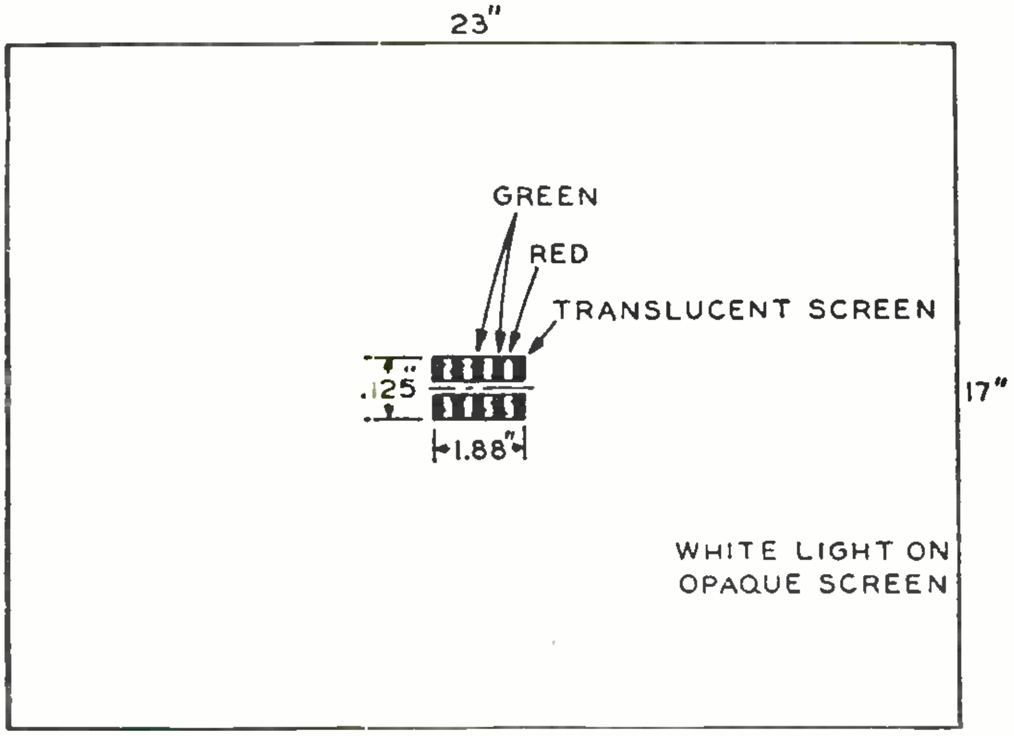


Fig. 4—Projected test pattern as observed with white surround.

illuminated screen as shown in Figure 4. The three projectors were provided with red, blue, and green Wratten color filters, Nos. 26, 48, and 57, respectively. Each projector was also provided with a coarse iris and a small-range voltage control for the lamp in order to obtain a wide range of brightness control without making a great change in lamp temperature which would seriously affect the color.

When measuring acuity for white light, the three colored projectors simultaneously illuminated the D_1 to D_4 areas in the lower part of the test pattern as shown in Figure 2. The individual brightnesses were chosen such as to make these areas white while the areas C_1 to C_5 were left black.[4] The particular quality of the white light was arbitrarily made the same as that provided by the 300-watt "white" surround projector operating at 115 volts. The

[4] A single white projector could have been used to produce this black-white pattern. It had been planned originally to have the observer read the upper colored patterns during the same sitting at which he read the lower black-white pattern.

brightness of the white portion of the test pattern was adjusted to 20 foot-lamberts as measured by a Macbeth illuminometer. This value of brightness was arbitrarily given the relative value of 100 per cent. The brightness of the white surround was adjusted to 10 foot-lamberts upon the assumption that the mean brightness of a television picture might average about half of the peak brightness.

Three quarters of the border between areas C_1 and D_1 is sharp, but one quarter of the border consists of a jagged saw-tooth outline. When viewed at the distance used in the tests, the individual jags are not resolved. Instead the eye attributes the light from the white areas of the "jags" equally to these white areas and to the adjacent intermeshed black areas. Therefore, since the jags consist of straight lines the transition in a horizontal direction from the black area C_1 to the white area D_1 is effectively a linear transition, which will appear as a blur between the larger areas when seen beyond a critical distance. The width of the blur is shown as ½ inch in Figure 2 but it becomes 0.07 inch (0.0058 foot) when projected as in Figure 4.

In conducting the test, the observer was allowed to sit at a distance of 15 feet in front of the illuminated screen with the room semidark for five minutes, in order to become adapted to the conditions. Then he was asked to say whether the blurred transition was in the first, second, third, or fourth position for each of the eight borders between C_1 and D_1, between C_2 and D_2, and so forth. Then he was seated nearer the screen and again asked to locate the blurred transitions. As an example of the results obtained, observer M30 gave two correct answers at 15 feet, three correct at 14 feet and seven correct at 13 feet. At shorter distances he was able to locate all eight blurred transitions with certainty. In interpreting the data, it was desired to determine and use the distance at which the true recognition is 50 per cent. Since the observer knows that each blur can occupy only one of the four possible positions, he would statistically get two out of the eight answers correct without seeing at all. This leaves only six more correct answers that could be made with perfect vision. Thus, if his true recognition is 50 per cent of perfect he would get half of these six additional correct answers, making a total of five correct answers.

From the above readings taken on observer M30, it was estimated by rough interpolation that he would have required a viewing distance of about 13½ feet to get the prescribed five correct answers. The white-black acuity of this observer was then calculated to be 2,330 reciprocal radians by dividing the viewing distance (13½ feet) by the width of blur (0.0058 feet). This value is recorded in line 1, column M30, of Table I. The values of white-black acuity obtained for three other observers, J31, D22 and D43 is recorded in other columns. The average for all four observers was 2,130 reciprocal radians. The numerical relation between the acuity obtained by this method and that obtained by resolving fine lines and other conventional methods, has not been determined. In fact, the present method may measure a somewhat different property of the eye since the linear blur used in the test produces the effect of a television system with a gradual frequency cutoff instead of a sharp cutoff such as that measured by the converging fine-line test pattern. Therefore, the values have not

TABLE I

SUMMARY OF ACUITY TESTS

Observer and His Age	M30	J31	D22	B43	Averages of Four Observers	Average Ratio of Viewing Distance to Surround Height
Acuity in reciprocal radians.						
1. White-black	2,330	1,900	2,240	2,070	2,130	8.3
2. Green-black	1,980	1,980	1,980	2,070	2,000	8.2
3. Red-black	2,330	1,730	1,900	1,730	1,920	7.8
4. Blue-black	390	650	470	730	560	4.6
Acuity in reciprocal radians, with weaker light adjusted for minimum acuity.						
5. Green-red	990	860	780	780	852	6.9
6. Green-blue	390	390	390	430	400	3.3
7. Red-blue	390	560	475	517	485	4.0
Per cent brightness of weaker light in three above tests.						
8. G-R (red = 100 per cent)	46	44	57	48	49	
9. G-B (blue = 100 per cent)	2.5	2.6	3.4	4.8	3.3	
10. R-B (blue = 100 per cent)	4.2	4.9	6.3	12.0	6.8	
Acuity in per cent of average white-black acuity.						
11. White-black	109	89	105	97	100	
12. Green-black	93	93	93	97	94	
13. Red-black	109	81	89	81	90	
14. Blue-black	18	30	22	34	26	
15. Green-red	46	40	37	37	40	
16. Green-blue	18	18	18	20	19	
17. Red-blue	18	26	22	24	23	

Note—Brightness of white surround in all tests was 10 foot-lamberts. Brightness of brightest color in pattern in all tests equaled the brightness that component would have to make a white brightness of 20 foot-lamberts.

been given in minutes of arc, which might be improperly compared with conventional eye-acuity data. The use of absolute units is not necessary in this study since only relative values are used.

At another sitting the same observers were individually used to measure the green-black acuity. This was done by using only the green projector, with the same adjustment of brightness that that projector had when used as one of the three color sources in projecting a white image of 20 foot-lamberts brightness. This value was arbitrarily called 100-per cent green brightness. The brightness of the surround was left at 10 foot-lamberts of white light. The procedure of the test was the same as that used for the white-black tests above. The average value of green-black acuity was 2,000 reciprocal radians as recorded in line 2 of Table I.

Similar tests were then made to determine the red-black and the blue-black acuity of the same persons. The blue-black tests differed from the previous tests in that the coarser upper part of the pattern (sections A_N and B_N) was used in order to allow the viewing distances to be more nearly like that used in other tests. The results indicated that the red-back acuity is nearly equal to the green-black acuity and the white-black acuity, but that the blue-black acuity is only 26 per cent of the other three.

III. Measurements of Acuity for Different Color Combinations

The above tests were measurements of acuity for detail residing in differences in brightness only.

The next tests used the same observers to measure acuity for detail residing in differences in color with the relative brightness being adjusted to minimize the acuity. In making the green-red test, the upper or coarse portion of the pattern of Figure 2 was used with the areas A_1, A_2, and so forth being projected in green light by a projector, using negative Slide No. 2 (mentioned earlier) and the green filter (Wratten No. 57) while the areas B_1, B_2 and the like were projected in red light by a projector using positive Slide No. 1 and the red filter (Wratten No. 26). The projected green and red images were carefully focused and positioned for accurate registration, so that the red and green jags between each pair of A_N and B_N areas accurately intermeshed. The surround was kept at 10-foot-lamberts of white light.

The red projector was adjusted to make the red portion of the image measure the same (100 per cent) brightness which it had in the previous tests. This brightness was measured with the Macbeth illuminometer, using a small red (Wratten No. 26) filter in the instrument to avoid the necessity of the eye having to compare brightnesses of two very different colors. (Of course, a reading of the brightness of the screen produced by the red projector alone had already been taken and recorded in a similar manner in the white-black tests.)

The observer was asked to adjust the brightness of the green light so that the junctions between the green and the red areas appeared least sharp to him. This was done at a great enough distance that he could not recognize the blurred transition and thereby remember their positions in the next step of the test. For all observers, the green brightness setting obtained was less than 100 per cent green brightness. As recorded in line 8 of Table I, the mean setting of the four observers was 49 per cent. (Preliminary observations had already shown that the green brightness settings would be less than 100 per cent; otherwise, the green would have been set at 100 per cent and the red brightness cut down for minimum acuity.)

Then, with the brightness of the red image at the value which provided the *least* acuity for himself, each observer was tested by having him locate the blurred transitions from a series of viewing positions which became closer and closer to the screen as in previous tests. The average value of green-red acuity for the four observers was 852 reciprocal radians as shown in line 5 of Table I. This is only 40 per cent of the average white-black acuity, as shown in line 15.

The green-blue acuity and the red-blue acuity for the same observers were measured in a similar manner. In each of these cases, the minimum acuity was obtained with a blue brightness of 100 per cent, and with the other brightness reduced to very low values which averaged 3.3 and 6.8 per cent, respectively.

Since each of the various acuity tests was made by varying the viewing distance, the ratio of viewing distance to the height of the surround varied with the value of the acuity obtained. In order to restrict the range of this variation, the upper part of the test pattern, which has wider blurred transitions, was used for those tests in which the acuity was very low. The resulting viewing-distance ratio still varied considerably as shown in the last column of Table I. However, other tests have shown that the acuity is not greatly affected by such changes in the surround as long as the angle subtended by the surround is fairly large.

Each of the four persons tested said he had normal color vision and acuity. The two subjects who usually wear glasses used them in the tests. All of the four subjects were men and their ages were 30, 31, 22, and 43 years, respectively, as indicated by their code names in Table I. These ages cover the range which may be considered most important in designing a broadcast television system, since persons above this age range will generally have poorer sight. Since the data taken on these four subjects show relatively good correlation, it is considered adequate to prove the soundness of the mixed-highs principle in color television.

IV. Application of Acuity Data in Mixed-Highs Simultaneous Color Television System

The most rclevant average values from Table I are repeated in Table II for easy inspection.

The greatest acuity for detail residing in color variations was measured for the green-red combination. Since the value of acuity for these colors is 40 per cent of that for brightness variations as shown by the white-black test, it appears that the three color picture signal components need to be kept separate up to 40 per cent of the top frequency. Above this crossover frequency, the highs of all three color images could ideally be combined without appreciable loss when the picture is viewed at a distance where the brightness detail is satisfactory. In fact since very high-chroma high-brightness red and green areas will occur adjacent to one another rather infrequently, a much lower crossover frequency would generally be acceptable.

TABLE II

Color Combination	Relative Brightness Values Used in Tests	Acuity in Per Cent
White-black	White = 100 per cent	100
Green-black	Green = 100 per cent	94
Red-black	Red = 100 per cent	90
Blue-black	Blue = 100 per cent	26
Green-red	Red = 100 per cent; Green = 49 per cent	40
Green-blue	Blue = 100 per cent; Green = 3.3 per cent	19
Red-blue	Blue = 100 per cent; Red = 6.3 per cent	23

Note—Brightness values are given in per cent of the brightness of the red, green, and blue colors which combine to produce white.

Since the blue-black acuity is only 26 per cent, which is considerably lower than the green-red acuity, the blue frequency band can be restricted accordingly and there appears to be no reason for including the blue picture highs with the green and red highs to form the "mixed" highs.

It is noted that in the green-red test, the minimum acuity of 40 per cent was obtained by adjusting the green brightness to 49 per cent of the brightness of the red. The green-black acuity was 94 per cent and the red-black acuity was 90 per cent. Thus it can be seen that if one starts with the red-black condition and then adds 49 per cent of green light to the black area adjacent to the red area, the discernible difference in the character of the two areas is minimized. That is to say, the eye becomes less able to determine the character of the junction between the two areas.

Each light pattern thus operates to obscure the outline of the other. The two brightnesses are then equal in their ability mutually to mask resolution. This will be called the masking brightness. Stated in this terminology, the green-red masking brightness of the red light is 49 per cent compared with 100-per cent green-red masking brightness of the green light when the light values have the proportions in which green, red, and blue light combine to produce white.

Now we note that the minimum green-blue resolution was obtained with a blue brightness of 100 per cent and the green brightness reduced to 3.3 per cent. From this one can conclude that the green-blue masking brightness of blue light is only 3.3 per cent compared with 100 per cent for green. The minimum red-blue acuity was obtained with 100-per cent blue brightness and 6.3-per cent red brightness. If now the red-blue masking brightness of the red light is arbitrarily set at 49 per cent, the same as was obtained above for the green-red masking brightness of the red light, the red-blue masking brightness for the blue light would then, by proportionality, become

$$0.49 \times 6.3 = 3.1 \text{ per cent}$$

This value is close enough to the green-blue masking brightness of blue light obtained above to indicate that the masking effect of a particular colored light is essentially the same value regardless of what other color light it is tested with. Accordingly, the three colors could be assigned the following relative values of masking brightness:

Green = 100 per cent
Red = 49 per cent
Blue = 3.1 per cent.

These values are applicable in determining the proportions of the red and the green signals to be used in making the mixed-highs signal. Specifically, the red and the green signals should be added in the proportions of 49 and 100 per cent, respectively, and then those highs above 40 per cent of the top frequency should be selected by a band-pass filter.

The correctness of this application of the data can be tested by considering the response of an abrupt transition from a green area of 49-per cent brightness to a red area of 100-per cent brightness. The green signal would have a downward or negative step of 49 per cent, and the red signal would have an upward or positive step of 100 per cent. In the mixed-highs circuits, these steps are multiplied by the factors 1.0 and 0.49, respectively, making their amplitudes equal. Since these steps have opposite polarities, the net mixed-highs component for this subject would be zero. This is the desired value since the tests showed that for adjacent green and red areas of these relative brightnesses, the eye is least able to observe the abruptness of the junction and, hence, no response is needed above 40 per cent of the top frequency.

At the receiver the mixed highs could ideally be applied to either the green or the red kinescope, or to both in equal or in unequal ratios. However, a given amount of highs added to the red kinescope is only 49 per cent as effective as the same amount applied to the green kinescope. In order to make the reproduction correct in regard to the total amplitude of highs, the "net effective gain" of the mixed-highs channel, from the light in the scene to light in the reproduced color picture, should be the same as the low-frequency gain in one of the color chains.[5] "Net effective gain," in this case, would be expressed by the ratio:

$$\frac{\text{(green high-frequency light output)} + 0.49\ \text{(red high-frequency light output)}}{\text{(green high-frequency light input)} + 0.49\ \text{(red high-frequency light input)}}$$

It should be remembered that each light value is expressed in per cent of the light of that color which is contained in subjective white light.

V. Effect of Nonlinearity in Kinescopes

Figure 5 shows the waves generated in a system with mixed green and red highs, sketched by inspection. It is assumed that the scene being scanned has 16 areas of various colors as shown by the strip at the top of the figure. The wave marked G is the output of the green pickup device having response out to 4 Mc with ideal phase. The wave marked G_L is the same signal with its response limited to 2 Mc. The green highs wave G_H is the difference between G and the green lows G_L. Likewise the waves R, R_L, R_H, B, and B_L are the corresponding red and blue signals. No use is made of the blue highs. For the sake of simplicity, the different "masking" brightness of the green and red lights and their different treatments were ignored in these curves. Therefore the mixed-highs signal is one half of the sum of waves G_H and R_H and is indicated by wave M_H. This wave is added to the green lows G_L and red lows R_L to make waves $(G_L + M_H)$ and $(R_L + M_H)$ which are the green and red kinescope signals, respectively. Careful comparison of these waves to the subject strip shows the nature of the picture produced by the mixed-highs system. The sum (not shown) of the waves $(G_L + M_H)$ and $(R_L + M_H)$ is equal to the sum of waves G and R. Therefore, if the kinescopes were entirely linear in brightness output versus input signal voltage, the picture would have correct

[5] A condition for color fidelity is that the low-frequency net gain is the same for each color.

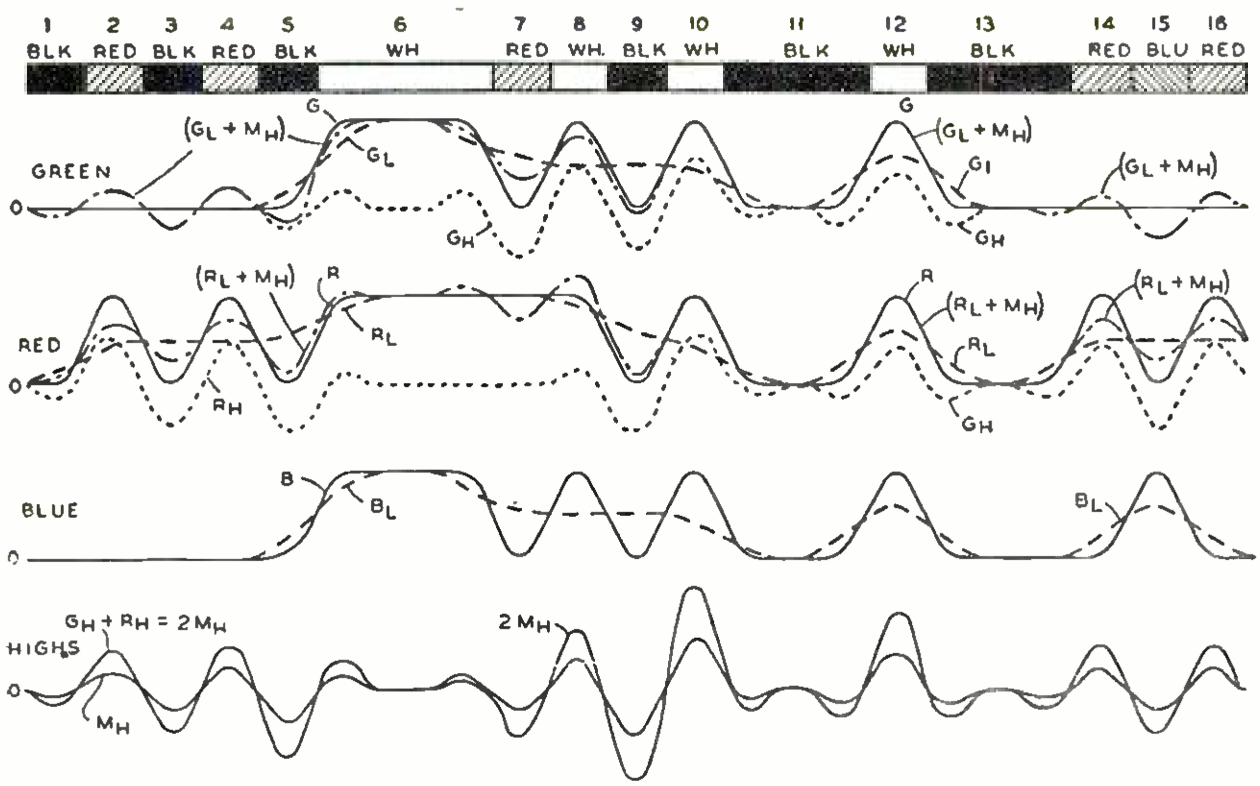


Fig. 5—Signal wave shapes in system using mixed green and red highs.

brightness in all areas up to 4 Mc. It will be noted that some of the curves showing the composite kinescope signal, such as $(G_L + M_H)$, for example, swing slightly below the zero level for certain types of picture subject. For this signal to be properly reproduced in light, the kinescope would have to generate negative light at these times. This is impossible. The kinescope characteristic could be substantially linear for upward swings of light ouput but it must be nonlinear at cutoff. Actually it is preferred that the kinescope have a logarithmic relation between the signal voltage and the light output in order to minimize the visibility of noise in the signals. This relation, which is easily approximated in commercial kinescopes is implied in the standards for black-and-white television transmission.

Circuits have been developed for use at the transmitter that precompensate for these effects of nonlinearity of the kinescope upon the mixed-highs reproduction. The precompensating circuit generates new low-frequency signals and new high-frequency signals as a result of the combined signal being applied to nonlinear circuits that are complementary to the kinescope characteristics. Tests with these precompensating circuits in a simultaneous color television system have indicated that they are helpful but are not necessary to a satisfactory mixed-highs system.

VI. Mixed Highs in the RCA Color Television System

The RCA color television system,[6] which employs dot multiplexing of the color signals, provides the same resolution as the standard black-and-white tele-

[6] RCA Laboratories Division, "A Six-Megacycle Compatible High-Definition Color Television System," *RCA Rev.*, Vol. 10, p. 504; December, 1949.

vision system within the same 4-Mc video bandwidth. This bandwidth is only one third as much as that which would be required by conventional methods.

The use of the mixed-highs principle reduces the required bandwidth to two-thirds of that which would otherwise be needed. A second bandwidth reduction to one-half of this reduced value is obtained by dot interlacing, which allows the picture repetition rate to be reduced from 30 complete pictures per second (as used in black-and-white television) down to 15 pictures per second. The property of the eye used in this case is that very small areas of light can flash on and off at a lower rate without the eye seeing flicker than can large areas. The above two bandwidth reduction factors together provide the net reduction factor of one-third which is required.

APPENDIX C

AN AUDIENCE SURVEY CONDUCTED TO EVALUATE THE MERITS OF A PROPOSED "PREFERRED" FREQUENCY RELATIONSHIP BETWEEN THE SOUND CARRIER AND THE COLOR SUBCARRIER IN THE RCA COLOR TELEVISION SYSTEM

July, 1952

During the last few months critical observations have been made to insure that the maximum degree of compatibility will be obtained with the RCA color television system. Laboratory experiments as well as tests at night using the Channel 4 facilities of NBC in New York, had revealed a preferred frequency relationship between the sound carrier and the color subcarrier. Since the sound carrier is nominally 4.5 megacycles higher than the picture carrier and the color subcarrier is approximately 3.9 megacycles above the picture carrier, a beat between the sound carrier and the color subcarrier may exist with a frequency of approximately 600,000 cycles. On some receivers this beat becomes visible in the picture, especially if the receiver is slightly mistuned. However, if the sound carrier is spaced from the picture carrer 4.5 megacycles plus 4.5 kilocycles, the beat has a frequency of 606,375 cycles. The color subcarrier frequency is 3,898,125 cycles. The beat frequency is exactly 77 times half the line frequency. That is, 77 $\times$ 7875 equals 606,375. Thus the interference pattern, where it may exist, is interlaced to give minimum visibility.

Standard black and white receivers were placed in the recreation room of RCA Laboratories in Princeton, New Jersey. The signals were received on Channel 4 from WNBT or KE2XJV in New York. The receiving antenna was a large rhombic pointed toward New York. The Channel 4 signal was passed through a broad-band amplifier and then distributed to the receivers by separate transmission lines. A six-decibel pad was used at each receiver. The peak signal at the 75-ohm receiver termination was 1900 microvolts. Audience tests were conducted on three days: July 9, 11, and 15. The observers were selected from the non-technical staff of RCA Laboratories, including employees from the model shop, drafting, accounting, purchasing, and secretarial staffs.

1. Conditions of Test on July 9, 1952.

Figure 1 shows the arrangement of receivers and the locations of the chairs. Thirty-six observers took part in this test.

The black and white receivers were:

RCA T-120 (12")
RCA 7T112 (17")
RCA 17T151 (17") (intercarrier sound)
Zenith 21J20 (17") (intercarrier sound)
RCA TC-166 (16")
Du Mont RA-103 (12")

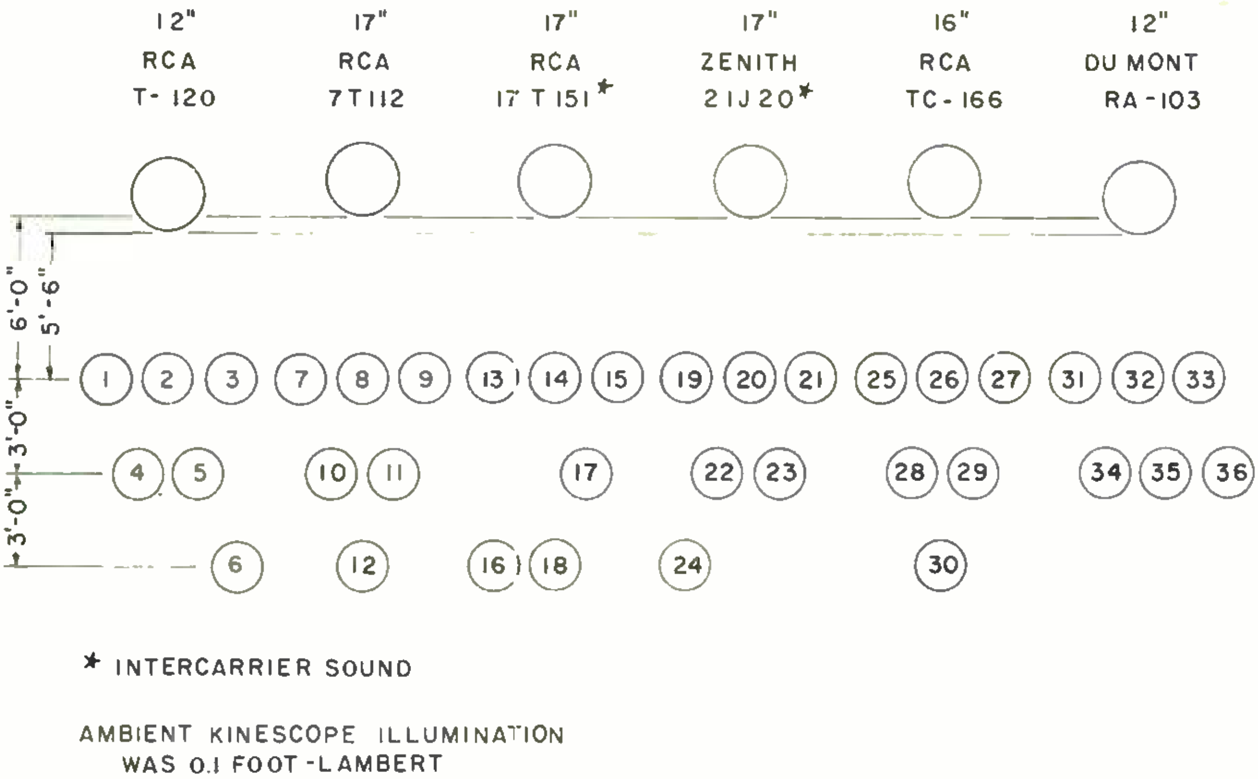


Fig. 1—Demonstration set-up, RCA Laboratories, July 9, 1952.

The ambient illumination in the room was 0.1 foot-lambert.

An introductory statement, given in Attachment 1, was made to the observers prior to the test. No explanation of the technical nature of the test was made, nor were the observers coached in any way.

The questionnaire shown in Attachment 2, with the fourth question omitted, was passed out at the conclusion of the broadcast.

On this day the sound carrier was in the preferred relationship throughout the color broadcast, that is, the separation between picture and sound carrier was 4,504,500 cycles.

2. Conditions of Test on July 11, 1952.

Figure 2 shows the arrangement of the receivers and the locations of the chairs. Thirty observers took part in this test. The questionnaire shown in Attachment 2 was used, with the fourth question omitted.

The black and white receivers were the same as used on July 9. The test was conducted in exactly the same manner as July 9. On this day, however, the sound carrier was 4,500,000 cycles from the picture carrier throughout the broadcast.

3. Conditions of Test on July 15, 1952.

Figure 3 shows the arrangement of receivers and the locations of chairs. Forty-eight observers took part in this test.

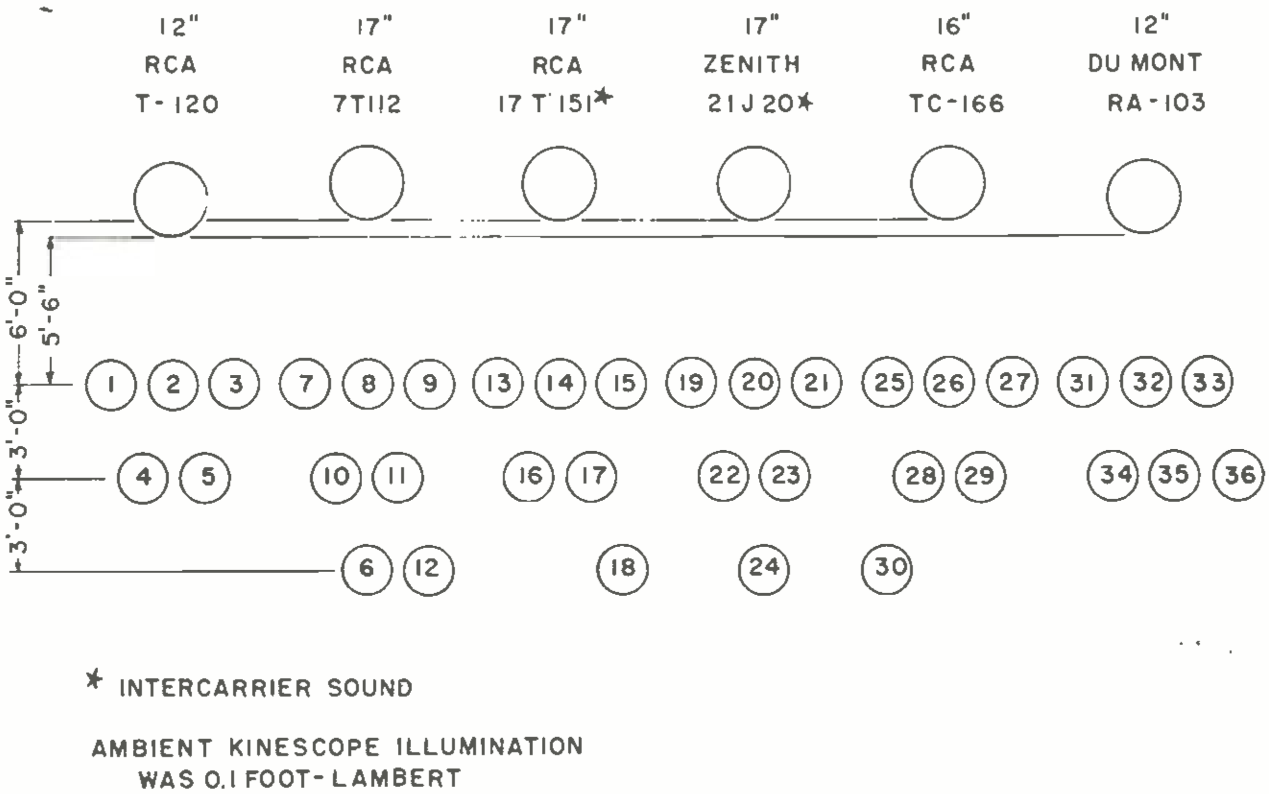


Fig. 2—Demonstration set-up, RCA Laboratories, July 11, 1952.

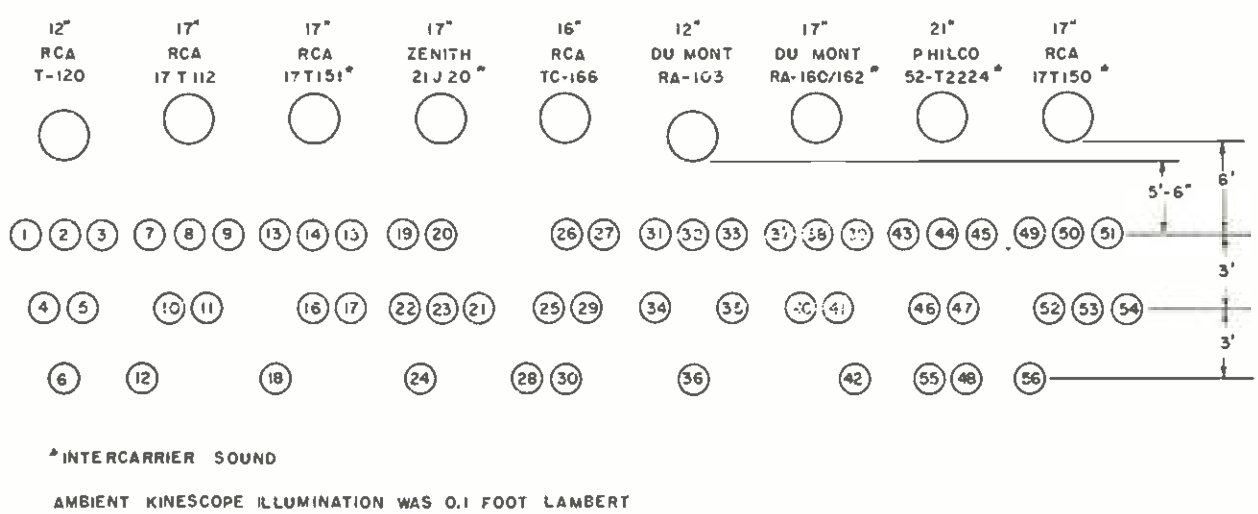


Fig. 3—Demonstration set-up, RCA Laboratories, July 15, 1952.

The black and white receivers were:

RCA T-120 (12″)
RCA 7T112 (17″)
RCA 17T151 (17″) (intercarrier sound)
Zenith 21J20 (17″) (intercarrier sound)
RCA TC-166 (16″)
Du Mont RA-103 (12″)
Du Mont RA-160/162 (17″) (intercarrier sound)
Philco 52-T2224 (21″) (intercarrier sound)
RCA 17T150 (17″) (intercarrier sound)

The complete introductory statement in Attachment 1 was used, as was the entire questionnaire shown in Attachment 2.

On this day the observers watched 15 minutes of a normal black and white broadcast, 7.5 minutes (condition "A") with the sound carrier in the preferred relationship and 7.5 minutes (condition "B") with the sound carrier in the normal position.

A summary of the answers given to the questionnaires for the three days is given in Attachment 3.

Attachment 1

Introductory Announcement at Princeton

Ladies and gentlemen, we wish to thank you for your co-operation in assisting in a field test of the RCA compatible color television system.

This morning from 9:30 to 9:45 you will see on representative black and white television receivers a program broadcast from WNBT, Channel 4, New York, on regular black and white transmission standards. From 9:45 to 10:00 A.M. you will view on these same black and white receivers black and white pictures received from experimental color television transmissions over Channel 4 of NBC's experimental television station KE2XJV in New York.

At the end of the program, you will receive questionnaires. You will be asked to compare the black and white pictures you saw during the two parts of the program, that is, those shown during the first part when the black and white pictures were received from standard black and white television signals with those shown during the second part when the black and white pictures were received from color television transmissions.

(The following additional paragraph was used during the July 15 test.)

During the color broadcasts, two conditions of transmission will be used. The first half of the color program will use condition "A"; the second half of the color program will use condition "B". You will be asked to compare the pictures you saw under the two conditions.

Attachment 2

Name.. Date...............

Seat No. ....

Television Questionnaire

Based on your observations of the television pictures you have just seen, would you please answer each of the following questions? For each question, please check one box.

1. How did the black and white reception of the color broadcast which you have just seen compare with the reception of the standard black and white broadcast you saw immediately preceding the color program?

- ☐ Much better than standard black and white
- ☐ Somewhat better than standard black and white
- ☐ About the same as standard black and white
- ☐ Somewhat poorer than standard black and white
- ☐ Much poorer than standard black and white

2. How would you rate the overall quality of the black and white pictures you saw received from the color television transmissions?

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Only fair
- ☐ Poor

3. How would you rate the clearness of the black and white pictures you saw received from the color television transmissions?

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Only fair
- ☐ Poor

4. How did the black and white pictures you saw from the color television transmissions operating under condition "A" compare with those you saw operating under condition "B"?

- ☐ "A" much better than "B"
- ☐ "A" somewhat better than "B"
- ☐ "A" about the same as "B"
- ☐ "A" somewhat poorer than "B"
- ☐ "A" much poorer than "B"

Attachment 3

Summary of Television Questionnaires for Observer Reaction Tests

RCA Laboratories, Princeton, New Jersey. July 9, 11 and 15, 1952

1. How did the black and white reception of the color broadcast which you have just seen compare with the reception of the standard black and white broadcast you saw immediately preceding the color program?

	July 9	July 11	July 15
Much better than standard black and white	4	1	3
Somewhat better than standard black and white	18	2	21
About the same as standard black and white	14	18	21
Somewhat poorer than standard black and white	0	9	3
Much poorer than standard black and white	0	0	0

2. How would you rate the overall quality of the black and white pictures you saw received from the color television transmissions?

	July 9	July 11	July 15
Excellent	7	6	2
Very good	15	8	32
Good	14	12	14
Only fair	0	3	0
Poor	0	1	0

3. How would you rate the clearness of the black and white pictures you saw received from the color television transmissions?

	July 9	July 11	July 15
Excellent	7	6	7
Very good	13	6	32
Good	14	12	9
Only fair	2	5	0
Poor	0	1	0

4. How did the black and white pictures you saw from the color television transmissions operating under condition "A" compare with those you saw operating under condition "B"?

	July 15
"A" much better than "B"	4
"A" somewhat better than "B"	25
"A" about the same as "B"	14
"A" somewhat poorer than "B"	5
"A" much poorer than "B"	0

APPENDIX D

REACTIONS TO A "PREFERRED" RELATIONSHIP BETWEEN SOUND CARRIER AND COLOR SUBCARRIER IN EXPERIMENTAL COLOR BROADCASTS

July, 1952

A REPORT PREPARED

FOR

RADIO CORPORATION OF AMERICA

BY

OPINION RESEARCH CORPORATION

Princeton, New Jersey

November 25, 1952

TABLE OF CONTENTS

Foreword

Radio Corporation of America conducted a series of experimental field tests of its color television system from 9:45 A.M. to 10 A.M. on July 9, 11 and 15, 1952.

The normal separation (4.5 megacycles) between the sound carrier and the picture carrier frequencies was employed during the second test program and during half of the third. Otherwise, a "preferred" separation (4.5 kilocycles greater than the normal separation) was used.

The purpose of the tests was to evaluate, as far as the viewing public is concerned, the effectiveness of the preferred relationship in reducing the beat resulting from the color subcarrier signal in some monochrome receivers when the normal relationship is used.

On July 9 (preferred relationship only) and July 11 (normal relationship only), viewers were asked to write in saying how the transmissions compared with regular black and white reception.

The preferred relationship was used for the first half of the July 15 test program and the normal relationship for the second half. Viewers were told that the method of transmission would be slightly different for the first and second halves, and were informed when the change took place. They were asked to write in their comments on how the reception during the first half compared with that during the second half.

No explanation of the technical aspects of the tests were given during any of the three test programs.

This report summarizes mail responses, which were received and acknowledged by RCA and given to Opinion Research Corporation for tabulation, as follows:

Test Program	*Number of Responses*
July 9	579
July 11	208
July 15	160

It is important to bear in mind that it is impossible to know to what extent those who mailed in responses are representative of all television set owners in the New York metropolitan area or to what extent they are representative of the viewers of these test programs.

PART I

The Test Situation

(Based on information furnished by RCA officials.)

1. Background

At the time of these tests, the sound carrier was normally 4.5 megacycles higher than the picture carrier, and the color subcarrier approximately 3.9 megacycles above the picture carrier. Therefore, a beat between the sound carrier and the color subcarrier may exist with a frequency of approximately 600,000 cycles. On some receivers, this beat becomes visible in the picture, especially if the receiver is slightly mistuned.

Laboratory experiments, as well as tests made late at night using Channel 4 facilities of NBC in New York, revealed a preferred frequency relationship between the sound carrier and the color subcarrier. If the sound carrier is spaced 4.5 megacycles plus 4.5 kilocycles from the picture carrier, the beat has a frequency of 606,375 cycles. The color subcarrier frequency is 3,898,125 cycles. The beat frequency is exactly 77 times half the line frequency. That is, 77 × 7875 equals 606,375. Thus the interference pattern, where it may exist, is interlaced and is of minimum visibility on receivers.

2. Purpose

The purpose of these tests was to evaluate, on the basis of responses from the viewing public, the effectiveness of the preferred relationship in reducing the visibility of the interference pattern from the color subcarrier and the sound carrier in some black and white receivers when the normal relationship (a separation of 4.5 megacycles between the sound and picture carriers) is used.

3. Test Conditions

The following table shows the separation between sound and picture carriers used on the three experimental field tests:

	Separation Between Sound and Picture Carriers
Wednesday, July 9 (9:45 to 10:00 A.M.)	Preferred (4.5 mc plus 4.5 kc)
Friday, July 11 (9:45 to 10:00 A.M.)	Normal (4.5 mc)
Tuesday, July 15 (9:45 to 10:00 A.M.)	
First half	Preferred (4.5 mc plus 4.5 kc)
Second half	Normal (4.5 mc)

4. Announcements and Program Content

Announcements relative to the tests and a brief description of the program content for each day are presented below:

a. Wednesday, July 9, 1952:

Opening Announcement

"The Radio Corporation of America and the National Broadcasting Company present color television. Ladies and gentlemen, greetings to you. This is Don Pardo speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV. You are about to view a field test of RCA's compatible all-electronic color television system. This test beginning at 9:45 this morning will be on the air for a period of fifteen minutes.

"All owners of television sets in the New York area will be able to see this color television test program in black and white. This is made possible because broadcasts with the RCA compatible color television system can be received on your black and white television sets without any changes.

"The public is cordially invited to assist us in this test by reporting how these transmissions compare with your regular black and white reception. We would appreciate it if you would send a postal card to RCA-NBC Color Television, New York 20, New York, telling us how you are receiving this test program. I repeat—please address your cards to RCA-NBC Color Television, New York 20, New York. It is important that you include your address, so that we may know if the reception varies in the areas covered. We would also appreciate it if you would report screen size, age and make of your set, whether it has an indoor or outdoor antenna, the date you saw the broadcast, and anything unusual in your reception of this test broadcast. Thank you. And now on with the show."

Program Content

Song by Connie Russell; description and demonstration of hobbies by Norman Brokenshire; a ballet, "Serenata."

Closing Announcement

"Ladies and gentlemen, you have been witnessing another field test of the RCA compatible all-electronic color television system.

"You are cordially invited to assist us by reporting how these transmissions compare with your regular black and white reception. We would appreciate it if you would send a postal card to RCA-NBC Color Television, New York 20, New York, telling us how you are receiving this test program. I repeat—please address your cards to RCA-NBC Color Television, New York 20, New York. It is important that you include your address, so that we may know if the reception varies in the areas covered. We would also appreciate it if you would report screen size, the age and make of your set, whether it has an indoor or outdoor antenna, the date you saw the broadcast, and anything unusual in your reception of this test broadcast.

"And now for the Radio Corporation of America and the National Broadcasting Company this is Don Pardo saying good-morning."

b. Friday, July 11, 1952:

Opening Announcement

"The Radio Corporation of America and the National Broadcasting Company present color television. Ladies and gentlemen, greetings to you. This is Bill Rippey speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV. You are about to view a field test of RCA's compatible all-electronic color television system. This experimental program will be on the air for the next fifteen minutes.

"Won't you assist us in this test by reporting how reception of this program compares with your regular black and white reception? Please send a postal card with your comments to RCA-NBC Color Television, New York 20, New York. It is important that you include your address, so that we may know if the reception varies in the areas covered. Also include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card July 11. Thank you."

Program Content

Song and dance by Ray Malone; description and demonstration of hobbies by Norman Brokenshire; song and dance by Ray Malone and Chris Karner.

Closing Announcement

"Ladies and gentlemen, you have been witnessing another experimental test of the RCA color television system.

"Won't you assist us by reporting how reception of this program compares with your regular black and white reception? Please send a postal card with your comments to RCA-NBC Color Television, New York 20, New York. It is important that you include your address, so that we may know if the reception varies in the areas covered. Also include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card July 11.

"And now for Radio Corporation of America and National Broadcasting Company this is Bill Rippey saying good-morning."

c. Tuesday, July 15, 1952:

Opening Announcement

"The Radio Corporation of America and the National Broadcasting Company present color television. Ladies and gentlemen, greetings to you. This is Bill Rippey speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV. You are about to view a field test of RCA's compatible all-electronic color television system. This experimental program will be on the air for the next fifteen minutes.

"The method we will use for transmission during the first half of the program will be slightly different from the method we will use during the second half of the program. We will announce when the change takes place. Won't you assist us in this test by reporting how your reception during the first half of the program compares with your reception during the second half? Please send a postal card with your comments to RCA-NBC Color Television, RCA Building, New York 20, New York. It is important that you include your address, so that we may know if the reception varies in the areas covered. Also include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card July 15. Thank you."

Program Content

Song by Connie Russell; description and demonstration of hobbies by Norman Brokenshire; Gerri Gale and Harry Jaeger.

Closing Announcement

"Ladies and gentlemen, you have been witnessing another experimental test of the RCA color television system.

"The method we used for transmission during the first half of the program was slightly different from the method we used during the second half of the program. We announced the change when it took place. Won't you assist us in this test by reporting how reception during the first half of the program compared with reception during the second half? Please send a postal card with your comments to RCA-NBC Color Television, RCA Building, New York 20, New York. It is important that you include your address, so that we may know if the reception varies in the areas covered. Also include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card July 15.

"And now for Radio Corporation of America and National Broadcasting Company this is Bill Rippey saying good-morning."

PART II

Receiver Characteristics and Geographical Location of Respondents

1. Receiver Age and Screen Size; Geographical Location of Respondents

The following tables show the age and screen size of respondents' receivers and the geographical area in which respondents live. The geographical areas shown are the service areas of Station WNBT. These are shown in detail on the map attached as Attachment 1. Area A extends approximately 25 miles from New York City on the east, north, and west and about 40-45 miles on the southwest and south. Area B extends 20-25 miles beyond Area A in all directions except to the south, where Area B goes 35-40 miles beyond Area A.

	July 9	*July 11*	*July 15*
Total respondents	*579*	*208*	*160*
Age of set:			
1952	90	26	32
1951	162	26	35
1950	146	57	37
1949	77	27	23
1948	22	25	8
1947 or earlier	6	7	2
Not reported	76	40	23
Screen size:			
12½ inches or less	178	60	50
14-17 inches	267	87	68
More than 17 inches	82	29	16
Not reported	52	32	26
Geographical area:			
Area A	456	163	123
Area B	85	24	14
Other	21	15	15
Not reported, or unclassifiable	17	6	8

2. Receiver Makes

The table below shows the makes of respondents' television sets:

	July 9	*July 11*	*July 15*
Total respondents	*579*	*208*	*160*
AMC	—	1	—
Admiral	60	21	10
Air King	1	—	—
Ambassador	1	—	—
Andrea	8	2	3
Artone	2	1	2
Arvin	—	—	1
Bendix	1	2	—
Brunswick	1	—	—
Capehart	11	3	4
Crosley	16	4	4
DeWald	1	—	—
DuMont	25	10	4
Emerson	38	11	13
Fada	—	3	3
Farnsworth	—	1	—
Freed Eiseman	2	—	1
General Electric	22	11	2
Hallicrafters	7	3	3
Hoffman	2	2	—
Hyde Park	4	1	3
Kaye-Halbert	1	—	—
Magnavox	15	2	3
Majestic	1	1	2
Mars	1	—	—
Motorola	23	9	13
Muntz	2	1	-

Receiver Makes (Cont.):

	July 9	July 11	July 15
Olympic	8	5	2
Philco	59	15	7
Pilot	3	7	—
RCA	172	47	48
Raytheon	1	—	—
Regal	—	—	1
Scott	1	—	—
Sentinel	—	1	1
Sightmaster	—	—	1
Silvertone	5	1	2
Sparton	—	—	1
Stewart-Warner	1	—	—
Stromberg-Carlson	7	3	2
Sylvania	8	5	1
Tele-King	2	5	—
Tele-Tone	2	2	2
Trad	—	—	1
Transvision	1	—	—
Trav-Ler	2	—	1
Westinghouse	9	3	3
Zenith	19	3	4
Not reported or unclassifiable	34	22	11

PART III

FINDINGS

1. SUMMARY TABLE

The table below presents a summary of the results for each of the three experimental programs.

On July 15, when the preferred and normal separations were used on the same test program, respondents gave the preferred separation a majority vote over the normal separation by a margin of about 8-to-1.

A comparison of the results for July 9, when the preferred separation was used throughout, with those for July 11, when the normal separation was used for the entire program, shows that respondents report a somewhat more favorable reaction to the preferred separation than to the normal separation, but the differences are much smaller than for the July 15 test.

These findings suggest that consistent differences in reception resulting from the two test situations under study can be noted by viewers, particularly when the test situations are presented as successive parts of the same program.

	July 15
Respondents	160
First half (preferred separation) better	58%
Second half (normal separation) better	7
No difference	25
Unclassifiable	10

	July 9 (Preferred Separation)	July 11 (Normal Separation)
Respondents	579	208
Better than regular black and white	32%	23%
Favorable comments with no mention of regular black and white	35	30
Just as good as regular black and white	26	34
Not as good as regular black and white	3	5
Unfavorable comments with no mention of regular black and white	3	3
Unclassifiable	1	5

2. DETAILED TABLES

The tables on the following pages present detailed tabulations of responses for each day's tests.

Breakdowns of responses are shown in terms of age of set, screen size, and geographical area.

For a detailed description of Areas A and B, see Part II, 1 and Attachment 1.

All tables read across.

WEDNESDAY, JULY 9, 1952 (PREFERRED SEPARATION)

		Test Program Compared with Regular Black and White					
	Respondents	*Better*	*Favorable Comments, No Mention of Regular B & W*	*Just as Good*	*Not as Good*	*Unfavorable Comments, No Mention of Regular B & W*	*Unclassifiable*
Total	579	32%	35	26	3	3	1
Age of set:							
1952	90	29%	33	30	5	2	1
1951	162	34%	37	23	3	3	0
1950	146	36%	35	23	3	3	0
1949	77	27%	40	29	1	3	0
1948 or earlier	28	32%	36	28	0	4	0
Not reported	76	28%	30	28	4	5	5
Screen size:							
12½ inches or less	178	33%	30	30	5	2	0
14-17 inches	267	33%	34	25	3	4	1
More than 17 inches	82	24%	44	23	1	5	3
Not reported	52	35%	44	15	0	4	2
Location:							
Area A	456	34%	33	26	3	3	1
Area B	85	26%	42	26	4	2	0
Other	21	24%	52	14	5	5	0
Not reported	17**						
Make of set:							
Admiral	60	33%	31	25	7	2	2
Emerson	38	26%	31	37	3	3	0
Philco	59	39%	27	30	2	2	0
RCA	172	32%	32	29	2	4	1
All others	250	30%	41	21	3	4	1

** Cases too few for analysis.

FRIDAY, JULY 11, 1952 (NORMAL SEPARATION)

		Test Program Compared with Regular Black and White					
	Respondents	*Better*	*Favorable Comments, No Mention of Regular B & W*	*Just as Good*	*Not as Good*	*Unfavorable Comments, No Mention of Regular B & W*	*Unclassifiable*
Total	208	23%	30	34	5	3	5
Age of set:							
1952	26	38%	19	35	4	0	4
1951	26	23%	23	38	12	0	4
1950	57	24%	42	30	2	0	2
1949	27	22%	37	26	0	11	4
1948 or earlier	32	25%	22	38	6	9	0
Not reported	40	13%	25	37	8	0	17
Screen size:							
12½ inches or less.	60	25%	30	30	5	5	5
14-17 inches	87	24%	30	36	6	2	2
More than 17 inches	29	34%	17	35	7	0	7
Not reported	32	9%	41	34	0	3	13
Location:							
Area A	163	23%	33	33	4	3	4
Area B	24	21%	17	42	8	4	8
All others	21	28%	24	33	5	0	10

TUESDAY, JULY 15, 1952

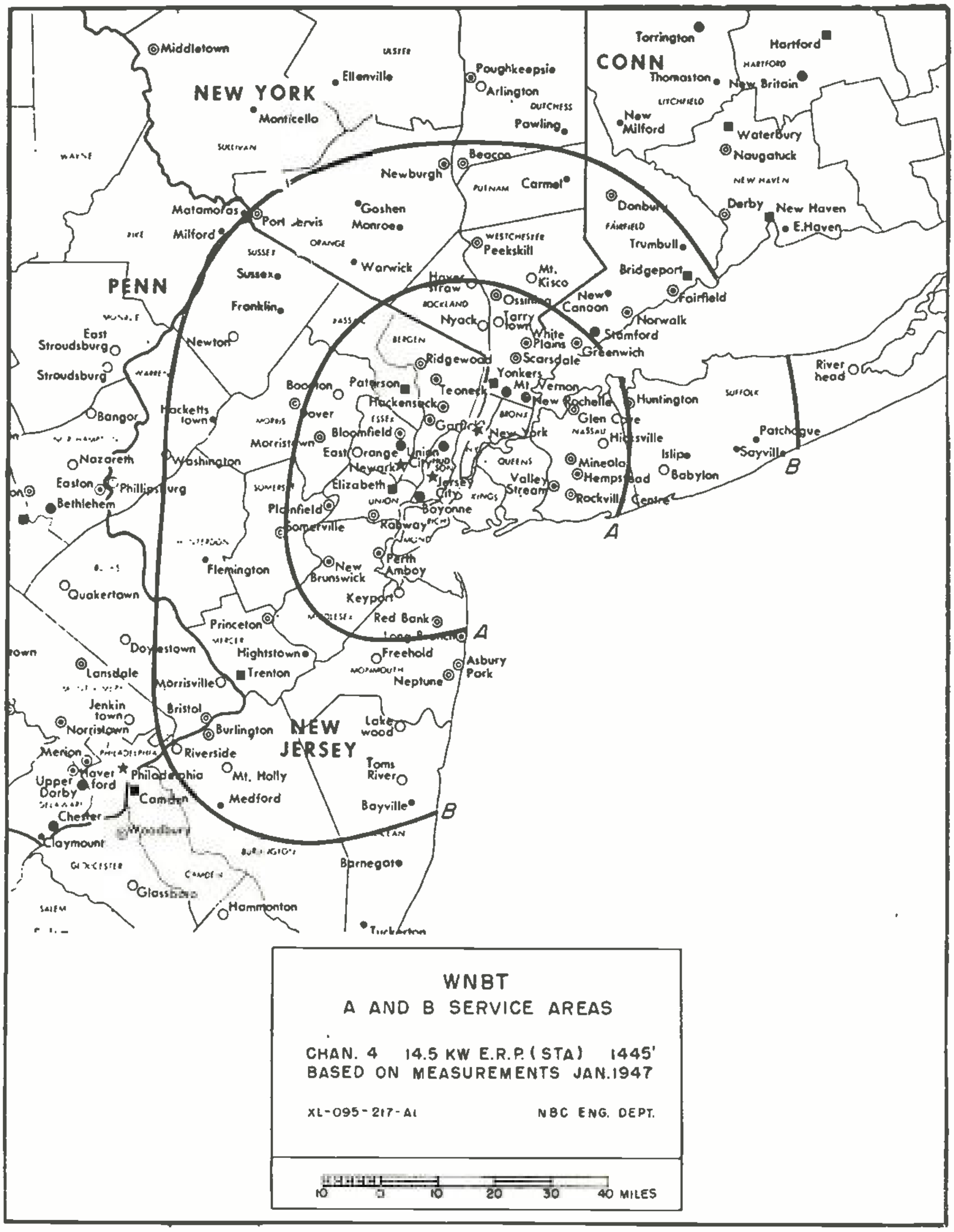
	Respondents	*First Half (Preferred Separation) Better*	*Second Half (Normal Separation) Better*	*No Difference*	*Unclassifiable*
Total	160	58%	7	25	10
Age of set:					
1952	32	66%	9	13	12
1951	35	66%	0	28	6
1950	37	51%	11	35	3
1949	23	56%	9	22	13
1948 or earlier	10**				
Not reported	23	52%	4	26	18
Screen size:					
12½ inches or less ..	50	56%	14	18	12
14-17 inches	68	62%	3	31	4
More than 17 inches.	16**				
Not reported	26	46%	4	31	19
Location:					
Area A	123	58%	6	27	9
All others	37	59%	11	16	14

** Cases too few for analysis.

PART IV

Attachment 1

Map of Station WNBT Service Areas



APPENDIX E

AN AUDIENCE SURVEY CONDUCTED TO EVALUATE THE INFLUENCE OF THE FREQUENCY OF THE SUBCARRIER AS IT RELATES TO COMPATIBILITY IN THE RCA COLOR TELEVISION SYSTEM

September, 1952

During the month of September, 1952, RCA and NBC conducted experimental field tests of the RCA color television system to evaluate the effect on black and white reception of the choice of the color subcarrier frequency. A detailed description of the test conditions, program content, and announcements are contained in a report "Reactions to Black and White Reception of Eight RCA Experimental Color Broadcasts" prepared by Opinion Research Corporation, Princeton, New Jersey. That report also contains an analysis of the replies received from the viewing audience.

To supplement the Opinion Research Corporation data, viewing tests were conducted in the recreation room of RCA Laboratories in Princeton, New Jersey. The signals were received on Channel 4 from KE2XJV (the experimental call letters of WNBT in New York). The receiving antenna was a large rhombic pointed toward New York. The Channel 4 signal was passed through a broadband amplifier and then distributed to the receivers by separate transmission lines. A six-decibel pad was used at each receiver. The peak signal at the 75-ohm receiver termination was 1900 microvolts.

The observers were selected from the non-technical staff of RCA Laboratories, including employees from the model shop, drafting, accounting, purchasing and secretarial staffs. The questionnaire used each day is included at the end of this report as Attachment 1.

Nine receivers were available for viewing. Three rows of chairs were provided, with the first row 6½ feet from the receivers, the second row 10 feet from the receivers, and the third row 13½ feet from the receivers. The viewers were asked to occupy the first two rows, but the third row was available for overflow observers who were not given questionnaires.

The receivers used for viewing were as follows:

Set No.	*Size*	*Make*	*Model*
1	17″	Crosley	EV-17 TOM
2	21″	RCA	21T176
3	17″	Emerson	727
4	17″	RCA	17T151
5	21″	Philco	52T2224
6	17″	Westinghouse	H-678R

Set No.	*Size*	*Make*	*Model*
7	17″	RCA	7-T-104
8	21″	Admiral	222 DX 16N
9	17″	RCA	17T155
	(Used only on September 16, 17, 18 and 19.)		
9	17″	DuMont	RA 160/162
	(Used only on September 24, 25, 26 and 30.)		

On September 16, three conditions of transmission were used. Standard black and white transmissions were obtained by using a monochrome camera. The color signals were obtained from color cameras each using three picture tubes, and the resulting electrical signals were encoded with a subcarrier frequency of 3.58 megacycles (3.583125) and with a subcarrier frequency of 3.89 megacycles (3.898125). It was observed during the course of the broadcast that much more thermal noise seemed to be present in the color camera than was usually the case. Hence on September 16 a very large proportion of the viewers preferred the black and white transmission, on the basis of thermal noise or snow in the picture. On September 17 and 18 black and white transmissions were obtained by disconnecting the encoders and transmitting only the brightness signal. Thus the snow was constant for the three conditions and the viewers were enabled to make judgments pertinent to the question of color subcarrier frequency.

A third color subcarrier frequency of 3.75 megacycles (3.740625) was introduced on September 17, 18 and 19.

An analysis of the viewers' replies to the questionnaires is presented below.

Date		*Conditions*		*No first*	
	No. 1	*No. 2*	*No. 3*	*choice*	*Total*
Sept. 16	44 (Mono)	1 (3.58)	3 (3.89)	6	54
Sept. 17	5 (3.89)	3 (BandW)	25 (3.75)	10	43
Sept. 18	17 (3.58)	5 (3.75)	15 (BandW)	10	47
Sept. 19	22 (3.75)	1 (3.89)	10 (3.58)	7	40
				Total....	184

For the tests of September 24, 25, 26 and 30, a camera arrangement was used which was designed to place a heavy burden on the compatibility situation. A standard black and white camera was used for all signals, thus insuring a picture relatively free from snow. To produce the simulated color picture, the output of this camera was fed into the green input and the red input of the encoders. Thus a completely yellow picture of high chroma was produced. On receivers possessing sufficient bandwidth to receive the color subcarrier, the appearance of the subcarrier was more pronounced than it would be from a normal color transmission. In the usual transmission of the RCA color television system, the color subcarrier disappears in white areas. In this simulated signal, the color subcarrier was present in full strength in the white areas.

The viewers replied to the questionnaires in the following manner:

Date		*Conditions*		*No first*	
	No. 1	*No. 2*	*No. 3*	*choice*	*Total*
Sept. 24	3 (3.58)	14 (BandW)	3 (3.89)	15	35
Sept. 25	1 (3.75)	0 (3.89)	18 (BandW)	16	35
Sept. 26	7 (3.58)	4 (3.89)	1 (3.75)	18	30
Sept. 30	9 (3.58)	2 (BandW)	4 (3.58)	7	22
				Total....	122

No clean-cut answer appeared from this survey. The rather uniform scattering over the three subcarrier frequency conditions, together with the large percentage of observers who were not able to make a choice, indicates that the subcarrier may be selected on the basis of other considerations than compatibility. It is interesting to note that 9 out of 22 observers picked the first part of the program as best on September 30, while 4 out of 22 picked the last part as best. Since both conditions were the same except for program content, it appears that the observers may have been straining to make a choice.

ATTACHMENT 1

TELEVISION QUESTIONNAIRE

Based on your observations of the television pictures you have just seen, and excluding from your consideration any differences in the quality of the sound, would you please answer each of the following questions?

1. Were you able to distinguish sufficient difference in the quality of the pictures during the three parts of the program you have just seen to give each part a different rating?

☐ Yes
☐ No

2. If the answer to Question 1 is "Yes", which part was
Best............................
Second Best.....................

3. If the answer to Question 1 is "Yes", were the pictures during the part of the program you selected as best
☐ Much better than during the other parts?
☐ Somewhat better than during the other parts?
☐ Only slightly better than during the other parts?

NAME: ....

TV SET NO. ....

DATE:

APPENDIX F

REACTIONS TO BLACK AND WHITE RECEPTION OF EIGHT RCA EXPERIMENTAL COLOR BROADCASTS

September, 1952

A REPORT PREPARED

FOR

RADIO CORPORATION OF AMERICA

BY

OPINION RESEARCH CORPORATION

Princeton, New Jersey

November 10, 1952

TABLE OF CONTENTS

Foreword

Radio Corporation of America conducted experimental field tests of its color television system from 9:45 A.M. to 10 A.M. on eight days during September, 1952 (September 16-19, 24-26 and 30).

During the test broadcasts the color subcarrier frequency was varied to determine audience reaction to the effect that this variation has on the reception of black and white pictures from RCA color television signals. Each fifteen-minute program was divided into three five-minute segments. During successive segments a different subcarrier frequency was used, or, in several cases as a further basis of comparison, a monochrome picture was broadcast.

The segments were identified for viewers only as "first condition," "second condition" and "third condition." This was done by holding up a card and making an announcement at the proper time. Viewers were asked to write in saying which of the conditions they liked best. They were also asked to include information as to the age, make and screen size of their television sets.

This report summarizes mail responses, which were received and acknowledged by RCA and given to Opinion Research Corporation for tabulation, as follows:

Test Program	*Number of Responses*
September 16	174
September 17	160
September 18	187
September 19	157
September 24	226
September 25	177
September 26	132
September 30	158

It is important to bear in mind that it is impossible to know to what extent those who mailed in responses are representative of all television set owners in the New York metropolitan area or to what extent they are representative of the viewers of these test programs.

PART I

The Test Situation

(Based on information furnished by RCA officials.)

1. Purpose

The purpose of the tests was to secure additional data on the effect which varying the subcarrier frequency has on the reception of black and white pictures from RCA color television signals.

2. Color Subcarrier Frequencies Used

The color subcarrier frequencies used were 3.58 megacycles, 3.75 megacycles and 3.89 megacycles. These three subcarrier frequencies are given as approximate values. The exact values are, in the same order, 455 times one half the horizontal scanning frequency, 475 times one half the horizontal scanning frequency, and 495 times one half the horizontal scanning frequency.

Each fifteen-minute test program was divided into three five-minute segments. During successive segments a different subcarrier frequency was used, or, in several cases as a further basis of comparison, a monochrome picture was broadcast.

On the last four days (September 24-26 and 30), monochrome cameras were used in conjunction with color encoders to generate the signal. The output of the camera was fed to the green and red inputs of the color encoder which was adjusted in accordance with the proposed standards of the National Television System Committee.

During the test broadcasts, the optimum relationship between the frequency of the color subcarrier and the unmodulated frequency of the sound carrier was maintained. This optimum relationship is such that the difference between these two frequencies is an odd multiple of one half the horizontal scanning frequency. The value of this relationship was confirmed in tests which the Federal Communications Commission authorized NBC to conduct in July, 1952.

Except as reference has been made above to changes, the recommended standards for field testing proposed by the National Television System Committee were used for color broadcasts during the tests.

The following table shows the color subcarrier frequencies used during the September tests:

	First Part	Second Part	Third Part
Tuesday, September 16 (9:45 to 10:00 A.M.)	Standard Black and White	3.58 mc	3.89 mc
Wednesday, September 17 (9:45 to 10:00 A.M.)	3.89 mc	Black and White from Color Camera	3.75 mc
Thursday, September 18 (9:45 to 10:00 A.M.)	3.58 mc	3.75 mc	Black and White from Color Camera
Friday, September 19 (9:45 to 10:00 A.M.)	3.75 mc	3.89 mc	3.58 mc
Wednesday, September 24 (9:45 to 10:00 A.M.)	3.58 mc	Standard Black and White	3.89 mc
Thursday, September 25 (9:45 to 10:00 A.M.)	3.75 mc	3.89 mc	Standard Black and White
Friday, September 26 (9:45 to 10:00 A.M.)	3.58 mc	3.89 mc	3.75 mc
Tuesday, September 30 (9:45 to 10:00 A.M.)	3.58 mc	Standard Black and White	3.58 mc

3. ANNOUNCEMENTS

The announcements relative to the tests were substantially the same for all eight test programs, except for the addition of one sentence in the closing announcements for the last six test programs (beginning September 18), as noted below:

OPENING ANNOUNCEMENT

"The Radio Corporation of America and the National Broadcasting Company present another color television test program. Ladies and gentlemen, greetings to you. This is .... speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV. You are about to view a test of RCA's all-electronic compatible color television system. This system makes it possible for you to see the color program on your present television sets in black and white.

"We would like to have you help us with this fifteen-minute test. The technical conditions under which we are broadcasting will be changed during the first, second and third parts of the program. When you see this number, Number 1 (holds up Number 1), you will know that we are using the first condition. Now — somewhere along in the program we will flash this number, Number 2 (holds up Number 2), and change the condition, and finally, we will flash this number, Number 3 (holds up Number 3), and again change the condition. We would like you to send us a card telling us how you would rate reception on your set during each of the three parts of the program. It is important that you include the age and make of your set, size of its screen and anything unusual in your reception. Please send your postcard to RCA-NBC Color Television, RCA Building, New York 20, New York, and date the card today, September ..... (Holds up Number 1 card.) We are now using the first condition. Now, on with the show —"

INTERMEDIATE ANNOUNCEMENTS

On time cue announcer enters and holds up card Number 2: "We are now broadcasting under the second condition."

On time cue announcer enters and holds up card Number 3: "We are now broadcasting under the third condition."

CLOSING ANNOUNCEMENT

"Ladies and gentlemen, you have been witnessing another experimental test of the RCA compatible color television system. As I explained to you at the beginning of the show, we used three somewhat different technical conditions of broadcasting and asked you to observe them. Now we would like you to rate each of them for us. On your card or letter just put down the numbers one, two, three and tell us which of these three conditions you liked best, next best and third best, and give us your comments. (Note: The following sentence was inserted at this point for the last six test programs, beginning with that for September 18: "If you noted no difference, please tell us that as well.")

"Please send your postcard to RCA-NBC Color Television, RCA Building, New York 20, New York. It is important that you include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card today, September .....

"We hope you will also assist us by observing different tests of the RCA color television system which we will broadcast at this same time ....

"And now for Radio Corporation of America and National Broadcasting Company, this is .... saying good morning.

"This is station KE2XJV, owned and operated by the National Broadcasting Company, and broadcasting over Television Channel Number 4. The previous period was devoted to experimental transmission."

4. PROGRAM CONTENT

The following is a summary of the program content for each of the eight tests:

Tuesday, September 16 (9:45 to 10:00 A. M.)	An educational program with Dr. Roy K. Marshall discussing how the eye sees color in nature and man's application of color in his daily life.
Wednesday, September 17 (9:45 to 10:00 A. M.)	A combined music and hobby program with Anita Ellis singing, Norman Brokenshire doing a hobby of raffia weaving and a dramatic pantomime of the Revolutionary War period.
Thursday, September 18 (9:45 to 10:00 A. M.)	A combined music and hobby program opening with Connie Russell and Jack Cassidy doing a duet, Norman Brokenshire doing a hobby of model automobiles and carriages, and the oriental dancer Mara doing a Siamese peasant dance.
Friday, September 19 (9:45 to 10:00 A. M.)	A musical revue featuring Jana Jones in a song, Cliff Norton in a comedy bit, a guitarist and a Flamenco dancer.
Wednesday, September 24 (9:45 to 10:00 A. M.)	Kukla, Fran & Ollie with the Kuklapolitan players.
Thursday, September 25 (9:45 to 10:00 A. M.)	Kukla, Fran & Ollie with the Kuklapolitan players.

Friday, September 26 (9:45 to 10:00 A. M.)	Kukla, Fran & Ollie with the Kuklapolitan players.
Tuesday, September 30 (9:45 to 10:00 A. M.)	A musical revue featuring Jack Cassidy, Sheila Bond, Patricia Marand, and Paul Valentine.

PART II

Receiver Characteristics and Geographical Location of Respondents

1. Receiver Age and Tube Size; Geographical Location of Respondents

The following tables show the age and tube size of respondents' receivers and the geographical area in which respondents live. The geographical areas shown are the service areas of Station WNBT. These are shown in detail on the map attached as Attachment 1. Area A extends approximately 25 miles from New York City on the east, north, and west and about 40-45 miles on the southwest and south. Area B extends 20-25 miles beyond Area A in all directions except to the south, where Area B goes 35-40 miles beyond Area A.

	Sept. 16	Sept. 17	Sept. 18	Sept. 19	Sept. 24	Sept. 25	Sept. 26	Sept. 30
Total respondents	174	160	187	157	226	177	132	158
Age of set:								
1952	21	32	47	25	31	27	30	34
1951	21	37	36	23	47	61	29	45
1950	56	44	49	56	61	50	39	42
1949	24	19	29	21	34	19	16	14
1948	14	10	5	12	22	11	6	3
1947 or earlier	11	2	2	4	12	0	1	3
Not reported	27	16	19	16	19	9	11	17
Tube size:								
12½ inches or less	49	37	46	45	71	51	28	53
14–17 inches	67	85	106	72	93	92	64	64
More than 17 inches	29	26	18	20	31	23	29	32
Not reported	29	12	17	20	31	11	11	9
Geographical area:								
Area A	147	139	158	134	193	159	118	136
Area B	19	12	17	12	16	12	8	11
Other	7	5	9	10	14	6	6	9
Not reported or unclassifiable	1	4	3	1	3	0	0	2

2. Receiver Makes

The table below shows the makes of respondents' television sets:

	Sept. 16	Sept. 17	Sept. 18	Sept. 19	Sept. 24	Sept. 25	Sept. 26	Sept. 30
Total respondents	174	160	187	157	226	177	132	158
Admiral	18	18	23	16	22	21	13	12
Air King	—	1	—	1	2	—	—	—
Ambassador	—	—	1	—	—	—	—	—

Receiver Makes (cont.):

	Sept. 16	Sept. 17	Sept. 18	Sept. 19	Sept. 24	Sept. 25	Sept. 26	Sept. 30
Andrea	1	—	3	1	—	1	1	4
Ansley	—	—	2	—	1	—	1	—
Artone	—	—	2	1	1	1	—	1
Arvin	—	—	—	—	—	1	—	—
Bendix	—	1	1	—	—	—	—	—
Brunswick	—	—	—	—	—	—	1	—
Capehart	1	—	2	3	4	2	2	1
Crosley	4	3	2	3	6	6	4	5
DeWald	—	—	—	—	1	—	—	—
DuMont	11	11	10	13	10	5	4	11
Electromatic	1	—	—	—	—	—	—	—
Emerson	10	10	17	8	8	4	4	7
Fada	2	—	4	3	7	1	2	1
Firestone	1	—	—	—	—	—	—	—
Freed Eiseman	1	—	—	—	2	2	1	—
General Electric	7	3	8	6	11	6	4	7
Hallicrafters	—	—	2	2	—	—	—	—
Hoffman	—	—	—	1	—	1	—	1
Hyde Park	3	7	1	1	4	1	2	6
Kaye-Halbert	—	—	1	—	—	—	1	—
Magnavox	5	2	3	3	7	9	3	7
Majestic	1	—	1	—	1	—	1	1
Mattison	—	1	—	—	—	—	—	—
Motorola	6	3	13	5	8	8	8	4
Muntz	—	—	—	—	1	1	1	2
National	—	—	—	—	—	1	—	1
Norelco	—	—	—	—	—	—	1	—
Olympic	1	2	1	3	6	2	1	3
Pathe	—	—	—	—	1	—	—	—
Philco	16	14	20	13	21	27	14	16
Philharmonic	—	1	—	—	1	—	—	1
Pilot	3	1	2	—	1	2	3	1
Plymouth	—	—	—	1	—	—	—	—
RCA	62	57	52	56	68	54	36	41
Raytheon	—	—	—	—	1	—	—	1
Regal	1	—	—	—	4	—	2	—
Sentinel	—	2	—	—	—	—	—	—
Shaw	—	—	—	—	—	—	1	—
Silvertone	—	1	3	3	—	—	—	1
Sparton	1	—	—	—	1	1	—	—
Starrett	1	—	—	—	—	—	—	1
Stewart-Warner	1	—	—	—	—	—	—	—
Stromberg-Carlson	—	1	2	1	1	2	3	—
Sylvania	—	2	—	—	1	2	—	1
Tech-Master	—	—	—	—	—	—	—	1
Tele-King	1	—	—	1	4	2	1	—
Tele-Tone	2	—	—	—	—	1	1	1
Trad	1	—	—	—	—	—	—	—
Transvision	1	1	1	—	—	2	3	1
Trav-Ler	—	—	1	—	2	—	—	1
U. S. Television	—	—	—	—	—	—	—	1
Video	—	—	—	—	—	—	—	1
Videcraft	1	—	—	—	—	—	—	—
Westinghouse	3	5	2	2	4	5	1	4
Zenith	2	5	3	3	4	3	6	5
Not reported or unclassifiable	5	8	4	7	10	3	6	6

PART III

FINDINGS

1. SUMMARY TABLE

The table below presents a summary of the preferences expressed for the three segments of each of the eight test broadcasts.

Taken together these data suggest that the differences in the conditions studied are such that viewers are unable to make judgments that fall into a consistent pattern. In this connection, note the following:

> On several days, particularly the last six,* relatively large proportions fail to indicate a first preference.
>
> No one color subcarrier frequency is consistently picked as first choice. However, the subcarrier frequency of 3.89 megacycles fairly consistently makes a poorer showing than the other conditions tested.

Summary of First-Choice Preference Votes

(Table reads across.)

Date	*Total Respondents*	*First Part*	*Second Part*	*Third Part*	*No First Choice*
Sept. 16		Standard Black and White	3.58 mc	3.89 mc	
Results:	174	75%	6%	9%	10%
Sept. 17		3.89 mc	Black and White from Color Camera	3.75 mc	
Results:	160	12%	13%	58%	17%
Sept. 18		3.58 mc	3.75 mc	Black and White from Color Camera	
Results:	187	21%	9%	46%	24%
Sept. 19		3.75 mc	3.89 mc	3.58 mc	
Results:	157	52%	6%	21%	21%
Sept. 24		3.58 mc	Standard Black and White	3.89 mc	
Results:	226	25%	24%	11%	40%

* It will be recalled that for the last six test programs, the closing announcement included the following sentence which was not in the announcements for the first two programs: "If you noted no difference, please tell us that as well."

Date	*Total Respondents*	*First Part*	*Second Part*	*Third Part*	*No First Choice*
Sept. 25		3.75 mc	3.89 mc	Standard Black and White	
Results:	177	24%	11%	36%	29%
Sept. 26		3.58 mc	3.89 mc	3.75 mc	
Results:	132	25%	29%	5%	41%
Sept. 30		3.58 mc	Standard Black and White	3.58 mc	
Results:	158	30%	22%	14%	34%

2. Detailed Tables

The tables on the following pages present detailed tabulations of responses for each day's tests.

Breakdowns of responses are shown in terms of age of set, screen size and geographical area. Geographical Area A extends approximately 25 miles from New York City in all directions except the southwest and south, where it extends about 40-45 miles from New York City. (For a detailed description of this area see Attachment 1.)

All tables read across.

TUESDAY, SEPTEMBER 16, 1952

		Part of Program Voted Best			
	Respondents	Standard Black and White (First Part)	3.58 mc (Second Part)	3.89 mc (Third Part)	No First Choice
Total	174	75%	6	9	10
Age of set:					
1952, 1951	42	67%	7	14	12
1950 or earlier	105	76%	6	8	10
Not reported	27	85%	4	7	4
Screen size:					
12½ inches or less ..	49	78%	8	6	8
14-17 inches	67	72%	6	12	10
More than 17 inches.	29	76%	3	7	14
Not reported	29	79%	4	10	7
Location:					
Area A	147	76%	5	10	9
All others	27	70%	7	8	15

WEDNESDAY, SEPTEMBER 17, 1952

	Respondents	Part of Program Voted Best: 3.89 mc (First Part)	Black and White from Color Camera (Second Part)	3.75 mc (Third Part)	No First Choice
Total	160	12%	13	58	17
Age of set:					
1952, 1951	69	9%	16	59	16
1950 or earlier	75	15%	12	58	15
Not reported	16**				
Screen size:					
12½ inches or less	37	11%	8	62	19
14–17 inches	85	15%	15	59	11
More than 17 inches	26	4%	8	50	38
Not reported	12**				
Location:					
Area A	139	12%	14	57	17
All others	21	14%	5	62	19

THURSDAY, SEPTEMBER 18, 1952

	Respondents	Part of Program Voted Best: 3.58 mc (First Part)	3.75 mc (Second Part)	Black and White from Color Camera (Third Part)	No First Choice
Total	187	21%	9	46	24
Age of set:					
1952, 1951	83	19%	7	47	27
1950 or earlier	85	22%	12	47	19
Not reported	19**				
Screen size:					
12½ inches or less	46	28%	9	48	15
14–17 inches	106	21%	9	44	26
More than 17 inches	18**				
Not reported	17**				
Location:					
Area A	158	21%	9	45	25
All others	29	24%	7	48	21

** Cases too few for analysis.

FRIDAY, SEPTEMBER 19, 1952

	Respondents	Part of Program Voted Best: 3.75 mc (First Part)	3.89 mc (Second Part)	3.58 mc (Third Part)	No First Choice
Total	157	52%	6	21	21
Age of set:					
1952, 1951	48	48%	8	23	21
1950 or earlier	93	56%	5	18	21
Not reported	16**				
Screen size:					
12½ inches or less ..	45	51%	5	22	22
14–17 inches	72	60%	4	18	18
More than 17 inches.	20	25%	15	30	30
Not reported	20	55%	10	20	15
Location:					
Area A	134	54%	6	20	20
All others	23	43%	9	26	22

WEDNESDAY, SEPTEMBER 24, 1952

	Respondents	Part of Program Voted Best: 3.58 mc (First Part)	Standard Black and White (Second Part)	3.89 mc (Third Part)	No First Choice
Total	226	25%	24	11	40
Age of set:					
1952, 1951	78	19%	17	12	52
1950 or earlier	129	26%	28	11	35
Not reported	19**				
Screen size:					
12½ inches or less ..	71	34%	27	10	29
14–17 inches	93	22%	20	10	48
More than 17 inches.	31	16%	20	19	45
Not reported	31	23%	32	10	35
Location:					
Area A	193	25%	27	11	37
All others	33	21%	6	12	61

** Cases too few for analysis.

THURSDAY, SEPTEMBER 25, 1952

	Respondents	3.75 mc (First Part)	3.89 mc (Second Part)	Standard Black and White (Third Part)	No First Choice
		Part of Program Voted Best			
Total	177	24%	11	36	29
Age of set:					
1952, 1951	88	25%	11	33	31
1950 or earlier	80	24%	11	40	25
Not reported	9**				
Screen size:					
12½ inches or less ..	51	27%	12	30	31
14–17 inches	92	25%	12	37	26
More than 17 inches.	23	17%	13	31	39
Not reported	11**				
Location:					
Area A	159	21%	12	38	29
All others	18**				

** Cases too few for analysis.

FRIDAY, SEPTEMBER 26, 1952

	Respondents	3.58 mc (First Part)	3.89 mc (Second Part)	3.75 mc (Third Part)	No First Choice
		Part of Program Voted Best			
Total	132	25%	29	5	41
Age of set:					
1952, 1951	59	19%	34	7	40
1950 or earlier	62	31%	27	5	37
Not reported	11**				
Screen size:					
12½ inches or less ..	28	29%	21	4	46
14–17 inches	64	20%	31	8	41
More than 17 inches.	29	24%	38	3	35
Not reported	11**				
Location:					
Area A	118	24%	30	6	40
All others	14**				

** Cases too few for analysis.

TUESDAY, SEPTEMBER 30, 1952

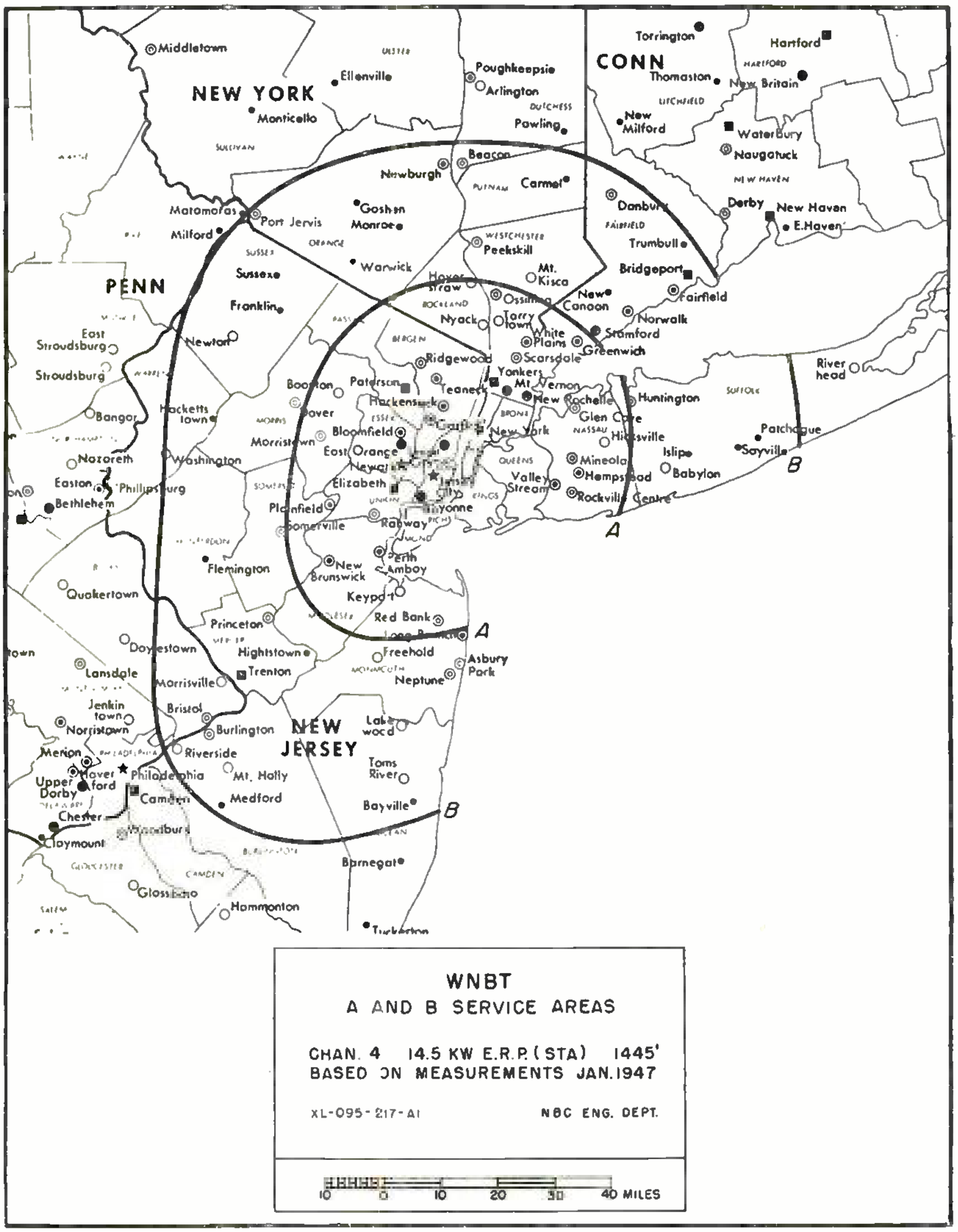
	Respondents	Part of Program Voted Best: 3.58 mc (First Part)	Standard Black and White (Second Part)	3.58 mc (Third Part)	No First Choice
Total	158	30%	22	14	34
Age of set:					
1952, 1951	79	29%	23	15	33
1950 or earlier	62	31%	23	11	35
Not reported	17**				
Screen size:					
12½ inches or less ..	53	34%	26	13	27
14–17 inches	64	26%	16	17	41
More than 17 inches.	32	31%	35	3	31
Not reported	9**				
Location:					
Area A	136	29%	22	14	35
All others	22	36%	23	14	27

** Cases too few for analysis.

PART IV

ATTACHMENT 1

MAP OF STATION WNBT SERVICE AREAS



APPENDIX G

REACTIONS TO BLACK AND WHITE RECEPTION OF SIX RCA EXPERIMENTAL COLOR BROADCASTS

November, 1952

A REPORT PREPARED

FOR

RADIO CORPORATION OF AMERICA

BY

OPINION RESEARCH CORPORATION

Princeton, New Jersey

January 5, 1953

TABLE OF CONTENTS

FOREWORD

Radio Corporation of America and the National Broadcasting Company, Inc. conducted experimental field tests of the RCA color television system on six days during November, 1952 (November 13, 14, 18, 19, 25 and 26). Broadcast time was 10:00-10:15 A. M. for the first four of these days and 9:45-10:00 A. M. for the last two.

On all six days the test broadcasts were divided into three five-minute segments. Each of the following was employed during one five-minute segment each day:

Color subcarrier frequency of 3.89 megacycles
Color subcarrier frequency of 3.58 megacycles with modifications
Black and white from color camera

RCA engineers have devised and tested certain modifications in the way color information is modulated on the subcarrier. The purpose of the tests was to evaluate, on the basis of responses from the viewing public, the effect that these modifications have on the reception of black and white pictures from RCA color television signals.

The segments were identified for viewers only as "first condition," "second condition" and "third condition." This was done by holding up a card and making an announcement at the proper time. Viewers were asked to write in saying which of the conditions they liked best. They were also asked to include information as to the age, make and screen size of their television sets.

This report summarizes mail responses, which were received and acknowledged by RCA or NBC and given to Opinion Research Corporation for tabulation, as follows:

Test Program	*Number of Responses*
November 13	132
November 14	91
November 18	109
November 19	124
November 25	130
November 26	106

It is important to bear in mind that it is impossible to know to what extent those who mailed in responses are representative of all television set owners in the New York metropolitan area or to what extent they are representative of the viewers of these test programs.

PART I

THE TEST SITUATION

(Based on information furnished by RCA officials)

1. TEST CONDITIONS

The fifteen-minute test programs were divided into three five-minute segments. Each of the following was employed during one segment of all test programs:

Color subcarrier frequency of 3.89 megacycles

Color subcarrier frequency of 3.58 megacycles with modifications

Black and white from color camera

The order in which these conditions occurred was varied from day to day.

The operations with 3.89 megacycles were in accordance with the standards proposed by the National Television System Committee.

The "preferred" separation of sound and picture carriers employed in the July, 1952 test broadcasts was used throughout these tests. This separation is such that the sound carrier is spaced 4.5 mc plus 4.5 kc from the picture carrier.

RCA engineers have devised and tested in the laboratory certain modifications with respect to the way in which color information is modulated on the subcarrier. The color information is encoded on the subcarrier by a method whereby the two branches of the encoder produce signals of unequal bandwidths. This is done in an effort to take further advantage of the psycho-physiological characteristics of the human eye. These modifications were in effect during the test operations with 3.58 megacycles.

The following table shows the technical conditions and subcarrier frequencies used during the November tests:

	First Part	Second Part	Third Part
Thursday, November 13 (10:00-10:15 A.M.)	3.89 mc	Black and White from Color Camera	3.58 mc with Modifications
Friday, November 14 (10:00-10:15 A.M.)	3.58 mc with Modifications	3.89 mc	Black and White from Color Camera
Tuesday, November 18 (10:00-10:15 A.M.)	Black and White from Color Camera	3.58 mc with Modifications	3.89 mc
Wednesday, November 19 (10:00-10:15 A.M.)	3.58 mc with Modifications	Black and White from Color Camera	3.89 mc
Tuesday, November 25 (9:45-10:00 A.M.)	3.89 mc	Black and White from Color Camera	3.58 mc with Modifications
Wednesday, November 26 (9:45-10:00 A.M.)	3.58 mc with Modifications	3.89 mc	Black and White from Color Camera

2. Purpose

The purpose of the tests was to secure data on public reaction regarding the effect that the modifications described above have on the reception of black and white pictures from RCA color television signals.

3. ANNOUNCEMENTS

The announcements relative to the tests were substantially the same for all six test programs:

OPENING ANNOUNCEMENT

"The Radio Corporation of America and the National Broadcasting Company present another color television test program. Ladies and gentlemen, greetings to you. This is .... speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV. You are about to view a test of RCA's all-electronic compatible color television system. This system makes it possible for you to see the color program on your present television sets in black and white.

"We would like to have you help us with this fifteen-minute test. The technical conditions under which we are broadcasting will be changed during the first, second and third parts of the program. When you see this number, Number 1 (holds up Number 1), you will know that we are using the first condition. Now — somewhere along in the program we will flash this number, Number 2 (holds up Number 2), and change the condition, and finally, we will flash this number, Number 3 (holds up Number 3), and again change the condition. We would like you to send us a card telling us how you would rate reception on your set during each of the three parts of the program. It is important that you include the age and make of your set, size of its screen and anything unusual in your reception. If you didn't see any difference, please let us know that too. Please send your postcard to RCA-NBC Color Television, RCA Building, New York 20, New York, and date the card today, November ... (Holds up Number 1 card.) We are now using the first condition."

INTERMEDIATE ANNOUNCEMENTS

On time cue announcer enters and holds up card Number 2: "Now we are in condition 2."

On time cue announcer enters and holds up card Number 3: "Now we are in condition 3."

CLOSING ANNOUNCEMENT

"Ladies and gentlemen, you have been witnessing another experimental test of the RCA compatible color television system. As I explained to you at the beginning of the show, we used three somewhat different technical conditions of broadcasting and asked you to observe them. Now we would like you to rate each of them for us. On your card or letter just put down the numbers one, two, three and tell us which of these three conditions you liked best, next best and third best, and give us your comments. If you noted no difference, please tell us that as well.

"Please send your postcard to RCA-NBC Color Television, RCA Building, New York 20, New York. It is important that you include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card today, November .....

"We hope you will also assist us by observing different tests of the RCA color television system which we will broadcast at this same time ....

(*Note:* This sentence was omitted on November 26.)

"And now for the Radio Corporation of America and the National Broadcasting Company, this is .... saying good morning.

"This is station KE2XJV, owned and operated by the National Broadcasting Company, and broadcasting over Television Channel Number 4. The previous period was devoted to experimental transmission."

4. Program Content

The following is a summary of the program content for each of the six tests:

Thursday, November 13 (10:00 — 10:15 A. M.)	A musical comedy based on the story of the announcer, Ben Grauer, wanting to own a farm. The cast included Connie Russell, Ray Malone and the Paulette sisters.
Friday, November 14 (10:00 — 10:15 A. M.)	A musical comedy based on the current football season with Norman Brokenshire acting as a football coach. Other members of the cast were: Dick Kallman, Ray Malone and Dorothy Love.
Tuesday, November 18 (10:00 — 10:15 A. M.)	A magic show with magician Jimmy Jimae. Songs and dances by Betty Ann Grove and Ray Malone.
Wednesday, November 19 (10:00 — 10:15 A. M.)	A musical comedy based on a western theme, with Cliff Norton as master of ceremonies. The cast included the Paulette sisters and a ballet featuring Howard Ford and Rain Winslow.
Tuesday, November 25 (9:45 — 10:00 A. M.)	A musical revue in song and dance dealing with the history of popular music. In the cast: Ray Malone, Cliff Norton, Betty Ann Grove and the Paulette sisters.
Wednesday, November 26 (9:45 — 10:00 A. M.)	A musical revue with a Spanish gypsy theme, featuring Anita Ellis, Dick Kallman, Mary Heath and Rain Winslow.

PART II

Receiver Characteristics and Geographical Location of Respondents

1. Receiver Age and Screen Size; Geographical Location of Respondents

The following tables show the age and screen size of respondents' receivers and the geographical area in which respondents live. The geographical areas shown are the service areas of Station WNBT. These are shown in detail on the map attached as Attachment 1. Area A extends approximately 25 miles from New York City on the east, north and west and about 40-45 miles on the southwest and south. Area B extends 20-25 miles beyond Area A in all directions except to the south, where Area B goes 35-40 miles beyond Area A.

	Nov. 13	Nov. 14	Nov. 18	Nov. 19	Nov. 25	Nov. 26	Total
Total respondents	132	91	109	124	130	106	692
Age of set:							
1952	22	18	20	23	20	20	123
1951	23	14	15	20	16	12	100
1950	35	29	23	31	46	29	193
1949	16	11	23	24	25	15	114
1948	17	5	10	8	12	10	62
1947 or earlier	3	4	7	7	3	4	28
Not reported	16	10	11	11	8	16	72
Screen size:							
12½ inches or less	35	26	36	36	33	31	197
14-17 inches	55	45	45	55	62	52	314
More than 17 inches	24	11	16	21	27	13	112
Not reported	18	9	12	12	8	10	69
Geographical area:							
Area A	108	77	87	92	112	84	560
Area B	17	9	12	14	18	12	82
Other	6	5	8	14	—	9	42
Not reported, or unclassifiable	1	—	2	4	—	1	8

2. Receiver Makes

The table below shows the makes of respondents' television sets:

	Nov. 13	Nov. 14	Nov. 18	Nov. 19	Nov. 25	Nov. 26	Total
Total respondents	132	91	109	124	130	106	692
Admiral	9	9	5	13	14	9	59
Airline	2	—	—	—	—	—	2
Ambassador	—	1	—	—	1	—	2
Andrea	2	5	1	1	2	—	11
Artone	—	—	2	1	1	1	5
Brunswick	—	1	—	—	—	—	1
Capehart	2	2	2	3	4	1	14
Century	—	—	—	1	—	—	1
Columbia	—	—	—	1	—	—	1
Crosley	5	1	2	2	2	1	13
DeWald	—	—	—	—	1	—	1

Receiver Makes (cont.):

	Nov. 13	Nov. 14	Nov. 18	Nov. 19	Nov. 25	Nov. 26	Total
DuMont	6	4	1	6	11	9	37
Emerson	10	5	5	6	7	2	35
Fada	3	1	2	3	3	2	14
Freed Eiseman	—	—	—	—	3	—	3
General Electric	3	5	8	8	9	6	39
Hallicrafters	2	1	2	1	2	1	9
Hoffman	1	—	2	—	1	1	5
Hyde Park	1	1	2	2	—	1	7
Macy	—	—	—	—	1	—	1
Magnavox	5	1	2	—	2	4	14
Majestic	—	—	2	1	—	—	3
Meck	—	—	—	—	1	—	1
Motorola	2	4	3	4	—	3	16
Muntz	1	1	—	1	5	1	9
Olympic	3	—	5	2	1	1	12
Pathe	—	1	—	—	—	—	1
Philco	5	3	7	15	12	6	48
Philharmonic	—	—	1	—	—	—	1
Pilot	3	3	2	2	2	3	15
RCA	40	28	36	30	30	31	195
Raytheon	1	—	—	—	—	1	2
Regal	1	—	—	—	1	1	3
Sentinel	—	—	1	2	—	—	3
Shaw	—	—	—	1	—	—	1
Silvertone	—	—	1	—	—	1	2
Sparton	1	1	—	—	1	—	3
Starret	—	—	—	—	—	1	1
Stewart-Warner	1	—	—	—	—	1	2
Stromberg-Carlson	—	1	2	3	3	3	12
Sylvania	—	—	—	1	2	1	4
Tele-King	2	1	—	—	1	—	4
Tech-Master	1	—	—	—	—	—	1
Tele-Tone	2	1	1	—	—	1	5
Televista	—	—	—	—	—	1	1
Transvision	1	—	1	1	—	—	3
Trav-Ler	—	1	—	1	—	1	3
U.S. Television	1	—	—	—	—	—	1
Wanamaker	—	—	—	1	—	—	1
Westinghouse	—	1	3	4	1	2	11
Wilcox-Gay	2	—	—	—	—	—	2
Zenith	3	—	3	5	6	3	20
Not reported or unclassifiable	11	8	5	2	—	6	32

PART III

FINDINGS

1. SUMMARY TABLE

The table below presents a summary of the preferences expressed for the three segments of each of the six test broadcasts.

Considered together these findings suggest that none of the three conditions has a decisive margin—

> Only on November 25 does any condition receive a majority first-choice vote.

None of the three conditions consistently receives larger proportions of the first-choice votes than does either of the others. Relatively large proportions of the respondents fail to indicate a first preference.

Cumulative figures for each condition are as follows:

	First-Choice Preference Vote
Total respondents	692
Black and white from color camera	32%
3.89 mc	24
3.58 mc with modifications	16
No first choice	28

(Table reads across.) Summary of First-Choice Preference Votes

Date	Respondents	First Part	Second Part	Third Part	No First Choice
Nov. 13		3.89 mc	Black and White from Color Camera	3.58 mc with Modifications	
Results:	132	23%	43%	8%	26%
Nov. 14		3.58 mc with Modifications	3.89 mc	Black and White from Color Camera	
Results:	91	7%	37%	26%	30%
Nov. 18		Black and White from Color Camera	3.58 mc with Modifications	3.89 mc	
Results:	109	12%	26%	35%	27%
Nov. 19		3.58 mc with Modifications	Black and White from Color Camera	3.89 mc	
Results:	124	23%	20%	17%	40%
Nov. 25		3.89 mc	Black and White from Color Camera	3.58 mc with Modifications	
Results:	130	4%	60%	19%	17%
Nov. 26		3.58 mc with Modifications	3.89 mc	Black and White from Color Camera	
Results:	106	11%	35%	25%	29%

2. Detailed Tables

The tables on the following pages present detailed tabulations of responses.

Breakdowns of responses are shown in terms of age of set, screen size, and geographical area.

For a detailed description of Areas A and B, see Part II, 1, and Attachment 1.

All tables read across.

THURSDAY, NOVEMBER 13, 1952

	Respondents	Part of Program Voted Best: 3.89 mc (First Part)	Black and White from Color Camera (Second Part)	3.58 mc with Modifications (Third Part)	No First Choice
Total	132	23%	43	8	26
Age of set:					
1952, 1951	45	24%	36	11	29
1950 or earlier	71	24%	46	7	23
Not reported	16**				
Screen size:					
12½ inches or less.	35	17%	46	9	28
14-17 inches	55	31%	42	9	18
More than 17 inches	24	17%	42	8	33
Not reported	18**				
Location:					
Area A	108	24%	45	6	25
All others	24	21%	33	17	29

FRIDAY, NOVEMBER 14, 1952

	Respondents	Part of Program Voted Best: 3.58 mc with Modifications (First Part)	3.89 mc (Second Part)	Black and White from Color Camera (Third Part)	No First Choice
Total	91	7%	37	26	30
Age of set:					
1952, 1951	32	9%	47	9	35
1950 or earlier	49	4%	31	37	28
Not reported	10**				
Screen size:					
12½ inches or less.	26	4%	23	35	38
14-17 inches	45	4%	40	27	29
More than 17 inches	11**				
Not reported	9**				
Location:					
Area A	77	4%	39	26	31
All others	14**				

** Cases too few for analysis.

TUESDAY, NOVEMBER 18, 1952

	Respondents	Part of Program Voted Best: Black and White from Color Camera (First Part)	3.58 mc with Modifications (Second Part)	3.89 mc (Third Part)	No First Choice
Total	109	12%	26	35	27
Age of set:					
1952, 1951	35	20%	34	26	20
1950 or earlier	63	9%	19	40	32
Not reported	11**				
Screen size:					
12½ inches or less	36	11%	22	45	22
14-17 inches	45	13%	27	36	24
More than 17 inches	16**				
Not reported	12**				
Location:					
Area A	87	14%	27	30	29
All others	22	5%	18	54	23

WEDNESDAY, NOVEMBER 19, 1952

	Respondents	Part of Program Voted Best: 3.58 mc with Modifications (First Part)	Black and White from Color Camera (Second Part)	3.89 mc (Third Part)	No First Choice
Total	124	23%	20	17	40
Age of set:					
1952, 1951	43	33%	19	9	39
1950 or earlier	70	19%	23	21	37
Not reported	11**				
Screen size:					
12½ inches or less	36	20%	22	22	36
14-17 inches	55	24%	20	14	42
More than 17 inches	21	38%	14	5	43
Not reported	12**				
Location:					
Area A	92	25%	20	15	40
All others	32	19%	22	22	37

** Cases too few for analysis.

TUESDAY, NOVEMBER 25, 1952

	Respondents	Part of Program Voted Best: 3.89 mc (First Part)	Black and White from Color Camera (Second Part)	3.58 mc with Modifications (Third Part)	No First Choice
Total	130	4%	60	19	17
Age of set:					
1952, 1951	36	3%	56	22	19
1950 or earlier	86	5%	62	17	16
Not reported	8**				
Screen size:					
12½ inches or less	33	6%	61	15	18
14-17 inches	62	2%	64	21	13
More than 17 inches	27	7%	52	15	26
Not reported	8**				
Location:					
Area A	112	3%	60	20	17
All others	18**				

WEDNESDAY, NOVEMBER 26, 1952

	Respondents	Part of Program Voted Best: 3.58 mc with Modifications (First Part)	3.89 mc (Second Part)	Black and White from Color Camera (Third Part)	No First Choice
Total	106	11%	35	25	29
Age of set:					
1952, 1951	32	16%	28	31	25
1950 or earlier	58	9%	41	21	29
Not reported	16**				
Screen size:					
12½ inches or less	31	13%	35	23	29
14-17 inches	52	11%	35	25	29
More than 17 inches	13**				
Not reported	10**				
Location:					
Area A	84	11%	32	26	31
All others	22	14%	45	18	23

** Cases too few for analysis.

TOTAL FIRST-CHOICE PREFERENCE VOTES

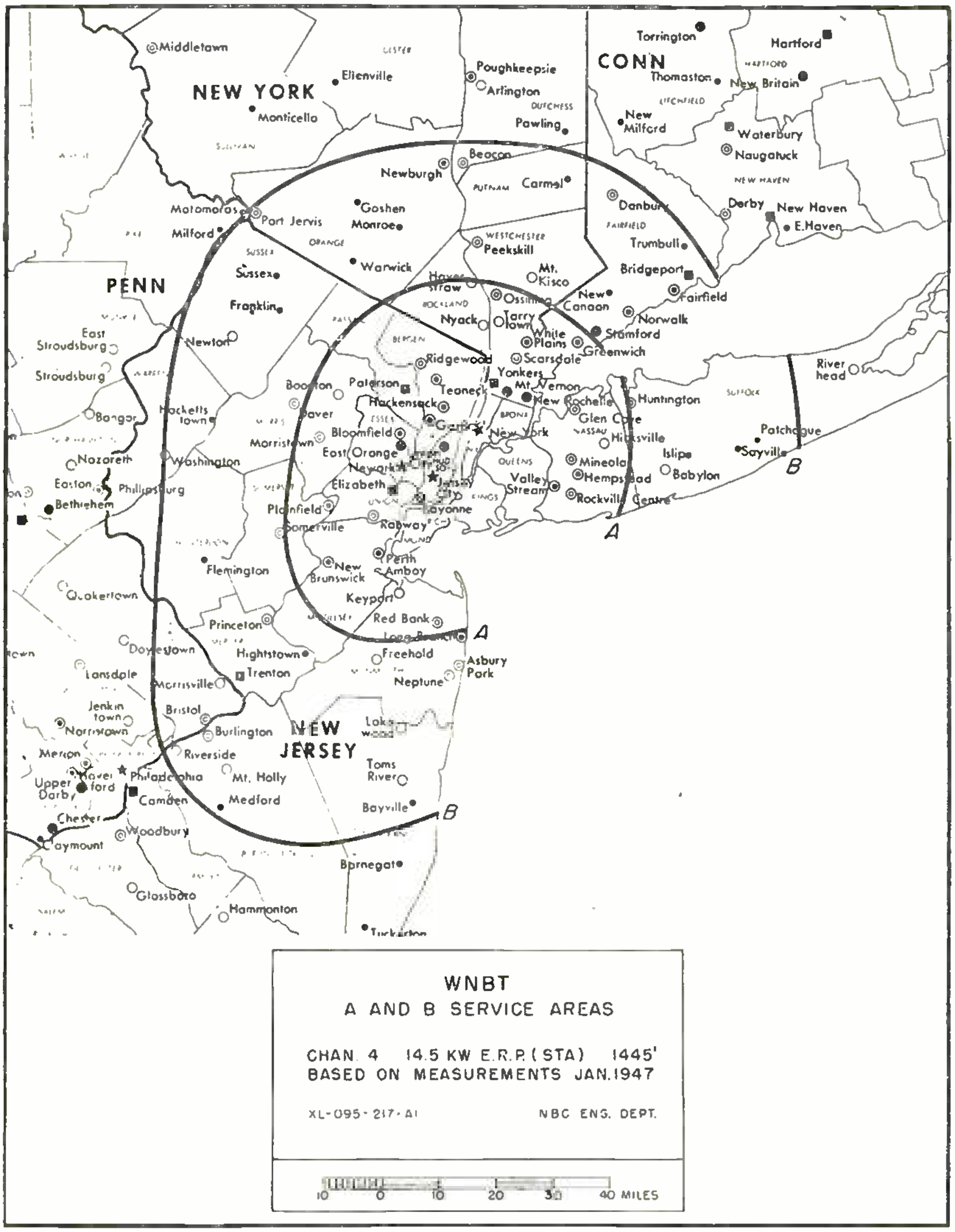
	Respond-ents	Part of Program Voted Best: 3.58 mc with Modifications	3.89 mc	Black and White from Color Camera	No First Choice
Total	692	16%	24	32	28
Age of set:					
1952	123	25%	21	27	27
1951	100	16%	23	31	30
1950	193	11%	28	35	26
1949	114	17%	24	36	23
1948	62	11%	19	34	36
1947 or earlier	28	14%	25	29	32
Not reported	72	17%	23	28	32
Screen size:					
12½ inches or less	197	14%	25	33	28
14-17 inches	314	16%	25	33	26
More than 17 inches	112	21%	17	31	31
Not reported	69	13%	29	26	32
Location:					
Area A	560	16%	23	33	28
Area B	82	17%	28	33	22
Other	42	19%	33	19	29
Not reported	8**				

** Cases too few for analysis.

PART IV

ATTACHMENT 1

MAP OF STATION WNBT SERVICE AREAS



APPENDIX H

OPTIMUM UTILIZATION OF THE RADIO FREQUENCY CHANNEL FOR COLOR TELEVISION*

BY

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Summary—This paper is a semitechnical presentation of the underlying engineering and physiological considerations which serve as the basis for a color television system utilizing the National Television System Committee (NTSC) field test signal specifications. The paper is intended to serve as an introduction to compatible color television for those engineers who are not familiar with the subject.

In order to have a proper understanding of some of the color television transmission standards now being field tested, it is well to review the basic thinking that has gone into their make-up. We can now transmit, in the radio-frequency channel allocated for monochrome television, a picture in color having practically the same detail as the present monochrome pictures. To do this we have had to make the most of our knowledge of communication engineering and a new field of study involving the subjective characteristics of normal vision.

The basic characteristics of the color television system now being field tested may be summed up as follows:

First: The signal is so arranged as to be compatible with present monochrome receivers.

Second: The signal has a minimum of redundancy.

Third: The signal make-up takes full advantage of the characteristics of vision. In order to achieve this:

(a) Three-color presentation is provided and needed in large areas.

(b) Two-color presentation along a preferred locus is provided and needed for intermediate area detail.

(c) No color information is provided or needed in small detail.

There follows a review of the manner in which these basic characteristics have been integrated into a practical color television system.

To produce a television picture in color, three video signals, each representing a different primary color, must be fed to the reproducer. There are a number of combinations of primary colors which might be used; the primaries used in the system to be described are red, green, and blue. The first signal, then, represents the detail and color content of the red components of the original scene, the second signal represents the same information relating to green, and the third signal to blue. These three signals are derived from an analysis of the

* To be published in June, 1953, issue of *RCA Review*.

red, green, and blue components of the scene being televised. The communication problem is that of transferring this information from the scene to the receiver with the greatest possible efficiency.

There are two important considerations in achieving this goal: the first relates to the transmission of the information with a minimum of redundancy, while the second is the necessity of assuring that only information useful to the eye is fed to the communication channel for transmission. Each of the red, green, and blue components of the scene to be transmitted contains brightness information as well as color information. To satisfy the requirement of compatibility, the brightness of the scene must be transmitted as amplitude modulation of the carrier in the normal way. This brightness signal is made up by adding the red, green, and blue signals in such proportions as to produce a signal representing the visual luminance of the scene. When transmitting the brightness components of the three color separations in this way, it would be redundant and a waste of communication channel to also transmit the same brightness information combined with the color information. To remove the brightness components from the color separations, the brightness signal is subtracted from each of the red, green, and blue color signals. This produces three signals representing red-minus brightness, green-minus brightness, and blue-minus brightness, which are denoted by R — Y, G — Y, and B — Y. If these three signals were transmitted to the receiver along with the brightness signal, signals corresponding to red, green, and blue could be recovered by simply adding the brightness signal to each of the three. However, the transmission of four pieces of information, when only three are required, would again represent the transmission of redundant information. The signal representing the green separation can be obtained at the receiver by subtracting the sum of the red and blue signals from the brightness signal, or by taking the sum of R — Y and B — Y to obtain — (G — Y). Therefore it is necessary to transmit only signals representing R — Y and B — Y along with the brightness signal.

Bedford[1] has pointed out that the eye can not see color in small detail, and that this property of vision may be used to advantage in a color television system. Here, then, is another opportunity to reduce the amount of information transmitted. It has been determined experimentally that the color information may be limited in band width to approximately one and one-half megacycles without the loss of information being detected by the eye. There now remains the problem of transmitting these two pieces of color information with a minimum of visibility along with the brightness signal. An advantageous arrangement for transmitting color information is the use of two carriers of the same frequency displaced in phase by 90 degrees. To generate such a signal the subcarrier voltage is divided into two parts. The first part is amplitude modulated with a signal representing R — Y and the second part is shifted in phase by 90 degrees and amplitude modulated with a signal representing B — Y. These components are then combined to form the transmitted signal. If, in the receiver, a voltage having a reference phase is available, the two signals may be detected without crosstalk,

[1] A. V. Bedford, "Mixed Highs in Color Television," *Proc. I.R.E.*, Vol. 38, p. 1003 (September, 1950).

since they are detected in quadrature. By transmitting a small sample of the subcarrier at a fixed phase during horizontal blanking time, the necessary synchronous voltage can be made readily available in the receiver for synchronous detection.

Now that we have all of the color information on a single subcarrier, the problem is to choose a subcarrier frequency which will produce a minimum of spurious signal effects in the brightness channel. One obvious way to determine this frequency is to simply look at the kinescope and change the frequency of the subcarrier until it is least visible. This occurs when the positive half cycles of the carrier, which appear as dots of light, interlace. This frequency is always an odd multiple of ½ the frame frequency and can be an odd multiple of ½ the line frequency, since line frequency is an odd multiple of frame frequency.

Another approach to the spurious signal problem is to interlace the subcarrier and its sidebands with the harmonics of frame and line frequencies. This also gives a subcarrier frequency which is an odd multiple of ½ the frame frequency. When approached from this direction it is called frequency interlace. Thus, it is apparent that frequency interlace always gives dot interlace and dot interlace always gives frequency interlace, so that both names describe the same process, the purpose of which is to reduce interference between the brightness video signal and the color subcarrier.

With the color subcarrier frequency so chosen as to have a minimum visibility, there are reasons for wishing to choose a frequency as high as may be passed by the receiver circuits and other reasons for wanting a lower frequency. The fact that the receiving kinescope is nonlinear contributes to the visibility of the subcarrier. Also, insufficient persistences of vision and the kinescope screen material contribute to the visibility of the subcarrier. For these reasons it is desirable to make the residual dot structure as fine as possible by selecting a high subcarrier frequency. The reason for wishing to choose a lower frequency will be considered in more detail.

A choice of a nominal 3.58 megacycles as a subcarrier frequency represents a balance between the various factors involved. With this carrier frequency there is .6 megacycle between the subcarrier and the end of the pass band assuming the receiver passes frequencies up to 4.2 megacycles. This means that the two signals representing color information can be transmitted in quadrature without crosstalk up to a frequency of .6 megacycle. Beyond this frequency the missing sideband causes the carrier phase to shift, introducing spurious signals into each color channel from the other. These spurious signals appear as incorrect color on the edges of objects. To prevent this crosstalk between the two color signals, one of the signals is limited to .6 megacycle. In this way the two color signals are transmitted in quadrature on the subcarrier only in the frequency range where double sideband transmission is possible. Beyond this point a single color signal is transmitted. The choice of 3.58 as a subcarrier frequency is the result of balancing the desire for reduced dot structure against the desire to transmit color signals in the range of detail where the eye can make use of the information.

Reference has been made to the signals R — Y and B — Y in quadrature on the same carrier. Obviously the carrier can have only a single instantaneous amplitude and phase—the resultant of the two color signal vectors in quadrature. In other words, the phase of the carrier actually represents color or hue information with the amplitude of the vector representing color saturation. Conversely, the single vector can be separated into other pairs of vectors at right angles to each other. By selecting pairs of vectors other than those representing R — Y and B — Y, it is possible to select, on the color triangle, various loci along which all colors are reproduced for frequencies between .6 and 1.5 megacycles.

There is considerable information in the literature indicating that the eye becomes progressively color blind as the size of the viewed object is reduced. First there is three-color vision, then two-color vision, and finally only brightness vision with no color sensation. To determine the preferred locus for the region of two-color vision, a series of tests was made using a complete color television system. The signal source was a studio camera. The viewers used were a tricolor tube and dichroic viewer using three kinescopes. The three-kinescope viewer had a highlight brightness of approximately 100 foot-lamberts which made possible critical viewing.

A series of Munsell colors covering the color gamut were viewed, each in turn superimposed on each of the others. The evaluation of the quality of the transition from one color to the other was on the basis of 10, one being excellent and 10 representing an unsatisfactory reproduction. The circuitry was so arranged that the two quadrature vector signals, one of which was limited in band width to .6 megacycle, could be made up of varying proportions of the three primary color signals. In this way the color locus for those frequencies between

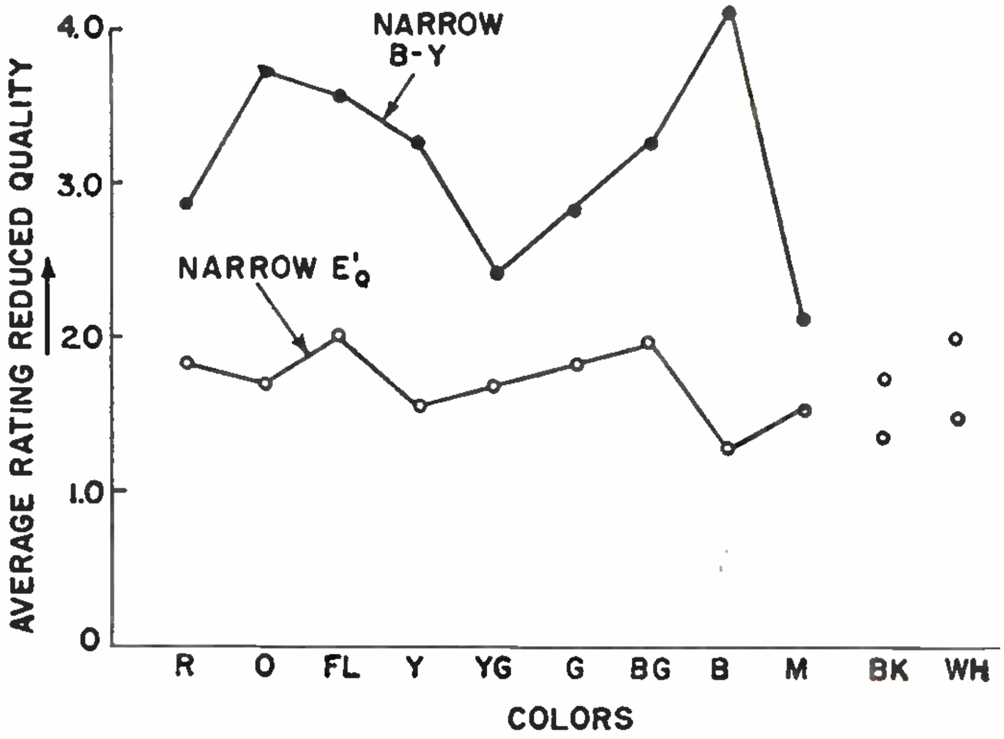

Fig. 1—Tabulation of average rating of deterioration of edges for indicated color versus all other colors for narrow band B-Y and NTSC field test signal specifications.

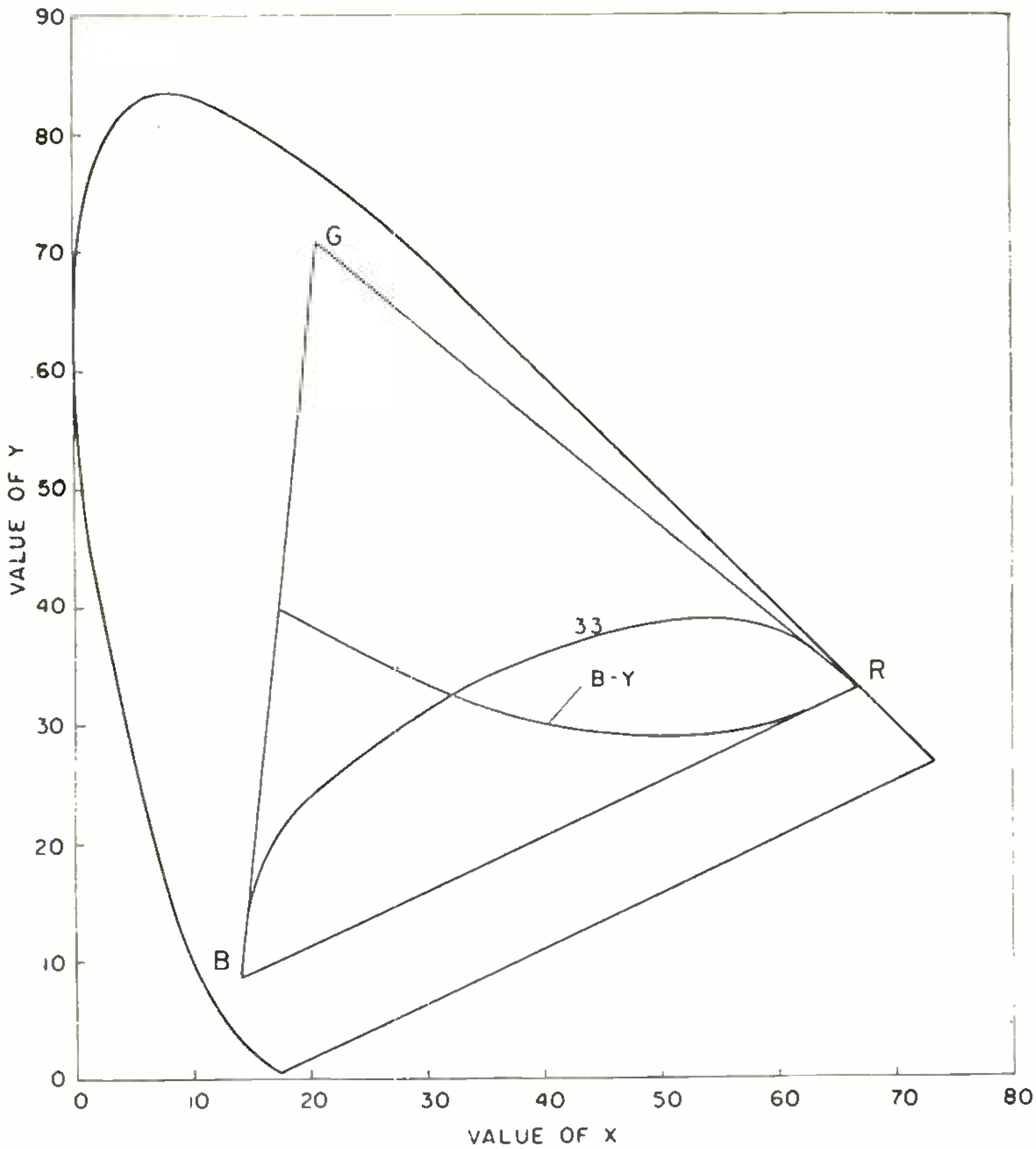

Fig. 2—Q = 0 axis for narrow-band B-Y (curve labeled "B-Y"), and Q = 0 axis for NTSC field test signal specifications (curve labeled "33").

.6 and 1.5 megacycles could be selected. As a result of the tests, a preferred pair of vectors was found approximately 33 degrees from the B — Y and R — Y pair.

The summarized data comparing this preferred pair of vectors which have been termed I and Q with R — Y and B — Y is shown in Figure 1. Here the average rating of quality of color transition from each color to all other colors is shown. It is seen that improvement is obtained on all color transitions with the greatest improvement coming in the region of flesh tones and blues.

The color locus for the limited band width of B — Y and the vector composed of color information such as to produce the Q vector, displaced 33 degrees from B — Y, is shown in Figure 2. The curvature is caused by the addition of color components to produce the desired vector after they have passed through the nonlinear circuits required for proper gamma reproduction.

With this selected choice of color vectors, a grid of transitions may be

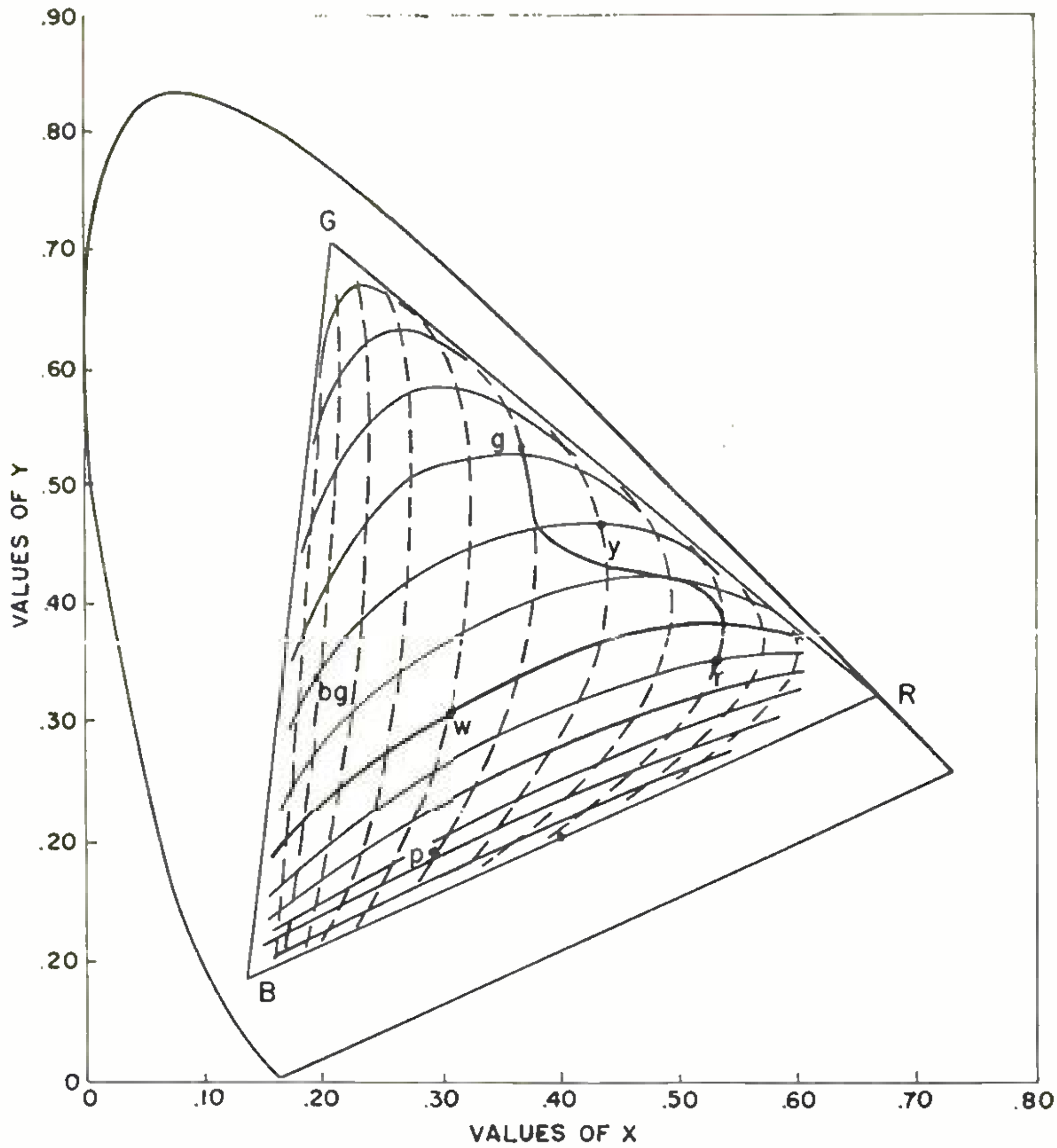

Fig. 3—Lines of constant I'/Y', and Q'/Y', for NTSC field test signal specifications showing transition between two colors.

plotted on the color triangle (Figure 3). The solid lines represent the paths taken by a color transition in the direction having a frequency response limit of 1.5 megacycles. The dotted lines represent the path taken by color transitions in the direction having a frequency response of .6 megacycle. Stated in another way, a color transition from *g* to *p* in Figure 3 would have a steepness of rise corresponding to a band pass of .6 megacycle, while a transition from *bg* to *y* would have a steepness of rise corresponding to a band pass of 1.5 megacycles. The transition from *g* to *r* would contain components of steepness passed by both the .6- and 1.5-megacycle circuits.

There is material in the literature which shows how the eye tends to have color perception only along a line locus for small color detail. For example Willmer and Wright,[2] Figure 4, were able to color match all the colors of the

[2] E. N. Willmer and W. D. Wright, "Color Sensitivity of the Fovea Centralis," *Nature*, Vol. 156, p. 119 (July 28, 1945).

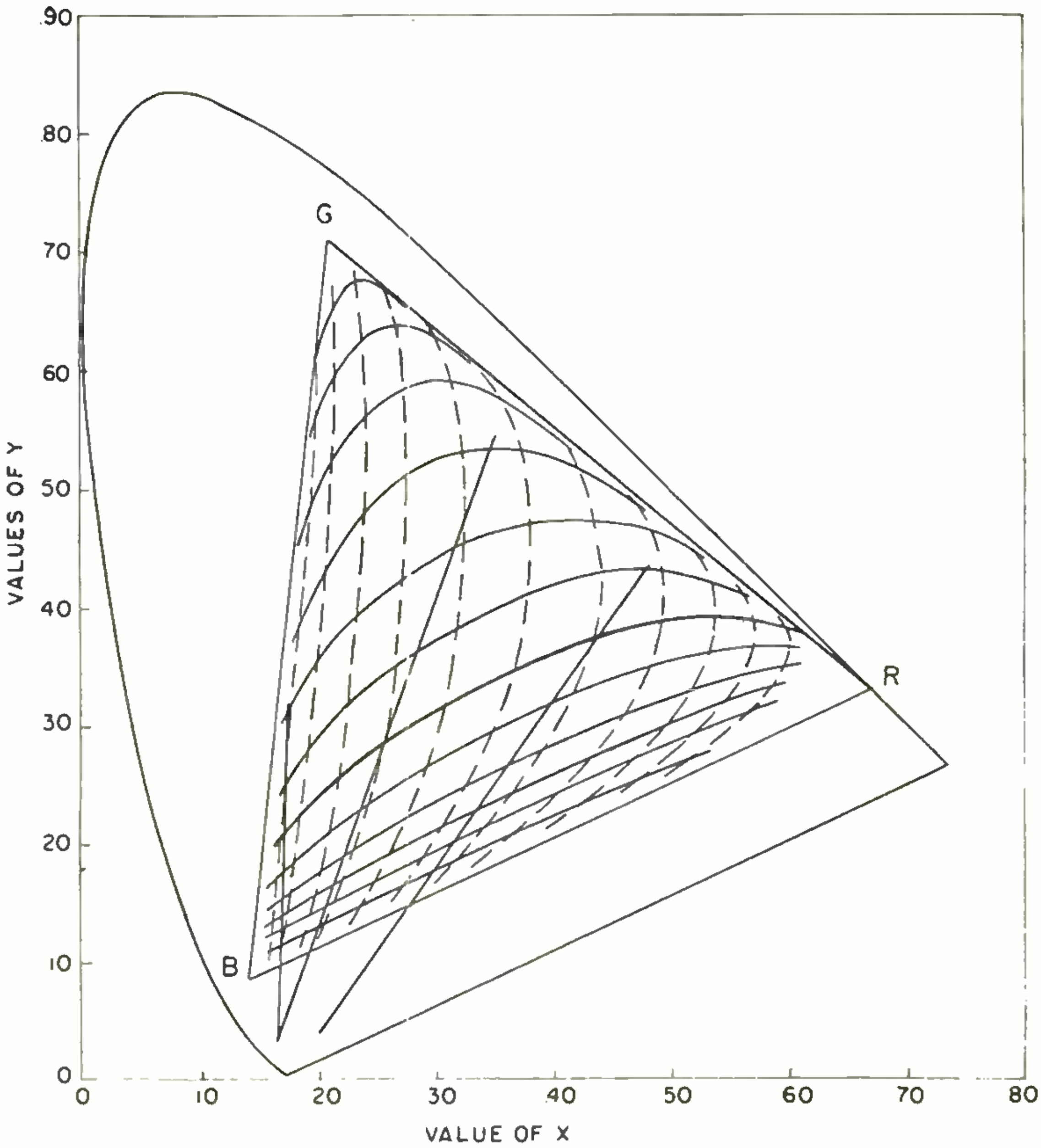

Fig. 4—Comparison of NTSC field test signal specifications with data of Wright and Willmer.

spectrum with only a blue and red light source when the object was sufficiently small. This data may be presented on the color triangle, in the form of a series of diverging lines which pass through the test colors and the color mixture which gives a match. These lines would be parallel to the locus of low frequency transitions if the correlation between the television tests and those of Willmer and Wright was perfect.

The data of Middleton and Holmes[3] is shown in Figure 5. Here may be seen the reduction of color sensitivity of the eye toward the color locus as experimentally chosen for our television system. Hartridge[4] has made similar

[3] W. E. K. Middleton and M. C. Holmes, "The Apparent Colors of Surfaces of Small Subtense—A Preliminary Report," *Jour. Opt. Soc. Amer.*, Vol. 39, p. 582 (July, 1949).

[4] H. Hartridge, "The Visual Perception of Fine Detail," *Phil. Trans. Roy. Soc.* Vol. 232, pp. 519-671 (May 15, 1947).

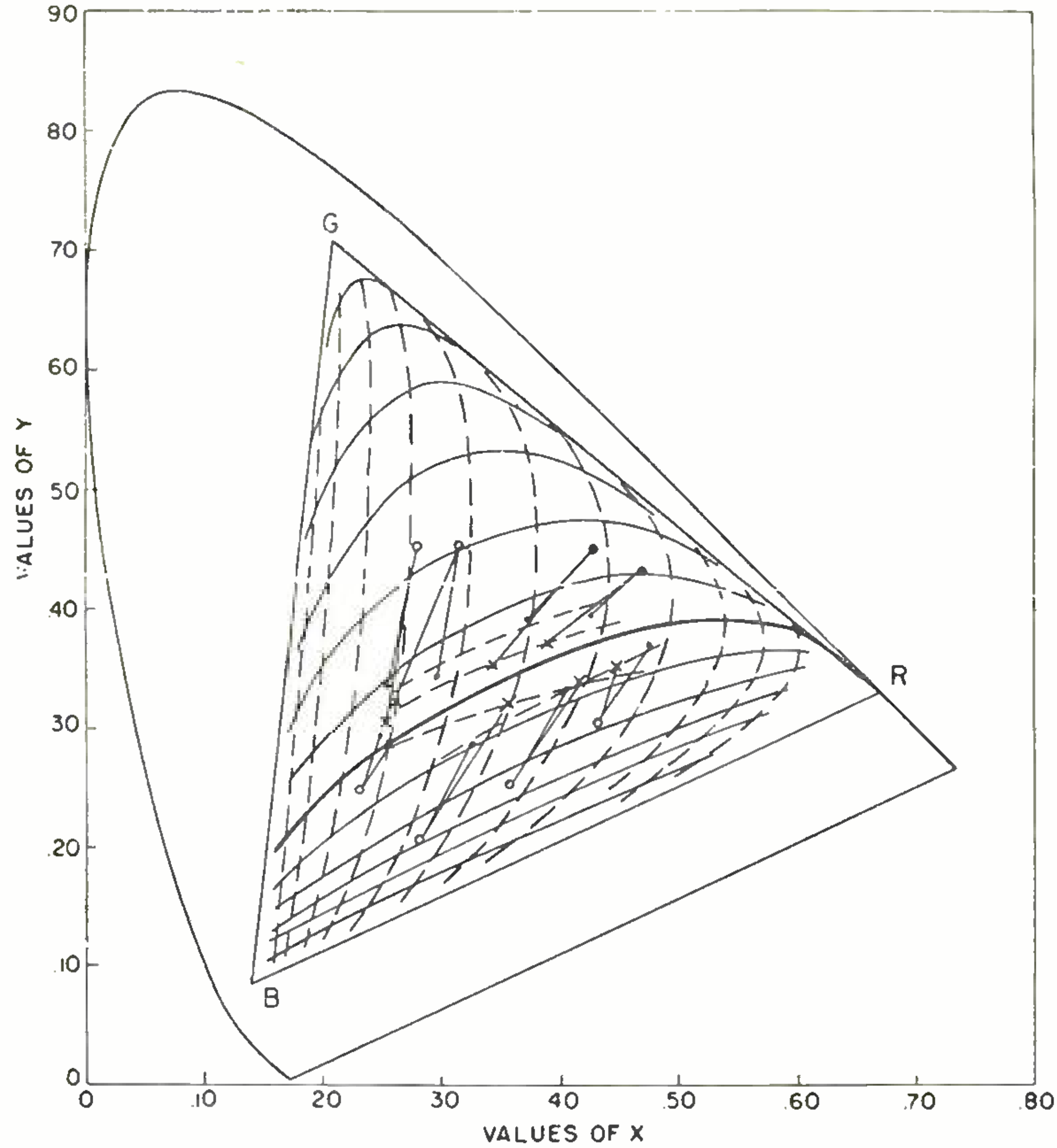

Fig. 5—Comparison of NTSC field test signal specifications with data of Middleton and Holmes.

tests on color acuity in small detail. His data is shown in Figure 6. Again the same locus is indicated.

A different approach to the selection of the wide band color locus may be based on color-photography experience. Here the assumption is that in two-color photography a color locus has been chosen as a result of experience to produce the most satisfactory result. This means that the two chosen colors are such as to approximate most closely the results obtainable with a three-color process. In other words, the difference between the two-color and three-color processes is subjectively a minimum. In this television system, this minimum difference is the information selected to be transmitted at the reduced band width.

The locus of colors as reproduced by a two-color process is shown in Figure 7. Here, again, from an entirely different approach, it is seen that the color reproduction is along the locus chosen for our television system.

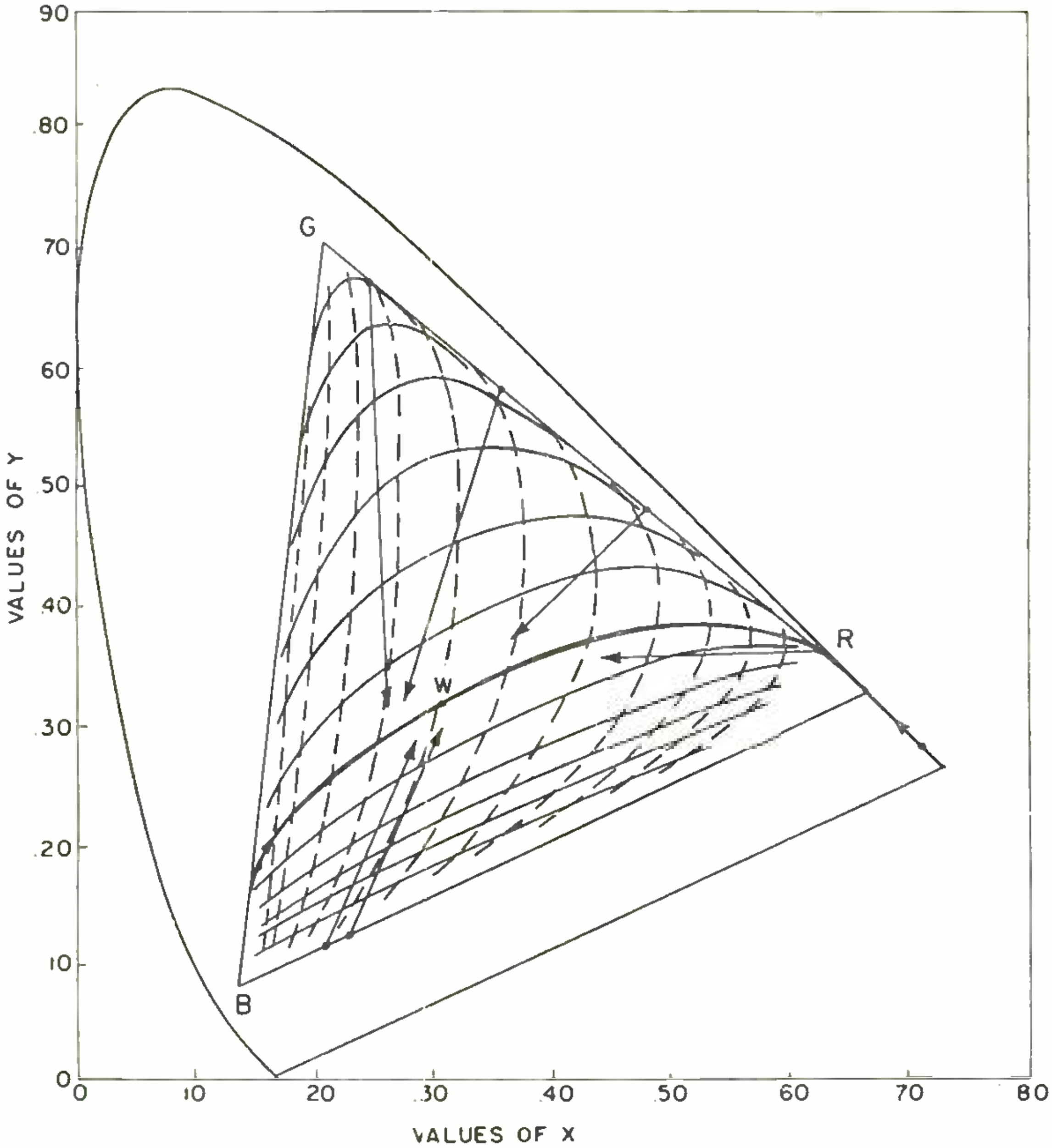

Fig. 6—Comparison of NTSC field test signal specifications with data of Hartridge.

From this brief review of some of the broad considerations involved in the proposed NTSC field test signal specifications, it can be seen that a compatible system has evolved which reduces to a minimum the transmission of redundant information and the transmission of information that, due to characteristics of vision, the eye cannot utilize. From the standpoint of ceiling performance it is believed that the broad concept of the proposed NTSC field test signal specifications has, in its make-up, the most efficient possible utilization of a six-megacycle channel for the transmission and reception of television in color.

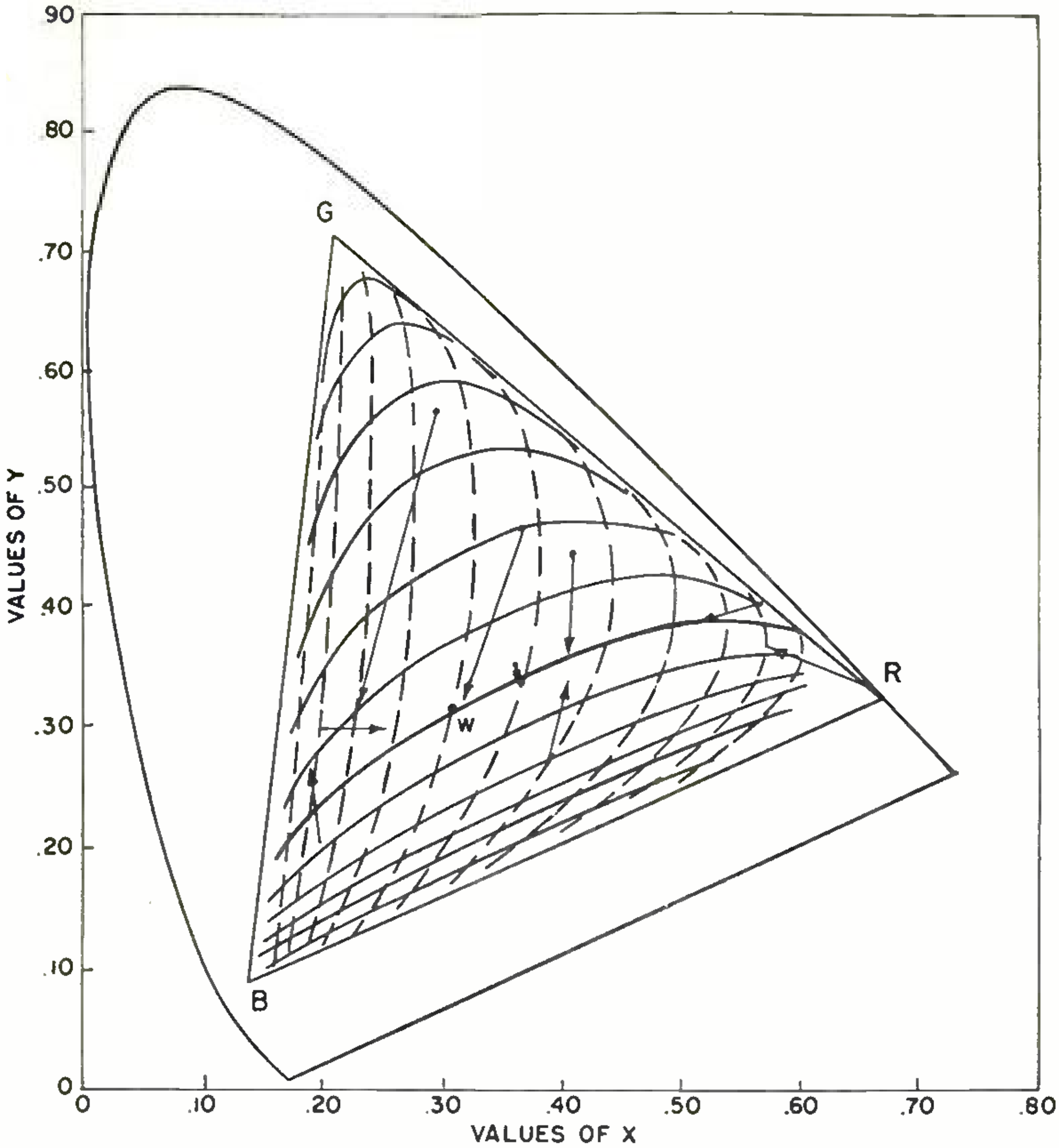

Fig. 7—Comparison of NTSC field test signal specifications with data of Kline.

APPENDIX I

A COMPARISON OF THE 1953 NTSC SIGNAL SPECIFICATIONS IN EXHIBIT 1 WITH THE SPECIFICATIONS OF THE "DOT-SEQUENTIAL" SIGNAL OF 1949-1950.

The signal specified in Exhibit 1 consists of a monochrome signal together with chrominance subcarrier to carry the color information. The earlier proposal of RCA[1] likewise consisted of a monochrome signal together with a chrominance subcarrier to carry the color information. There are differences in detail but the basic areas are common.

In 1950, RCA proposed that the subcarrier frequency should be 455 times half the line frequency, with a specific value of 3,583,125 cycles per second on the assumption of 15,750 lines per second. The present specification relates the subcarrier frequency to half the line frequency by the same factor, 455, but stipulates a line frequency of 15,734.264 lines per second (picture-sound intercarrier beat of just 4,500,000 cps, divided by 286) and a color subcarrier frequency of 3,579,545 cycles per second.

Using equation (2),[2] equation (5) may be rewritten

(1953)
$$E_m = E_Y + 0.447\, E_B \sin(\omega t\text{-}12.5°) + 0.593\, E_G \sin(\omega t\text{-}119.5°) + 0.632\, E_R \sin(\omega t\text{-}256.5°). \tag{7}$$

The 1949-50 signal was often written in the form[3]

(1949-50)
$$E_m = E_Y + \frac{2}{3} E_B \sin \omega t + \frac{2}{3} E_G \sin(\omega t\text{-}120°) + \frac{2}{3} E_R \sin(\omega t\text{-}240°) \tag{8}$$

where
$$E_Y = \frac{E_B}{3} + \frac{E_G}{3} + \frac{E_R}{3}. \tag{9}$$

Comparison of equations (7) and (8) shows striking similarity.

Figure 1 shows the phase and amplitude of the total subcarrier signal of equation (8), for the three primary colors and their respective complementary colors. This figure may be compared directly to Figure 17 of Exhibit 4.

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[1] RCA Laboratories Division, "An Analysis of the Sampling Principle of the Dot-Sequential Color-Television System," *RCA Review*, Vol. XI, Nos. 2 and 3, pp. 255-286 and 431-445 (June and September, 1950).

[2] See Part IV, E, of Exhibit 4.

[3] See note 1, *supra*.

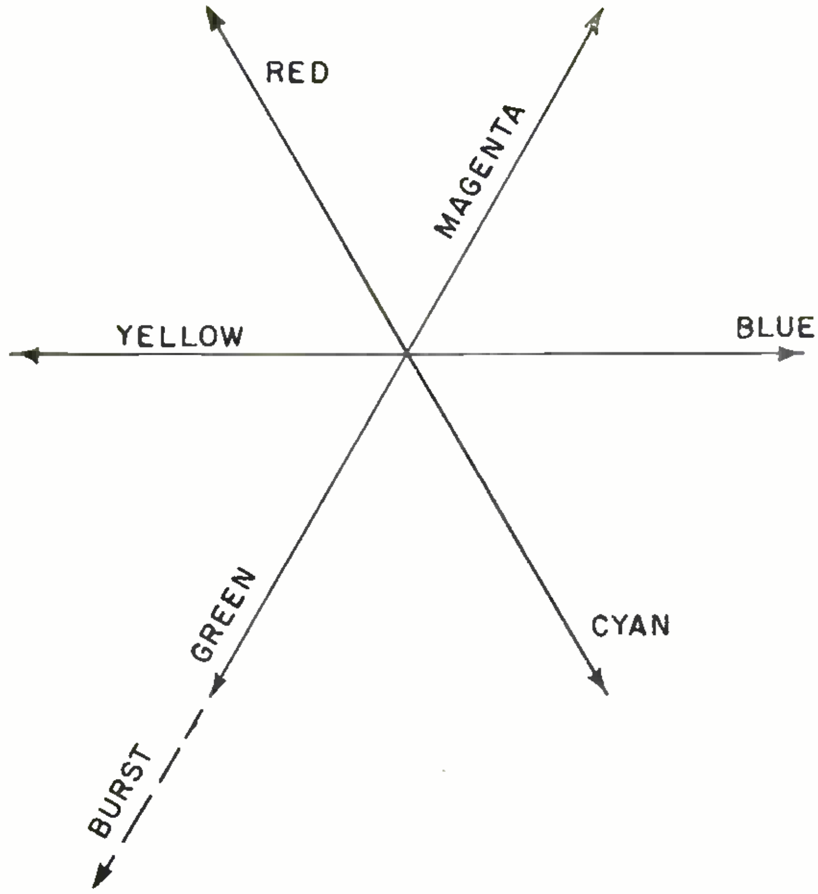


Fig. 1 — Phase and amplitude of the total subcarrier for the RCA signal specification of 1949-1950. This figure may be compared directly to Fig. 17 of Exhibit 4.

It has become the fashion to express the 1953 signal specification (equation (5)) in terms of "color difference" signals. The 1949-50 signal lends itself to the same treatment. Appropriate manipulation of equations (5) and (8) yields:

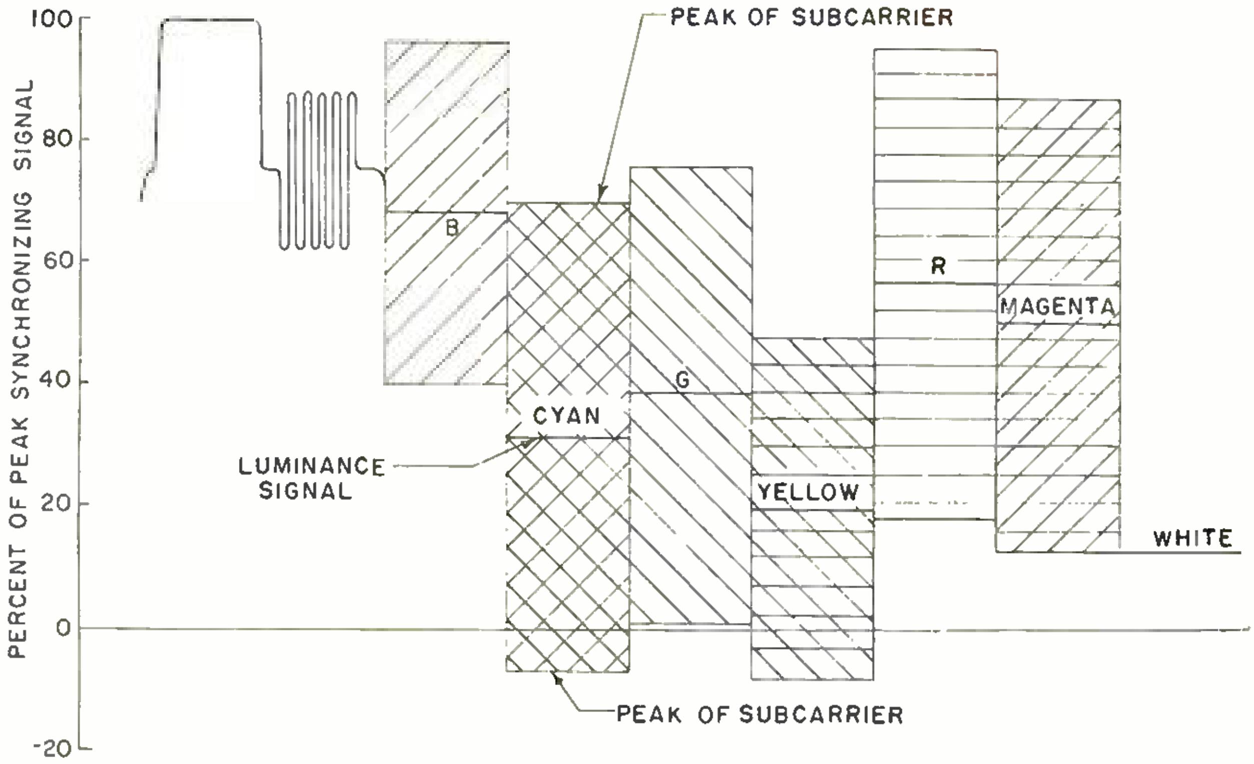
$$\text{(1953)} \quad E_m = E_Y + 1.44\ (E_G\text{-}E_Y) \sin (\omega t\text{-}123°) + [0.41\ (E_B\text{-}E_Y) - 0.48\ (E_R\text{-}E_Y)] \sin (\omega t\text{-}33°) \qquad (10)$$

and

$$\text{(1949-50)} \quad E_m = E_Y + (E_G\text{-}E_Y) \sin (\omega t\text{-}120°) + [0.577\ (E_B\text{-}E_Y) - 0.577\ (E_R\text{-}E_Y)] \sin (\omega t\text{-}30°). \qquad (11)$$

The similarity between equations (10) and (11) is also striking.

The total video signal combined with the horizontal synchronizing signal and the color synchronizing burst is shown in Figure 2a for the (1953) signal and in Figure 2b for the (1949-50) signal. Figure 2 uses as its zero reference for video voltage the value to be applied to the radio modulator to reduce picture-transmitter output to zero.



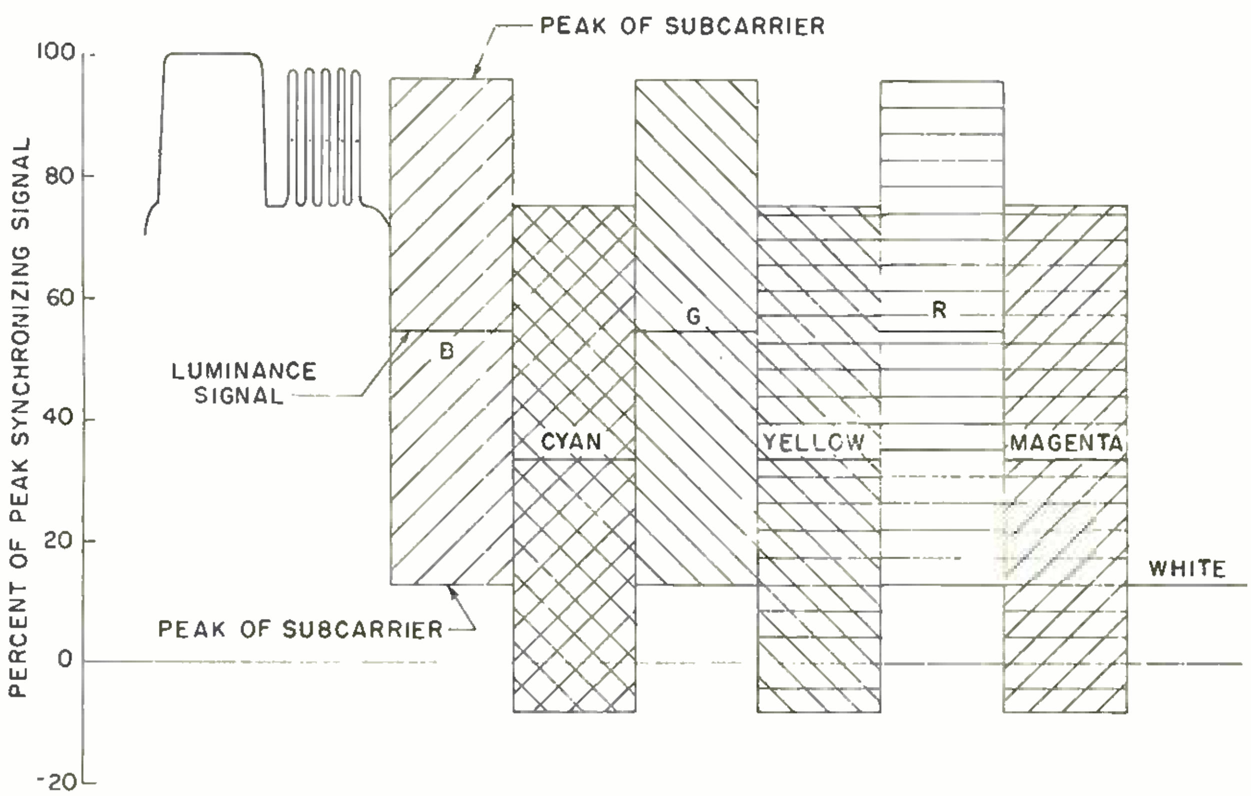


Fig. 2 — The total video signal combined with the horizontal synchronizing signal and the color synchronizing burst.

(a) The 1953 signal specification.

(b) The 1949-1950 signal specification.

APPENDIX J

THE CONSTANT-LUMINANCE CONDITION IN TERMS OF THE CONSTRUCTION OF THE MONOCHROME SIGNAL

As shown by equations (1) or (8),[1] the color-subcarrier type of signal is made up of a monochrome signal and a chrominance subcarrier. The monochrome signal is formed by combining the voltages E_G, E_R and E_B.

$$E_Y = aE_G + bE_R + cE_B. \tag{12}$$

The individual voltages may assume values between zero and unity, while the coefficients in equation (12) are subject to the condition

$$a + b + c = 1. \tag{13}$$

Then the total video signal (for the low-frequency components) may be written as

$$E_m = E_Y + rE_B \sin \omega t + pE_R \sin (\omega t + \theta_R) + qE_G \sin (\omega t - \theta_G) \tag{14}$$

where the coefficients r, p, and q and the angles θ_R and θ_G may be chosen quite independently of the construction of E_Y and subject only to the restraining condition

$$r \sin \omega t + p \sin (\omega t + \theta_R) + q \sin (\omega t - \theta_G) = 0 \tag{15}$$

or simply

$$r + p \cos \theta_R + q \cos \theta_G = 0 \tag{16}$$

and

$$p \sin \theta_R - q \sin \theta_G = 0. \tag{17}$$

Once we have specified the coefficients in equation (12) and selected the values to satisfy equations (16) and (17), we may always express the chrominance subcarrier signal in terms of two color-difference components. Then (14) may be written

$$E_m = E_Y + K_1 (E_B - E_Y) \sin (\omega t + \beta) + K_2 (E_R - E_Y) \sin (\omega t + \gamma). \tag{18}$$

If equation (18) is identical with equation (14),

$$\begin{aligned} &rE_B \sin \omega t + pE_R \sin (\omega t + \theta_R) + qE_G \sin (\omega t - \theta_G) \\ &= K_1 (E_B - E_Y) \sin (\omega t + \beta) + K_2 (E_R - E_Y) \sin (\omega t + \gamma). \end{aligned} \tag{19}$$

[1] See Part IV, E, and Appendix I of Exhibit 4.

If we now apply equations (12), (16) and (17) to (19), we find

$$K_1 \sin \beta = \frac{c}{a} p \sin \theta_R \tag{20}$$

$$K_1 \cos \beta = \frac{(1-b)}{a} r + \frac{c}{a} p \cos \theta_R. \tag{21}$$

Then,

$$K_1 = \sqrt{(K_1 \sin \beta)^2 + (K_1 \cos \beta)^2} \tag{22}$$

and

$$\tan \beta = \frac{c\, p \sin \theta_R}{(1-b)\, r + c\, p \cos \theta_R}. \tag{23}$$

Likewise

$$K_2 \sin \gamma = \frac{1-c}{a} p \sin \theta_R \tag{24}$$

$$K_2 \cos \gamma = \frac{br}{a} + \frac{(1-c)}{a} p \cos \theta_R \tag{25}$$

so

$$K_2 = \sqrt{(K_2 \sin \gamma)^2 + (K_2 \cos \gamma)^2} \tag{26}$$

and

$$\tan \gamma = \frac{(1-c)\, p \sin \theta_R}{br + (1-c)\, p \cos \theta_R}. \tag{27}$$

Thus, we have shown that the chrominance subcarrier may be expressed in terms of two color-difference signals. The color-difference information may then be extracted at the receiver by means of two synchronous detectors. In the synchronous detector used to extract the term $(E_B - E_Y)$, the local oscillator signal should be in quadrature with the sin $(\omega t + \gamma)$ term in equation (18). Thus, the local oscillator signal is chosen to be 2 sin $(\omega t - 90° + \gamma)$. The first synchronous detector then forms the product

$$\begin{aligned} 2 \sin (\omega t - 90° + \gamma)\, [K_1 (E_B - E_Y) \sin (\omega t + \beta) + K_2 (E_R - E_Y) \sin (\omega t + \gamma)] \\ = K_1 (E_B - E_Y) \sin (\gamma - \beta) - K_1 (E_B - E_Y) \cos (2\omega t - 90° + \gamma + \beta) \\ - K_2 (E_R - E_Y) \cos (2\omega t - 90° + 2\gamma). \end{aligned} \tag{28}$$

The last two terms in equation (28) are lost in the low-pass filter, since they have frequencies double that of the subcarrier, so the output of the first synchronous detector is simply

$$K_1 (E_B - E_Y) \sin (\gamma - \beta). \tag{29}$$

The local oscillator signal in the second synchronous detector is 2 sin $(\omega t+90°+\beta)$, and the output of this detector, after the filter, is

$$K_2 (E_R - E_Y) \sin (\gamma - \beta). \tag{30}$$

The amplification after the first synchronous detector is adjusted to be $\dfrac{1}{K_1 \sin (\gamma - \beta)}$ so that the signal shown by (29) arrives at the blue reproducer simply as $E_B - E_Y$ where it is added to the monochrome signal E_Y, giving a voltage E_B at the blue reproducer. Likewise, the gain of the second synchronous detector channel is adjusted to be $\dfrac{1}{K_2 \sin (\gamma - \beta)}$ to produce E_R at the red reproducer.

The green color-difference signal may be obtained by mixing (matrixing) the two color-difference signals already available. Thus

$$E_G - E_Y = m (E_R - E_Y) + n (E_B - E_Y). \tag{31}$$

Substituting (12) in (31)

$$\begin{aligned}(1-a)\, E_G - bE_R - cE_B \\ = (-ma - na)\, E_G \\ + [m(1-b) - nb]\, E_R \\ + [-mc + n(1-c)]\, E_B.\end{aligned} \tag{32}$$

Since the voltages E_G, E_R, and E_B vary independently one from another, the equality expressed in (32) applies to the coefficients of the respective voltages, giving three simultaneous equations.

$$-(1-a) = +m\,a + n\,a \tag{33}$$

$$-b = m(1-b) - n\,b \tag{34}$$

$$-c = -m\,c + n(1-c). \tag{35}$$

Since (33) is the sum of (34) and (35), only the latter two are needed for a solution. Then

$$n = -\frac{b}{a} \tag{36}$$

and

$$n = -\frac{c}{a}. \tag{37}$$

It is interesting to apply the above analysis to the (1949-50) signal given by equations (8) and (9). In this case,

$$a = b = c = \frac{1}{3}$$

$$p = q = r = \frac{2}{3}$$

$$\theta_R = 120°$$

$$\theta_G = 120°.$$

From equations (20), (21), (22) and (23), we find

$$K_1 \sin\beta = \frac{1}{\sqrt{3}}$$

$$K_1 \cos\beta = 1$$

$$K_1 = \frac{2}{\sqrt{3}} \text{ and } \beta = 30°.$$

Likewise from equations (24), (25), (26) and (27), we obtain

$$K_2 \sin\gamma = \frac{2}{\sqrt{3}}$$

$$K_2 \cos\gamma = 0$$

$$K_2 = \frac{2}{\sqrt{3}} \text{ and } \gamma = 90°$$

so, from equation (18)

$$(1949\text{-}50)\ E_m = E_Y + \frac{2}{\sqrt{3}} (E_B - E_Y) \sin (\omega t + 30°)$$
$$+ \frac{2}{\sqrt{3}} (E_R - E_Y) \sin (\omega t + 90°). \quad (38)$$

The local oscillator signal in the $(E_B - E_Y)$ channel is 2 sin (ωt) and the gain in this channel is $\frac{1}{K_1 \sin(\gamma - \beta)} = 1.0$, while the local oscillator signal in the $(E_R - E_Y)$ channel is 2 sin $(\omega t + 120°)$ with a channel gain of unity.

From (31), (36) and (37) we find

$$(E_G - E_Y) = -(E_R - E_Y) - (E_B - E_Y). \quad (39)$$

For the low-frequency components of the NTSC signal specification given by equation (5),

$$K_1 = 0.493, \beta = 0°$$

$$K_2 = 0.877, \gamma = 90°.$$

The local oscillator signal in the $(E_B—E_Y)$ channel is 2 sin(ωt) and the gain in this channel is $1/0.493 = 2.03$. In the $(E_R—E_Y)$ channel, the local oscillator signal is 2 cos ωt, while the channel gain is 1/0.877 or 1.14. From (31), we find

$$(E_G—E_Y) = —0.51\ (E_R—E_Y) — 0.19\ (E_B—E_Y).$$

Now let us return to the generalized expressions and examine the conditions existing when an interfering sine-wave voltage is present. For the sake of simplicity, we shall confine the discussion to a white area of the picture $(E_B=E_G=E_R)$ so the transmitted subcarrier disappears and the only signal going through the synchronous detectors is the interfering signal, S sin $(\omega_1 t+\tau)$. If the interfering signal has a frequency f_1 close to the subcarrier frequency, its effect will be manifested in two ways. First, the signal will pass to the three color reproducers through the by-pass monochrome channel and appear as a high-frequency bar or herring-bone pattern, just as on a normal black and white receiver. Secondly, it will beat with the local oscillator signal in each color-difference channel, producing a low-frequency pattern in color. For instance, with a subcarrier frequency of 3.58 mc, an interfering signal with a frequency of 3.48 mc will produce a new signal with a frequency of 0.1 mc on each color reproducer.

The interfering signal will beat with 2 sin $(\omega t—90° + \gamma)$ in the $(B—Y)$ channel to produce a signal on the blue reproducer (after the gain factor is applied) of

$$\frac{S}{K_1 \sin(\gamma—\beta)} \cos [(\omega—\omega_1)t — 90° + \gamma — \tau]. \tag{40}$$

The signal on the red reproducer will be

$$\frac{S}{K_2 \sin(\gamma—\beta)} \cos [(\omega—\omega_1)t + 90° + \beta — \tau]. \tag{41}$$

The signal on the green reproducer is found by applying (40) and (41) to (31):—

$$—\frac{c}{a} \cdot \frac{S}{K_1 \sin(\gamma—\beta)} \cos [(\omega—\omega_1)t—90°+\gamma—\tau]$$

$$—\frac{b}{a} \cdot \frac{S}{K_2 \sin(\gamma—\beta)} \cos [(\omega—\omega_1)t+90°+\beta—\tau]. \tag{42}$$

If the light-output versus voltage-input characteristics of the reproducer are linear, or if the interfering signal is small in amplitude compared to the desired signal, then expressions (40), (41) and (42) are proportional to the intensity of light from the blue, red and green reproducers, respectively.

The resulting pattern on the face of the reproducer consists of a series of broad stripes across the picture. The relative subjective brightness of the three primary interference patterns, that is to say, the relative brightnesses as they appear to an observer, are obtained by multiplying the expressions (40), (41) and (42) by the relative luminance of the phosphor corresponding to each signal. Thus the apparent brightness produced on the blue reproducer is

$$L_B = Y_B \cdot \frac{S}{K_1 \sin(\gamma - \beta)} \cos[(\omega - \omega_1)t - 90° + \gamma - \tau] \tag{43}$$

while

$$L_R = Y_R \cdot \frac{S}{K_2 \sin(\gamma - \beta)} \cos[(\omega - \omega_1)t + 90° + \beta - \tau] \tag{44}$$

and

$$L_G = -\frac{c}{a} Y_G \cdot \frac{S}{K_1 \sin(\gamma - \beta)} \cos[(\omega - \omega_1)t - 90° + \gamma - \tau]$$
$$-\frac{b}{a} Y_G \cdot \frac{S}{K_2 \sin(\gamma - \beta)} \cos[(\omega - \omega_1)t + 90° + \beta - \tau] \tag{45}$$

where Y_G, Y_R and Y_B are the relative luminance values derived in Appendix K of Exhibit 4.

The total luminance, or apparent brightness, is the sum of equations (43), (44) and (45)

$$L_T = L_B + L_R + L_G$$
$$= (Y_B - \frac{c}{a} Y_G) \frac{S}{K_1 \sin(\gamma - \beta)} \cos[(\omega - \omega_1)t - 90° + \gamma - \tau]$$
$$+ (Y_R - \frac{b}{a} Y_G) \frac{S}{K_2 \sin(\gamma - \beta)} \cos[(\omega - \omega_1)t + 90° + \beta - \tau]. \tag{46}$$

Then if we choose the coefficients of the monochrome signal so that

$a = Y_G$, $b = Y_R$, and $c = Y_B$, we see

that L_T is zero. Under this condition, the interference pattern changes color across the picture but maintains "constant luminance," thus reducing annoyance to the viewer. The constant-luminance feature applies also to reduce the visibility of high-frequency components of the monochrome signal which pass through the decoding channels of the receiver as well as high-frequency thermal noise.

It is interesting to note that the proper specification of the monochrome signal (the choice of a, b and c) completely establishes the constant-luminance effect.

APPENDIX K

NUMERICAL DETERMINATION OF THE RELATIVE LUMINANCE VALUES OF THE RECEIVER PRIMARIES

The trichromatic coefficients of the assumed receiver phosphors, as selected by NTSC, are given in Exhibit 1. This information, together with the knowledge that Illuminant C is to be used as standard white, enables one to compute the relative luminance values of the primaries. Because the tristimulus values of a *mixture* of lights are the sums of the corresponding tristimulus values of the components of the mixture, one may apply the method of moments to the color triangle of Figure 2 of Exhibit 4.

First we take the weighted moments of the sums of the tristimulus values about a horizontal axis passing through white, and obtain

$$(X_R+Y_R+Z_R)(y_R-y_W) + (X_G+Y_G+Z_G)(y_G-y_W) + (X_B+Y_B+Z_B)(y_B-y_W) = 0. \qquad (47)$$

Since, by definition, $y = \dfrac{Y}{X+Y+Z}$ equation (47) becomes

$$Y_R \frac{(y_R-y_W)}{y_R} + Y_G \frac{(y_G-y_W)}{y_G} + Y_B \frac{(y_B-y_W)}{y_B} = 0. \qquad (48)$$

Similarly, when moments are taken about a vertical line through white, we obtain

$$Y_R \frac{(x_R-x_W)}{y_R} + Y_G \frac{(x_G-x_W)}{y_G} + Y_B \frac{(x_B-x_W)}{y_B} = 0. \qquad (49)$$

Since our interest lies solely in the *relative* values of the luminances, we may add a third constraining condition for ease in solving the equations, that is,

$$Y_R + Y_G + Y_B = 1. \qquad (50)$$

The simultaneous equations (48), (49) and (50) may then be readily solved.

When one uses the values:—

$$x_W = 0.310, \quad y_W = 0.316$$

$$x_R = 0.67, \quad y_R = 0.33$$

$$x_G = 0.21, \quad y_G = 0.71$$

$$x_B = 0.14, \quad y_B = 0.08$$

one finds

$$Y_G = 0.5866$$

$$Y_R = 0.2988$$

$$Y_B = 0.1146.$$

These values, when rounded off to two places, yield the luminance values specified by NTSC:—

$$Y_G = 0.59$$

$$Y_R = 0.30$$

$$Y_B = 0.11.$$

EXHIBIT 5

RCA TRICOLOR KINESCOPES AND ASSOCIATED COMPONENTS

RCA TRICOLOR KINESCOPES AND ASSOCIATED COMPONENTS

INDEX

EXHIBIT 5

RCA TRICOLOR KINESCOPES AND ASSOCIATED COMPONENTS

PART I

Introduction

THIS exhibit describes the advances made by RCA in the development and production of color kinescopes and associated components for home television receivers. The exhibit begins with a description of the basic requirements for a color reproducer. It then continues with a discussion of some of the many experimental color reproducers that were devised and tested. As a result of these tests, together with a careful analysis of production possibilities based on optimum use of existing manufacturing techniques, the three-gun shadow-mask tricolor kinescope was considered one of the designs offering the greatest promise for early fulfillment of both performance and commercial requirements.

The exhibit passes from the research stage to the production design stage and continues with a detailed description of the construction and operating principles of the tricolor kinescope. Also described are improvements in tube construction and how these improvements have brought about not only improved performance but also a simplification of the fabricating and assembly operations. Specific constructional and processing advancements are discussed.

In addition to progress in the development of the RCA tricolor kinescope, advances made in the design and development of components necessary for its operation are also described, particularly those used for deflection and beam convergence.

These advances have carried the development of the tricolor kinescope from the early model shop stage, through the pilot plant-development stage, and into pilot production in anticipation of a mass-production program.

PART II

Early Work on Electronic Color Reproduction[1]

Inventors and scientists have been concerned with television reproduc-

[1] This Part II and the two succeeding ones (III and IV) are based on the paper, "Methods Suitable for Television Color Kinescopes" by E. W. Herold, RCA Laboratories Division, Princeton, N. J., one of a series of eleven papers entitled "Direct-View Color Kinescopes," which appeared in the October, 1951, issue of the *Proceedings of the Institute of Radio Engineers.* Much of the material is verbatim. Some changes have been made, however, to provide better integration with the organization and content of this Exhibit and to avoid repetition. Reference is also made to the other papers in this series.

tion in color ever since the late 1920's when a number of color television demonstrations were given using scanning-disc techniques. Although the patent literature and occasional publications indicate that thought was being given to all-electronic means for color reproduction, the most successful work of the 1930's continued to use mechanical methods. This work reached its ultimate about 1940 when the field-sequential color television system using a rotating color disc was extensively demonstrated and publicized. Although the addition of the cathode-ray tube to the color-disc method eliminated some of the more complex moving parts of the mechanical scanning system, there were inherent limitations in reproduction, namely, the inability to provide color sequences at a sufficiently rapid rate for other than frame- or field-sequential methods and the inherently small size picture.

Recognition of these limitations stimulated efforts toward electronic solutions. Work in this direction by the Radio Corporation of America led, early in 1940, to a demonstration before the Federal Communications Commission of color reproduction using three optically superimposed images from three cathode-ray tubes, thereby eliminating all moving parts. By 1942, J. L. Baird, in England, also demonstrated all-electronic color pictures, but by means of a single cathode-ray tube producing two adjacent images optically combined to give a two-color effect. His British patent applications of 1942 and 1943 showed that he had more ingenious tubes in mind. One of these, using a two-sided phosphor screen for a two-color picture, was actually demonstrated in principle by Baird in 1944. At the same time he described a more complex tube suitable for three colors. RCA engineers also continued to study the single-tube color reproducer during this period, but it was not until after World War II that factors such as improved high-voltage and deflecting systems, metal kinescopes, and aluminized phosphors provided the key to some of the problems. As a result of this progress, it became possible, early in 1950, to demonstrate that a single-tube three-color reproducer for the home was practicable.

PART III

Requirements of a Color Reproducer

Colorimetry makes use of the International Commission of Illumination (CIE) chromaticity diagram shown in Figure 1. The entire range of colors observable by the normal eye is found within the horseshoe-shaped figure, the periphery of which bears numbers to indicate pure spectral wave lengths in millimicrons. A color reproducer should use primary colors which in an optimum case would lie so that lines joining their CIE coordinates encompass the most important part of the area of the horseshoe of Figure 1. Suitable primary colors, as suggested by Hardy and Wurzburg,[2] are shown by the circled points in Figure 1.

[2] A. C. Hardy and F. L. Wurzburg, Jr., "The Theory of Three-Color Reproduction," *Jour. Opt. Soc. of Amer.*, Vol. 27, pp. 227-240 (July, 1937).

In order to obtain the maximum possible number of hues and saturation of color, means must be provided for the addition of variable amounts of two or more of the primary colors. One possible means of addition of the primary colors would be by straightforward superposition.

Considerable flexibility in the means of addition of the primary colors is permissible, however, because of two characteristics of the eye, namely, persistence of vision and inability to resolve detail beyond a finite limit. One or both of these characteristics of the eye may be considered in the design of a color reproducer.

If the entire picture area to be viewed is divided into many small picture elements (lines, squares, triangles, dots, etc.) so that at a normal viewing distance the elements can not be resolved by the eye, then the various elements in juxtaposition may be composed of groups of color primaries, and the eye will in effect add these primaries and see them as the single color represented by the added primaries.

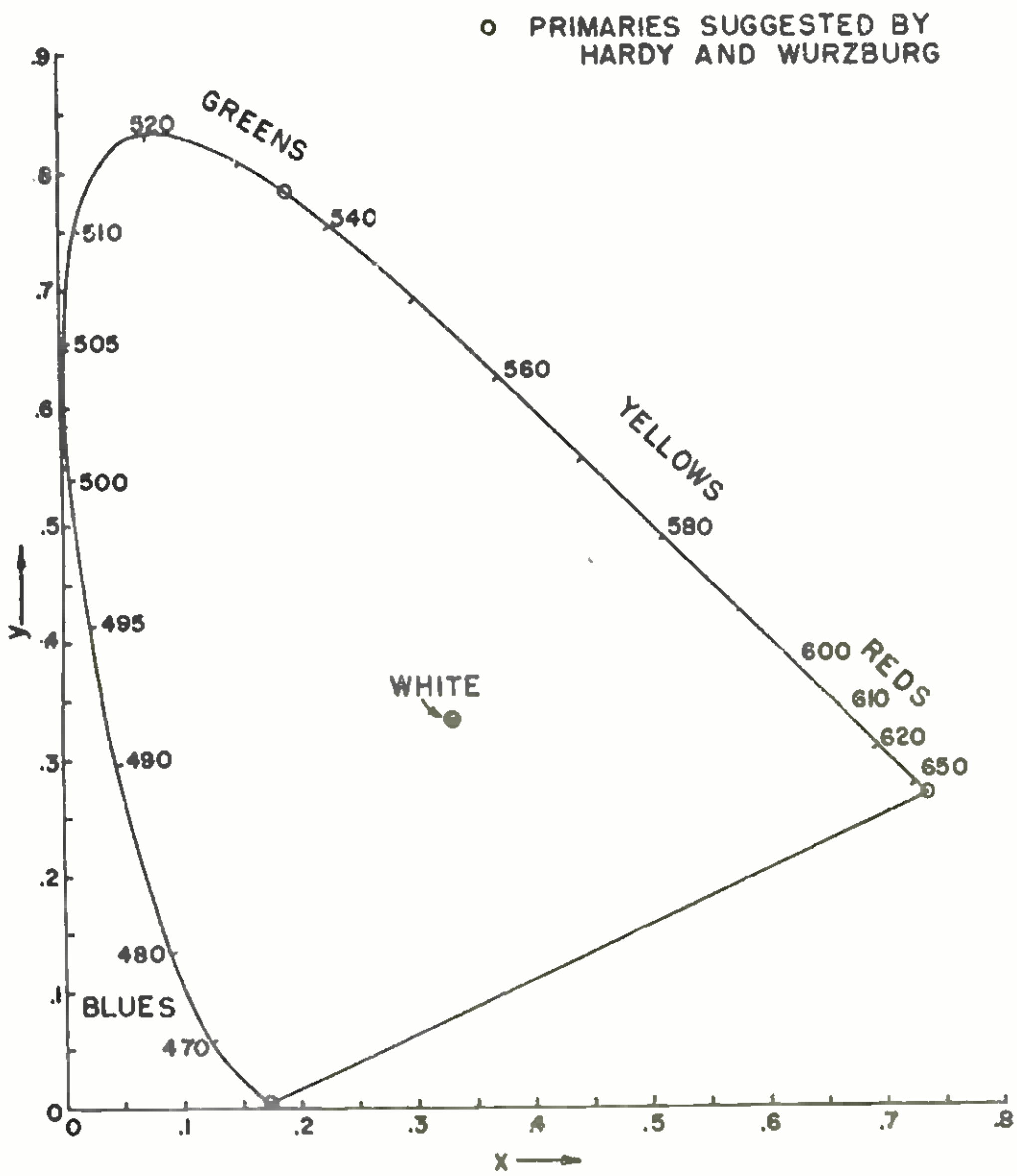


Fig. 1 — The CIE color diagram includes all visual colors.

Finally, the minute picture elements in juxtaposition need not be excited simultaneously. If the color elements are excited in sequence at a rapid enough rate, persistence of vision of the eye will make it appear as if the color elements were excited simultaneously and provide the necessary color addition.

In summary, the major consideration for a color reproducer is that, as viewed by the eye, it is capable of adding variable amounts of three primary colors. There are other general requirements which may be briefly stated as follows: The picture area should be as large as practicable. Picture brightness should be comparable to that of black and white home television reproduction. A good contrast range should be achieved. (It should be noted that the effect of ambient white light illumination, which reduces contrast in black and white pictures, has the additional effect of reducing chromaticity in color reproduction.) Finally, the color reproducer should provide resolution capabilities, or ability to reproduce fineness of detail somewhat better than that which the television system is capable of conveying.

PART IV

Cathode-Ray Tubes as Color Reproducers

The requirements for a color reproducer can be well fulfilled by a cathode-ray device, provided suitable color-emitting phosphors or color filters are used. Most luminescent materials have characteristic colors other than white, and the "white" phosphors of the black and white kinescope are actually mixtures of phosphors of two complementary colors, or three-color mixtures which give white. In view of this, it is clear that use of such a "white," with a color filter, makes inefficient use of the electron beam since the beam energy must divide itself among two or three color phosphors, with only one portion of the light going through the filter at a time. The best use of cathodoluminescence is to eliminate filters as much as possible by choice of phosphors with high light output and CIE points close to the values of Figure 1.

An examination of the different ways in which phosphors can be used for a color kinescope follows.

A. Accurate Beam-Scanning Method

The earliest proposals for a color kinescope were extensions of the black and white technique, specifying that the white phosphor screen should be covered by a "checkerboard" of color filters, or should be replaced by one of ruled phosphor lines of the three colors in succession. Although, with the line screen, scanning by the single electron beam could be either parallel or transverse to the phosphor lines, scanning accuracy was easier to achieve with the former. Figure 2 illustrates this method.

Obviously, extreme scanning accuracy in one direction is required

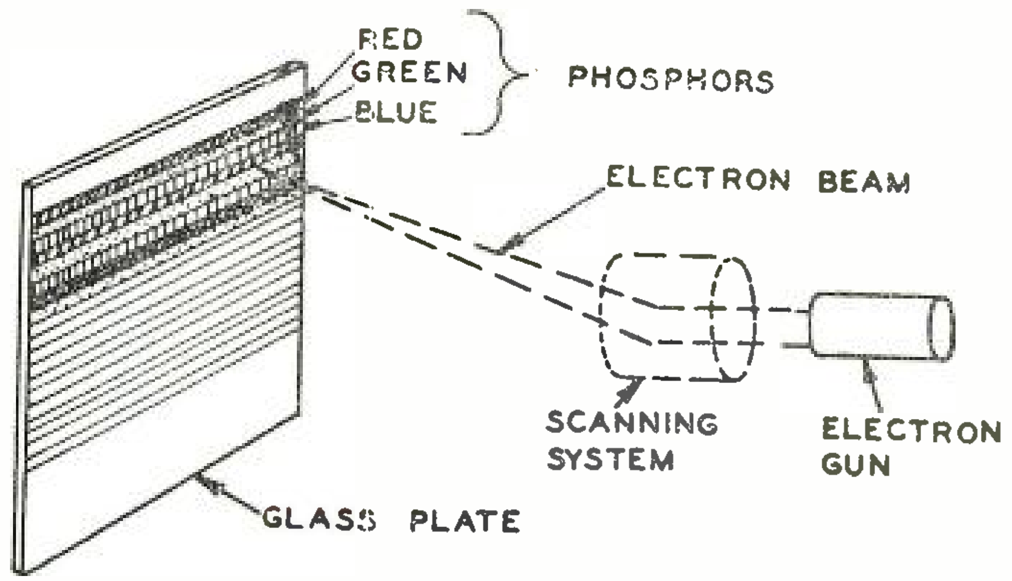


Fig. 2—Example of line-screen color kinescope using one electron beam. To assure correct colors, beam scanning must be highly accurate. No automatic registry means are shown.

if color dilution or error is to be avoided, and a high-definition system seems very difficult to achieve. The checkerboard color screen, or dot screen, requires accuracy of scan in both directions; it was once considered difficult to make and would certainly be difficult to operate. The colors may be sequentially presented when only one electron gun and beam are used and, of course, are controllable by slight shift in beam position. If the beam is controlled to excite more than one color strip or spot at a time, simultaneous presentation with a single beam is possible. A beam may also be split into three or more parts, separately controlled, but through a common deflecting system, to achieve simultaneous presentation.

Line or dot screens with this method require phosphor lines or dots which are of a size less than one-third of the distance between scanning lines (when scanned parallel) or less than one-third of a picture-element size (when scanned transversely).

The achievement of high scanning accuracy is aided by automatic control and registry by feedback methods, of which a large variety have been devised during the past decade. Although the achievement of automatic registry by control signals or feedback may lead to complex circuitry, it seems clear that a single-beam, line-screen, color kinescope can be made with relatively little complexity since it would require few more parts than the conventional black and white kinescope. Among the disadvantages of such a tube is the color error when the beam is misregistered, or incorrectly focused.

Over a number of years, experiments with line screens were made at RCA by a three-step phosphor-settling process through a movable mask. Subsequently, suitable screens were made by a development in which the three-color phosphor line-groups were printed, using the silk-screen process. A demonstration of the principle of a line-screen tube was shown by RCA to the Federal Communications Commission on October 10, 1949. At RCA Laboratories, color pictures were achieved both with accurate scanning linearity alone and with associated feedback circuits to lock the beam in its correct position at all times.

B. Signal Control by Beam-Scanning Position

The method of the previous section requires extreme scanning accuracy because the scanning and the color signals are essentially independent phenomena. If, however, the color signals can be made dependent on the scanning, the latter need be no more accurate than in black and white practice, since the scanning now controls the colors. This may be done by use of a color-sensitive photo device, or other special signal-generating means built into the screen, by which the kinescope control grid is automatically switched to the correct primary color signal, depending on the instantaneous beam position. The method has been suggested for transverse scanning of line screens but, because of the need for an extremely small focused spot, it is subject to some of the same disadvantages as the accurately controlled scanning method described in the previous section.

C. Adjacent-Image Method

Not far behind the accurate beam-scanning method in point of time were proposals for a color kinescope involving two or more complete television images, in different colors, which were optically combined by mirrors or by projection. The method can be used with three beams allowing simultaneous presentation or with one beam which, in this case, is restricted to sequential presentation. Figure 3 illustrates the method in one form. Although either field-sequential or line-sequential systems are

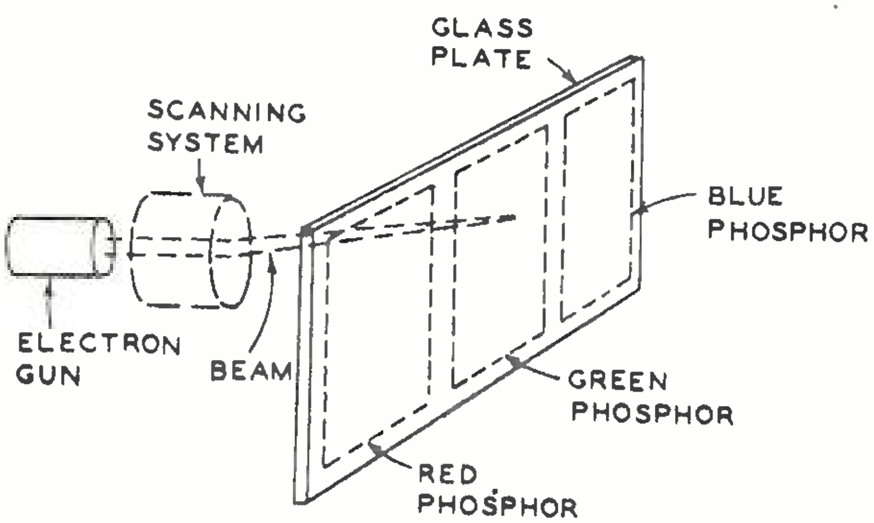


Fig. 3 — Kinescope with adjacent color images. Optical combining means for direct view or projection are required.

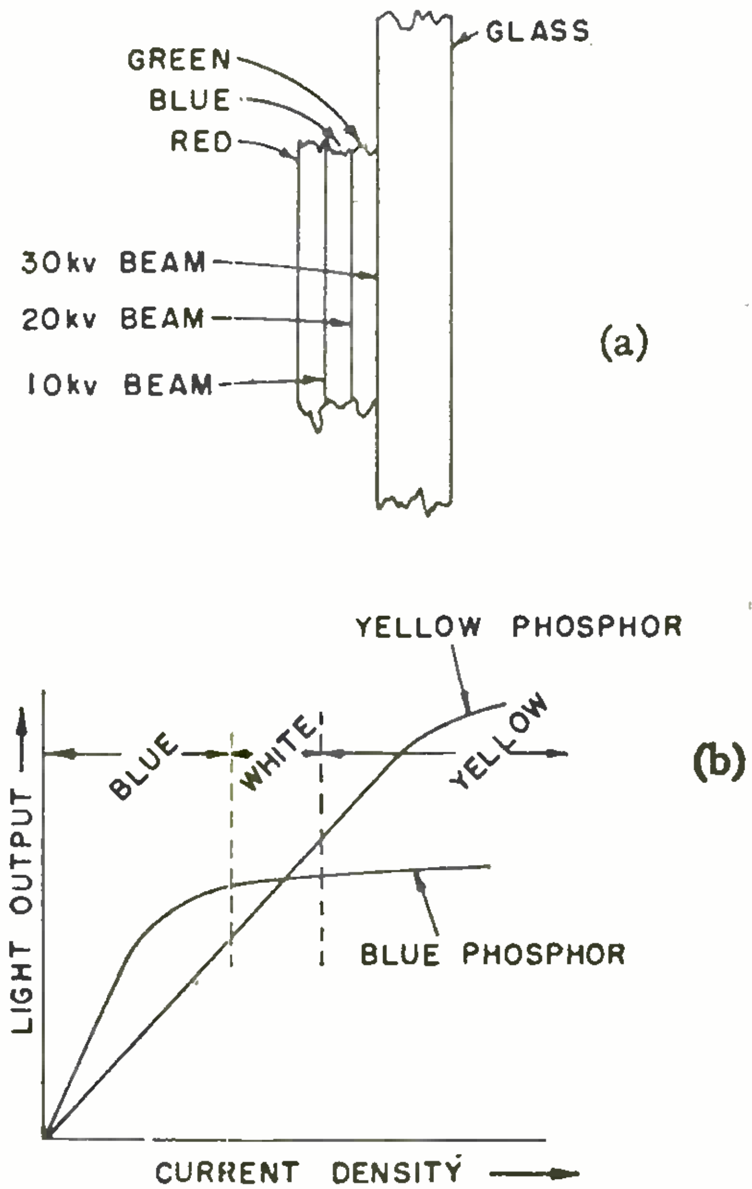


Fig. 4 — Multicolor phosphor screen: (a) shows a multiple-layer screen with color depending on beam velocity, and (b) shows how saturation in a two-component screen makes color dependent on current density.

well suited for the one-beam tube, the latter system has received particular attention because a single line scan can be made to traverse all three areas. Because of the optical registration, which is very similar to that needed for three separate color kinescopes, the combination of the three images in one tube is not a sufficient advantage to make the method attractive. For a direct-view kinescope, furthermore, the front face area is very inefficiently used. Although good performance is difficult to achieve, such an all-electronic picture reproducer device has been frequently demonstrated, probably because the tube is so easily constructed.

The J. L. Baird two-color tube using one color phosphor on one side of a mica sheet and the second phosphor on the opposite side, with two electron guns at opposite sides and at an angle to permit viewing, is to be classified as in the adjacent-image group but requires no optical registry.

However, a two-color system is severely handicapped in comparison with a three-color one.

D. Color Controlled by Electron Velocity or Current Density

A superficially attractive possibility for a color kinescope uses a single phosphor or a combination of phosphors in which color is responsive to either electron velocity or current density. Considering the former, it is possible to build up a three-layer screen so that electrons of one velocity penetrate only the first layer, producing one color, whereas faster electrons will penetrate to the second layer and the fastest electrons reach the third layer, so producing three colors, as shown in Figure 4a. A variation of the method uses barriers of different thickness on the beam side of the color phosphors. Either a single gun, in which the cathode potential is varied to change the electron velocity, or three guns of differing cathode potentials can be used for color rendition. Unfortunately, it appears unlikely that such screens can be made to operate with electron-velocity differences of less than around ten kilovolts, so that sequential switching is verv difficult at best. There may be inherent color dilution as well, so as to affect color fidelity. Use of three electron sources at such large velocity differences has other difficult problems, such as scanning amplitude differences.

A change of color with current density has often been observed when saturation of one or more of the phosphor components sets in (See Fig. 4b). This effect has been proposed for a color kinescope by using variable-frequency pulses for brightness modulation and changes in current density for color. The color change in the usual two- or three-component phosphors due to saturation is slight and high-chroma colors are difficult to achieve. However, a color effect has been observed in certain single phosphors which have high-chroma emission of two widely separated colors, depending on current density. If such a phosphor can be made with light efficiencies comparable to those now widely used, a new technique for color reproduction will become practical.

E. Beam Control at Phosphor Screen for Changing Color

A general method, which offers an extremely fertile field for particular and interesting variations in a color kinescope, is one in which the electron beam is deflected, or otherwise controlled, in the vicinity of the phosphor screen. In simplest form, only one electron beam is used, but modifications using multiple beams can also be employed.

Historically, the switching-at-screen approach was first used to eliminate the need for accurate scanning with the color line screens of Figure 2. The method involved insulating the color phosphor strips from each other and applying a high positive potential to the strips whose colors are to be excited, with a low or even a negative potential to the strips containing the other colors.

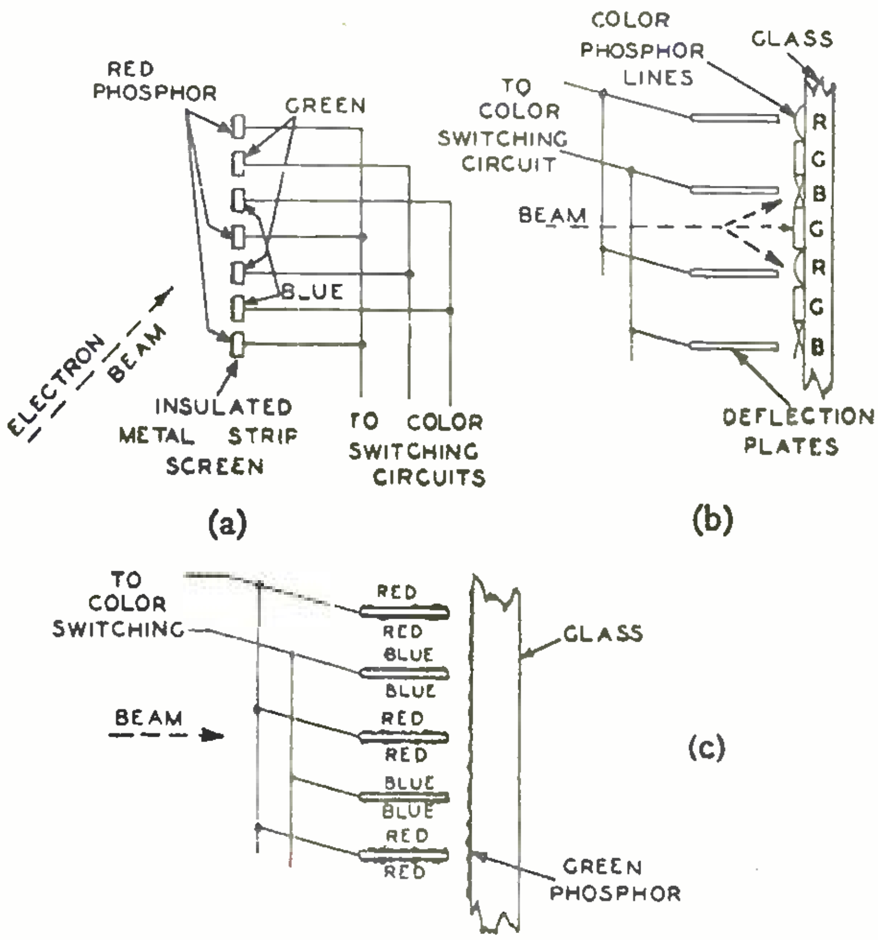


Fig. 5 — Beam control at phosphor screen for changing color. (a) Simple line-screen color switching. (b) Deflection switching of colors with line screen. (c) Deflection switching without requiring registry.

An illustration is shown in Figure 5a, in which the phosphors are deposited on the surface of metal strips, the electron beam coming in at an angle to permit viewing. Because of the closeness of the color strips as required for high definition the electric field needed for deflection to the correct color is confined to a region very close to the screen and high voltage differences are required. The color-changing circuits must, therefore, operate with voltages of many kilovolts, and are difficult to make in practical form. The difficulties increase rapidly as the switching rate is increased. There are even greater practical disadvantages when a magnetic field is used for switching color.

One modification of the high voltage switching method eliminates the line nature of the screen by using three closely spaced, phosphor-coated grids. This makes the phosphor screen easier to fabricate, but the high voltage color-changing and insulation problems remain. In addition, there is now parallax because the three color phosphors are no longer in the same plane; this can be overcome by projection rather than direct viewing, provided depth of focus is sufficient in the projection optics.

The impracticality of such high color-changing voltages suggests actual deflection electrodes at the phosphor screen, so that a single beam can be deflected to the correct color with much lower voltage differences than needed with Figure 5a. One such device is shown in Figure 5b which shows deflection plates (or wires may be used) aligned with the rows of color-phosphor lines. It is seen that, when there is no potential difference between deflection electrodes, the beam strikes the green-emitting phosphor. Since alternate deflection electrodes are connected, a potential difference causes the beam to be bent toward either the red- or blue-emitting lines, depending on which group of electrodes is more positive.

A simple calculation shows that, with deflection plates of 1 centimeter or more in width, spaced by about one picture element, only some tens of volts are required to change colors, in contrast to Figure 5a which requires from 100 to 500 times more voltage. The capacitance of the two groups of plates, since there are of the order of 150 to 300 of them in each group, is sufficiently high to pose serious difficulty when rapid color changes are needed. For sequential presentation, correct gating signals applied to the electron gun permit a sine wave to be applied to the color deflection plates, and this permits tuned circuits to be used, thus reducing the power as compared with square-wave switching forms.

The registry of such a large number of deflection plates with the phosphor lines is a mechanical difficulty of the Figure 5b method, which has been overcome by depositing two of the color phosphors directly on the deflection plates, as proposed and constructed at RCA. An illustration is shown in Figure 5c. This simplifies tube construction but prevents use of aluminizing over the phosphors, since the red and blue light must pass through the green phosphor, which acts as a diffusing screen to reduce undesired directivity of the red and blue colors. When aluminizing is not used, care must be taken to prevent differences in charging up of the phosphors, which cause nonuniform deflection.

Special techniques, of course, are also required for use of anode potentials on the kinescope above the "sticking potential" of the phosphors. Improved phosphor conductivity and transparent conducting coating under the green phosphor are methods which may be used but, in general, much more care must be taken in such a tube than in black and white tubes because three different and unmixed phosphors are involved. There is also limited red and blue definition, due to a finite number of deflection plates in the one direction and the diffussion of the red and blue light through the green-emitting phosphor in the other direction. On the other hand, the tube requires comparatively little mechanical registration (chiefly a tilting of the plates to keep them parallel to the deflected electron beam).

The use of fine-meshed control grids at the phosphor screen assembly for overcoming high color-changing voltages was developed also by RCA. In such tubes the light-emitting area is composed of a set of parallel, closely spaced, phosphor screens, which are separated by color control grids operated near cathode potential. When one of the color control grids is slightly positive in potential, the electron beam can pass through a subsequent phosphor screen. When the grid is negative in potential, the beam is turned back to strike a preceding phosphor screen. In a two-color tube, one control grid separates two phosphor screens. In a three-color tube, two control grids interleave with three phosphor screens. When such kinescopes are used for a sequential color picture presentation, sine wave switching can be used for high sequence rates and the capacitance is considerably less than the deflection-plate methods of Figures 5b and 5c. There is, however, parallax between the color images which either limits the viewing angle or suggests the use of projection optics, as previously discussed, for the tube having phosphor-coated grids.

A switching-at-screen color kinescope, which uses a single electron beam at an average angle of 45 degrees with the viewing screen, was developed by RCA. All three color-emitting phosphors are now placed on the front surface of a perforated metal sheet in adjacent line-like areas. By varying the voltage on a nearby and parallel transparent conducting coating, the electron beam is reflected back in a path which can be slightly altered to strike one, or another, color. The phosphor areas and the openings in the sheet are so located that the same color is emitted no matter at what point on the raster the beam is deflected, assuming a fixed reflecting-electrode potential. To obtain a rectangular raster, keystone correction is applied to the deflection circuits. This device has a mechanical requirement, namely, accurate parallelism of the perforated sheet and the transparent reflecting electrode, but in other respects it has many advantages, among which is an effectively perfect superposition of the three color images. A sine wave can be used for sequential color switching, when necessary at a rapid rate, using circuits developed by RCA.

Each of the color kinescopes in this section has been described with a single electron beam; for sequential color presentation only one beam is needed. For a simultaneous presentation, brighter pictures are obtained by use of three separate electron beams. With the kinescopes using a color control mechanism at the screen, one may use three separate electron guns by operating them at different cathode potentials. The three guns are located as closely together as possible (if a single deflecting system is to be employed). In the methods of Figure 5a, or in the gridded tube, the differences in cathode potentials are so large that a single deflecting system would be impracticable. However, for the grid-controlled color tube, or the 45-degree reflection tube, only a small cathode potential difference is required for the three electron guns to cause the fixed-potential color control system at the screen to act differently on each beam. With the type of operation using a transverse control field, as in Figures 5b and 5c, the analogous procedure (i.e., three guns at slightly different cathode potentials) would not be applicable and one is led to a separation of the electron guns in space, with no control field. This becomes a direction-sensitive color screen (treated in the next section), which depends on shadowing.

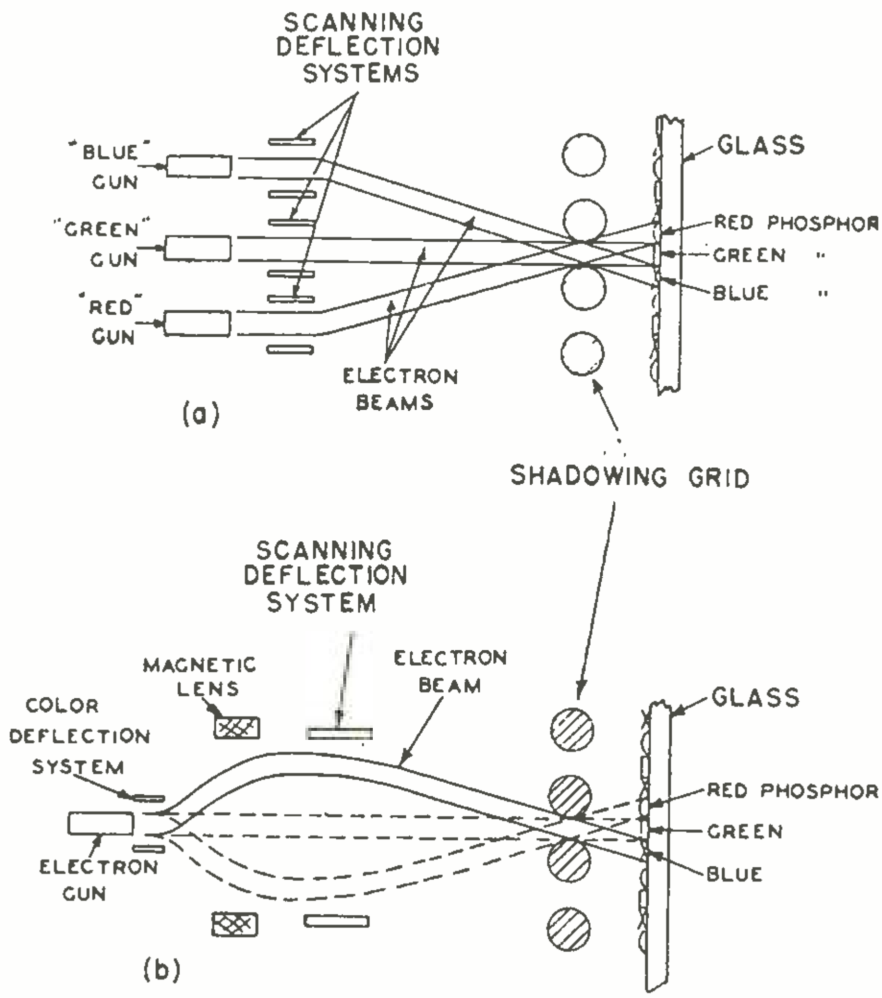


Fig. 6 — Proposal by Flechsig using color phosphor lines shadowed by wire grid, (a) with three beams, (b) with one beam deflected at the gun.

F. Direction-Sensitive Color Screens Using Electron Shadowing

Because electrons in a field-free region move in substantially straight lines, one can make use of shadow techniques to produce a color-emitting phosphor screen in which color depends on the direction of arrival of the impinging electron beam. An early proposal by W. Flechsig (1938) using color phosphor lines shadowed by an aligned grid is shown in Figure 6. It is seen in Figure 6b that a single beam may be deflected and reconverged so as to appear to come from three positions in time sequence. Alternatively, three separate and spaced electron guns may be used as in Figure 6a. Flechsig also describes a network of fine wires electrically charged to produce electron focusing instead of electron shadowing.

The first direction-sensitive method to receive considerable publicity made use of a nonplanar surface, and was proposed by Baird for a three-color kinescope. Shown in Figure 7, it used a ridged transparent plate with the color phosphors deposited as strips along the ridges. The third color was produced on the opposite side. Modified nonplanar color screens using all three beams on the same side were devised, for which a typical illustration is shown in Figure 8.

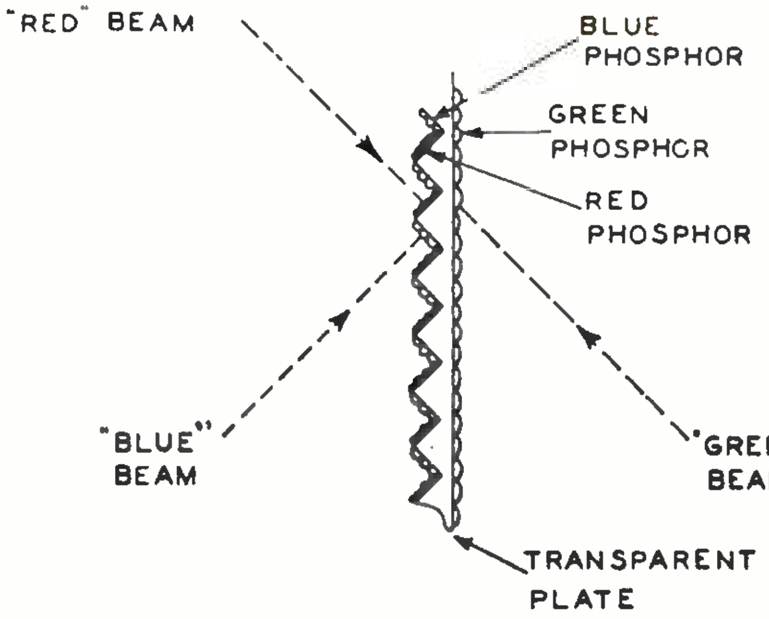


Fig. 7 — Baird three-color nonplanar color screen, in principle.

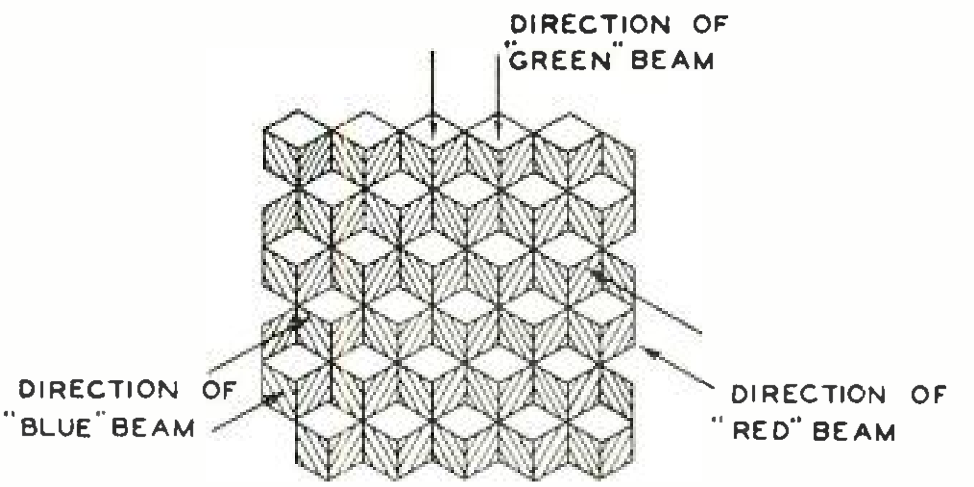


Fig. 8 — Cubical-pyramid nonplanar color screen. Sides of cubes facing in different directions are coated with different color phosphors.

The major problems of such a tube, aside from fabrication, lie in obtaining good color directivity and in the complex deflection problems. It is necessary to produce a rectangular raster with three off-axis, keystone-corrected guns, in which not only the edges but each scanning line should be registered with those of the other two guns. These problems have not yet been overcome practically, although much work has been done on them. A few years ago, RCA studied means for reducing the angle of separation of the three beams by using very steep pyramids on the nonplanar surface, and also by constructing alternative nonplanar surfaces, two varieties of which are shown in Figures 9a and 9b. Unfortunately, the deposition of phosphors so nearly parallel to the direction of viewing leads to so large a light loss that widely spaced guns, with their attendant deflection problems, may be essential.

There is, of course, a very substantial advantage in a direction-sensitive color screen with such a narrow angle between electron beams that a single deflection yoke can be used. Although it is possible to do this with the line-screen shadow device of Figure 6, it appears to be much easier to adopt another proposal. Special techniques developed at RCA showed the practicality of the arrangement and permitted successful tubes to be made using three beams, one for each color. This screen uses color phosphors arranged in groups of three dots in an equilateral triangle. Close to the phosphor screen and between it and the electron guns is an aperture mask which produces the shadowing. For each group of three phosphor dots, there is a hole in the shadow mask of about the same size as one dot. An electron beam approaching the shadow mask at a slight angle (of the order of 1 degree) from the line to the center of deflection, will land only on a single color in any one of three rotational positions, 120 degrees apart. Thus, by placing the three guns at an appropriate distance from the axis of the tube and at the correct azimuthal orientation, the three beams may be converged to a point on the

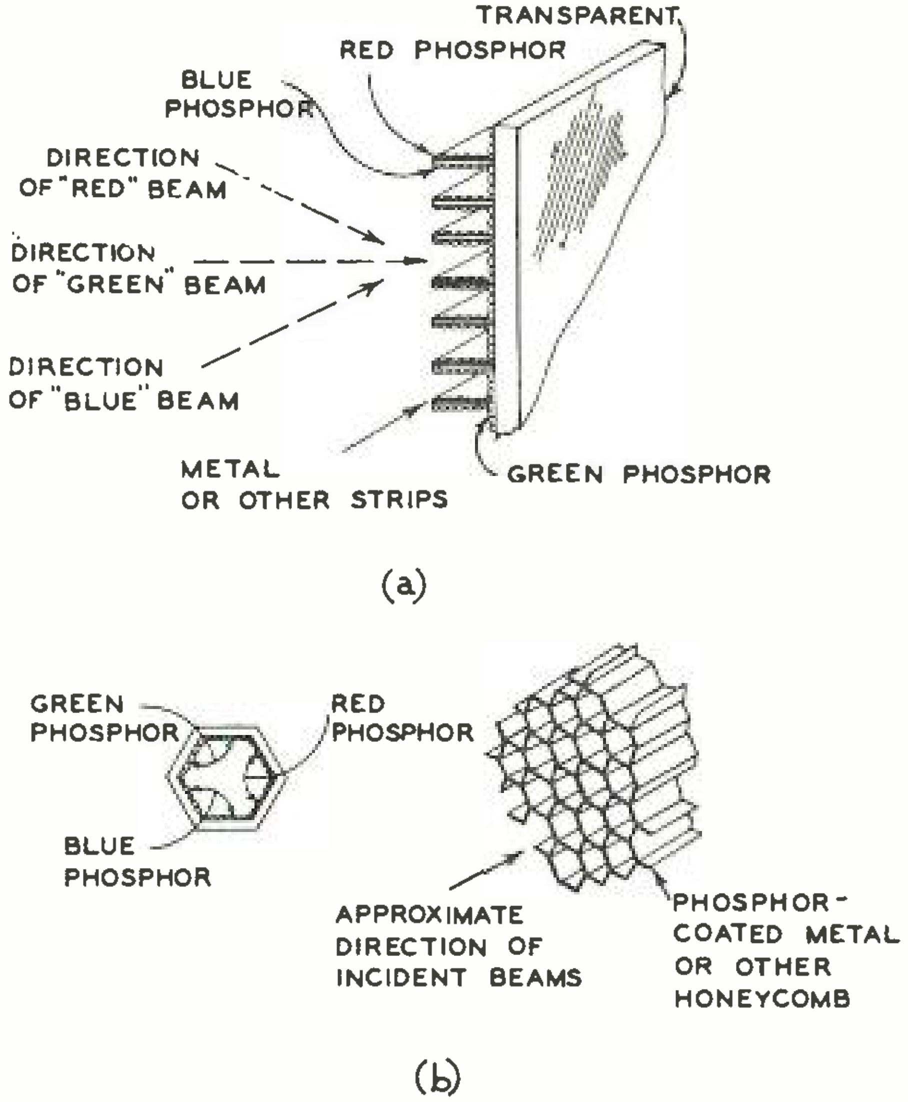


Fig. 9 — Two forms of nonplanar direction-sensitive color screen.

screen, and each beam is able to excite only a single color. Use of a very large number of dot groups prevents discernment by the viewer of the picture structure, just as in color printing. The three beams are converged to a single point on the mask, even through wide angles of deflection, by using an anastigmatic deflection yoke and convergence system.

A modification of the shadow-mask color kinescope is attainable by use of an ingenious development. In this development only a single electron beam is used. Prior to the normal scanning deflection, a small additional deflection at the gun and subsequent convergence moves the beam to different azimuth positions so as to cause any desired color to be emitted. When this is done in time sequence, so as to display each primary color in turn, a sequential color presentation is achieved, and it appears possible to use simple circuit components even at very high sequence rates.

PART V

Early Three-Beam Shadow-Mask Tricolor Kinescope

This extended exploration of various methods of color-reproducer design resulted in substantial progress. By early 1950, advanced research models of direction-sensitive, shadow-mask tubes employing either one or three electron guns capable of producing pictures of high color fidelity were available. Both of these types of tubes were demonstrated by RCA in Washington, D. C. in March and April, 1950, both to the public and as a part of the hearings before the Federal Communications Commission. A more detailed description of the three-gun shadow-mask tube demonstrated and its principles of operation follows.

A. Description of Tricolor Kinescope

1. Phosphor Viewing Screen

Among the fundamental differences which distinguish the tricolor picture tube from black and white kinescopes is, first and foremost, its phosphor viewing screen. In contrast to the uniformly coated phosphor mixture used in a black and white kinescope, the color-tube screen is composed of an orderly array of small closely spaced phosphor dots, arranged in triangular groups (trios) accurately deposited in interlaced positions on a supporting glass surface. Each trio consists of a green-emitting dot, a red-emitting dot, and a blue-emitting dot. The phosphor dots emitting these colors are kept separate without waste of space and yet without overlapping. The phosphor-dot plate of the tricolor kinescope demonstrated in March and April, 1950, had approximately 117,000 dot trios or 351,000 dots and was metalized after application of the phosphor dots to increase light output, insure a zero voltage gradient on the surface of the plate, and prevent ion-spot blemish.

The phosphors used were willemite (Zn_2SiO_4: Mn) for the green and another silicate ($CaMg(SiO_3)_2$: Ti) for the blue. The third phosphor was a readily available cadmium borate ($2CdO \cdot B_2O_3 : Mn$), which has a red-orange color which many observers judged to be not close enough to the optimum red. To provide a better red, a didymium glass filter was used which has a sharp rejection band at the yellow sodium lines; at other wave lengths it is very much like a neutral filter with 40 to 50 per cent absorption. This filter made the color reproduction satisfactory, and, although a substantial loss of light resulted, there was a slight compensating advantage in the improved contrast due to the neutral filter action. However, the borate red left much to be desired in efficiency, and the output of the more efficient green and blue phosphors had to be reduced to achieve a color balance.

2. Shadow Mask

A second difference between this color tube and the conventional black and white kinescope is the shadow mask. From the position of the tube viewer, the mask is located parallel to and just back of the phosphor-dot plate. The mask provides color separation by shadowing two of the three arrays of phosphor dots from two of the electron beams, while exposing the proper array to bombardment by each beam. In order to obtain precise alignment between the apertures in the mask and the phosphor dots, the mask and phosphor-dot plate are mounted together in an assembly. This assembly is then placed in the tube and held in proper relationship to the gun.

The metal shadow mask, interposed between the electron gun structure and the phosphor-dot plate, contains round holes equal in number to the dot trios. Thus, for this tricolor kinescope the mask had approximately 117,000 apertures. Figure 10 illustrates the manner in which the mask holes are lined up with the color dots.

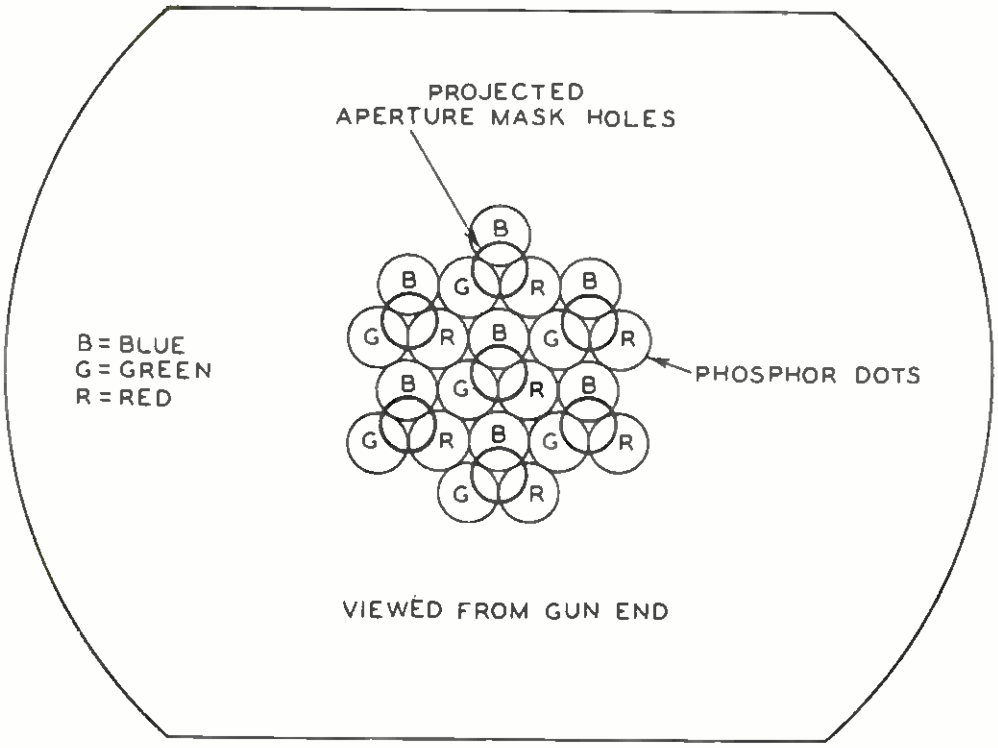


Fig. 10 — Orientation of projected mask holes with phosphor dots.

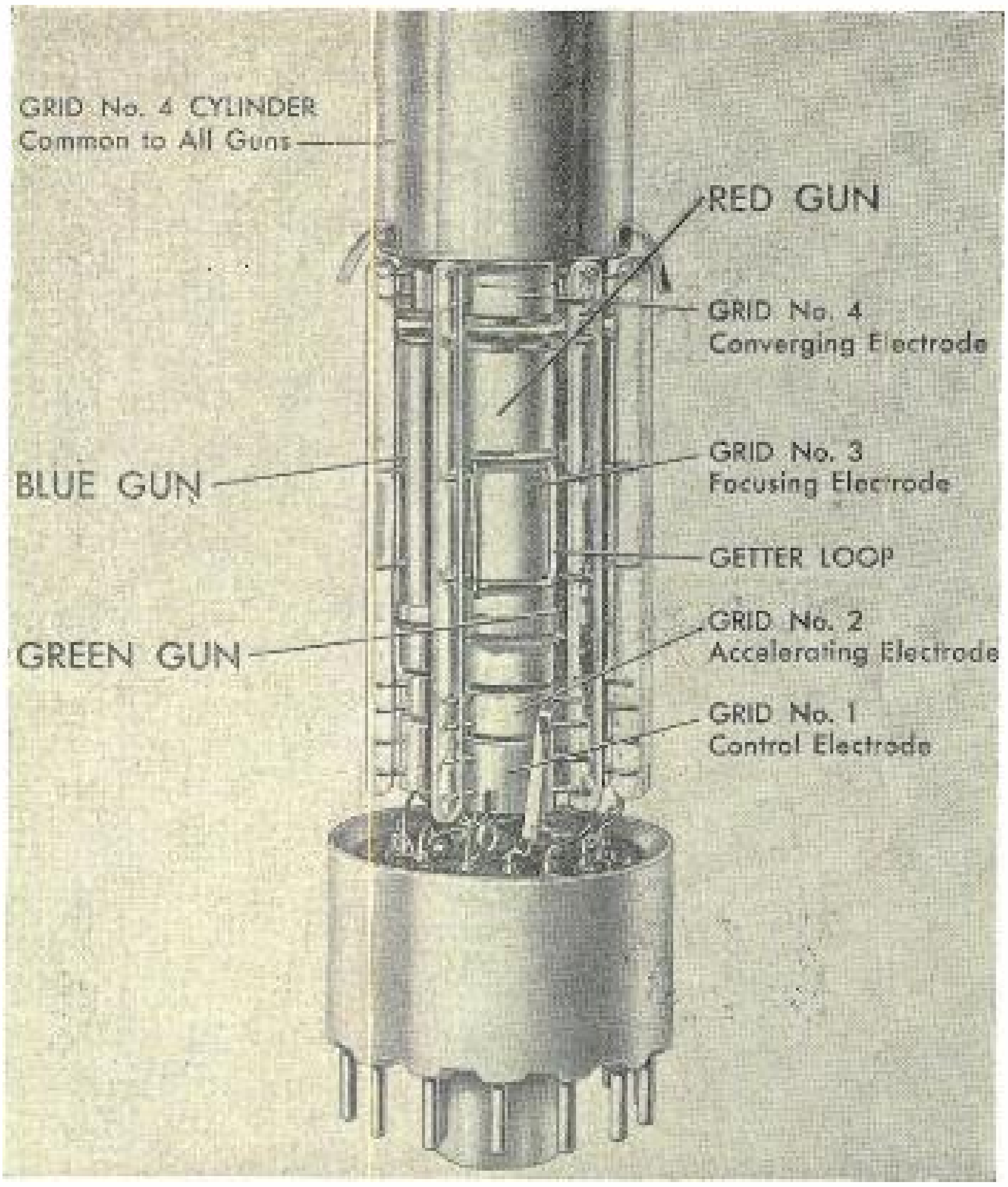


Fig. 11 — Structure of three-gun assembly used in developmental color kinescope.

3. Three-Gun Assembly

In this tube three parallel, closely spaced electron guns, built into a unit, provide separate beams for excitation of the three different phosphor arrays. Thus, it became possible to control the brightness of each of the three colors independently of the other two. A photograph of such a gun assembly is shown in Figure 11.

4. Envelope

The envelope, because of ease of availability, was a standard 16-inch round kinescope envelope, modified as required to permit the viewing screen assembly to be mounted near the face of the tube. This envelope accommodates a viewing screen assembly which will provide a picture size 11½ inches by 8⅜ inches with rounded ends.

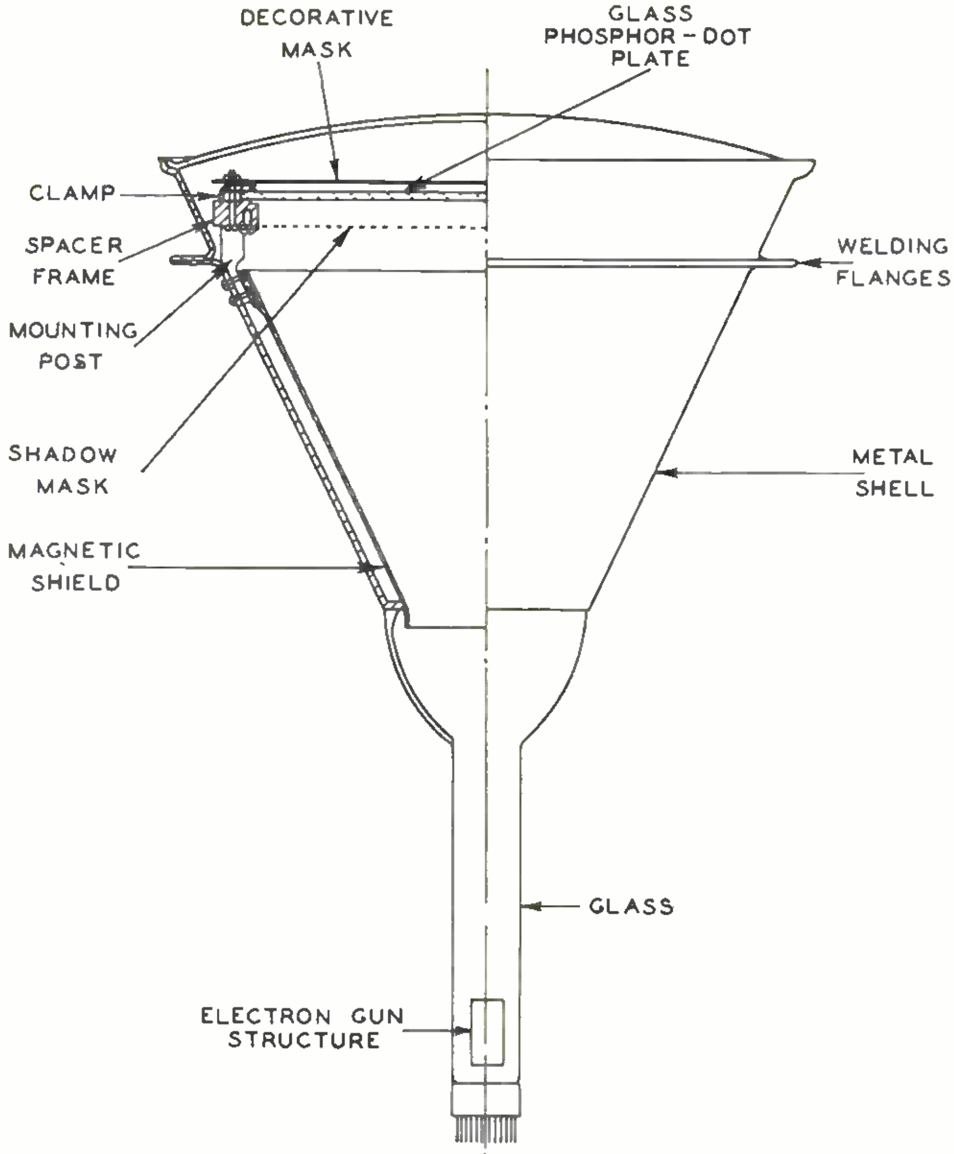


Fig. 12 – Cross section of envelope – old design.

A high-permeability metal magnetic shield was provided inside the envelope to eliminate the effects which external stray magnetic fields would have on the electron beams.

After the viewing screen assembly was mounted in the envelope, the flanges on the envelope and the face plate assembly were welded together to complete the tube enclosure.

A cross-sectional view of this early tricolor kinescope is shown in Figure 12.

B. Operating Principles

The electrode arrangement of a three-gun assembly is shown in the gun structure photograph of Figure 11. The axes of the beams from the three electron guns are made to converge at the shadow mask by an electrostatic lens produced by the voltage difference between grid No. 4 (converging electrode) and grid No. 5 (neck coating). From Figure 13, it is seen that the

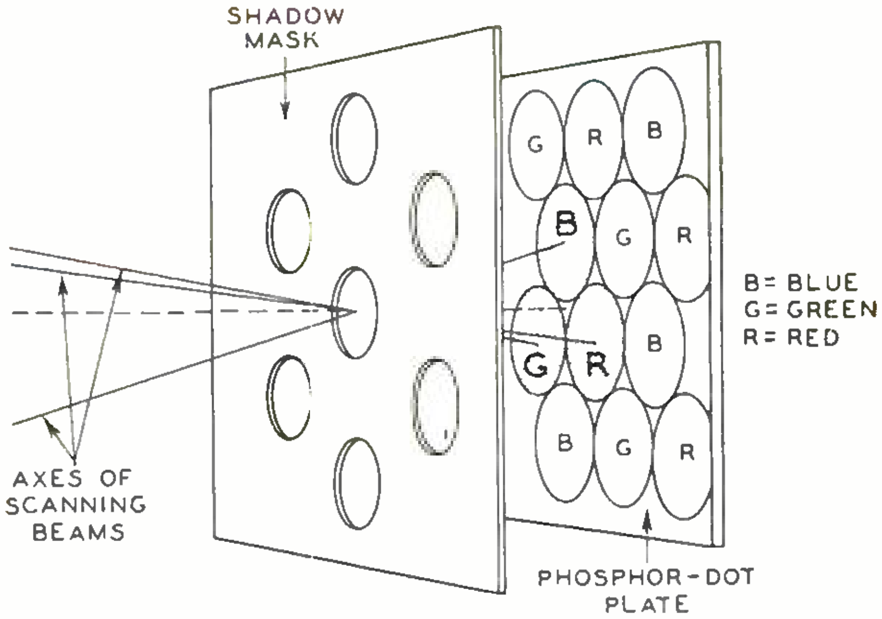


Fig. 13 — Relationship of scanning beams, shadow mask, and phosphor-dot plate.

three beams must be made to converge at the aperture corresponding to the dot trio being scanned at any moment. The three beams are converged as a unit by adjustment of grid No. 4 voltage. Individual positioning of each beam to accomplish proper convergence usually requires the use of three small external magnets located near the guns.

Because the shadow mask and the phosphor-dot screen are flat and because of deflection considerations, it is necessary that the focal length of the converging lens be made to vary as a function of the deflecting angle. This dynamic converging is accomplished by applying voltage derived from the horizontal and vertical deflection circuits so as to vary the potential applied to the converging electrode (grid No. 4).

The different angles at which the beams from the three guns reach the shadow mask determine the particular color phosphor dot which is energized by each beam. Thus, one gun is associated with each of the primary colors so that control of the beam current from that gun controls the amount of the primary color developed. Figure 13 illustrates the effect of approach angle of the three beams. The shadow mask is oriented so that with correct approach angle electrons from one of the three beams can strike phosphor dots of only a single color no matter which part of the phosphor-dot plate is being scanned. Thus, three color signals controlling the three beams produce independent pictures in the primary colors. These primary colors from the three phosphor dots comprising a picture element (trio) appear to the eye to blend because of the close spacing of the dots, and as a result the eye sees a full-color picture.

Focusing of the three beams is accomplished electrostatically by adjustment of the voltage applied to the three No. 3 grids which are interconnected within the tube and have a common pin terminal. Because the beam-path length from the focusing lenses to the flat screen assembly is a function of the position of the screen area being scanned, and because these lenses are affected by the dynamic converging voltage applied to grid No. 4, it is desirable that the grid-No. 3 voltage be varied as a function of the position of the trio being scanned. This dynamic focusing is accomplished by applying voltage derived from the horizontal and vertical deflection circuits so as to vary the potential applied to the focusing electrodes (grids No. 3).

A deflecting yoke, consisting of four electromagnetic coils, is required for deflecting the three electron beams simultaneously after they pass through the converging lens. The coils are used in pairs; the coils for each pair are located diametrically opposite each other. The axes of the two fields should intersect at right angles to each other and to the tube axis. The yoke design and development will be described in more detail in Part VII.

PART VI

Tricolor Kinescope Improvements

At the time of the demonstrations in March and April, 1950, it was clearly indicated that the basic principles of a single tube to reproduce color pictures as a part of a compatible television system had been developed. Although the tubes demonstrated could not be considered a finished design for production purposes, the problems still to be solved were generally of a nature capable of relatively straightforward solution by those skilled in the art. Accordingly, a program was initiated to arrive at a tube design suitable for mass production. The major accomplishments of this program are covered in this exhibit. This program, however, was conducted concurrently with extensive research and development activity on a number of other color reproducer methods.

In the development of a color tube and the associated equipment suitable for mass production, many interrelated factors have to be weighed one against the other in order to arrive at an optimum balance. Many times an improvement in one factor results in the deterioration of another factor, and the proper balance between the two can only be reached after a considerable number of tests seasoned by the judgment of a fairly large cross section of observers. Directions of improvement and balance are thus indicated, and the tube and circuit designer can then take another step forward, after which the results are again subject to review and appraisal prior to a subsequent step.

Throughout the development of a tricolor kinescope design suitable for mass production, the program has centered around three basic objectives. These objectives are:

1. Improvement in performance
2. Improvement in constructional features
3. Increase in picture size

The first two objectives are closely interrelated. Improvements in performance, of course, are the result of improvements in materials or fabricating techniques. Certain constructional improvements, however, may not result in any picture improvements but resolve tube fabrication problems so that production and assembly will be simpler, faster, and better. The material following will cover both types of improvements. The special problems related to increased picture size will be treated separately.

A. Improvements in Performance

1. Resolution

By an increase in the number of dots in the viewing screen from the original 351,000 to the present 585,000, the resolution capabilities of the tricolor kinescopes have been improved so that they meet the requirements for black and white picture standards.

2. Color Purity

Improvements in screen-making techniques, and in construction and assembly techniques, which will be described in more detail in a subsequent section, have resulted in greatly increased purity of the color fields permitting excellent color rendition for color television, as well as whites without color blemish in the reception of black and white pictures.

3. Light Output and Color Balance

An improved red-emitting phosphor ($Zn_3(PO_4)_2{:}Mn$) was synthesized shortly after the March and April, 1950, demonstrations. The use of this new phosphor eliminated the need for the didymium filter. A further development was an improved blue phosphor. In the early tricolor kinescopes, the blue phosphor used had a relatively longer decay characteristic than the corresponding red and green phosphors. This decay characteristic resulted in so-called "trailing", which gave a slight bluish color to the trailing edge of objects in motion, as well as a general bluish overcast. The remedy for these defects was the development of a new blue-emitting phosphor (ZnS:Ag:MgO) which gave a much better balance with the red-emitting and green-emitting phosphors. Curves of the spectral-energy emission characteristics of phosphors currently used are given in Figure 14. In Figure 15, a comparison is made between the range of the color primaries for the tricolor kinescope and the color primaries of modern printing inks. It is evident that the phosphor primaries are superior in range and sufficiently close to the values suggested by Hardy and Wurzberg for excellent color reproduction.

Improvements in the method of application of the phosphors, as well as improved processing schedules, have resulted in higher phosphor efficiency and resulting light output. Beam energy to the phosphors had been limited by the amount of beam energy which the shadow mask could dissipate

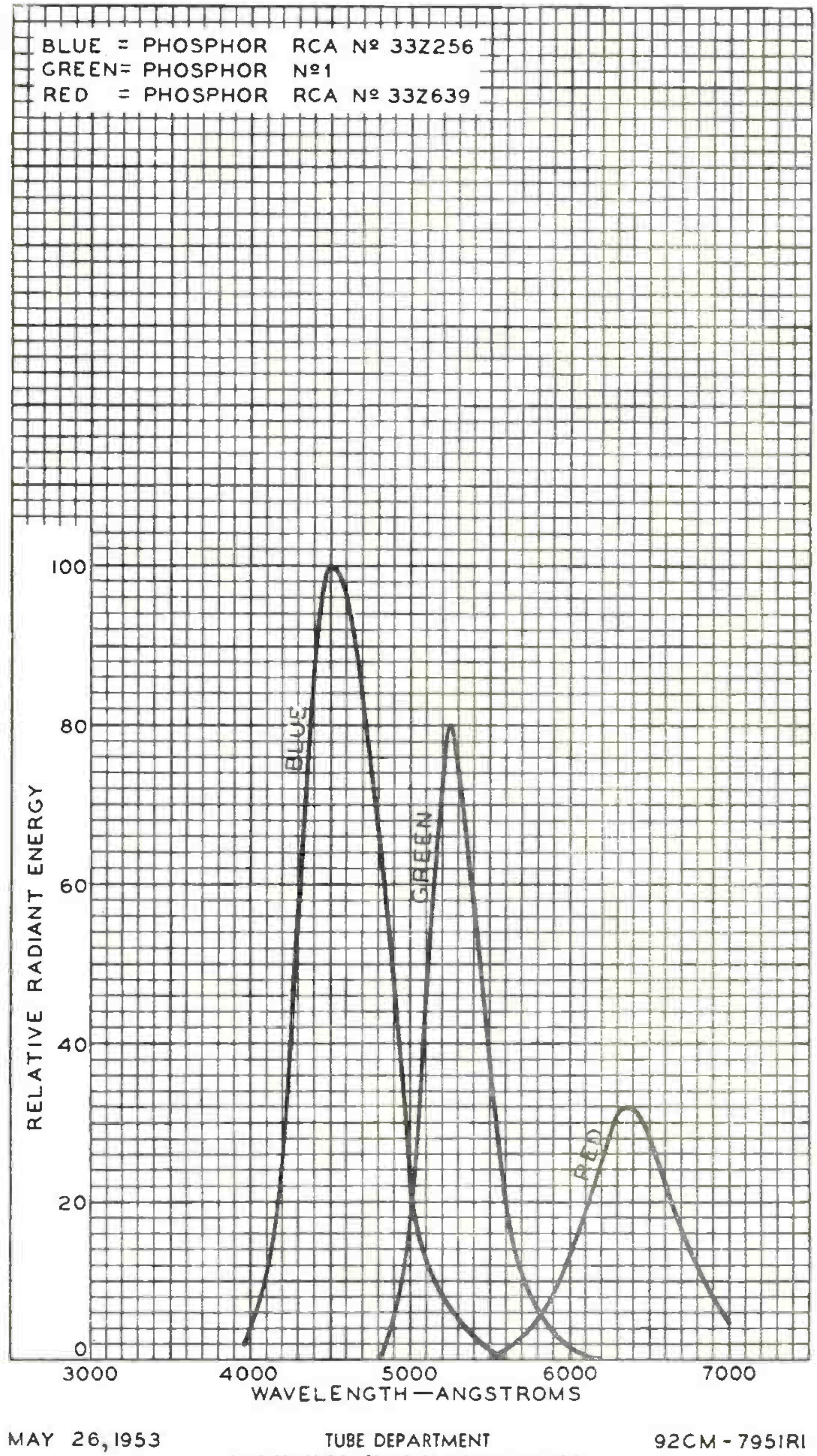


Fig. 14—Spectral-energy emission characteristics of phosphors used in color kinescopes.

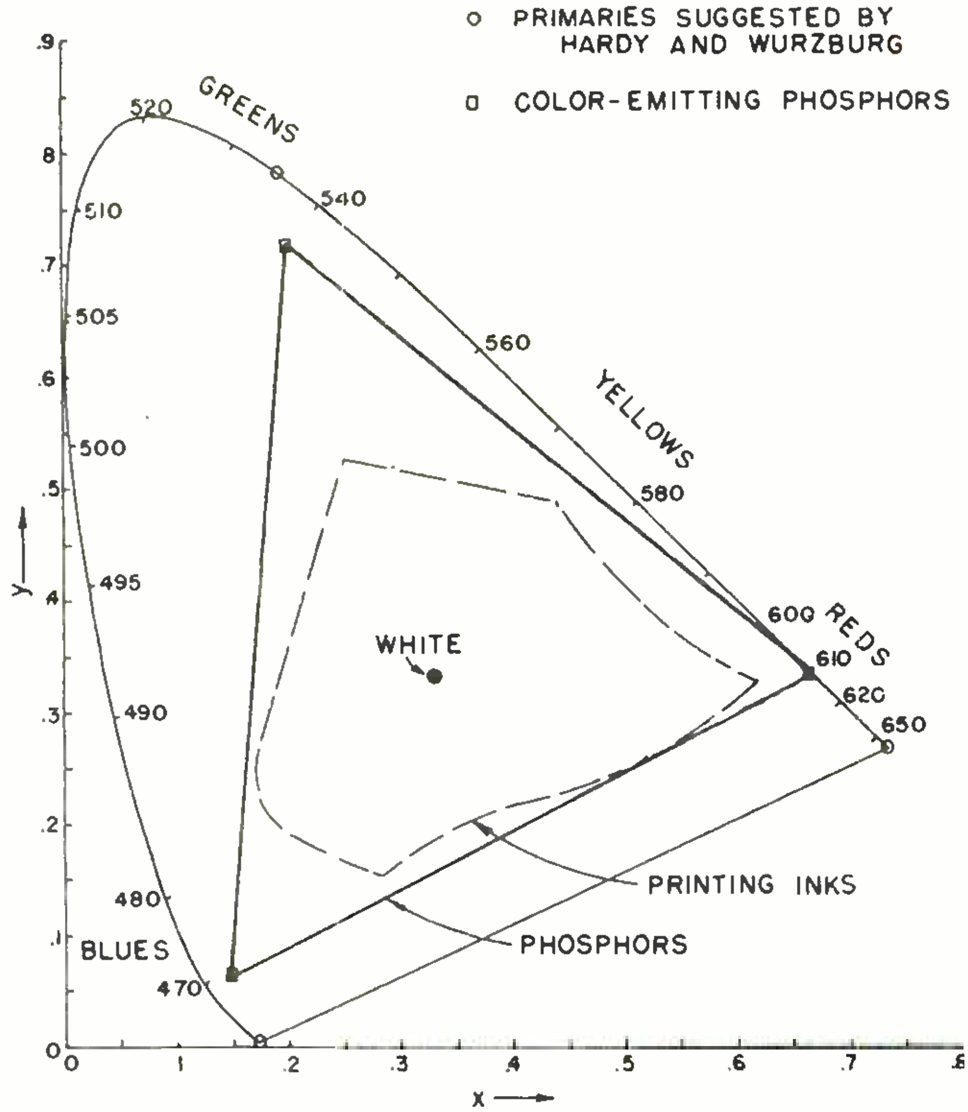


Fig. 15 — Three color primaries achieved by unfiltered phosphors compared with idealized primaries of Hardy and Wurzburg. The area possible with modern color printing (according to MacAdam) is shown by the dashed-line figure.

before it reached a temperature at which it warped due to differential expansion between the mask and frame causing the apertures and dot trios to become misregistered. By development of an improved method of processing the mask, as well as improvement in mask material, the beam energy which may be dissipated by the mask was increased by a factor of about 2½. This increase in the dissipation capacity of the mask, of course, proportionately increases the permissible beam energy to the phosphors resulting in increased light output.

4. Contrast

Improvement in contrast ratio has been obtained in several ways. The first of these was by substituting a neutral filter glass (also often referred to as "grey" or "black" glass) for the clear glass phosphor-dot plate. The second was by development of improved techniques for aluminizing the phosphor-dot plate resulting in a uniform coating of just the right thickness needed to obtain the best balance between contrast improvement and light output.

A very careful balance was achieved between the factors controlling contrast ratio and the factors controlling light output, so that a picture was obtained having a contrast ratio equal to that obtainable in black and white tubes of comparable size and a highlight brightness capability of between 30 to 40 foot-lamberts. This light output is considerably greater than that which could be obtained from the tubes shown at the first demonstrations.

B. Improvements in Construction

From the foregoing material on improved performance factors, it will be noted that there have been no basic changes in principles of tube operation, but that the improvements in performance have been associated with improved materials and improved constructional, processing, and assembly features. This section will discuss some of these features in more detail.

1. Viewing-Screen Assembly

The viewing-screen assembly is the heart of the tricolor kinescope. A great amount of engineering time has been expended to study and develop this assembly so that it could be produced in volume at a reasonable cost. For purposes of comparison, a brief description of the early viewing-screen assembly precedes a more detailed description of the improved assembly.

a. Early Design

The parts used in the viewing-screen assembly for the early developmental tricolor kinescope, including those displayed and sampled through most of 1952, are shown in Figure 16. The major parts are the shadow mask, spacer frame, and phosphor-dot plate. Also shown are the necessary auxiliary parts, the mask clamping segments, alignment pins, glass clamps, and screws. Each part of this assembly required extremely precise and, consequently, costly fabrication. The spacer frame between the mask and the phosphor-dot plate had to be machined to an accuracy within $\pm$ 0.001 inch. The alignment hole and slot on opposite sides of the spacer frame were located by a drill jig and then drilled and milled to a plus tolerance of 0.0005 inch.

During tube operation, the shadow mask receives a portion of the beam current, which heats the mask and which could cause it to expand if no counter action were taken. If this expansion were permitted, misregistry between the apertures and phosphor-dot trios would result. To overcome this problem, a "hot-blocking" or prestressing technique was developed. With a temperature difference between the shadow mask and steel frame slightly higher than that encountered in tube operation, the mask is expanded

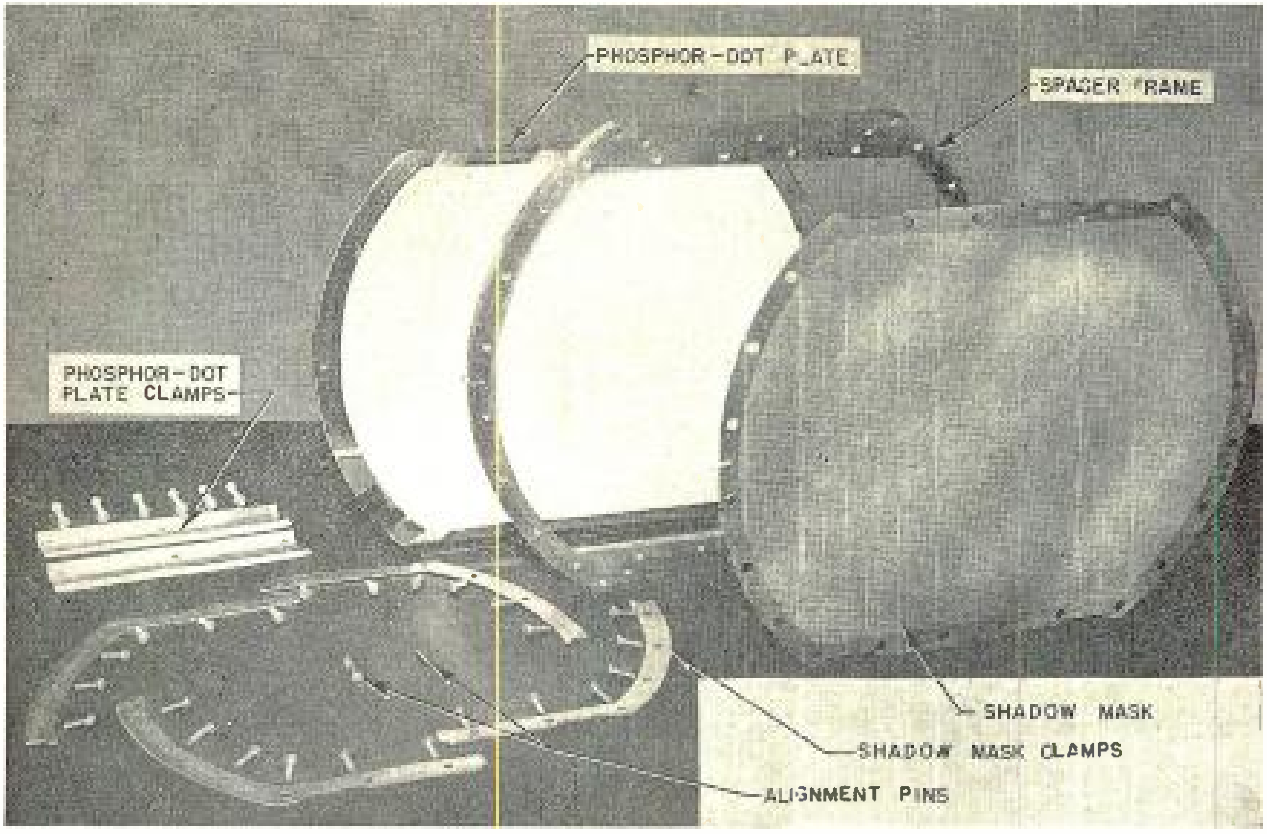


Fig. 16 — Exploded view of viewing-screen assembly — early design.

and then clamped to the frame. On cooling, the mask is held in its expanded state under tension.

Registration between the apertures and phosphor-dot trios on the glass plate was obtained by transferring the location of the alignment slot and hole in the frame to a gelatin stencil and then accurately aligning the holes in the glass plate with the hole and slot in the gelatin stencil using a microscope as a visual aid. This required considerable skill on the part of the operators at each stage of the processing.

Each viewing-screen assembly had to be treated as an individual unit, i.e., a gelatin screening stencil had to be prepared for each "hot-blocked" shadow-mask-frame assembly, and the phosphor-dot plate screened from this stencil had to be properly identified so that it could be assembled later with the proper shadow-mask-frame assembly. The production problems associated with this design are obvious.

b. Improved Viewing-Screen Assembly

The parts for the new viewing-screen assembly are shown in Figure 17. The major parts are the phosphor-dot plate, shadow mask, and the frame, now in two parts. Also shown are the necessary auxiliary parts, the clamping screws, phosphor-dot plate clamps, and nuts. None of the parts require precision machining.

The mask is still of super nickel (an alloy of 70% copper, 30% nickel) but may be 0.002 to 0.004 inch thick. The material need only be as thick as can be conveniently handled in production, in order to ease the chemical etching process and to lessen the load on the frame provided by the stressed shadow mask. Figure 18 is a view of the improved shadow mask. It shows in the border three radially elongated holes, a number of narrow radial slots, two identification tabs, and twenty-four large holes. By improved mass-production photoengraving techniques it is now practical to produce all holes and slots in the shadow mask at the same time and to hold the diameters of the small apertures to a tolerance of less than ± 0.0005 inch.

The uniformity of the aperture size and spacing has been improved considerably by making a new master dot array and developing a more homogenous alloy for the mask. This improvement has resulted in more uniform color fields and, hence, better color rendition in the viewed picture. Uniform fields are of particular importance when black and white pictures are reproduced on the tricolor kinescope.

The shadow masks now are given a chemical treatment so that the surfaces have higher thermal radiating properties. This treatment permits a greater electron beam energy to be dissipated by the mask before the

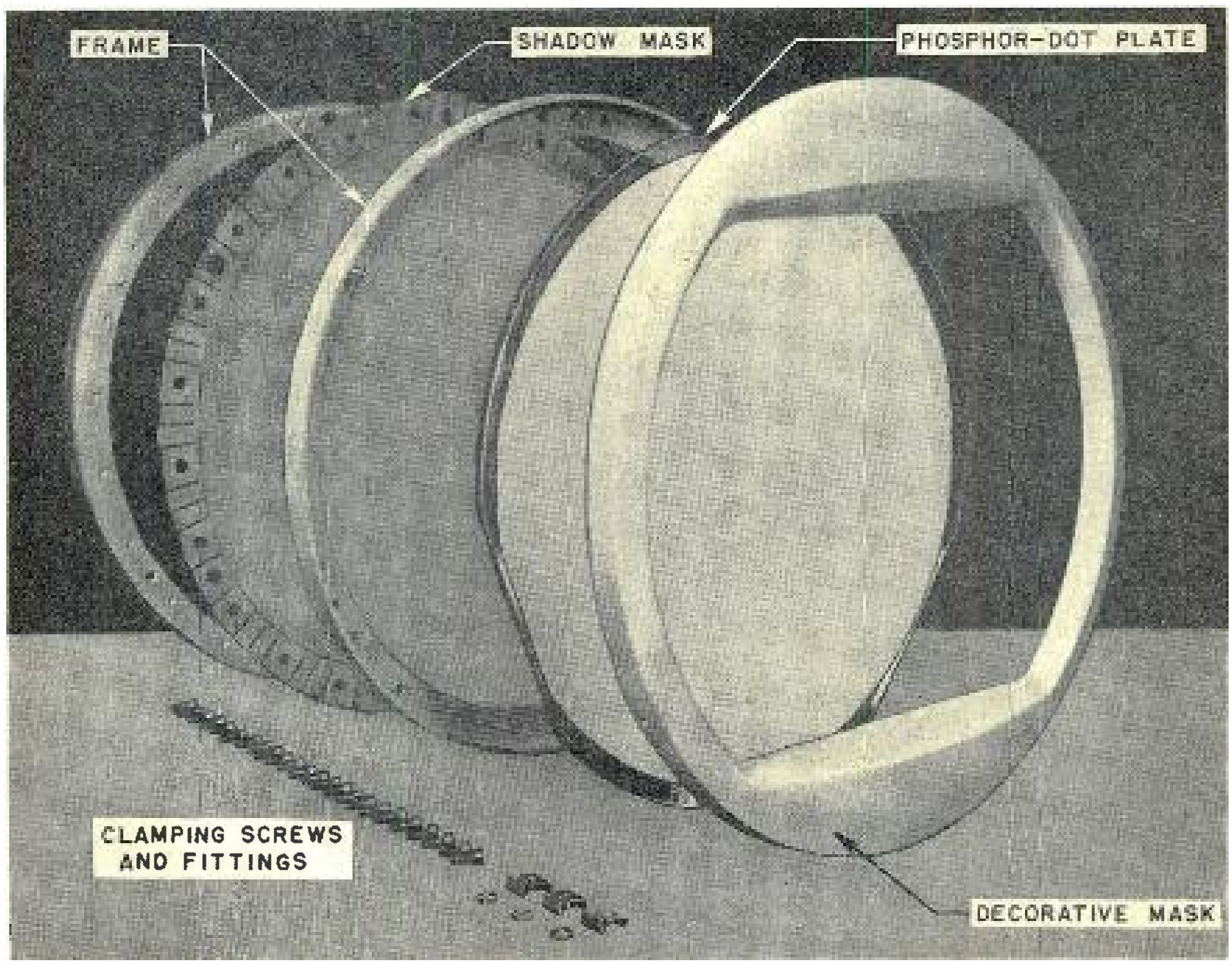


Fig. 17 — Exploded view of new viewing-screen assembly.

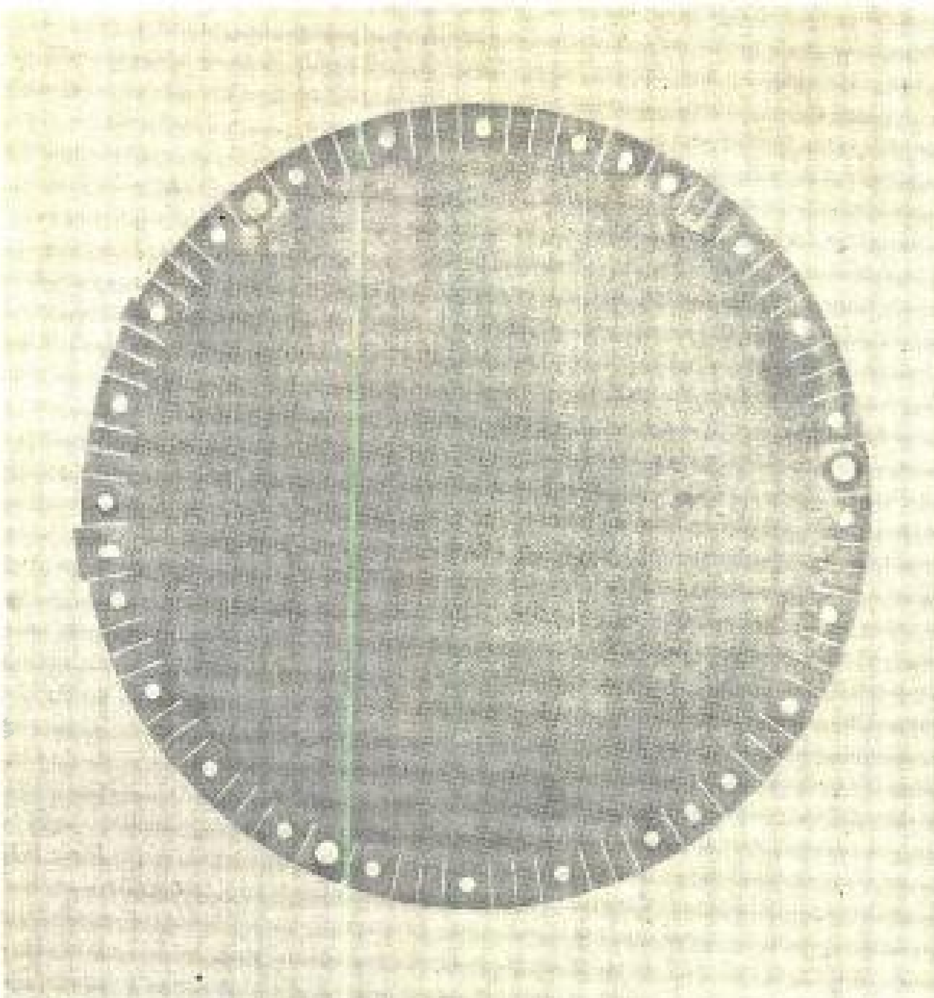


Fig. 18 — Plan view of shadow mask.

temperature is reached at which all the stress is relieved; a further increase in temperature would cause mask buckling. As mentioned in the section on "Improvements in Performance", this feature allows a greater highlight brightness and light output.

The frame, shown in Figure 17, consists of two parts, the upper section and the lower section. These frame sections are drawn from ⅛ inch hot-rolled steel sheet by conventional methods. The only special requirement is that the land on the bottom of the frames be flat to within 0.003 inch of a plane. This flatness is readily achieved in practice with normal precautions. All the holes for the clamping screws and fittings are pierced at one time in a press by conventional methods to commercial tolerances. In the lower frame it is necessary to tap the holes for the clamping screws. The miscellaneous fittings are welded or furnace brazed in position using standard commercial techniques.

It was originally thought necessary to center load the frame to prevent the frame from warping. Hence, the frame was designed with two similar parts, the upper and lower sections, with the mask sandwiched between the two sections. Recent tests have shown that the frame may be fabricated from 1/16 inch instead of ⅛ inch thick steel; or, only one ⅛ inch thick steel frame section may be used with the shadow mask welded rather than clamped to the frame.

The means for obtaining and holding registration between the apertures and phosphor-dot trios is unique and deserves attention since it is through this design that the parts of the viewing-screen assembly can be interchanged, making it unnecessary to treat each shadow-mask-frame assembly as an individual unit. This interchangeability feature eliminates the need for making a gelatin screening stencil for each shadow-mask-frame assembly and makes it possible for a number of phosphor-dot plates to be printed from a single gelatin screening stencil. In fact, an etched metal screening stencil may be substituted for the less durable gelatin, or any one of a number of printing techniques may be used.

The method used to obtain the adjustable spacing between the shadow mask and phosphor-dot plate is shown in Figure 19. Three straight-sided pins fitting in collets equipped with locking nuts are located on the periphery of the frame 120° apart. The heads of the pins carry a hemisphere which is located off the axis of the pin. These heads mate with the three V grooves in the glass plate. This design fulfills the basic kinematic requirement of the six points of contact. Therefore, there is one and only one position in which the glass plate can fit upon the three hemispherically headed pins. The glass plate may be lifted off the pins and replaced. When replaced, it will always seat in exactly the same position. It is interesting to note that the dimensions of the heads of the pins and grooves are not critical in order to obtain perfect mating of the parts. To change the separation or spacing between the shadow mask and phosphor-dot plate it is only necessary to slide the pin in the collet. To bring the apertures and phosphor-dot trios in alignment, the pins are rotated, thereby translating the plate to the desired position. See detail of eccentric adjustment, Figure 19b. To determine the proper position of the eccentric pins, the "hot-blocked" shadow-mask-frame assembly is placed in a jig called an "alignment light-house". This jig holds the viewing screen assembly in proper relation to a small light source located in a position corresponding to that of one of the electron beams as it passes through the deflection center in an actual tube. The "alignment light-house" is equipped with a mechanism for readily moving the eccentric pins and tightening the collet locking nuts. The proper position of the phosphor-dot plate relative to the shadow mask is determined by observing the halo around the phosphor dots, created by the light rays passing through the apertures, with the aid of a magnifying lens or by observing the diffraction patterns which appear around the light source.

Another important feature of the new viewing-screen assembly is that the maximum misregistration between an aperture and phosphor-dot trio is reduced to one half the magnitude for the old assembly. With the old assembly, when the phosphor-dot plate (glass) expanded during normal operation of the tube, all the movement occurred at one end of the screen assembly. The plan view of the new assembly, Figure 19c, shows that the

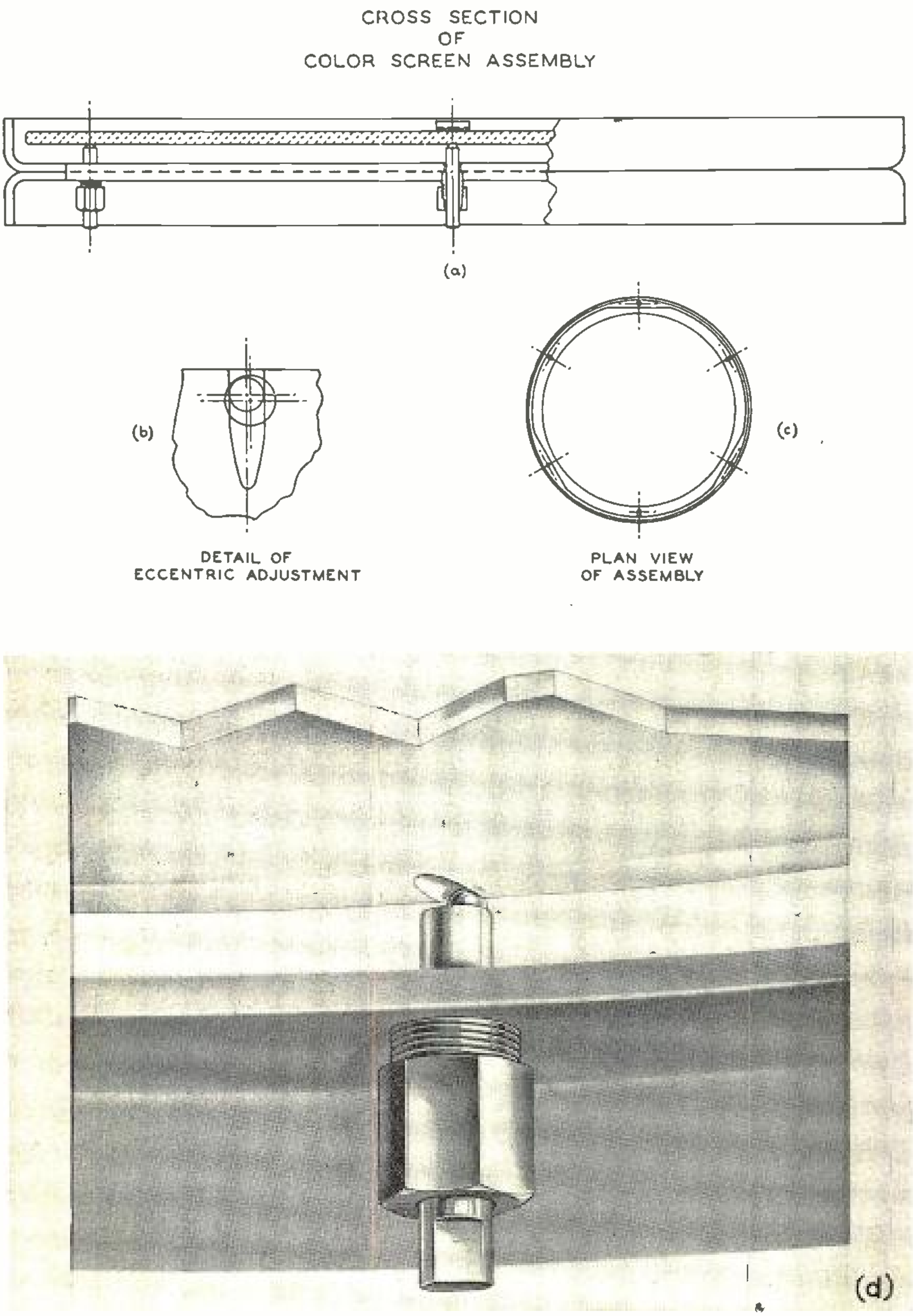


Fig. 19 — (a), (b), and (c) Sectional views of new viewing-screen assembly. (d) Detail of phosphor plate adjustment mechanism.

center is artificially fixed. The expansion of the phosphor-dot plate is uniform about this center and hence the edge apertures move with respect to their phosphor-dot trios only one-half as much as they would if the plate expanded about a pin at the edge of the glass plate.

c. *Improved Fabricating Equipment*

In addition to the aforementioned improvements in the design of the viewing-screen assembly, several significant advances have been made in the equipment used for the fabrication of the components used for this assembly. One of these advances is in the photographic equipment used for making the screening stencils. This equipment utilizes a "lighthouse" which simulates optically the front end of a color tube. In the early equipment a very small, intense light source located at a position corresponding to the deflection center of one of the three beams was used. The mask-and-frame assembly was placed at a position corresponding to the one it would take in the finished tube, and the photographic plate, emulsion side toward the mask, was placed in the position later to be occupied by the phosphor-dot plate. With this arrangement a slightly enlarged image of the mask was in effect projected upon the photographic plate. This image corresponds to the viewing-screen area as seen through the mask from the point which will later become a deflection center for one of the three electron beams. In other words, the photograph made in the "lighthouse" contained the pattern of the phosphor-dot array which was to be deposited on the glass plate for emission of one of the three primary colors. After being exposed in the lighthouse, the photographic plate was developed, dipped in clear lacquer, dried, and covered on the emulsion side with a light coating of paste wax. A photosensitized paper-backed pigmented gelatin sheet was then applied to the emulsion side of the photographic plate, exposed in a printing frame, and developed in warm water. During development, the unexposed areas (dots) were dissolved out. While still wet, the gelatin and plate were placed, gelatin side down, on the fine wire mesh stretched taut on the printing frame. After the gelatin was dried, the photographic plate was removed leaving the gelatin stencil adhering to the mesh. The stencil was then used for printing the phosphor-dot screen.

With the early method, the dots on the center of the pattern were very often larger than the dots at the edge of the pattern. This condition resulted from the non-uniform distribution of the light intensity across the photographic plate, as illustrated in Figure 20. The light intensity at the edge of the photographic plate was only 73 per cent of the light at the center. To remedy this condition, a new "lighthouse" was developed. In the new "lighthouse", also illustrated in Figure 20, the spacing between the mask, photographic plate, and light source is expanded by a three to one ratio. As a result of this new arrangement, the edges receive 96 per cent of the light intensity of that at the center and the phosphor-dot shape, therefore, is uniform.

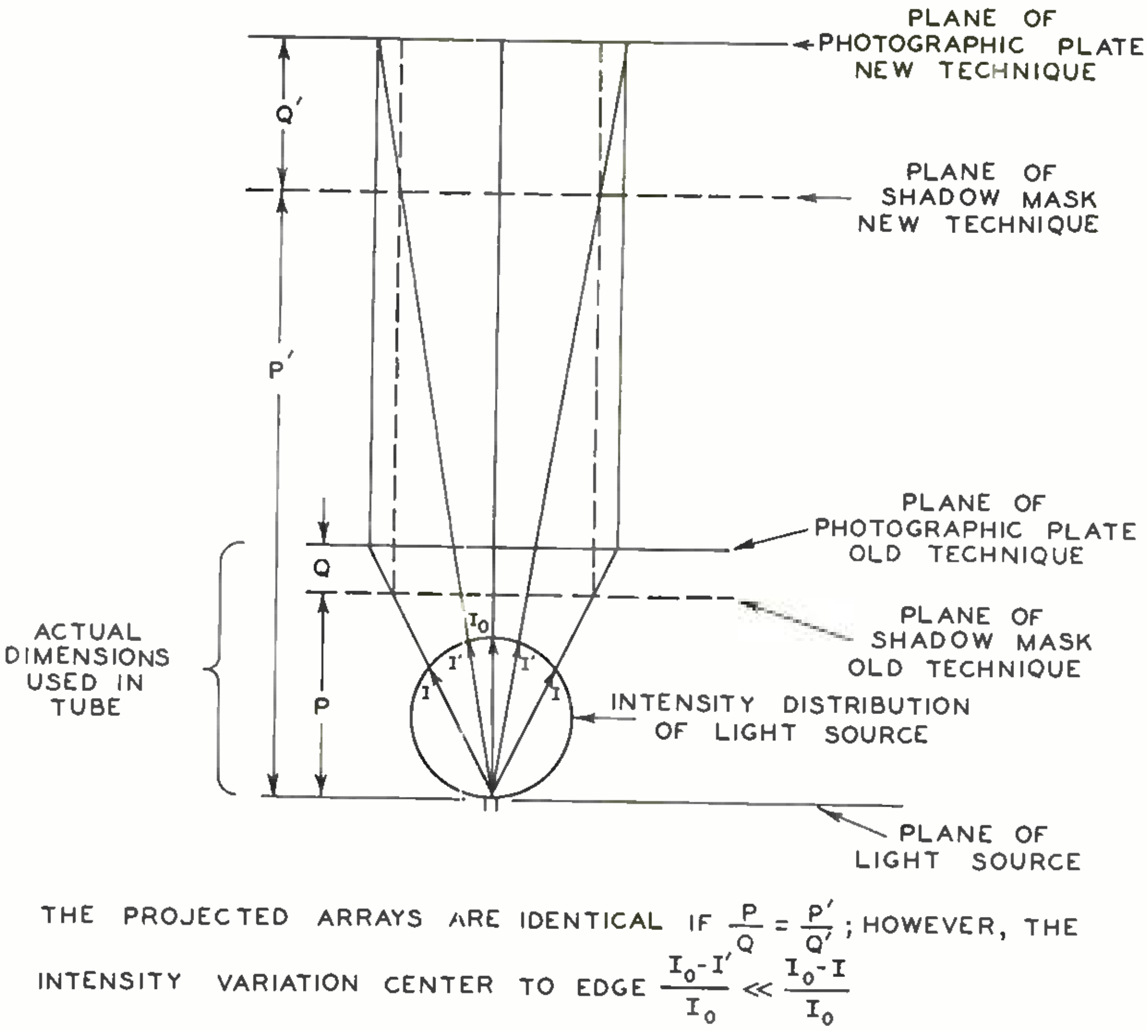


Fig. 20 — Diagram of improved photographic lighthouse arrangement.

Another important piece of fabricating equipment that has undergone considerable design and development improvement is the device used for removing the stencil frame from the phosphor plate after printing. Originally, a hinged stencil frame such as is used in conventional silk-screen printing was employed. Such a frame, however, did not permit a good, even release of the stencil from the plate being printed, and uneven printing often resulted. The new device utilizes four air pistons mounted on the printing-table frame in contact with the stencil frame at its four corners. By actuating the four air pistons simultaneously, the entire frame is raised uniformly and quickly above the glass plate. This operation provides a clean break of the stencil away from the glass plate and results in a sharply printed, uniform pattern.

The equipment used for cleaning the stencil between printings has also undergone considerable improvement. For the early color tubes, the stencil frame was moved after each phosphor application to a cleaning hood. Here, in the cleaning position, the stencil was carefully cleaned with industrial cleaning tissues saturated with amyl acetate to insure freedom from color contamination. Absorbent paper-toweling sheets were placed underneath the stencil to absorb both the solvent and the phosphor powder. The screen was washed a minimum of three times; fresh tissues and absorbent paper sheets were used each time. This cleaning process was slow, costly, and not always thorough.

Present equipment for cleaning the stencil frame is automatic. Cleaning takes about one-quarter of the time of the previous manual method. In the automatic washing equipment, two frames are cleaned at one time. They are held in a vertical position and sprayed for one minute through an array of jets by the cleaning solvent. The spray shuts off automatically and is followed by a spray of drying air from the air jets. The drying time is two minutes. The used cleaning solvent is collected, filtered, and re-used. This new equipment is rapid, economical, and thorough.

In the early tubes, the platens for "hot-blocking" the shadow masks on to the spacer frames were heated in electrically heated laboratory-type ovens. The ovens were slow heating and difficult to control, and the platens were awkward to handle. As a result, obtaining consistent mask tension was a problem. This no longer is a problem because special equipment, shown in Figure 21, has been designed for "hot-blocking". Prior to the "hot-blocking" operation, the mask is placed in proper alignment between the upper and lower frame sections and the twenty-four screws are placed in the tap holes but not drawn up tight. This loose assembly is then placed in the equipment for "hot-blocking". In this equipment there is a heated platen just below the mask; the upper platen, also heated to a predetermined temperature, is lowered, applying slight pressure to the mask and heating it while the frame remains at approximately room temperature. While the mask is in the expanded condition, the clamping screws are tightened by a pneumatic screwdriver. The upper platen is then lifted and the mask-frame assembly is then removed from the "hot-blocking" press and the mask allowed to cool.

2. Other Construction Improvements

The electron-gun assembly has not been changed in basic design, but refinements have been made to improve ruggedness, centering, and high-voltage operating characteristics. The envelope assembly, also, has been improved, particularly in the matter of the brackets for supporting the viewing-screen assembly. The new brackets are fewer in number (three instead of four), do not require machining, and are welded rather than bolted to the metal shell. The magnetic shield which was included in the envelope of each tube is no longer used. Instead, an external shield may now be used as part of the receiver construction. The glass neck-and-funnel assembly now uses standard drawn neck tubing and can be sealed to the lower metal shell without requiring the use of a jig fixture.

The exhaust and processing techniques are only slight modifications of conventional methods. Accordingly, it has been found possible to make only minor changes in standard equipment and exhaust the tricolor kinescope on a high-production, straight-line-exhaust machine. The use of a

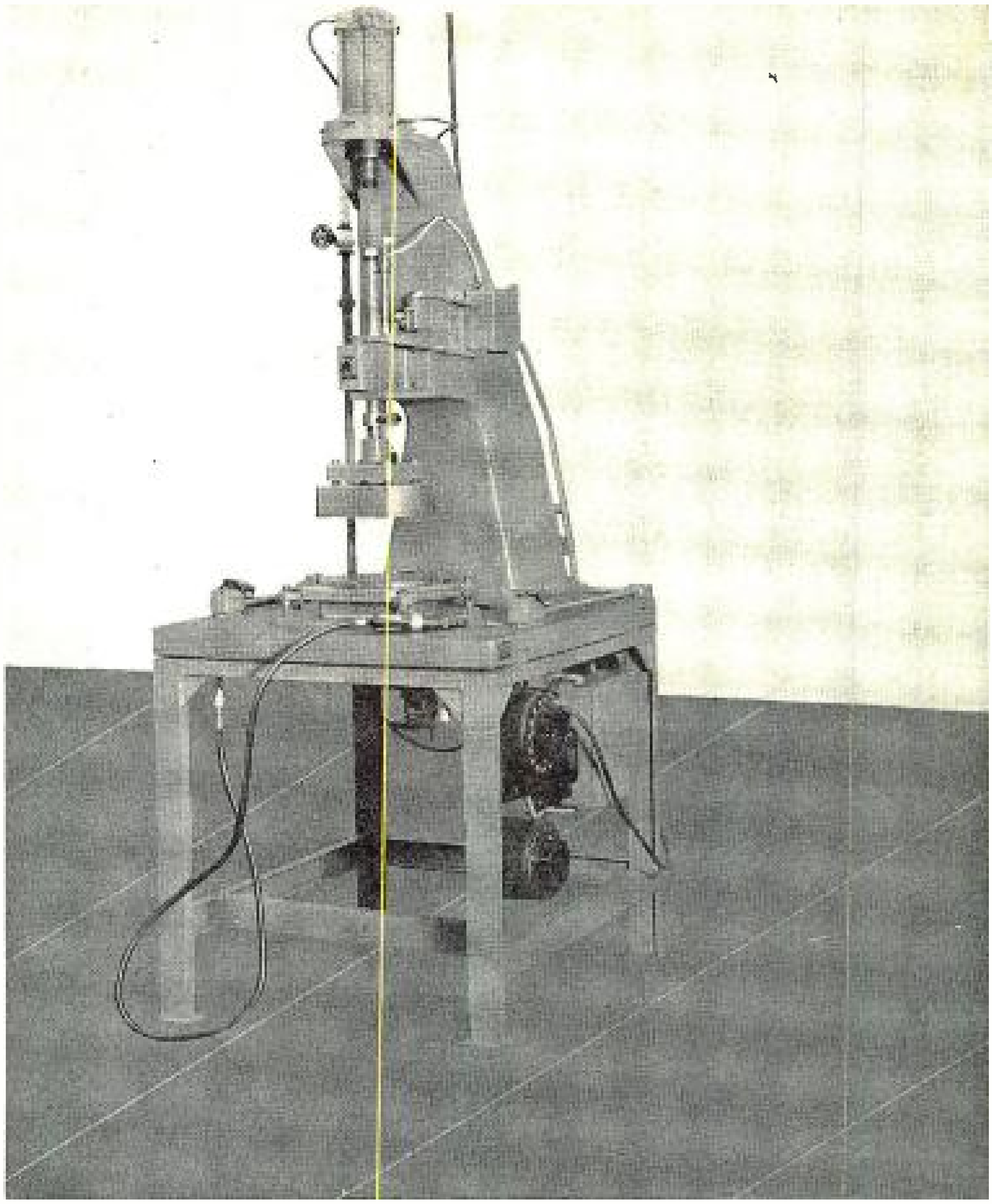


Fig. 21 — Factory "hot-blocking" equipment.

glass envelope has also been studied. It appears that the assembly, exhaust, and processing techniques, in general, are practicable with either glass or metal envelopes.

A further development of importance to receiver design is an improved envelope (glass or metal) specifically designed to accommodate the viewing screen assembly more compactly. The new envelope, which will supersede the 16-inch metal envelope initially used because of its availability, is 15 inches in diameter. The reduction in envelope diameter does not in any respect reduce the picture size previously provided by the 16-inch version.

It is planned that the new 15-inch envelope will be used for quantity production.

C. Increase in Picture Size

The third major objective of the engineering program was increase in picture size. The tricolor picture tube in a 16-inch metal envelope is capable of producing a full color or a black and white picture 11½ inches by 8⅝ inches with rounded sides. It may be of interest to compare the size of this picture with that of the post-war commercial black and white television receivers. The picture dimensions of these highly popular receivers were 8 inches by 6 inches, just a little over half the picture size of the developmental tricolor kinescopes.

There would be no new problems associated with the design of color kinescopes capable of reproducing large pictures if it were possible to simply scale-up the 16-inch envelope color kinescope, i.e., increase each dimension in proportion to the increase in picture size. However, experience in marketing receivers for black and white television has demonstrated that there are two practices of the viewing public which prevent the simple scale-up. First, people tend to sit more or less the same distance from the receiver, regardless of the picture size; and second, cabinets deep enough to accommodate kinescopes longer than 26 inches present a difficult consumer acceptance problem from the standpoint of both furniture placement and appearance and difficulty in moving through some doors.

To prevent the viewer who sits close to the receiver from being distracted by dot structure in the picture, it is necessary to maintain the phosphor-dot size in the screen of large color kinescopes essentially the same size as that presently used in the smaller tubes, i.e., approximately 0.014 inch. This requirement makes fabrication of large-size viewing-screen assemblies somewhat more difficult because tolerances on registration and other critical parts of the assembly cannot usually be scaled-up along with the physical dimensions of the assembly. It has been found in practice, however, that the screen-assembly design described in this exhibit could be scaled-up and the necessary closer tolerance on registration obtained to produce a highly satisfactory assembly by placing closer controls on the various processing steps.

Because the overall length of the 16-inch envelope color kinescope is almost 26 inches, it has been considered necessary to use a wider deflection angle for larger size picture tubes. To deflect the three beams over wide angles and still maintain the beams converged at all points on the screen has presented a formidable problem to the engineers. The solution requires a neat balance between such factors as operating voltage, light output, good color rendition, yoke design, and beam spacing and convergence control. The first public demonstration of large-size pictures was made in New York on July 9, 1951, using tubes with envelopes 21 inches in diameter having a deflection angle of 62°. The picture had roughly twice the area (15⅝ inches by 11¾ inches with rounded sides) of that of the 16-inch envelope tube, yet the length of the tube was kept essentially the same, 26⅝ inches.

Except for size and a few other characteristics, the early 21-inch envelope color kinescope resembles the 16-inch envelope model and has undergone a similar evolution since its first inception. Several examples of the changes follow.

The phosphor-dot size in the screens of the early tubes was somewhat larger than that of the 16-inch envelope tube. However, for reasons given above, the later tubes have phosphor dots of essentially the same size. The usable screen area of the most recent models contains 969,000 dots. The screen assembly of the first models used frames machined from heavy steel plate. These tubes weighed 52 pounds. By incorporating a screen assembly patterned after the improved version now being used in the 16-inch envelope tube, and by eliminating the internal magnetic shield, the tube weight has been reduced 16½ pounds.

A number of triple-beam electron-gun designs have been developed and others are being studied, in association with suitable circuits and components to provide maximum accuracy of beam convergence at the shadow mask for all scanning angles.

The 21-inch envelope picture tube demonstrated during April and May, 1953, showed a substantial improvement in performance over those demonstrated in July, 1951. Further improvements in performance are clearly indicated as a result of developments in tubes, components, and circuitry now approaching completion.

PART VII

Components for Tricolor Kinescopes

A. Component Requirements

One of the basic advantages of the tricolor shadow-mask kinescope is that its geometry is such as to permit a very small angular displacement between beams. As a result, it is practical to pass the array containing the three beams through a single deflecting yoke with a minimum of separation and deflect them in unison by approximately the same magnetic field. With the shadow-mask kinescope, therefore, it is possible to avoid the electrical and mechanical registration problems associated with the separate deflection of three individual beams such as are used in systems requiring a large angular difference between beams.

Although the problem of separate deflection is eliminated, a number of effects of second order remain. The effects are introduced by (1) the geometrical effects of scanning a plane screen, (2) the geometrical effects resulting from the simultaneous deflection of slightly displaced converging electron beams, (3) the slight differences in the magnetic fields traversed by the separate beams, and (4) the need for practical manufacturing tolerances. In the deflection system developed for use with the RCA tricolor kinescope,

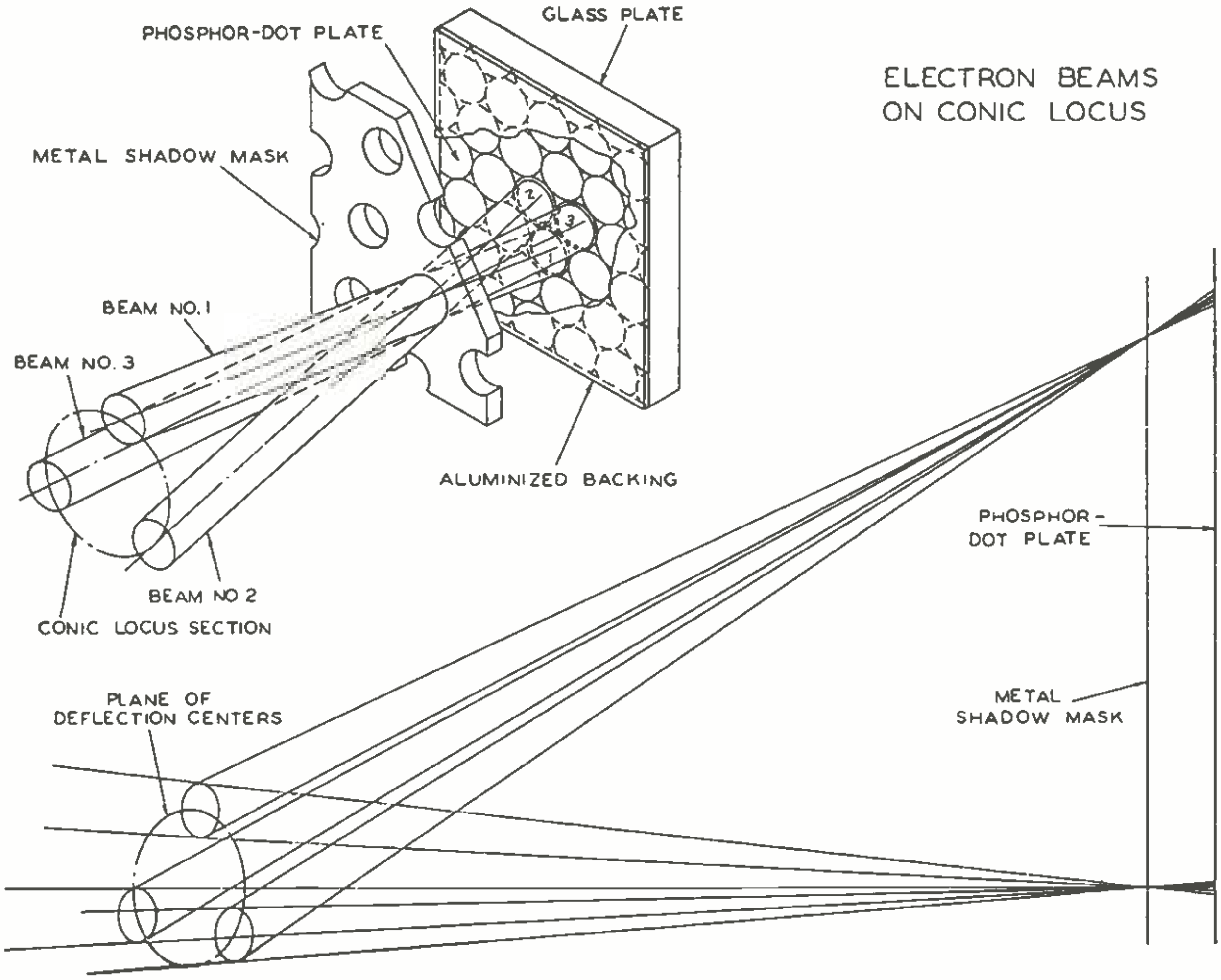


Fig. 22 – Diagram illustrating beam convergence.

these effects have been taken into account and a deflecting yoke and beam converging system providing a color picture of excellent quality has been developed.

B. Deflecting Yoke

The deflecting yoke is second in importance only to the tricolor kinescope in its effect on the quality of the color picture. Accordingly, considerable engineering study has been devoted to the design and development of this major component.

The basic problem to be considered in the design of a yoke for the tricolor kinescope concerns the deflection of a relatively large electron beam. As shown in Figure 22 the three electron beams as they pass through the yoke are equivalent to three segments of a large converging beam. Since it is desired to deflect all three beams in unison and since to achieve maximum deflection each one of the beams must pass through a space previously occupied by one of the other beams, separate treatment of the magnetic field for each beam to provide proper convergence is not practical. It was decided, therefore, to develop a yoke which would provide, within narrow limits, a uniform transverse magnetic field in the central section of the space inside

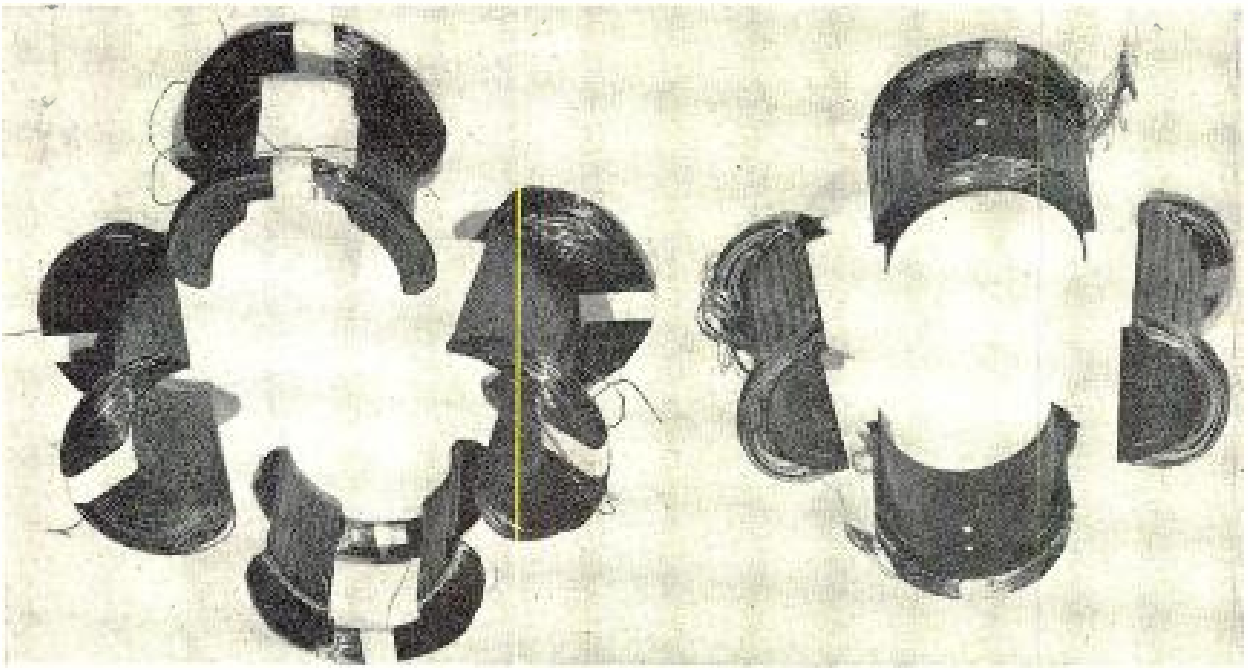


Fig. 23 — Deflecting coils designed for tricolor kinescope. Left: Early design using section-wound coils. Right: Later design using continuously wound coils.

the yoke. It was known that such a uniform field would result in a "pin-cushioned" raster on a flat screen, but the difficulties of correction seemed less in this case than the difficulties which would be encountered in the design of a yoke which would provide a suitable convergence pattern and at the same time produce a rectangular raster.

The first yokes for the tricolor kinescope used coils of the type illustrated at the left in Figure 23. These coils were produced by winding the wire in sections to produce a nearly ideal distribution of turns. Each section of the coil was fixed accurately in place in the final yoke assembly and every precaution was taken to make certain that possible variations in performance between yokes would be minimized. Because of the tremendous practical advantages of a continuously wound coil, an investigation was started to determine the possibility of using this method of manufacture. The coils shown at the right of Figure 23 resulted from this development. They are wound and formed in a mold and make use of materials and processes employed today in the production of yokes for black and white receivers.

It is most important that symmetry of field with respect to the electron beams be maintained. Achieving symmetry in the face of known variations in the position of the beams with respect to the neck of the kinescope has necessitated that the central hole in the yoke be made larger than the neck of the kinescope to permit radial adjustment of the position of the yoke and its field.

One of the problems of yoke design results from the oppositely directed axial and other stray fields within the region of the neck-to-funnel junction of the kinescope produced by the turned-up ends of the coils. This problem can be solved in a number of ways. One way is the use of "com-

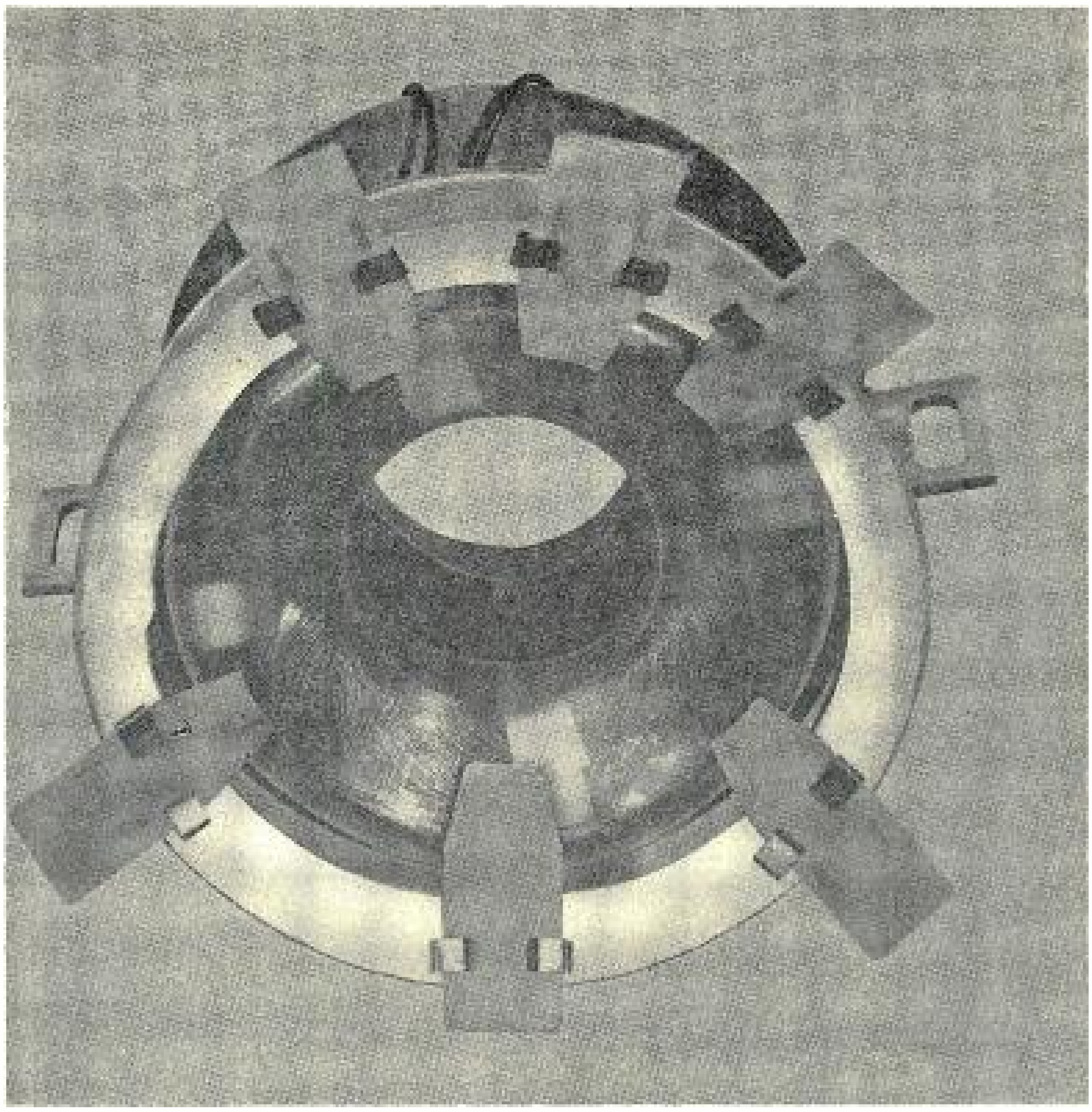


Fig. 24 — Developmental deflecting yoke showing field-compensating tabs.

pensating tabs" which provide a flexible adjustment of the end fields. Originally, twelve tabs were used to provide the adjustment required. Modifications of the end turns, however, permitted a reduction in the number of the tabs from twelve to six or less. Such a yoke is illustrated in Figure 24. This change not only reduced the number of adjustments required, but reduced the loss of deflection power and allowed the approximate plane of deflection to occur somewhat farther forward, thus minimizing "neck-shadow" trouble.

Further study of the effect of end turns resulted in the development of new yokes which provide the required flux distribution at the front of the yoke for acceptable beam convergence without the use of compensating tabs necessitating field adjustment.

C. Other Components

In order for the yoke to provide proper beam convergence for the whole area of the flat shadow mask, the convergence angles of the three beams must be suitably corrected. The geometry of the system is such that the locus of convergence of two beams deflected in a direction perpendicular to the plane through the beams will fall on a circle tangent to the mask. The locus of the convergence points of two beams deflected in the plane of the beams falls on a curve which is tangent to the shadow mask at the center of the system but which deviates markedly from a circle as the deflection angle decreases. It is necessary, therefore, to vary the convergence angles of the three beams during scanning in such a manner as to provide proper convergence at all parts of the shadow mask.

To provide an acceptable dynamic-convergence correction for the 16-inch envelope color kinescope, a suitable voltage waveform is applied to the converging electrode. The 60-cycle per second and 15,750-cycle per second waveforms required for convergence correction are referenced to the vertical and horizontal scanning frequencies respectively and are coupled to the converging electrode through transformers. These transformers are conventional in design.

Other components required for operating the 16-inch envelope tricolor kinescope are also of conventional design and need only be mentioned. The color-purifying coil, located on the neck of the kinescope, is used to adjust the position of the common axis of the three electron beams so that when deflected they approach each hole in the shadow mask at the proper angle to strike the appropriate color phosphor dots. The three beam-positioning magnets, placed on the neck of the kinescope over the guns, aid in achieving proper convergence of the beams by correcting slight dissymmetries caused by manufacturing variations in the tube and by the effects of stray fields. The external magnetic shield, mentioned previously, is a contribution to lowered maintenance as well as lowered manufacturing cost in that it need not be replaced in the event of kinescope replacement. This shield fits around the lower portion of the metal shell and isolates the beam from the effects of extraneous magnetic fields.

PART VIII

Industry Sampling Program

In order to assist the television set and tube manufacturing industry in participating and contributing to the maximum extent to the introduction of satisfactory color television, a symposium on the RCA tricolor television picture tube was held on June 19 and 20, 1951, in New York City. At this symposium, technical and engineering information on the tricolor kinescope, its operation, and associated components was presented in considerable detail. Each manufacturer attending was advised that if he sent a letter stating that he was engaged in color television development work, he would be sent a tricolor kinescope and a set of associated components without charge. Tube manufacturers engaged in color television development work were advised that in addition they would be sent without charge one complete set of parts for the three-gun tricolor kinescope. As part of this industry sampling program, 152 companies were given kinescopes and associated components. Subsequently, some of these companies as well as other companies interested in color television bought additional samples so that by the middle of March, 1953, 477 tricolor kinescopes had been supplied to 177 companies. Sample tubes are still being sold.

PART IX

Processing and Assembly Facilities

Most of the early work on tricolor television picture tubes was done in the model shops of the various RCA research and engineering centers. The number of tubes that could be produced by these facilities was necessarily quite small, but was adequate to demonstrate the feasibility of the basic design principles involved.

A. Pilot Production-Development Stage

The next logical step after the demonstration that the basic design of the shadow-mask tricolor kinescope was satisfactory was the establishment of a pilot production-development unit. The purpose of this unit was to study and establish a pilot operation for design and production development in order to have adequate facilities to produce the number of developmental tubes needed and to work out production techniques. In addition, such a unit would establish a trained nucleus of operators, supervisors, and engineers for an ultimate manufacturing program. Such a pilot operation was established at the RCA Lancaster, Pennsylvania, plant in August, 1950, so as to be associated closely with existing kinescope engineering and manufacturing activities. The pilot production-development unit occupied approximately 7500 square feet of floor space devoted to production of the tricolor kinescope screen assembly, general assembly, and exhaust operations. The regular manufacturing centers supplied other parts and services needed.

By October, 1951, the pilot production-development unit employed some 60 persons for direct assembly and exhaust operations, and 20 engineers and supervisors. This figure was the highest number of persons employed in this unit, since military efforts later required that the activities of certain persons be redirected.

The pilot production-development unit was able to start from 10 to 15 tubes per day as engineering tests. Over any period of time these tubes were of many different constructions, made in different ways, and tested to various standards. Production figures and shrinkage and scrap data, therefore, do not have much significance. The gross number of tubes started, however, is indicative of the activity expended to develop a satisfactory tube for production. Since the inception of the production-development unit, a total of approximately 7000 tubes has been started in production. Tubes considered to be good in accordance with standards current at the time of production are held in inventory for further engineering tests, circuit development work, or sampling to other manufacturers for their development work. The total inventory of such tubes is limited to around 400. As new tubes are produced to improved quality standards, older tubes of lesser quality are removed from stock, opened, and the parts salvaged for reuse so as to conserve materials.

B. Pilot Production Plant Program

Considerable success attended the efforts of the pilot production-development unit. As a result of these efforts, engineering and production personnel were convinced that tricolor tubes were adaptable to high speed commercial production. Accordingly, by November, 1951, planning was started for a pilot production plant program to provide facilities capable of producing in the order of 2000 16-inch envelope tricolor kinescopes per month. All facilities were to be designed to incorporate considerable flexibility so that, in so far as possible, tubes of different sizes could be accommodated.

The organization can be expanded and trained, and materials procured to attain a going rate of 2000 tricolor kinescopes per month in a period of from six to nine months from the date the decision to proceed is made.

C. Projected Mass-Production Program

The pilot production facilities are being located at the Lancaster, Pennsylvania, plant adjacent to the present black and white kinescope facilities. In this way, as the need arises for more tricolor kinescopes than can be produced in the pilot production unit, operations may be expanded into the existing black and white kinescope production facilities with suitable modification of these facilities and the addition of the specialized items needed for tricolor kinescope production.

EXHIBIT 6

RECEIVERS FOR THE RCA COLOR TELEVISION SYSTEM

RECEIVERS FOR THE RCA COLOR TELEVISION SYSTEM

Index

Appendixes

EXHIBIT 6

RECEIVERS FOR THE RCA COLOR TELEVISION SYSTEM

PART I

Introduction

THIS Exhibit outlines various work done by the RCA Victor Division on color television receivers. Early work on design and development is summarized and detailed engineering descriptions of the current color television receiver models are contained in Appendixes A and B. RCA's plans concerning production of color television receivers are summarized.

PART II

Color Television Receiver Development Work

For a number of years, RCA has continued an aggressive development program to improve receivers designed for use with the RCA compatible color television system.

In addition to work continued at the RCA Laboratories, a special Color Product Development Group of the Home Instrument Department of the RCA Victor Division was created early in 1950.

Since the formation of this Group, a number of basic designs of color receivers, with several variations, each an improvement over its predecessor, have been developed. Moderate quantities of each design have been built and tested.

A. Trinoscope Receiver Model No. 1

Prior to the formal organization of the Color Product Development Group, engineers of the Home Instrument Department had cooperated with the RCA Laboratories Division in the development and construction of a trinoscope, or three kinescope receiver, identified as Trinoscope Receiver Model No. 1 (Figures 1 and 2). This model was started in development in August, 1949, and the samples had been completed by February, 1950. The model employed a total of 108 tubes, required four separate chassis units, and was housed in a cabinet 49 inches high, 49 inches wide, and 25½ inches deep.

Following completion of this sample, it was decided to start development on another trinoscope model in order to reduce size and circuit complications. Consequently, the development of Trinoscope Receiver Model No. 2 was undertaken by the newly formed Color Product Development Group of the Home Instrument Engineering Department in Camden.

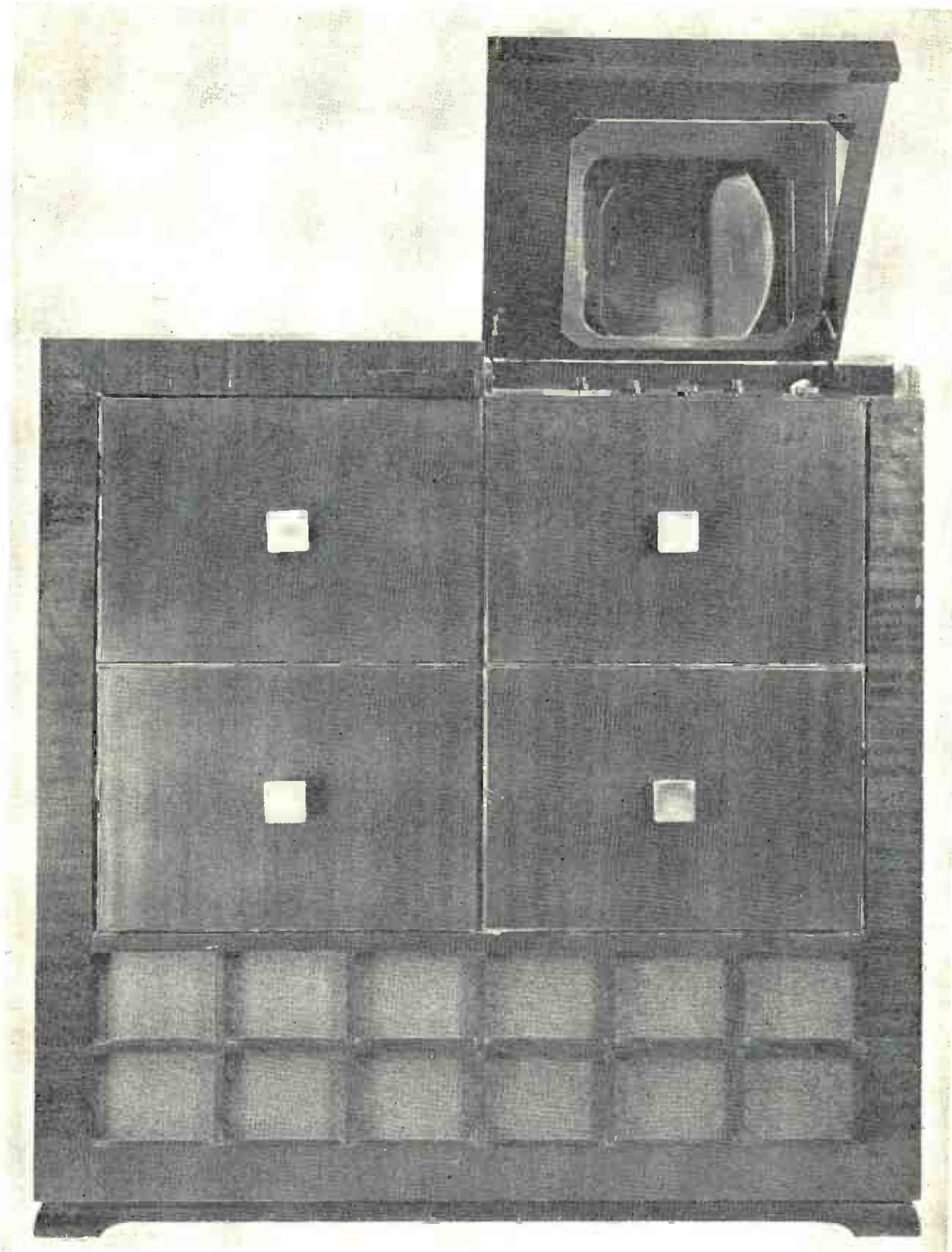


Fig. 1 — Trinoscope Receiver Model No. 1

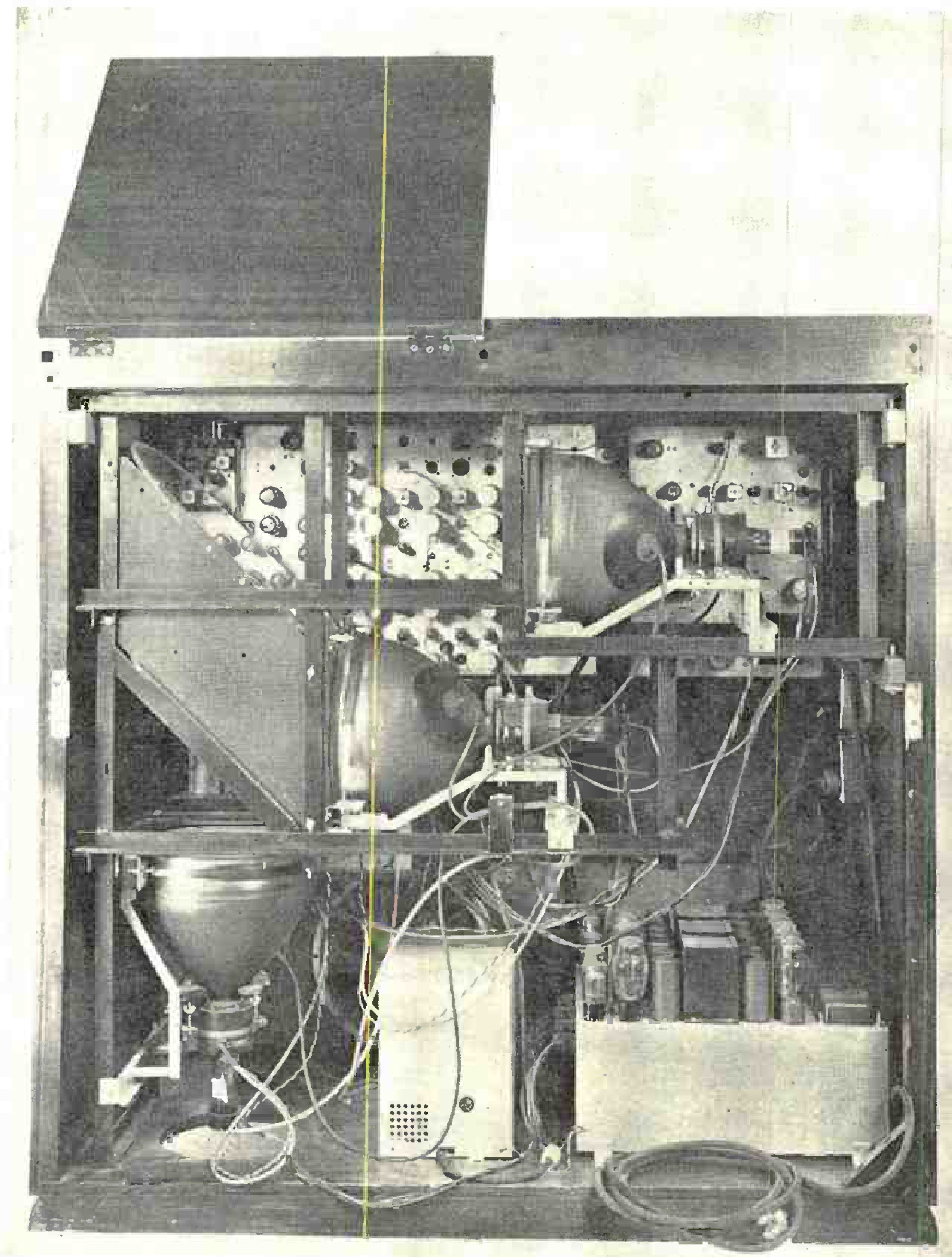


Fig. 2 — Trinoscope Receiver Model No. 1

B. Trinoscope Receiver Model No. 2

The first model completed by the Color Product Development Group, identified as Trinoscope Receiver Model No. 2, was started in development during March, 1950 (Figures 3 and 4). A quantity of ten was completed by May, 1950. The model employed three 10-inch kinescopes, a total of 44 tubes, required four separate chassis units, and was housed in a cabinet 40 inches high, 37½ inches wide, and 21 inches deep. Following field tests of this model, it was decided to stop further development of the trinoscope, or three-kinescope, type of receiver. Laboratory samples of the RCA tricolor kinescope had become available and work from this time on was concentrated on the development of receivers employing this type of kinescope.

C. 16-inch Tricolor Kinescope Receiver Model No. 1

The second basic model, identified as 16-inch Tricolor Kinescope Receiver Model No. 1, was started in development during April, 1950 (Figures 5 and 6). A quantity of 35 was completed by December, 1950. This model used a 16-inch envelope tricolor kinescope, a total of 45 tubes, and required two separate chassis bases.

At various times, during the period from April to December, 1950, various of the 35 samples of this model underwent degrees of alteration. Demonstrations were made to RCA officials in September and October. During December, 1950, six sample receivers of this model were demonstrated in Washington, D. C., to members of the press and to RCA licensees. It became apparent that certain improvements could be made and accordingly development work was started on an improved model.

D. 16-inch Tricolor Kinescope Receiver Model No. 2

The third basic model, identified as 16-inch Tricolor Kinescope Receiver Model No. 2, was started in development during December, 1950 (Figures 7 and 8). A quantity of 71 was completed by October, 1951. This model employed a 16-inch envelope tricolor kinescope, a total of 54 tubes, and required two separate chassis bases. The sampling frequency used was 3.58 megacycles with color phase alternation.

Six of these receivers were field tested in New York during April, 1951. Additional receivers were demonstrated in July and September, 1951.

In addition, these receivers were used for simultaneous demonstrations in New York and Washington, using communication links of both the cable and microwave types.

E. 16-inch Tricolor Kinescope Receiver Model No. 2A

Development work on this variation of the third basic model started during November, 1951. Thirty-five samples were completed by February, 1952. These samples were designed for operation on the then current NTSC signal specifications. The sampling frequency was 3.89 megacycles with color phase alternation.

These 35 samples were used primarily for field testing. While this field testing was in progress, work was started on a new model, with simplified circuitry, incorporating all known improvements, and with potentially reduced manufacturing cost.

F. 16-inch Tricolor Kinescope Receiver Model No. 3

The fourth basic model, identified as 16-inch Tricolor Kinescope Receiver Model No. 3, was started in development during December, 1951 (Figures 9 and 10). Twelve samples were completed by July, 1952. This model employed a 16-inch envelope tricolor kinescope and a total of 35 tubes with all components mounted on a single chassis base. It was housed in a console cabinet generally comparable in size to current black and white television console cabinets.

This model represented a distinct advance in engineering design by the elimination of 19 tubes, and reduction of chassis units to a single base, while still preserving the performance features of previous models.

This model was used for field testing and also to test compatibility aspects of NTSC technical signal specifications. Various considerations suggested the possibility that the sampling frequency might be changed from 3.89 megacycles to 3.58 megacycles. Concurrently, research activity had suggested the elimination of color phase alternation. These developments led to further receiver design work, and Model No. 3 gave way to Model No. 3A.

G. 16-inch Tricolor Kinescope Receiver Model No. 3A

This RCA color television receiver is identified as 16-inch Tricolor Kinescope Receiver Model No. 3A. Development work on this revision of Model No. 3 was started during October, 1952. Twenty-one models have been completed.

This model is essentially similar to Model No. 3 but was designed to accept the NTSC field test signal specifications of February 2, 1953. It is the model that was demonstrated at Princeton in April and May, 1953, to members of the Federal Communications Commission, the Committee on Interstate and Foreign Commerce of the House of Representatives and others.

An engineering description of Model No. 3A is contained in Appendix A.

H. 16-inch Tricolor Kinescope Receiver Model No. 4

Development work is now nearing completion on another RCA color television receiver identified as 16-inch Tricolor Kinescope Receiver Model No. 4. Model No. 4 varies in some respects from Model No. 3A as Model No. 3A was designed for more convenient alteration to varying field test conditions, whereas Model No. 4 is being simplified to meet fixed rather

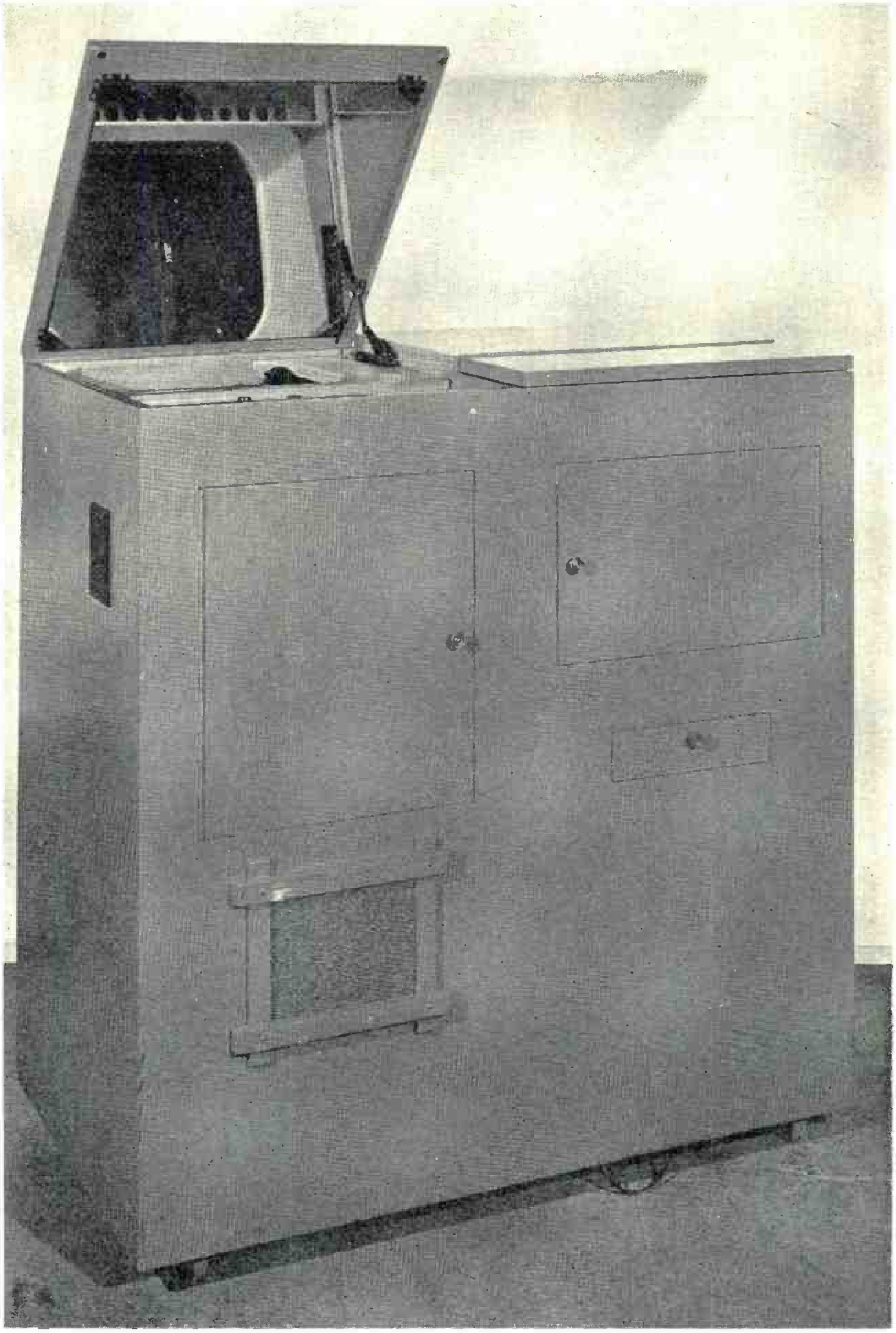


Fig. 3 – Trinoscope Receiver Model No. 2

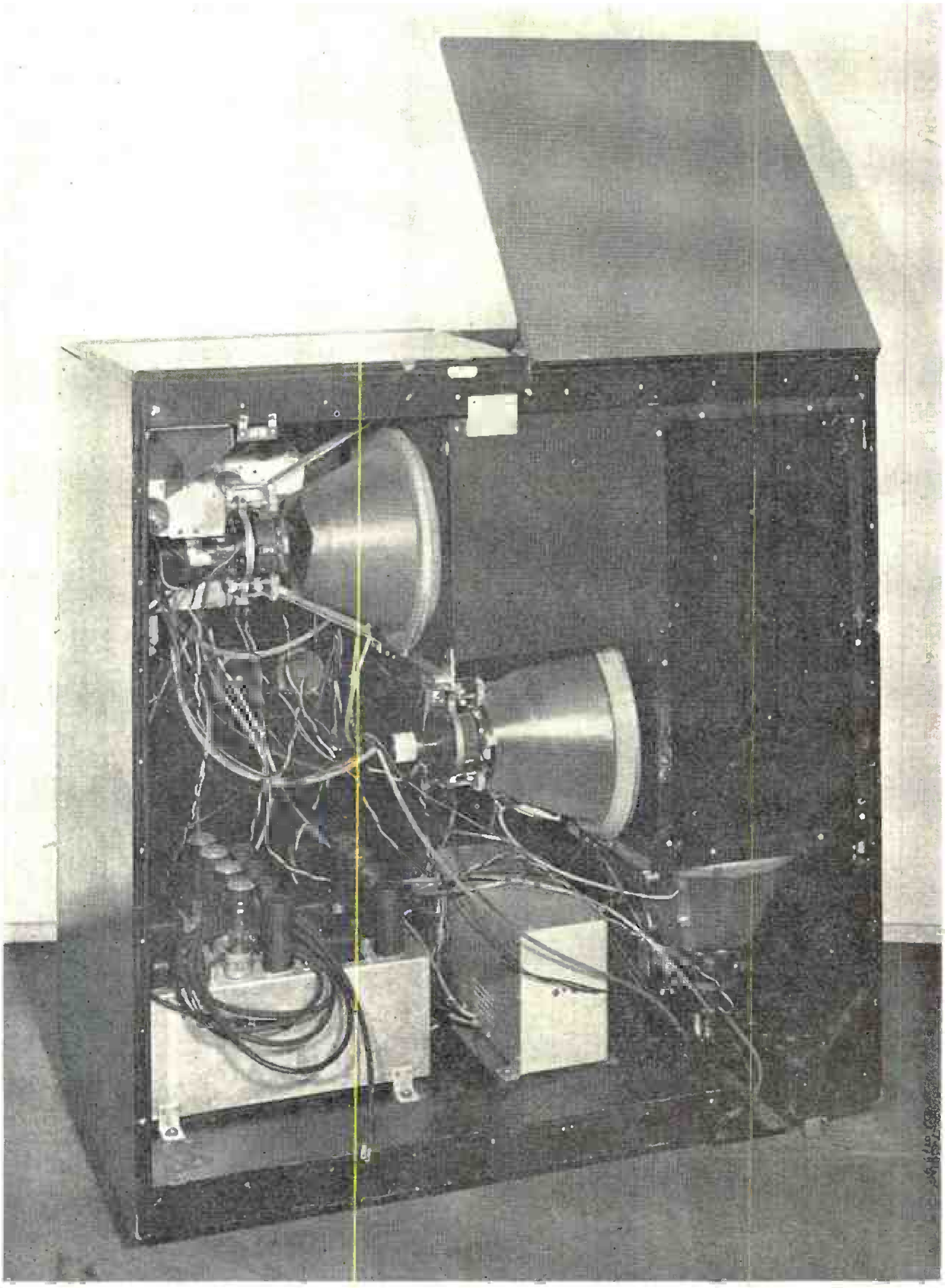


Fig. 4 — Trinoscope Receiver Model No. 2

Fig. 5 — 16-inch Tricolor Kinescope Receiver Model No. 1

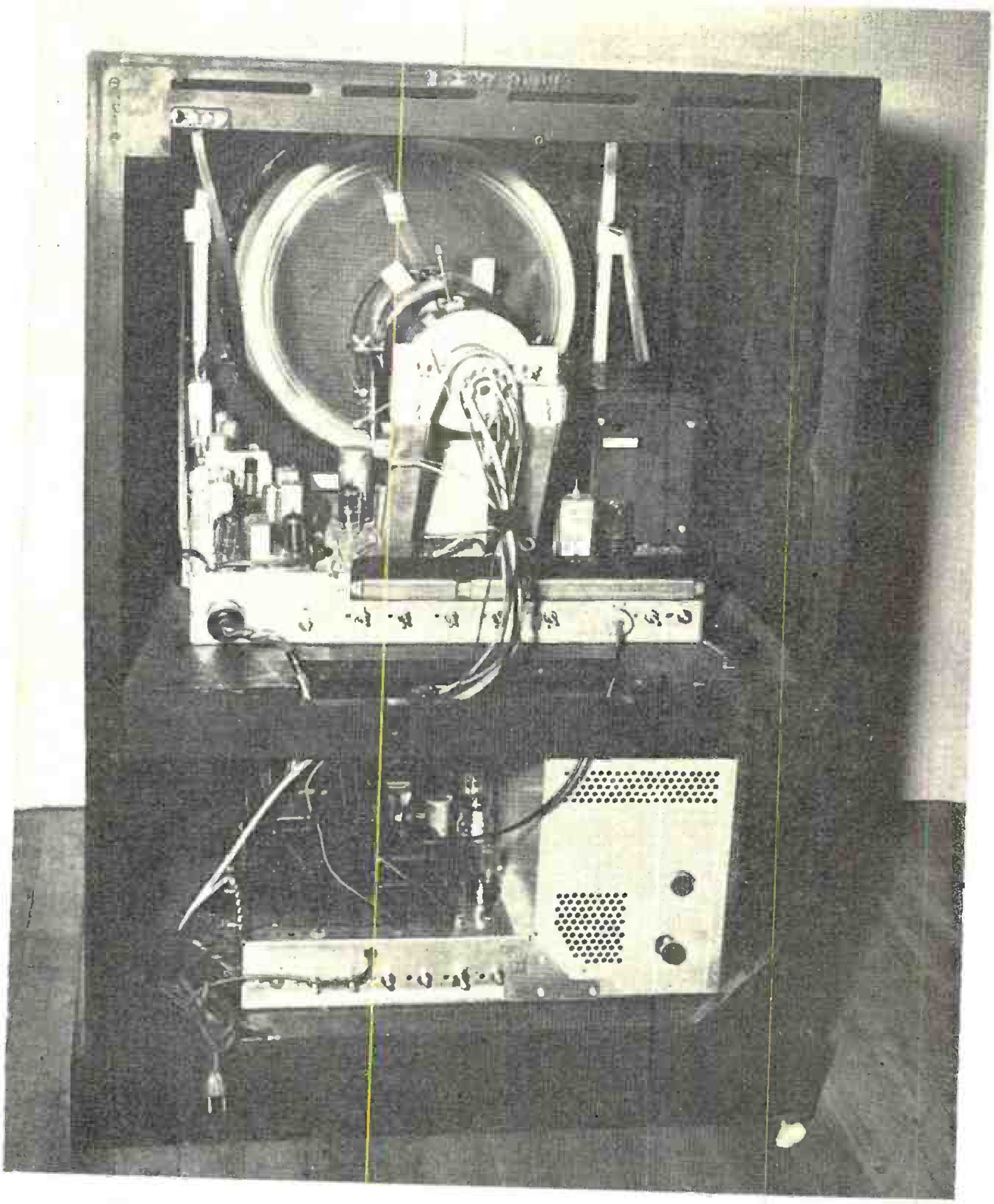


Fig. 6 — 16-inch Tricolor Kinescope Receiver Model No. 1

Fig. 7 — 16-inch Tricolor Kinescope Receiver Model No. 2

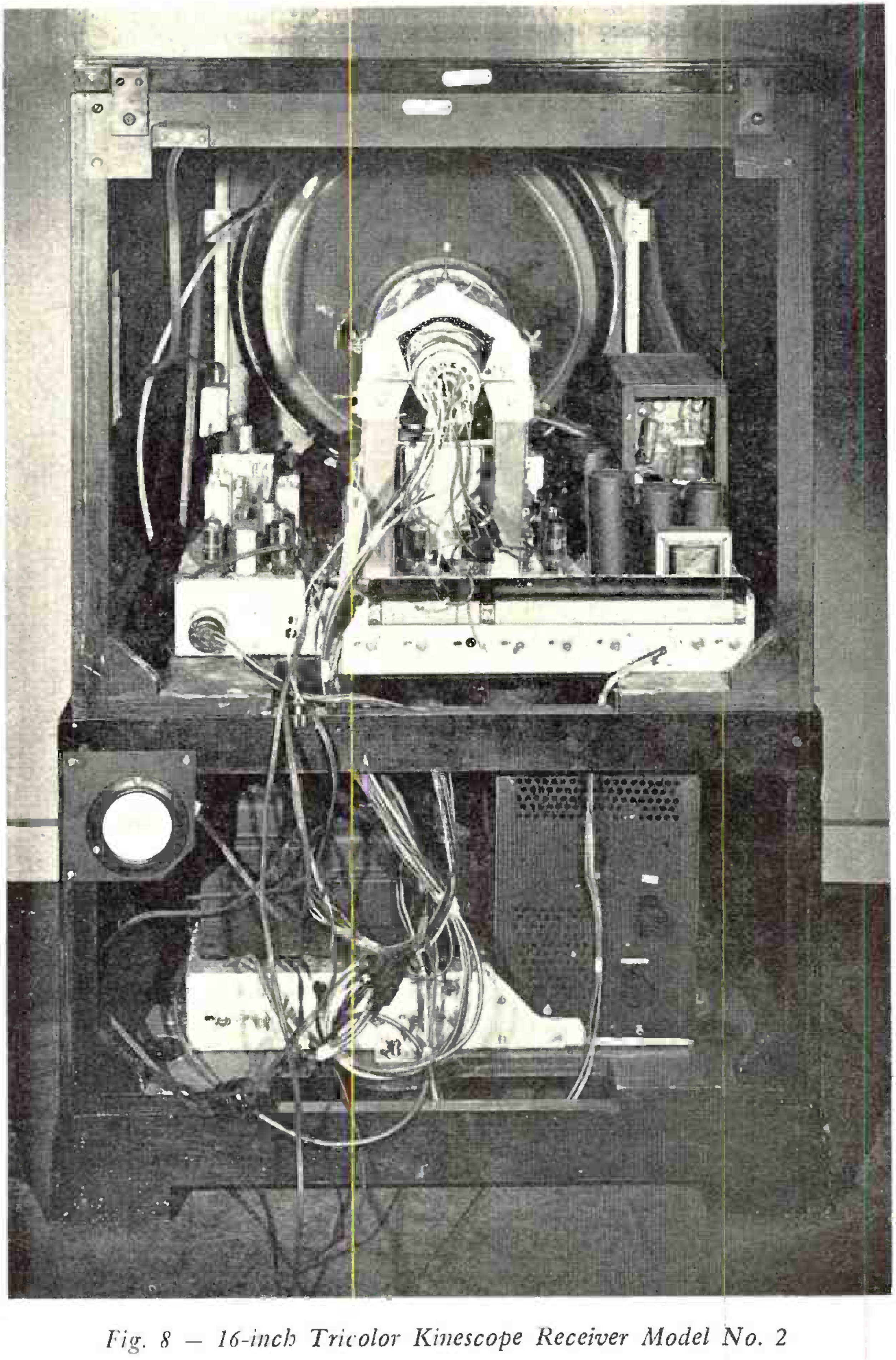


Fig. 8 — 16-inch Tricolor Kinescope Receiver Model No. 2

Fig. 9 — 16-inch Tricolor Kinescope Receiver Model No. 3

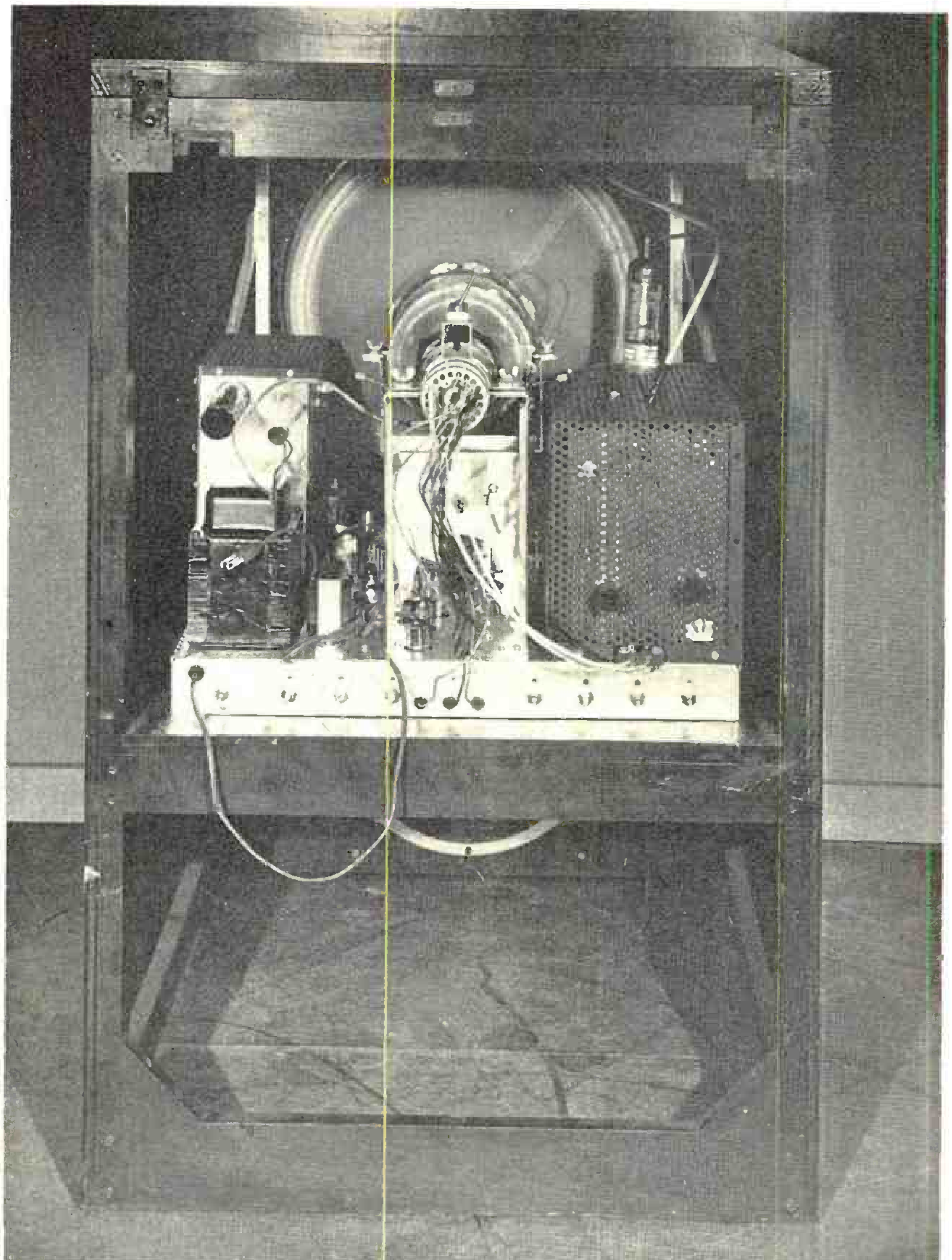


Fig. 10 — 16-inch Tricolor Kinescope Receiver Model No. 3

than varying conditions. Since a final production model should make provision for both UHF and VHF reception, Model No. 4 is equipped with a combined UHF-VHF tuner.

In Model No. 4 several controls have been relocated under the control cover and are equipped with knurled shafts. In a production model the service controls would probably be screw-driver adjustments and thus would not normally be used by the viewer. A color hue control has been added and will probably be included in the production model under the control cover as a viewer control. This control would permit a viewer to make minor adjustments in the hue of the picture to satisfy his own personal preference. Model No. 4 also employs a new high voltage supply in which the convergence and focus controls have been made accessible at the side of the cabinet. Model No. 4 has been changed from Model No. 3A in other respects as well in order to improve performance, to facilitate manufacturing and to reduce costs.

An engineering description of Model No. 4 is contained in Appendix B.[1]

PART III

Plans for Production of Color Television Receivers

A. Probable Production Model

If the Commission approves the proposed technical signal specifications, RCA Victor will proceed immediately to start production on a tricolor kinescope receiver similar in basic characteristics to Model No. 4.

B. Development Work on Larger Color Picture Models

While thus far work on the 16-inch tricolor kinescope receiver has been discussed, considerable work has also been done on receivers designed to employ larger kinescopes than the 16-inch envelope kinescope. Receiver design for larger direct view tricolor kinescopes can be carried to conclusion within very reasonable time cycles following final determination of kinescope characteristics in larger sizes.

Development models employing 21-inch envelope tricolor kinescopes were demonstrated at the David Sarnoff Research Center at Princeton during April and May, 1953, along with 16-inch Model No. 3A, and indicate what may be expected in larger pictures as soon as these larger tricolor kinescopes can be made available.

Development work is also proceeding on projection type receivers employing three 3-inch kinescopes used in an optical system to project 15 x 20 inch, or perhaps 18 x 24 inch, color pictures. A development model of an 18 x 24 inch projection color receiver has been demonstrated.

While it is reasonable to suppose that larger pictures will follow, initial production plans are based on the use of the 16-inch envelope tricolor kinescope.

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[1] RCA work on color converters is described in Appendix C.

C. Production

The RCA Victor Division is proceeding with plans for the manufacture of color receivers, similar in basic characteristics to Model No. 4. Factory space is available. Necessary test equipment has been determined, and covering orders for required equipment have been placed.

Manufacturing personnel have examined the engineering samples of Model No. 3A and are agreed that no unusual manufacturing problems are involved. Model No. 4 will still further simplify manufacturing. While it is recognized that a substantially increased number of component parts are required for a color television receiver as compared with a black and white television receiver, and that circuits are more critical, requiring a greater degree of testing and adjustment, manufacturing techniques are basically the same as for black and white receivers.

D. Timing

If Commission approval of the proposed technical signal specifications is forthcoming by the end of the Summer of 1953, engineering schedules call for engineering sign-off of a production model, based on engineering Model No. 4, in the Fall of 1953. It is estimated that, on this schedule, actual production of color receivers could start during the Spring of 1954.

It is also estimated that approximately three months from the start of production, training of factory operators will have been completed and production lines will be operating. If Commission approval were forthcoming as indicated above, RCA Victor Division would plan for the production of substantial quantities of color television receivers during 1954.

E. Commercial Models

It is probable that during the first ten or twelve months, production would be confined to the production model of the 16-inch Tricolor Kinescope Receiver Model No. 4.

Present engineering development schedules indicate the possible production of models having a larger picture approximately nine to ten months after the earliest production of the initial model.

F. Future Trends

We expect that color television will conform to the general pattern of all revolutionary new products or developments in the electronics field. Rapid progress in improved manufacturing techniques after production is commenced, mounting production volume, and subsequent engineering developments, will all combine to reduce cost and improve the product.

APPENDIX A

ENGINEERING DESCRIPTION OF THE RCA 16-INCH TRICOLOR KINESCOPE RECEIVER MODEL NO. 3A

TABLE OF CONTENTS

PART I

INTRODUCTION

The color television receiver shown in Figures 1a and 1b uses the RCA shadow-mask type, three gun, directly viewed tricolor kinescope housed in a 16-inch envelope. This type of display device utilizes the three continuously available primary signals to produce a simultaneous picture. The kinescope is assembled to a supporting mask which makes the receiver an integral unit convenient for maintenance work. The "chroma" control is a new function due to color and is the only front panel adjustment added as compared to monochrome instruments.

The design technique used in this receiver afforded considerable circuit flexibility in order to accommodate possible transmission changes that might be recommended by the NTSC. The treatment of this receiver is based on the NTSC technical signal specifications released February 2, 1953.

Features of this receiver (Figure 2) include: a KRK-11 RF unit with provisions for 300-ohm balanced or 75-ohm single ended inputs; an intercarrier 41.25 mc IF system; high level second detector operation for maximum linearity; keyed AGC; noise inversion sync separation; stabilized horizontal AFC; horizontal pulse type regulated high voltage supply; electrostatic convergence and focus along with dynamic modulation of these kinescope anodes; quartz crystal-AFC color synchronization; low level color demodulation using quadrature techniques; kinescope grid drive with DC restoration; and a color "killer" to disable the color channel during monochrome transmissions.

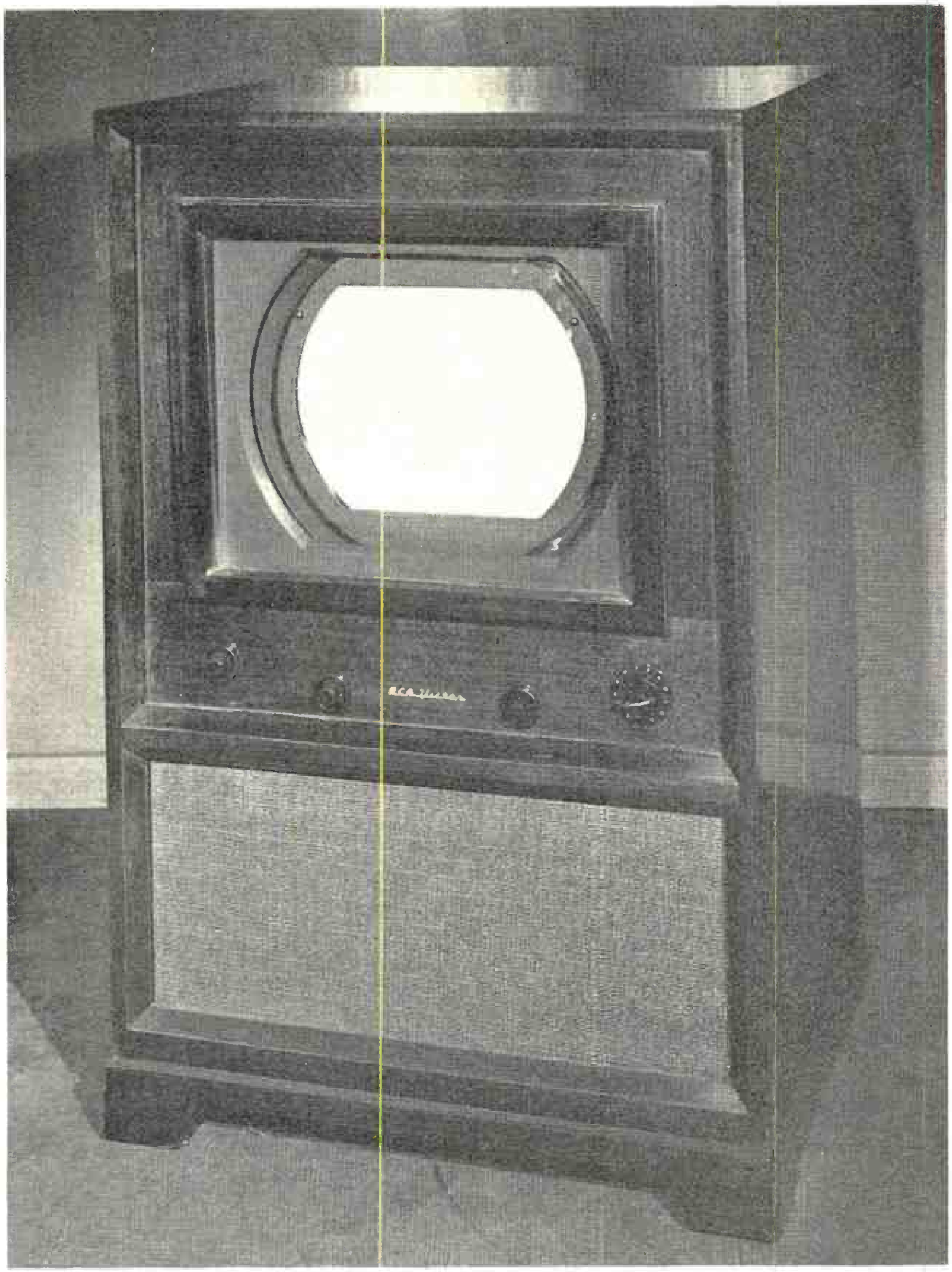


Fig. 1a—Front view of 16-inch Tricolor Kinescope Receiver Model No. 3A.

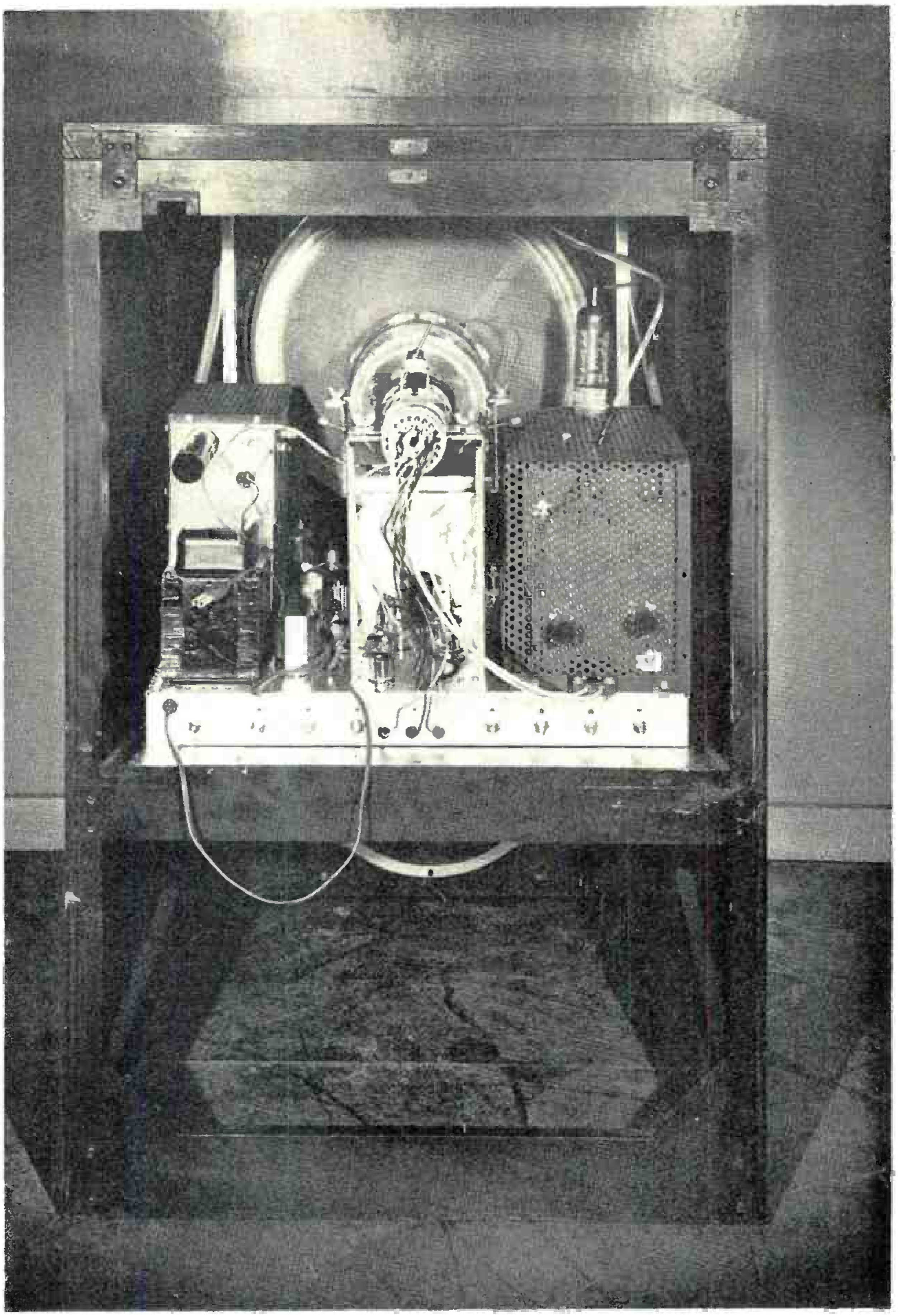


Fig. 1b—Back view of 16-inch Tricolor Kinescope Receiver Model No. 3A.

PART II

RF TUNER

The KRK-11 television RF tuner is a two tube, band switch type tuner, covering television channels 2 to 13, inclusive. It is designed to provide a sound IF output of 41.25 mc and a picture IF output of 45.75 mc. See Figure 3a.

The input circuit contains an elevator transformer to match the tuner to either a 300-ohm balanced or 72-ohm coaxial line, and to attenuate noise which may be induced in the transmission line. Matched to the elevator is an m-derived filter having a constant k mid-section and a band of maximum attenuation in the IF range. An additional tunable trap is provided for rejection of FM signals. This is followed by the single tuned input circuit, with a switched inductance for each channel, which provides gain and selectivity at the grid of the RF amplifier. The constants and configuration have been selected to provide optimum noise factor for all channels rather than perfect impedance match between the antenna circuit and RF amplifier.

The RF amplifier is a dual triode (6BQ7) especially designed for driven grounded-grid operation. It has the gain and stability of a pentode with the improved noise factor of a triode. Low output to input capacity minimizes local oscillator feed-through. The output of the RF amplifier contains a double-tuned, m-derived, band-pass filter with the frequency of maximum attenuation tracked at approximately the image frequency of each channel. Thus, high image attenuation is attained and oscillator feed-through is greatly reduced.

The mixer is the pentode section of a triode-pentode tube (6X8). Since the higher IF (41.25-45.75 mc) falls close to channel 2, "Miller Effect" becomes

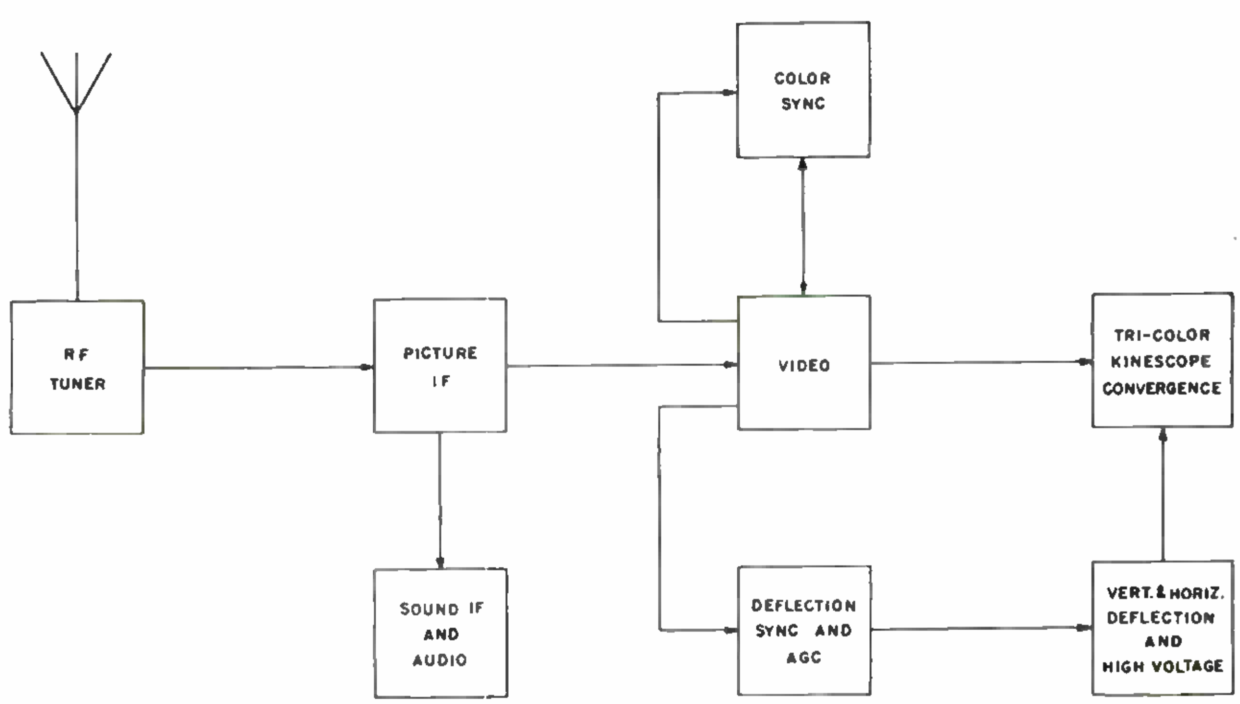


Fig. 2—Color television receiver master block diagram.

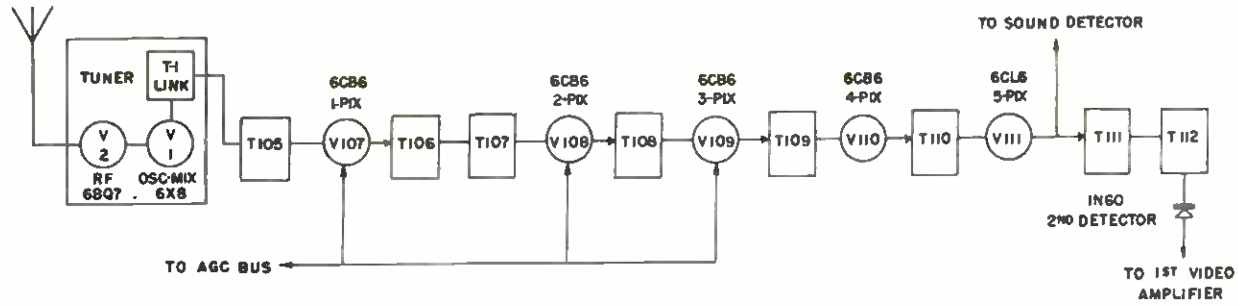


Fig. 3a—RF tuner and IF channel.

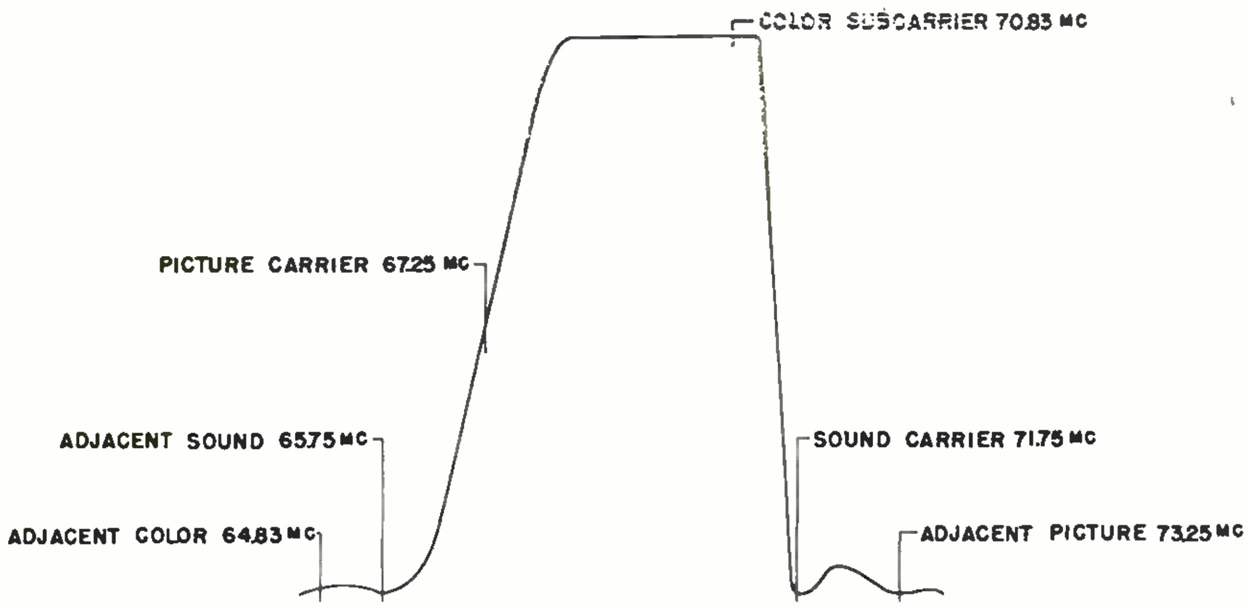


Fig. 3b—Overall RF-IF response channel 4.

an important consideration and the low gridplate capacitance is desirable in this application. The mixer plate circuit contains a double-tuned, link-coupled, band-pass circuit, one-half being located on the tuner chassis and the other on the IF chassis. Use of a link-coupled transformer reduces the oscillator voltage fed out of the RF unit from this source.

The oscillator employs a temperature-compensated Colpitts circuit and utilizes the triode section of the 6X8 mixer-oscillator tube. Tuning is accomplished, as in the other RF circuits, by switching incremental inductances to resonate the tank circuit to the proper frequency. Tuning of the incremental inductances is available from the knob end of the tuner. A fine tuning control, located concentrically on the channel selector shaft, permits fine adjustment of the local oscillator frequency.

PART III

Picture IF Channel

The picture IF amplifier is designed for a 45.75 mc picture carrier, 42.17 mc color subcarrier, and a 41.25 mc sound carrier. The amplifier consists of five stages, using four 6CB6's and one 6CL6. The second detector uses a 1N60 crystal and is operated at 10 volts peak output level in the interests of linearity. The overall sensitivity is approximately 12 micro-volts across the antenna terminals for 10 volts peak at the second detector. Figure 3b shows the overall RF-IF response characteristic for channel 4.

A pentode mixer (½ 6X8) is used between the RF and IF circuits in order to eliminate some of the problems encountered with triode mixers due to interaction between the plate and grid circuits. The mixer output circuit is double-tuned, link-coupled, band-pass circuit. An absorption trap tuned to the sound carrier (41.25 mc) is coupled to the grid side of the circuit. In order to reduce cross-modulation, the sound carrier was attenuated as soon as possible in the IF amplifier.

The first picture IF (6CB6) employs an m-derived band-pass circuit with the rejection traps tuned for accompanying sound (41.25 mc) and adjacent sound (47.25 mc).

The second (6CB6), third (6CB6), and fourth (6CB6) picture IF form a staggered triple with the second and third stages tuned, respectively, to the low and high frequency side of the pass-band. The fourth stage is tuned to approximately the center of the band. An absorption trap tuned to the adjacent sound frequency (39.75 mc) is coupled to the second stage. A low "Q" absorption trap is coupled to the third stage to compensate for the high frequency corner of the m-derived circuits in the first and fifth picture IF stages. The staggered triple provides a means of compensating for product variations in the overall amplifier, since each stage will affect a different portion of the passband.

The fifth picture IF (6CL6) uses a bridged-T, m-derived, band-pass circuit with the rejection traps tuned for accompanying sound (41.25 mc) and adjacent sound (47.25 mc).

PART IV

Sound IF and Audio Channel

In most monochrome intercarrier sound receivers the sound take-off is after the second detector. Also, it has been found that the optimum ratio of picture carrier to sound carrier at the take-off point should be approximately 15 to 1. However, in order to reduce the 920 kc beat between sound carrier and color subcarrier so that it does not appear on the face of the kinescope, it is necessary to attenuate sound much greater than 15 to 1. In the interests of sound gain it is desired to take off sound information as late as possible in the IF. Therefore, the plate of the fifth picture IF tube is used as this point. The additionally needed sound rejection is then obtained by bridging the m-derived, band-pass circuit for maximum sound rejection.

Intercarrier sound reception is used with a corresponding sound IF of 4.5 mc. The sound information is taken off at the plate of the fifth picture IF amplifier and is detected by a 1N60 crystal diode feeding a single tuned circuit in the grid of the sound IF amplifier (6AU6). The output circuit is a high impedance, double-tuned, band-pass transformer. Following is the driver (6AU6) for the ratio detector, which is operated with low screen voltage and grid leak bias in order to provide limiter action for AM rejection. The ratio detector is single ended because of the common cathode in the 6V8, the triode half of this tube serving as the first audio amplifier. In order to achieve maximum AM rejection the perveance of the two diodes in the ratio detector circuit are balanced by means of a variable resistance placed in series with one of them.

The audio channel is single ended with a two tap compensation on the volume control. The audio output stage is a 6AQ5 and feeds a 12-inch PM speaker. The maximum audio power output is approximately 3.0 Watts.

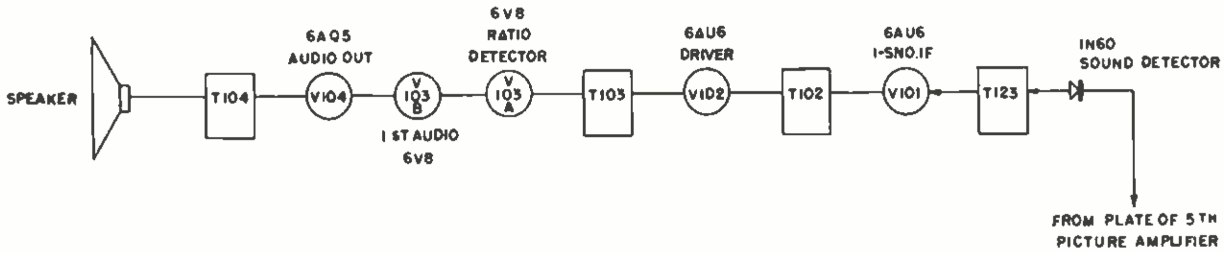


Fig. 4—Sound IF and audio channel.

PART V

VIDEO

The video consists of three separate functions, luminance channel, chrominance channel, and the matrix which combines the two channels.

The luminance (Y) channel serves a purpose substantially similar to that performed in standard monochrome receivers, that of amplifying the luminance information to a level satisfactory for application to a kinescope. The only difference here is that the information is applied to the kinescope via the matrix.

The chrominance channel serves to recover the color difference information contained in the color subcarrier and its accompanying side bands. By the process of synchronous detection in phase quadrature, two independent signals are recovered from the color subcarrier. These signals are called I (in phase) and Q (quadrature phase). Both the I and Q channels are band limited according to NTSC signal specifications. The Q channel passes information up to approximately 0.5 mc and the I channel passes information up to approximately 1.8 mc. While band limiting of these channels prevents cross talk, it necessitates equalization of signal delay time since the channels have different bandwidth characteristics. Similar equalization is also required in the luminance channel.

The tricolor kinescope requires simultaneous excitation with red, blue and green signals as derived from the composite signal. The matrix provides these simultaneous red, blue and green signals by combining predetermined proportions of Y, I and Q information.

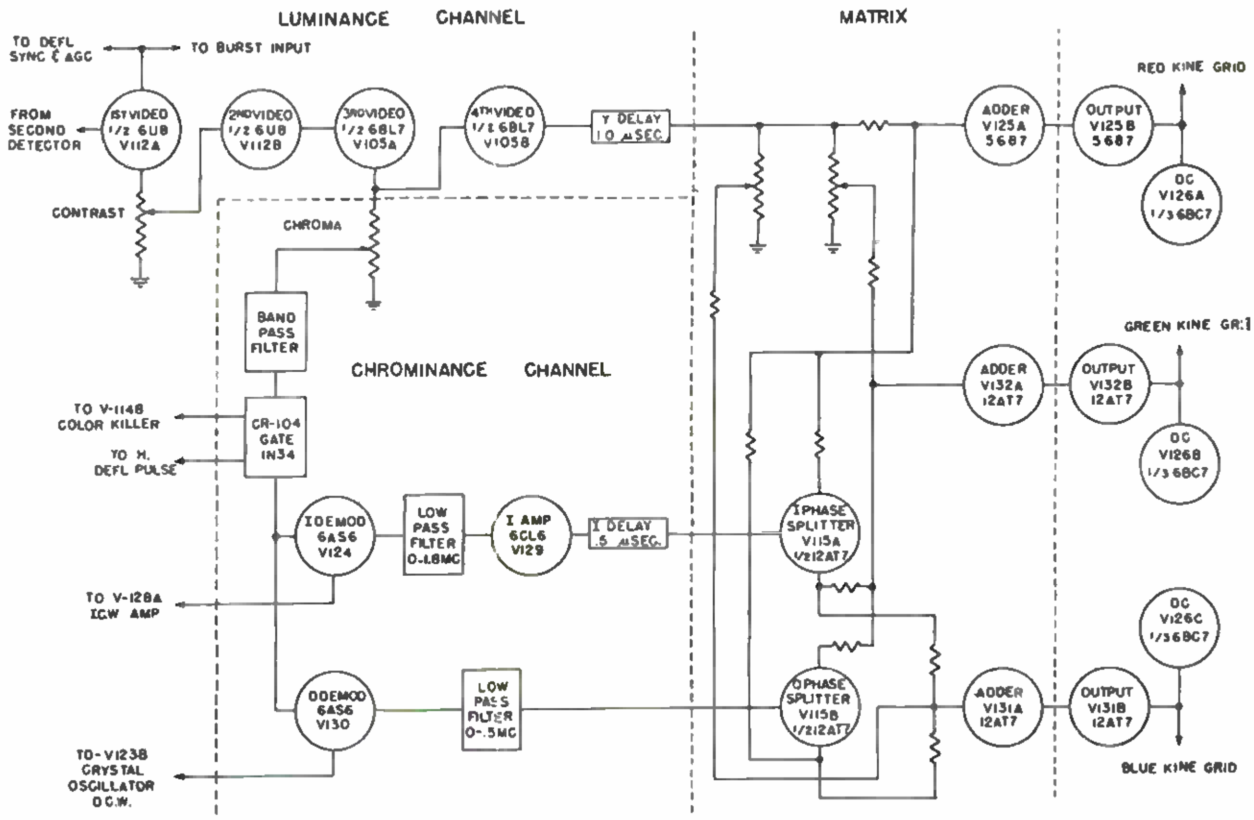


Fig. 5—Video.

1. Luminance Channel

The first video stage, a triode section of a 6U8, provides both polarities of video. Positive polarity for sync, AGC, and burst take-off is obtained in the plate, while a potentiometer in the cathode circuit provides a contrast control and a wide band video for both luminance and chrominance channels. After further amplification in the second video, a pentode section of a 6U8, the video signal is fed to a cathode follower, one half of a 6BL7. This cathode follower, with a potentiometer in the cathode, drives the band pass, and provides for a chroma control. The luminance signal is taken from the top of the chroma control and fed to the second section of the 6BL7 which drives the Y delay line. The line provides a time delay of approximately 1.0 micro-second, thereby assuring time coincidence of all signals arriving at the matrix input. The bandwidth of the Q channel being the narrowest has the longest delay time and is therefore used as the reference in determining the necessary amount of Y delay. The frequency response at this point is essentially similar to that encountered in standard monochrome receivers with some additional attenuation at the color subcarrier frequency.

2. Chrominance Channel

The chroma signal from the cathode of the third video amplifier is fed to a 1.8 mc to 4.3 mc band-pass filter. The band-pass filters out the low frequency components of the signal and retains the color subcarrier and its sidebands. In order to obtain maximum double sideband color operation, the first band-pass filter section consists of a tuned circuit which exhibits a peak of about 6db in the 4.0 mc region. In order to maintain a flat response to the demodulator grids, it is necessary to align the band pass by an overall sweep method so that the aforementioned peaking in the band pass can correctly compensate for the cutoff characteristic of the picture IF channel, Figure 6.

The band-pass filter contains a crystal diode CR-104 gating circuit which normally conducts signal to the demodulator grids. During each burst interval, however, it is keyed off by a pulse derived from kickback. Keying burst out in this manner avoids color background unbalance due to the DC restorers clamping on burst spikes rather than on tips of sync.

CR-104 also operates in conjunction with the color killer tube, one half of a 6BL7. This tube is held at cutoff bias by a negative DC voltage developed by the burst phase detector. In the absence of burst, that is a standard monochrome transmission, the killer tube conducts and biases off the crystal diode circuit, thereby insuring that no signal information gets to the demodulator grids via the band-pass filter.

Demodulation of the chroma signal is accomplished by a pair of 6AS6 synchronous detectors operating in quadrature; color subcarrier frequency is applied to the suppressors while the chroma signal is applied to the grid. The detected I and Q signals appear at the plate circuits which are band limited with low pass type filters. The frequency response of the I and Q channels is shown in Figures 7 and 8.

The Q signal which has a bandwidth of approximately 0.5 mc is fed into a phase inverter to provide both polarities of signals for matrixing purposes. The I signal which has a bandwidth of 1.80 mc is peaked at approximately 800 kc in order to compensate for the loss of double sidebands. Peaking is accomplished by cathode degeneration of the I-6AS6 with a series resonant circuit to peak at 800 kc. The effect of this peaking circuit can be observed at the cathode of the I phase inverter when sweeping overall. A peak occurs in the response curve in the region of 2.8 mc. Thus the beat down or low frequency response of I will have a peak at 3.58 — 2.8 mc or approximately 800 kc.

The I signal, being of wider bandwidth than Q signal, has less time delay. Thus it is necessary to insert delay to match I to Q and Y. This is accomplished by a delay line stage (6CL6) between the I demodulator and the phase splitter stage.

3. Matrix

Adding is accomplished in the adder stages, ½ 12AT7 for green and blue, and ½ of 5687 for red. These stages are highly degenerated by feedback and have a wide response with a gain of approximately 1. The added luminance and chrominance signals are then amplified by the second half of the triode sections and serve as the drive for the respective kinescope grids. Unequal drives are required, due to the unequal phosphor efficiencies of a tricolor kinescope, red being in the order of 100 volts while blue and green require approximately 50-70 volts drive. Variable monochrome control is accomplished by feeding red

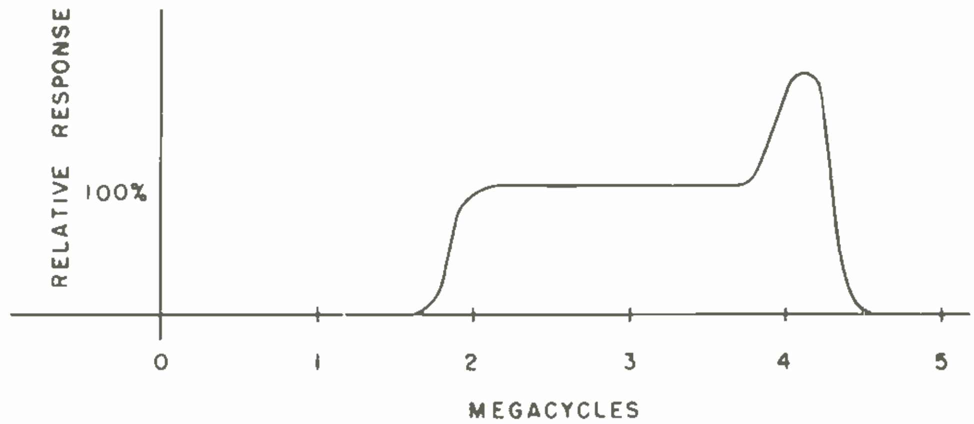


Fig. 6—Band-pass filter response.

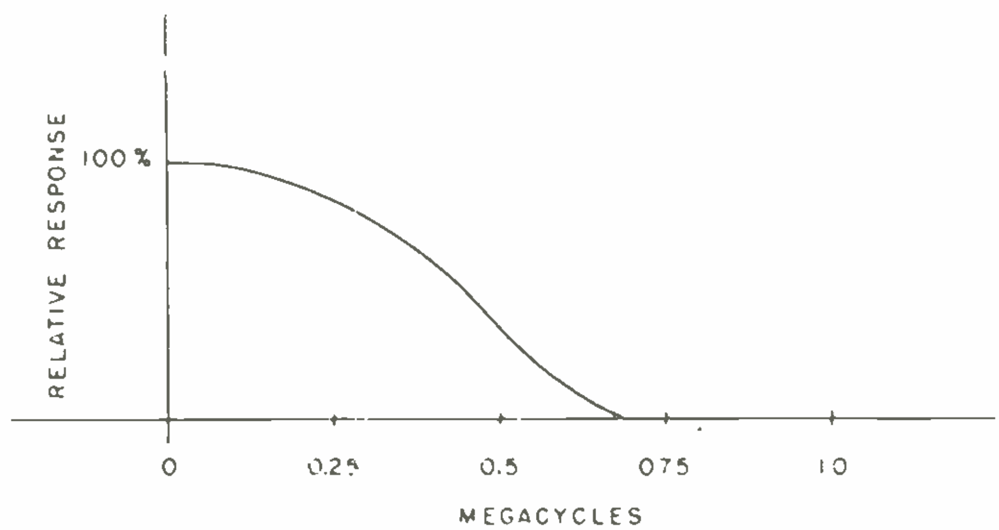


Fig. 7—Q channel frequency response.

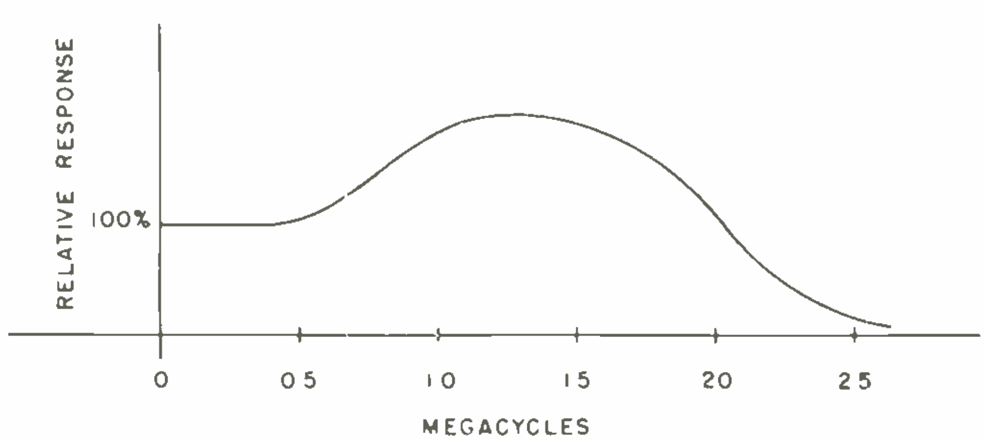


Fig. 8—I channel frequency response.

monochrome direct from the Y delay line and taking blue and green monochrome off with potentiometers. Variable color control is accomplished by means of the matrix potentiometers in the cathodes of the I and Q phase inverters. Overall gain from the second detector to kine grid is approximately 10 times. DC restoration is applied to the red, blue and green output signals by a 6BC7, a triple diode tube. The plate return circuits for these three restorers are arranged in a bridge circuit which is adjusted in such a way as to maintain proper tracking of the three kine grid bias values throughout the range of the master brightness control.

PART VI

COLOR SYNCHRONIZATION, DEFLECTION SYNCHRONIZATION AND AGC

1. COLOR SYNCHRONIZATION

In order to recover the color information contained in an NTSC type signal, it is necessary to generate a local subcarrier of proper frequency and phase. To accomplish this, phase reference information is transmitted as a component of the composite color video signal. This color synchronizing information is transmitted in the form of a "burst" of approximately 8 cycles of the color subcarrier frequency and appears immediately following each horizontal synchronizing pulse in the composite signal.

This "burst" is separated from the composite video signal and is used in establishing two continuous wave signals of color subcarrier frequency, having a 90° phase displacement from each other. These two signals, called I cw and Q cw are generated by a quartz crystal oscillator whose exact frequency is controlled by a reactance tube. The reactance tube derives its control information from an error signal proportional to the difference in phase between the transmitted "burst" and the local crystal oscillator output.

This color synchronizing channel includes a keyed burst amplifier stage, phase detector—3.579 mc driver, crystal oscillator, reactance tube, and 90° phase shift 3.579 mc amplifier.

The burst amplifier stage is driven from a single tuned coil in series with the first video amplifier plate load resistor. A secondary winding on this input coil provides an out of phase voltage which is used for neutralizing the grid to plate capacity of the first video amplifier stage. The burst amplifier stage is cathode keyed by a negative pulse derived from a special winding on the horizontal deflection transformer. Bias is provided for this stage by partial cathode bias and partial B+ tap down. The burst plate transformer has a high impedance primary and a bi-filar secondary tightly coupled to the primary. With a turns ratio of 6:1, the output is about 60 v peak to peak of burst pulse of 180° polarity.

The phase detector and phase detector—3.579 mc driver are combined in a single tube (6V8). Due to the common cathode, the phase detector operates as a cathode follower driven from the oscillator and the cw on the cathode appears as the phase detector voltage. The detector diode resistors are balanced by means of a 50 K potentiometer. Due to the shields in the 6V8, the capacitances

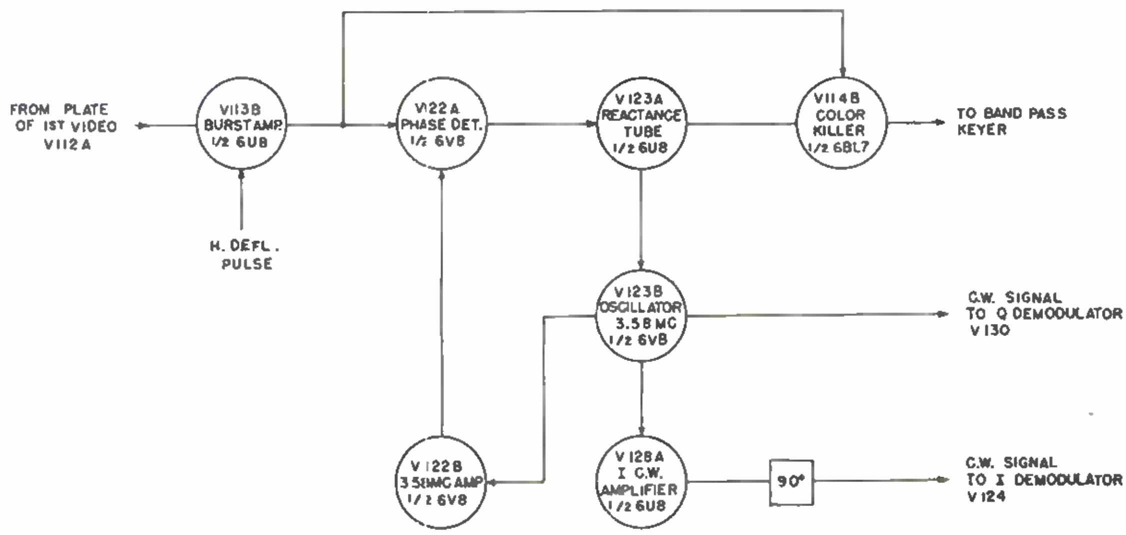


Fig. 9—Color synchronization.

across the diodes are unequal. Unbalance of this nature causes unwanted coupling between the burst transformer and this 3.579 mc driver cathode coil, which ultimately appears as an error in the DC output of the phase detector. A trimmer is provided to balance out the capacity differences.

The reactance tube circuit is the capacitive type. Nominal bias for the reactance tube is applied through the phase detector by biasing the low side of the phase detector driver transformer.

Operating the oscillator as a cathode follower has the basic advantage of eliminating the spurious oscillation to the reactance tube plate coil. This occurs because operation as a cathode follower oscillator requires the cathode tank to be tuned below 3.579 mc. It falls between the tuning points of the crystal and the reactance tube plate coil. The oscillator cathode coil has a bi-filar secondary tightly coupled to the primary. The bi-filar center tap is brought out on a fifth lead and is connected to the Q demodulator suppressor bias resistor. The Q demodulator is directly connected through a shielded lead to the bi-filar output with the same phase as the oscillator cathode.

The triode portion of a 6U8 in common with pentode AGC provides a 90° phase shift 3.579 mc amplifier. Its plate coil is tapped for a neutralizing voltage. The I demodulator suppressor is directly connected through a shielded lead to the top of the coil and the suppressor bias resistor connected at the tap.

With voltages available of 180° polarity to Q and I suppressor drives, neutralization of stray suppressor to grid feed through is accomplished by capacity taps and adjustable trimmers to the 6AS6 common grids.

2. Deflection Synchronization

The first sync separator employs a 5915 pentagrid converter. This stage has the function of stripping sync and providing a noise immune sync signal. A sync positive video signal is AC coupled to the No. 3 grid. Grid leak bias is used and separated sync appears at the output plate. A sync negative video signal is DC coupled to the No. 1 grid which is held at a slight positive bias by virtue of a potentiometer (threshold control) from a varying source of + voltage in the IF noise pulses appearing at the No. 1 grid (which is normally slightly positive) will be in the negative direction and will cut the tube off. Consequently when noise pulses coincide with sync, a hole will occur in the signal. This same action occurs at other than sync time also, and as an overall result this type of sync signal has less of a disturbing effect on the timing circuits and sync stability with noise present is greatly improved. The amount of inversion needed is accomplished by the threshold control which is normally set so that with a weak signal with no noise present the output sync begins to clip with clockwise rotation of the control. Tracking of the noise inversion is accomplished by providing a less positive going bias to the No. 1 grid as signal strength decreases. A second stage, triode half of a 6U8, serves as a double clipper and separator. The signal at the plate of this stage contains both the horizontal and the vertical synchronizing information. Horizontal is fed directly to the horizontal oscillator circuit, while the vertical is derived from the output of a three stage integrator and fed to the vertical blocking oscillator.

3. AGC

The AGC amplifier employs the pentode half of a 6U8. It is a fully keyed type of AGC, utilizing a positive pulse obtained from the horizontal yoke for developing a negative bias voltage. Variation of the height of sync tips applied to the grid of the 6U8, controls the amount of pulse rectification and consequently, the bias applied to the RF and IF bias is delayed approximately six volts in order to provide better signal to noise ratio.

PART VII

Horizontal Deflection, Vertical Deflection and High Voltage

1. Horizontal Deflection and High Voltage

The horizontal deflection system supplies the high voltage potentials along with the horizontal scan. This stage is preceded by a dual triode 6SN7 horizontal oscillator and AFC which is similar to that system used by many monochrome receivers. In order to produce the regulated 20 kv high-voltage output, the transformer used is so designed to store that amount of energy required for this purpose. The yoke is AC coupled from the transformer and has shunting it a variable inductance which serves as a variable impedance width device, and also supplies the DC path for electrical centering.

Regulation of the rectified kick-back pulse is achieved by using a shunt regulator 2C175, which has the effect of maintaining a constant load on the high-voltage system. During an all black picture, the regulator absorbs the

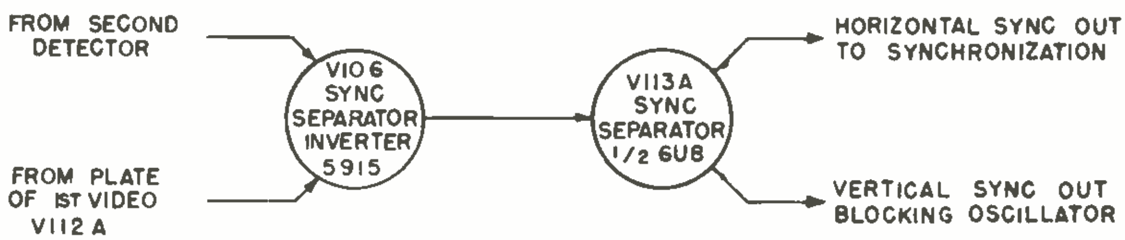


Fig. 10—Deflection sync separator.

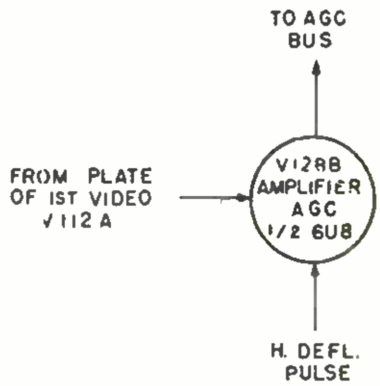


Fig. 11—AGC.

entire load and conversely during an all white picture, the kinescope takes the load and the regulator very little.

A variable tap on the high voltage bleeder is used to provide approximately 10 kv for the convergence electrode of the tricolor kinescope. A similar type variable tap on the focus voltage bleeder provides approximately 4 kv for the focus electrode.

2. Vertical Deflection

Vertical deflection is supplied by a dual triode 6BL7, the first half being a blocking oscillator and the second half driving the vertical yoke section by way of an output transformer. Electrical centering is also used.

PART VIII

Tricolor Kinescope and Dynamic Convergence

1. Tricolor Kinescope

The tricolor kinescope, as used, is a simultaneous color display device. Structurally, the tube consists of three electron guns mounted with their axes parallel to the central axis of the tube, and spaced 120° with respect to each other. Each gun has a focus electrode whose potential is adjusted to cause the beams to focus at the phosphor-dot plate. All three beams pass through an electrostatic lens system, whose potential is adjusted to cause the three beams to converge in the plane of the aperture mask. The three beams are electromagnetically deflected by a common yoke. Further information on this subject is contained in Exhibit 5.

Those functions associated with the kinescope are divided into two categories, namely static and dynamic adjustments.

Into the static adjustment classification fall purity, center convergence, cut-off, and background tracking. The purity adjustment is made in order to align the electron beams so that they will be originating from a source whose position is equivalent to that of the original light source used in manufacturing the shadow mask. Once the purity yoke and deflection yoke positioning is established, individual fields of the primary colors will be obtained.

Successful operation of a master background control requires that some provision be made for the differences in the three phosphor efficiencies and also for the variation in gun cutoffs. With the brightness control at maximum

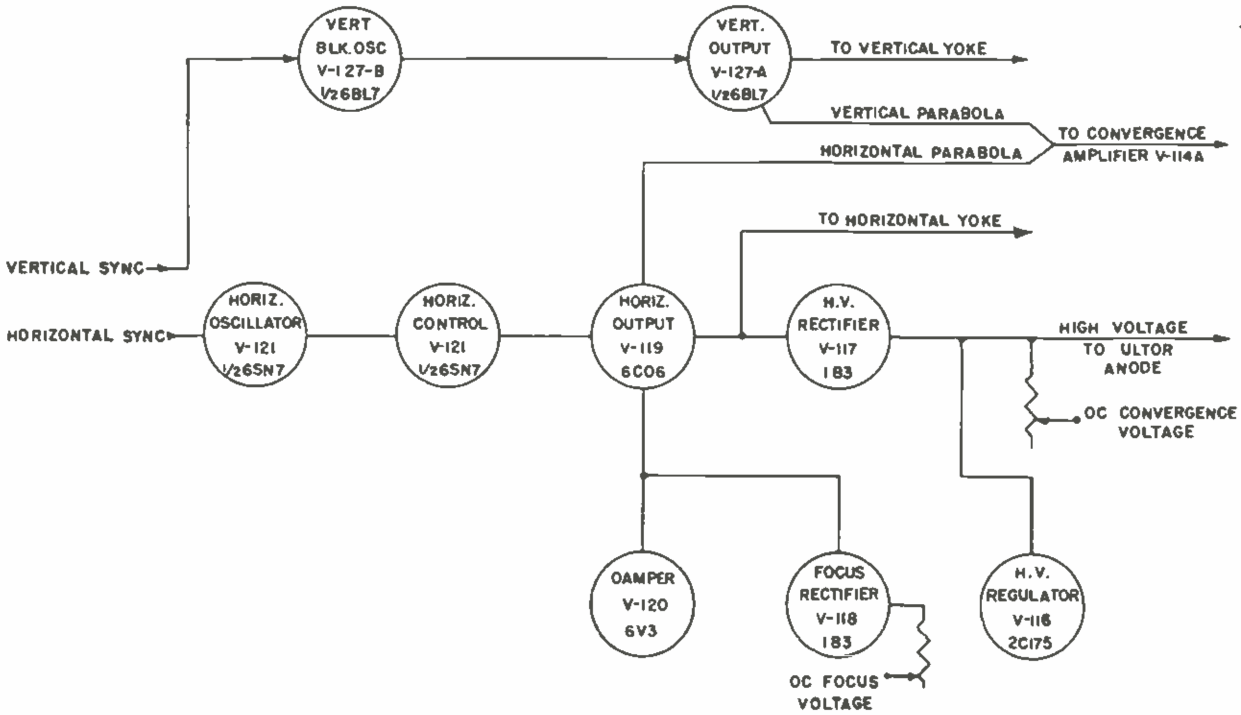


Fig. 12—Deflection and high voltage.

clockwise position the screen potential potentiometers are adjusted to give a gray low-light. The low-light bias tracking is done by the blue and green dividers across the top portion of the master background potentiometer.

Center convergence of the three beams is done by adjusting the DC potential of the convergence electrode for best superpositioning. That error which still exists is due to the mechanical inaccuracies of the gun alignment and is corrected for by the use of the individual beams convergence magnets. In order to effect overall beam coincidence, dynamic convergence is added.

2. Dynamic Convergence

Since the phosphor plate and the aperture mask are flat surfaces, the

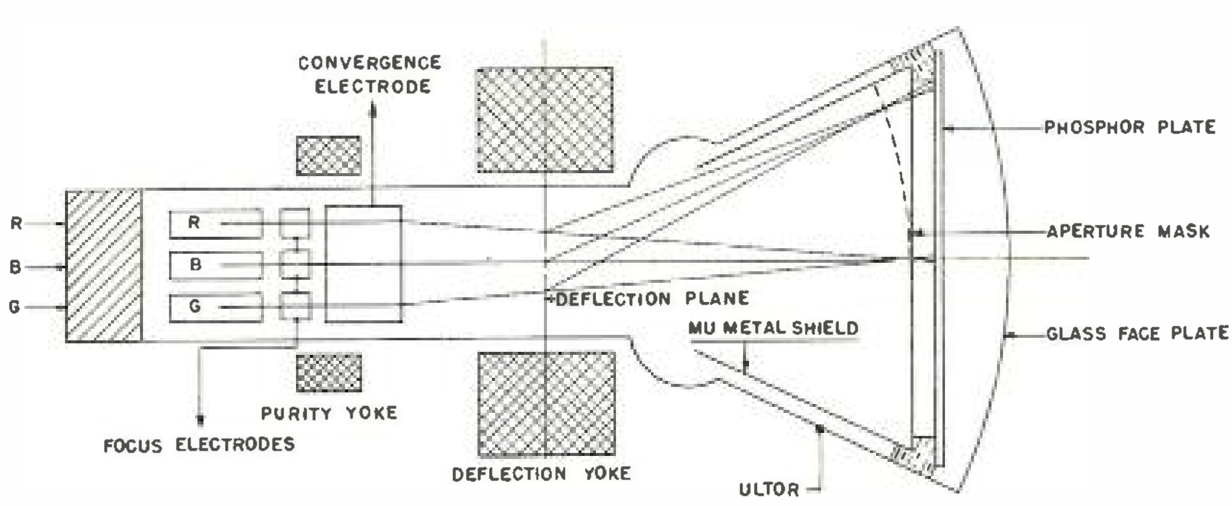


Fig. 13—Tricolor kinescope.

distance the beams must travel from the deflection plane to the central area of the aperture mask is less than the distance they must travel when the beams are deflected away from the central area. If the potential on the convergence electrode, which was necessary to produce center convergence remained unchanged, the three beams would then cross over at some point before reaching the aperture mask. This would result in a misregistered picture. To correct this condition, it is necessary to modulate the DC potential on the convergence electrode in such a manner as to produce a larger convergence electrode voltage as the deflection angle increases. This condition also exists with respect to focus.

The dynamic convergence voltage and focus modulation voltage, each having the proper waveform, amplitude and synchronism with deflection are generated by the use of two tapped transformers and a single triode amplifier

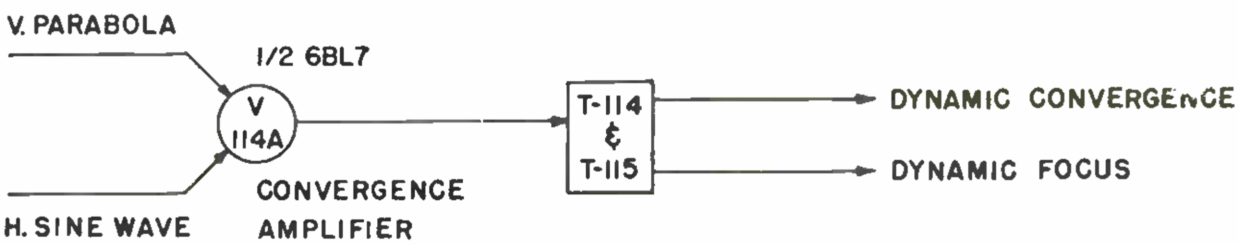
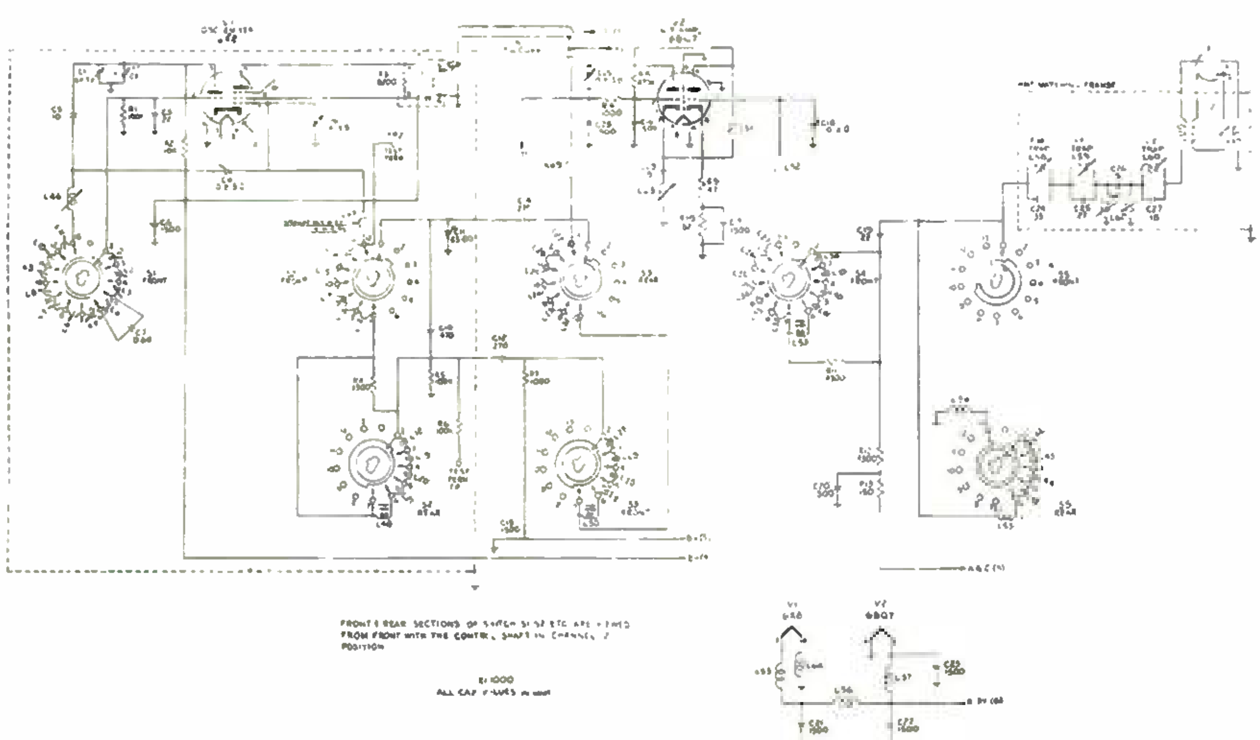


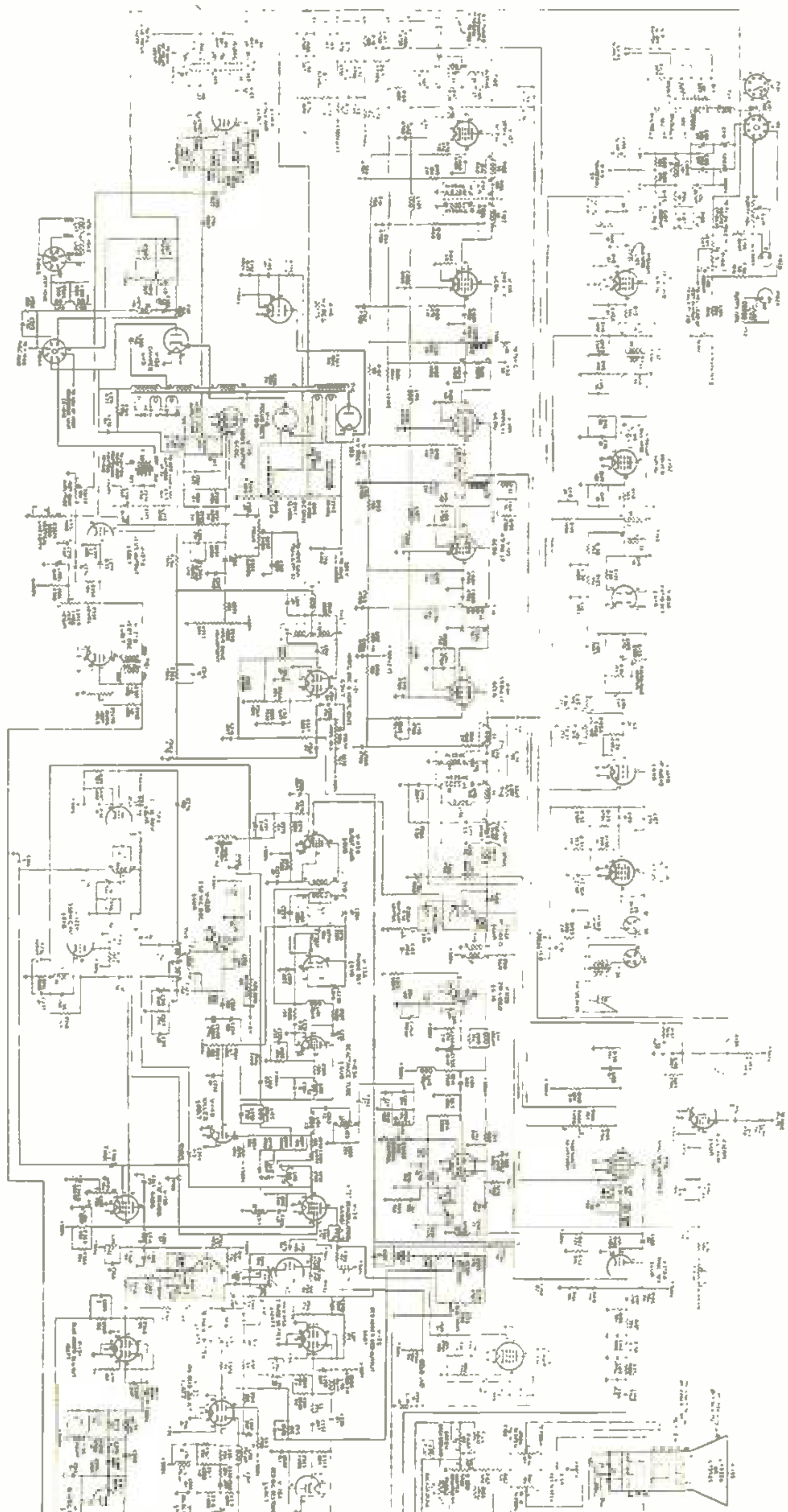
Fig. 14—Dynamic convergence.

½ 6BL7. These dynamic voltages are produced by linear addition of horizontal and vertical waveforms derived from the cathodes of the respective deflection output stages. The composite alternating output voltage is coupled to the kinescope convergence electrode and focus electrode through their respective output transformer taps.

Schematic diagrams of the complete receiver follow:



RF Tuner Circuit Diagram



Receiver Circuit Diagram

APPENDIX B

ENGINEERING DESCRIPTION OF THE RCA 16-INCH TRICOLOR KINESCOPE RECEIVER MODEL NO. 4

TABLE OF CONTENTS

PART I

INTRODUCTION

THE color television console receiver shown in Figures 1a and 1b uses the RCA shadow-mask type, three gun, directly viewed tricolor kinescope housed in a 16-inch envelope. This type of display device utilizes the three continuously available primary signals to produce a simultaneous picture. The kinescope is assembled to a supporting mask which maintains the receiver as an integral unit convenient for maintenance work. For convenience of receiver set up adjustment and in keeping with present style trends, all functional controls are brought out to the front of the receiver. With the exception of volume-brightness-on-off and channel-selector-fine-tuning, the controls are located behind the front cover panel.

Features of this receiver (Figure 2) include: a KRK-12, VHF-UHF tuner with provisions for 300-ohm balanced antenna input on either VHF or UHF, and a special 72-ohm antenna input for UHF; an intercarrier 41.25 mc IF system; high level second detector operation for maximum linearity; keyed AGC; noise inversion sync separation; stabilized horizontal AFC; horizontal pulse type regulated high voltage supply; electrostatic convergence and focus along with dynamic

Fig. 1a—Front view of 16-inch Tricolor Kinescope Receiver Model No. 4.

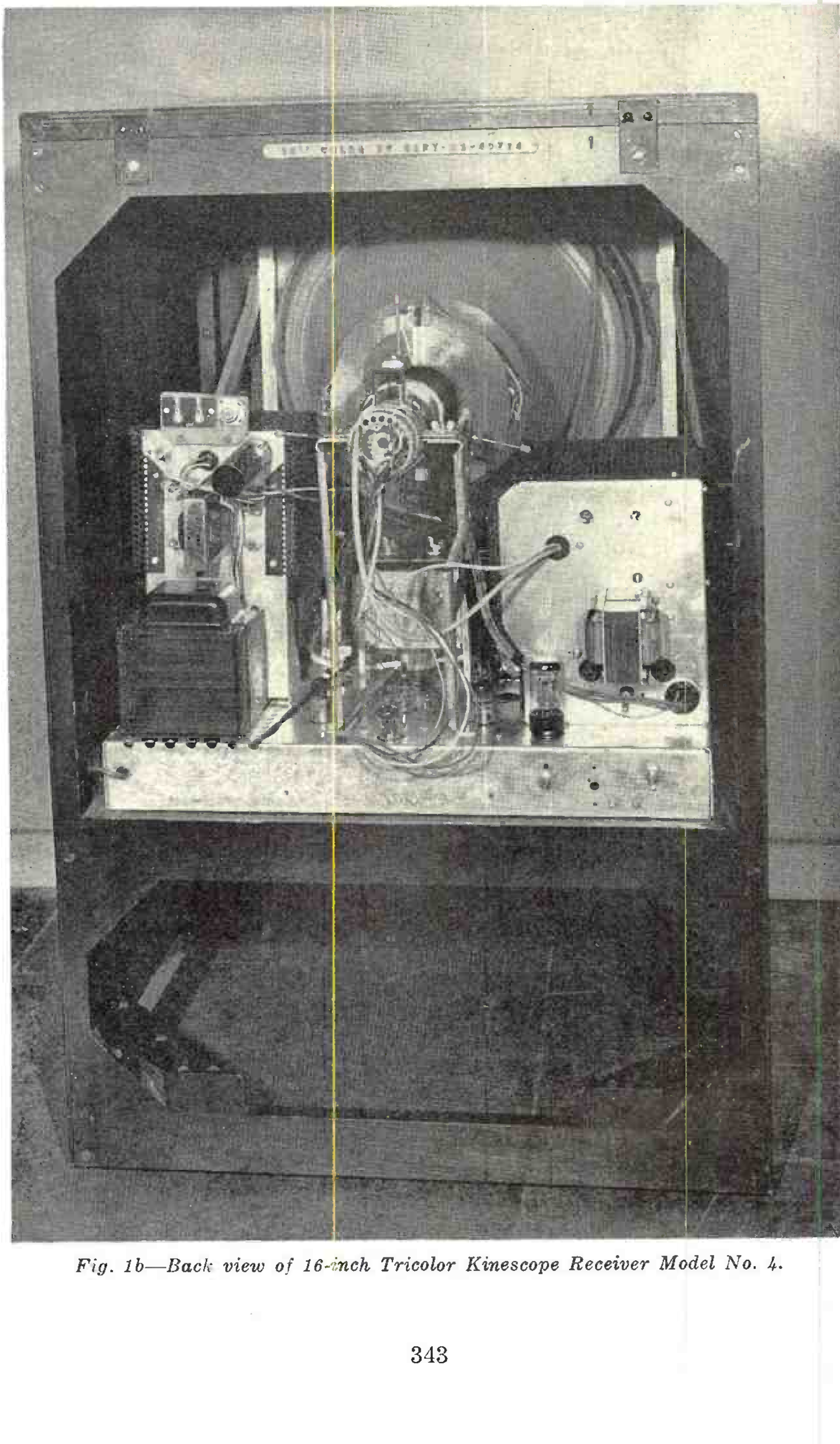


Fig. 1b—Back view of 16-inch Tricolor Kinescope Receiver Model No. 4.

modulation of the kinescope anodes; quartz crystal-AFC color synchronization; low level color demodulation using quadrature techniques; kinescope grid drive with DC restoration; and a color "killer" to disable the color channel during monochrome transmissions.

PART II

RF TUNER

The KRK-12 television RF tuner is a three tube, sixteen position, turret type tuner covering both the VHF and UHF television channels, and providing a 40 mc IF output. The tube complement for this tuner consists of 6BQ7A for the VHF RF amplifier, a 6AF4 for the VHF-UHF oscillator, and a 6BQ7A for the IF amplifier. A 1N82 silicon crystal is used in the mixer circuit for both VHF and UHF. In the VHF range a low noise RF amplifier is used ahead of the crystal mixer, which in turn is followed by another low noise stage operating at IF. For the UHF range, the arrangement is similar except there is no RF amplifier ahead of the crystal mixer.

1. VHF CIRCUITS

The antenna input circuit consists of a link-coupled, single-tuned circuit with the 300-ohm balanced antenna input tapped down for impedance match. However, the constants and configuration have been selected to provide optimum noise factor for all channels rather than perfect impedance match between the antenna circuit and the RF amplifier. Traps are placed in series with the primary of the input transformer to provide IF attenuation. A tuned section of 300-ohm transmission line is mutually coupled to the input line to provide FM attenuation.

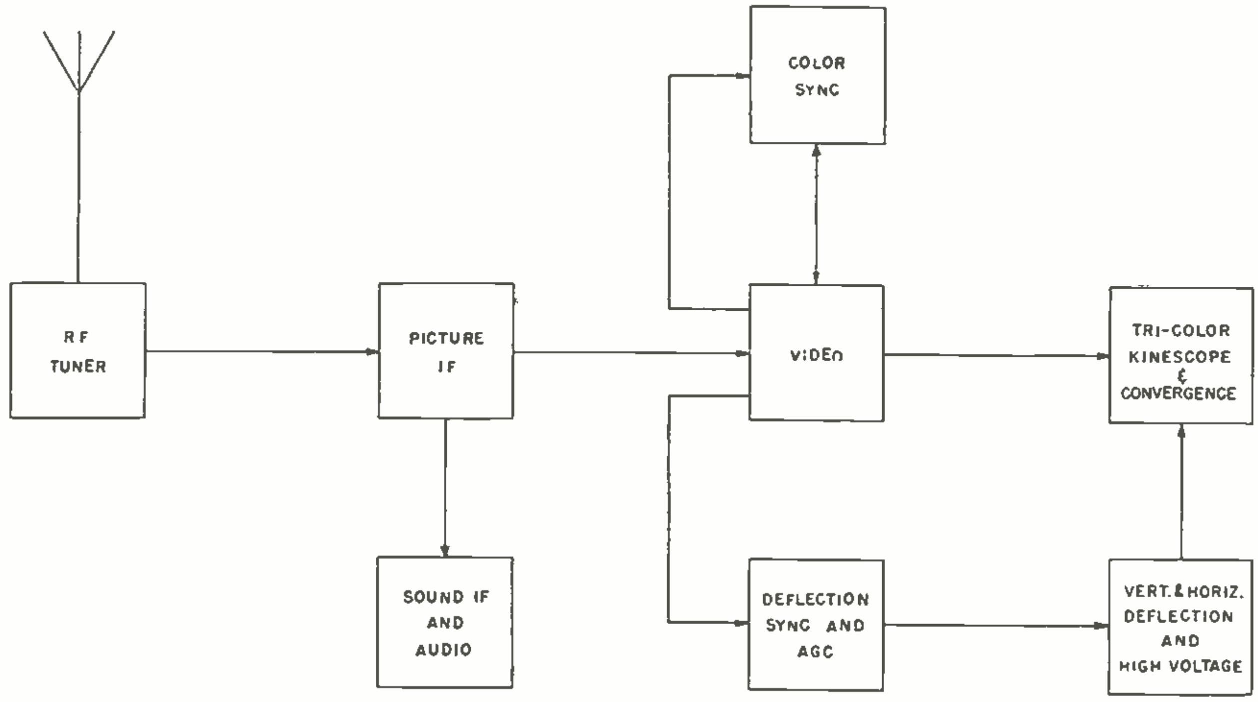


Fig. 2—Color TV receiver master block diagram.

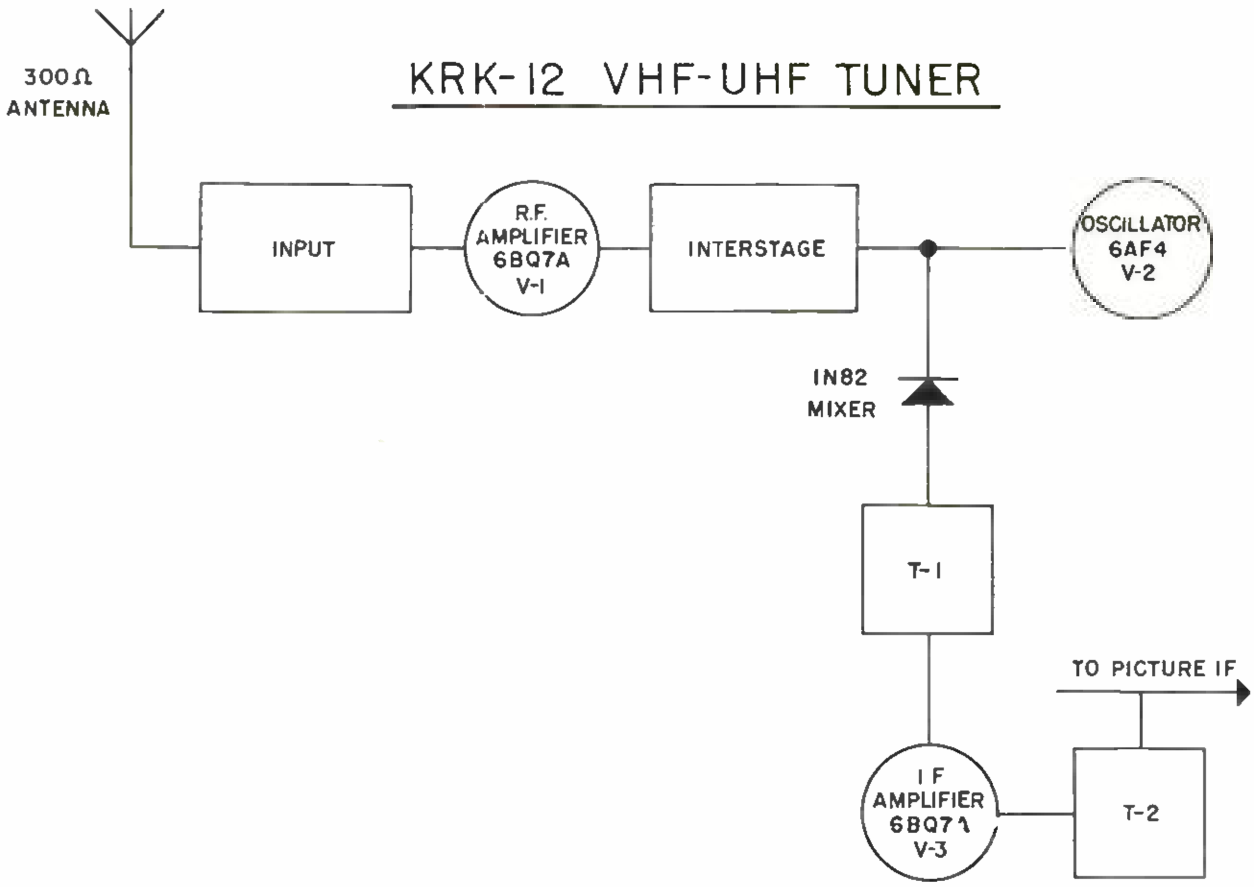


Fig. 3a—RF tuner — VHF operation block diagram.

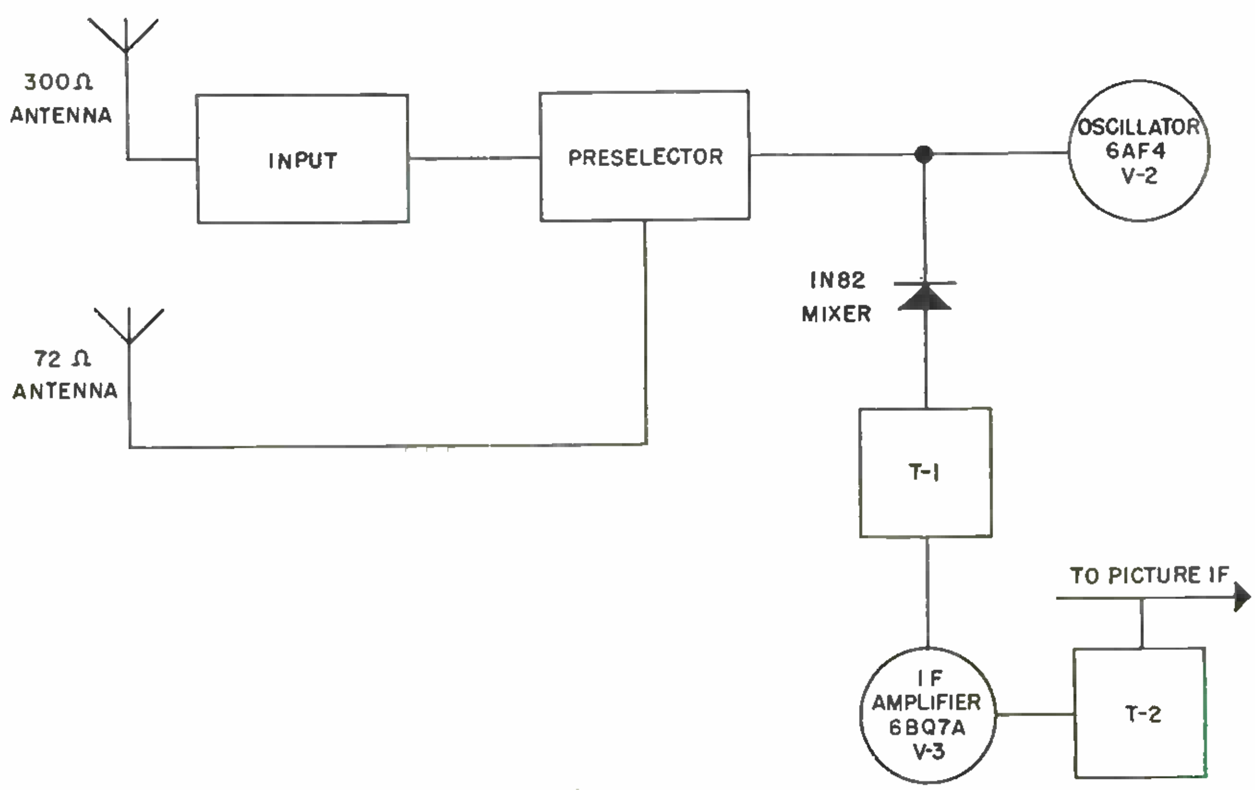


Fig. 3b—RF tuner — UHF operation block diagram.

The RF amplifier is a dual triode (6BQ7A) especially designed for driven grounded grid operation. It has the gain and stability of a pentode with the improved noise factor of a triode. Low output to input capacitance minimizes local oscillator feed-through. To prevent detuning of the input circuit with change in grid bias because of "Miller Effect" and to improve the noise factor of the amplifier, a capacity bridge type of neutralization is used. The output of the RF amplifier contains a capacity coupled double-tuned circuit. The secondary is tapped for desired amplitude characteristic on the basis of the loading of the crystal diode (1N82). This silicon crystal mixer having low noise characteristics, feeds a tuned bifilar transformer in the grid of the IF amplifier. Oscillator injection for the mixer is obtained through capacity coupling on the lower VHF channels and mutual inductance coupling on the upper VHF channels.

The oscillator employs a temperature compensated Colpitts circuit with a 6AF4 triode. Tuning is accomplished, as in the other RF circuits, by switching in the correct inductance to resonate the tank circuit to the proper frequency. A fine tuning control, located concentrically on the channel selector shaft, permits vernier adjustment of the local oscillator frequency.

2. UHF Circuits

On UHF an input circuit impedance of 300 or 72 ohms may be used. The 300-ohm input is the same as that used for VHF but the 72-ohm input is made separate so that an independent UHF antenna may be used if so desired. The 72-ohm UHF input consists of a tap on the input coil of the triple-tuned pre-selector circuit. The output of the circuit is tapped for the crystal mixer circuit. Both taps were designed on the basis of optimum noise factor. Oscillator injection is obtained by means of an adjustable inductance in the ground side of the mixer circuit. The output of the mixer circuit is the same as for VHF.

The UHF oscillator circuit corresponds to that used for the VHF range except that the tuning for the required channel is accomplished by switching in a variable capacitance in series with an inductance. The capacitance is preadjusted for the correct oscillator frequency.

PART III

Picture IF Channel

The picture IF amplifier is designed for a 45.75 mc picture carrier, 42.17 mc color subcarrier, and a 41.25 mc sound carrier. The amplifier consists of six stages, using one 6BQ7A, four 6CB6's, and one 6CL6. The second detector uses a 1N60 crystal and is operated at six volts peak output level in the interests of linearity. The overall sensitivity is approximately 12 micro-volts across the antenna terminals for six volts peak at the second detector. Figure 4b shows the overall RF — IF response characteristic for channel 4.

The noise factor of the tuner on UHF depends primarily on the noise contributed by the crystal mixer and by the first IF amplifier following the mixer circuit. Therefore, a low noise, driven grounded-grid stage is used for this IF

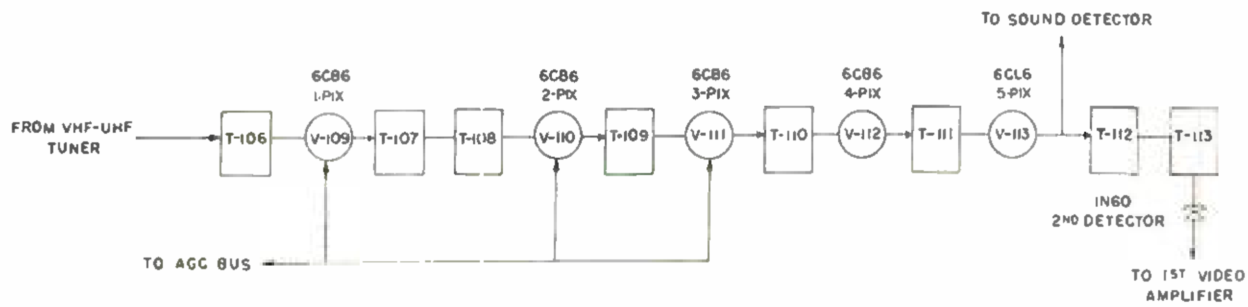


Fig. 4a—Picture IF channel block diagram.

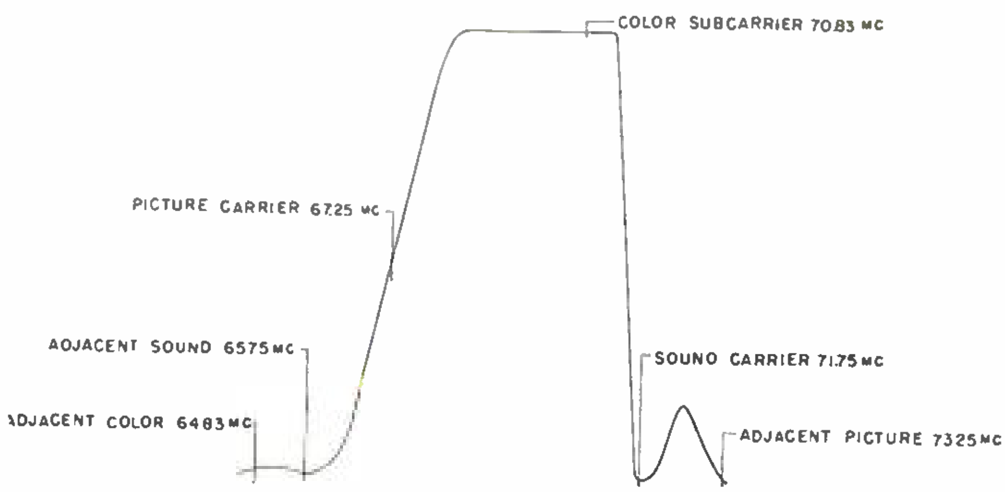


Fig. 4b—Overall RF-IF response channel 4.

amplifier. This amplifier (6BQ7A) is fed from the crystal mixer by means of a single-tuned circuit. The output network is a link-coupled, bridged-T, m-derived, band-pass circuit with a rejection trap tuned for accompanying sound (41.25 mc). In order to reduce cross-modulation, the sound carrier is attenuated as soon as possible in the IF amplifier.

The first picture IF (6CB6) employs a bridged-T, m-derived, band-pass circuit with the rejection traps tuned for adjacent picture (39.75 mc) and adjacent sound (47.25 mc).

The second (6CB6), third (6CB6), and fourth (6CB6) picture IF stages form a staggered triple with the second and third stages tuned, respectively, to the high and low frequency side of the pass band.

The fourth stage is tuned to approximately the center of the band. A low "Q" absorption trap is coupled to the second stage to compensate for the high frequency corner of the m-derived circuit in the first picture IF stage.

The staggered triple provides a means of compensating for production variations in the overall amplifier, since each stage will affect a different portion of the pass band.

The fifth picture IF (6CL6) uses a bridged-T, m-derived, band-pass circuit and a mutually coupled absorption trap. The rejection traps are tuned for accompanying sound (41.25 mc) and adjacent sound (47.25 mc).

PART IV

SOUND IF AND AUDIO CHANNEL

In most monochrome intercarrier sound receivers the sound take-off is after the second detector. Also, it has been found that the optimum ratio of picture carrier to sound carrier at the take-off point should be approximately 15 to 1. However, in order to reduce the 920 kc beat between sound carrier and color subcarrier so that it does not appear on the face of the kinescope, it is necessary to attenuate sound much greater than 15 to 1. In the interests of sound gain it is desired to take off sound information as late as possible in the IF. Therefore, the plate of the fifth picture IF tube is used as this point. The additionally needed sound rejection is then obtained by bridging the m-derived, band-pass circuit for maximum sound rejection.

Intercarrier sound reception is used with a corresponding sound IF of 4.5 mc. The sound information is taken off at the plate of the fifth picture IF amplifier and is detected by a 1N60 crystal diode feeding a single tuned circuit in the grid of the sound IF amplifier (6AU6). The output circuit is a high impedance, double tuned, band-pass transformer. Following is the driver (6AU6) for the ratio detector, which is operated with low screen voltage and grid leak bias in order to improve AM rejection. The ratio detector is single ended because of the common cathode in the 6V8; the triode half of this tube serving as the first audio amplifier. In order to achieve maximum AM rejection the perveance of the two diodes in the ratio detector circuit are balanced by means of a variable resistance placed in series with one of them.

The audio channel is single ended with a two tap compensation on the volume control. The audio output stage is a 6AQ5 and feeds an 8-inch PM speaker. The maximum audio power output is approximately 3.0 watts.

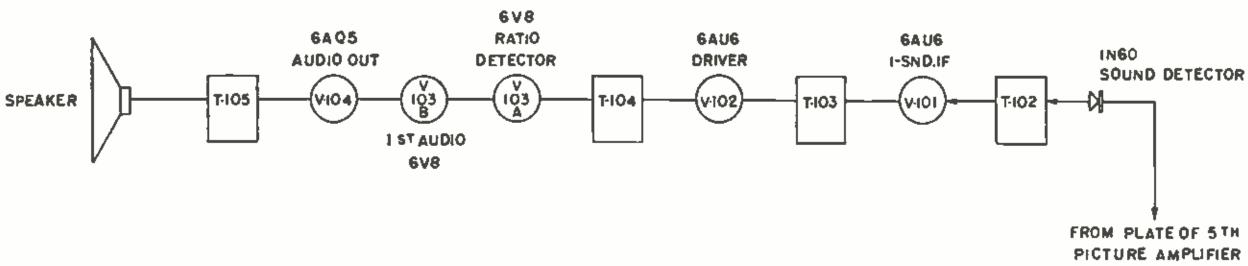


Fig. 5—Sound IF and audio channel block diagram.

PART V

VIDEO

The video consists of three separate functions: luminance channel, chrominance channel, and the matrix which combines the two channels.

The luminance (Y) channel serves a purpose substantially similar to that performed in standard monochrome receivers, that of amplifying the luminance information to a level satisfactory for application to a kinescope. The only difference here is that the information is applied to the kinescope via the matrix.

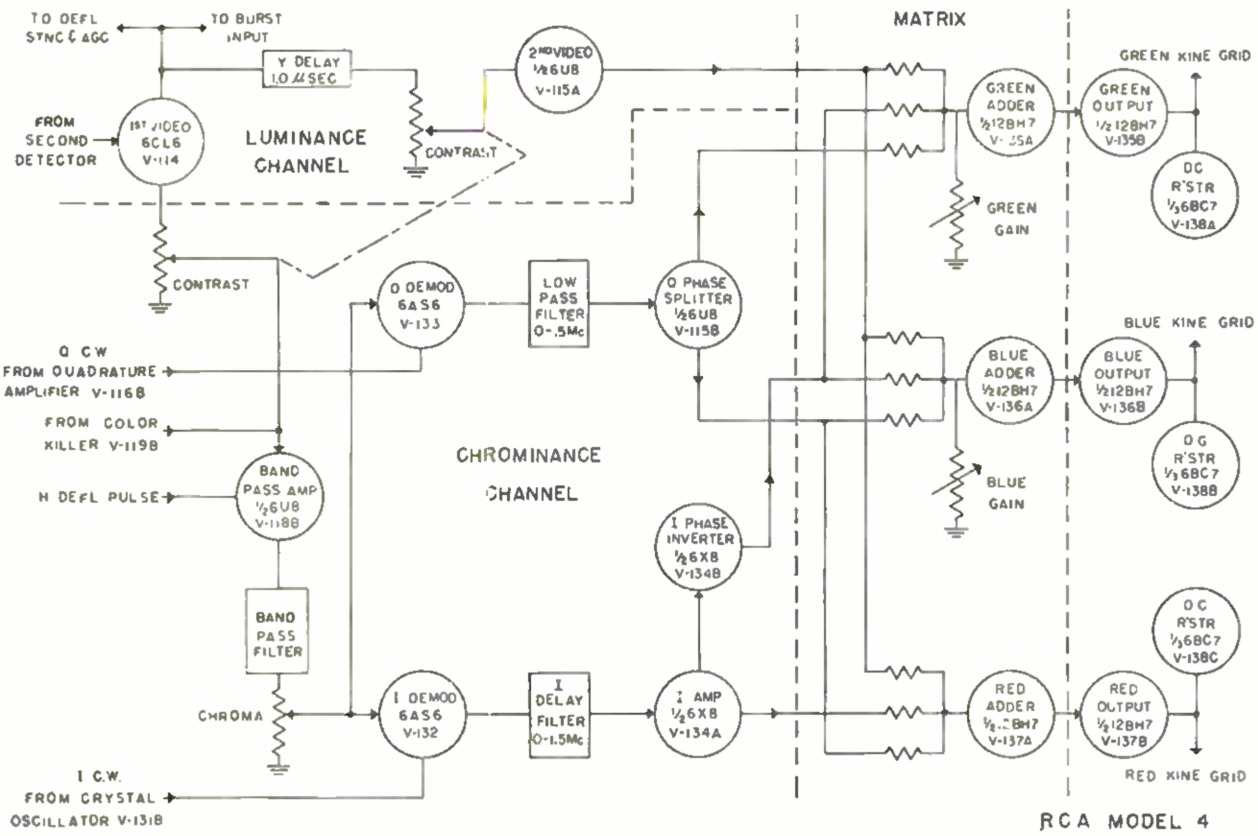


Fig. 6—Video section block diagram.

The chrominance channel serves to recover the color difference information contained in the color subcarrier and its accompanying side bands. By the process of synchronous detection in phase quadrature two independent signals are recovered from the color subcarrier. These signals are called I (in phase) and Q (quadrature phase). Both the I and Q channels are band limited according to NTSC signal specifications. The Q channel passes information up to approximately 0.5 mc and the I channel passes information up to approximately 1.5 mc. While band limiting of these channels prevents cross talk, it necessitates equalization of signal delay time since the channels have different band width characteristics. Similar equalization is also required in the luminance channel.

The tricolor kinescope requires simultaneous excitation with red, blue and green signals as derived from the composite signal. The matrix provides these simultaneous red, blue and green signals by combining predetermined proportions of Y, I and Q information.

1. Luminance Channel

The first video amplifier stage, a 6CL6, provides both polarities of video. Positive wide band video at the plate provides the luminance channel signal as well as the sync, AGC, and burst signals. The luminance signal is fed to the Y delay line which provides a time delay of approximately 1.0 micro-second, thereby effecting time coincidence with the other signals arriving at the matrix input.

The Y delay line is electrically terminated by a potentiometer which is one section of a two section contrast control. A potentiometer in the cathode of this stage serves as the second section of the contrast control arrangement, and as the source of video to the chrominance channel. These two potentiometers, comprising the contrast control, have their shafts mechanically ganged so as to track together from maximum to minimum rotation. This tracking maintains a constant relationship between the luminance channel and chrominance channel signals for all contrast settings.

Further amplification of the luminance signal in the second video amplifier stage, pentode section of a 6U8, brings the signal to a level suitable for application to the matrix. The frequency response at this point is essentially similar to that encountered in standard monochrome receivers with some additional attenuation at the subcarrier frequency.

2. Chrominance Channel

The chrominance signal from the cathode of the first video amplifier is fed to the band-pass amplifier, pentode section of a 6U8. The plate circuit of this stage contains the band-pass filter which removes the low frequency components of the signal and retains the color subcarrier and its sidebands. This filter has a bandwidth of approximately 2.4 to 5.0 mc (Figure 7), and is terminated by a potentiometer which serves as the chroma control.

During each burst interval the band pass amplifier is keyed off by applying a negative pulse derived from horizontal deflection to the screen of the tube. Keying burst out in this manner avoids color kinescope background unbalance due to the DC restorers clamping on demodulated burst rather than on tips of sync.

The grid circuit of the band-pass amplifier operates in conjunction with the color killer tube, triode section of a 6BL7. The killer stage is held at cut-off by a negative DC voltage developed by the burst phase detector. In the absence of burst, that is a standard monochrome transmission, the killer stage conducts and biases the band-pass amplifier to cutoff, thereby assuring that no signal information passes to the demodulator grids via the band pass filter.

Demodulation of the chroma signal is accomplished by a pair of 6AS6 synchronous detectors operating in quadrature; color subcarrier frequencies are applied to the suppressors while the chroma signal from the arm of the band pass terminating potentiometer is applied to the control grids.

The detected Q signal appears at the plate of the Q demodulator and is band limited by a 0.5 mc low pass type filter (Figure 8). This signal is fed to the Q phase splitter whose outputs provide the positive and negative Q signals necessary for matrixing.

The detected I signal appearing at the plate of the I demodulator is fed to a negative mutual type filter which both limits the I channel bandwidth to 1.5 mc (Figure 9), and provides high frequency time delay compensation. This signal is further amplified by the I amplifier, pentode section of a 6X8. The positive I signal necessary for matrixing is derived from the plate circuit, while the negative I signal necessary for matrixing is derived from the plate of the I phase inverter, triode section of a 6X8.

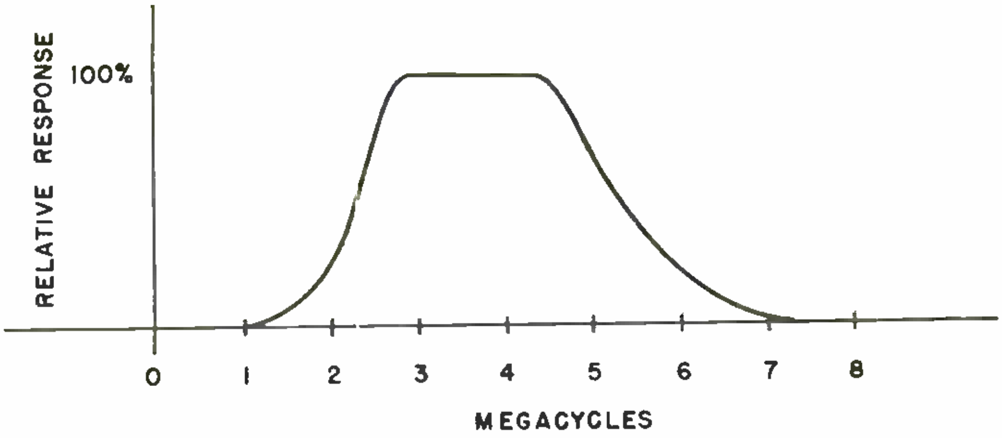


Fig. 7—Band-pass filter response.

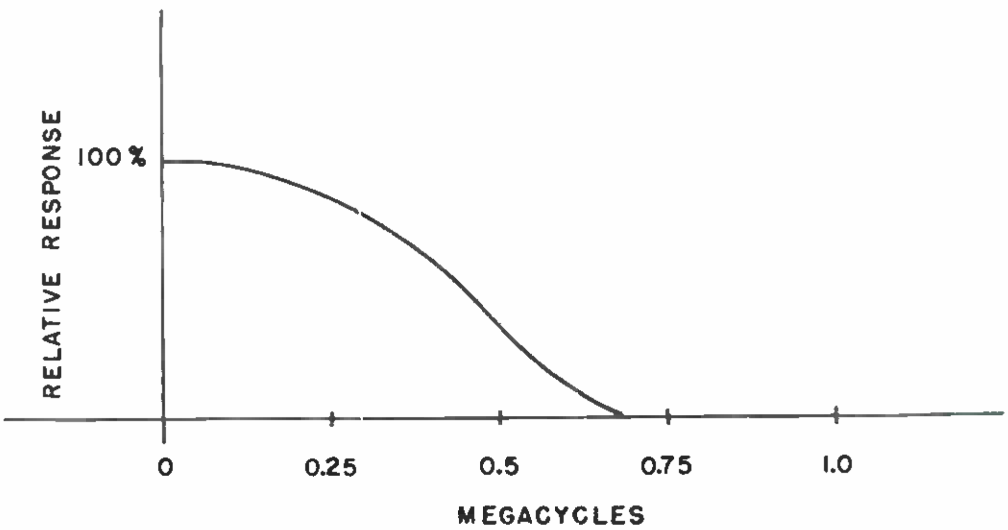


Fig. 8—Q channel frequency response.

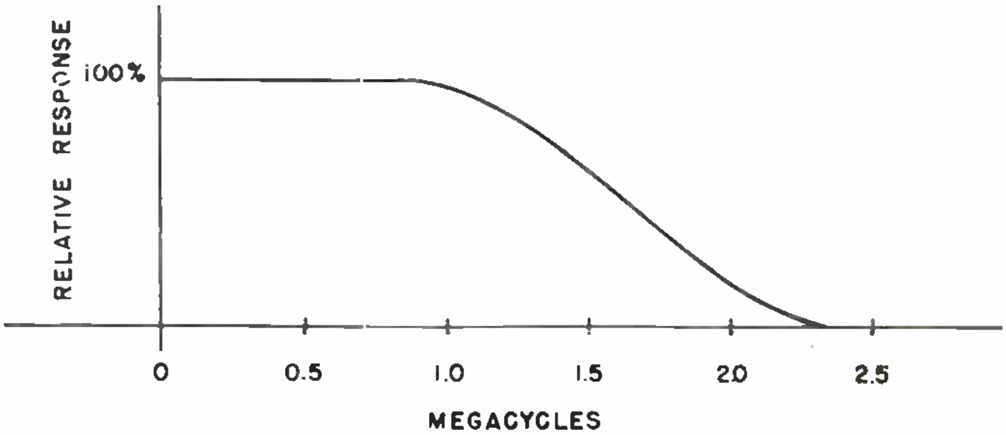


Fig. 9—I channel frequency response.

3. Matrix

In order to synthesize the red, green and blue drive signals, required by the kinescope, from the Y, I and Q signals, a fixed resistive mixing type of feedback amplifier is employed. Using one triode section of a 12BH7 in conjunction with three fixed matrix resistors for the red, green, and blue adder stages respectively, linear addition of Y with the proper amplitude and polarity of I and Q is accomplished.

The added luminance and chrominance signals are then amplified by the output amplifier stages, second half of the twin triode 12BH7, to a level satisfactory for application to the respective kinescope grids. Unequal kinescope drive signals are required due to the unequal phosphor efficiencies of the tricolor kinescope. Red is the order of magnitude of 100 volts while blue and green require approximately 50 to 70 volts of drive. Overall gain controls for the green and blue channels are provided.

DC restoration is applied to the red, blue and green output signals by a 6BC7, a triple diode tube. The plate return circuits for these three restorers are arranged in a bridge circuit which is adjusted in such a way as to maintain proper tracking of the three kine grid bias values throughout the range of the master brightness control.

PART VI

Color Synchronization, Deflection Synchronization and AGC

1. Color Synchronization

In order to recover the color information contained in an NTSC type signal, it is necessary to generate a local subcarrier of proper frequency and phase. To accomplish this, phase reference information is transmitted as a component of the composite color video signal. This color synchronizing information is transmitted in the form of a "burst" of approximately 8 cycles of the color subcarrier

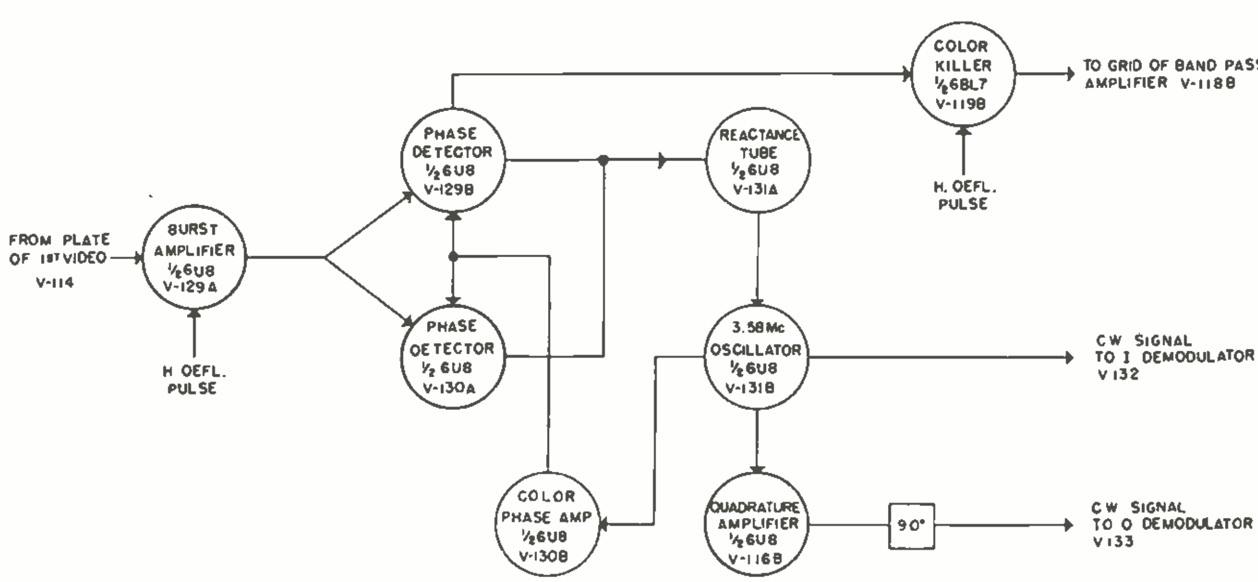


Fig. 10—Color synchronization channel block diagram.

frequency and appears immediately following each horizontal synchronizing pulse in the composite signal.

This "burst" is separated from the composite video signal and is used in establishing two continuous wave signals of color subcarrier frequency having a 90° phase displacement from each other. These two signals, called I c.w. and Q c.w. are generated by a quartz crystal oscillator whose exact frequency is controlled by a reactance tube. The reactance tube derives its control information from an error signal proportional to the difference in phase between the transmitted "burst" and the local crystal oscillator output.

This color synchronizing channel includes a keyed burst amplifier stage, phase detector — 3.579 mc driver and color phasing amplifier, crystal oscillator, reactance tube, and quadrature 3.579 mc amplifier.

The burst amplifier stage, pentode section of a 6U8, is driven from a single tuned coil coupled to the first video amplifier plate. The burst amplifier cathode is keyed by a negative pulse derived from horizontal deflection. Bias is provided for this stage by partial cathode bias and partial B+ tap down. The burst plate transformer has a high impedance primary and a bi-filar secondary tightly coupled to the primary. With a turns ratio of 6:1, the output is approximately 60 V. peak to peak of burst pulse on either side of the secondary center tap.

The phase detector uses the triode sections of two 6U8's connected as grid-cathode diodes with the plates acting as shields. The phase detector compares the phase of the incoming burst signal with the phase of the locally generated c.w. signal. This locally generated signal is the output of the color phasing amplifier. The output of the phase detector is a DC error voltage which is the reactance tube control signal. The color phasing amplifier, pentode section of a 6U8, serves the additional function of an overall phase control. The phase control potentiometer associated with this circuit permits manual adjustment of the phase of the local oscillator so as to produce the desired color tone rendition.

The reactance tube stage, pentode section of a 6U8, is of the capacitive type. A cathode resistor provides self bias, hence the phase detector and the reactance tube grid operate at approximately zero volts.

Operating the oscillator, triode section of a 6U8, as a cathode follower has the basic advantage of eliminating the spurious oscillation to the reactance tube plate coil. This occurs because operation of an oscillator as a cathode follower requires the cathode tank to be tuned below 3.579 mc. It falls between the tuning points of the crystal and the reactance tube plate coil. The oscillator cathode transformer has its secondary tightly coupled to the primary. The low side of the secondary is directly connected to the demodulator bias source, while the high side is connected to the Q demodulator suppressor through a shielded lead. This is the I continuous wave signal required for synchronous detection. The quadrature 3.579 mc amplifier, triode section of a 6U8 is driven from the oscillator. A coupled transformer in the plate circuit yields a 3.579 mc voltage having a 90° phase displacement with respect to the phase of the oscillator voltage. This is the Q continuous wave signal required for synchronous detection.

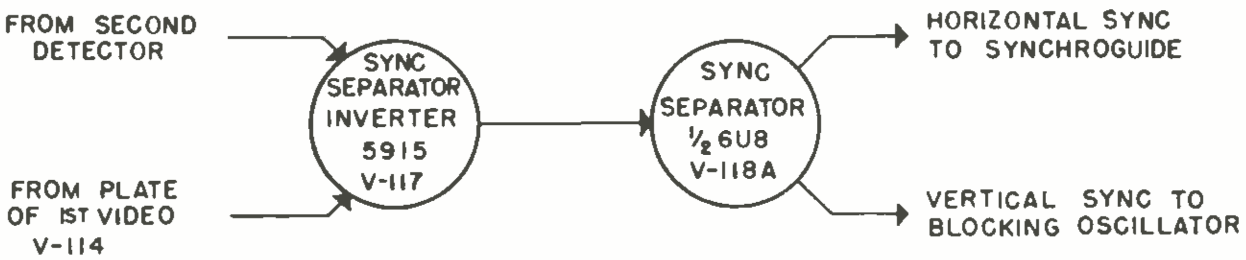


Fig. 11—Deflection synchronization channel block diagram.

2. DEFLECTION SYNCHRONIZATION

The first sync separator employs a 5915 pentagrid converter. This stage has the function of stripping sync and providing a noise immune sync signal. A sync positive video signal is AC coupled to the No. 3 grid. Grid leak bias is used and separated sync appears at the output plate. A sync negative video signal is DC coupled to the No. 1 grid which is held at a slight positive bias by virtue of a potentiometer (threshold control) from a varying source of + voltage in the IF. Noise pulses appearing at the No. 1 grid, which is normally slightly positive, will be in the negative direction and will cut the tube off. Consequently when noise pulses coincide with sync, a hole will occur in the signal. This same action occurs at other than sync time also, and as an overall result this type of sync signal has less of a disturbing effect on the timing circuits and sync stability with noise present is greatly improved. The amount of inversion needed is accomplished by the threshold control which is normally set so that with a weak signal with no noise present the output sync begins to clip with clockwise rotation of the control. Tracking of the noise inversion is accomplished by providing a less positive going bias to the No. 1 grid as signal strength decreases. A second stage, triode section of a 6U8, serves as a double clipper and separator. The signal at the plate of this stage contains both the horizontal and the vertical synchronizing information. Horizontal is fed directly to the horizontal oscillator control circuit, while the vertical is derived from the output of a three stage integrator and fed to the vertical blocking oscillator.

3. AGC

The AGC Amplifier employs the pentode section of a 6U8. It is a fully keyed type of AGC, utilizing a positive pulse obtained from the horizontal yoke for developing a negative bias voltage. Variation of the height of sync tips applied to the grid of the 6U8 controls the amount of pulse rectification and consequently the bias applied to the RF and IF. Bias is delayed approximately six volts on the RF in order to provide better signal to noise ratio.

PART VII

HORIZONTAL DEFLECTION, VERTICAL DEFLECTION AND HIGH VOLTAGE

1. HORIZONTAL DEFLECTION AND HIGH VOLTAGE

The horizontal deflection system supplies the HV potentials along with the horizontal scan. This stage is preceded by a dual triode 6SN7 horizontal oscillator

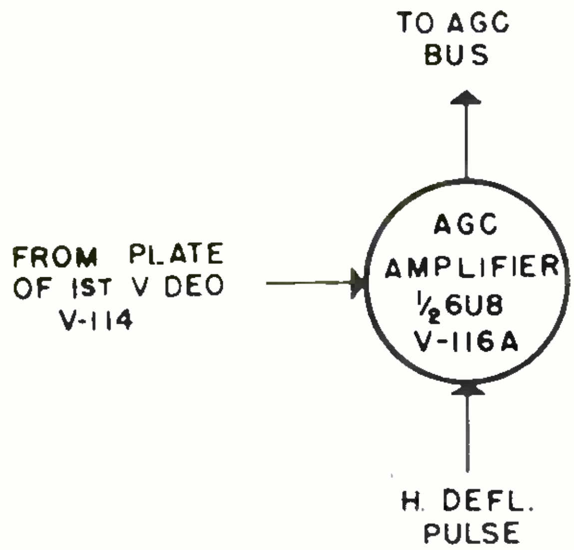


Fig. 12—AGC block diagram.

and AFC which is similar to that system used by many monochrome receivers. In order to produce the regulated 20 kv high-voltage output, the transformer used is so designed to store that amount of energy required for this purpose. The yoke is AC coupled from the auto-transformer and has shunting it a variable inductance which serves as a variable impedance width device and also supplies the DC path for electrical centering.

High voltage is obtained by means of a diode coupled pulse doubler rectifying the boosted retrace pulse. Regulation of the rectified retrace pulse is achieved by using a shunt regulator tube, which has the effect of maintaining a constant load on the HV system. During an all black picture the regulator absorbs the

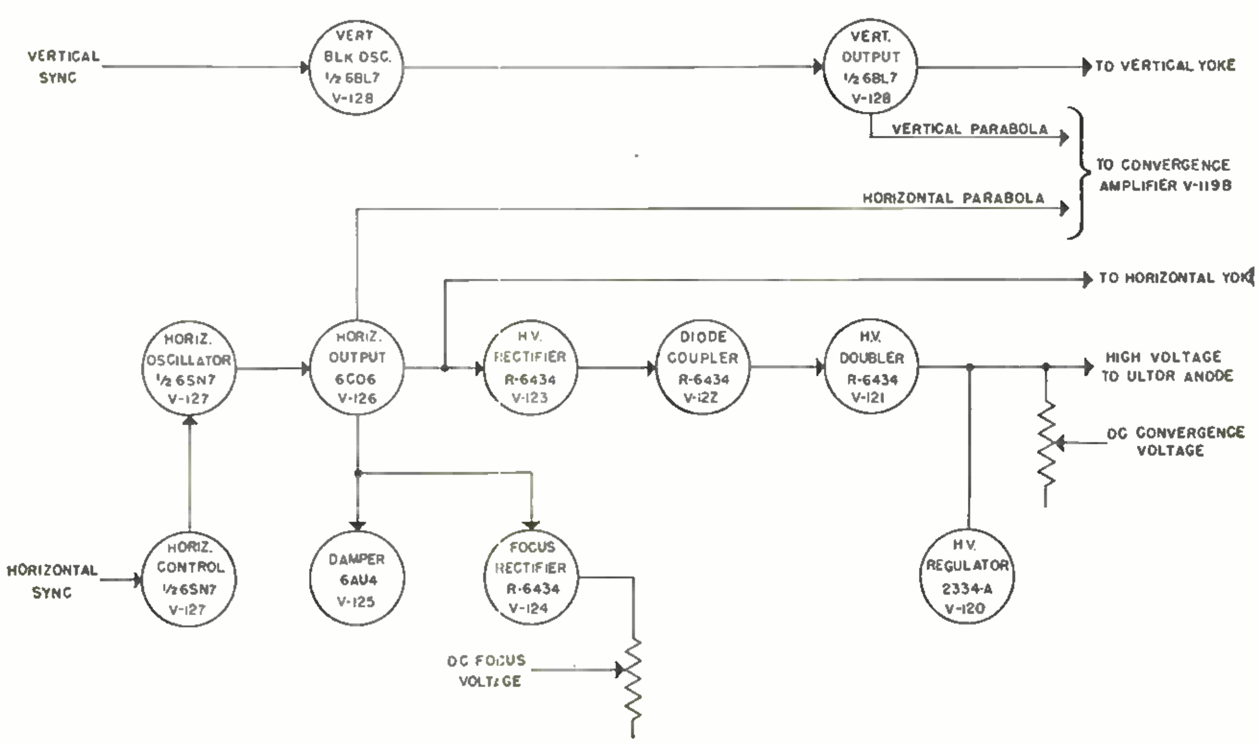


Fig. 13—Deflection and high voltage block diagram.

entire load and conversely during an all white picture the kinescope takes the load and the regulator very little.

A variable tap on the high voltage bleeder is used to provide approximately 10 kv for the convergence electrode off the tricolor kinescope. A simple type variable tap on the focus voltage bleeder provides approximately 4 kv for the focus electrode.

2. Vertical Deflection

Vertical deflection is supplied by a dual triode 6BL7, the first half being a blocking oscillator and the second half driving the vertical yoke section by way of an output transformer. Electrical centering is also used.

PART VIII

Tricolor Kinescope and Dynamic Convergence

1. Tricolor Kinescope

The tricolor kinescope, as used, is a simultaneous color display device. Structurally, the tube consists of three electron guns mounted with their axes parallel to the central axis of the tube and spaced 120° with respect to each other. Each gun has a focus electrode whose potential is adjusted to cause the beams to focus at the phosphor-dot plate. All three beams pass through an electrostatic lens system, whose potential is adjusted to cause the three beams to converge in the plane of the aperture mask. The three beams are electromagnetically deflected by a common yoke.

Those functions associated with the kinescope are divided into two categories, namely static and dynamic adjustments.

Into the static adjustment classification falls purity, center convergence, cutoff, and background tracking. The purity adjustment is made in order to align the electron beams so that they will be originating from a source whose position

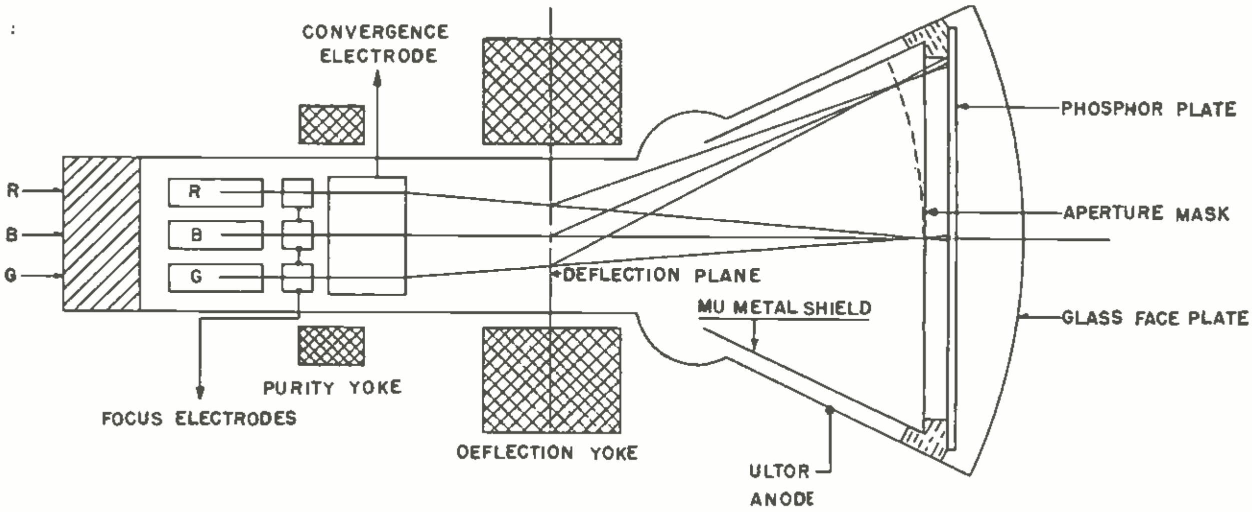


Fig. 14—Tricolor kinescope diagram.

is equivalent to that of the original light source used in manufacturing the shadow mask. Once the purity yoke and deflection yoke positioning is established, individual fields of the primary colors will be obtained.

Successful operation of a master background control requires that some provision be made for the differences in the three phosphor efficiencies and also for the variation in gun cutoffs. With the brightness control at maximum clockwise position the screen potential potentiometers are adjusted to give a gray low-light. The low-light bias tracking is done by the blue and green dividers across the top portion of the master background potentiometer.

Center convergence of the three beams is done by adjusting the DC potential of the convergence electrode for best superpositioning. That error which still exists is due to the mechanical inaccuracies of the gun alignment and is corrected for by the use of the individual beams convergence magnets. In order to effect overall beam coincidence, dynamic convergence is added.

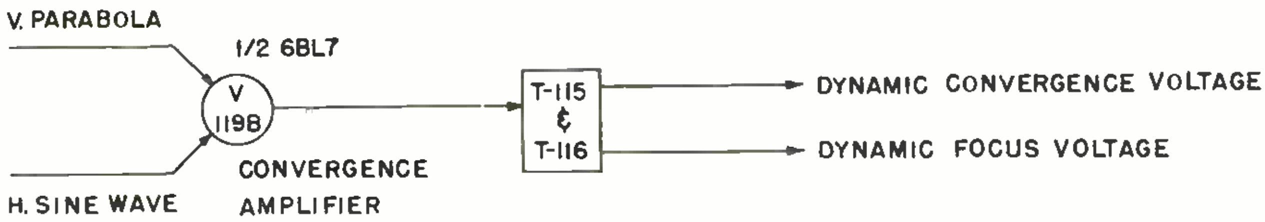


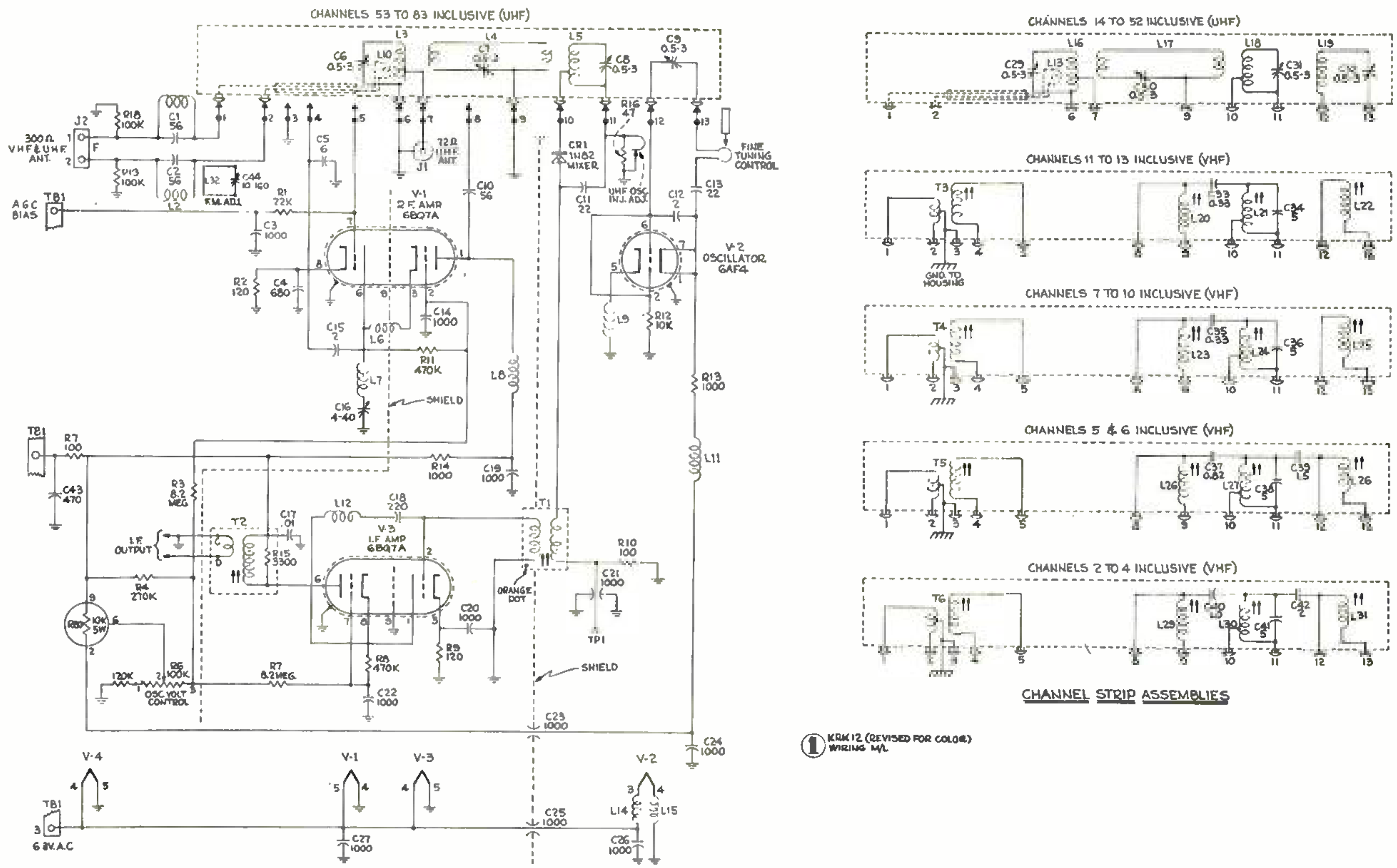
Fig. 15—Dynamic convergence block diagram.

2. Dynamic Convergence

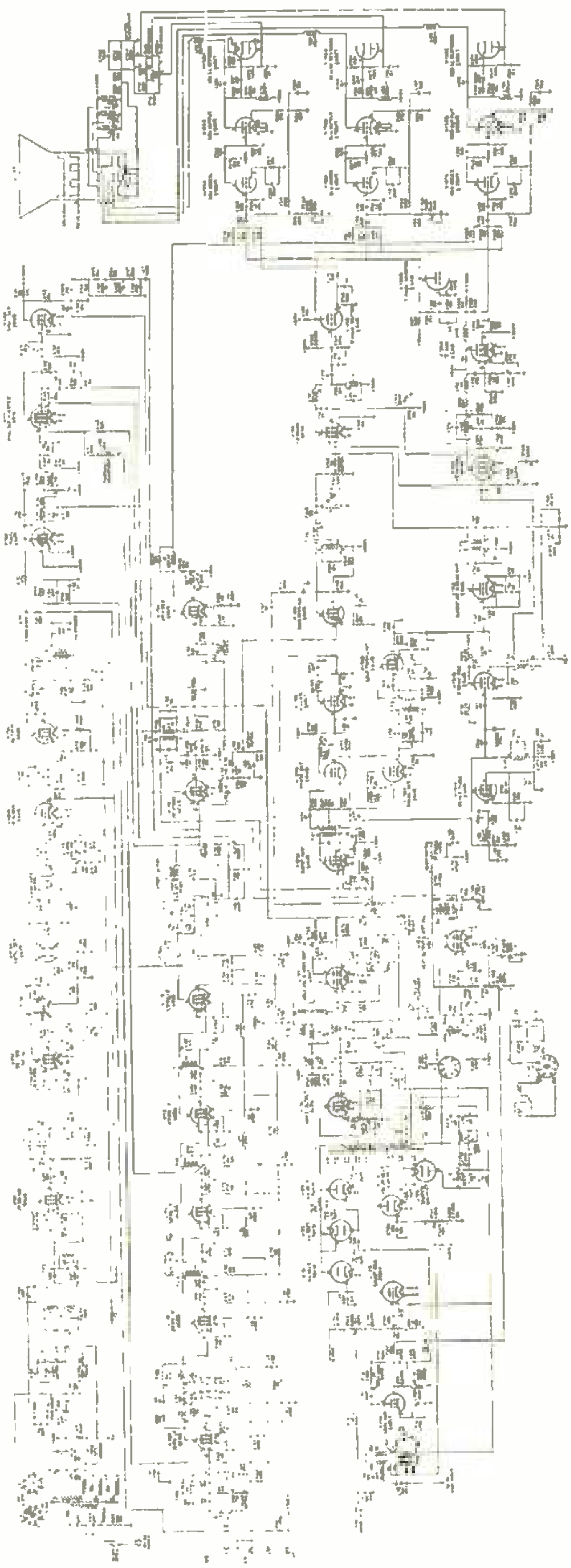
Since the phosphor plate and the shadow mask are flat surfaces, the distance the beams must travel from the deflection plane to the central area of the shadow mask is less than the distance they must travel when the beams are deflected away from central area. If the potential on the convergence electrode, which was necessary to produce center convergence remained unchanged, the three beams would then cross over at some point before reaching the shadow mask. This would result in a misregistered picture. To correct this condition, it is necessary to modulate the DC potential on the convergence electrode in such a manner as to produce a larger convergence electrode voltage as the deflection angle increases. This condition also exists with respect to focus.

The dynamic convergence voltage and focus modulation voltage, each having the proper wave form, amplitude and synchronism with deflection are generated by the use of two tapped transformers and a single triode amplifier, one half of a 6BL7. These dynamic voltages are produced by linear addition of horizontal and vertical waveforms derived from the cathodes of the respective deflection output stages. The composite alternating output voltage is coupled to the kinescope convergence electrode and focus electrode through their respective output transformer taps.

Schematic diagrams of the complete receiver follow:



RF tuner circuit diagram.



Receiver circuit diagram.

APPENDIX C

CONVERTERS

The Color Product Development Group of the Home Instrument Engineering Department of the RCA Victor Division has made a study of conversion possibilities in two possible categories:

> Type No. 1 Converters — This type conversion contemplates the alteration of existing black and white television receivers to permit the reception of color telecasts in color.
>
> Type No. 2 Converters — This type conversion contemplates the addition of a color unit to an existing black and white television receiver — a so called "Slave Converter" — to permit the reproduction of color telecasts in color. In this type of conversion, the additional unit housing the tricolor kinescope and associated circuitry employs the RF-IF portion of the black and white receiver as a source of signal.

TYPE NO. 1 CONVERTERS

During the period April, 1950 through February, 1951, two basic models of Type No. 1 Converters were developed, supplemented by several variations of the basic models (Figures 1, 2, and 3). A basic factor, in this type of conversion, is the substitution of a tricolor kinescope for the black and white kinescope with which the receiver to be converted was originally equipped.

Work on these two basic models rapidly developed the fact that this type of conversion was not commercially practical because:

1. Varying black and white kinescope sizes preclude the possibility of tricolor substitution unless tricolor kinescopes should be produced in more sizes and shapes than originally may be economically feasible.

2. A great majority of the existing black and white receivers have insufficient IF bandwidth to handle adequately a color television signal.

In view of these two basic handicaps, commercial development on Type No. 1 Converters was stopped.

TYPE NO. 2 CONVERTERS

During the period November, 1950 through February, 1951, a basic model Type No. 2 Converter, in several variations was developed and built (Figures 4 and 5). While the so-called "Slave Converter" performed satisfactorily when used with black and white receivers having a four megacycle IF bandwidth, it was considered commercially impractical because:

Fig. 1—Front view of a Type No. 1 Converter.

1. A great majority of existing black and white receivers have less than a four megacycle IF bandwidth and so are incapable of adequately handling a color signal.

2. A Type No. 2 Converter eliminates only the RF and IF parts of a complete receiver, and so may represent approximately 90 to 95 per cent of the cost of a complete receiver.

From the commercial point of view, an accessory unit costing within 5 or 10 per cent of the price of a complete color television receiver would find only a very restricted market, if any. This opinion, coupled with the fact that only a small percentage of black and white television receivers now in use have IF bandwidths sufficiently wide to give satisfactory performance on a color signal, has resulted in stopping commercial development work on Type No. 2 Converters, as well as on Type No. 1 Converters.

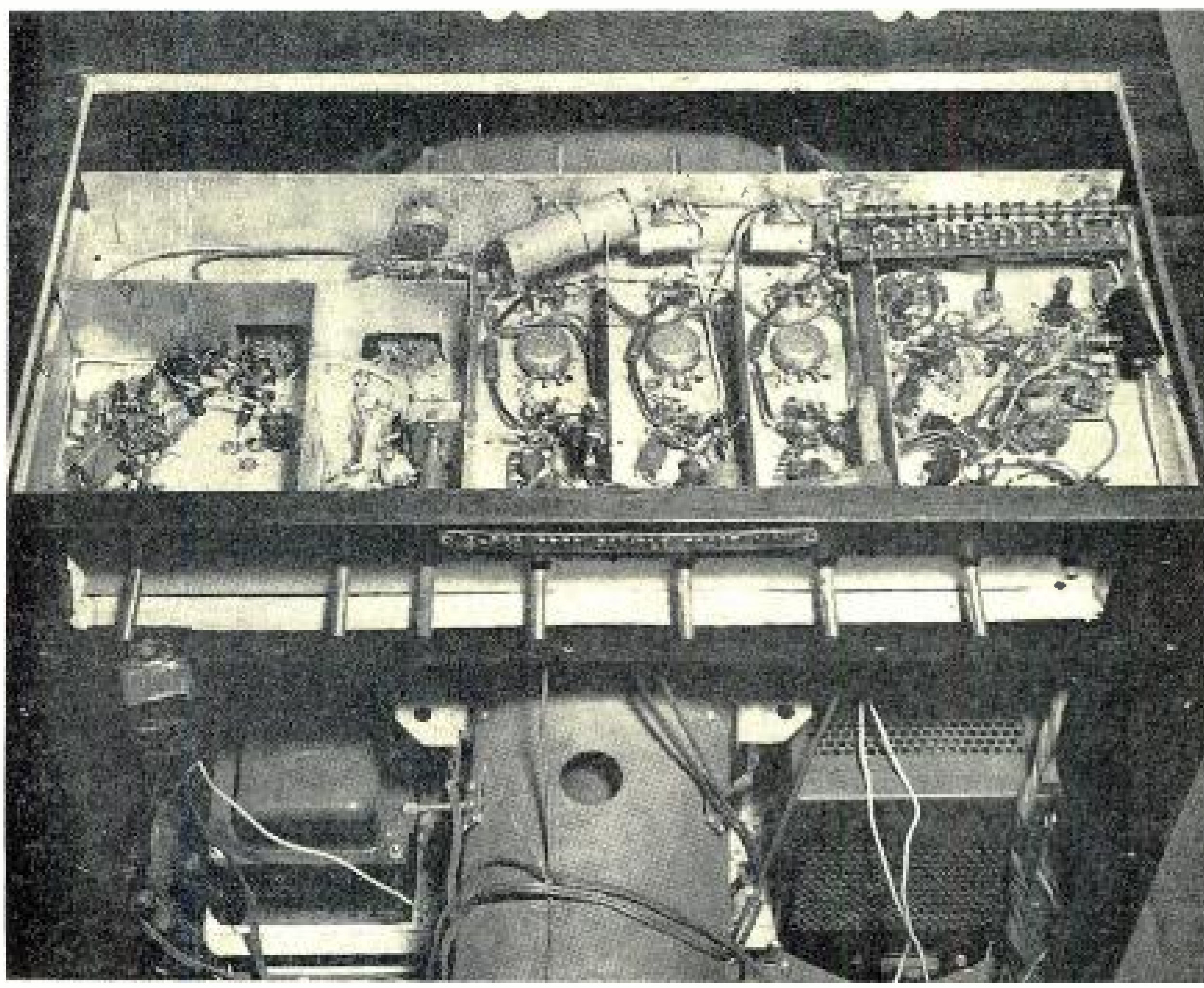


Fig. 2—Rear view of a Type No. 1 Converter.

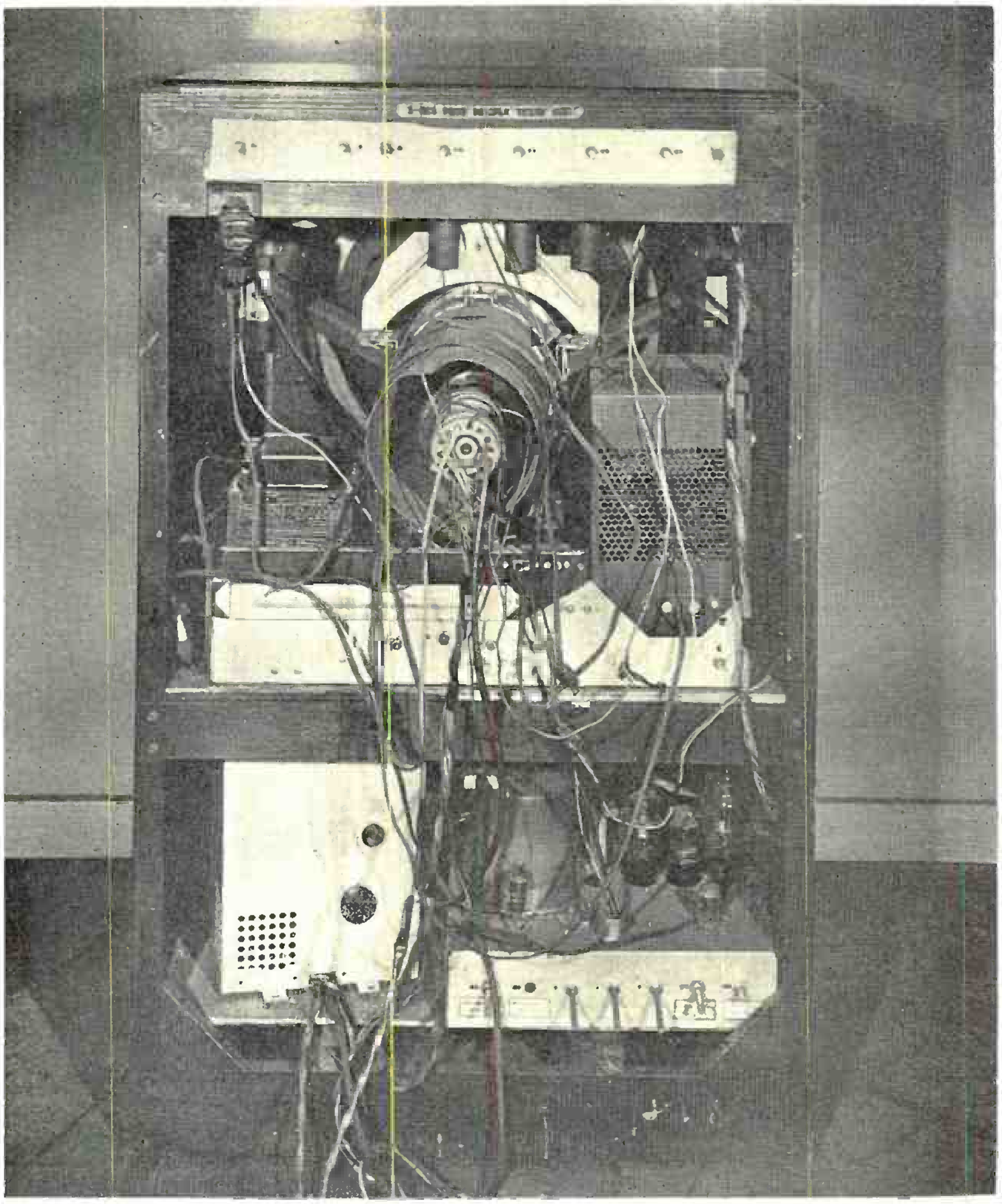


Fig. 3—Rear view of a Type No. 1 Converter.

Fig. 4—Front view of a Type No. 2 Converter.

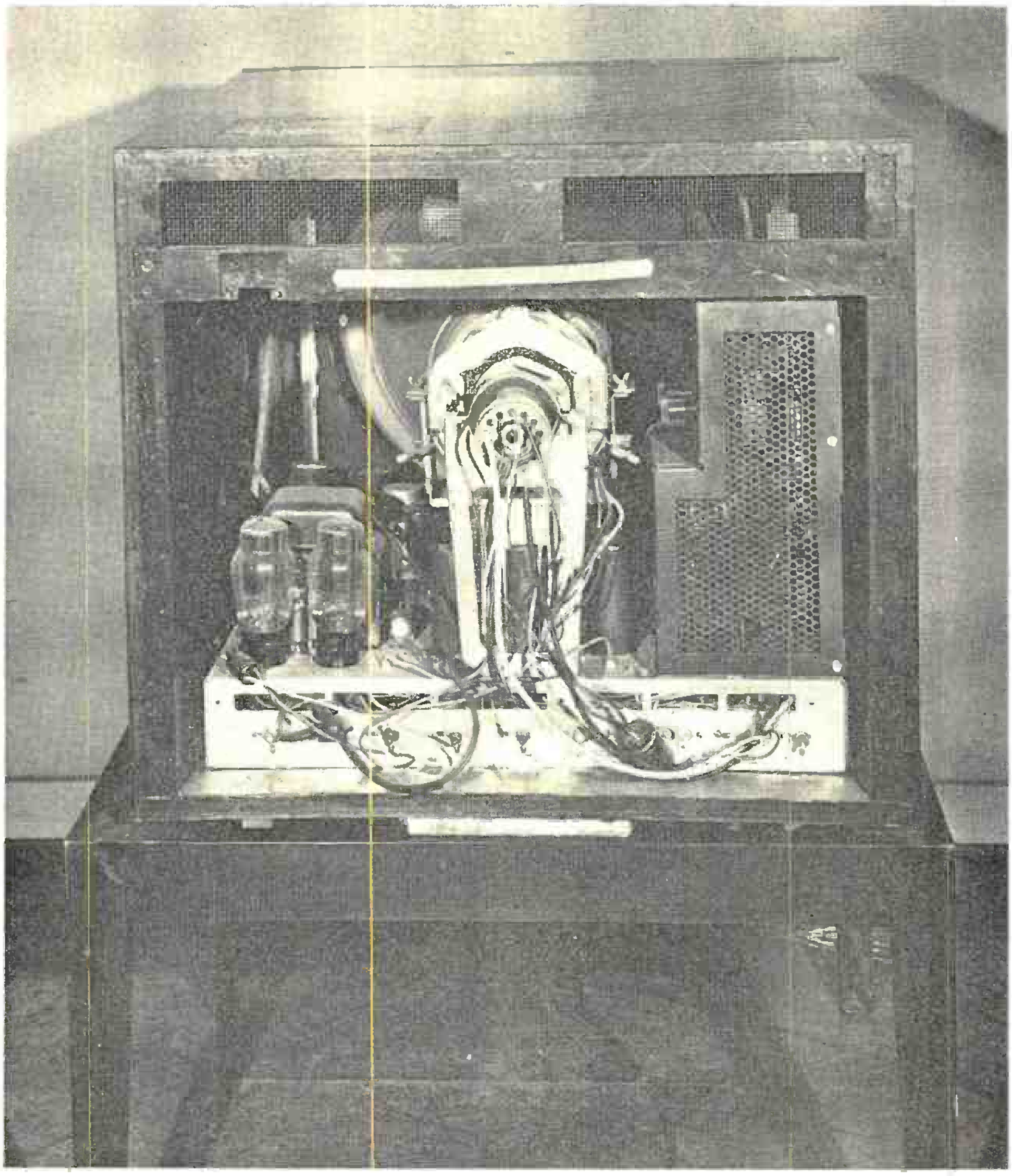


Fig. 5—Rear view of a Type No. 2 Converter

EXHIBIT 7

ENGINEERING STUDY OF PICTURE QUALITY IN THE RCA COLOR TELEVISION SYSTEM

ENGINEERING STUDY OF PICTURE QUALITY IN THE RCA COLOR TELEVISION SYSTEM

Index

Appendixes

EXHIBIT 7

ENGINEERING STUDY OF PICTURE QUALITY IN THE RCA COLOR TELEVISION SYSTEM

PART I

Introduction

IN order to evaluate the performance of the RCA color television system, the following procedure was evolved. A group of twenty-eight technical personnel, with experience in television, were asked to view a series of color television pictures and to record their impressions by answering questions relating to them.

In considering this engineering study it is important constantly to bear in mind that the results represent an engineering evaluation by trained technical personnel who looked for any possible technical criticism of pictures they observed. To determine public reaction—which this exhibit *does not* purport to reflect—to recent RCA system color pictures, reference should be made to the survey conducted by Opinion Research Corporation during the first week of June, 1953 (Exhibit 2).

The television pictures for the tests originated in the color television studios of the National Broadcasting Company in New York and were reproduced via a radio frequency signal generator on tricolor and monochrome receivers. The pictures consisted of both slide material reproduced by a flying-spot scanner and direct studio shots employing studio type cameras. The color television equipment was operated by the regular crew in exactly the same manner as it would normally be handled on a show. The receivers were set up and adjusted by servicemen from the RCA Service Company.

The persons used as observers were all employees of NBC or RCA and most of them have been actively engaged in color television engineering work during the course of the recent field tests in New York. They were asked to express their frank, truthful opinions regarding the questions asked and not to sign the questionnaire if for any reason whatsoever they wished to remain anonymous. The opinions are believed to be their own individual thoughts, as they did not confer with one another during the course of a series of observations. Each checked his own questionnaire independently of the others. A copy of the questionnaire, containing a summary of the answers received, is attached hereto as Appendix A. Wherever applicable, the results of this study are referred to and included under each of the following subheadings having to do with the performance capabilities of the RCA color television system.

PART II

Performance of the RCA Color Television System When Receiving Color Signals on RCA Color Television Receivers

A. Overall Picture Quality

In general, the tests established that the RCA color television system is capable of producing pleasing pictures in color entirely satisfactory for home viewers from the standpoint of overall picture quality when reproduced on typical receivers of the types demonstrated.

The observers were each shown a total of six Kodachrome slides and four direct studio shots. These are identified in Appendix B. From the twenty-eight observers used in the tests, a total of 275 ratings were recorded. Their opinions ranged from excellent, to good, to passable, and only in a few instances to not quite passable. The relative percentages are 22.1% excellent, 52.1% good, 22.9% passable, 2.9% not quite passable, 0% poor and 0% not usable. This is in substantial agreement with the lay opinion referred to above[1] and clearly supports the conclusion that the average individual who has viewed the color pictures produced by the RCA color television system believes them to be satisfying as regards overall picture quality.

B. Flicker-Brightness

Flicker may be present in almost any cyclic process which depends upon the rapid presentation of a sequence of discrete pictures for conveying the impression of continuity. The question is not one of whether or not flicker is present, but rather whether the flicker is noticeable or objectionable with the particular viewing device used at the repetition rates and picture brightness levels employed. Very complete studies were made by Engstrom[2] and others in the early days of black and white television in order to determine acceptable standards for which the flicker problem would be essentially nonexistent. There is the Ferry-Porter Law[3] which expresses the relationship between the product of screen area $\times$ luminance and picture repetition rate. In the case of television, there is an important additional factor which includes the rate of decay of the kinescope phosphor.[4]

For commercial black and white television, it has been concluded by numerous observers that a 60 field double interlaced picture, reproduced on a kinescope such as used in television receivers today and having a phosphor decay characteristic as shown in Figure 1A, produces for most observers

[1] See Exhibit 2.

[2] E. W. Engstrom, "A Study of Television Image Characteristics," *Proc. I.R.E.*, Vol. 23, pp. 295-310 (April, 1935).

[3] See *The Science of Color*, p. 370, a report of the Committee on Colorimetry of the Optical Society of America, published by Crowell & Co., New York.

[4] O. H. Schade, "Electro-Optical Characteristics of Television Systems," *RCA Review*, Vol. IX. pp. 22-23 and 272-278 (1948).

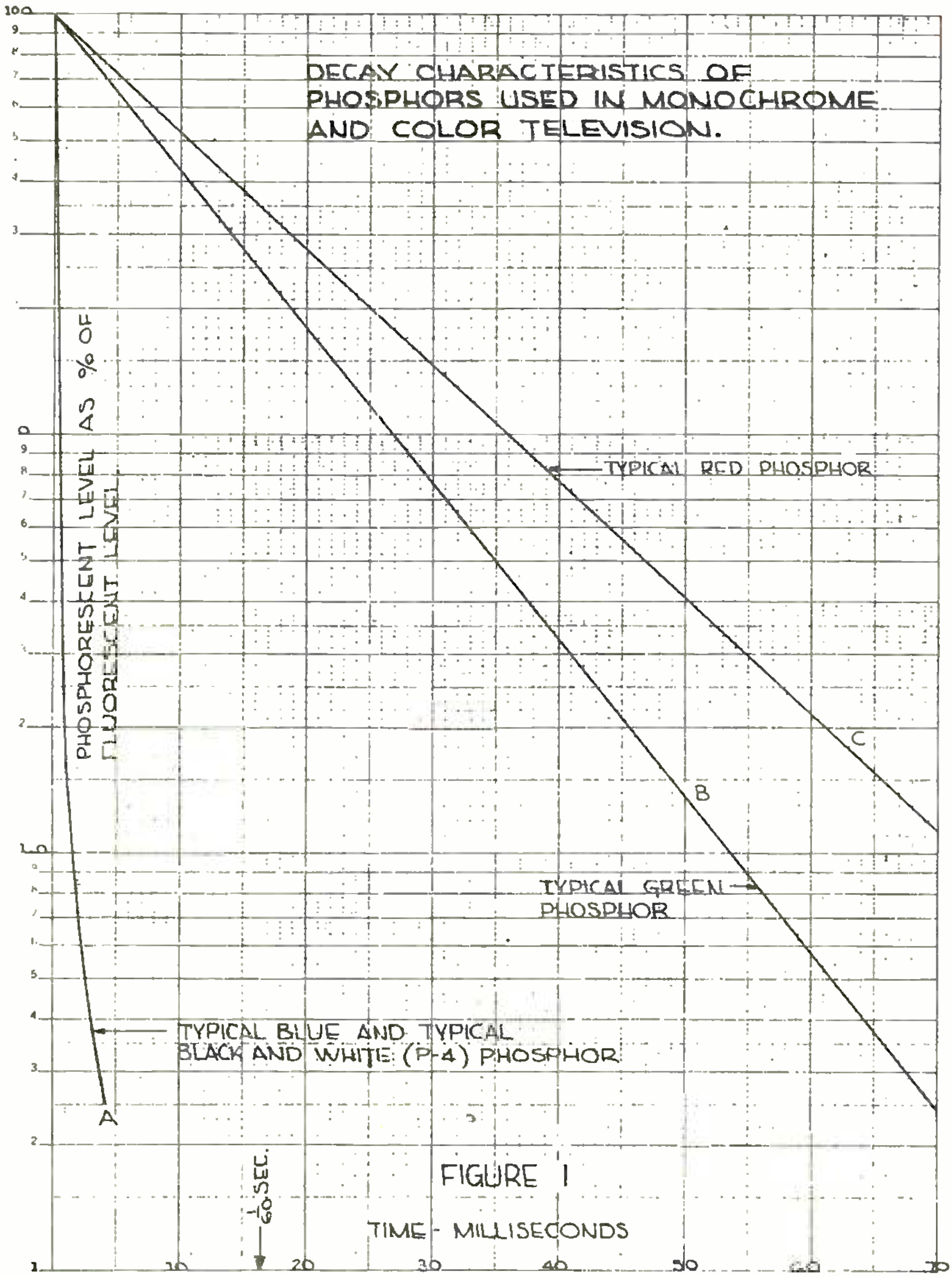


Fig. 1 — Decay characteristics of phosphors used in monochrome and color television.

essentially no flicker for large area highlight luminances of the order of 50 – 100 foot lamberts.[5] This is considerably in excess of the highlight luminance displayed on many home receivers. The wisdom of such a choice is readily attested to by the complete freedom from noticeable flicker in commercial television service in spite of considerable increase in kinescope brightness over the past years. Seldom does one hear of people objecting to the flicker in standard black and white television broadcasts.

The red and green phosphors currently used in the RCA tricolor kinescopes have a longer decay time than conventional P4 sulphide screens. The blue phosphor decay time is comparable to that of a standard black and white kinescope (P4 screen). The measured characteristics of such phosphors are shown in Figure 1. The decay characteristic of a P4 (sulphide) phosphor, Figure 1A, is such that the light output has dropped to 1.0% of its excited value, 2 milliseconds after the removal of the excitation. In the case of the red and green phosphors, Figures 1B and 1C, the decay characteristics are considerably longer. It would be concluded from this that, all other factors being the same, the flicker perceptibility threshold for the color system would occur at a higher brightness than in the case of the black and white television system employing kinescopes with P4 phosphors.

In the tests made in conjunction with that portion of the questionnaire dealing with the subject of flicker-brightness, the observers were shown pictures produced by a slide scanner. These are identified and described in Appendix B. One slide was chosen to have large red areas, a second to have large blue areas, a third to have large green areas and the fourth to have large white areas. These pictures were reproduced in full color on two different display devices. The receivers designated "a" and "b" were RCA color receivers employing 16-inch envelope tricolor tubes of the shadow-mask type. They were connected to a small radio frequency transmitter which was modulated by the signal from the color studio.

Receiver "a" was set for a maximum highlight luminance of approximately 10 foot lamberts. Ambient room illumination was approximately .18 foot candles. From the 28 observers who viewed the pictures a total of 112 opinions were obtained. One hundred and eleven, or 99%, indicated no discernible flicker in the pictures, while one, or 1%, indicated a slight amount of flicker.

Receiver "b" was adjusted to produce a maximum highlight luminance of approximately 40 foot lamberts. Seventeen of the observers who viewed receiver "a" above were asked to view receiver "b". The same slides were used in both cases. The observations were made on different days but under similar conditions of ambient room illumination. Out of a total of 68 opinions (17 observers, each viewing 4 slides) there were 57, or 84%, which indicated

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[5] See note 4. *supra*.

no flicker and 11, or 16%, which indicated a slight flicker in some of the pictures.

In no case did anyone think that the flicker was annoying.

When viewing a monochrome set displaying the same pictures at approximately the same luminance level, 53, or 78%, of the opinions of the same observers found no flicker and 15, or 22%, indicated a slight flicker. As in the case of observation of the color receiver, no one thought that the flicker was annoying but merely perceptible in some instances.

The meters used to measure the luminance of the highlights were of the Salford SEI Photometer[6] type and had been carefully checked by an outside laboratory prior to the test.

C. Contrast

Measurements of the overall contrast performance capability of the system under typical operating conditions are presented in Figure 2. They show that a scene brightness range of 16 to 1 can be reproduced on the face of a tricolor kinescope as a luminance range of 50 to 1 with a reasonably constant average gradient of approximately 1.40. The maximum gradient was 1.60. These measurements were made under conditions of no ambient room illumination where the receiver was viewed.

Room illumination, particularly if it strikes the face of the tube, will of course reduce the range of reproduced luminance. The data shown in Figure 3 were taken under typical operating and viewing conditions. Here the luminance range on the face of the kinescope has been reduced to a measured value of 16/1 due at least in part to ambient room illumination.

The measurements of overall system contrast were made by placing some Munsell chips in the studio and lighting them according to standard studio practice. The reflected luminance of each of the chips was then measured with an SEI meter. The studio color television camera was used to pick up the scene including the chips and the signal so produced fed to a color receiver. Using the same SEI meter, the luminance of each chip as displayed on the color kinescope was then measured. The measured luminances of the chips as observed in the studio were plotted as the abscissa on the curves in Figures 2 and 3, the brightest chip being taken as 100% and the rest expressed as a per cent of this one. This is called scene luminance, $\%B_{max}$, where B_{max} is the luminance of the brightest chip, in this case Munsell chip #8. In a like manner the ordinates of the curves in Figures 2 and 3 were obtained by expressing each of the measured luminances of the reproduced chips as a per cent of the measured luminance of the reproduction of chip #8. This was called kinescope luminance, $\%b_{max}$, where b_{max} is the reproduced luminance of chip #8.

The luminance range or contrast handling ability of the equipment

[6] Manufactured by Salford Electrical Instruments, Ltd., London, England.

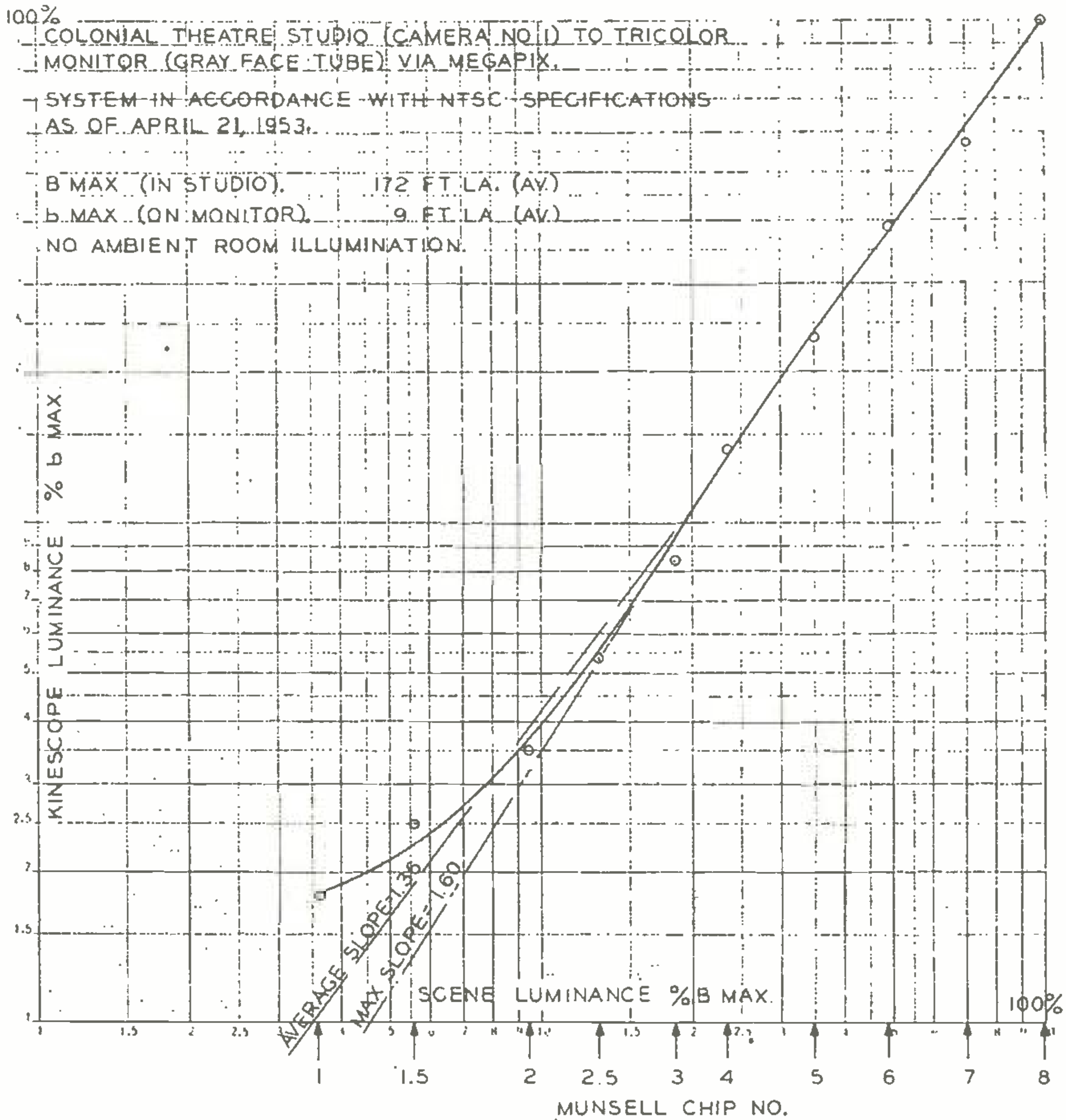

Fig. 2 — Light in vs. light out characteristic of color television system.

presently being used in the RCA color television system can undoubtedly be improved beyond its present status. Some of the techniques for extending the contrast capabilities of the black and white kinescopes have been applied to the tricolor tubes such as the use of gray glass.

The observers viewed color pictures under two different conditions of ambient room illumination, .18 foot candles and approximately 1.0 foot candle. A few, 28.5%, thought that they could discern a difference in the contrast range of the pictures under the condition of higher ambient room illumination. Some thought the pictures were improved and some that they had deteriorated. Most of the observers, 93%, thought that the contrast

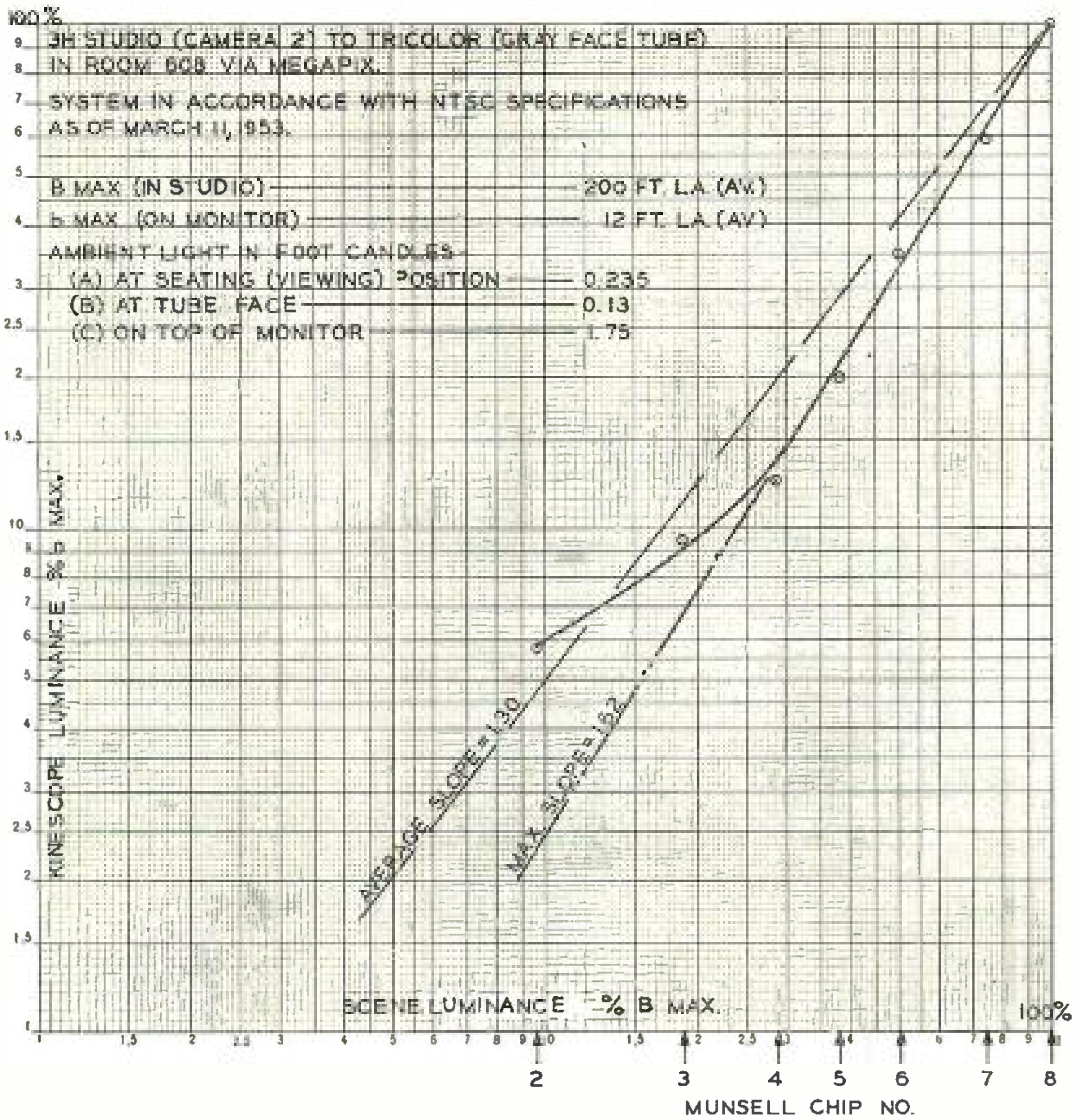

Fig. 3 — Light in vs. light out characteristic of color television system.

range in the pictures was adequate while 7% indicated that they would like more contrast range.

D. Color Fidelity

The question of color fidelity in a color television system is not necessarily a purely scientific or engineering matter.[7] The objective is to produce in the mind of the viewer a pleasing and satisfying sensation of color. The RCA color television system achieves this desired objective.

When one sees a movie in full color, he is seldom concerned with the question of whether or not he is viewing an exact color reproduction of

[7] D. G. Fink, "Alternative Approaches to Color Television," *Proc. I.R.E.*, Vol. 39, pp. 1124-1134 (October, 1951); W. T. Wintringham, "Color Television and Colorimetry," *id.* at pp. 1135-1172.

the original. If in his mind he thinks that the color in the pictures is a reasonably good rendition of what he thinks was the original, his conclusion is that the color is good — he is satisfied and content to accept what his mind tells him. It is much the same in the case of color television. People want to see and enjoy good, bright, pleasing colors and they are not too much concerned with the question of whether or not the color is an absolutely exact reproduction of the original. If it is a pleasing and appealing reproduction of the original as the mind thinks it might have been, they are satisfied that the color fidelity is good.

The opinions of the observers regarding the color fidelity capabilities of the RCA color television system were 15.4% excellent, 73% good and 11.6% passable. These observations were made by viewing the reproduction of familiar objects on a color kinescope. In this case the subject matter was a bowl of fresh fruit and freshly cut flowers.

There will be times when it will be desirable and undoubtedly necessary to reproduce certain colors faithfully. This will be particularly true of skin texture of people. Everyone is conscious of skin tones and immediately detects when he believes they are reproduced incorrectly. To display certain types of advertising copy will likewise require good color fidelity in the system.

In order to determine the colorimetric fidelity of reproduction in large areas on the RCA color television system using NTSC field test signal specifications, a typical chain of color television equipment was set up and adjusted in normal fashion by one of the operating crews at the Colonial Theatre studio. A field test receiver was also set up and adjusted by a service man from the RCA Service Company in the usual manner. The receiver was fed via a small radio frequency transmitter which in turn was modulated by a signal from the studio color equipment.

The results of the measurements are shown on Figures 4 and 5, which give respectively the fidelity of chromaticity and luminance reproduction of a typical chain of RCA color television studio equipment and field test receiver employing a shadow-mask tricolor tube.

A color is specified colorimetrically by giving its chromaticity and luminance. Chromaticity specifies that characteristic of the color stimulus which gives rise to the sensation of hue (indicated by the terms red, yellow, blue, etc.) and saturation (indicated by the terms pastel, pale, deep, etc.). Luminance specifies that characteristic of the color stimulus which gives rise to the sensation of brightness.

The chromaticity of a color is plotted as a point on a chromaticity diagram. Fidelity of chromaticity reproduction is indicated by the distance on the diagram between the points representing the original and reproduced chromaticities. The shorter this distance the better the chromaticity reproduction. Thus Figure 4 shows a chromaticity diagram in which the encircled points represent the chromaticities of the original colors, i.e., as seen by the television camera and the ends of the arrows emanating from the encircled

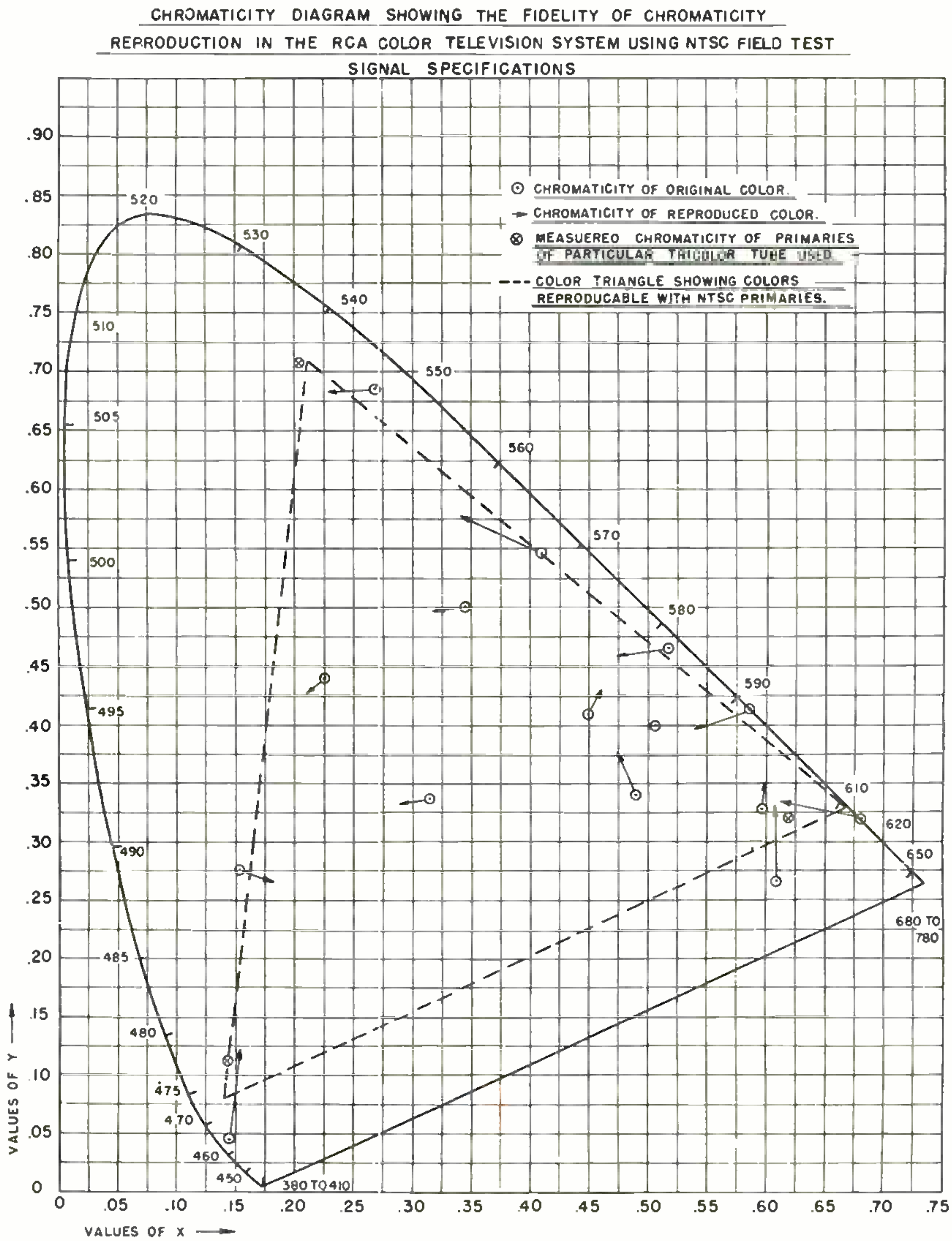

Fig. 4 — Chromaticity diagram showing the fidelity of chromaticity reproduction in the RCA color television system using NTSC field test signal specifications.

TRANSFER CHARACTERISTIC SHOWING THE MEASURED LUMINANCE REPRODUCTION OF 15 COLOR SAMPLES.

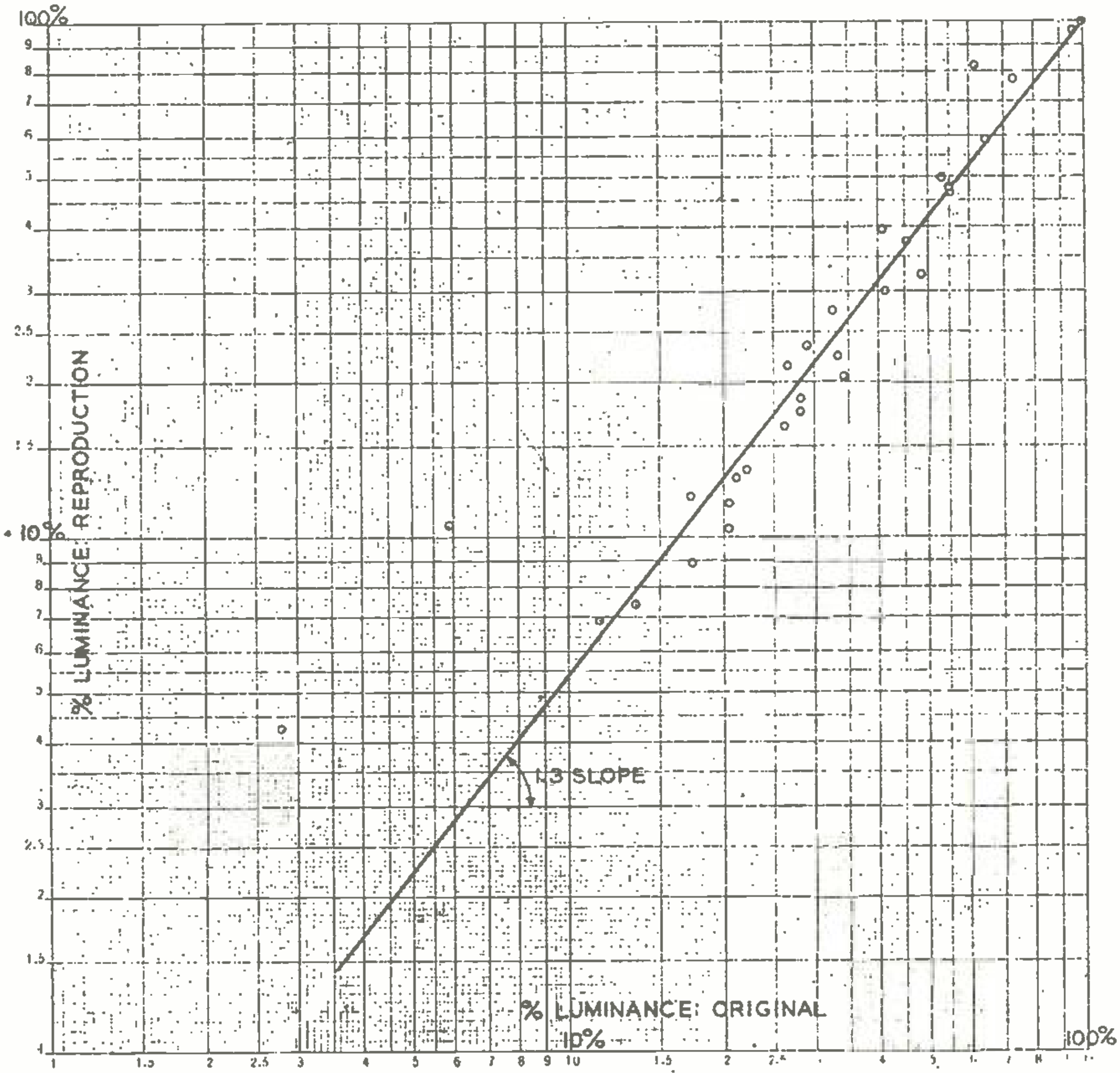

Fig. 5 — Transfer characteristics showing the measured luminance reproduction of 15 color samples.

points represent the chromaticity of the color as reproduced on the tricolor tube.

The fidelity of luminance reproduction is indicated by the transfer characteristic (plot showing light output vs. light input). Perfect luminance reproduction is obtained with a linear transfer characteristic. Figure 5 shows the measured transfer characteristic plotted on log. log. paper. For perfect luminance reproduction the slope of the line would be unity.

The distortions in chromaticity shown on Figure 4 are sufficiently small as to expect good color reproduction. This is borne out by the enthusiastic expressions of people having seen demonstrations of color broadcasts.

Figure 5 shows that luminance reproduction is distorted to the extent that the overall transfer characteristic departs from linearity. This luminance distortion is not a necessary characteristic of the system and can be corrected. However, as in the case of film reproduction, it has been found that it often aids in producing more pleasing pictures.

The distortions in chromaticity shown in Figure 4 are due to a large number of causes. Foremost among these are (1) the nonlinear transfer characteristic of the system, (2) some colors placed before the camera being outside of the gamut of colors reproducible by the receiver primaries, (3) the primaries of the tricolor tube not coinciding exactly with those proposed by NTSC, (4) lack of perfect precision of measurement, (5) normal tolerance of adjustment at studio and receiver and (6) power lines variations and residual hum.

These measurements were made on the complete system under typical operating conditions. It is to be expected that as greater experience of operation is attained even the above sources will be reduced, just as was the case in monochrome television.

E. Resolution

The resolution capabilities of the RCA color television system are theoretically the same as those of the standard monochrome system. All of the fine detail information is conveyed by the luminance channel which has a nominal bandwidth of 4.25 megacycles per second as in black and white television. Schade[8] gives an analysis of the capabilities of an imaging system and the same approach and terminology will be used in discussing that subject here.

The Commission's Standards of Good Engineering Practice for Television Broadcast Stations prescribe a horizontal and vertical blanking width of 17.5% and 6.5% of a line and field interval respectively. In a television channel the total number of picture elements is the number of half-cycles at cut-off frequency Δf in the active scanning time for one complete frame. Thus the total number of picture elements, n, would be:

$$n = 2 \times .825 \times .925 \times T_f \times \Delta f$$

$$= 1.53\, T_f \times \Delta f \qquad (1)$$

where T_f = time of one frame

Δf = video bandwidth of channel to cut-off (cycles/second).

The smallest detail area "a" which can be resolved by an imaging process is an equivalent square the linear dimension of which is specified by the limiting resolution line number N_c or the balanced cut-off line number $\overline{N}_{co}$

[8] O. H. Schade, "Electro-Optical Characteristics of Television Systems," *RCA Review*, Vol. IX, pp. 492-493 (1948).

in the image. This area is defined as a "picture element". The number of picture elements is then

$$n = \overline{N}^2_{co} \times H/V \quad (2)$$

where H/V is the aspect ratio of the image

Equating (1) and (2)

$$\overline{N}^2_{co} \times \frac{H}{V} = 1.53\ T_f \times \Delta f.$$

Since $T_f = \frac{1}{30}$ second for the television system, for an aspect ratio $H/V = 1.33$

$$\Delta f = 26.1\ \overline{N}^2_{co}. \quad (3)$$

Thus for a 4.25 megacycle channel

$$\overline{N}_{co} = \sqrt{\frac{4.25 \times 10^6}{26.1}} = 404 \text{ the balanced resolution of the system.}$$

Since there are .925 × 525 = 485 active scanning lines in the picture from top to bottom, and since the balanced resolution is the geometric mean between the maximum horizontal, N_h, and vertical, N_v, resolution

$$N_{co} = \sqrt{N_v \times N_h}$$

for $N_v = 485$

$N_h = 340$ lines the maximum horizontal resolution which the system is capable of producing.

Inasmuch as the proposed signal specifications as regards the luminance channel, which carries all of the detail information, are the same for color as for monochrome, the color system should be capable of producing the same detail resolution.

A standard RTMA test chart was used in the studio and the signal produced by the color camera and associated equipment was fed via a radio frequency signal generator to a color receiver and to a standard RCA Model 17T250 television receiver. On the monochrome receiver, the limiting horizontal resolution in the center of the picture was of the order of 320-330 lines and the corresponding vertical resolution was over 400 lines. This shows that the system as used produced essentially the full resolution capabilities of a 4.25 megacycle channel. The receiver was checked and found to have normal RF, IF, and VF responses and is believed to be typical of an average receiver. A good average factor to use for a typical value of practical vertical resolution as normally observed on an RTMA test pattern in practice is about 75% of the theoretical maximum. This would be 360 lines.

As reproduced on the color receiver, the maximum center horizontal resolution was seen to be about 285 lines and the corresponding vertical number was about 350 lines.

Inasmuch as the essentially full horizontal resolution capability of the 4.25 megacycle channel was observed on the monochrome receiver, it must be concluded that the system is capable of reproducing full horizontal resolution for the luminance or brightness channel and the fact that the tricolor receiver did not so indicate is a result of the viewing equipment employed.

In the present monochrome cameras and kinescopes, the corner resolution is reduced by 10 to 20% due to the defocusing action at the extremes of deflection in both camera and kinescope tubes. The same situation exists in the color television system.

The group of observers were asked to record the maximum horizontal and vertical resolution which they could see on the monochrome and color receivers. The average of their observations gave a horizontal figure of 312 and a vertical figure of 406 lines for the center resolution on the monochrome receiver and 284 and 330 respectively for the center readings on the color receiver.

F. Registration

There is some residual misregistration in the pictures reproduced by the equipment presently being used in the RCA color television system but such misregistration as exists does not interfere with enjoyment of the color picture. It is due to present apparatus and is not a system limitation.

In the camera used, although it is necessary accurately to register three scanning rasters, an unusual amount of success has been attained. Test pictures were made by feeding to a black and white receiver the signals produced by scanning a line and RTMA pattern. Misregistration would be indicated by a thickening or multiplicity of some lines near the outer extremities of the pictures. Essentially no deleterious effects due to misregistration were observed. There may have been a slight tendency for a thickening of some lines near the outer edges but there were no signs of any multiple lines.

In the case of the color kinescope, such misregistration as occurred was due to lack of complete convergence at the outer edges of the picture raster.

In the questionnaire, 18% of the viewers found misregistration was not observable. From the standpoint of the pictures as a whole, 52% of those who could observe misregistration thought it was just perceptible, 39% definitely perceptible but not objectionable, and only 9% somewhat objectionable. Some people thought it was most apparent at the edges of the pictures while others thought it showed up on the left side only. No observers found misregistration definitely objectionable. Such limitations as exist are mainly ones of present day equipment and will be overcome by refinements and new designs as experience is gained by manufacturing larger quantities of equipment. In any event, the limitations are not fundamental to the system, but rather indicate that equipment presently being used can still be improved.

G. Picture Texture

There are many factors that enter into the broad classification of picture texture. In the RCA color television system there are the same number of active lines in the picture as in standard monochrome television. Therefore the line structure should be the same. Apparently it has been satisfactory in present day commercial television, so there is good reason to believe that it will be satisfactory for color television. At most convenient viewing distances the line structure, on a well interlaced picture, is not visible to the average person. The line structure blends into a reasonably smooth background. All twenty-eight observers reported no line structure observable in the pictures on the color receiver when seated at their preferred viewing distance from the screen.

There are approximately 900 colored phosphor dots along a line in the 16-inch RCA tricolor kinescope and about 700 from the top to the bottom of the normal raster area. This would mean that the diameter of an individual dot is about 70% of the thickness of a scanning line. Since the lines are not usually visible at normal viewing distances, the individual red, green and blue phosphor dots are even less visible. In answer to the question of whether or not they could observe any dot pattern on the color receiver, 93% reported no, and only 7% thought that they could.

The size and number of the color phosphor dots in the picture raster is not a system limitation but rather a practical consideration with the tubes as made today. Obviously sufficient dots must be used to give the impression of a continuous white background when all three guns are properly excited. There is little, if any, need to employ more than enough to give a pleasing smooth appearance without jagged edges to objects. The 585,000 dots in the present 16-inch envelope tube are adequate for this size of picture raster at normal viewing distances.

H. Spurious Effects

In some color pictures, as produced on color kinescopes of the shadow mask type, spurious signal patterns have been observed. They are sometimes caused as a consequence of the signal generated by the action of the scanning beam in traversing the mesh screen. It has been found expedient to reduce the amplitude of the subcarrier signals somewhat by means of a filter or trap placed in the brightness channel which in turn greatly minimizes the tendency for spurious patterns in the resultant picture. Such attenuation at subcarrier frequency does reduce the fine detail resolution capabilities in the final display by 10 to 15%, but materially enhances picture texture.

One of the more objectionable features of the field sequential color television system was color breakup. This usually occurred when there was relative motion between the viewer's eyes and the viewing screen. If one looked away from the screen of a sequential receiver momentarily, there was almost invariably a tendency to see the picture in one of its primary colors or in some cases a flash of red, green or blue. This cannot happen in the RCA color television system inasmuch as an image is never shown in its entirety in a separate primary color. The system is simultaneous in its nature and the images are always shown in all three colors at all times.

Another objectionable feature of the sequential system was color fringing due to movement of an object in the field of view. When viewing pictures with rapid movement on a sequential receiver, there was frequently a tendency to observe red, green, and blue outlines or edges on the moving objects. In the case of extremely rapid movement, such as a baseball travelling through the air, one might even see the ball in red, green and blue colors—a somewhat disconcerting effect when one knows that there is only one ball and that it should be white at all times. Inasmuch as all three primary color signals are present all the time, this effect cannot occur in the RCA color television system.

Referring now to the answers contained in the questionnaire, none of the observers reported any color breakup when viewing the color receiver. The opinions were likewise unanimous in that there was no observable line or dot crawl in the color pictures. As regards the presence of color fringing, 39.1% of the observers, or 9. saw none, 21.7%, or 5, said it was just perceptible, 34.8%, or 8 said it was definitely perceptible but not objectionable. The remaining single observer said it was somewhat objectionable but no observer found it definitely objectionable or not usable.

I. Viewing Conditions

For a similar size picture, the viewing distance for color television pictures is essentially the same as it is for black and white. Most of the observers preferred to sit from 4 to 7 feet from the receiver which is from 6 to 10 times picture height.

There is no more deterioration in the color picture as one views it from the side than there is in the standard black and white kinescope. Most of the observers, 89%, thought that the color receiver exhibited the same broad angle of view which is characteristic of all directly viewed black and white sets. Due to the fact that the color screen in the tricolor kinescopes used in the tests is set back from the face of the curved front of the kinescope, there is very insignificant restriction of the viewing angle.

The ambient room lighting condition will vary with individuals and circumstances. Some people prefer to have room lights on, others prefer to turn off most room lights and view pictures in more or less subdued light.

PART III

Performance of the RCA Color Television System When Receiving Color Signals on Standard Monochrome Television Receivers

One of the fundamental objectives of the RCA color television development program has been to evolve a system which would produce not only good pictures in full color on a color receiver but which would produce at the same time good monochrome pictures on any black and white set without modification. This objective has been completely realized in the standards now being proposed to the Commission for adoption. The importance of this feature cannot be overemphasized from the standpoint of the set owner, the broadcaster, or the sponsor.

A. Overall Picture Quality

During the past several months, experimental color broadcasts have been viewed by millions on their monochrome sets.[9] Hundreds of letters have been received commenting upon the fine quality of the black and white renditions of the color programs on their receivers. In fact, a substantial number have said that the picture quality was in many instances superior to that of normal black and white service.

Our observers thought that the overall picture quality of the color signals as reproduced on a standard monochrome television receiver was very satisfactory. Out of a total of 279 ratings, 10.7% were excellent, 60.2% good, 27.3% passable, 1.4% not quite passable, .4% poor and 0% not usable. This again is in substantial agreement with the opinions as expressed by the public when commenting upon the quality of color programs when viewed on their home receivers.

B. Flicker-Brightness

Inasmuch as the basic standards are the same as for black and white transmissions, the performance as regards flicker-brightness, contrast, resolution and viewing conditions should be unchanged. When viewing the monochrome set which was adjusted for approximately 8 foot lamberts, none of the observers reported any flicker in the pictures.

When viewing the monochrome receiver which was adjusted to produce a maximum highlight brightness of 40 foot lamberts, 22% of the opinions reported a slight amount of flicker.

C. Contrast

The contrast range in the pictures as reproduced on the black and white sets would be essentially the same as in the case of color receiver reception.

[9] Concerning some of these tests, see report of Opinion Research Corporation entitled Reactions to Black and White Reception of Fourteen RCA Experimental Color Broadcasts, January-March, 1953, contained in Appendix C.

The slopes of the signal-in vs. light output characteristic of the color and monochrome kinescopes are reasonably alike.

The distribution of shades throughout the range from highlights to shadows has been generally considered to be superior in the case of reception of color signals.

D. Resolution

The resolution of the pictures as reproduced on a monochrome receiver should have the full resolution capability of the 4.25 megacycle channel. The signal which one actually sees on the black and white kinescope is essentially the brightness or luminance part of the composite color signal. This is transmitted with the full bandwidth available. The modulated subcarrier which carries the color information also appears on the monochrome kinescope but its effects insofar as producing light output is concerned are for most practical purposes cancelled out due to the reversal of its polarity on successive scans. In the picture of an RTMA test chart reproduced on a standard monochrome receiver the observers averaged 312 lines horizontally and 378 vertically in their tabulations.

E. Registration

The observers thought that misregistration in the color pictures as reproduced on the black and white sets was of a very small degree. Only five out of twenty-eight observed any misregistration at all and these five thought that such misregistration was just perceptible.

F. Picture Texture

As mentioned above, the public has repeatedly commented upon the fine pictures on their black and white receivers when watching a color broadcast. They have not complained about any peculiarities in picture texture which might be caused by the presence of the subcarrier in the video signal. When receiving a color signal on a monochrome set the effect of the subcarrier is supposed to cancel itself out on alternate scans due to the polarity reversal. If the kinescope were a completely linear device such would undoubtedly be the case. Since it is not, there is sometimes a trace of the subcarrier signal which shows up as a dot pattern or a cross-hatched pattern on the face of the black and white kinescope. The pattern, however, is finer in texture than the line structure on current monochrome sets and is not generally visible at normal viewing distances. Out of a total of twenty-eight observers, 11 or 39% reported that they could observe the lines in the raster on the black and white set. However, 96.5% reported no discernible dot pattern in the background.

G. Spurious Effects

Inasmuch as there is no mask in a standard black and white kinescope, there is no spurious signal developed as a consequence of scanning which can produce beat patterns by combining with the subcarrier signal components of the composite signal. Due to incomplete cancellation of the subcarrier light output producing capability, there are sometimes faint traces of a regular cross-hatched effect on the face of the black and white kinescope.

Twenty-six or 92.9% of the observers saw no dot crawl. Only two observers thought that they could detect a movement in the pattern which has been called dot crawl. Twenty-seven or 96.4% of the observers detected no line crawl on the monochrome receiver while one observer thought he did. Generally speaking, an average person could not discern either of these effects at a normal viewing distance of 6 to 10 times picture height.

H. Viewing Conditions

The viewing conditions would, of course, be the same as in black and white. It is the same kind of a picture one has been looking at for years and there is no reason why it should be different in these respects.

APPENDIX A

EVALUATION BY TECHNICAL PERSONNEL OF PERFORMANCE CAPABILITIES OF THE RCA COLOR TELEVISION SYSTEM EMPLOYING NTSC FIELD TEST SIGNAL SPECIFICATIONS

PICTURES VIEWED ON RCA RECEIVERS USING AN RF SIGNAL GENERATOR

I. OVERALL PICTURE QUALITY

A. What is your opinion of the overall picture quality of the pictures on the color and monochrome receivers? Please use the following terms in evaluating picture quality: — excellent, good, passable, not quite passable, poor, not usable.

Color Total No. of Ratings—275*		*Monochrome* Total No. of Ratings—279*	
Excellent	22.1%	Excellent	10.7%
Good	52.1%	Good	60.2%
Passable	22.9%	Passable	27.3%
Not quite passable	2.9%	Not quite passable	1.4%
Poor	0%	Poor	.4%
Not usable	0%	Not usable	0%
Total—	100%	Total—	100%

The color receiver has been set to produce approximately 10 foot lamberts maximum highlight brightness and the monochrome receiver has been set for 8 foot lamberts. Ambient room illumination is .18 F.C.

B. The ambient room illumination will now be raised to .95 foot candles and the first four slides will be shown again. Will you please express your opinion of the overall quality of the pictures under these viewing conditions.

Color Total No. of Ratings—111*		*Monochrome* Total No. of Ratings—108*	
Excellent	14.4%	Excellent	5.5%
Good	62.2%	Good	72.2%
Passable	20.7%	Passable	21.3%
Not Quite Passable	.9%	Not Quite Passable	1.0%
Poor	1.8%	Poor	0%
Not Usable	0%	Not Usable	0%
Total—	100%	Total—	100%

* Some observers did not rate all pictures.

C. Do you think there has been any appreciable change in the contrast range of the pictures as you have viewed them as a result of raising the room illumination?

Yes 28.5% (8) No 71.5% (20) Improvement (4)
Deterioration (4)

D. Do you think that the contrast range in the pictures in "B" above, the condition of higher ambient room illumination, is

Excessive	0%
Adequate	93% (26)
Insufficient	7% (2)

II. VIEWING ANGLE (Use scenes 1, 2, 3, or 4 and ambient light of .18 foot candles.)

A. Is there any restriction as regards viewing angle when viewing the color pictures as compared to the monochrome pictures?

Yes 10.7% (3) No 89.3% (25)

III. PICTURE TEXTURE (Observer will select his preferred viewing distance which is 5-7 feet. Use scenes 1, 2, 3, or 4 and ambient room light of .18 foot candles except for "H" which will use a studio camera and action.)

A. Can you observe the line structure in the pictures on the color receiver?

Yes 0% No 100% (28)

Does it appear to be more or less perceptible than on an ordinary black and white picture from a standard monochrome broadcast?

More 3.7% (1) Less 63% (17) Same 33.3% (9) No answer (1)

B. Can you observe the line structure in the pictures on the monochrome receiver?

Yes 39% (11) No 61% (17)

Does it appear to be more or less perceptible than on an ordinary black and white picture from a standard monochrome broadcast?

More 7.1% (2) Less 25% (7) Same 67.9% (19)

C. Do you observe any dot pattern on the color receiver?

Yes 7.1% (2) No 92.9% (26)

D. Do you observe any dot pattern on the monochrome receiver?

Yes 3.5% (1) No 96.5% (27)

E. Do you observe color break-up in the pictures on the color receiver when you look away quickly or move your hand rapidly in front of your eyes? (For the purpose of this test, color break-up is defined as any spurious color caused by a difference in the condition of the observer's eye from one field to the next.)

Yes 0% No 100% (28)

F. Do you observe line crawl on the color receiver?

Yes 0% No 100% (28)

Or dot crawl?

Yes 0% No 100% (27) No answer (1)

G. Do you observe line crawl on the monochrome receiver?

Yes 3.6% (1) No 96.4% (27)

Or dot crawl?

Yes 7.1% (2) No 92.9% (26)

H. Do you observe any color fringing resulting from rapid movement of an object in the field of view of the camera?* (For the purpose of this test, color fringing is defined as spurious colors introduced into the picture by the change in position of the televised object from field to field.)

None 39.1% (9)
Just perceptible 21.7% (5)
Definitely perceptible but not objectionable 34.8% (8)
Somewhat objectionable 4.4% (1)
Definitely objectionable 0%
Not usable 0%

IV. Registration (Observers will remain seated as in "III". Pictures from studio.)

A. Do you observe misregistration in any of the color pictures on the color receiver?

Yes 82% (23) No 18% (5)

B. If so, from the standpoint of the picture as a whole, is such misregistration

* Twenty-three observers used in this test.

Just perceptible 52% (12)

Definitely perceptible, not objectionable 39% (9)

Somewhat objectionable 9% (2)

Definitely objectionable 0%

Not usable 0%

C. In what part of the picture was it most apparent?

Edges, right and left sides
Hair and flesh line of model

D. Do you observe misregistration in any of the pictures on the monochrome receiver?

Yes 18.5% (5) No 81.5% (22) No answer (1)

E. If so, from the standpoint of the picture as a whole, is such misregistration

Just perceptible 100% (5)

Definitely perceptible, but not objectionable 0%

Somewhat objectionable 0%

Definitely objectionable 0%

Not usable 0%

F. In what part of the picture was it most apparent?
Edges, right and left sides

V. Color Fidelity

A. How would you rate the color fidelity of the color pictures you have just seen?

Excellent 15.4% (4)	Not quite passable 0%
Good 73.0% (19)	Poor 0%
Passable 11.6% (3)	Not usable 0%

No answer (2)

VI. Resolution (RTMA Resolution Chart)

A. Please record the maximum horizontal and vertical resolution on the color receiver.

	Center		*Corner*	
	Horizontal	*Vertical*	*Horizontal*	*Vertical*
Av.	284	330	246	263

B. Please record the maximum horizontal and vertical resolution on the monochrome receiver.

	Center		*Corner*	
	Horizontal	*Vertical*	*Horizontal*	*Vertical*
Av.	312	406	275	317

VII. FLICKER-BRIGHTNESS

A. Please observe each of the receivers carefully to determine if you can detect any flicker in the pictures.

COLOR RECEIVERS

	Receiver "a"		Receiver "b"	
Scene	*Flicker*	*Comment*	*Flicker*	*Comment*
1	None	96.4% (27)	None	88% (15)
	Slight	3.6% (1)	Slight	12% (2)
	Annoying	0%	Annoying	0%
2	None	100% (28)	None	82% (14)
	Slight	0%	Slight	18% (3)
	Annoying	0%	Annoying	0%
3	None	100% (28)	None	65% (11)
	Slight	0%	Slight	35% (6)
	Annoying	0%	Annoying	0%
4	None	100% (28)	None	100% (17)
	Slight	0%	Slight	0%
	Annoying	0%	Annoying	0%

Receiver "a" has been set for a highlight brightness of approximately 10 foot lamberts.

Receiver "b" has been set for a highlight brightness of approximately 40 foot lamberts.

MONOCHROME RECEIVERS

	Receiver "a"		Receiver "b"	
Scene	*Flicker*	*Comment*	*Flicker*	*Comment*
1	None	100% (28)	None	65% (11)
	Slight	0%	Slight	35% (6)
	Annoying	0%	Annoying	0%
2	None	100% (28)	None	88% (15)
	Slight	0%	Slight	12% (2)
	Annoying	0%	Annoying	0%
3	None	100% (28)	None	76% (13)
	Slight	0%	Slight	24% (4)
	Annoying	0%	Annoying	0%
4	None	100% (28)	None	82% (14)
	Slight	0%	Slight	18% (3)
	Annoying	0%	Annoying	0%

Receiver "a" has been set for a highlight brightness of approximately 8 foot lamberts.

Receiver "b" has been set for a highlight brightness of approximately 40 foot lamberts.

B. Scenes will now be shown in which there is a rapid horizontal and vertical motion of red, green, blue, yellow and white objects. Do the receivers appear to you to display the illusion of smooth continuity of motion?

Yes 85.8% (24) No 14.2% (4)

APPENDIX B

DESCRIPTIVE INFORMATION RELATING TO EVALUATION IN APPENDIX A OF PERFORMANCE CAPABILITIES OF RCA COLOR TELEVISION SYSTEM

I. Overall Picture Quality

A. Scene

1. Aviator NTSC Slide No. 6
2. Sleigh Ride NTSC Slide No. 15
3. Sunflower Girl NTSC Slide No. 1
4. Boat-Ashore NTSC Slide No. 11
5. Crayon Boy NTSC Slide No. 7
6. Girl in Hat—Slide
7. Head and shoulders of model—studio close-up shot
8. Bowl of fresh fruit—studio shot
9. Model—studio medium shot
10. Bouquet of fresh flowers—studio shot.

B. Scene

1. Aviator NTSC Slide No. 6
2. Sleigh Ride NTSC Slide No. 15
3. Sunflower Girl NTSC Slide No. 1
4. Boat-Ashore NTSC Slide No. 11

II. Viewing Angle

A. One or more of the slides used in IB

III. Picture Texture

A, B, C, D, E, F, G Use one or more of the slides used in IB

H. Close-up of white ping pong ball being bounced against paddle—studio shot

IV. Registration

A, B, C, D, E, F

1. Head and shoulders shot of model with colored objects in corners of picture area—studio shot
2. Close-up of bowl of fresh flowers—studio shot

V. Color Fidelity

A. Close-up of bowl of fresh flowers and fruit—studio shot

VI. Resolution

A. RTMA resolution chart using studio camera

VII. Flicker-Brightness

A. Scene

1. Crayon Boy NTSC slide No. 7 for large red areas
2. Hawser Man NTSC slide No. 9 for large blue areas
3. Landscape scene for large green areas—a slide
4. Southern Mansion NTSC slide No. 16 for large white areas

B. Red, green, blue, yellow and white ping pong balls being bounced against a paddle—studio shot

APPENDIX C

REACTIONS TO BLACK AND WHITE RECEPTION OF FOURTEEN RCA EXPERIMENTAL COLOR BROADCASTS

January — March, 1953

A REPORT PREPARED

FOR

RADIO CORPORATION OF AMERICA

BY

OPINION RESEARCH CORPORATION

Princeton, New Jersey

May 14, 1953

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Foreword

Radio Corporation of America and the National Broadcasting Company, Inc., conducted a series of experimental field tests of the RCA compatible color television system on January 27 and 29, February 3, 5, 10, 12, 17, 19, 24 and 26, and March 3, 5, 12 and 19, 1953. Broadcast time of each test was 12:45-1:00 P.M.

For all fourteen field tests covered in this report, the National Television System Committee's field test signal specifications, released for publication on February 2, 1953, were used.

On all days the same operating condition was used throughout each test. Viewers were asked to write in saying how they received the program and to include information as to the age, make and screen size of their television sets.

The purpose of the tests was to evaluate, on the basis of responses from the viewing public, the reception of black and white pictures from RCA color television signals under the operating conditions employed.

This report summarizes mail responses, which were received and acknowledged by RCA or NBC and given to Opinion Research Corporation for tabulation, as follows:

Test Program	*Number of Responses*
January 27	96
January 29	78
February 3	85
February 5	55
February 10	61
February 12	187
February 17	100
February 19	52
February 24	55
February 26	59
March 3	62
March 5	66
March 12	103
March 19	77
Total	1136

It is not possible to know to what extent those who mailed in responses are representative of all television set owners in the New York metropolitan area or to what extent they are representative of the viewers of these test programs.

PART I

The Test Situation

(Based on information furnished by RCA officials)

1. Test Conditions

All fourteen tests employed the National Television System Committee's field test signal specifications, released for publication on February 2, 1953.

2. Announcements

The announcements were substantially the same for all fourteen test programs covered in this report.

Opening Announcement

"The Radio Corporation of America and the National Broadcasting Company present another color television test program. Ladies and gentlemen, greetings to you. This is Ben Grauer speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV. You are about to view a test of RCA's all-electronic compatible color television system. By 'compatible' we mean that it is possible for you to see the color program on your present television sets in black and white.

"We would like to have you help us with this fifteen-minute test. Please send a card or letter to RCA-NBC Color Television, RCA Building, New York 20, New York and let us know how you receive this program. It is important that you include the age and make of your set, size of its screen and anything unusual in your reception. And now on with the show—"

Closing Announcement

"Ladies and gentlemen, you have been witnessing another experimental test of the RCA compatible all-electronic color television system. As I mentioned to you at the beginning of the show, we would like you to help us with this test.

"Please send us a card and let us know how you received this program. Send your postcard to RCA-NBC Color Television, RCA Building, New York 20, New York. It is important that you include the age and make of your set, size of its screen and anything unusual in your reception. Please date your card today, ...

"We hope you will also assist us by observing different tests of the RCA color television system which we will broadcast at this same time .... (*Note:* This sentence was omitted on March 19.)

"And now for the Radio Corporation of America and the National Broadcasting Company, this is Ben Grauer saying good afternoon."

3. Program Content

The following is a summary of program content:

Tuesday, January 27 A musical revue.

Thursday, January 29	An educational program on the manufacture of stained glass windows.
Tuesday, February 3	First of two talks by Charles J. Caudle on atomic energy.
Thursday, February 5	Dan Blum's collection of dolls and a Siamese dance.
Tuesday, February 10	Second of two talks by Charles J. Caudle on atomic energy.
Thursday, February 12	Excerpts from "Madame Butterfly."
Tuesday, February 17	Excerpts from "Madame Butterfly."
Thursday, February 19	Talk by Ivan Sanderson on caves.
Tuesday, February 24	Talk by John N. Booth on his experiences in Tibet.
Thursday, February 26	A musical revue.
Tuesday, March 3	Talk by Edward Snow, professional treasure hunter, on buried pirate treasure along the Atlantic seaboard.
Thursday, March 5	A musical revue.
Thursday, March 12	A musical revue with Jack Lane's birds.
Thursday, March 19	Kukla, Fran & Ollie with the Kuklapolitan players.

PART II

Receiver Characteristics and Geographical Location of Respondents

1. Receiver Age and Screen Size; Geographical Location of Respondents

The following tables show the age and screen size of respondents' receivers and the geographical area in which respondents live. The geographical areas shown are the service areas of Station WNBT. These are shown in detail on the map attached as Attachment 1. Area A extends approximately 25 miles from New York City on the east, north, and west and about 40-45 miles on the southwest and south. Area B extends 20-25 miles beyond Area A in all directions except to the south, where Area B goes 35-40 miles beyond Area A.

Total respondents	1136
Age of set:	
1953	77
1952	198
1951	225
1950	243
1949	139

1948	83
1947 or earlier	23
Not reported	148
Screen size:	
12½ inches or less	288
14-17 inches	455
More than 17 inches	231
Not reported	162
Geographical area:	
Area A	930
Area B	136
Other	66
Not reported or unclassifiable	4

2. RECEIVER MAKES

The table below shows the makes of respondents' television sets:

Total respondents	1136
AMC	1
Admiral	75
Air King	4
Airline	2
Ambassador	4
Andrea	7
Artone	9
Arvin	2
Bendix	5
Brunswick	3
Capehart	18
Century	1
Columbia	3
Crosley	28
DeWald	2
DuMont	67
Emerson	59
Fada	22
Firestone	2
Freed Eiseman	7
Garod	3
General Electric	58
Gimbels	2
Hallicrafters	12

Receiver Makes *(Cont.)*

Hoffman	1
Hyde Park	10
International	2
Lafayette	1
Macy	3
Magnavox	29
Majestic	3
Mars	2
Midwest	1
Montgomery Ward	1
Motorola	45
Muntz	11
Olympic	18
Pathe	1
Philco	71
Philharmonic	1
Pilot	7
RCA	314
Radio Craftsmen	1
Raytheon	7
Regal	9
Regent	1
Rembrandt	1
Royal	1
Sentinel	2
Shaw	2
Silvertone	20
Sparton	3
Stewart-Warner	2
Stromberg-Carlson	19
Sylvania	6
TCS	1
Tech-Master	2
Tele-King	7
Tele-Tone	4
Transvision	3
Trav-Ler	8
Videcraft	1
Videola	1
Wanamaker	2

Westinghouse	18
Zenith	32
Not reported or unclassifiable	66

PART III

Findings

1. Summary Table

The table below presents a summary of viewer responses for the fourteen test broadcasts.

Cumulative data for the series of tests covered in this report show that the reaction obtained was considerably more favorable than unfavorable—

61% favorable
- 11% said that reception of the test programs was better than regular black and white.
- 50% made favorable comments without reference to regular black and white.

14% unfavorable
- 9% said that reception was not as good as regular black and white.
- 5% made unfavorable comments without reference to regular black and white.

Comparison of results day by day show some fairly large differences. These should be interpreted with caution because of the small number of responses for individual test programs.

		Test Program Compared with Regular Black and White					
Table reads across	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	1136	11%	50	21	9	5	4
January 27	96	16%	54	18	7	3	2
January 29	78	8%	61	21	4	1	5
February 3	85	6%	41	25	13	9	6
February 5	55	9%	49	26	5	7	4
February 10	61	5%	46	33	8	5	3
February 12	187	13%	54	24	3	4	2
February 17	100	13%	54	16	9	5	3
February 19	52	12%	38	23	19	6	2
February 24	55	9%	62	15	9	5	0
February 26	59	5%	42	22	10	12	9
March 3	62	5%	51	18	14	10	2
March 5	66	9%	38	17	21	8	7
March 12	103	17%	47	21	7	4	4
March 19	77	21%	49	18	5	4	3

2. Detailed Tables

The tables following present detailed tabulations of responses.

For a fuller description of the test conditions, see Part I, 1.

Breakdowns of responses are shown in terms of age of set, screen size, and geographical area.

For a detailed description of Areas A and B, see Part II, 1 and Attachment 1.

All tables read across.

Tuesday, January 27, 1953

		Test Program Compared with Regular Black and White					
	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	96	16%	54	18	7	3	2
Age of set:							
1953, 1952, 1951	42	12%	55	19	7	2	5
1950 or earlier	44	16%	52	18	9	5	0
Not reported	10**	—	—	—	—	—	—
Screen size:							
12½ inches or less	22	14%	59	18	9	0	0
14-17 inches	44	16%	57	14	5	4	4
More than 17 inches	17**	—	—	—	—	—	—
Not reported	13**	—	—	—	—	—	—
Location:							
Area A	75	13%	53	19	8	4	3
All others	21	24%	57	14	5	0	0

** Cases too few for analysis.

THURSDAY, JANUARY 29, 1953

		Test Program Compared with Regular Black and White					
	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	78	8%	61	21	4	1	5
Age of set:							
1953, 1952, 1951	40	10%	50	22	5	3	10
1950 or earlier	26	8%	73	19	0	0	0
Not reported	12**	—	—	—	—	—	—
Screen size:							
12½ inches or less	13**	—	—	—	—	—	—
14-17 inches	29	7%	73	17	0	0	3
More than 17 inches....	22	9%	45	23	9	5	9
Not reported	14**	—	—	—	—	—	—
Location:							
Area A	66	9%	59	21	5	2	4
All others	12**	—	—	—	—	—	—

TUESDAY, FEBRUARY 3, 1953

		Test Program Compared with Regular Black and White					
	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	85	6%	41	25	13	9	6
Age of set:							
1953, 1952, 1951	35	6%	37	26	11	11	9
1950 or earlier	36	3%	56	22	11	8	0
Not reported	14**	—	—	—	—	—	—
Screen size:							
12½ inches or less	31	0%	49	32	3	13	3
14-17 inches	30	10%	43	20	20	7	0
More than 17 inches....	13**	—	—	—	—	—	—
Not reported	11**	—	—	—	—	—	—
Location:							
Area A	68	6%	37	23	15	12	7
All others	17**	—	—	—	—	—	—

** Cases too few for analysis.

THURSDAY, FEBRUARY 5, 1953

	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
		Test Program Compared with Regular Black and White					
Total	55	9%	49	26	5	7	4
Age of set:							
1953, 1952, 1951	30	7%	53	20	3	10	7
1950 or earlier	22	9%	45	32	9	5	0
Not reported	3**	—	—	—	—	—	—
Screen size:							
12½ inches or less	11**	—	—	—	—	—	—
14-17 inches	28	11%	43	25	7	11	3
More than 17 inches	11**	—	—	—	—	—	—
Not reported	5**	—	—	—	—	—	—
Location:							
Area A	44	7%	50	25	7	7	4
All others	11**	—	—	—	—	—	—

TUESDAY, FEBRUARY 10, 1953

	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
		Test Program Compared with Regular Black and White					
Total	61	5%	46	33	8	5	3
Age of set:							
1953, 1952, 1951	31	3%	48	26	13	7	3
1950 or earlier	24	4%	38	50	4	4	0
Not reported	6**	—	—	—	—	—	—
Screen size:							
12½ inches or less	17**	—	—	—	—	—	—
14-17 inches	23	4%	44	22	17	4	9
More than 17 inches	14**	—	—	—	—	—	—
Not reported	7**	—	—	—	—	—	—
Location:							
Area A	46	2%	43	37	7	7	4
All others	15**	—	—	—	—	—	—

** Cases too few for analysis.

THURSDAY, FEBRUARY 12, 1953

	Respondents	Test Program Compared with Regular Black and White: Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	187	13%	54	24	3	4	2
Age of set:							
1953, 1952, 1951	70	13%	47	27	3	7	3
1950 or earlier	91	13%	56	24	3	4	0
Not reported	26	15%	61	12	4	0	8
Screen size:							
12½ inches or less	43	9%	63	23	0	5	0
14-17 inches	69	15%	49	29	3	4	0
More than 17 inches....	42	12%	55	24	2	2	5
Not reported	33	18%	49	12	9	6	6
Location:							
Area A	157	14%	53	23	3	4	3
All others	30	10%	53	27	7	3	0

TUESDAY, FEBRUARY 17, 1953

	Respondents	Test Program Compared with Regular Black and White: Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	100	13%	54	16	9	5	3
Age of set:							
1953, 1952, 1951	38	8%	45	19	18	5	5
1950 or earlier	46	20%	54	17	2	7	0
Not reported	16**	—	—	—	—	—	—
Screen size:							
12½ inches or less	28	25%	53	14	4	4	0
14-17 inches	39	13%	56	10	10	8	3
More than 17 inches	19**	—	—	—	—	—	—
Not reported	14**	—	—	—	—	—	—
Location:							
Area A	80	12%	56	15	9	4	4
All others	20	15%	45	20	10	10	0

** Cases too few for analysis.

THURSDAY, FEBRUARY 19, 1953

	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
		Test Program Compared with Regular Black and White					
Total	52	12%	38	23	19	6	2
Age of set:							
1953, 1952, 1951	19**	—	—	—	—	—	—
1950 or earlier	26	11%	58	23	0	4	4
Not reported	7**	—	—	—	—	—	—
Screen size:							
12½ inches or less	21	14%	43	28	5	5	5
14-17 inches	11**	—	—	—	—	—	—
More than 17 inches	16**	—	—	—	—	—	—
Not reported	4**	—	—	—	—	—	—
Location:							
Area A	44	11%	36	23	23	5	2
All others	8**	—	—	—	—	—	—

TUESDAY, FEBRUARY 24, 1953

	Respondents	Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments. No Mention of Regular B & W	Unclassifiable
		Test Program Compared with Regular Black and White					
Total	55	9%	62	15	9	5	0
Age of set:							
1953, 1952, 1951	28	7%	68	14	7	4	0
1950 or earlier	19**	—	—	—	—	—	—
Not reported	8**	—	—	—	—	—	—
Screen size:							
12½ inches or less	9**	—	—	—	—	—	—
14-17 inches	22	5%	59	18	9	9	0
More than 17 inches	13**	—	—	—	—	—	—
Not reported	11**	—	—	—	—	—	—
Location:							
Area A	47	11%	57	17	9	6	0
All others	8**	—	—	—	—	—	—

** Cases too few for analysis.

THURSDAY, FEBRUARY 26, 1953

	Respondents	Test Program Compared with Regular Black and White					
		Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	59	5%	42	22	10	12	9
Age of set:							
1953, 1952, 1951	31	10%	32	26	16	10	6
1950 or earlier	24	0%	54	21	4	13	8
Not reported	4**	—	—	—	—	—	—
Screen size:							
12½ inches or less	16**	—	—	—	—	—	—
14-17 inches	29	10%	52	14	17	7	0
More than 17 inches	9**	—	—	—	—	—	—
Not reported	5**	—	—	—	—	—	—
Location:							
Area A	51	6%	43	23	10	12	6
All others	8**	—	—	—	—	—	—

TUESDAY, MARCH 3, 1953

	Respondents	Test Program Compared with Regular Black and White					
		Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	62	5%	51	18	14	10	2
Age of set:							
1953, 1952, 1951	29	10%	41	14	21	10	4
1950 or earlier	25	0%	64	24	4	8	0
Not reported	8**	—	—	—	—	—	—
Screen size:							
12½ inches or less	15**	—	—	—	—	—	—
14-17 inches	19**	—	—	—	—	—	—
More than 17 inches	15**	—	—	—	—	—	—
Not reported	13**	—	—	—	—	—	—
Location:							
Area A	47	4%	58	15	15	6	2
All others	15**	—	—	—	—	—	—

** Cases too few for analysis.

THURSDAY, MARCH 5, 1953

	Respondents	Test Program Compared with Regular Black and White: Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	66	9%	38	17	21	8	7
Age of set:							
1953, 1952, 1951	28	7%	32	14	25	11	11
1950 or earlier	31	13%	36	23	19	6	3
Not reported	7**	—	—	—	—	—	—
Screen size:							
12½ inches or less	12**	—	—	—	—	—	—
14-17 inches	31	13%	42	19	10	6	10
More than 17 inches	13**	—	—	—	—	—	—
Not reported	10**	—	—	—	—	—	—
Location:							
Area A	58	9%	39	15	19	9	9
All others	8**	—	—	—	—	—	—

THURSDAY, MARCH 12, 1953

	Respondents	Test Program Compared with Regular Black and White: Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	103	17%	47	21	7	4	4
Age of set:							
1953, 1952, 1951	45	20%	45	25	4	4	2
1950 or earlier	42	17%	48	21	7	2	5
Not reported	16**	—	—	—	—	—	—
Screen size:							
12½ inches or less	32	19%	56	19	3	0	3
14-17 inches	46	11%	42	28	11	4	4
More than 17 inches	16**	—	—	—	—	—	—
Not reported	9**	—	—	—	—	—	—
Location:							
Area A	88	16%	45	23	8	5	3
All others	15**	—	—	—	—	—	—

** Cases too few for analysis.

Thursday, March 19, 1953

	Respondents	Test Program Compared with Regular Black and White: Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	77	21%	49	18	5	4	3
Age of set:							
1953, 1952, 1951	34	20%	44	18	3	9	6
1950 or earlier	32	22%	53	19	6	0	0
Not reported	11**	—	—	—	—	—	—
Screen size:							
12½ inches or less	18**	—	—	—	—	—	—
14-17 inches	35	20%	54	17	3	3	3
More than 17 inches	11**	—	—	—	—	—	—
Not reported	13**	—	—	—	—	—	—
Location:							
Area A	59	21%	49	19	3	5	3
All others	18**	—	—	—	—	—	—

Combined Results For All Fourteen Days

	Respondents	Test Program Compared with Regular Black and White: Better	Favorable Comments, No Mention of Regular B & W	Just as Good	Not as Good	Unfavorable Comments, No Mention of Regular B & W	Unclassifiable
Total	1136	11%	50	21	9	5	4
Age of set:							
1953	77	6%	43	23	13	8	7
1952	198	12%	44	23	9	8	4
1951	225	12%	46	19	12	6	5
1950	243	10%	53	23	6	7	1
1949	139	11%	50	27	9	2	1
1948	83	13%	64	17	2	3	1
1947 or earlier	23	26%	35	30	9	0	0
Not reported	148	10%	57	14	10	3	6
Screen size:							
12½ inches or less	288	11%	51	25	5	6	2
14-17 inches	455	11%	51	20	9	6	3
More than 17 inches	231	10%	44	21	13	6	6
Not reported	162	12%	52	19	9	4	4
Location:							
Area A	930	11%	49	21	9	6	4
Area B	136	9%	53	22	8	6	2
All others	70	20%	52	17	9	1	1

** Cases too few for analysis.

PART IV

Attachment 1

Map of Station WNBT Service Areas

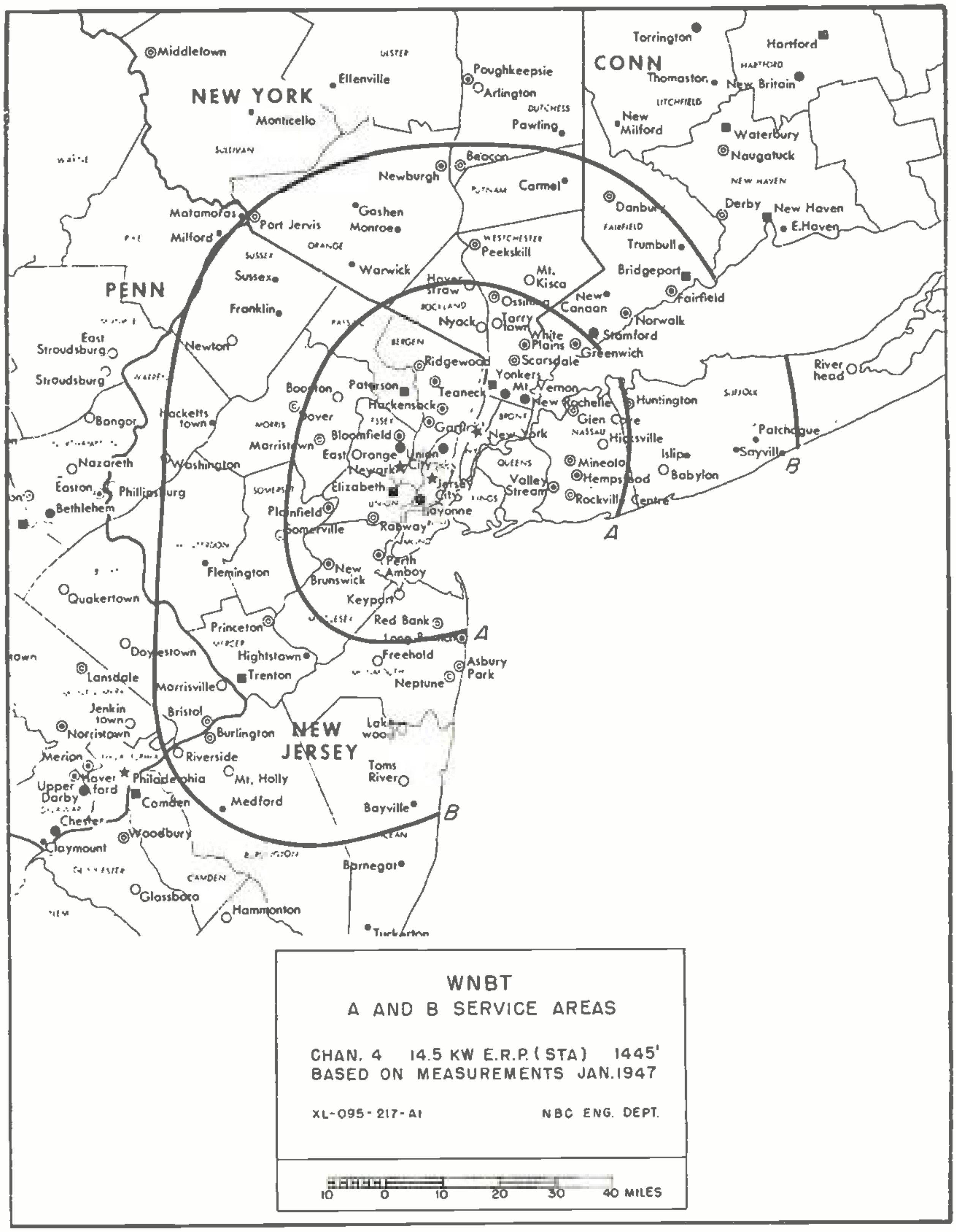

EXHIBIT 8

A COMPARISON OF MONOCHROME AND COLOR TELEVISION WITH REFERENCE TO SUSCEPTIBILITY TO VARIOUS TYPES OF INTERFERENCE

A COMPARISON OF MONOCHROME AND COLOR TELEVISION WITH REFERENCE TO SUSCEPTIBILITY TO VARIOUS TYPES OF INTERFERENCE

INDEX

EXHIBIT 8

A COMPARISON OF MONOCHROME AND COLOR TELEVISION WITH REFERENCE TO SUSCEPTIBILITY TO VARIOUS TYPES OF INTERFERENCE

PART I

Introduction

THE purpose of the study covered by this Exhibit was the accumulation of data which would measure the relative susceptibility of standard monochrome television and color television[1] to co-channel and adjacent channel interference, random and impulse noise, multipath, and sine wave interference.

Observers differ appreciably in their reactions to interference. A certain ratio of desired to interfering signal may cause intolerable degradation of the picture for a sensitive observer and entirely tolerable imperfections for a less susceptible observer. The measurement of such subjective reactions calls for viewing tests with a sufficiently large number of observers. The "average observer" is then the hypothetical person who finds that the arithmetic average of the ratios of all observers in a particular test marks the limit of tolerability or threshold perception as the case may be. In these tests the term, tolerable ratio, is the ratio of desired signal to interfering signal which corresponds to interference that is just at the point of becoming annoying in the test picture. Signals are measured at the peak of sync. The threshold ratio denotes the point at which interference is just about to disappear from view.

Test runs were made with 15 to 25 observers drawn from the non-technical staff of the David Sarnoff Research Center of the RCA Laboratories, approximately half of whom were men and half were women.

All tests were performed in the laboratory under conditions that simulated an actual transmitter-receiver relationship, as illustrated in the block diagram of Figure 1. The picture transmitters were television signal generators complete with vestigial sideband filters. The transmission amplitude characteristics are shown in Figures 2a and 2b. Synchronizing waveforms for the desired and interfering signals were generated by completely independent synchronizing and burst generators. Other test information is summarized below:

> Color receiver: RCA color field test receiver operating according to the NTSC color field test specifications dated February 2, 1953.

[1] According to the NTSC color field test specifications dated February 2, 1953.

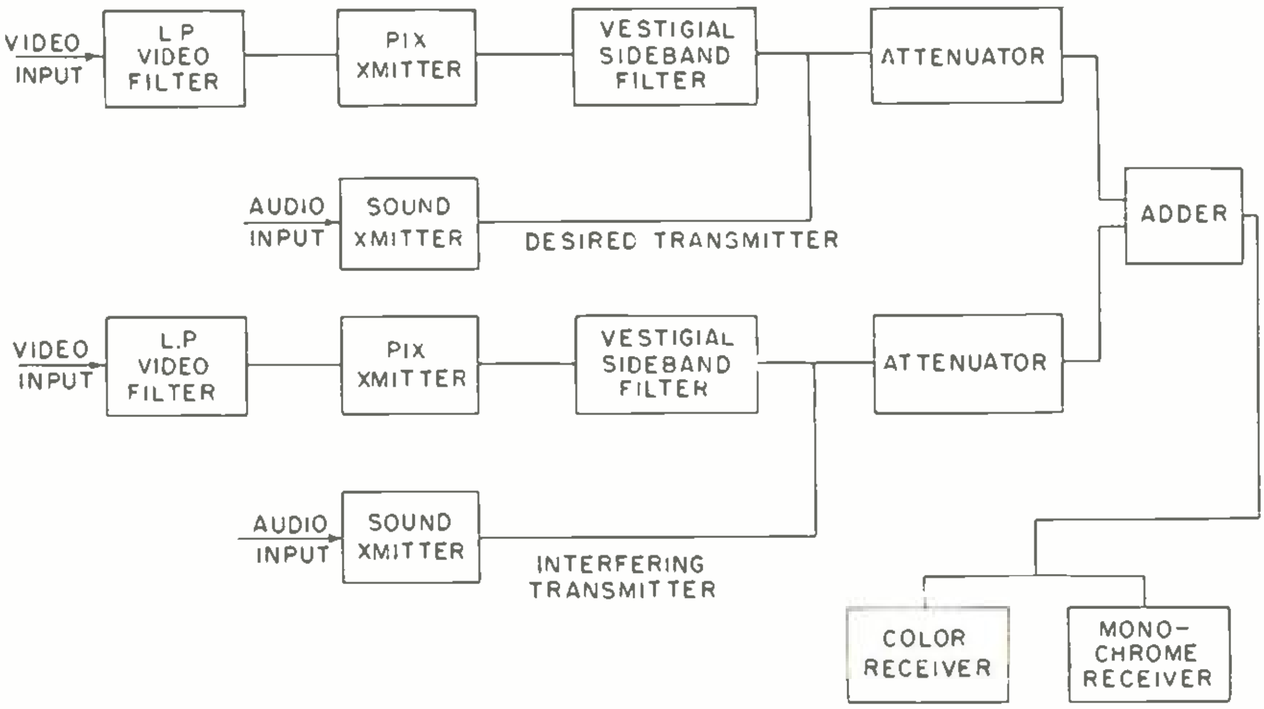

Fig. 1 — Arrangement of apparatus for co-channel and adjacent channel interference observations.

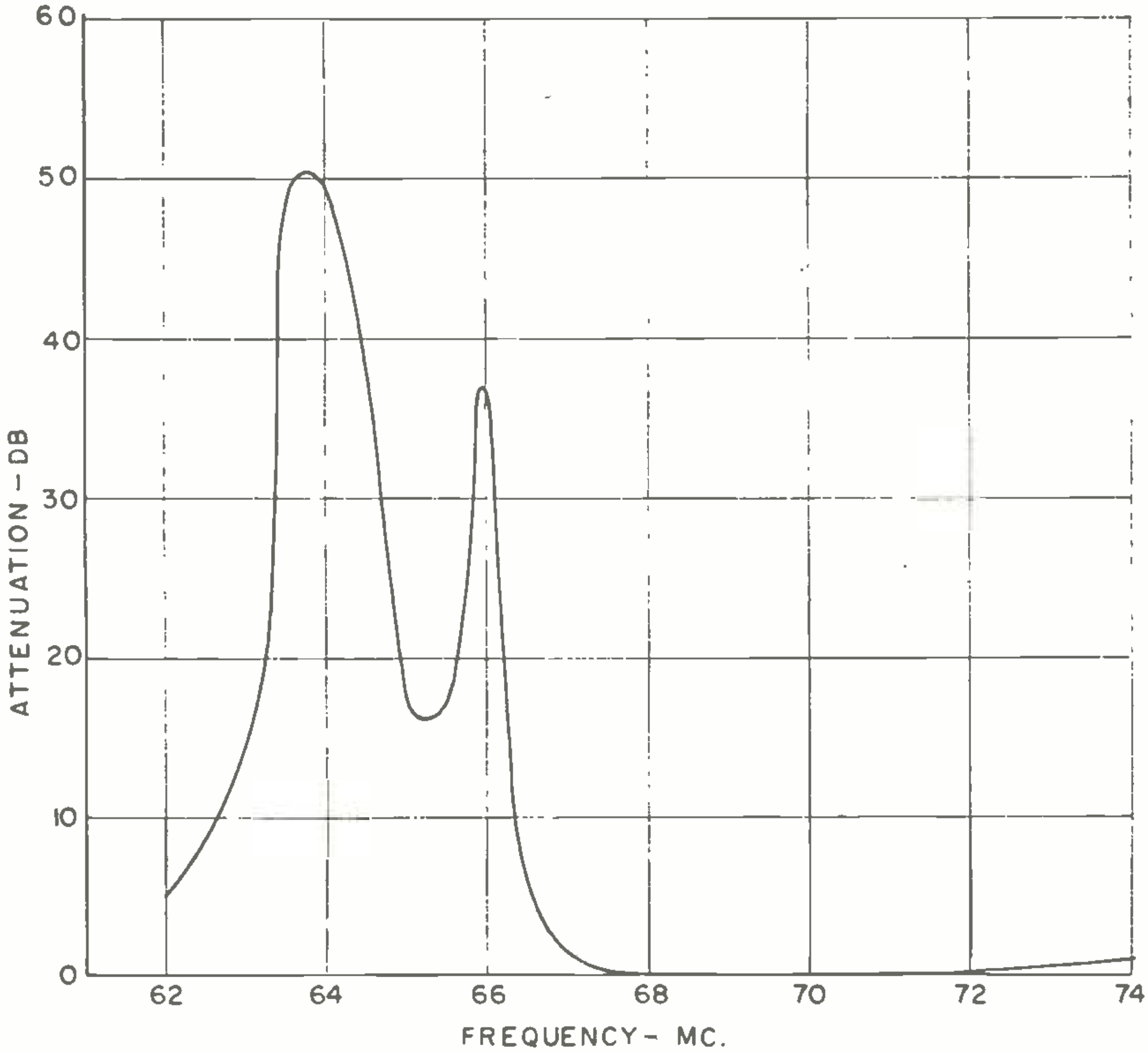

Fig. 2a — Transmission characteristic channel 4 (undesired).

Monochrome receiver: (a) RCA color field test receiver with chroma channels turned off; (b) standard RCA monochrome receiver, type T120.

Picture size: 8½" x 11".

Picture highlight brightness: 12 foot lamberts.

Viewing distance: 6 feet.

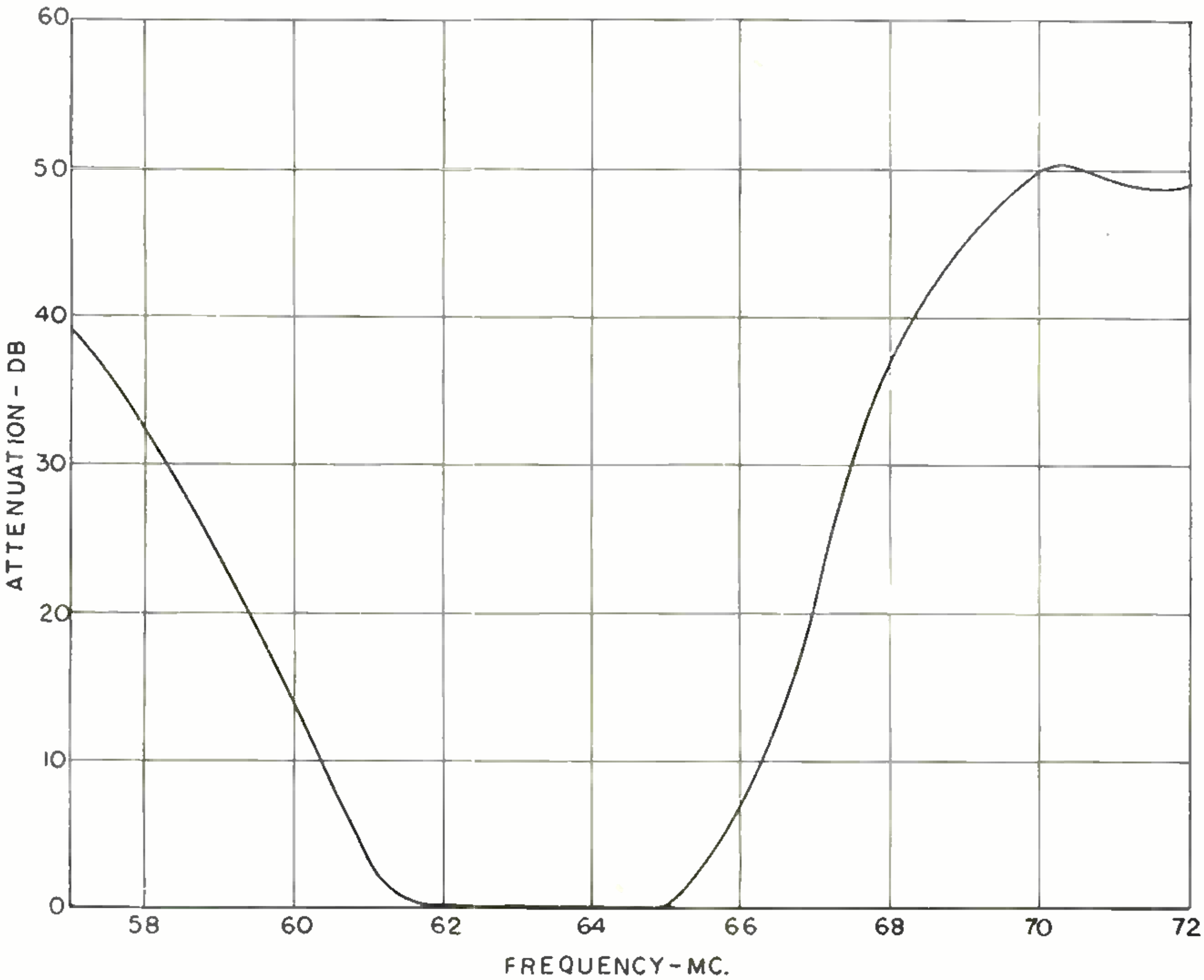

Fig. 2b — Transmission characteristic channel 3.

Desired picture: Color slide (Fig. 3a) scanned by flying spot scanner. Figure 3a is a black and white reproduction of a Kodachrome slide used by RCA, NTSC and others for test purposes; the same is the case with respect to Figures 3b and 3e.

Interfering picture for co-channel and lower adjacent channel interference tests: Color test pattern (Fig. 3b) by color camera.

Interfering picture for upper adjacent channel interference: Scene by color camera (Fig. 3c).

Sound: Frequency modulated sound according to current monochrome standards. Ratio of picture signal to sound signal, 1.4. Frequency relation of co-channel picture carriers: 10.5 kc offset.

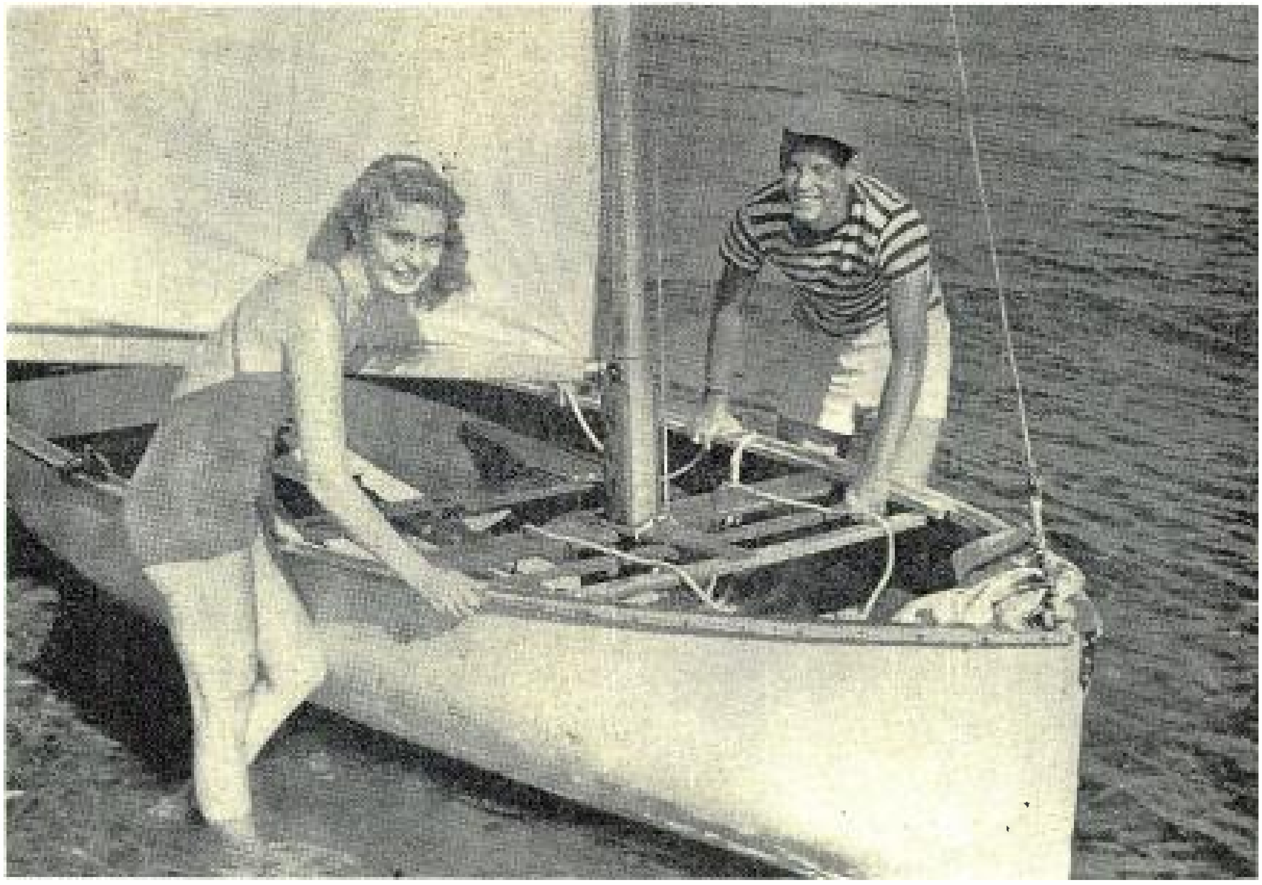

Fig. 3a — Desired picture (black and white reproduction of Kodachrome slide).

Test channels: Channel 4 for co-channel interference. Channels 3 and 4 for adjacent channel interference.

PART II

Co-Channel Interference

An observer of co-channel interference views the desired picture through a superimposed pattern of regularly spaced horizontal bars of light and shade. The frequency of the bars corresponds to the difference frequency of the two picture carriers. The visibility of the bars considered as a function of the beat frequency varies in a cyclical manner with alternating minima and maxima having a separation of 30 cycles, as illustrated in Figure 4. Points of minimum visibility also exhibit a cyclic variation with least minima occurring at odd multiples of half line frequency. It will be recognized that the frequency components of the desired and interfering signals are interleaved for offset frequencies corresponding to the minima points and that they coincide at the maxima points.

An allocation plan for television stations cannot utilize the optimum offsets corresponding to the least minima since two stations in a group of three stations in the same channel would be offset by a multiple of line frequency which results in maximum interference. However, stations may be offset by approximately 10.5 kilocycles with equal though somewhat reduced benefit to each. The offset which is standard was not specified with the view of taking advantage of the fine structure illustrated in Figure 4 since the present broadcast crystals do not have the required stability for holding the frequency offset within a few cycles of the optimum. However. the stability is sufficiently good to bring about prolonged periods of maximum visibility.[2] In all of the present observations of co-channel interference, the offset frequency was adjusted about the nominal frequency of 10.5 kilocycles for maximum visibility.

SIGNAL COMBINATIONS USED IN THE PRESENT TESTS

Four Signal Combinations Are Possible:	*Abbreviation*
1. Desired signal, color; interfering signal, color.	C/C
2. Desired signal, monochrome; interfering signal, color.	M/C
3. Desired signal, monochrome; interfering signal monochrome.	M/M
4. Desired signal, color; interfering signal monochrome.	C/M

The monochrome signal was the brightness component of the color signal.

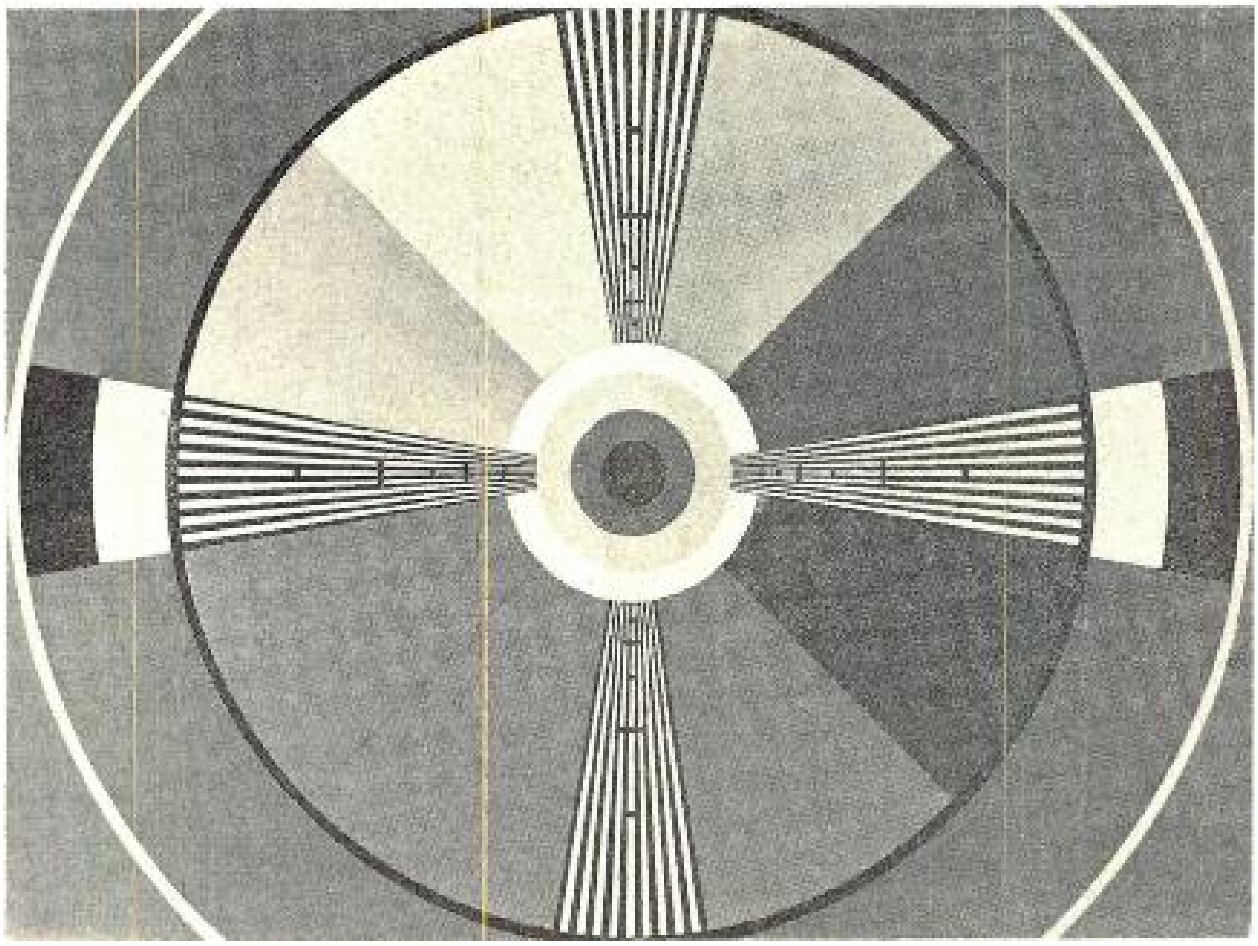

Fig. 3b — Interfering test pattern (black and white reproduction of Kodachrome slide).

[2] Figure 4 is to be regarded only as illustrative and not quantitatively accurate.

Three Conditions of Reception Are Possible:

1. Color receiver with chroma channels switched off (simulated monochrome receiver). (CM)
2. Color receiver. (C)
3. Standard monochrome receiver. (M)

A comparison of the interference properties of the standard monochrome system and the color system is more straightforward if the same color receiver is adjusted for monochrome operation by switching off the chroma circuits. This comparison is favored here although a full set of observations was made on a standard monochrome receiver.

TABLE 1

Co-Channel Interference Ratios

Signal Condition		Receiver					
desired	interfering	Standard Monochrome (M)		Color (C)		Color used as Monochrome (CM)	
		threshold DB	tolerable DB	threshold DB	tolerable DB	threshold DB	tolerable DB
C	C	42.0	31.8	39.8	28.9	38.9	30.2
M	C	42.2	32.4	39.7	29.5	37.2	28.3
M	M	42.3	32.7	39.3	30.0	37.4	28.9
C	M	42.0	32.0	39.5	30.1	38.3	30.7

TEST RESULTS

A summary of the average ratios of desired carrier to interfering carrier amplitudes for threshold and tolerable interference appears in Table 1. On the basis of the data it must be concluded that no substantial difference exists between color and standard monochrome[3] with regard to co-channel interference. In general, the average observer does not detect the change in the visual interference level corresponding to a change in the ratio of less than about 2 db.

Ratios taken with the monochrome receiver are higher by about 3 db than the corresponding ratios recorded with the color receiver with chroma channels switched off. Differences in spot size and method of dc restorations and kinescope characteristic could account for this small discrepancy.

The average ratios for the monochrome receiver for the four signal

[3] Color receiver used as monochrome receiver.

combinations differed by 0.9 db. A similar picture is revealed for the less important threshold perception. It is noted that on the average, the tolerable ratio is about 9 db lower than the threshold ratio.

The spreads of twenty-five observers' ratios are shown in Figure 5. If the normal law is followed in observations of this kind, the data points should be along a straight line when plotted on arithmetic probability paper.

PART III

Upper Adjacent Channel Interference

Upper adjacent sound is 10.5 megacycles removed from the desired picture carrier and is not a source of interference. The concern is only with the upper adjacent picture carrier and sidebands. The appearance and visibility of the interference are controlled by the following factors:

(1) Attenuation of the receiver for the upper adjacent picture carrier.

(2) Attenuation characteristic of the vestigial sideband filter at the interfering transmitter for the lower sidebands of the picture carrier.

(3) Nearness of the two synchronizing generators to an in-step condition.

(4) Amplitudes of the lower sidebands of the interfering carrier.

Fig. 3c — Interfering picture (black and white reproduction of Kodachrome slide).

Fig. 3d — Flower garden scene for multipath reception (black and white reproduction of Kodachrome slide).

(1) is under the control of the receiver designer, (3) is controlled by standardization, and (2) and (4) are transmitter considerations.

Insufficient attenuation of the upper adjacent carrier permits the interfering picture to appear either as a meaningless fleeting interference, or, if the desired and interfering synchronizing signals are almost in step, as a recognizable picture. Since the NTSC color specifications for synchronizing signals call for crystal control, the interference from a color transmission will be a clearly defined picture in slow motion across the desired picture when adjacent picture carrier attenuation is inadequate. This type of interference was not observed in the present study since both receivers offered ample adjacent picture carrier attenuation.[4]

Conditions (2) and (4) were found to be controlling. The net effect of (2) and (4) is proportional to the product of the amplitude of the lower sideband spectrum of the interfering signal and the attenuation offered by the vestigial sideband filter (Fig. 2a).

The data in Table 2 indicates that under the present test conditions color reception is more susceptible to interference from a color signal to the extent of about 6-8 db than reception of a monochrome signal with mono-

[4] See Figures 6 and 7.

chrome interference. This observation is brought about by the interaction of the desired color subcarrier signal and the lower sidebands of the interfering carrier that lie in the vicinity of the color subcarrier. In monochrome reception beats must occur with the picture carrier. In this instance, lower sidebands of the interfering carrier in the vicinity of 3.58 megacycles produce a fine beat pattern which is less visible.

The 6 db margin in standard monochrome reception is of no special consequence since the average ratios of tolerable interference for all signal combinations of color and monochrome in Table 2 are at least as favorable as —16 db. The present allocation plan of the Federal Communications Commission indicates that the tolerable ratio of 0 db is satisfactory. The margin of safety is therefore adequate in the present tests. Figure 8 shows the spread of the ratios for the group of 15 observers.

TABLE 2

Upper Adjacent Channel Interference Ratios*

Signal Condition		Receiver					
desired	interfering	Standard Monochrome (M)		Color (C)		Color used as Monochrome (CM)	
		threshold	tolerable	threshold	tolerable	threshold	tolerable
		DB		DB		DB	
C	C	—16.1	—20.9	—11.5	—16.3	—16.8	—22.0
M	C	—16.3	—20.4	—13.1	—16.1	—17.4	—22.1
M	M	—16.9	—22.5	—15.3	—20.0	—19.0	—24.5
C	M	—16.9	—22.4	—13.7	—20.0	—19.5	—24.7

* A negative sign indicates that the interfering signal was stronger by the amount indicated.

PART IV

LOWER ADJACENT CHANNEL INTERFERENCE

Interference from the picture and sound transmitters on the lower adjacent channel is determined by the attenuation of the receiver in this region. In the present series of tests, the average observer found that interference due to the sound signal became intolerable before interference from the picture signal was noticeable, irrespective of the nature of the picture signal, whether color or monochrome.

Table 3 lists the ratios for the various signal combinations and receiver conditions. Figure 8 shows the spread in values for the 25 observers. Ratios for the color receiver are approximately (—23 ± 1) db and for the monochrome receiver (—15 ± 1) db. The difference between the ratios is accounted for by the increased attenuation of 8 db which the color receivers offered to the lower adjacent sound signal.[4]

The present allocation plan of the Federal Communications Commission indicates that the tolerable ratio of 0 db is satisfactory. The margin of safety is therefore adequate in the present tests.

TABLE 3

Lower Adjacent Channel Interference Ratios*

Signal Condition		Receiver					
desired	interfering	Standard Monochrome (M)		Color (C)		Color used as Monochrome (CM)	
		threshold	tolerable	threshold	tolerable	threshold	tolerable
		DB		DB		DB	
C	C	—10.0	—14.0	—20.3	—23.2	—22.0	—24.3
M	C	—12.0	—15.7	—20.3	—22.6	—21.5	—24.7
M	M	—12.0	—15.7	—20.9	—23.2	—21.2	—24.2
C	M	—11.3	—15.3	—20.5	—22.9	—22.4	—24.3

* A negative sign indicates that the interfering signal was stronger by the amount indicated.

PART V

RANDOM NOISE

The relative susceptibilities of color and monochrome pictures to random noise were measured for a group of 25 observers. Random noise of uniform spectral distribution was added in controllable amounts to a high level RF signal and each observer was requested to compare a monochrome picture and a color picture. As in previous tests, the monochrome signal was derived from the color signal by elimination of burst and color components at the encoder. All chroma circuits were turned off in the color receiver when a monochrome rendition was desired. Noise was introduced into the signal in three steps which could be described as:

(1) Moderate noise.
(2) Noise somewhat greater than could be tolerated by most observers.
(3) Heavy, intolerable noise.

For each of the three steps, the average observer found that color was only slightly more susceptible to random noise — to the extent of about 1 db. The results of individual observations are listed in Table 4.

[4] See Figures 6 and 7.

TABLE 4

Random Noise*

Type	Number of observers reporting reading	Reading DB
1	2	—2
	2	—1
	9	0
	2	1
	3	2
	7	3
		average 1
2	1	—3
	1	—1
	11	0
	5	1
	3	2
	4	3
	1	4
		average 1
3	13	0
	1	1
	5	2
	6	3
		average 1.2

* A positive sign indicates that color is more susceptible to the extent indicated.

PART VI

SINE WAVE INTERFERENCE

The relative susceptibility of monochrome and color reception to RF sine wave interference was measured by one expert observer for the test picture shown in Figure 3a. Since a relative measure is of principal interest, the difference in tolerable ratios for monochrome and color were plotted as a function of sine wave frequency in Figure 9. The monochrome signal was derived from the color signal by omitting burst and the chroma component. Variations in the characteristics not related to color of a standard monochrome and a color receiver were eliminated by switching off the chroma circuits of the color receiver when monochrome reception was desired.

Observations indicate that monochrome and color reception are about equally susceptible to sine wave interference in the range of frequencies 1.7 megacycles on both sides of the picture carrier in which the interference appears as a brightness beat. Above this range the beat frequency continues to increase in frequency and become more tolerable. In color reception, a second beat with the color subcarrier appears as a rainbow bar pattern that increases in visibility as the subcarrier frequency is approached.

Over a narrow band about the associated sound carrier there is less divergence between color and monochrome susceptibility due to the trapping action around the position of the associated sound carrier.

In reality, Figure 9 is the locus of the maxima of interference which occur in the color picture at intervals separated by line frequency (15,750 cycles per second).

PART VII

Multipath Reception

Reflections were introduced in the RF signal by the addition of controllable amounts of the same signal delayed by transmission through a coaxial cable. Delays of approximately 0.5, 2, and 4 microseconds corresponding to 2, 7, and 14 cycles at the subcarrier frequency were viewed by 15 observers. The delays corresponded to spacings on the receiving screen of approximately 0.1, 0.4, and 0.9 inches respectively. Through the use of additional short delay lines, each multipath signal could be phased relative to the phase of the main RF signal.

Observers were shown the color and monochrome pictures reproduced by the same color receiver and requested to indicate when the multipath effects were equally objectionable in the two pictures. For this test, the amplitude of the reflection was fixed at 8 db below the desired signal for color. In all trials, the RF phasing of the main and reflected signals was adjusted for the greatest degradation of the picture.

Since it was anticipated that the nature of the scene would influence the observer's judgment of the amount of degradation, three widely different stationary scenes were used — (1) the boat scene reproduced in Figure 3a, (2) a garden scene including distant scenery reproduced in Figure 3d, and (3) a close-up of an assorted fruit bowl reproduced in Figure 3e.

A somewhat increased susceptibility of color to degradation by multipath reception is indicated in Table 5 for the average observer. Generalization of the test results probably justify an average estimate of 1-2 db. In any event, the factor is small. In attempting to correlate the results to field experience the following comments have a bearing:

(1) A reflection only 8 db down relative to the desired signal is strong and probably may be regarded as not tolerable by the average observer whether in monochrome or color.

(2) Reflections from fixed objects do not arrive in the most unfavorable phase relation on the average.

(3) The RF phase relations and the delay of a reflection from a moving object vary continuously. In color reception this means that the hue of the reflection changes in rainbow fashion.

TABLE 5

Relative Susceptibility of Color and Monochrome to Multipath*

Multipath delay (μsec)	0.5	2	4
	Relative susceptibility DB		
Scene			
(1) Boat scene	0	3	1.9
(2) Flower garden	1.4	1.5	0.3
(3) Fruit bowl	1.3	2.5	2.7

* A positive sign indicates that color is more susceptible to the extent indicated.

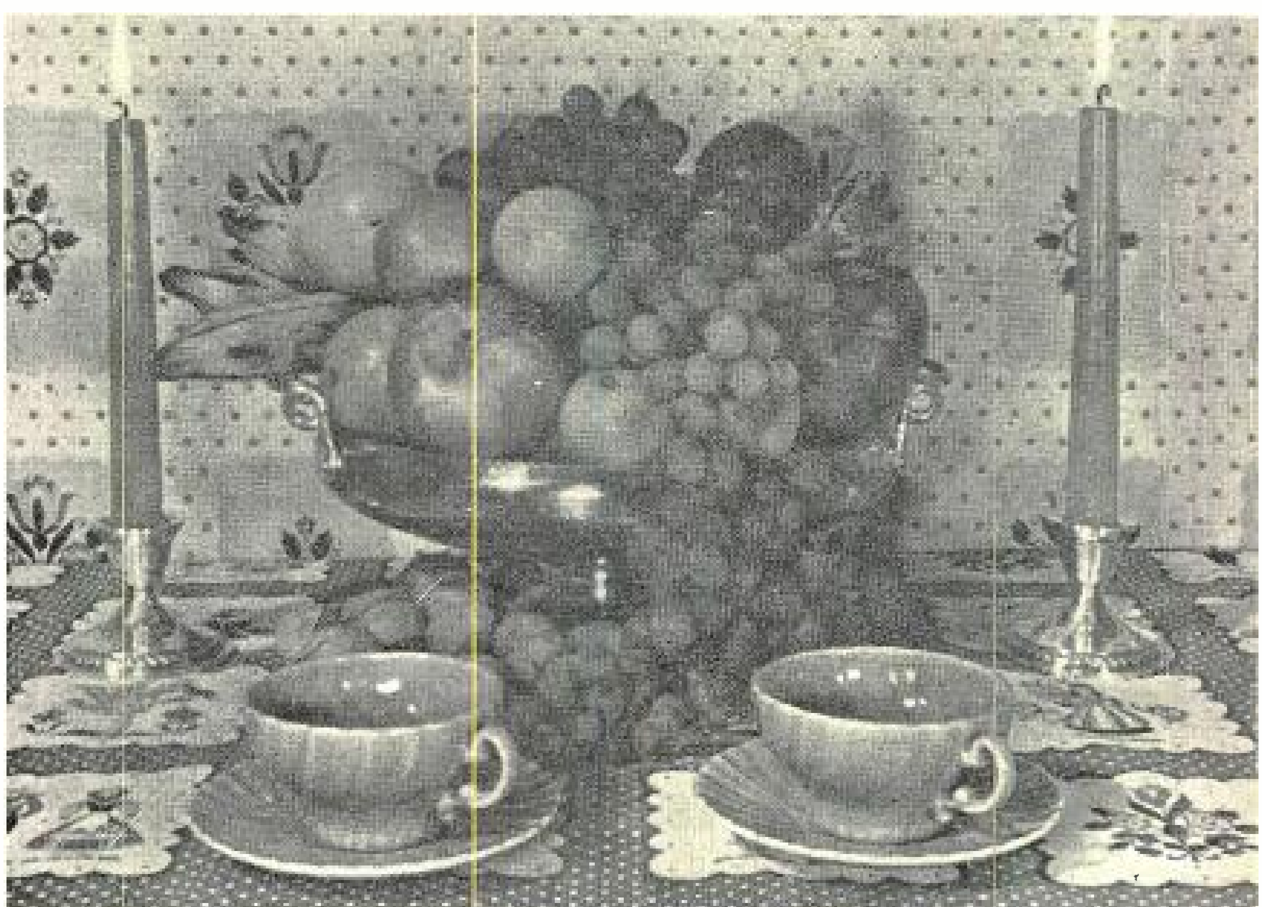

Fig. 3e — Fruit bowl scene for multipath reception (black and white reproduction of Kodachrome slide).

PART VIII

Impulse Noise

Information was sought on the relative susceptibility of the monochrome and the color systems to impulse noise. Special or different handling of impulse noise in one test receiver and not in another would confuse the comparison. Hence in these tests the color receiver served as a monochrome receiver when the chroma circuits were turned off. Random impulse noise generated by an electric pencil eraser was mixed with the RF signals giving definitely noisy reproductions of the boat scene (Fig. 3a). Observers were

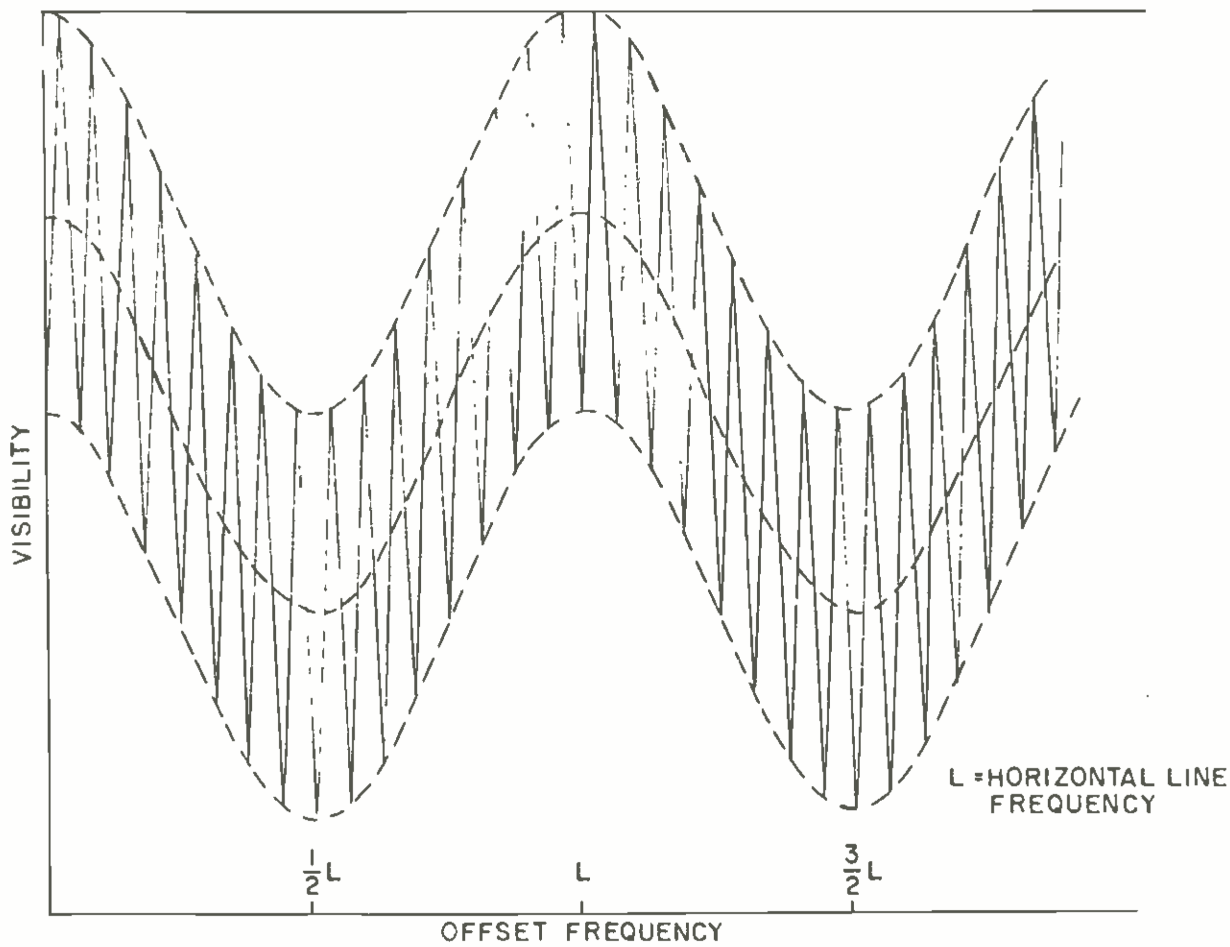

Fig. 4 — Illustrative sketch of visibility of co-channel interference as a function of offset frequency.

shown color and monochrome renditions and then requested to classify their comparison under one of the following headings:

(1) Monochrome deteriorated considerably more than color.
(2) Monochrome deteriorated just noticeably more than color.
(3) Substantially no difference.
(4) Color deteriorated just noticeably more than monochrome.
(5) Color deteriorated considerably more than monochrome.

Four observers registered opinions that the color picture was deteriorated

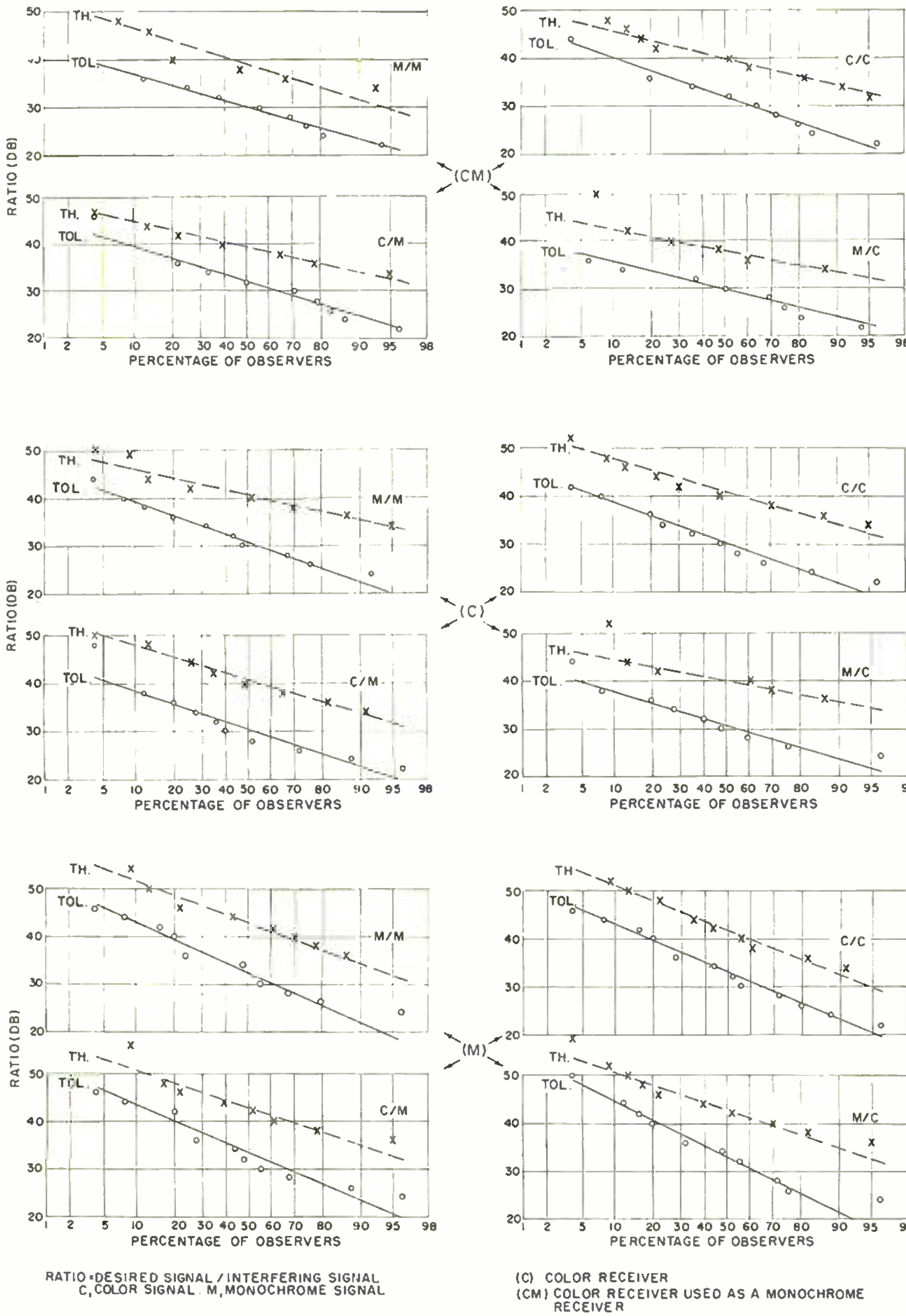

Fig. 5 — Tolerable (Tol.) and Threshold (Th.) values of co-channel interfering television signals as a function of the percentage of observers requiring ratios greater than the ordinate values.

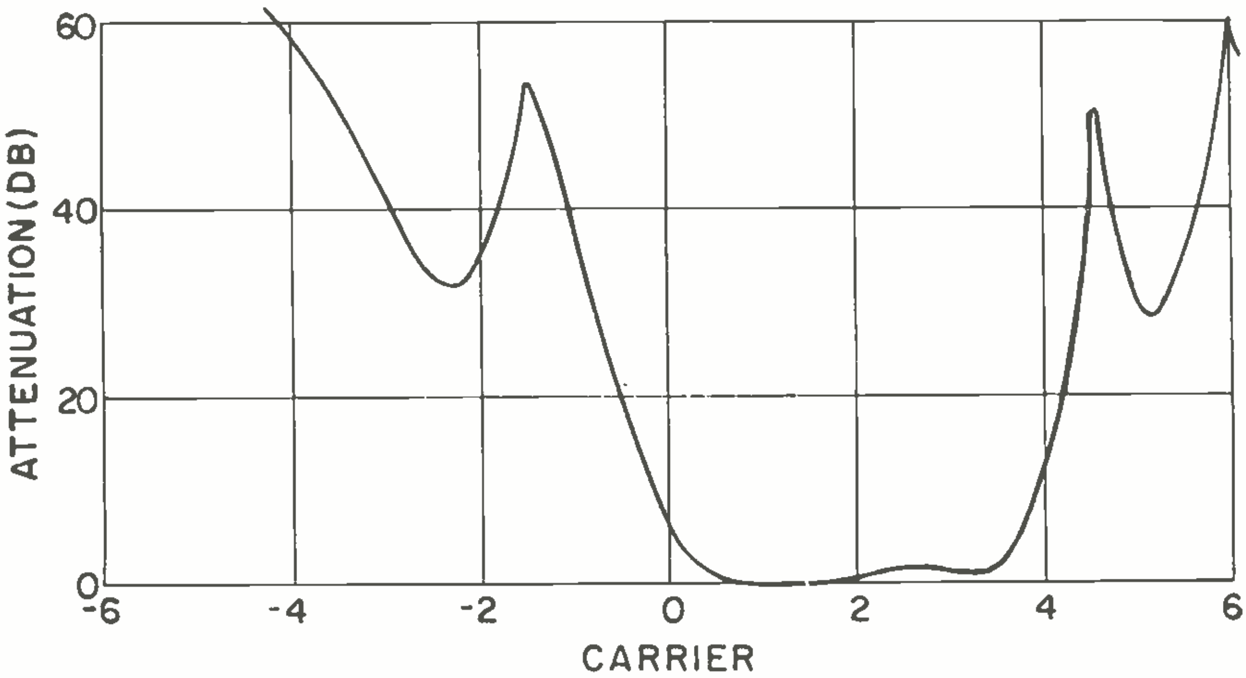

Fig. 6 — Selectivity characteristic of monochrome receiver.

just noticeably more than the monochrome picture; 4 observers reported that the monochrome picture was deteriorated just noticeably more; and 17 observers saw no noticeable difference. The conclusion is that the average observer placed color and monochrome on an equal basis with reference to impulse interference.

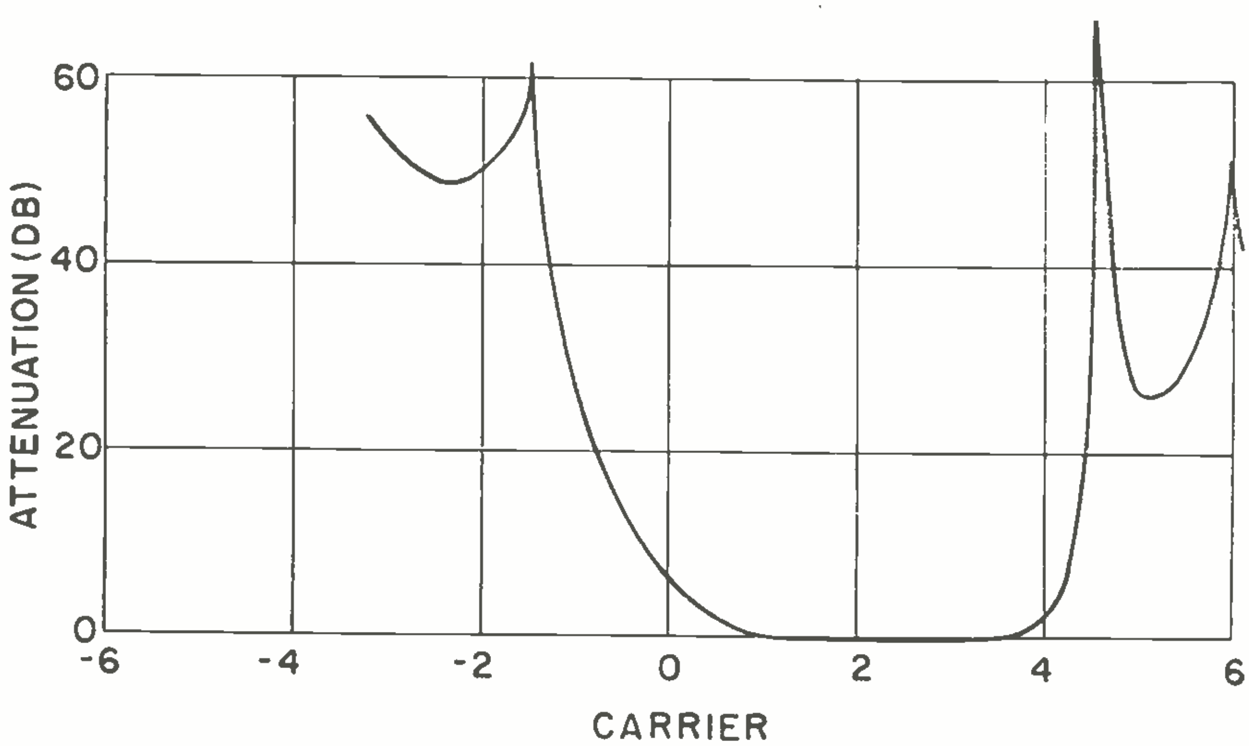

Fig. 7 — Selectivity characteristic of color receiver.

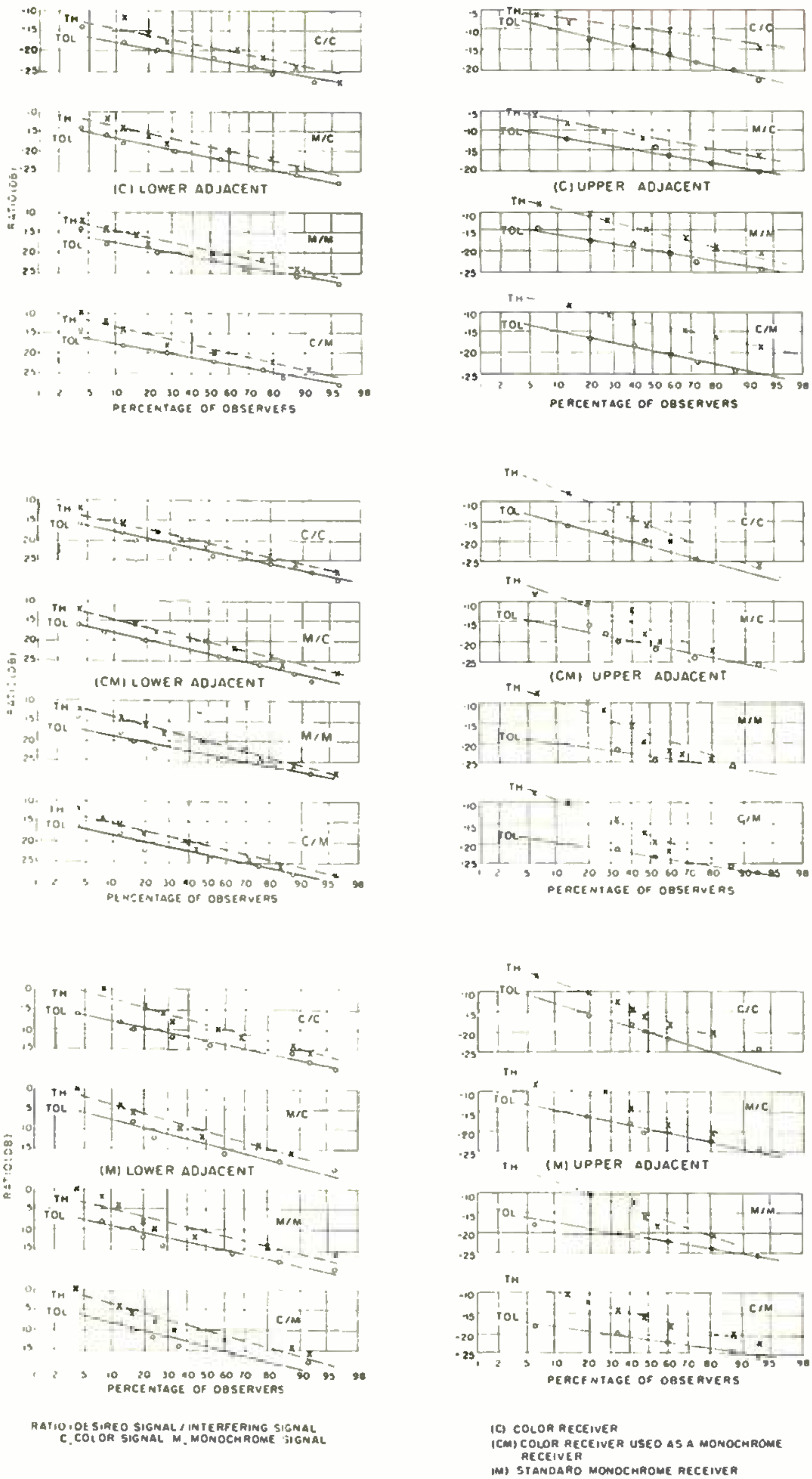

Fig. 8 — Tolerable (Tol.) and Threshold (Th.) values of adjacent channel interfering television signals as a function of the percentage of observers requiring ratios greater than the ordinate values.

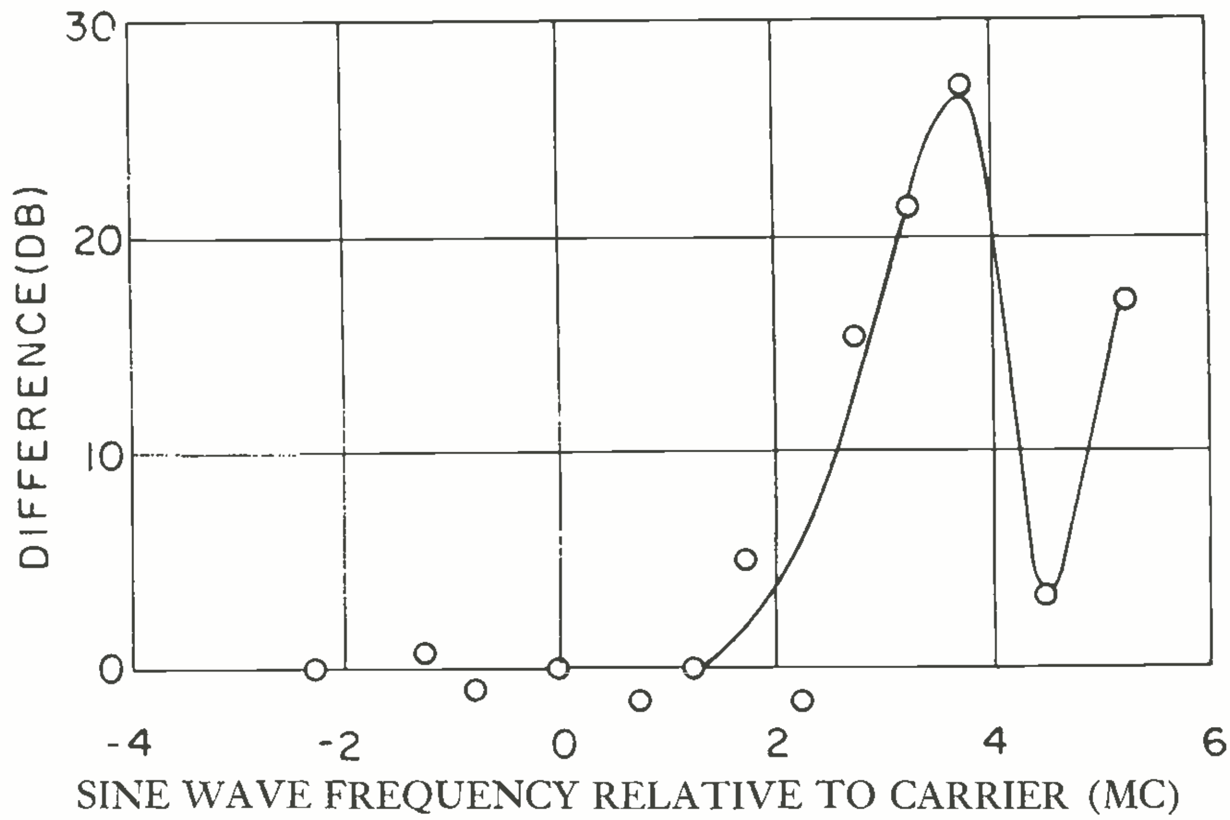

Fig. 9 — Difference between tolerable ratios for sine wave interference for monochrome and color reception as a function of the sine wave frequency. Positive ratio indicates less susceptibility in monochrome.

PART IX

Conclusions

1. Co-channel Interference	Color and monochrome are substantially equally susceptible.
2. Lower Adjacent Channel Interference	Color and monochrome are substantially equally susceptible. Lower adjacent sound signal is predominant cause of interference. Receiver attenuation in lower adjacent channel is a determining factor.
3. Upper Adjacent Channel Interference	Color is somewhat more susceptible than monochrome (6-8 db) in the present tests. Transmitter attenuation in the adjacent channel is the determining factor provided that receiver attenuation for the adjacent picture carrier is sufficient. However, the ratio desired carrier to interfering carrier of —16 db for tolerable interference is well above the ratio of 0 db set by the Federal Communications Commission.
4. Random Noise	Color is only slightly more susceptible to random noise—only about 1 db.
5. Sine Wave Interference	Color is more susceptible to sine wave interference but only in the vicinity of the color subcarrier (see Fig. 9).
6. Multipath	Color is only slightly more susceptible—only about 1-2 db.
7. Impulse Noise	Color and monochrome are substantially equally susceptible.

EXHIBIT 9

TERMINAL EQUIPMENT FOR THE RCA COLOR TELEVISION SYSTEM

TERMINAL EQUIPMENT FOR THE RCA COLOR TELEVISION SYSTEM

Index

APPENDIX

EXHIBIT 9

TERMINAL EQUIPMENT FOR THE RCA COLOR TELEVISION SYSTEM

PART I

Introduction

THIS exhibit describes electronic equipment to produce a color television signal based on the NTSC color field test specifications released February 2, 1953, and to put it "on the air" within a standard 6 megacycle television broadcast channel. It must be emphasized at the beginning that color television equipment, like black and white television equipment, may be arranged in a great variety of ways to achieve any desired degree of operating flexibility. This exhibit is not intended to include the many possible types of operating arrangements, but will be confined mainly to descriptions of the various pieces of basic equipment actually developed, built and field-tested by RCA.

It will be obvious to those familiar with black and white television station operation that many of the basic units to be discussed are subject to minor modifications in design when used in operating arrangements different from the types assumed here. It should also be pointed out that some of the equipment to be described was designed specifically for a field test program and includes some features that would not be necessary in equipment designed specifically for commercial operation. Detailed equipment requirements for broadcast stations and preliminary price estimates are discussed in Appendix A.

PART II

Studio Equipment

Figures 1 and 2 are block diagrams showing the basic units needed in a color television studio arranged in two types of operating systems. The difference between the two figures lies in the switching method employed. Note that in both cases three local signal sources are assumed (two "live pickup" cameras and a flying-spot scanner for color transparencies), and two remote sources. In the arrangement shown in Figure 1, the camera switching is done before multiplexing so that red, green, and blue video lines must be switched simultaneously. This means, of course, that the camera switching system must have triple relays. A separate switching unit is required to mix the studio output with the remote signals since remote signals would normally come in on one line only. In the arrangement shown in Figure 2, each camera chain has its own colorplexer or multiplexing unit so that only one cable is required from each camera chain for connection to the switching system. In this case, an ordinary single-relay switching system may be employed and the remote lines may be fed through the same switching system.

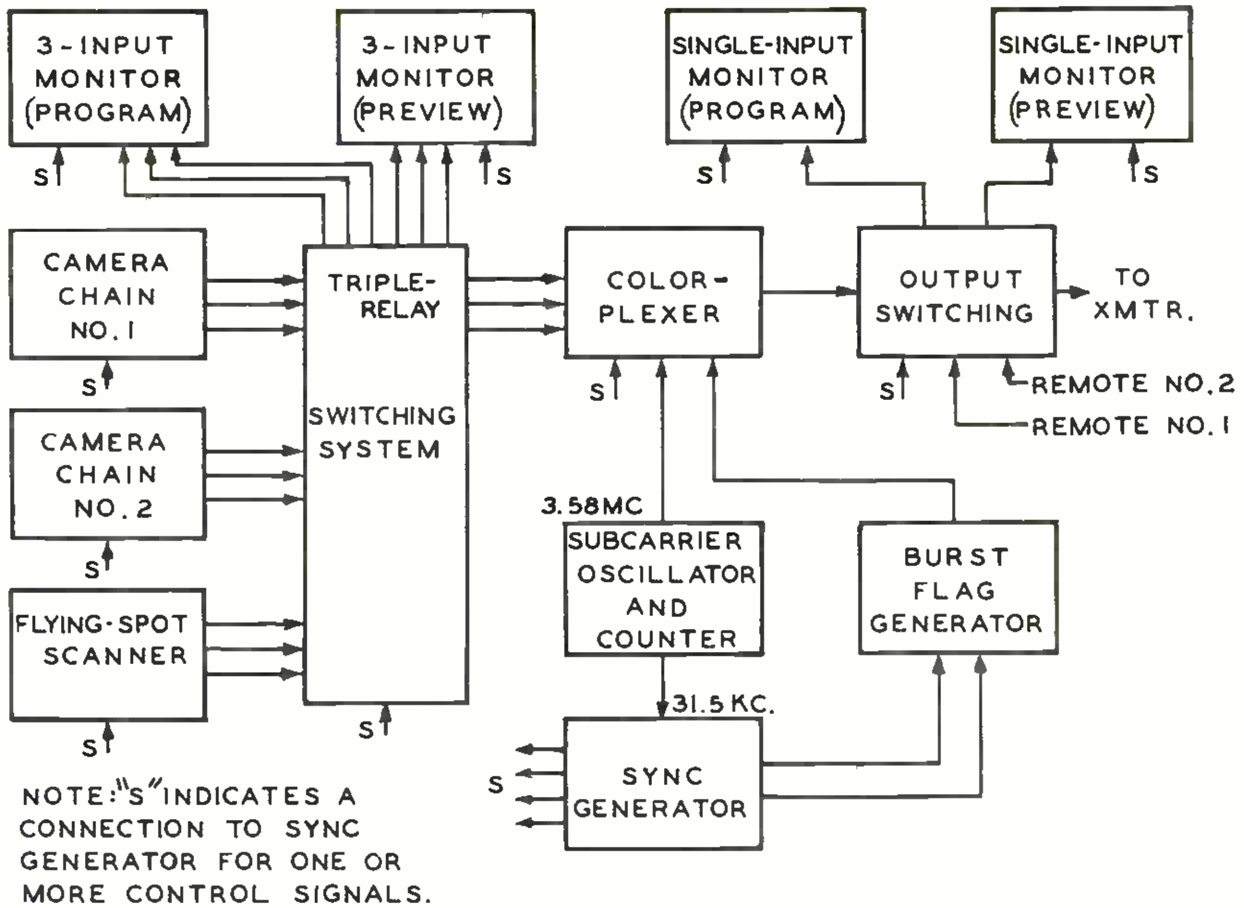

Fig. 1 — Block diagram showing a possible arrangement of color television studio equipment when switching is done before multiplexing.

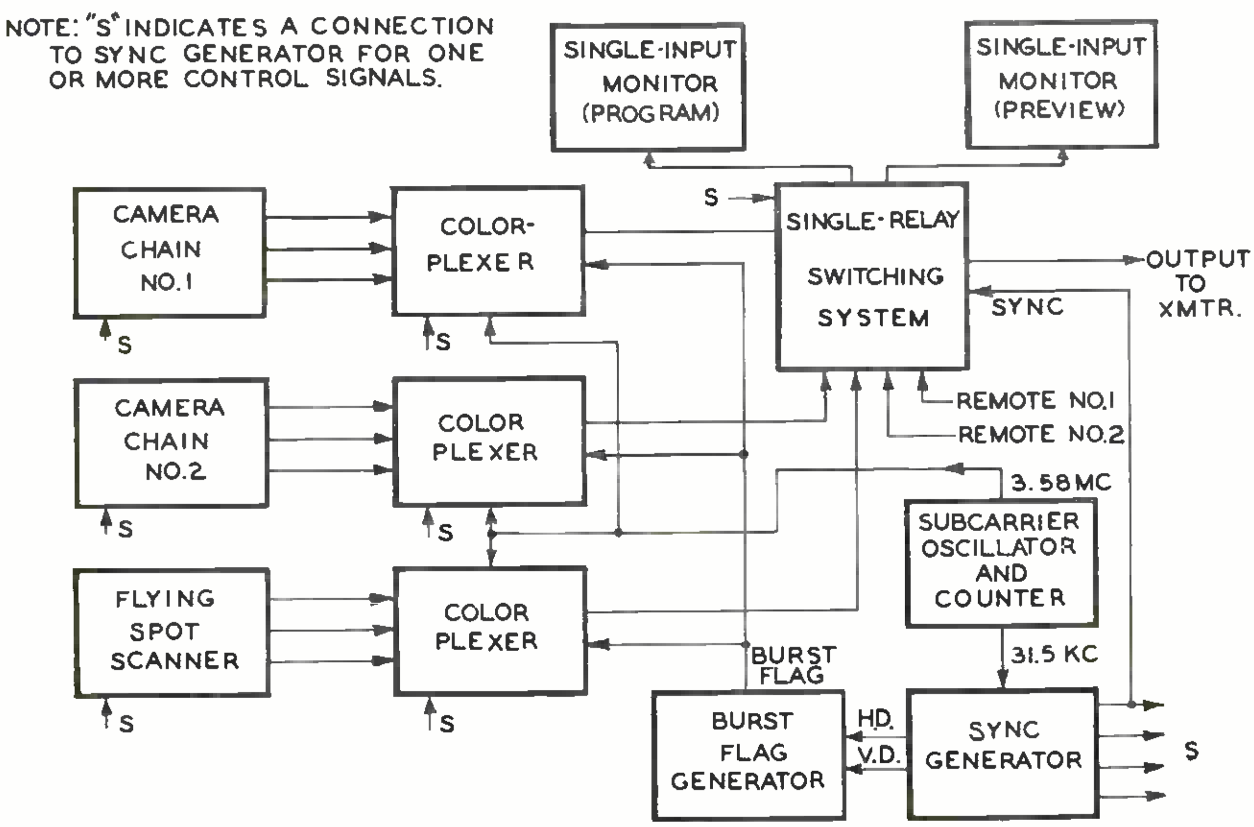

Fig. 2 — Block diagram showing an arrangement of color television studio equipment when switching is done after multiplexing.

The equipment shown in Figures 1 and 2 may be divided into six categories for purposes of this exhibit:

(1) Generators for synchronizing and control signals,

(2) Image orthicon camera chain,

(3) Flying spot scanners,

(4) Switching equipment,

(5) Colorplexers, and

(6) Monitors.

A. Generators for Synchronizing and Control Signals

Six basic signals are needed for the control of cameras, monitors and other units in an RCA color studio. Four of these basic signals are the same as those provided by a conventional synchronizing generator:

(1) Horizontal drive,

(2) Vertical drive,

(3) Blanking, and

(4) Sync.

The other two control signals required for the RCA color system are:

(5) A subcarrier signal locked in to an odd multiple of one-half the line frequency, and

(6) A burst keying pulse occurring in time shortly after each horizontal sync pulse.

1. Subcarrier Oscillator and Counter

The color subcarrier frequency proposed in the NTSC field test signal specifications is 3.579545 mc. Two important considerations influenced the choice of this particular frequency.

In order to utilize the frequency-interlace principle most effectively, it is desirable to make the subcarrier frequency some odd multiple of one-half the line frequency. Also, in order to minimize any possible interaction between the subcarrier and the sound carrier as far as the images are concerned, it is desirable to make the frequency spacing between the subcarrier and the sound carrier equivalent to some odd multiple of one-half the line frequency. The frequency indicated above satisfies both these conditions; 3.579545 mc is 455/2 times the line frequency which is specified as the 286th subharmonic of 4.5 mc (which is the standard spacing between picture and sound carrier frequencies). The line frequency specified in this way is only 0.1% lower than the nominal value of 15,750 cps.

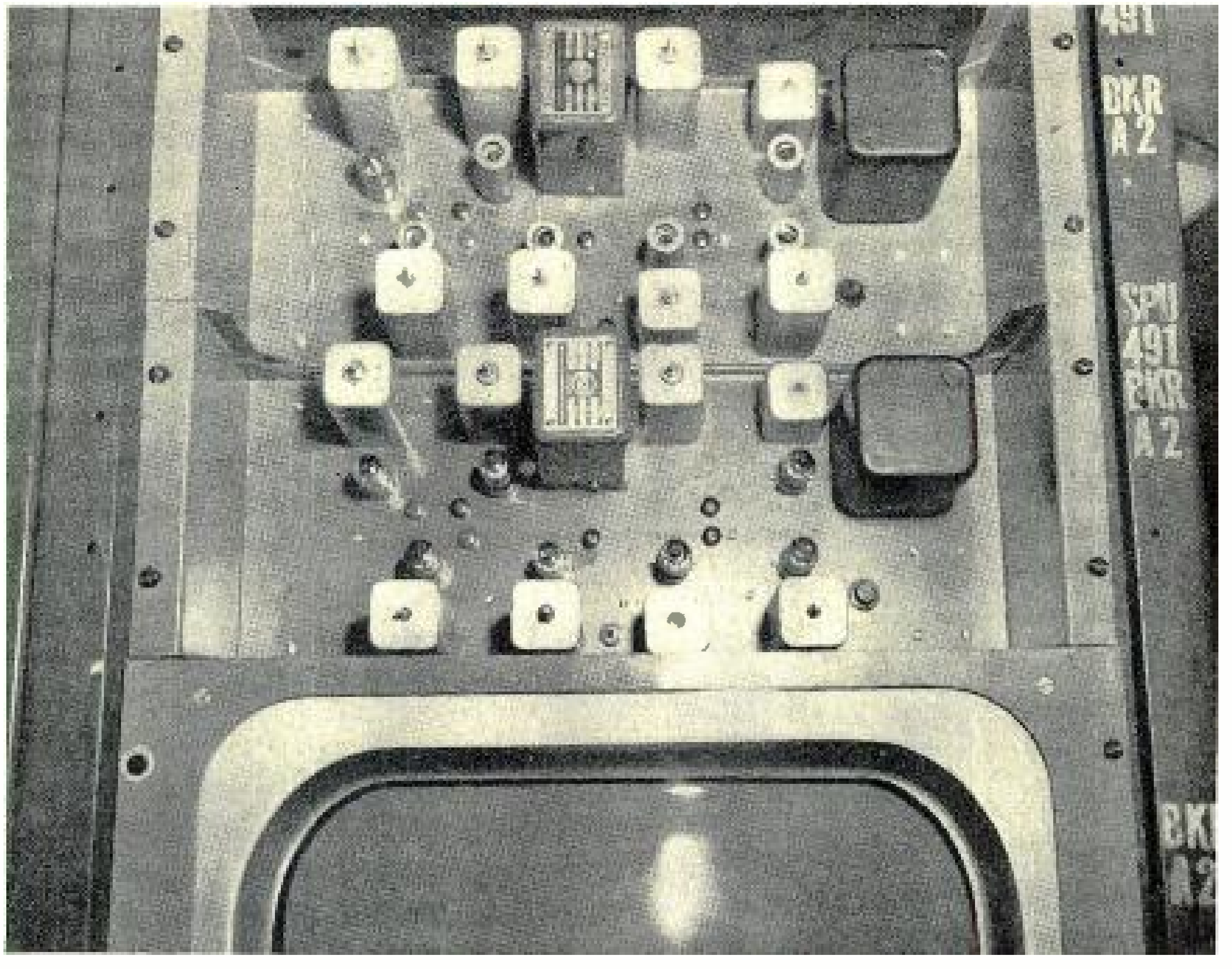

Fig. 3 — Subcarrier oscillator and counter unit (lower chassis). Upper chassis is a similar unit designed for 3.898125 mc.

It has been found that the most practical way to maintain the proper harmonic relationship between the color subcarrier frequency and the scanning signals is by making the subcarrier oscillator the frequency standard of the system and using a counter chain to obtain a 31.5 kc (nominal value) signal to control a standard synchronizing generator. A typical oscillator and counter unit is shown in Figure 3. The crystal of the master oscillator is mounted in a thermostatically controlled oven to insure frequency stability within the ±.0003% tolerance recommended by the NTSC. The operation of the oscillator and counter unit is illustrated by the block diagram in Figure 4. The subcarrier output is obtained from a buffer amplifier to avoid loading of the master oscillator.

A frequency reduction of 455 is obtained by means of three dividing stages which "count down" by factors of five, seven, and thirteen; the dividing stages in the unit illustrated consist of locked-in oscillators. A times-four multiplier is included in the counter chain because the sync generator may be most readily controlled by a 31.5 kc signal (equalizing pulse frequency), which is four times one-half the line frequency. The number 31.5 kc used in the preceding paragraph is nominal only. The precise value is one-tenth of one percent lower.

2. Synchronizing Generator

A standard television synchronizing generator such as the RCA TG-1A shown in Figure 5 may be used in the RCA color television system. The only modification required is the inclusion of an arrangement whereby the 31.5 kc signal from the subcarrier oscillator and counter unit may be substituted for the 31.5 kc signal normally generated within the sync generator itself.

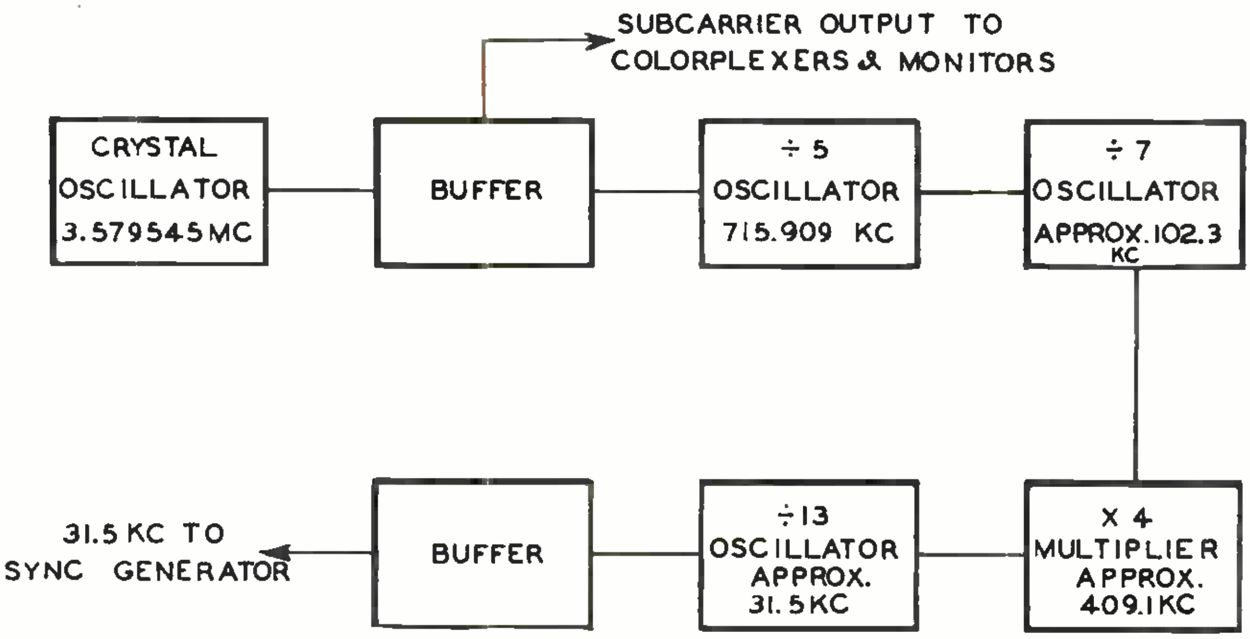

Fig. 4 — Block diagram of a subcarrier oscillator and counter unit.

The frequency control selector switch for the TG-1A includes an "external" position which may be utilized in making this simple modification. The 31.5 kc signal is used (after suitable shaping) to form the equalizing pulses and the serrations in the vertical sync pulses. A two-to-one counter is included in the sync generator to provide a 15,750 cps (nominal value) signal for the horizontal drive, horizontal blanking, and horizontal sync pulses, and a 525-to-one counting chain (operating in steps of seven, five, five, and three) provides the 60 cps signal needed for vertical drive and the vertical portions of the blanking and sync waveforms. Since conventional synchronizing generators have been fully described in the existing literature, no further discussion of them will be undertaken here.

3. Burst Flag Generator

The color synchronizing bursts in the RCA color television system are usually produced by gating circuits located within the colorplexer, the unit which multiplexes the red, green and blue signals to produce a single composite signal for transmission. The burst keying pulse used in such an arrangement is commonly known as a "burst flag", which may be produced by a unit called a burst flag generator.

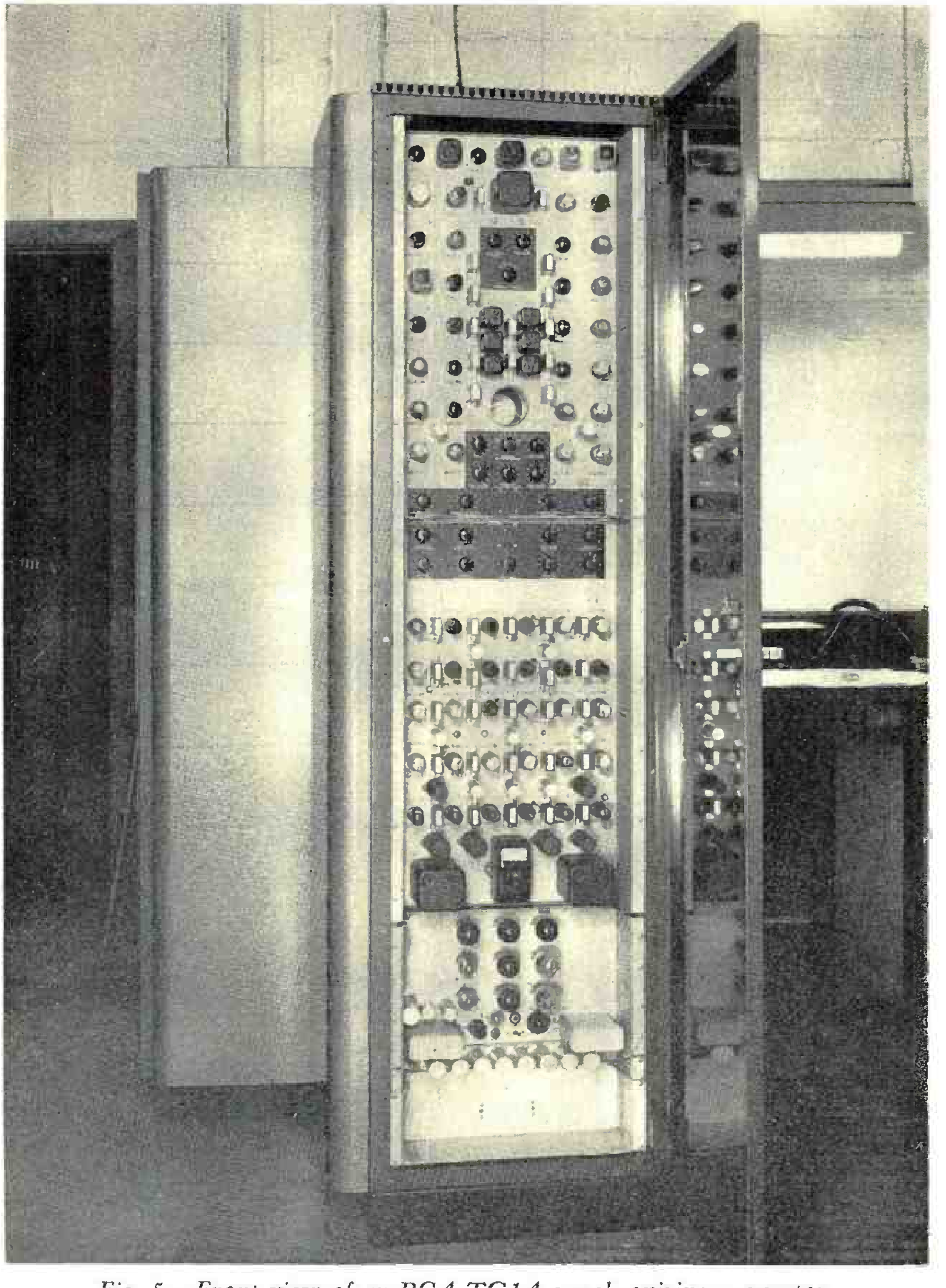

Fig. 5 — Front view of an RCA TG1A synchronizing generator.

A typical burst flag generator is shown in block diagram form in Figure 6. In this circuit basic timing information for the burst flag pulses is obtained from the standard horizontal driving signal. The nine horizontal drive

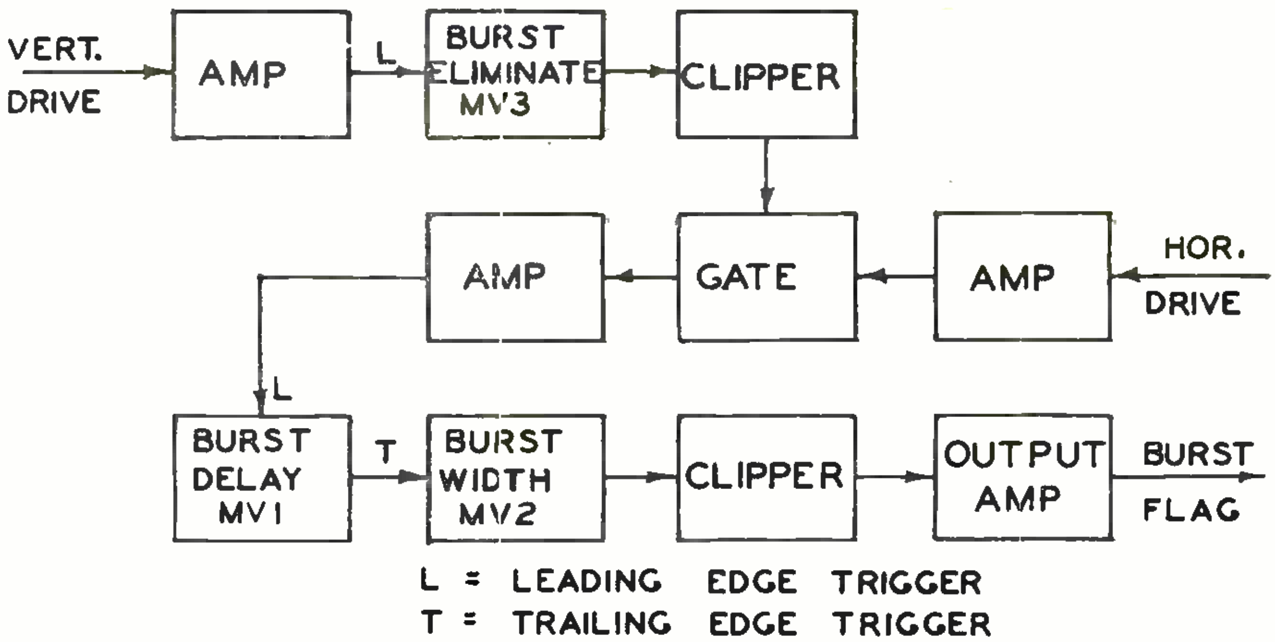

Fig. 6 — Block diagram of a burst flag generator.

pulses that occur during the equalizing pulse and vertical sync intervals are keyed out by means of a 60 cycle pulse of adjustable width derived from vertical drive. This elimination circuit prevents bursts from appearing on top of vertical sync, where they would increase the total amplitude range required for the signal. The leading edges of the remaining horizontal drive pulses are used to trigger a multivibrator whose pulse width can be adjusted to establish the proper timing for the beginning of the burst flag pulses.

The trailing edge of the "burst delay" pulse is used to trigger a second multivibrator whose pulse width is adjusted to conform to the desired burst duration. The physical appearance of a burst flag generator is shown in Figure 7.

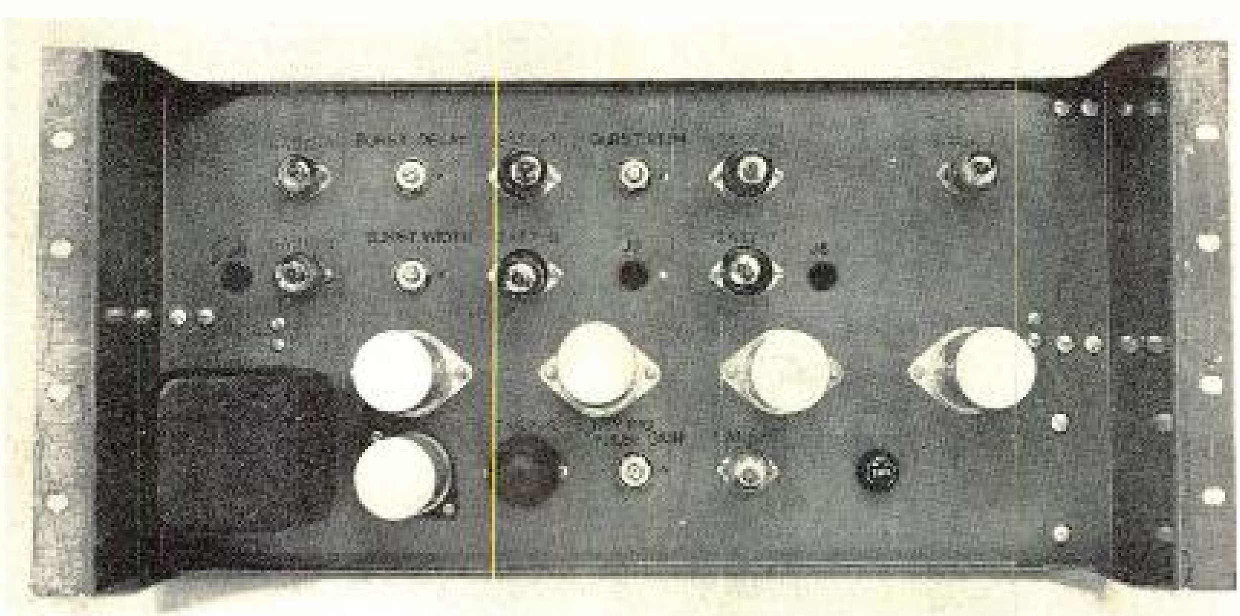

Fig. 7 — Burst flag generator.

B. Image Orthicon Camera Chain

1. Components of the Camera Chain

Live pick-up cameras using three separate image orthicon tubes to provide red, green and blue signals have been developed for the RCA color television system. As in the case of black and white television equipment, a complete camera chain includes a number of electronic units in addition to the camera proper. Figure 8 shows a complete RCA color camera chain, except for power supplies, and indicates the interconnections between the various units.

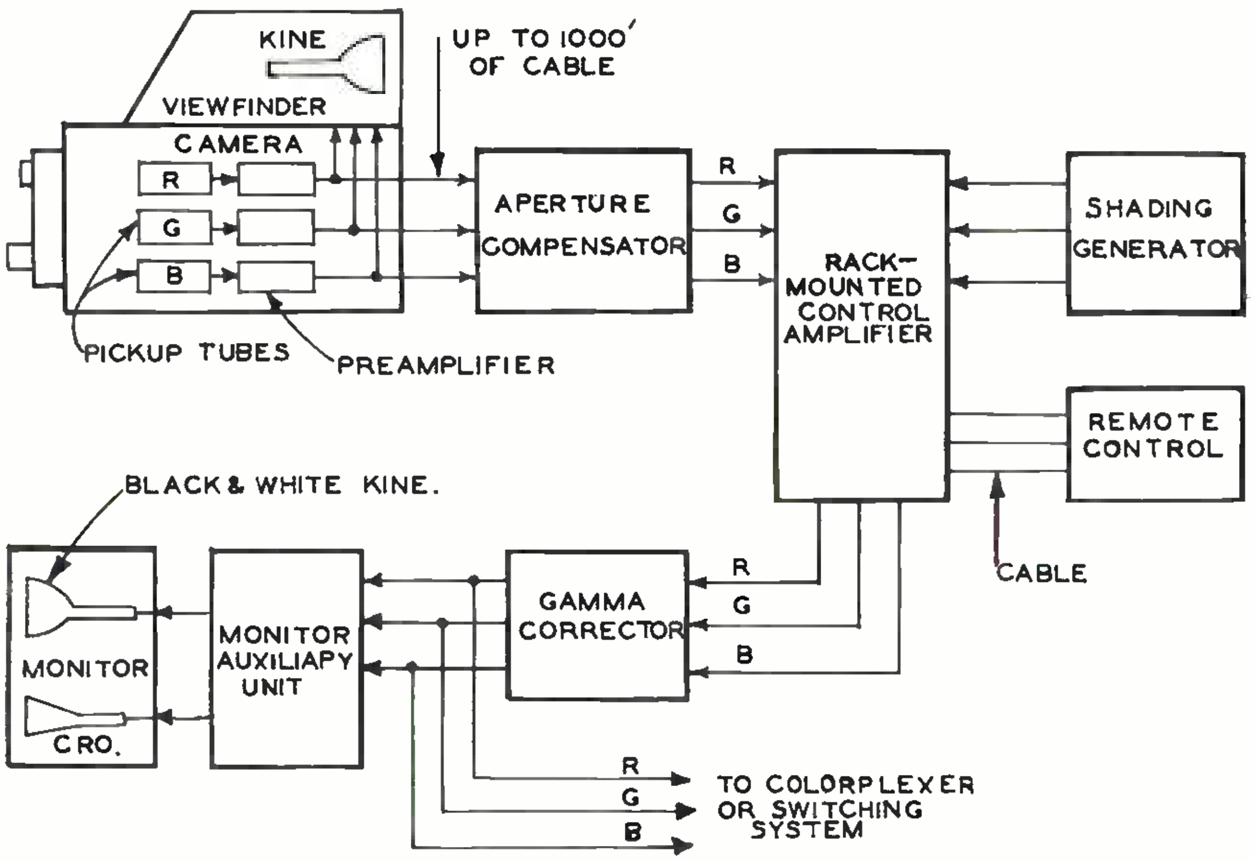

Fig. 8 — Block diagram showing the arrangement of units in an RCA color television camera chain.

The camera proper contains a light splitting optical system, three image orthicon tubes, three video preamplifiers, horizontal and vertical deflection circuits for the image orthicon tubes, and a high voltage power supply. The electronic viewfinder consists of a black and white kinescope with the necessary deflection and video circuits to provide a picture for the camera operator.

The rack-mounted camera control amplifier provides circuits for the preparation of the camera signals for transmission; this amplifier provides shading correction, the insertion of standard blanking pulses, gain control, and pedestal control. Separate units are used for aperture compensation and gamma correction. The important circuits in the camera proper and in the control amplifier may be operated from a remote control position mounted in a standard console section. A standard black and white master monitor, equipped with an auxiliary unit, provides both kinescope and CRO displays of the camera signals for the video operator.

2. Optical System

The heart of the RCA color television camera is the image dividing relay optical system shown in Figure 9. The provision for four different objective lenses of different focal lengths on a rotatable turret gives the program director the same degree of freedom that he enjoys in black and white television in planning his "shots"; focal lengths from 50 mm to 25 inches can be accommodated, and lenses may be changed rapidly by the camera operator by means of a turret handle.

The objective lens in use forms a real image within its associated condenser lens. The image is kept in focus by moving the lens turret along its axis; the condenser lenses revolve with the turret but do not move longitudinally.

A fixed relay lens system is used to transfer the real image within the condenser lens to the photocathodes of the image orthicons. This relay lens system provides the necessary working distance for the dichroic-mirror light splitter, which divides the light roughly into its red, green and blue components.

The dichroic-mirror assembly introduces astigmatism in the light path because the displacement of the light rays by double refraction in passing through the mirrors is different in the horizontal and vertical directions. To correct for this astigmatism, two sheets of optically ground glass are mounted ahead of the relay lenses at the same angle with respect to a vertical axis that the dichroic mirrors are mounted with respect to a horizontal axis.

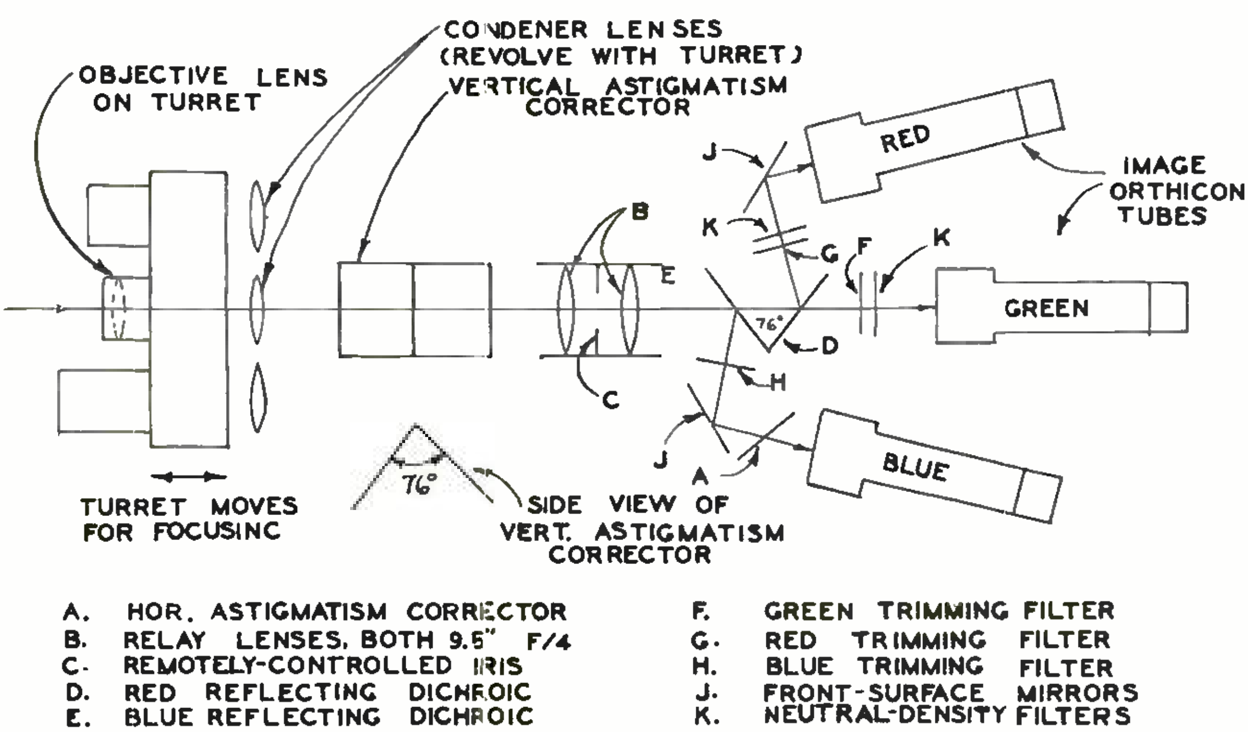

Fig. 9 — Sketch of the optical system used in an RCA three-tube color television camera.

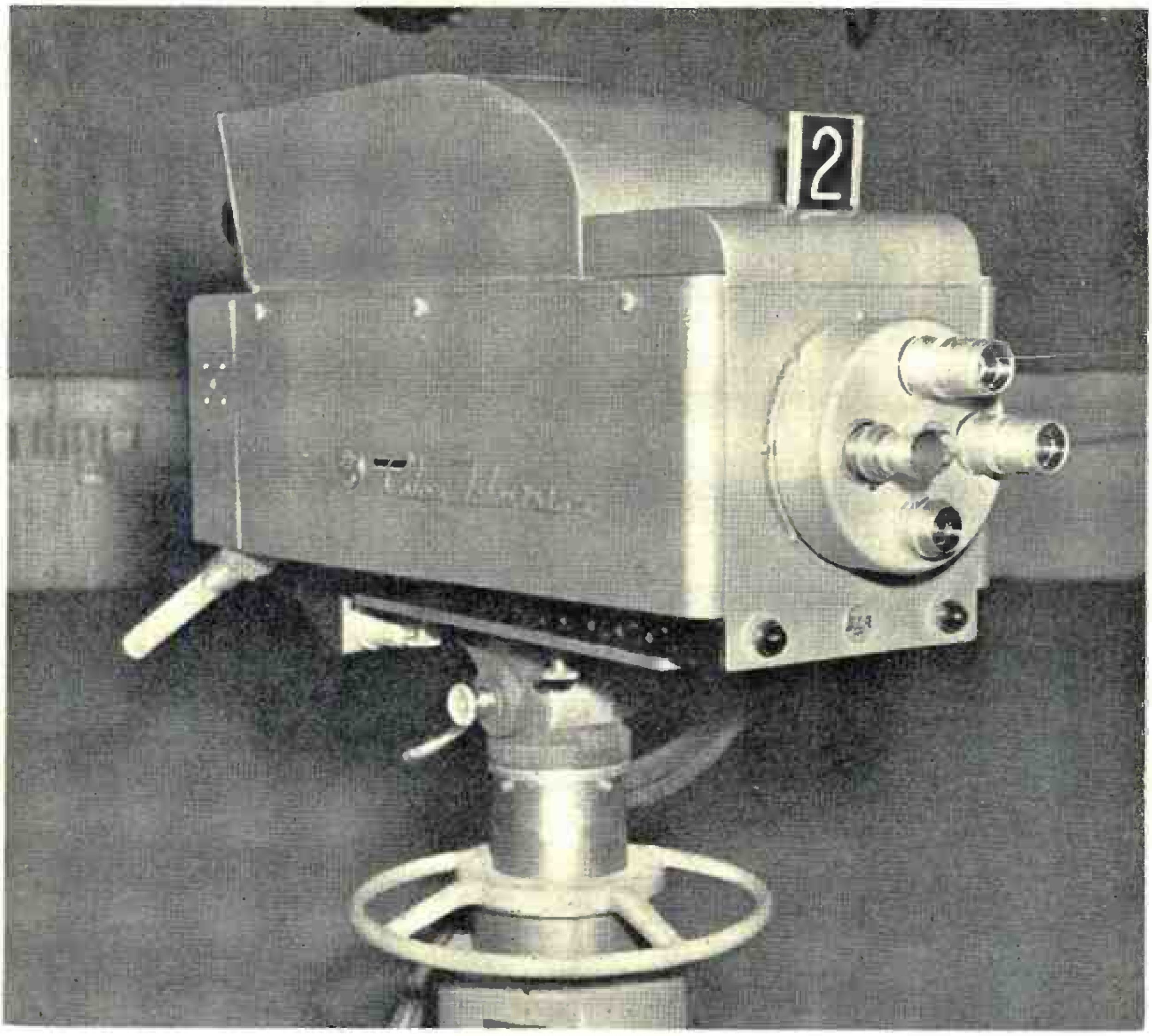

Fig. 10 — RCA three-tube color television camera with viewfinder attached.

It is also necessary to insert a horizontal astigmatism corrector in the blue channel so that the light rays in the red, green, and blue channels may all pass through the same total thickness of glass. All glass surfaces in the optical system are coated to minimize reflections. The remotely controlled iris mounted between the two relay lenses serves as the major overall gain control for the entire camera chain.

A number of light filters are needed in the optical system. Dyed-gelatin or glass trimming filters are used to supplement the selectivity of the dichroic mirrors to achieve the exact spectral sensitivity curves desired for the camera. (The normal spectral sensitivity curve of the Type 1854 image orthicon tubes must also be considered when determining the required spectral characteristics for the trimming filters.) Neutral-density filters are needed to adjust the relative sensitivities of the three pick-up tubes so that they all work over the same portion of their transfer characteristics.

Only two neutral-density filters are needed, since it is only necessary to reduce the sensitivities of two of the channels to match the least sensitive. When the camera is used in a studio illuminated by tungsten lamps, the blue channel is usually the least sensitive (because of the deficiency of blue energy in the light), so neutral-density filters are most commonly used in the red and green channels.

3. CAMERA PROPER

The physical appearance of the camera proper, with viewfinder attached, is shown by the photograph in Figure 10. The camera proper is about 15 inches high and 39 inches long from front panel to rear panel. The width varies from about 16 inches at the front to 21 inches at the rear. The only parts of the optical system that are exposed when the camera doors are closed are the turret control handle (not visible in the photograph) and the lens turret itself.

Optical focus is controlled by twisting one of the handle-bar type control handles which project from the rear of the camera. The same handles are used for the control of panning and tilting motions. The outside of the camera is coated with aluminum paint so as to minimize the absorption of radiant heat energy.

Figure 11 is a photograph of the camera with the side doors open and one of the deflection chassis swung out so as to show the form of construction and the accessibility of all components. The relay optical system is mounted

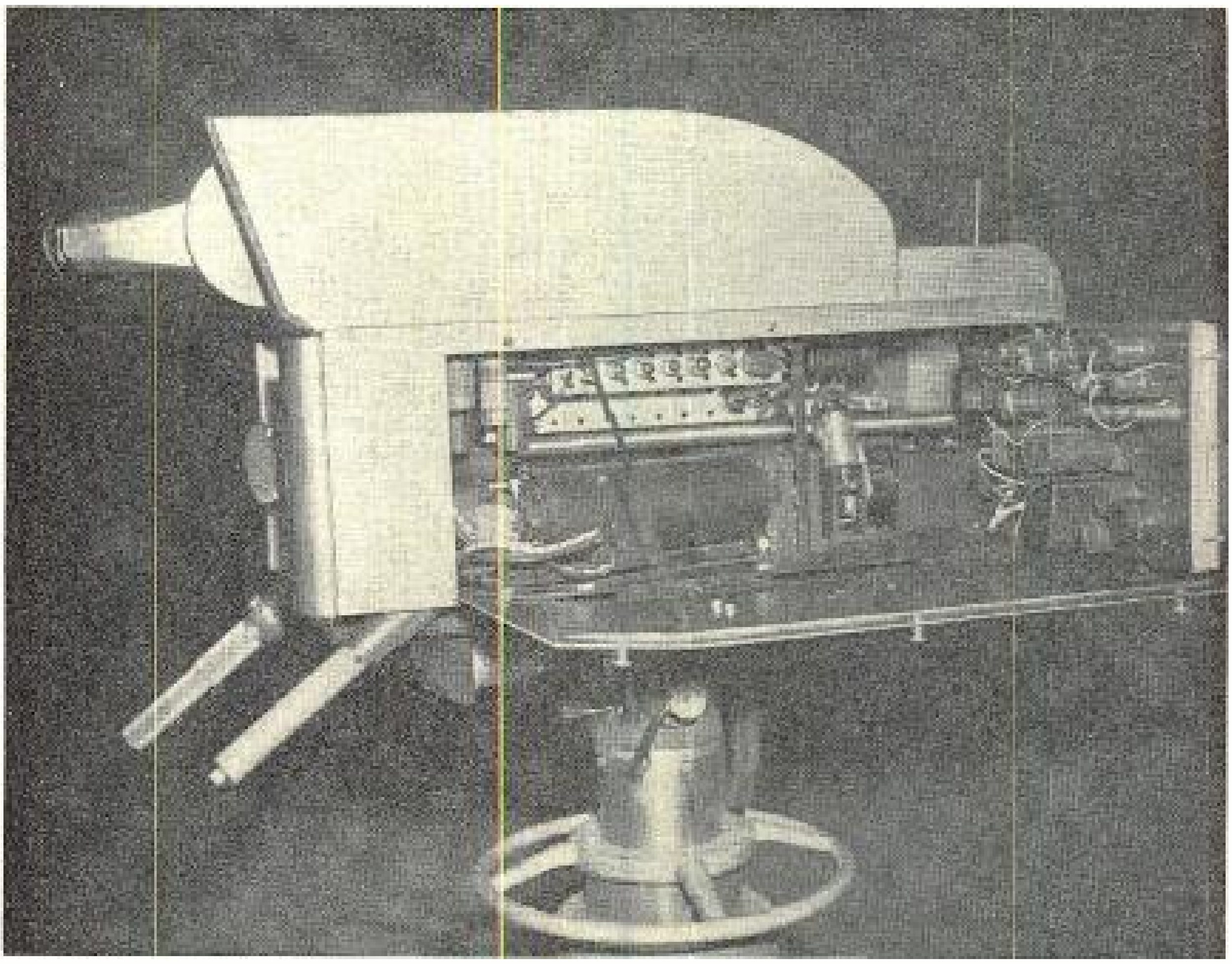

Fig. 11 — RCA color television camera with doors open, showing accessibility of components.

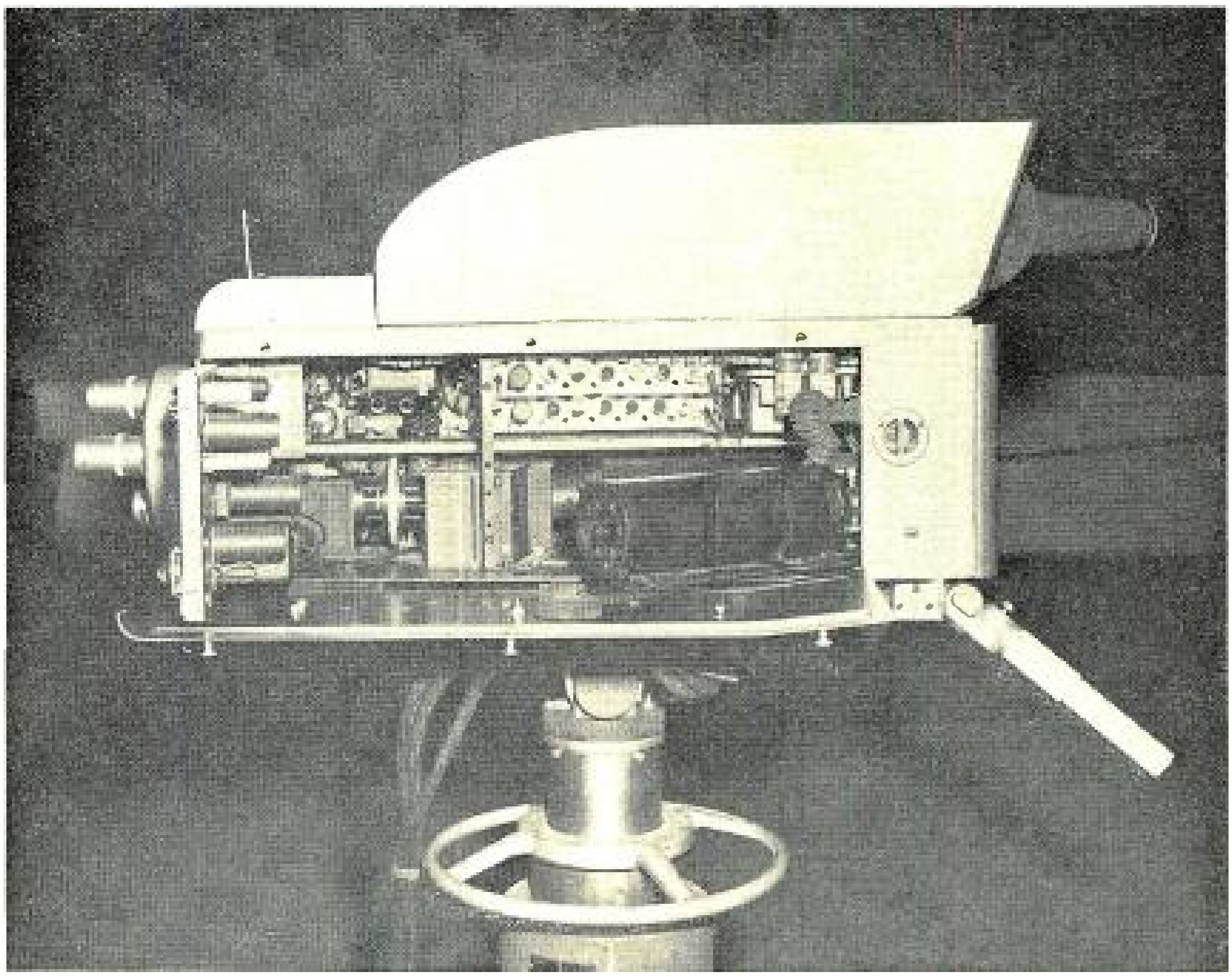

Fig. 12 — RCA color television camera showing one tube assembly swung out for image orthicon replacement. Note flexible hose for blower connection.

on a rigid T-plate, which is in turn mounted directly on the base plate of the camera. The selsyn motor which drives the remotely-controlled iris may be seen in Figure 11. The selsyn transmitter which operates this motor is mounted at the video operator's console position. A potentiometer is coupled to the iris so that its setting may be indicated on a meter at the remote control position. The three image orthicon tubes are mounted within conventional focus and scanning coil assemblies which are located at the rear of the camera. Three separate blowers are used to cool the image orthicon tubes. Cooling air is brought into the socket end of each yoke assembly by means of a flexible hose leading from the blower.

Any of the image orthicon tubes may be quickly replaced by swinging the entire tube and yoke assembly out the side of the camera, as shown in Figure 12, and then withdrawing the tube from the front of the yoke. The middle assembly may be swung out the left side when the outside assembly is first swung to its extreme outward position, while the third assembly is accessible from the right side of the camera.

The tube and yoke assemblies are locked in place against accurately machined V-blocks during normal operation. When the image orthicon assemblies are in normal operating position, the entire optical system is light shielded so that the camera may be operated with the side doors open.

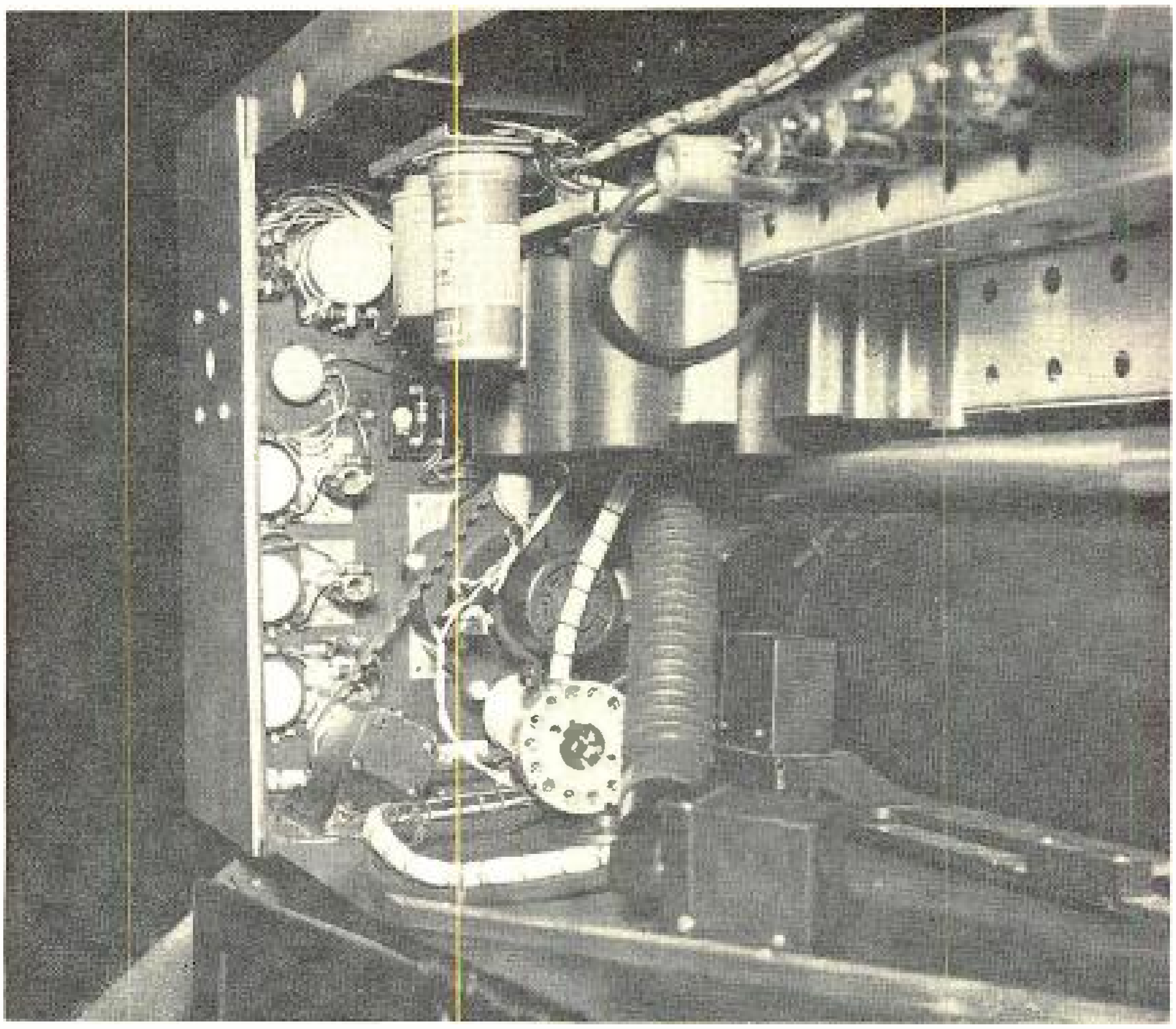

Fig. 13 — Close-up view of inside rear of RCA color television camera, showing focus control linkage.

All electronic components in the camera are readily accessible for servicing. The vertical deflection circuits are mounted on a hinged chassis on the left side of the camera. This chassis may be swung outward to expose the tubes and larger components (and incidentally to obtain access to the optical system), and may be left in position to gain access to the smaller components and the wiring (see Figure 12).

The horizontal deflection circuits and the high voltage power supply are mounted on a similar hinged chassis on the right side of the camera as shown in Figure 11. The video preamplifiers, mounted above the image orthicon tubes, are plug-in units that may readily be removed for replacement or servicing. A few miscellaneous electronic components are mounted on a shelf assembly at the rear of the camera which is quite accessible when the viewfinder is removed.

The long shaft which may be seen in Figures 11 and 12 extending down the center of the camera is the turret control shaft. It actually consists of two parts — an outer sleeve which does not revolve but moves longitudinally to control the focussing action, and an inner shaft which is controlled by the indexing handle at the rear of the camera to rotate the turret and the condenser lens assembly. Part of the mechanical linkage which provides coupling between the focus control and the outer sleeve of the turret control shaft is shown in Figure 13. The rotational movement of one of the panning handles is coupled to a lead screw by means of a set of beveled gears and a toothed belt and pulley arrangement. This lead screw in turn imparts a longitudinal movement to the outer sleeve of the turret control shaft. (In some models of the camera, the focus control consists of a crank type knob mounted on one side of the camera.)

Details of the turret itself are shown in Figure 14. The turret, shown at the extreme right, rotates over a stationary drum which serves as a light trap. Detents are used to lock the turret into any one of its four operating positions. The "spider" shown within the light-shielding drum on the left hand side of the photograph is used to mount the condenser lenses.

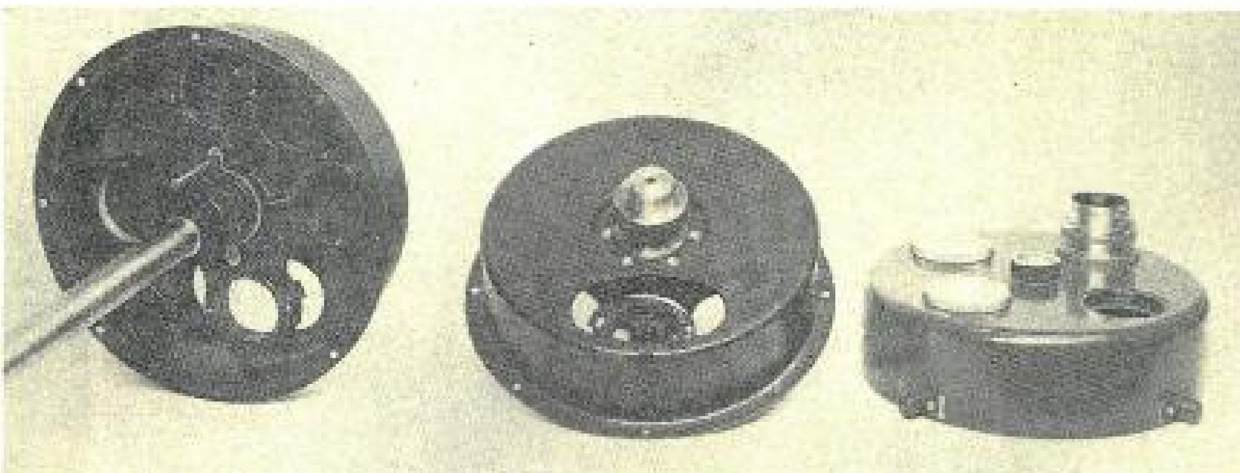

Fig. 14 — Lens turret assembly for a color television camera.

4. Registration Controls

Both optical and electrical adjustments are provided to permit the camera operator to achieve good registration of the three images. The relative positions of all components in the optical system are adjustable, and the individual tube assemblies are fitted with limited-range adjustments of longitudinal position to insure that all three primary images are brought to a focus simultaneously. To simplify electrical registration adjustments, the three deflection yokes are driven in parallel from common deflection circuits.

To compensate for manufacturing tolerances in yokes and other components, the following electrical registration controls are provided: independent centering controls for the three tubes, independent height controls, independent width controls, and independent skew controls for the red and blue channels.

The individual size controls (height and width) consist of small impedances in series with the respective deflection coils; overall size controls vary the amplitudes of the saw-tooth waveforms applied to the common deflection circuits.

Skew controls are needed to correct for the tendency of some yokes to

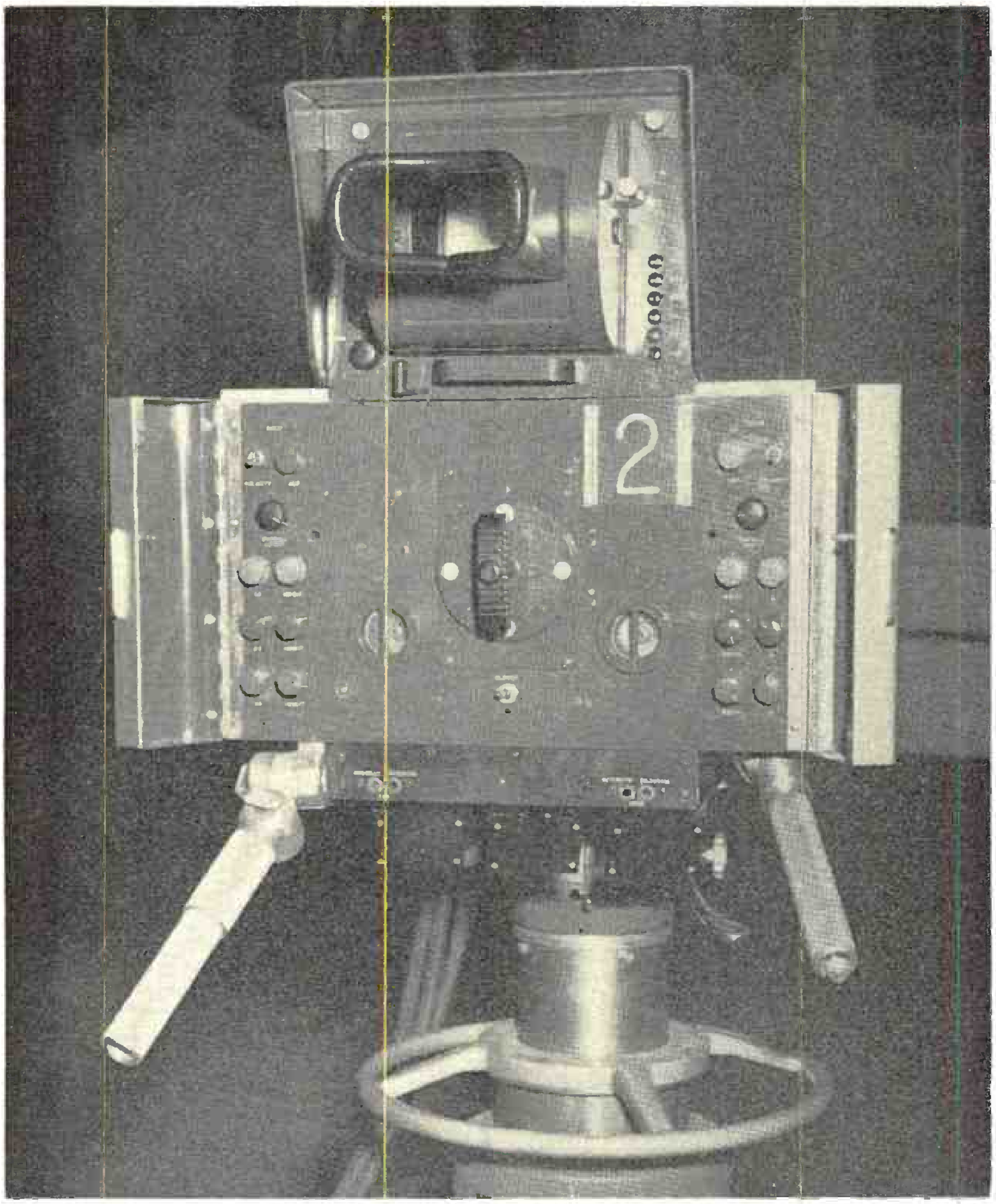

Fig. 15 — Rear view of an RCA color television camera, showing electrical controls.

produce rasters which are slightly rhombic instead of perfectly rectangular. Skew correction is provided by feeding a very small amount of vertical-frequency saw-tooth current into the horizontal deflection circuits. In making registration adjustments, the green raster is arbitrarily chosen as a reference and the others are made to match it for size, skew and relative position.

The operating controls on the back panel of the camera are shown in Figure 15. The size and skew controls are manipulated by the camera operator during the initial set-up process. The "G5" controls at the left control the potentials on the decelerator electrodes in the image orthicons. The Q controls at the right are series resistors in the horizontal yoke circuits which must be adjusted in conjunction with the width controls (which are series inductances) to maintain uniform linearity. During normal operation these electrical controls are protected by hinged covers; the camera operator is required only to move the camera, to select the proper lens, and to keep the picture in optical focus during normal operation. The electronic viewfinder which mounts above the camera proper has control knobs at the rear for focus, brightness, and contrast.

The push-buttons at the right enable the camera operator to view any channel separately, to view the red or blue image superimposed on green, or to view all three images superimposed. The latter positions are useful for registration adjustments. All presentations are in black and white only. Figure 15 also shows the turret indexing handle, a pair of intercom jacks for the headsets of the camera and dolly operators, the blower control switch, and two of the air intakes for the blowers which circulate cooling air to the yoke assemblies and all other parts of the camera.

5. Aperture Compensator

The video preamplifiers located within the camera proper amplify the output signals from the image orthicon tubes up to a level of approximately

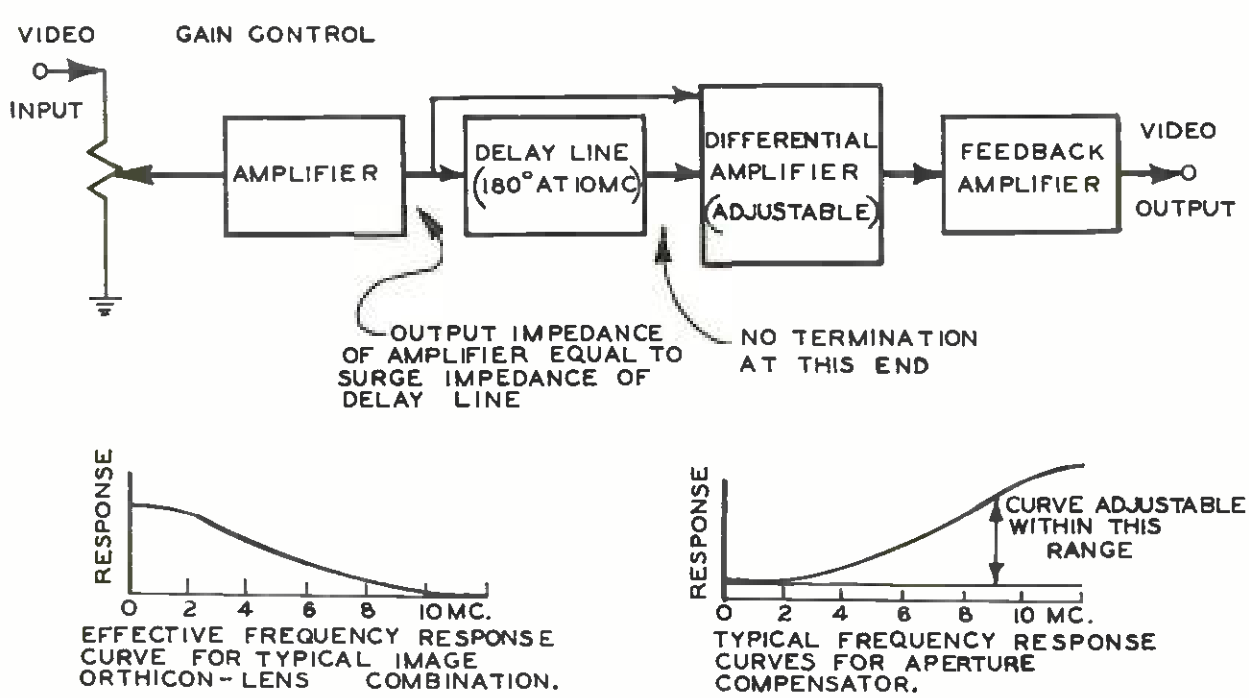

Fig. 16 — Block diagram of constant delay line aperture compensator.

.3 volt. At the control room end of the camera cable, the three video signals are applied to an aperture compensator which provides adjustable high frequency peaking. The need for aperture compensation is illustrated by the effective frequency response curve shown at the lower left in Figure 16.

The response characteristic of any television pick-up device tends to fall off rather rapidly at high frequencies (corresponding to fine detail in the image) both because of the limited resolution capabilities of even the best optical lenses and because of the finite size of the scanning aperture. This falling response characteristic is present even when the electrical circuits associated with the camera have flat response out to 8 mc or more. These same finite-aperture effects cause an effective loss in vertical resolution as well as in horizontal resolution, but little can be done to correct this situation because the number of scanning lines is fixed by the scanning standards. It is possible, however, to improve the response as far as horizontal resolution is concerned by providing some form of electrical high peaking which compensates for the falling response inherent in the image producing and scanning process.

The curve at the lower right in Figure 16 shows typical response curves for one channel of the aperture compensator used in the RCA color television camera. A simplified block diagram for one channel of this unit is shown in the upper part of Figure 16. Each channel utilizes a "constant delay line" compensation circuit which provides high frequency amplitude boost with linear phase shift over the entire video band.

This circuit utilizes a small section of open-circuited artificial transmission line. As indicated on the diagram, the length of this line is adjusted to correspond to 180 degrees at 10 mc, which is the frequency considered optimum for maximum boost. It is an interesting characteristic of such an

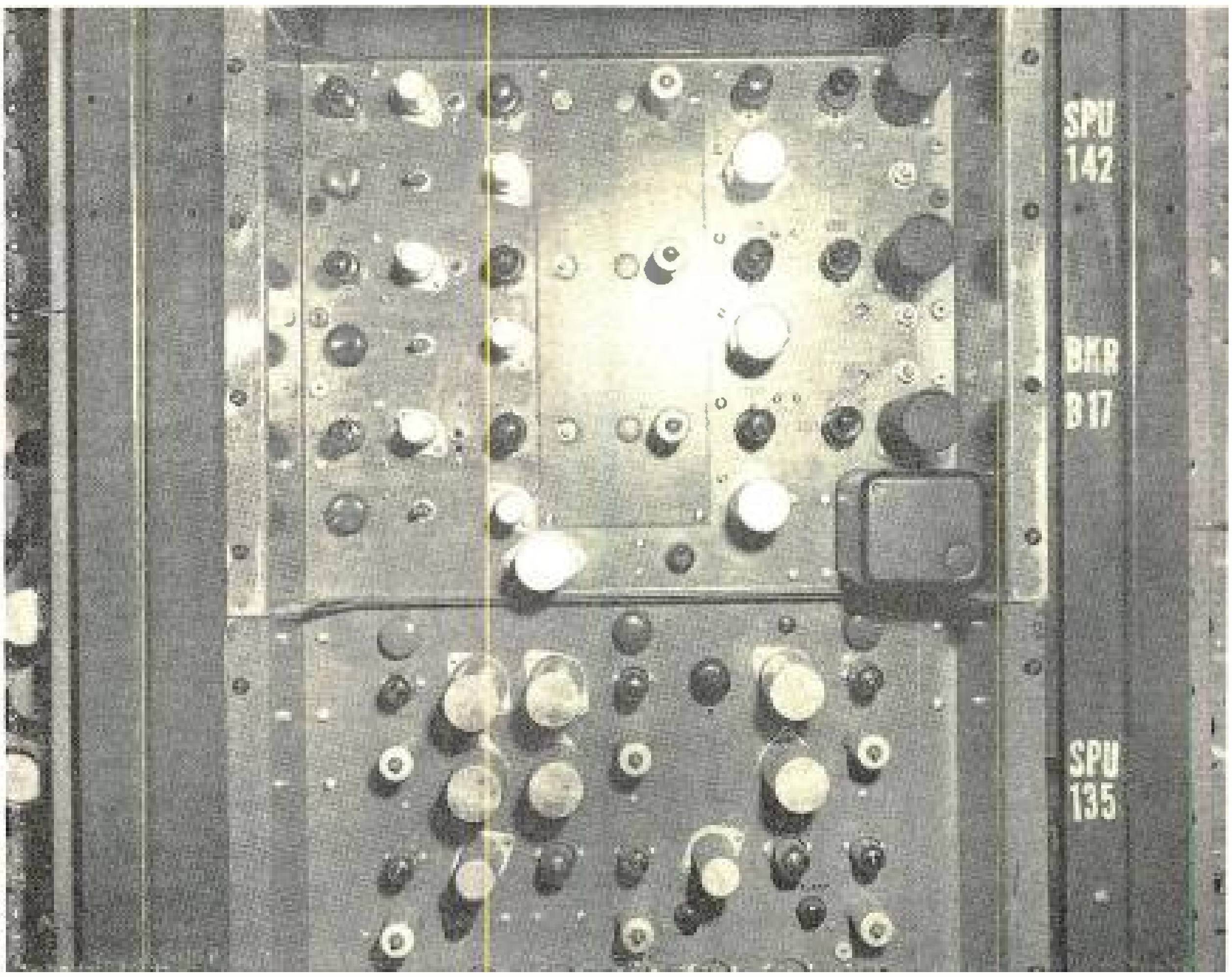

Fig. 17 — Three-channel aperture compensator (upper chassis).

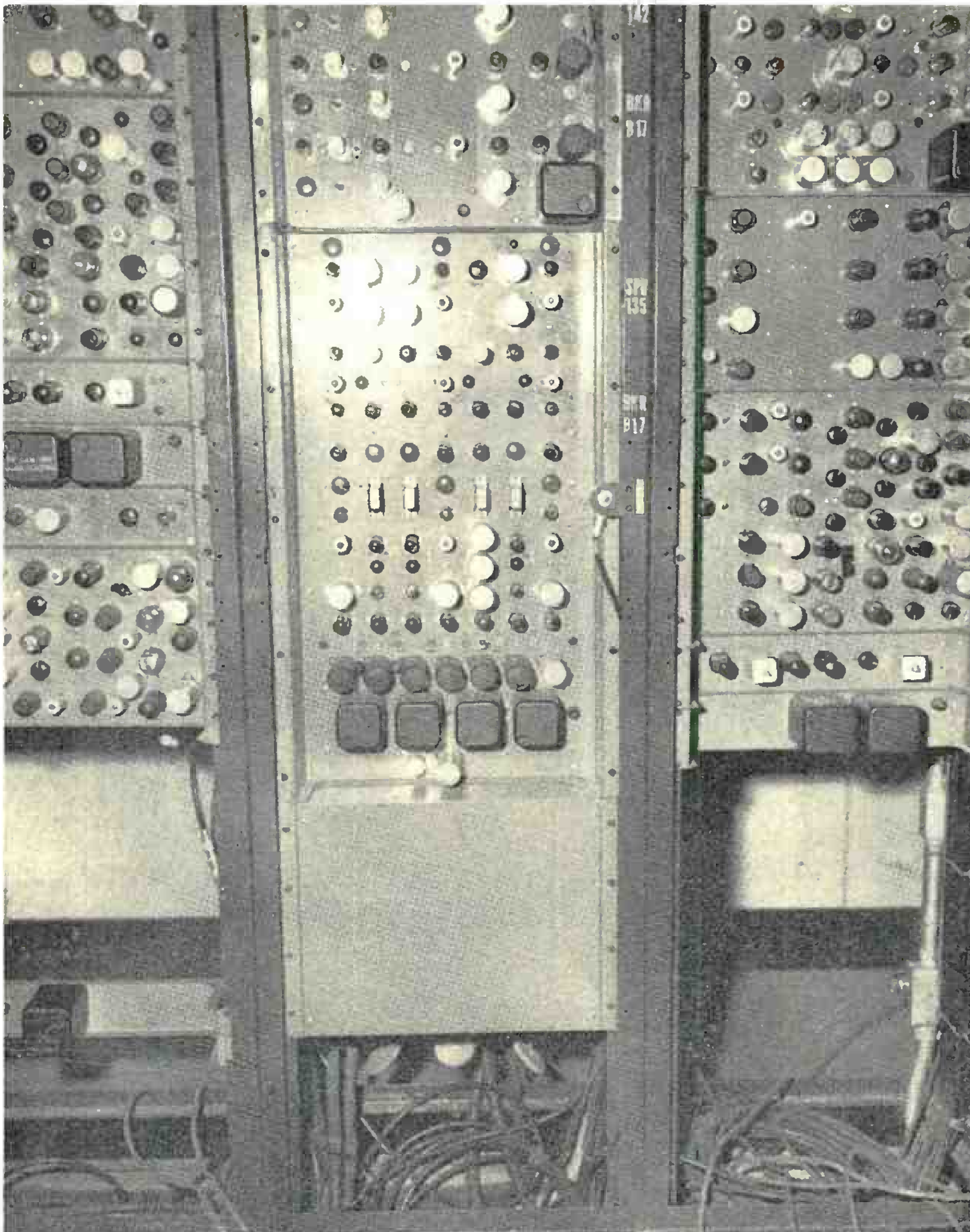

Fig. 18 — A rack-mounted camera control amplifier (lower two-thirds of middle rack).

open-circuited delay line that the voltages appearing at the two ends are always of the same phase but differ in amplitude as a function of frequency. The voltage at the unterminated end of the delay line tends to remain constant with frequency but the voltage at the input end of the delay line varies with frequency because of the action of the reflected signal from the unterminated end. The voltages from the two ends of the delay line are subtracted in a differential amplifier which is adjusted so that the cancellation never reaches zero.

By controlling the relative gains of the two parts of the differential amplifier, the amount of high frequency boost can be adjusted over a wide range. The circuit is capable of providing a boost of approximately ten-to-one at 10 mc. The amount of boost that can be used in practice is usually limited either by noise or by excessive amplification of the spurious signal that results from the target mesh in the image orthicon tube. A two-tube feedback amplifier applies the output of the high boost circuit to the output terminal of the unit.

The gain control in the aperture compensator is normally adjusted for unity gain so that no change in level occurs when the aperture compensator is switched in or out. A photograph of a three-channel aperture compensator is shown in Figure 17.

6. Camera Control Amplifier

Figure 18 is a photograph of a rack-mounted camera control amplifier. The functions performed by this unit are shown by the block diagram in

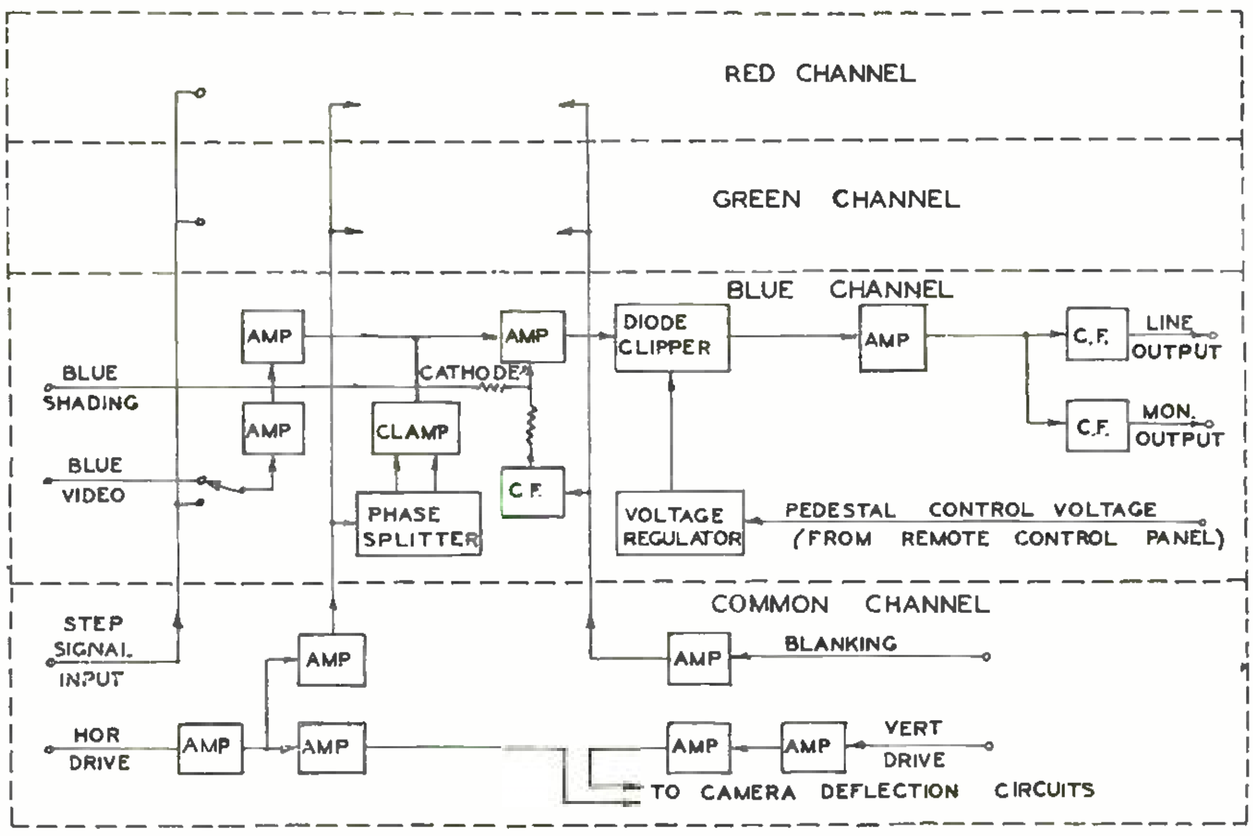

Fig. 19 — Block diagram showing functions of a color television camera control amplifier.

Figure 19. Most of the stages are used for operations on the video signals provided by the camera through the aperture compensator, but several tube sections are used to amplify the horizontal and vertical driving signals for transmission up the camera cable to operate the camera deflection circuits.

Each of the three video signals is amplified, mixed with a shading signal

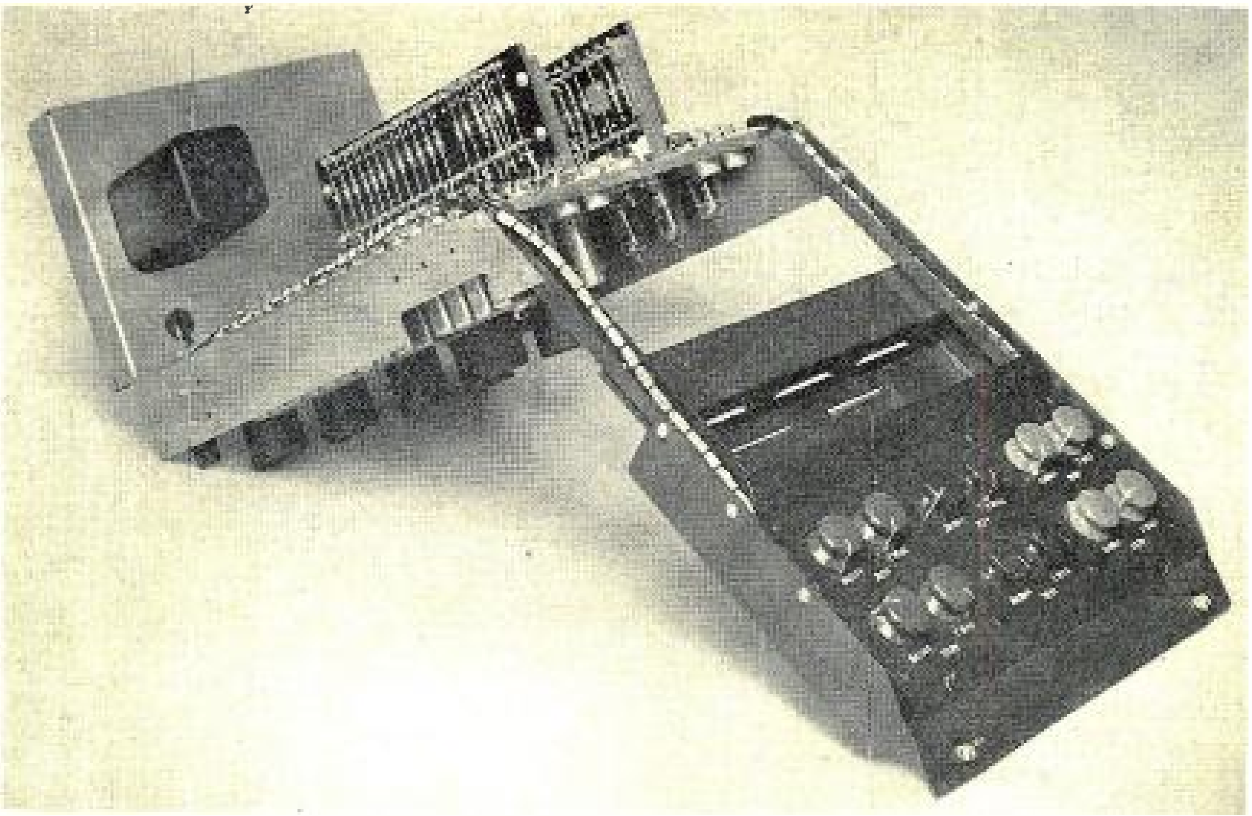

Fig. 20 — Shading generator.

to correct for non-uniformities in the pick-up tube, mixed with blanking, and clipped to provide a noise-free blanking interval for the later insertion of synchronizing information. The second video stage includes an adjustable high-peaker that may be used to compensate for losses in long lengths of camera cable. This high peaking operation is independent of the aperture compensation discussed previously. Cables to the camera proper and to the remote control panel are terminated in the panel space immediately below the camera control amplifier, as shown in Figure 18.

7. Shading Generator

The shading correction signals are provided by a special unit which is mounted in the bottom section of the console housing which supports the remote control panel. This unit provides horizontal-frequency and vertical-frequency parabolic, and saw-tooth waveforms of either polarity and of adjustable amplitude. Three independent outputs are provided — one for each color channel. A photograph of the shading generator is shown in Figure 20. The shading controls are mounted in the sloping portion of the console shelf.

8. Gamma Corrector

The red, green, and blue video signals leave the camera control amplifier at a level of approximately 1 volt peak-to-peak. As shown in Figure 8, they are passed through a gamma corrector, which is a unity gain device having a non-linear transfer characteristic. This gamma corrector is needed to compensate for the non-linearities of both pick-up tubes and the receiver kinescopes.

In order to achieve good color fidelity in a color television system, it is necessary that the transfer characteristic of the overall system from light input at the camera to light output on the kinescope screen be closely controlled. It so happens that the curvature in the transfer characteristics of image orthicon tubes is in the right direction to provide a partial compensation for the curvature that is inherent in typical kinescope characteristics. The inherent compensation is not perfect, however, so the gamma corrector is inserted to provide a final trim for the overall transfer characteristic. A block diagram of one channel of the gamma corrector is shown in Figure 21. There is only one stage in each channel where the non-linear correction is actually applied. The other stages indicated in Figure 21 are necessary to amplify the input signal up to a reasonable voltage level and then to drive an output amplifier which supplies signals to the coaxial circuits leading to color monitors and to the colorplexers or other units in the studio system.

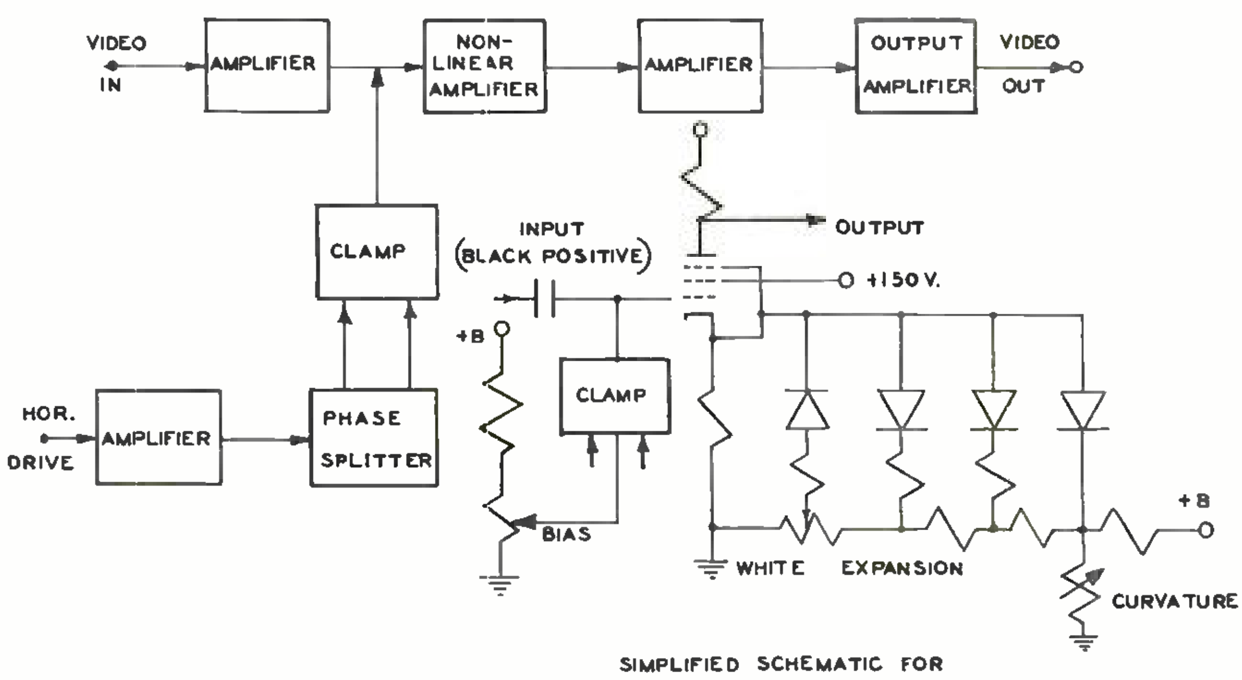

Fig. 21 — Block diagram of one channel of a gamma corrector for a color television camera.

As in the case of all non-linear operations, it is necessary to restore the DC component of the signal before gamma correction is applied. A driven clamp is provided in the gamma corrector for this purpose.

The simplified schematic shown in Figure 21 shows the type of non-linear amplifier circuit currently used for gamma correction in RCA color television camera chains. The required curved characteristic is obtained by utilizing a non-linear feedback circuit in the cathode of a conventional amplifier stage. The non-linear feedback circuit consists of a group of diodes with series resistors shunting the cathode resistor. The diodes are returned to different bias voltages so they become operative at different voltage levels;

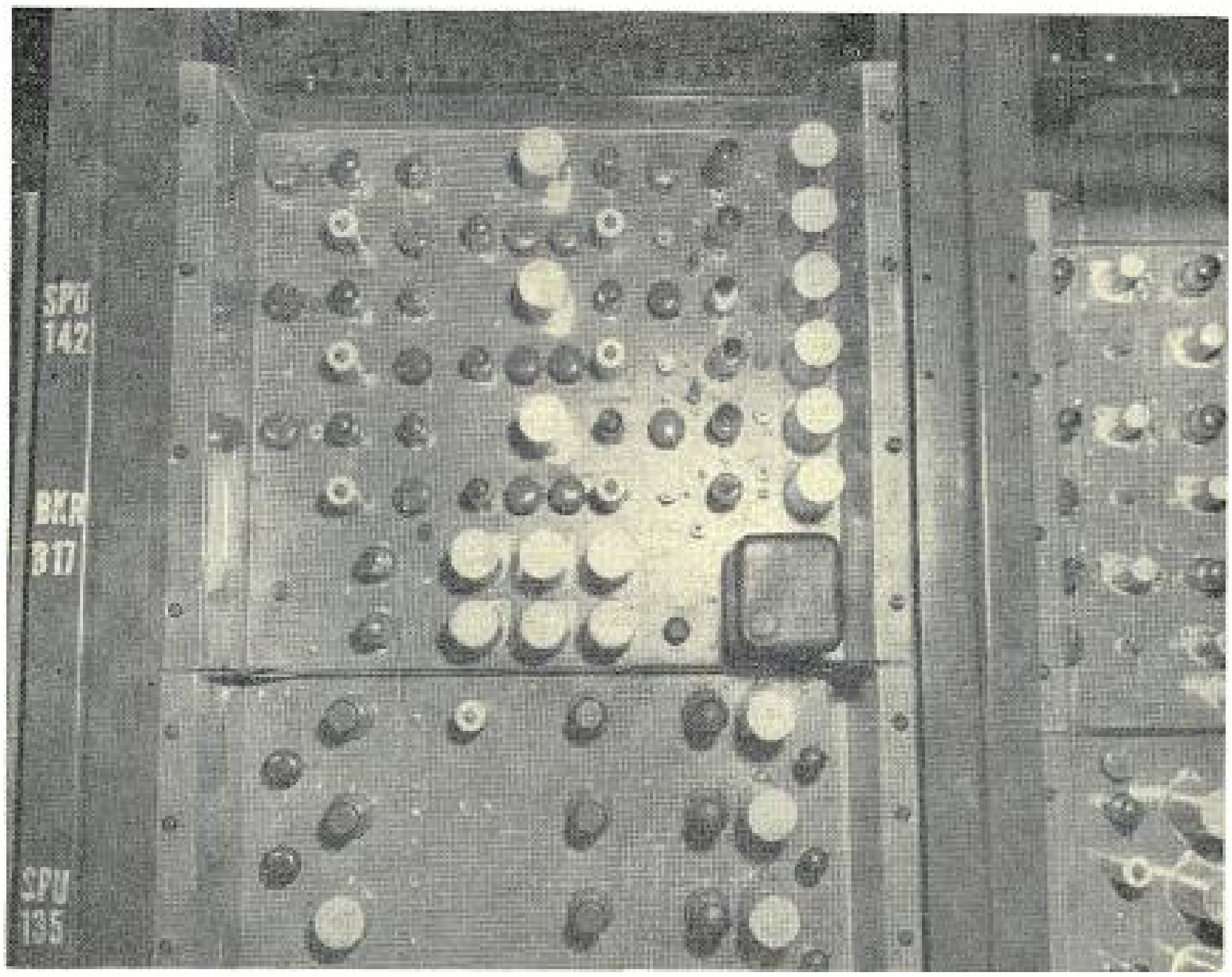

Fig. 22 — Three-channel gamma corrector (upper chassis).

consequently, the effective gain of the stage varies over the signal range. The particular circuit shown is capable of adjustment to provide both black stretch and white stretch. The physical appearance of the gamma corrector is shown in Figure 22.

9. Operator's Console

A video operator's control position for an RCA color television camera is shown in Figure 23. Two standard console sections are required for each color camera chain. The section on the left contains the remote control panel in the upper section and the shading generator in the lower section. The right-hand console housing contains a picture and waveform monitor in the upper section and a monitor auxiliary unit in the lower section. Mounted on the remote control panel are knobs or switches to perform the following functions in the individual color channels: horizontal and vertical centering, alignment (of the image orthicon beams), orthicon focus, image focus, multiplier focus, image accelerator voltage, target voltage, beam current, multiplier gain, and pedestal. As indicated in the photograph, the operating controls are mounted in vertical columns; the sequence from left to right is red, blue, and green.

Small "test" buttons mounted near the "target" knobs provide a convenient means for setting the target 2 volts above cut-off; the target voltage is adjusted to cut-off with the button depressed, and is automatically raised by two volts when the button is released. Tip jacks are provided to permit metering of the target voltage. Also included on the remote control panel are a master pedestal control, a master electrical gain control, a master on-off switch, and the master control which operates the iris between the relay lenses in the camera proper. The last-mentioned control is the most satisfactory overall gain control for normal operation of the chain.

10. Monitor and Auxiliary Unit

The monitor shown in Figure 8 as part of the color television camera chain and pictured in Figure 23 is a standard "master monitor", consisting of a 10″ kinescope with a standard P4 phosphor, a 5″ CRO for viewing waveforms, and the necessary deflection circuits and video amplifiers. The only change required in the monitor is the alteration of the CRO sweep circuits to operate at either 20 or 5,250 cps (one-third of the field and line frequencies, respectively) instead of the customary 30 and 7,875 cps rates, so that either three lines or three fields may be displayed side by side instead of the usual two.

An auxiliary unit is mounted in the lower section of the console housing. This unit, which is shown in Figure 24, has two major functions: (1) it

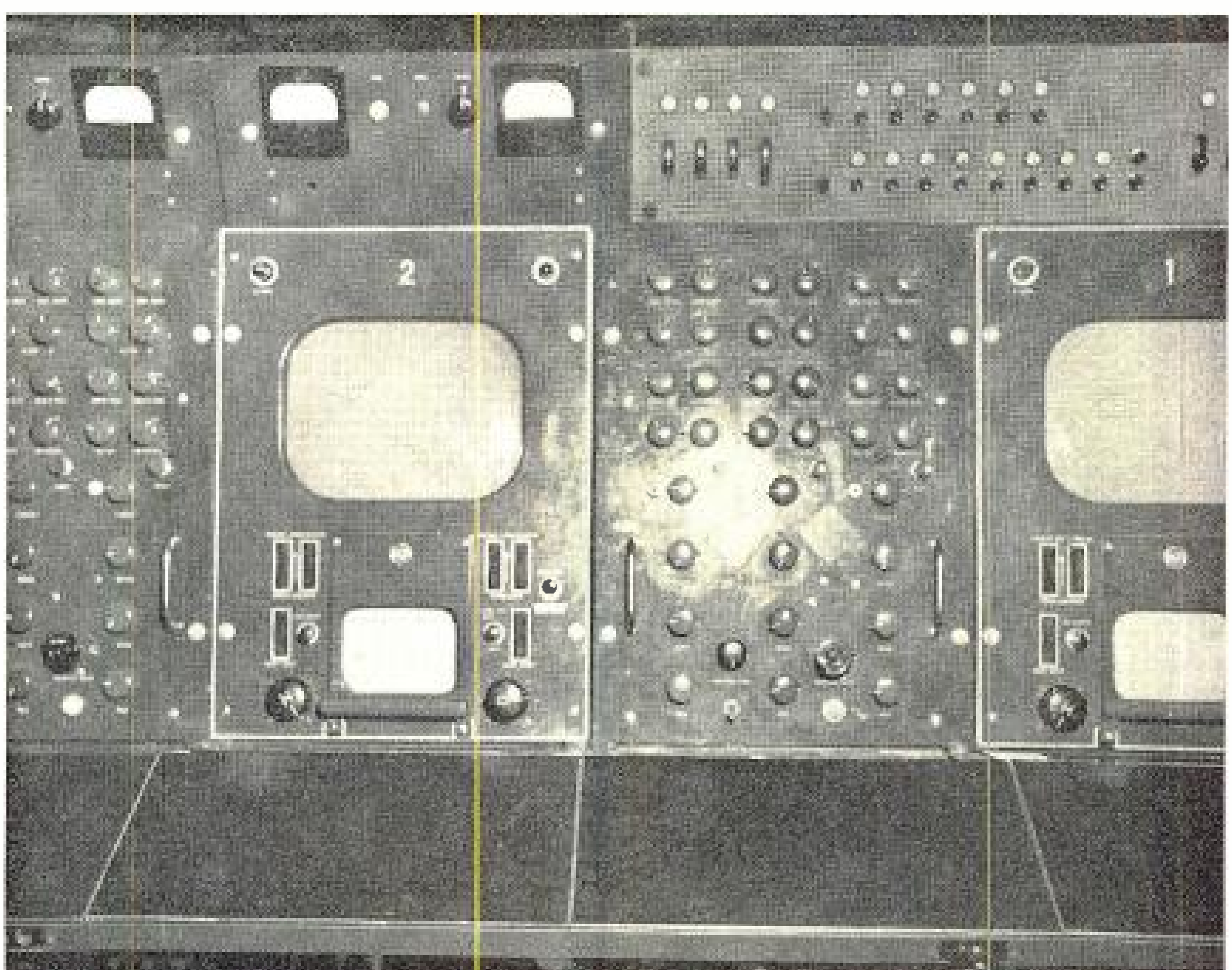

Fig. 23 — Video operator's position for an RCA color television camera.

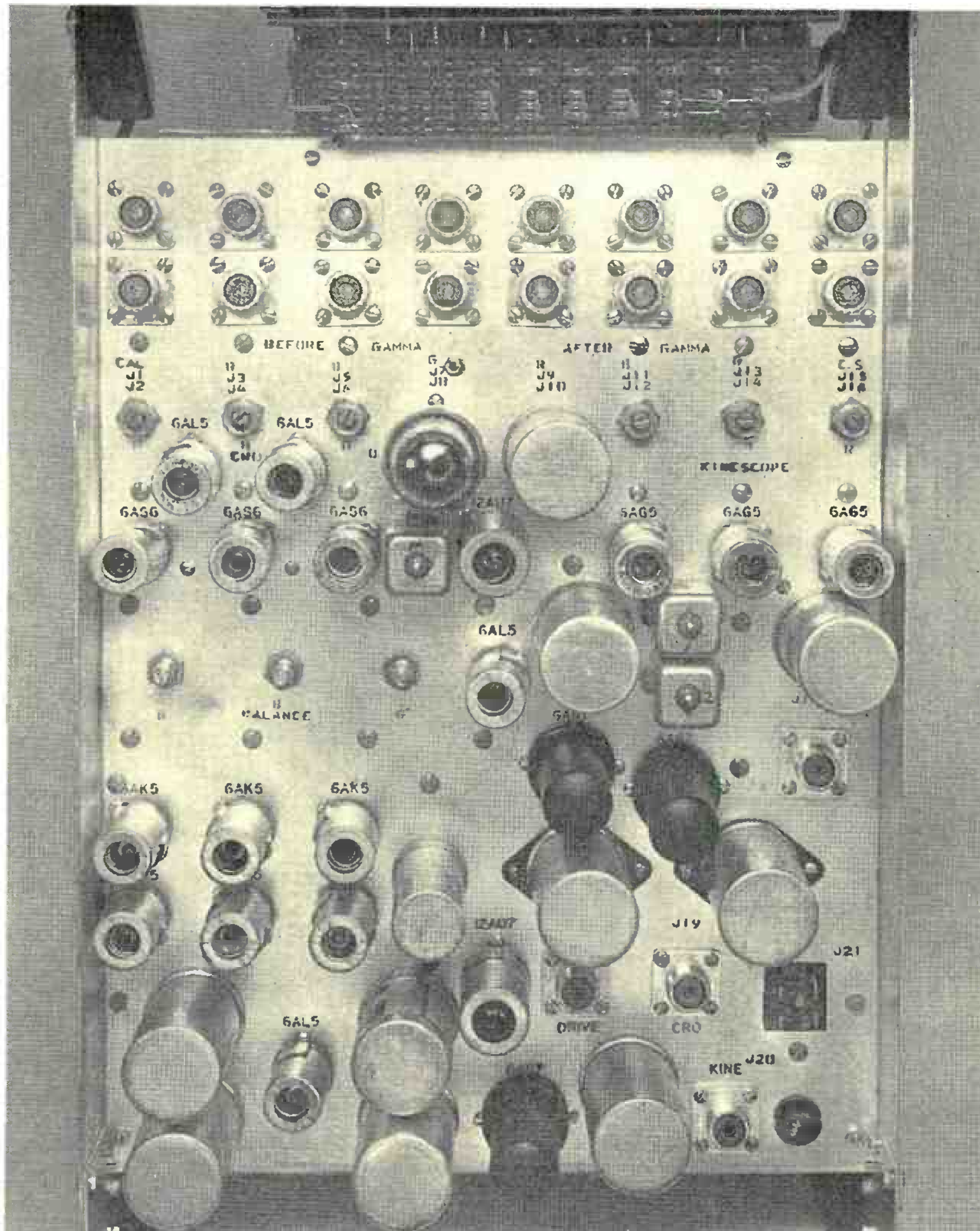

Fig. 24 — Photograph of monitor auxiliary unit.

provides either a field-sequential or line-sequential signal for display on the monitor CRO, and (2) it provides switching facilities to enable the operator to choose the signal for display on the kinescope. The control panel for the auxiliary unit is mounted in the sloping portion of the console shelf just below the monitor, as shown in Figure 25. Push-button switches permit

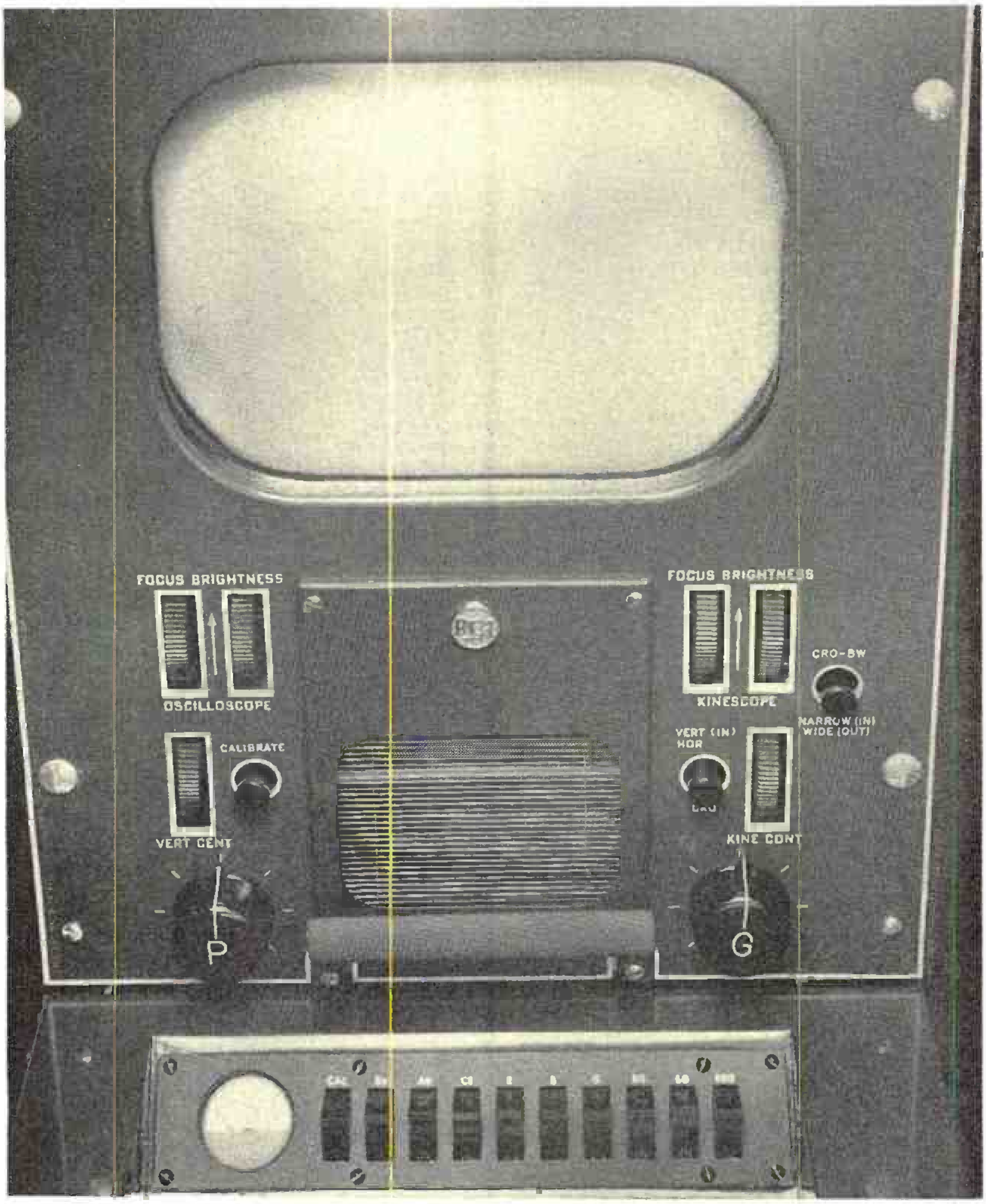

Fig. 25 — Close-up view of master monitor and control panel of auxiliary unit.

the video operator to view the red, green, or blue signals separately, the red or blue superimposed on green, or all three signals superimposed.

The camera signals may be monitored either before or after the gamma correction circuits, and a push-button is provided to permit the monitoring of the composite signal at the output of the colorplexer. The small meter shown at the left in Figure 25 is used to indicate the calibration voltage when signal levels are measured.

11. Power Requirements

The total +B power requirement for a color television camera chain is about 2.8 amperes at +280 volts. A small −500 volt supply is needed for the electrodes in the image sections of the image orthicons, and a focus coil current regulator is needed to provide three independent currents (about 75 ma each) for the image orthicon focus coils.

C. Flying-Spot Scanners

1. The Flying-Spot Principle

Flying-spot scanners have been found to be very useful for the generation of color television signals from Kodachrome slides or similar transparencies and from motion picture film. The flying-spot principle is illustrated by the block diagram in Figure 26. The color transparency is illuminated by light from an unmodulated kinescope raster; an image of the raster is sharply

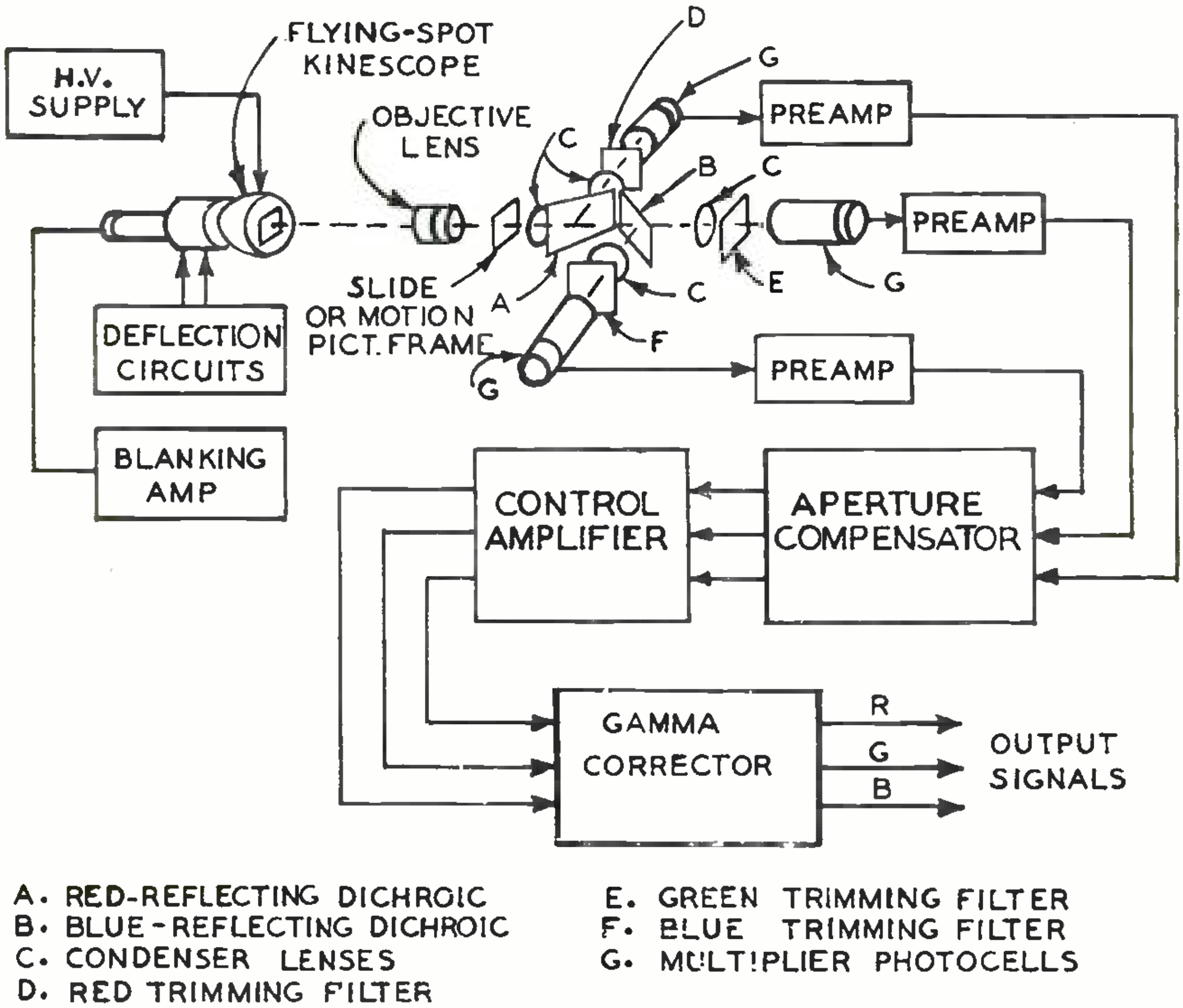

Fig. 26 — Block diagram of a flying-spot scanner for color transparencies.

focused on the slide, so that only a small spot on the slide is illuminated at any given instant. Light passing through this slide is collected by a condensing lens system, split three ways by a pair of dichroic mirrors, and applied to three photocells adjusted to the required spectral sensitivity curves for the red, green, and blue primaries of the system.

One outstanding advantage of a flying-spot scanner is that the three signals are inherently in register. Only one scanned raster is involved, and only one optical image of that raster. The condenser lenses indicated in Figure 26 are not required to form focused images but serve only to collect the light transmitted through the slide so that it may be directed to the sensitive surfaces of the photocells.

2. Phosphor Decay Compensation

The phosphor of a flying-spot kinescope is designed for extremely short persistence, but even with special phosphors, it is necessary to apply decay-time compensation to video signals. Finite phosphor decay-time produces an effect very similar to that of a low-pass filter, so compensation may be obtained by means of exponential high-peaking circuits in the preamplifier

Fig. 27 — Waveforms resulting from the scanning of a white bar on a black background in a flying-spot scanner, showing the effect of phosphor decay time.

stages. Flying-spot signals with and without decay-time compensation are shown in Figure 27.

3. Electronic Components

The electronic components used with a flying-spot scanner are very nearly the same as those used with an image orthicon camera chain. The aperture compensator performs the same function discussed earlier. The control amplifier is basically similar to the control amplifier previously discussed except that no shading signals are needed for a flying-spot scanner. The gamma corrector has the same block diagram as that shown in Figure 21, but the actual non-linear stage is adjusted to produce a somewhat different curve.

The inherent characteristic of a flying-spot scanner is very nearly linear so the curve introduced in a gamma corrector for a flying-spot scanner must be approximately equal to the inverse of a typical kinescope characteristic.

4. Slide Scanner

A photograph of a practical flying-spot scanner for color slides is shown in Figure 28. The same equipment with protective covers removed is shown in Figure 29. The flying-spot kinescope is mounted at one end of a flat table and the optical head and preamplifiers are mounted at the other end. The rack space below the top panel is used for the high voltage power supply for the kinescope, the −500 volt supply for the photocell multipliers, and the blanking and deflection circuits needed to produce the blank raster on the kinescope. The aperture compensator, control amplifier, and gamma corrector are rack-mounted units practically identical in appearance to the units shown in Figures 17, 18, and 22, respectively. A "master monitor," with associated auxiliary unit, is frequently used in conjunction with a flying-spot scanner to provide indications of optical and electrical focus and signal levels.

5. Motion Picture Scanners

Figure 30 is a photograph of a flying-spot scanner combined with a fast pull-down projector for the generation of color television signals from 16mm motion picture film. The same basic flying-spot components discussed earlier are used in this equipment. The flying-spot kinescope itself is mounted crosswise on the table within the housing shown at the left in the photograph. This housing also encloses a 45-degree mirror which deflects the light from

Fig. 28 — Flying-spot scanner.

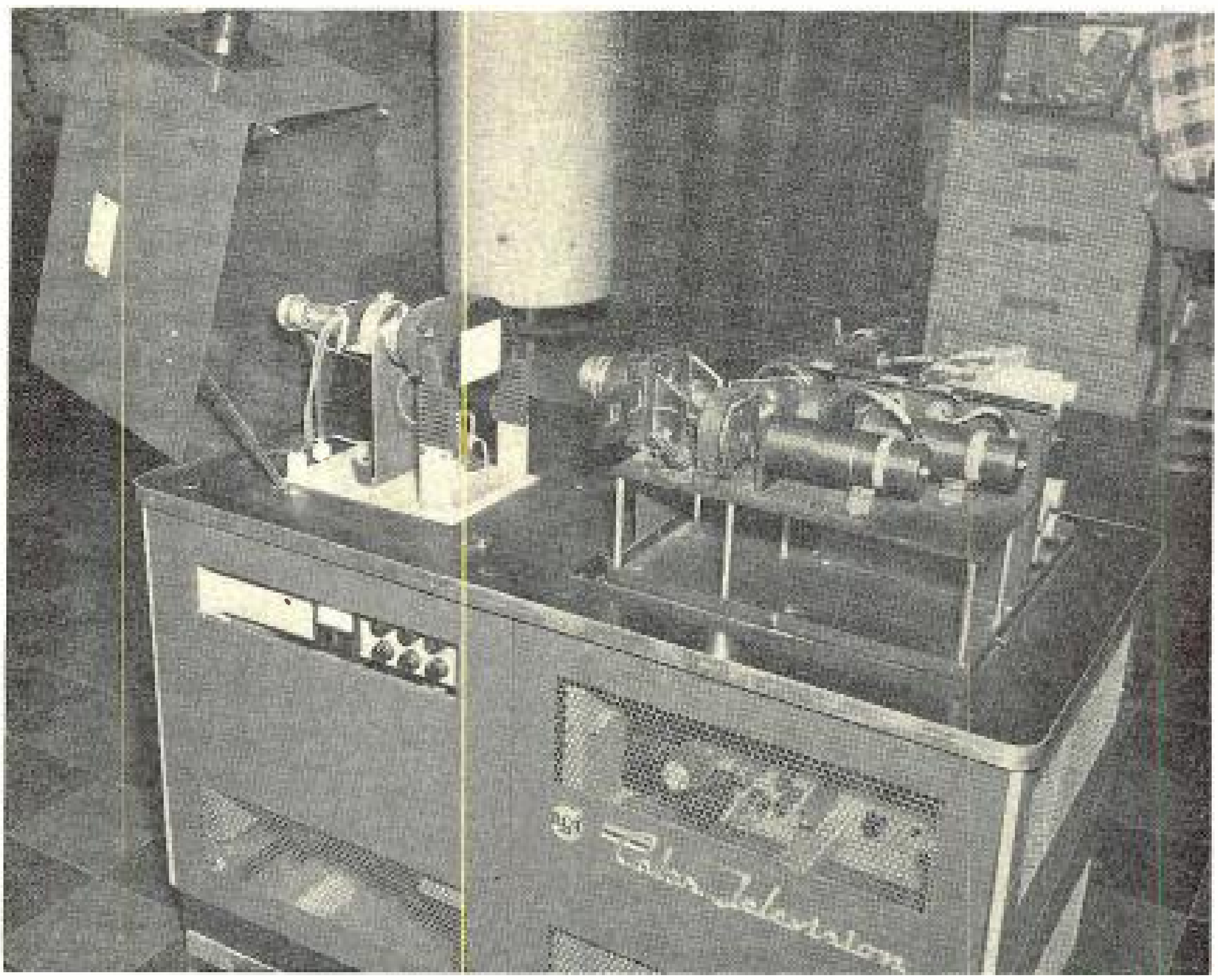

Fig. 29 — Flying-spot scanner with protective covers removed.

the kinescope toward the projector, which is mounted along the front edge of the table. The photocells are mounted in metal tubes which are attached to an optical block containing the condenser lenses and the dichroic mirrors; the green photocell tube extends toward the right end of the table, the red photocell tube extends straight up, while the blue photocell tube extends toward the rear of the table. The film gate and pull-down mechanism are attached to the left side of the optical block. The sound pickup head is located below the objective lens, between the optical block and the kinescope housing. The video preamplifiers are mounted on a chassis located behind the projector.

The projector used in the color motion picture scanner is quite different from the standard television projectors used in most broadcast stations today in that it pulls down the film from one frame to the next in an extremely short period of time. This special feature is made necessary by the non-storage property of the flying-spot scanner. In other types of film cameras, using such tubes as the iconoscope or the image orthicon, the storage property plays a very important role. With such cameras, it is conventional to pass light through the film only in very brief flashes, usually during the vertical blanking time (while the picture is not being scanned at all). The light flashes are produced either by a rotating shutter or by a pulse-type of light source. Each light flash builds up an image in the form of an electric charge pattern on the mosaic or target of the camera tube, and this charge pattern remains in the tube (i.e., it is "stored") until it is removed by the action of the scanning beam. For this type of operation, the projector mechanism may be designed so that it uses almost the entire vertical scanning period (1/60th of a second) to pull down the film from one frame to the next, since the image must be stationary only during the brief pulses of light. In the case of the flying-spot scanner, however, the situation is quite different. Since the scanner has no storage property, the projector design must be such that the film image remains stationary during the entire scanning period; otherwise the motion of the film would appear as a corresponding motion in the television image.

There are two ways in which a projector may be designed to meet this requirement. One approach is to use an optical system with moving parts which produces a stationary image from continuously moving film. In such a projector, there is no pull-down action at all; each frame gradually dissolves into the next, and the image is present continuously. RCA is developing a projector of this type for use with 35mm film, and other companies are also active in this field. The projector shown in Figure 30 uses the alternative approach, involving an intermittent movement which operates fast enough to pull down the film from one frame to the next during the relatively brief vertical blanking period (approximately 830 microseconds). This rapid

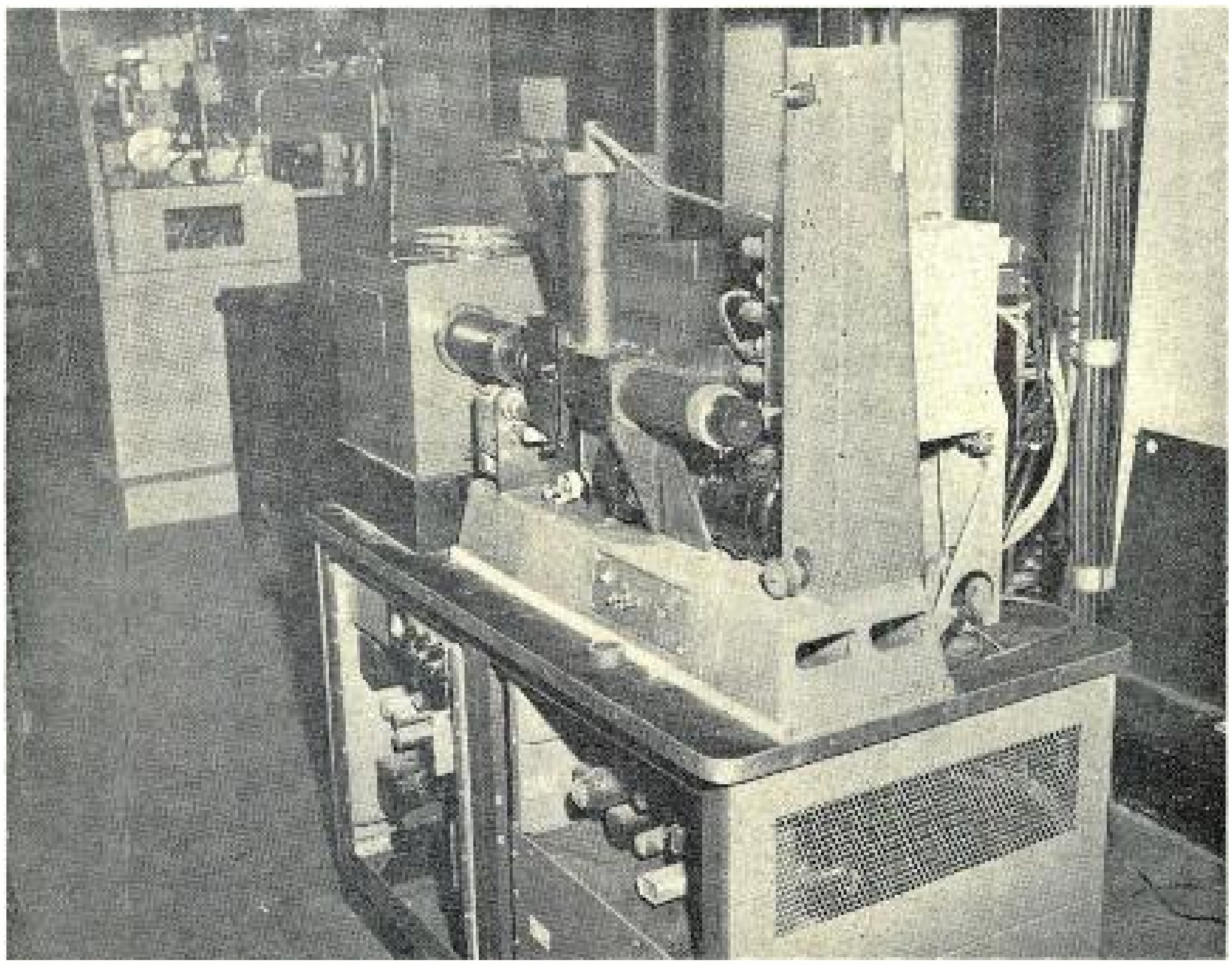

Fig. 30 — Motion picture scanner.

action is obtained by combining a 3-2 Geneva intermittent with a pair of accelerating gears and a claw-type pull-down mechanism. (The 3-2 action is necessary to convert the 24-frame motion picture standards to the 30-frame television standards.) A new method for achieving proper registration of the film in the gate has been developed, so that the wear on the film is no greater than in a conventional television projector.

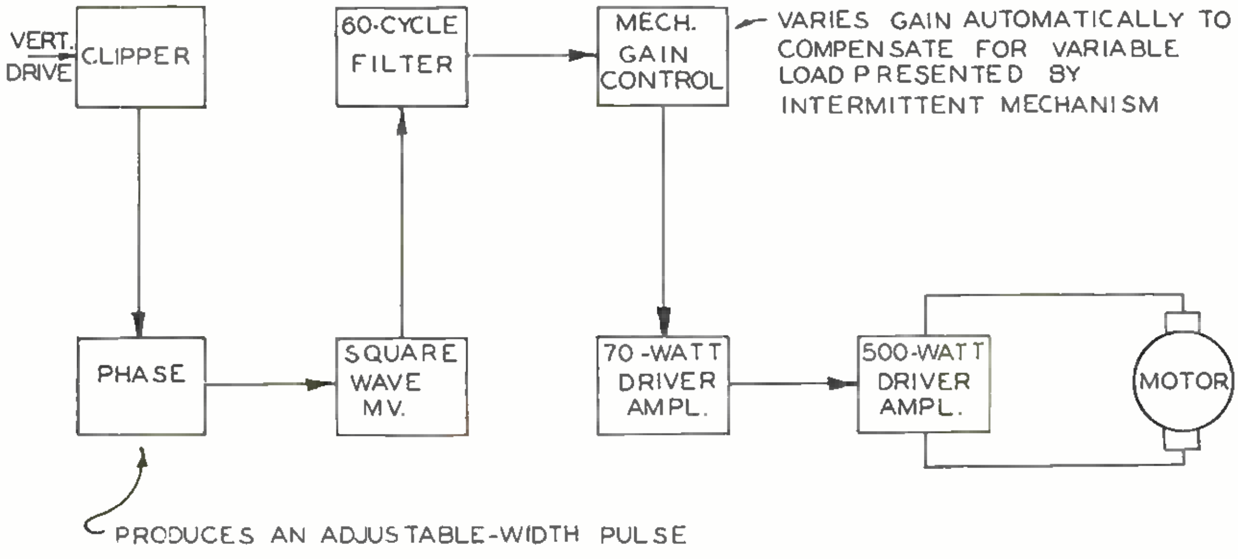

Fig. 31 — Block diagram of motor drive circuit for motion picture scanner.

Since the frequency standard for the color television system is the master subcarrier oscillator, the field frequency is not exactly synchronous with the power line frequency. If the projector motor were operated directly from the 60-cycle power line, a horizontal bar, corresponding to the pull-down disturbance, would appear to drift through the picture. To avoid this difficulty, the projector motor is driven by a special 60-cycle source which is locked in to the field rate of the television system. The circuit used to drive the motor is shown in block diagram form in Figure 31. A vertical drive signal from the television system triggers a 60-cycle multivibrator, whose pulse width can be adjusted to control the phase of the following multivibrator, which generates a symmetrical square wave. This square wave is filtered to recover only the fundamental component, which is then amplified to a power level high enough to drive the synchronous motor in the projector (which is rated at 1/20 HP). A gain control mechanically coupled to the motor shaft varies the amplifier gain periodically to compensate for the variable load presented by the 3-2 intermittent mechanism. The phasing control in this motor drive circuit is adjusted to make the film pull-down occur during the vertical blanking period. The physical appearance of the motor drive equipment is shown in Figure 32. The 500-watt power amplifier is mounted in the lower section of the rack, with a power transformer for coupling to the motor below it and the 70-watt driver and control chassis mounted above it.

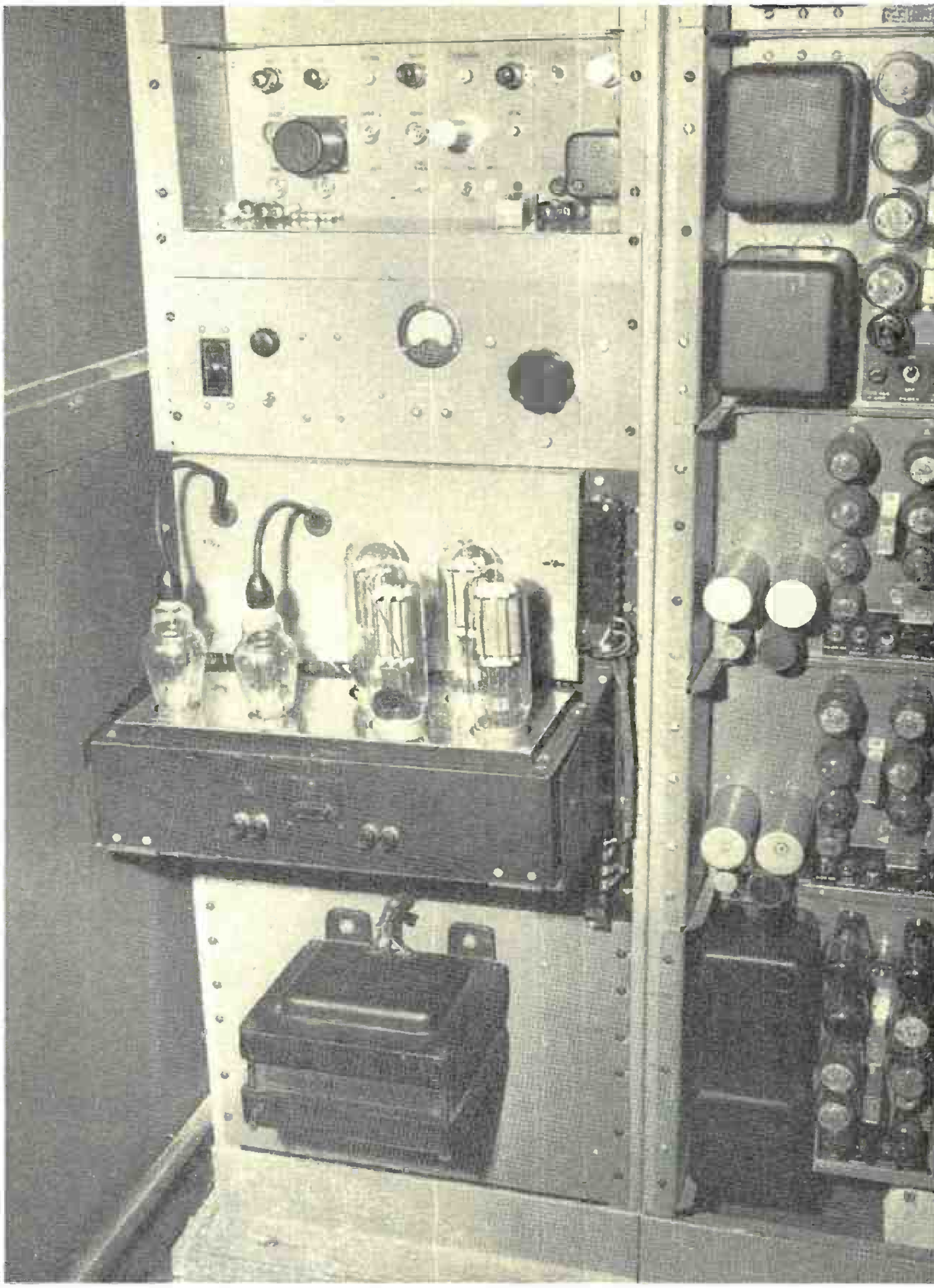

Fig. 32 — Motor drive equipment for motion picture scanner.

D. Switching Equipment

When switching is done in a color studio at points before multiplexing, as in the case of the system illustrated in Figure 1, it is necessary to use three

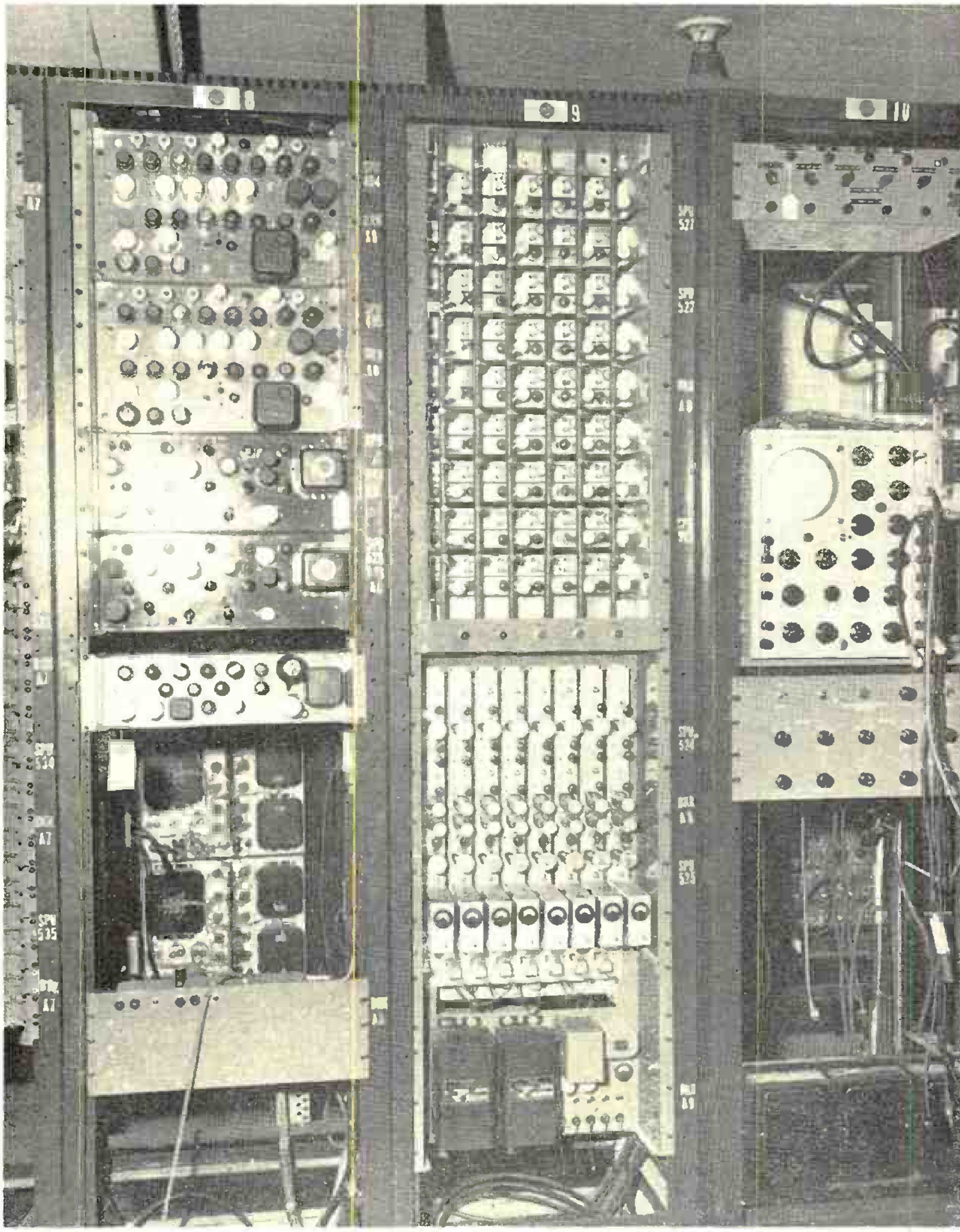

Fig. 33 — Relay switching panel (middle rack).

complete sets of switching equipment, since three independent signals must be handled simultaneously. Conventional relay switching equipment may be used, however, and it is a simple matter to parallel the relay control circuits so that all channels may be switched simultaneously by a single push-button. Switch gear may be arranged to accommodate any desired number of input and output circuits.

The need for three identical sets of switching equipment can be eliminated by including a colorplexer as part of each camera chain, as shown in Figure 2, so that only a single output signal (containing a subcarrier component) need be handled by the switching equipment. When this approach to the problem is used, the synchronizing signal should be added at a common point after switching so that control information to the deflection circuits of home receivers is never interrupted. Of course, there are some cases where switching of control information along with the picture information is unavoidable, as when a switch is made from a local signal to a remote signal. In such cases, it is not uncommon for the picture to "roll over" once on home receivers before the vertical oscillator resumes control. This problem is no different in color television than in black and white television; in either case, special "genlock" devices may be devised to prevent the problem by

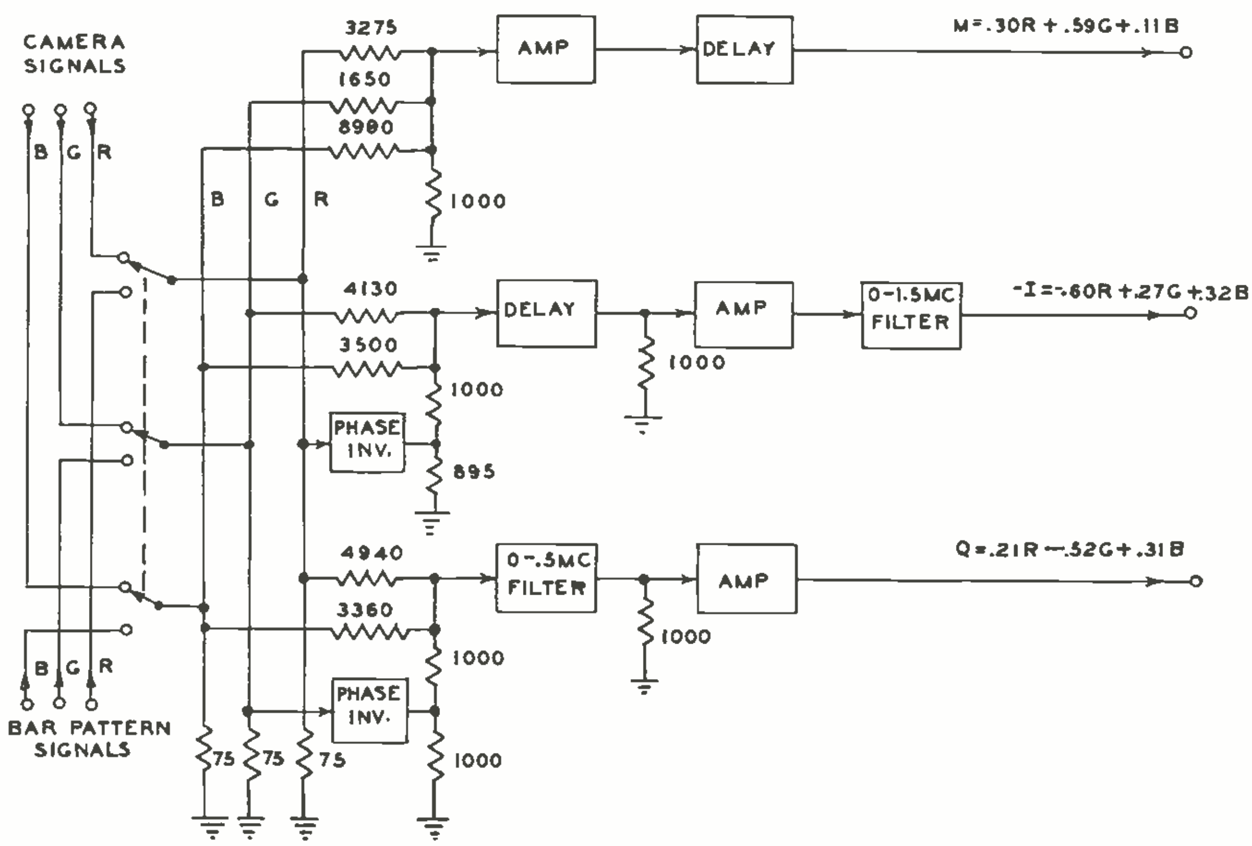

Fig. 34 — Block diagram for a colorplexer matrix section.

locking in the local synchronizing generator (and subcarrier oscillator, in the case of a color system) to the generator controlling the remote signal source.

To insure that the color synchronizing bursts are always in the proper phase relative to the subcarrier components of the video signal, it has been found desirable to provide burst keyers within each colorplexer so that the bursts are added to the rest of the subcarrier signal as soon as possible after modulation and hence have no opportunity to drift in relative phase. Switching equipment intended to handle multiplexed (single channel) color signals should have carefully adjusted delay characteristics, so that the time delay for signals passing from any of the colorplexers to the common point where synchronization is added is approximately the same (within 10 or 15 degrees at the subcarrier frequency) no matter what switch combination is actually in use. This avoids the problem of forcing receiver oscillators to adjust themselves to different absolute phases each time a signal is switched. To prevent the complete loss of color synchronizing information whenever the picture is faded to black, it is desirable to provide one input to the switching system consisting of nothing but burst; this may be labelled "black".

Color television switching equipment may include provisions for fading, superimposing, wiping, and other special effects, whether the switching is done before or after multiplexing. The physical appearance of a typical rack of switch gear is indicated in Figure 33. This is the switching relay panel in NBC's Colonial Theater studio in New York City. Switching is done in this studio after multiplexing and the switch gear is designed to accommodate four camera chains plus a flying-spot scanner and several remote lines. The switching relays are controlled by push-buttons located on the technical director's console.

E. Colorplexers

A colorplexer is a device which performs two important functions in the RCA color television system: (1) it performs the matrix operation which cross-mixes red, green, and blue video signals to produce a monochrome or luminance signal plus two chrominance signals and (2) it performs the multiplexing operations which make possible the transmission of these three signals in a single 4.3 megacycle channel.

For purposes of analysis, it is very convenient to divide the colorplexer into two sections corresponding to these two different functions. As a matter of fact, this division into sections is sometimes carried over into physical design. A great many different colorplexer designs have been used by RCA and others during color television field tests. The block diagrams to be discussed here reflect some of the most recent developments in colorplexer designs.

1. Matrix Section

The matrix section of a colorplexer may actually be regarded as a simple form of analog computer which automatically solves the following three equations, which are incorporated in the NTSC color television field test signal specifications:

$$M = .30R + .59G + .11B$$

$$I = .60R - .27G - .32B$$

$$Q = .21R - .52G + .31B$$

A typical colorplexer matrix is shown in Figure 34. A choice of two inputs is provided; it has been found that artificially-generated bar pattern signals are very useful for making set-up adjustments in a colorplexer. The 75-ohm resistors shown at the bottom left of the figure are the resistors which terminate the input coaxial cable. Shown at the upper left in the figure is a simple resistance mixer which adds together the proper amounts of red, green, and blue to produce the signal $M = .30R + .59G + .11B$.

The two resistance mixers which produce the I and Q signals both require phase inverters since one of the input signals in each case must be inverted in polarity in order to provide the correct output signal. The phase inverters are nothing more than single stages of amplification adjusted for approximately unity gain. It is very easy to adjust the gains of these phase inverters by making the outputs of the I and Q channels equal to zero when a white or neutral signal is applied at the colorplexer input. The 1000-ohm terminating resistors at the end of the delay line in the I channel and the 0 to .5 mc filter in the Q channel both must be regarded as parts of the resistance mixing networks. In keeping with the proportioned bandwidths concept, which plays an important role in the RCA color television system, it is necessary to pass the I and Q signals through two different low-pass filters so as to limit their bandwidths.

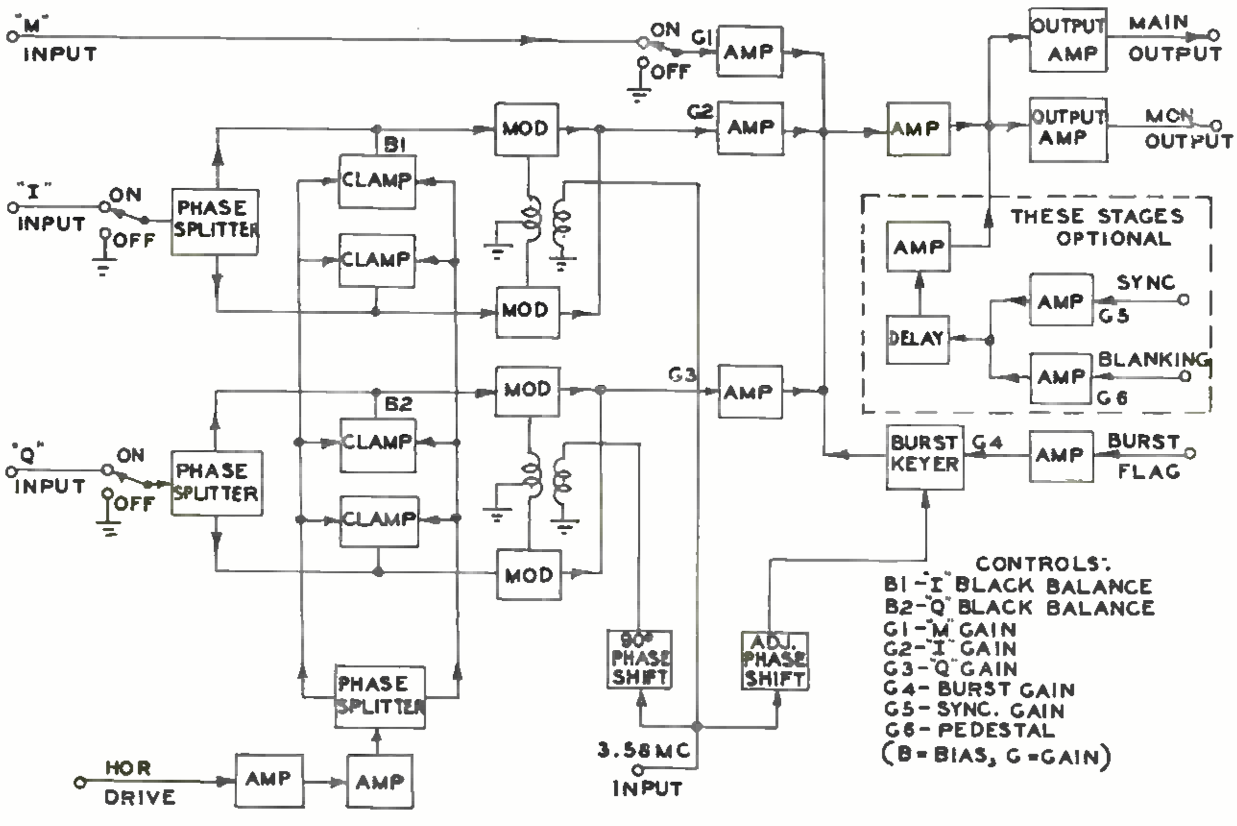

Fig. 35 — Block diagram for a colorplexer modulator and mixer section.

The I signal is passed through a filter of approximately 1.5 mc bandwidth, while the Q signal is passed through a filter of approximately .5 mc bandwidth. The exact shapes of these filter characteristics must be adjusted to conform to the proposed NTSC signal specifications. Inasmuch as the time delay associated with a narrow band low-pass filter is considerably greater than the time delay involved in a wider-band filter, it is necessary to insert delay lines in the M and I channels of the colorplexer to compensate for the greater delay inherent in the Q filter.

The delay line inserted in the M channel, which has no filter to limit

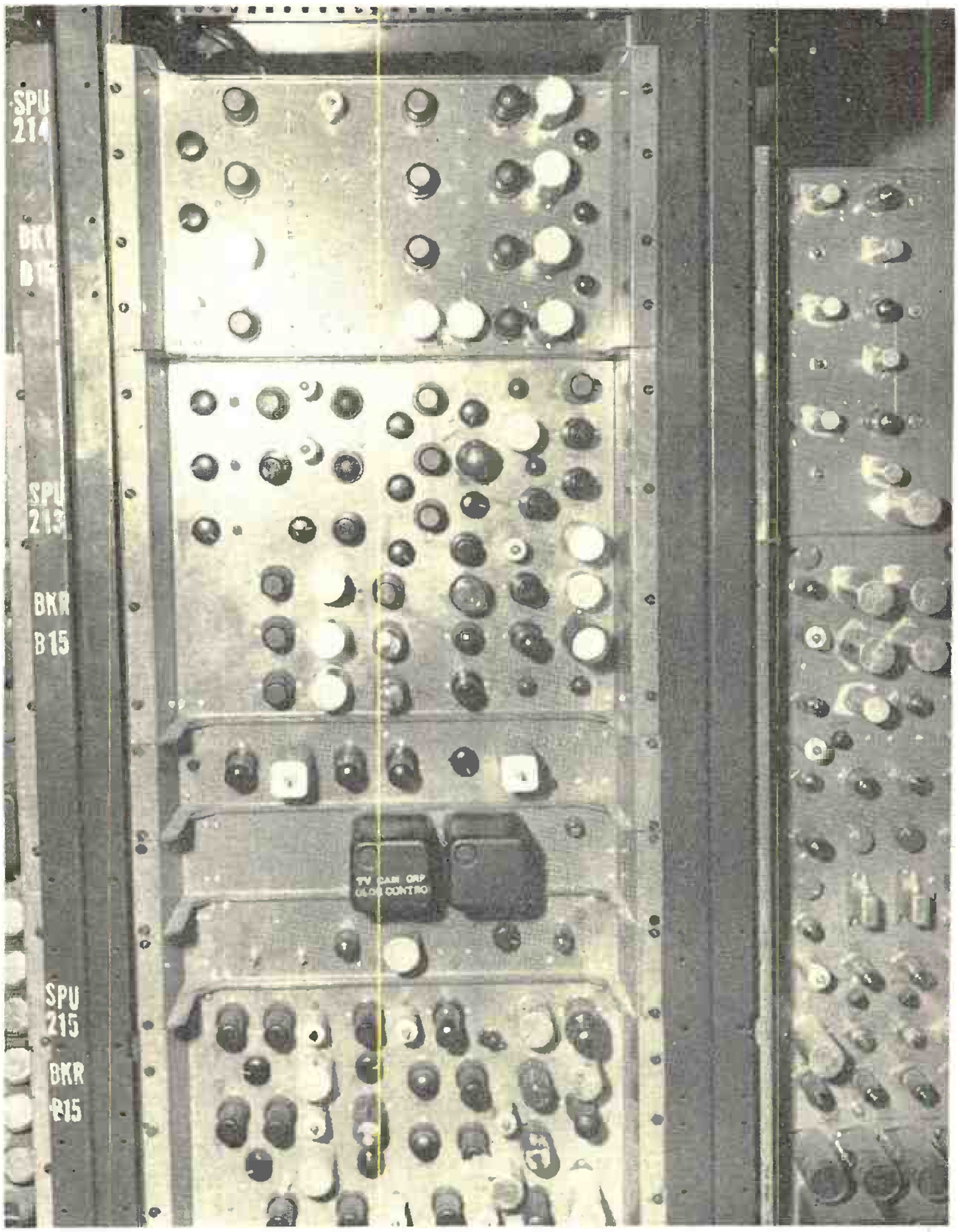

Fig. 36 – Typical colorplexer (upper two chassis).

its bandwidth other than the limited response of the overall system, must be equal to the total time delay in the Q filter. For the type of filter most commonly used in RCA colorplexers, the time delay compensation required is of the order of 1.4 microseconds. The delay inserted in the I channel must be equivalent to the difference between the delay of the Q filter and that of the 0 to 1.5 mc filter provided in the I channel; in colorplexers made by

RCA, the delay compensation required is of the order of .8 microseconds.

Before completing a description of the matrix section of the colorplexer, it should be noted that the signals actually supplied by the arrangement illustrated in Figure 34 are M, Q, and —I. The opposite polarity of the I signal does not constitute any particular problem because it is very easy to adjust the modulator, in the modulator and mixer section to be discussed below, to provide the desired polarity at its output. It so happens that it is much easier to generate —I than I in the type of circuit illustrated in Figure 34.

2. Modulator and Mixer Section

A typical modulator and mixer section for a colorplexer is shown in Figure 35. Two modulator tubes, arranged in a doubly-balanced circuit, are used for each chrominance signal. Because the modulator tubes in each pair have common outputs but have phase splitters in both their video and carrier inputs, the two original signals cancel out in the output, leaving only the product signal (in the form of sidebands surrounding the subcarrier).

Clamps are provided at the video input to each modulator tube so that black level in the signals corresponds to a specific voltage on each modulator grid. The bias on one of the two modulators in each pair is made adjustable so that the carrier may be perfectly cancelled at black level. The subcarrier applied to the doubly-balanced modulator for the Q signal is shifted in phase by 90 degrees relative to the subcarrier applied to the doubly-balanced modulator for the I signal. As a result of this phase shifting action, the two modulated waves appearing at the outputs of the I and Q modulators are in phase quadrature. These two modulated waves and the M or luminance signal are added together by means of three tubes with a common load impedance. The burst may be produced by means of a keying or gating tube with carrier of appropriate phase on one grid and a burst flag pulse on the other. To prevent the burst flag pulse from appearing at the output of the burst keyer, it is necessary to use either a balanced keying circuit or a high-pass filter following the keyer.

If the colorplexer is used in an arrangement similar to that of Figure 1, it may be desirable to add synchronizing and blanking signals; this may be done by means of the mixing stages shown within dotted lines in Figure 32. In other studio arrangements, of the type illustrated by Figure 3, these mixing stages might not be needed.

Blanking may be added to provide a small amount of fixed set-up in the signals, in keeping with the practice recently adopted by many black and white television station operators. Both the blanking and synchronizing signals are passed through a delay network to adjust their timing relative to the picture components of the signal. It is customary to provide at least two outputs from a colorplexer so that a monitor may be connected to the colorplexer output without disturbing the main output line which feeds a transmitter or some other part of the overall system.

The physical appearance of a typical colorplexer is shown in Figure 36.

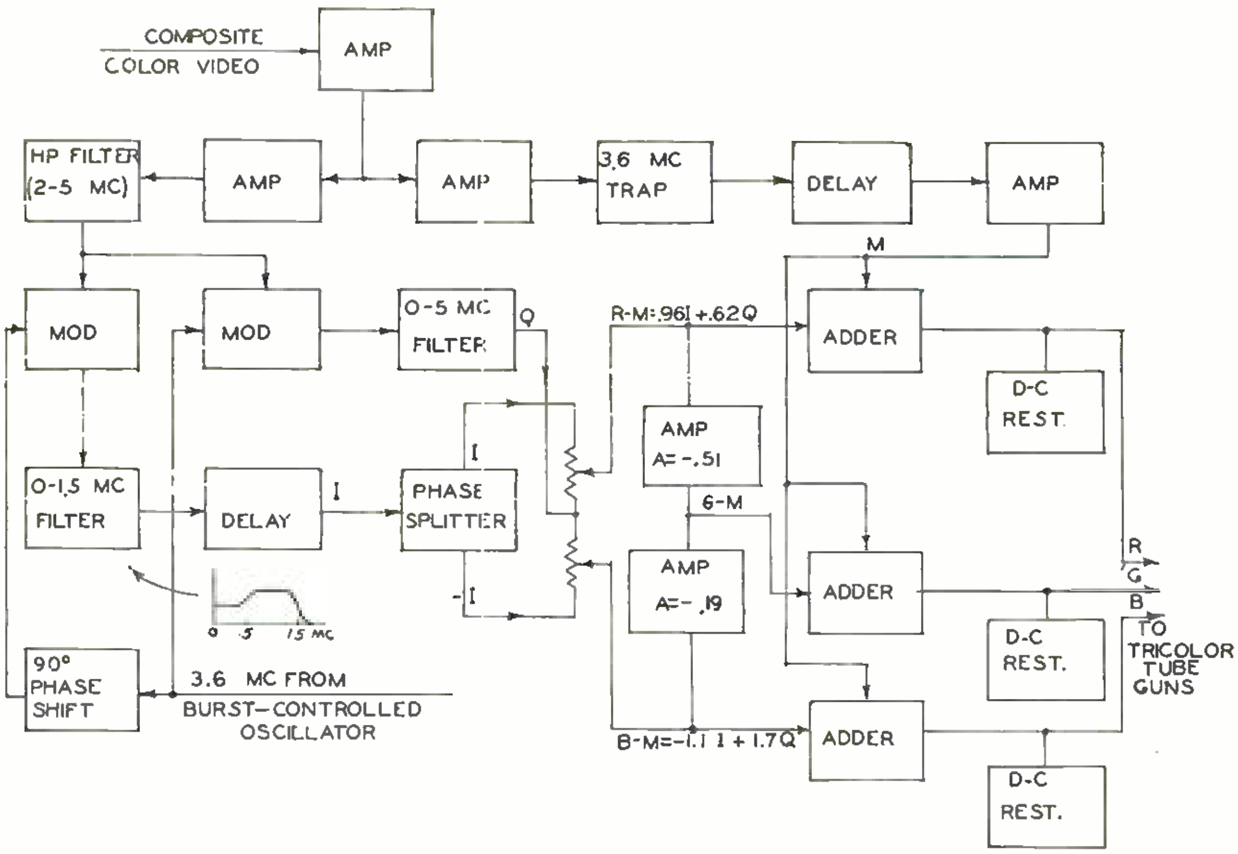

Fig. 37 — Block diagram showing video circuits for a single-input color monitor.

The smaller of the two chassis shown is the matrix section, while the larger chassis contains the modulator and mixer circuits. The time delay compensation circuits for this particular unit consist of lengths of RG65/U which are coiled up at the rear of the unit. More recent colorplexer designs employing miniature tubes require only about two-thirds of the rack space occupied by the unit illustrated in Figure 36.

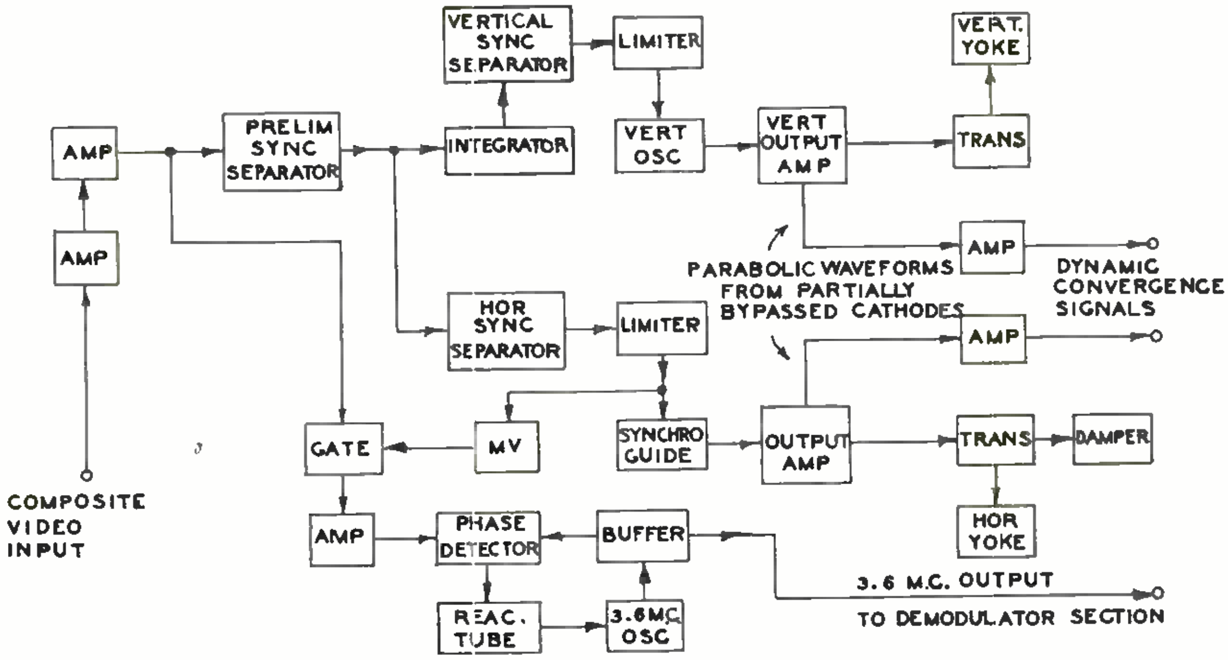

Fig. 38 — Block diagram showing sync separator, deflection, and burst-controlled oscillator circuits for a single-input color monitor.

F. Color Monitors

1. Types of Color Monitors

As indicated in Figure 1, there are two basic types of color monitors: (1) single input monitors for the viewing of multiplexed signals from colorplexers or remote sources, and (2) three-input monitors for the viewing of simultaneous signals as they leave the camera chains. The three-input monitors are very simple in principle, consisting of nothing more than three separate video amplifiers to apply the three primary signals to the red, green, and blue guns of a tricolor tube plus, of course, the deflection and power supply circuits needed to operate the tube. The two types of monitors are very similar in physical appearance, but the single-input type requires additional video circuits to demodulate the chrominance signals and to cross-mix the luminance and chrominance signals to form the original primary signals. Consequently, the discussion in this section will be confined mainly to single-input monitors.

2. Demodulator Section

The operation of a typical single-input color monitor may be explained with the aid of Figures 37 and 38. The video circuits are shown in block diagram form in Figure 37, and the synchronizing separator, horizontal and vertical deflection circuits, and the burst-controlled oscillator are shown in Figure 38.

The functions performed by the circuits in Figure 37 are the inverse of the functions performed by the colorplexer; that is, these circuits separate the single composite signal into its red, green, and blue primary color components. As shown on the diagram, the input signal is used in two ways. It is applied through a wideband channel having a trap adjusted for the color subcarrier frequency to separate the M or luminance component of the signal. A delay line is inserted in this channel to compensate for the greater time delay inherent in the narrower band chrominance channels. The M component of the signal is applied to all three kinescope guns in equal proportions by means of the adders shown at the right hand side of the figure. The input signal is also passed through a high-pass filter to separate the modulated color subcarrier signal which is then applied to a pair of modulators operated as synchronous detectors. Each of these modulators heterodynes the color subcarrier signal against a reference subcarrier generated by an oscillator within the monitor in order to demodulate or separate one of the chrominance components. The carrier components applied to these two modulators are separated 90 degrees in phase. The absolute phase of the oscillator in the monitor is adjusted so that the signal that appears at the output of one modulator is Q while the signal at the output of the other modulator is I.

The output of the Q modulator is passed through a 0 to .5 mc (nominal value) filter to separate only those frequency components that convey Q information. It will be recalled that the Q signal was narrow-banded in

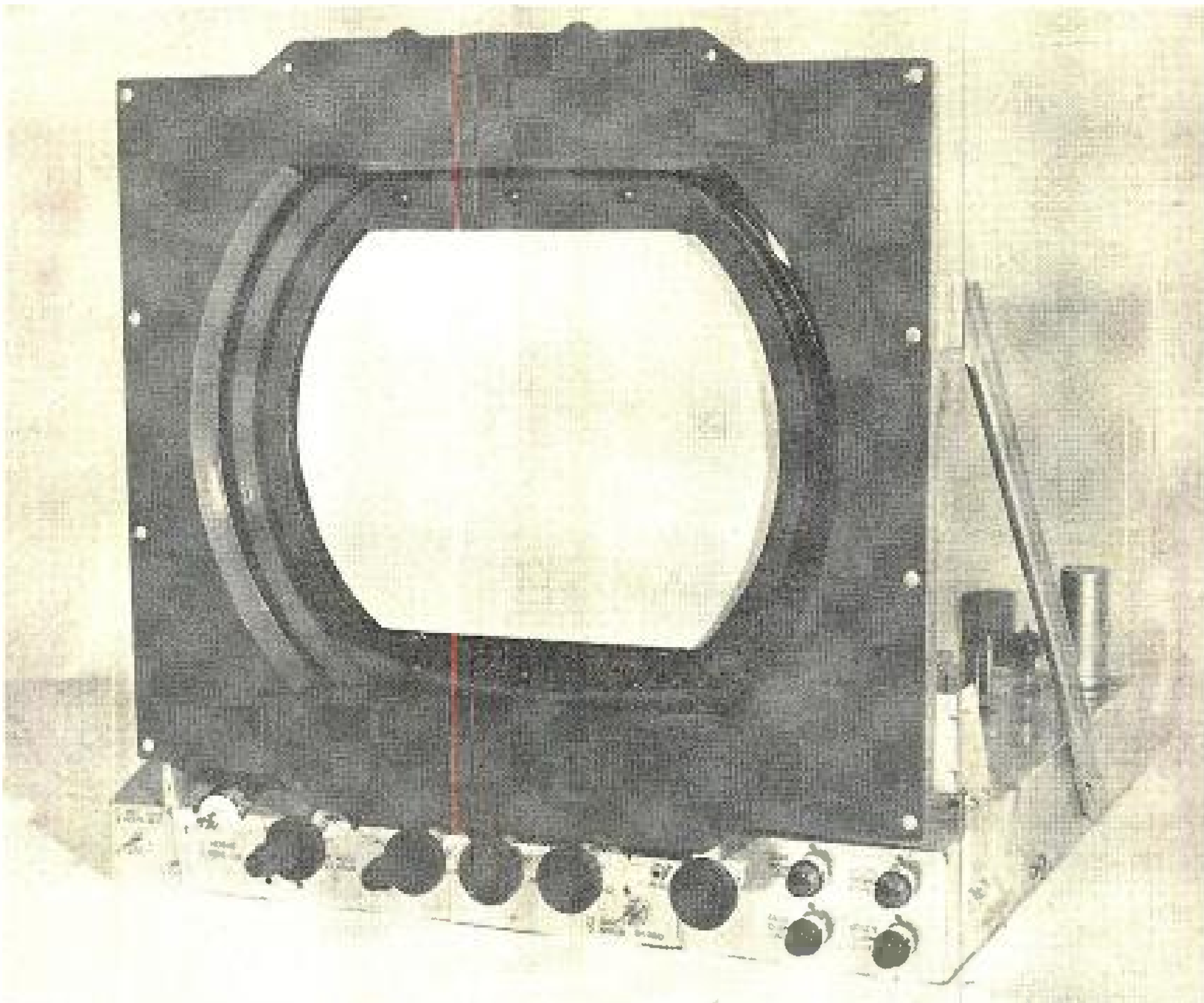

Fig. 39 — Front view of a color television monitor.

the colorplexer. The output of the I modulator is passed through a 0 to 1.5 mc filter which has a step type characteristic as illustrated by the sketch. This step type characteristic in the response curve of the filter is necessary because double sideband conditions prevail for the I signal for frequencies up to .5 mc; for higher frequencies, only the lower sideband is normally transmitted through the system. A delay line is also inserted in the I channel to compensate for the greater time delay inherent in the narrowband filter used in the Q channel.

3. Matrix Circuits

There are two matrix operations involved in the color monitor illustrated in Figure 37. First of all, the I and Q signals are cross-mixed to produce two signals proportional to R-M and B-M where R and B designate the desired red and blue video signals and M designates the monochrome or luminance signal. This part of the matrix circuit consists of a phase splitter for the I signal coupled to a pair of simple resistance mixers. In the second matrix operation, the M, R-M, and B-M signals are cross-mixed to produce the red, green, and blue video signals needed to control the tricolor tube. The R-M and B-M signals may be added directly to M to produce red and blue. In order to produce the green signal, R-M and B-M are first of all cross-mixed by means of a pair of tubes with a common load impedance having the relative gains indicated on the figure. This cross-mixing operation produces a G-M signal which may then be added to M to produce green. DC restorers are provided for all three kinescope guns.

4. Sync and Deflection Circuits

If a monitor were to be used exclusively in the same studio in which the color signals to be monitored originated, it would be possible to use the horizontal drive, vertical drive, and subcarrier signals provided by the studio distribution system to control the deflection circuits and demodulators in the monitor. Single-input monitors might be needed to view remotely-generated signals, however, so those actually built by RCA have included synchronizing and burst separation circuits to provide control signals from the information contained in the composite color signal. Typical deflection and subcarrier oscillator circuits for a single-input color monitor are shown in Figure 38.

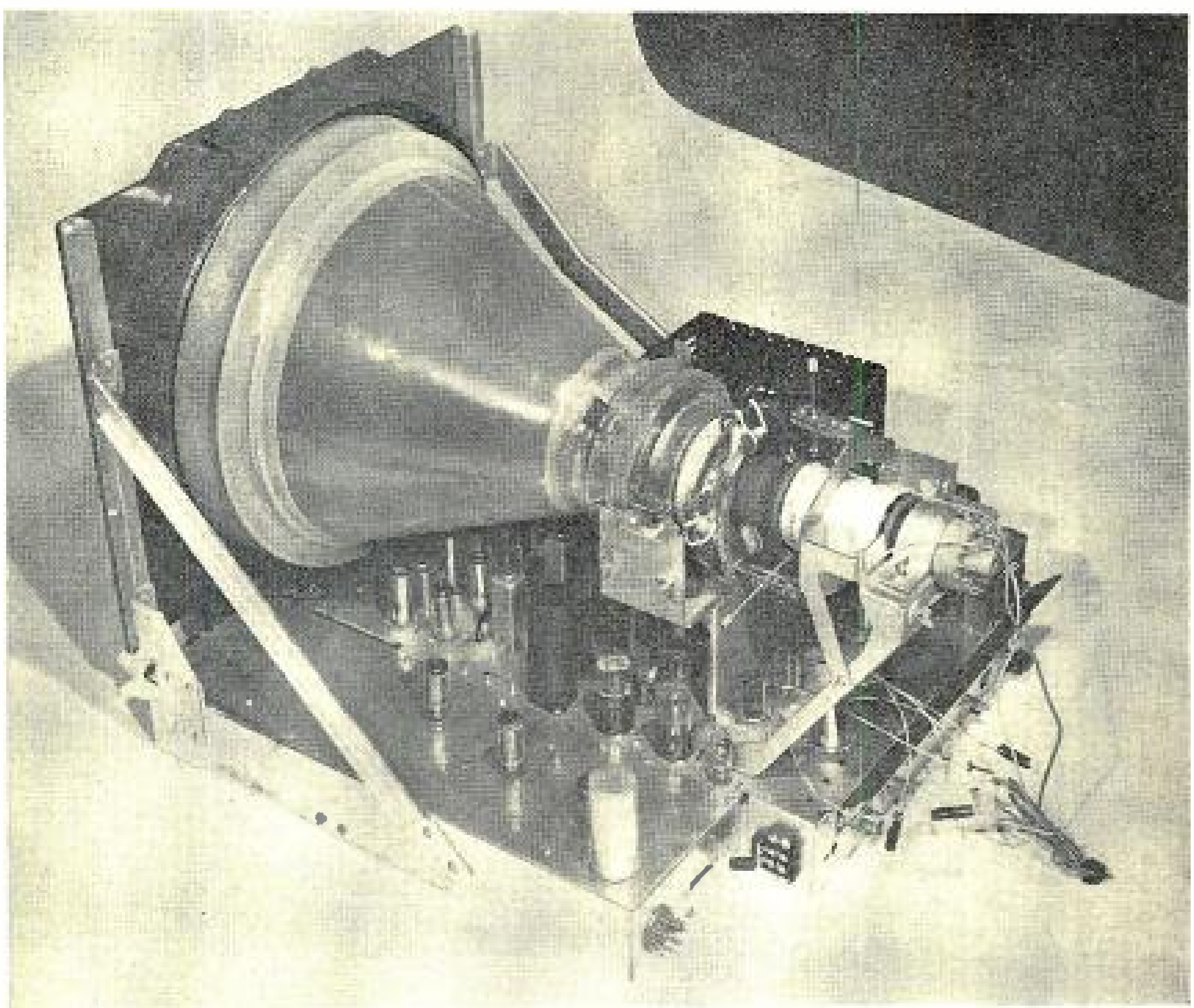

Fig. 40 — Rear view of a color television monitor.

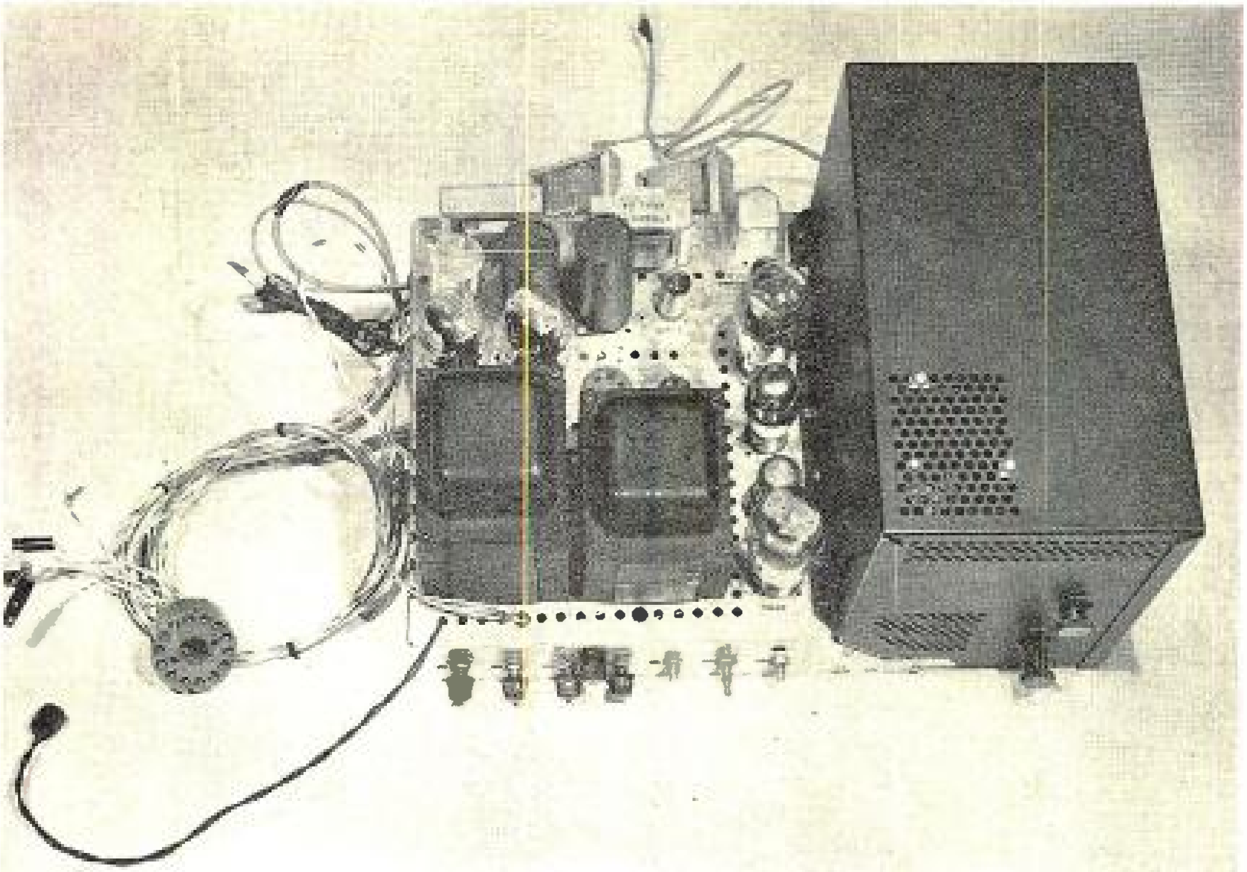

Fig. 41 — Power supply and convergence chassis for a color television monitor.

The synchronizing separator and deflection circuits are conventional, and are very similar to those used in home receivers. The burst is separated from the composite signal by a gating tube operated by pulses from a multivibrator controlled by horizontal sync. The separated bursts are compared with the output of a local oscillator in a phase detector, and the resultant error signal controls the local oscillator through a reactance tube. Since the subcarrier control information is received in the form of bursts separated in time by nearly a complete line period, the error signal actually obtained from the phase detector consists of a series of pulses. These pulses are smoothed out by an integrating network before they are applied to the reactance tube. The time constant for this integration circuit is long enough so that the entire burst control circuit has good noise immunity.

5. Physical Characteristics

The physical appearance of a single-input color monitor is shown in Figures 39 and 40, which are photographs taken from the front and rear, respectively. The color kinescope used is the RCA tricolor tube of the three-gun, shadow-mask type. Mounted on the chassis shown in these photographs are all the video circuits, the burst-controlled oscillator, and the deflection circuits. An auxiliary chassis, shown in Figure 41, is used for the power supplies and the convergence circuits. The RF power supply for the kinescope is mounted within the shielded compartment shown at the right of the photograph.

G. Auxiliary Equipment

In addition to the basic units discussed in the preceding pages, there are certain pieces of equipment used for special purposes in a color studio. For example, the step-wedge generator illustrated in Figure 42 provides a test signal having a "staircase" waveform at horizontal frequency which is very useful for adjusting the gamma correctors and for checking linearity in other parts of the system. Another very useful piece of auxiliary equipment is the color-bar generator which was mentioned earlier in connection with the adjustment of colorplexers. The physical appearance of this unit is shown in Figure 43.

The color-bar generator consists of a group of multivibrators which generate pulses in the red, green, and blue video channels capable of producing "pure" primary colors. As indicated earlier, these artificially generated signals are very useful for test purposes because they produce waveforms that are readily recognizable at various points in the system. It is to be expected that these and similar pieces of special test equipment will play an important role in the development of a color television broadcast service, just as such devices as the "window generator" and the "burst generator" have found great utility in black and white television systems.

H. Physical Arrangement of Equipment

Color television terminal equipment may be arranged physically in color studio control rooms in approximately the same manner as the corresponding black and white television terminal equipment. Figures 44 and 45 are photographs showing possible arrangements for some of the units discussed in the preceding pages. Figure 44 is a view of the control room in NBC's Colonial Theater studio in New York City.

The program director and the technical director sit at a console facing a row of color monitors and also a window looking directly out to the studio floor. The video operators are seated at a second console located behind the program director's console. The video operators have black and white monitors that are used for making such adjustments as electrical focus and registration in the individual camera chains.

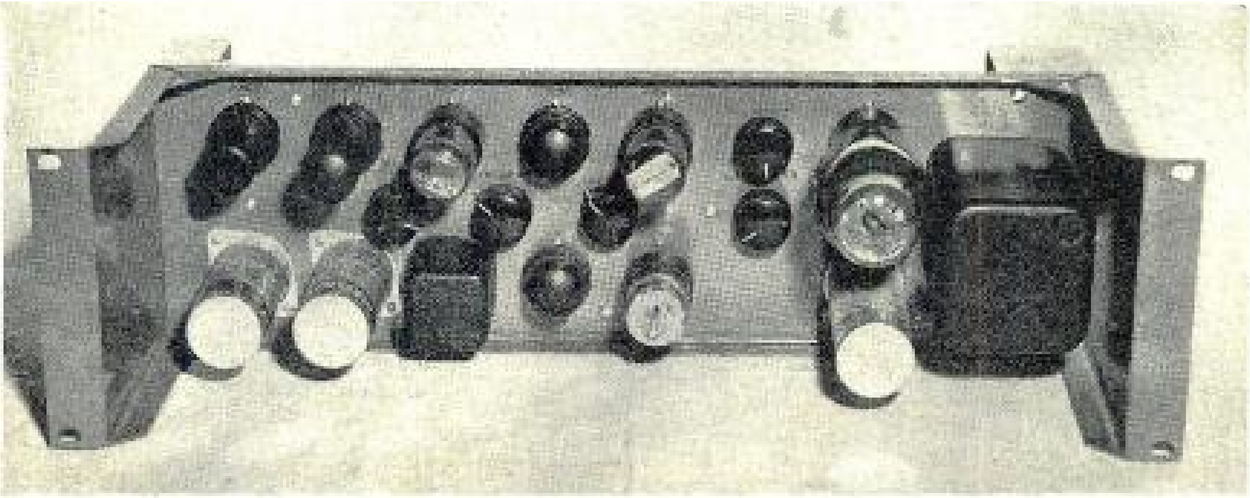

Fig. 42 — Step-wedge generator.

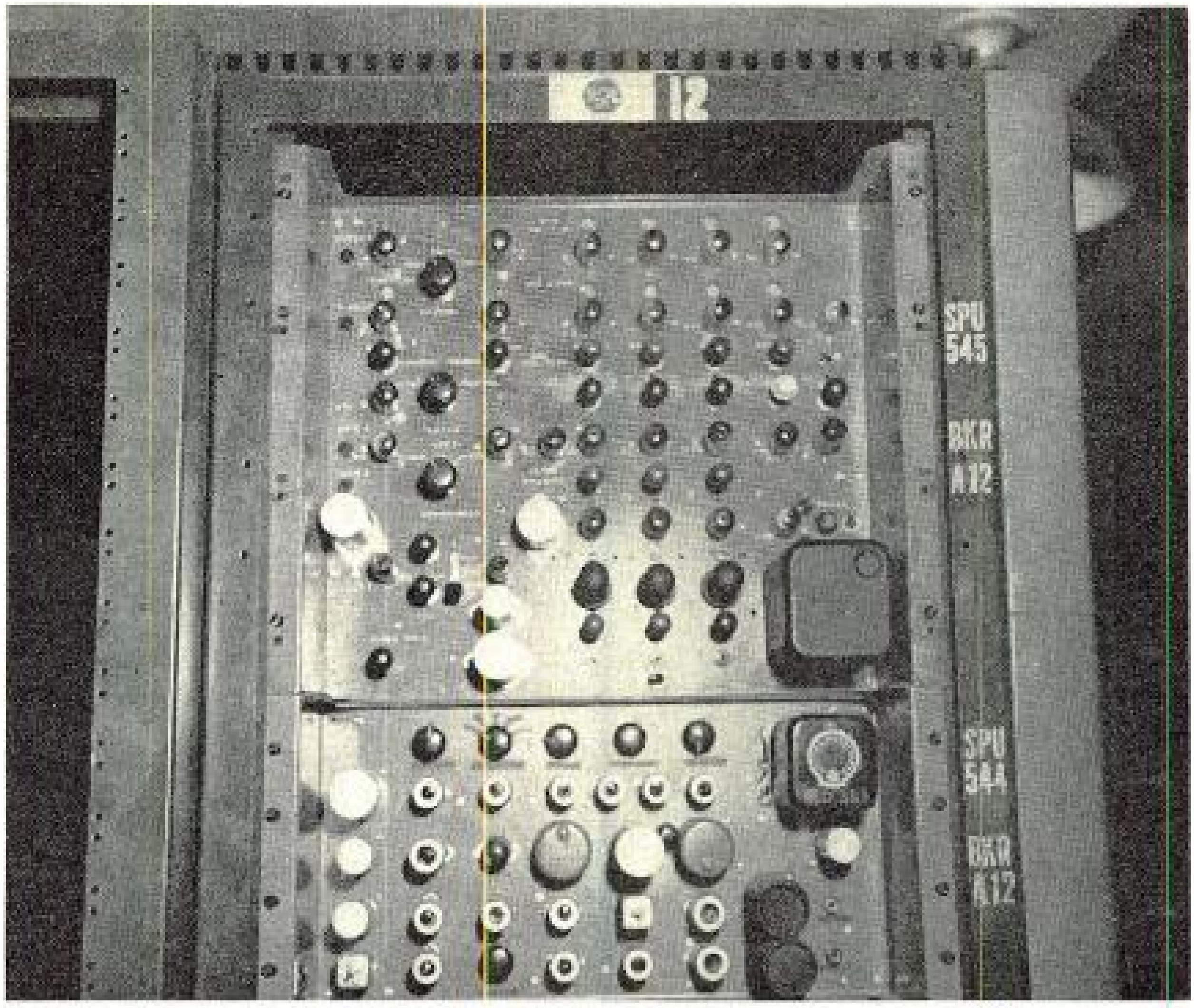

Fig. 43 — Color-bar generator (upper chassis).

The video operators also have a row of waveform monitors located just above the operating position. Another view of this same control room is presented in Figure 45, showing some of the racks for video equipment which are located behind the video operator's console. Such units as the colorplexers, camera control amplifiers, gamma correctors, and aperture compensators are located in these racks.

In keeping with the practice most commonly followed in black and white television studios, the power supplies are located in separate racks in another part of the control room where the heat generated by these units may be more readily exhausted.

I. Stabilizing Amplifiers

1. Functions of a Stabilizing Amplifier

Stabilizing amplifiers are frequently used in television systems at the receiving end of long transmission links, such as coaxial or microwave network links, to remove hum and microphone disturbances, to re-shape the synchronizing pulses, and to adjust the relative levels of the synchronizing and picture portions of the signal.

There are two rather different types of stabilizing amplifiers in common use in black and white television stations today; examples of these two basic types are the RCA models known as the TA5B and the TA5C (the TA5D currently on the market is of the same basic type as the TA5C but includes a few circuit refinements). Both of these stabilizing amplifiers have gated clamp circuits to remove hum and other low frequency disturbances; they differ mainly in the way that they solve the problem of re-shaping the synchronizing pulses and establishing the relative level of the synchronizing signal.

In the TA5B, the synchronizing pulses already present on the signal are simply stretched out or amplified more than the picture signal and then are clipped off at some arbitrary level.

In the TA5C the original sync pulses are completely clipped from the main picture signal and are re-shaped in entirely separate circuits and then added back to the picture signal prior to the output stage. Either of these basic types of stabilizing amplifiers may be adapted to handle a color television signal.

The TA5B can be used with only relatively minor circuit modifications as will be discussed below. The TA5C or the TA5D requires the use of an auxiliary unit to regenerate the burst portion of the signal.

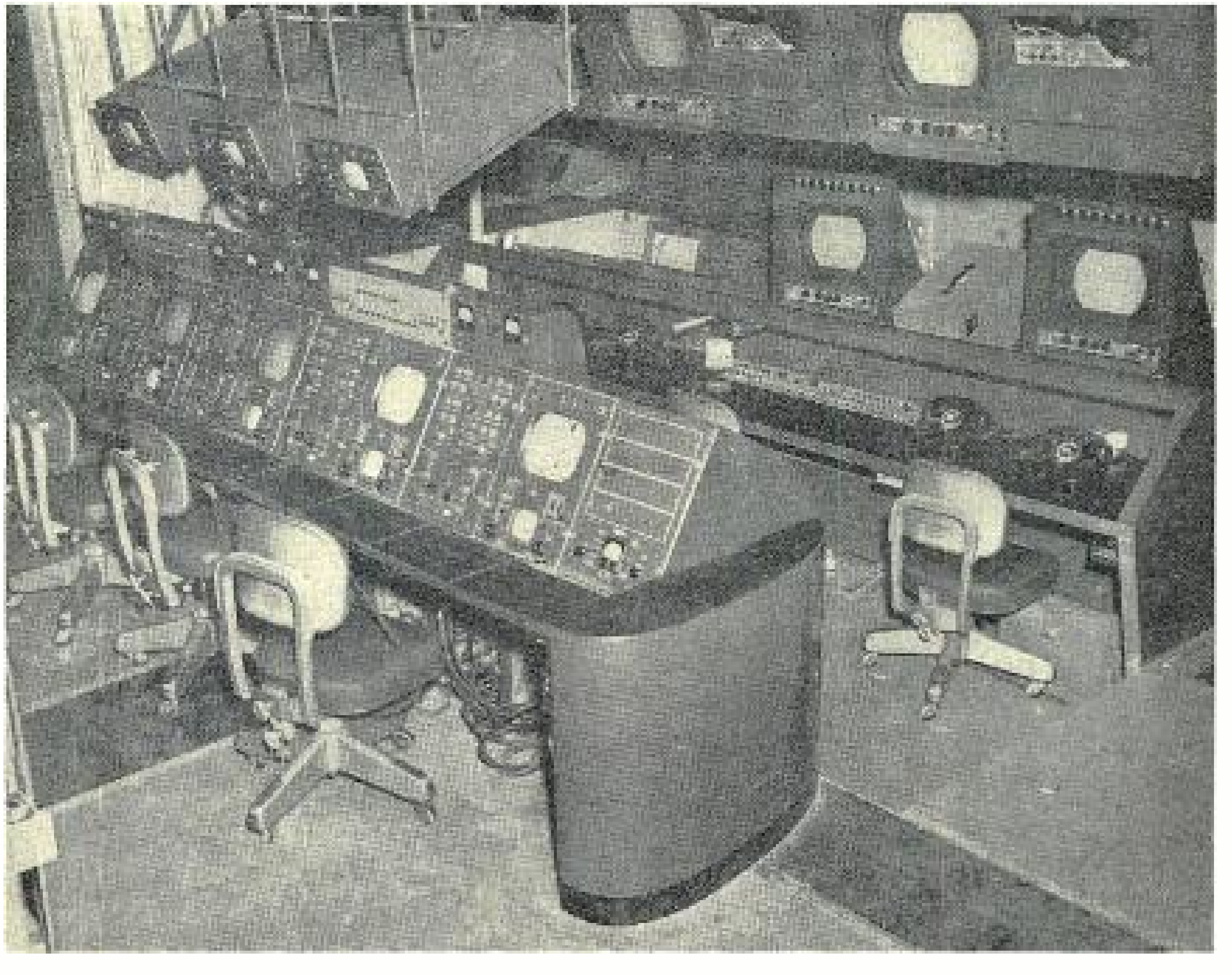

Fig. 44 — View of video operator's and program director's consoles in NBC's Colonial Theater Studio.

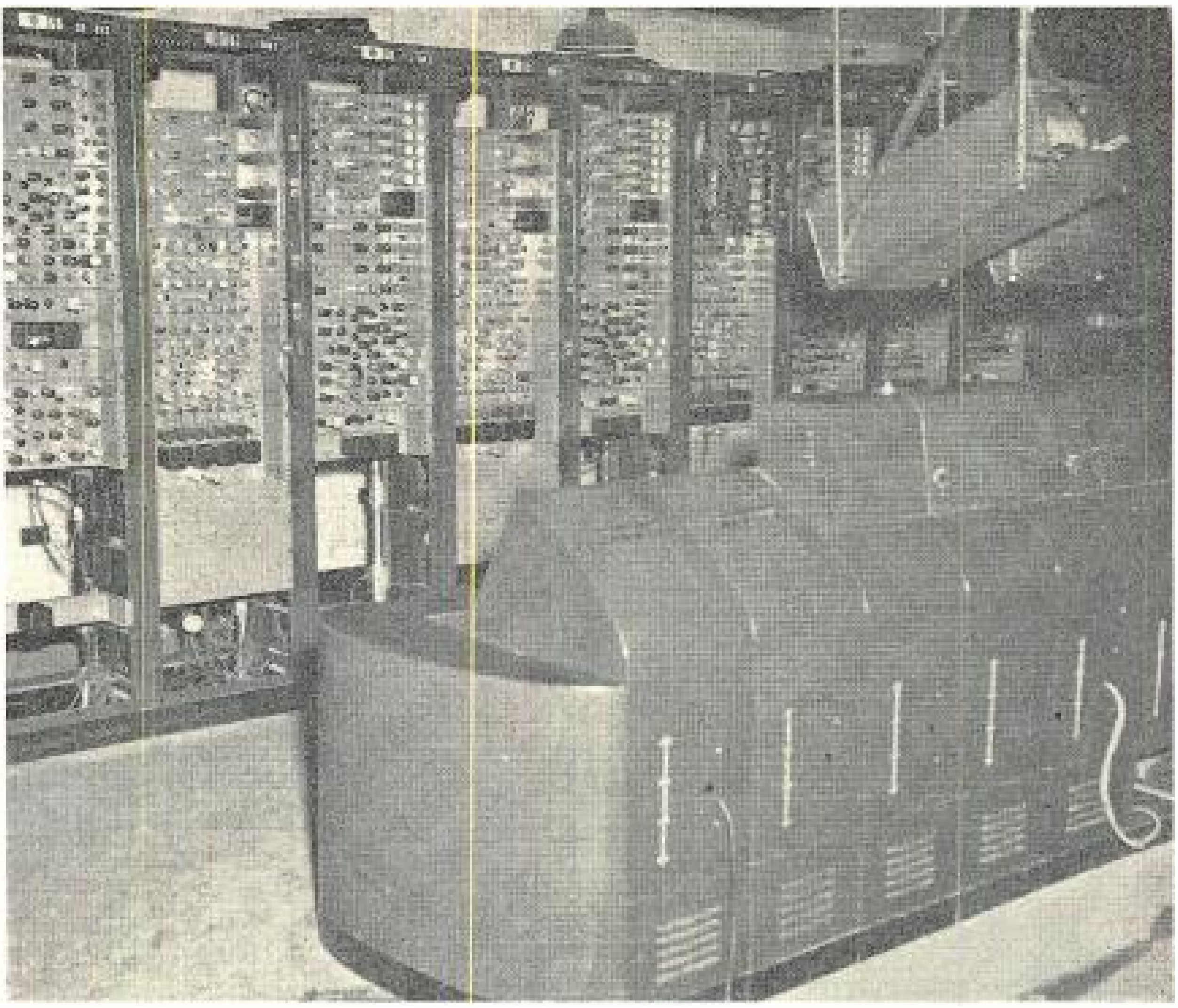

Fig. 45 – View of video racks in NBC's Colonial Theater Studio.

2. Sync-Stretching Amplifiers

A simplified block diagram of the TA5B stabilizing amplifier is shown in Figure 46. This diagram does not show some of the amplifier's special features, such as provision for the addition of external synchronizing pulses and dual outputs. In this amplifier a synchronizing signal separator is provided to strip the synchronizing pulses from the composite video signal at the input in order to provide timing information for the clamp keying pulses. At one point in the circuit, there are two amplifier stages in parallel. One of these is a simple linear amplifier which amplifies the entire signal. The other stage is so biased that most of the signal is below cut-off and only the tips of the synchronizing pulses are amplified. By adjusting the bias on this stage, the synchronizing pulses may be amplified more than the rest of the picture signal. The effect of this parallel combination is to stretch out the synchronizing pulses without affecting the rest of the picture appreciably. In the following stage, the stretched out synchronizing pulses are clipped off at some arbitrary level to establish the desired ratio of synchronizing signal to picture signal.

The changes which should be made in the TA5B for color service are as follows:

(1) A tuned circuit or resistor should be added to the second clamp circuit in order to provide an impedance at the subcarrier frequency so that the bursts are not distorted by the action of the clamp which takes place during the burst interval.

(2) The response of the amplifier stages at the input preceding the sync stretching operation should be attenuated somewhat at the high frequencies so that the level of the burst and the overshoots into the blacker-than-black region is sufficiently reduced that stretching of the synchronizing signal may occur without also stretching the burst and overshoot portions of the signal. The high frequency response in one of the output stages should be peaked up slightly to restore the overall circuit to a flat response characteristic.

(3) In order to avoid any possibility of shifting the phase of the burst through the action of the stabilizing amplifier, the delays through the two parallel paths in the synchronizing stretching circuit should be equalized.

(4) The bias of the synchronizing signal amplifier should be carefully adjusted to avoid stretching of the bursts or the blacker-

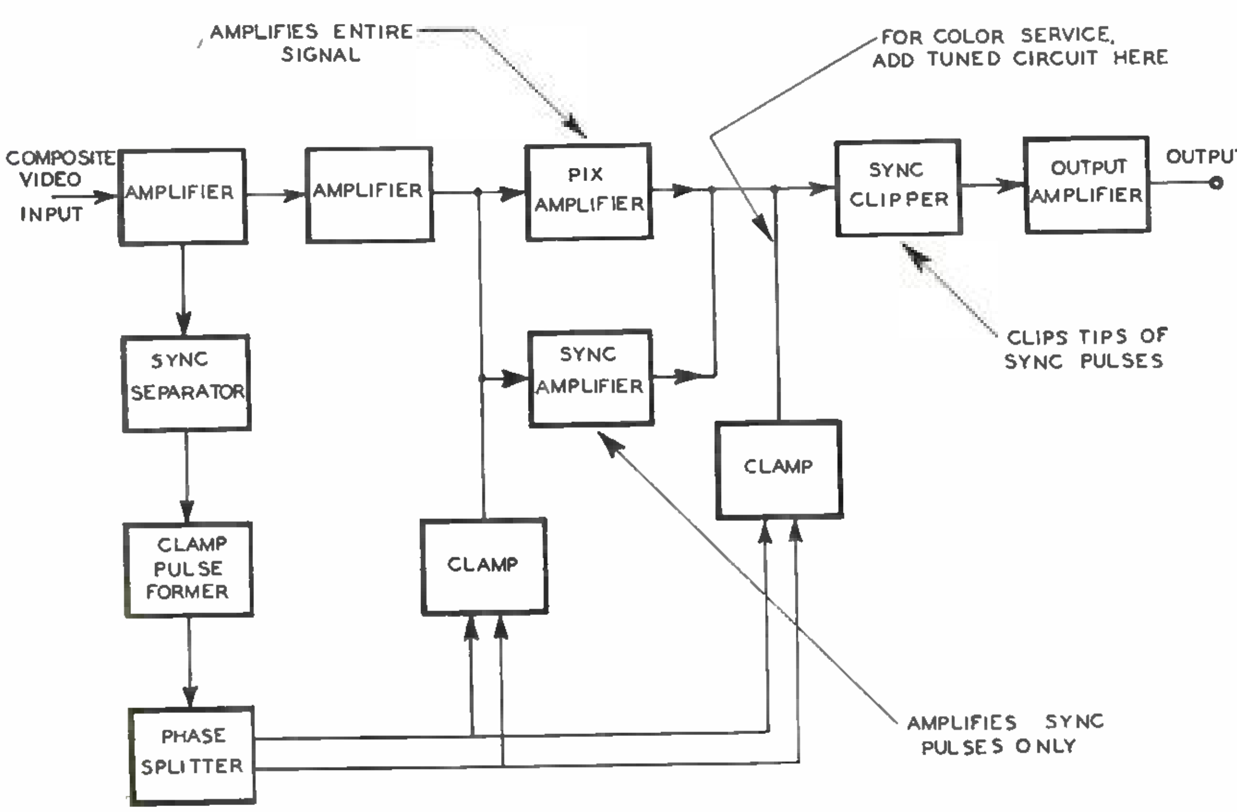

Fig. 46 — Simplified block diagram for a TA5B stabilizing amplifier.

than-black overshoots in the video signal. This is an operating adjustment and does not require circuit modifications.

3. Sync-Regenerating Amplifiers

One manner in which a TA5C or TA5D stabilizing amplifier may be used in the RCA color system is illustrated by Figure 47. This block diagram shows a TA5C in considerably simplified form, together with an auxiliary unit known as a burst regenerator. The TA5C stabilizing amplifier performs its usual functions: the input signal is amplified and clamped to remove low-frequency disturbances and to restore the DC component for the subsequent clipping operations. The synchronizing information is then wiped off in a linear clipper, and the video signal is amplified by itself. The synchronizing signal is separated from the video in another stage, and is re-shaped by double clipping—thus providing a clean waveform for controlling the clamp circuit, for subsequent addition to the output video signal, and for an external output to a genlock or other equipment. Since the synchronizing and picture signals are handled in separate stages, it is possible to adjust the level of one relative to the other.

The only change required in the stabilizing amplifier for satisfactory handling of a color signal is a re-adjustment of the frequency-response characteristics of the various stages to provide attenuation at the subcarrier frequency before clipping and sufficient high-peaking after clipping to restore the overall characteristic to flatness. This step is necessary to avoid clipping of the blacker-than-black overshoots of the color signal. The clamp circuit need not be altered, even though the clamping action occurs during the burst interval, because the burst information is recovered in the auxiliary unit before the signal is clamped.

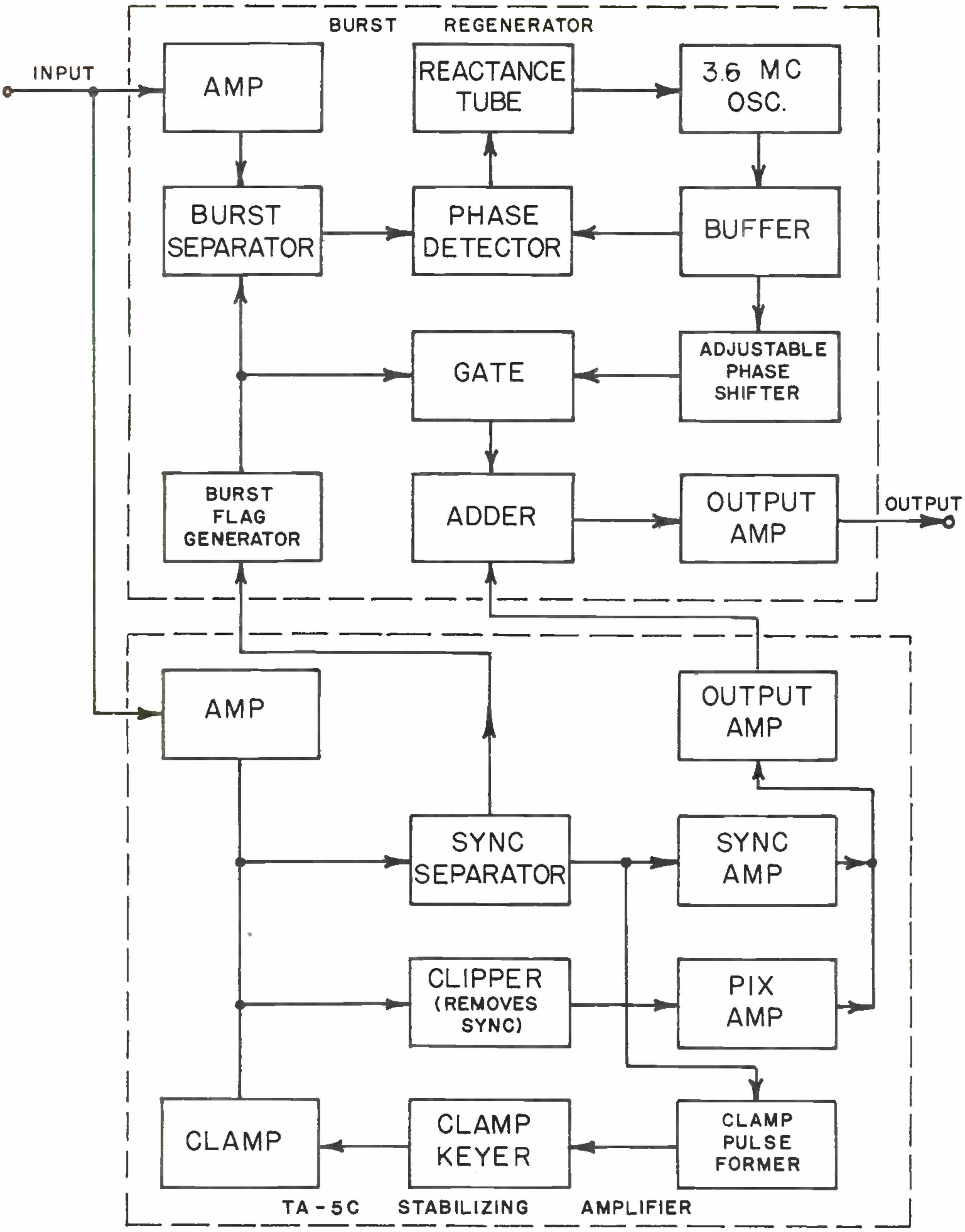

Fig. 47 — Simplified block diagram for a TA5C stabilizing amplifier and burst regenerator.

PART III

Transmitters

A. Transmitter Requirements

Transmitter requirements for compatible color television may be described most concisely by saying that they are basically the same as for black and white television but that the tolerance limits are tighter. A color television signal occupies the same spectrum space as a standard black and white television signal, but it contains a great deal more information. It is important, therefore, that the color signal be handled carefully to avoid intermodulation and other distortion effects which might give rise to cross-talk beween the various components of the signal. Specifically, there are three different characteristics that must be carefully controlled when a television transmitter is to be used to radiate a color signal. These are:

(1) Amplitude response as a function of frequency.

(2) Phase response or envelope delay as a function of frequency.

(3) The transfer characteristic, which controls both the differential gain and the subcarrier phase as a function of signal amplitude.

Closely related to the third characteristic mentioned above are two specific circuit problems. Whenever a gated clamp is used in the transmitter or in associated equipment, it may be necessary to make a slight modification by the addition of a tuned circuit or a resistor to make sure that there is no distortion of the color synchronizing burst during the clamping interval. Whenever parallel stages are used in the transmitter (many transmitters use groups of tubes in parallel to increase power levels at certain points), it is important that the time delay through all possible paths be the same so that there is no possibility of a phase shift in the subcarrier as a function of amplitude level in cases where the transfer characteristics of the parallel stages are not perfectly matched.

Since the color subcarrier component of the signal is transmitted near the upper part of the video band, it is important that the amplitude versus frequency characteristic be uniform in this region. Under the NTSC color television field test signal specifications, the frequency response of the transmitter must extend to at least 4.18 mc above the picture carrier prior to 2 db attenuation. The response characteristic for the lower sideband and for the mid-frequency range is the same as that specified in the present Federal Communications Commission standards for black and white television.

The proposed NTSC signal specifications include a statement which specifies the optimum time-delay-versus-frequency characteristic for the transmitter. This statement specifies that the time delay should be constant for all video frequency components up to 2.5 mc, but that the time delay for frequency components higher than 2.5 mc should decrease linearly with frequency so as to be .26 microsecond less for the color subcarrier frequency than for the low frequencies below 2.5 mc. Tolerance limits of ±.05 microsecond have been suggested for this optimum time-delay curve. This non-uniform time-delay-versus-frequency curve provides pre-compensation for the time delay errors associated with typical receiver circuits. In order to achieve this characteristic, a transmitter must have three types of phase compensation:

(1) The cut-off characteristic of the vestigial sideband filter for the lower sideband of the transmitted signal must be compensated so that there is no disturbance in the overall time-delay curve in the mid-frequency region (from about .5 to 1.3 mc) when the signal is detected after passing through a filter with the ideal vestigial sideband slope.

(2) Phase compensation must be provided for the cut-off of the upper sideband by the diplexer or other selective elements in the transmitter output, so that the time-delay characteristic of the transmitter itself is uniform to 4.3 mc above the picture carrier.

(3) Pre-compensation for receiver cut-off must be provided in accordance with the optimum time-delay curve mentioned above. This pre-compensation may be provided most conveniently by the insertion of a passive network specifically designed for the purpose.

When a television transmitter is used to radiate a color signal, it is very important that the transfer characteristic (that is, the relationship between the output and input signal amplitudes) be linear at least within the black-to-reference-white range. The effect of a non-linear transfer characteristic

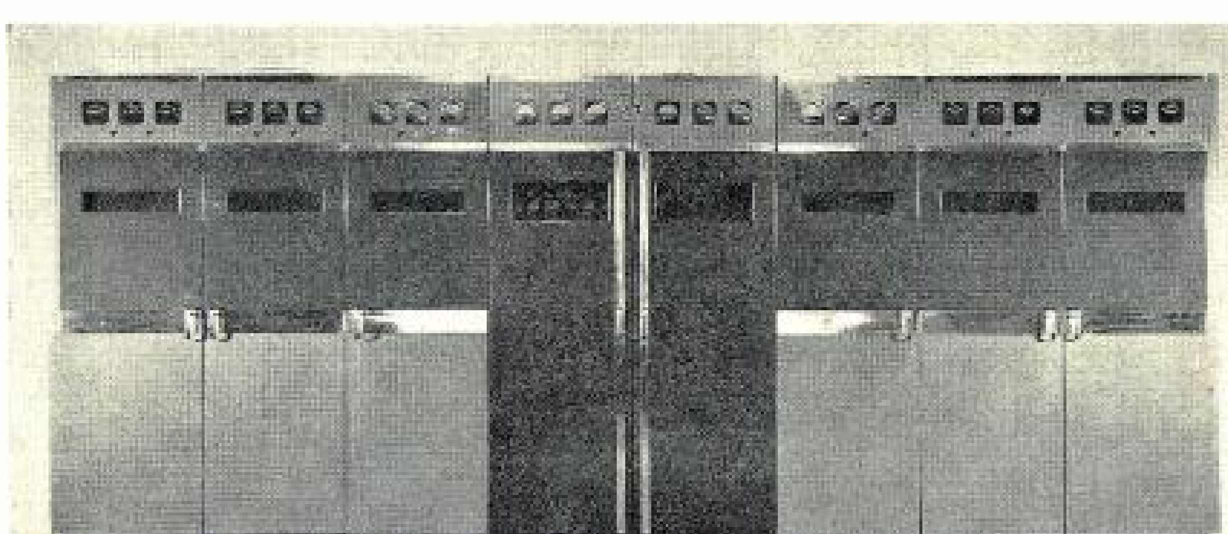

Fig. 48 — RCA TT5A television transmitter.

in a black and white system is to alter the gray scale rendition of the various areas in the picture. A curved transmitter characteristic in a color television system not only alters the luminance values in a reproduced picture but may also cause slight variations in chromaticity because of intermodulation effects between the luminance and subcarrier components of the signal. These difficulties may be avoided if the transmitter's characteristic is kept linear in the black-to-reference-white range.

Transmitters are customarily operated with the reference-white level set at about 12.5% of peak carrier.

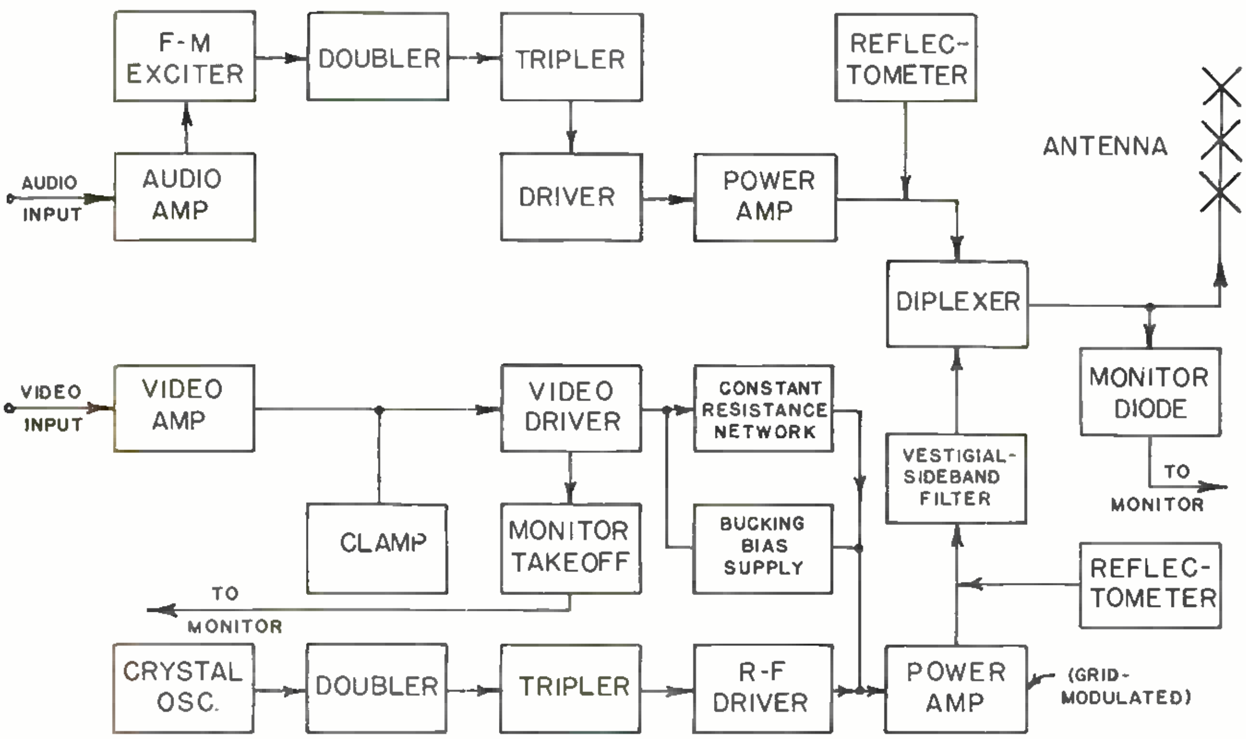

Fig. 49 – Simplified block diagram for a TT5A television transmitter.

Under some conditions, the color signal may contain subcarrier components which overswing into the whiter-than-white region far enough to reach zero carrier. Failure of a transmitter to transmit these whiter-than-white overshoots without distortion does not constitute a serious practical problem. Bright, highly saturated colors which cause severe overshoots are almost never encountered in the form of reflecting surfaces, so normal camera signals very seldom swing outside the normal black-to-white range. Even under the worst possible overshoot conditions, represented by artificially generated color bar signals, the distortions resulting from non-linearity in a transmitter's characteristic in the vicinity of zero carrier are relatively slight. Extreme linearity in the sync portion of the transfer characteristic is not required as long as there is no tendency to shift the phase of the burst.

Since the performance requirements for a color television transmitter are basically the same as those for a black and white transmitter except that the tolerance limits are tighter, it follows that any transmitter that is capable of radiating a color signal is in excellent condition for the radiation of a black and white signal. When a transmitter has the required amplitude versus frequency response characteristic for color operation, it is capable of handling a black and white signal with a minimum degradation of resolution. Careful control of the transmitter's time delay characteristic not only permits it to handle a color signal satisfactorily but also improves the transient response for black and white operation, making it possible to transmit pictures with optimum subjective sharpness. The time delay pre-compensation for receiver cut-off that is included in the NTSC field test signal specifications is also desirable for black and white television operation. Finally, close control of the transfer characteristic of a television transmitter not only makes it possible to transmit color signals without undesirable intermodulation effects, but also makes it possible to transmit black and white signals without gray scale distortion.

B. The RCA TT5A Transmitter

The transmitter that has been used by NBC to radiate color television for field test purposes in the New York City area is an RCA TT5A, a photograph of which is shown in Figure 48. A few relatively minor adjustments were made in the transmitter and a few pieces of auxiliary equipment (discussed in Part III C of this Exhibit) were added to enable it to handle the color signal most effectively. A simplified block diagram of the TT5A is shown in Figure 49.

In the aural section of the transmitter, the audio signal is frequency-modulated around a center frequency of 1/6 the final sound carrier frequency. This FM signal is then doubled, tripled, and amplified to a high power level (nominally 2500 watts) before transmission to the diplexer and thence to the antenna. In the picture section, the carrier is derived from a crystal oscillator which operates at 1/6 of the final carrier frequency. The oscillator frequency is doubled, tripled, and amplified to the necessary level to drive the grid-modulated output stage. The DC component of the video signal is restored by means of a gated clamp at the input to the video driver. For color service, this clamp is modified by the addition of a simple 2200 ohm resistor to provide sufficient impedance to prevent distortion of the burst during the clamping interval.

The video driver is direct-coupled to the grid-modulated power output stage through a constant-resistance network which provides a constant load for the video driver from DC up to the highest frequencies used. The difference in DC potential between the plates of the video driver stage and the grids of the power amplifier (approximately 1100 volts) is compensated for by means of a "floating" bias supply. The output of the power amplifier is transmitted to the antenna through the vestigial sideband filter and the diplexer, which combines the picture and sound signals. If it is desired to radiate an additional FM signal from the same antenna, a triplexer may be used.

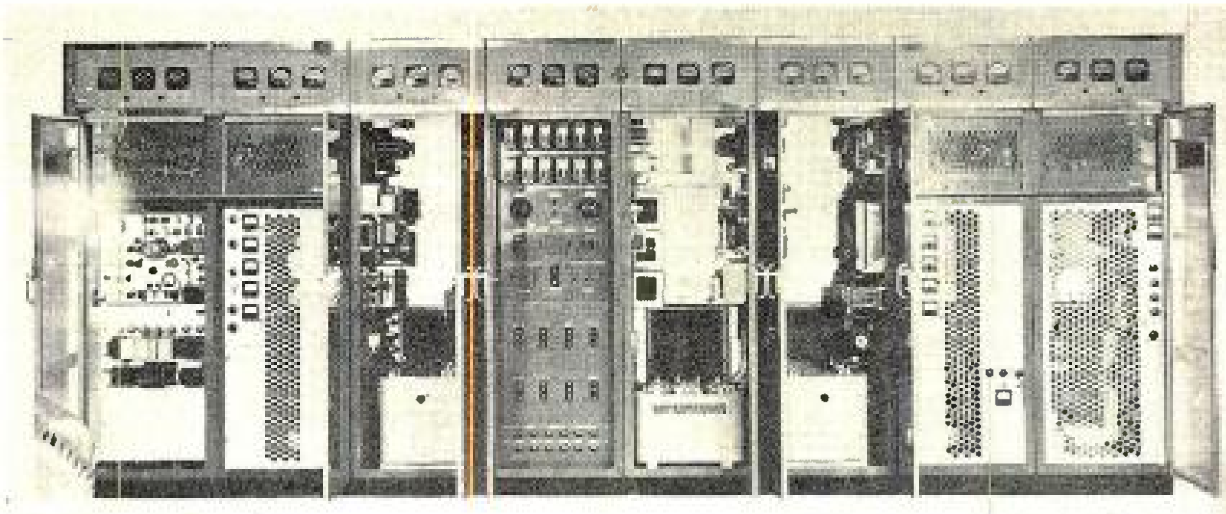

Fig. 50—Front view of a TT5A television transmitter with doors open.

Reflectometers are provided on the transmission lines leading from both the picture and sound transmitters to permit measurements of the standing wave ratios and the power outputs. Monitor diodes which demodulate the picture signal may be connected to probes installed at various points in the transmission line. A monitor diode is shown in Figure 49 in the line leading from the diplexer to the antenna. Similar diodes might be used at the input to the vestigial sideband filter or between the filter and the diplexer. It is also desirable to provide a vestigial sideband demodulator to sample the signal in the transmission line leading to the antenna. Such a vestigial sideband demodulator has a frequency response characteristic corresponding to that of an ideal receiver; the signal available from such a demodulator most closely approximates the signal that should be displayed on the kinescope of a high quality receiver tuned to the transmitter.

The arrangement of components in the TT5A television transmitter is indicated by Figure 50, which is a front view of the transmitter with the doors open. The first three racks on the left contain the aural transmitter, the fourth is the master control panel, and the four on the right contain the picture transmitter. The aural and picture power amplifiers are mounted in the upper sections of the last two racks on the left and right respectively. The FM exciter for the aural transmitter is located in the lower section of the first rack and the RF driver is in the second rack. The third rack contains power supplies for the aural transmitter. Racks five and six contain power supplies and part of the constant resistance network for the picture transmitter. The lower section of rack seven is occupied by the crystal oscillator, the frequency multipliers, and the RF driver for the picture transmitter. The video stages, the video driver, the "floating" bias supply, and the remaining sections of the constant-resistance network are located in rack eight.

The transmitter controls that must be manipulated during routine operation are mounted in a console, a photograph of which is shown in Figure 51. The panel at the left is the power control panel; in addition to switches for controlling the application of power to various parts of the transmitter, it provides a number of pilot lights to indicate proper operation of such devices as water pumps, tower lights, etc., in addition to the various stages of the transmitter itself. At the center of the console is a master monitor which provides both a kinescope display for viewing pictures and a display for viewing video waveforms. The right hand panel provides controls for both the audio and video signals. Switches are provided to select the desired input to the transmitter and to select the signals for transmission to the monitor loudspeaker or for display on the master monitor. The video signal may be monitored at the input to the transmitter, at the output of the video driver stage, at the output of one or more monitor diodes connected to probes in the transmission lines to the vestigial sideband filter and antenna, or at the output of the vestigial sideband demodulator.

C. Auxiliary Equipment for Television Transmitters

If the proposed NTSC field test signal specifications for color television are adopted, it is to be expected that all television transmitters designed and built in the future will be capable of radiating a color signal without modification; those currently being manufactured by RCA were designed with color requirements in mind. Existing transmitters may be used for color broad-

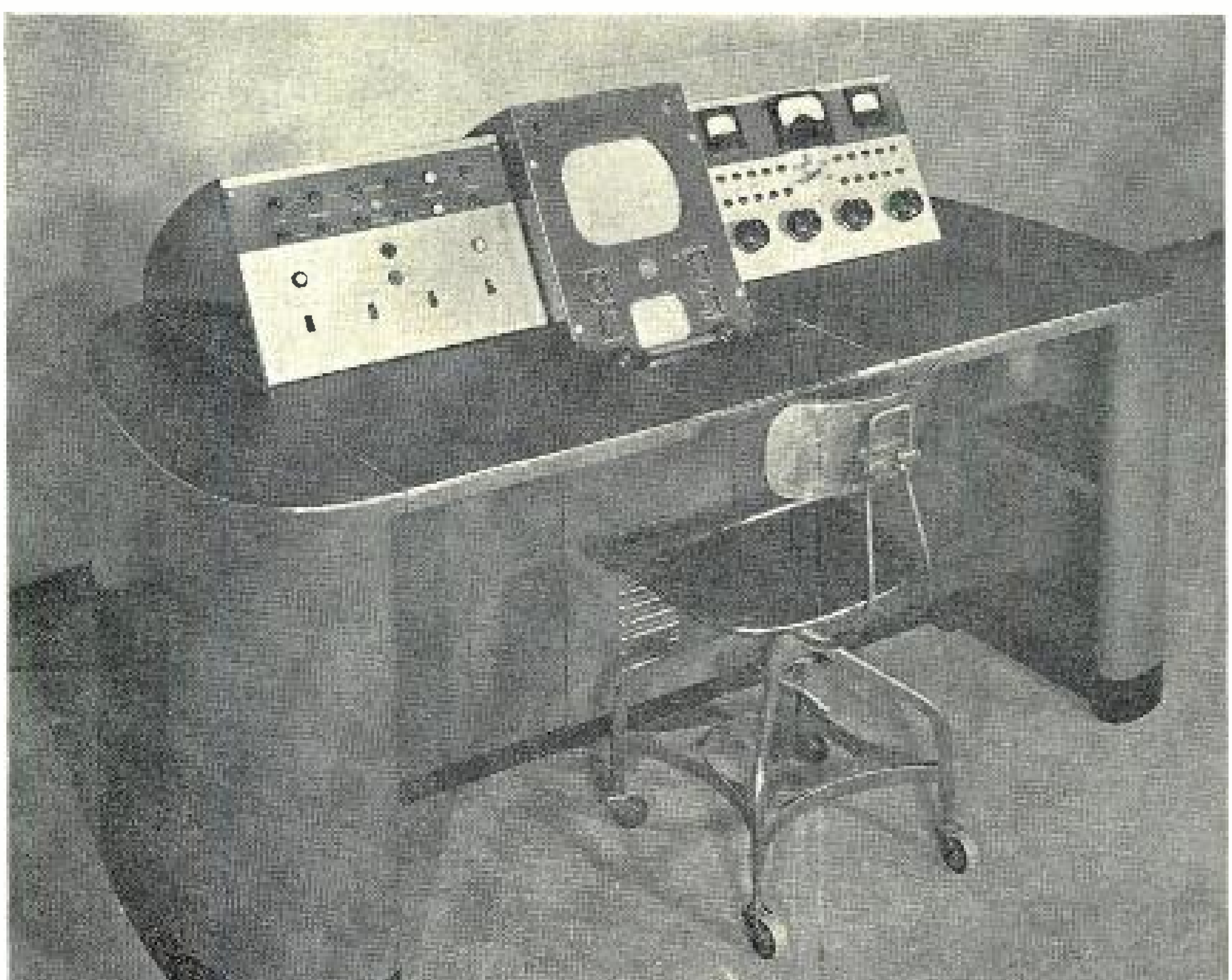

Fig. 51 — Control console for a TT5A television transmitter.

casting by adjusting them for optimum performance and by inserting a few pieces of auxiliary equipment in the video input to compensate for various characteristics that require tighter tolerance limits than those initially provided in the transmitter. A typical arrangement of transmitter equipment for color television service is shown in Figure 52.

The stabilizing amplifier is used at the video input in order to remove low frequency disturbances from the signal and to establish the proper relative levels of picture and synchronizing signal. The operating characteristics

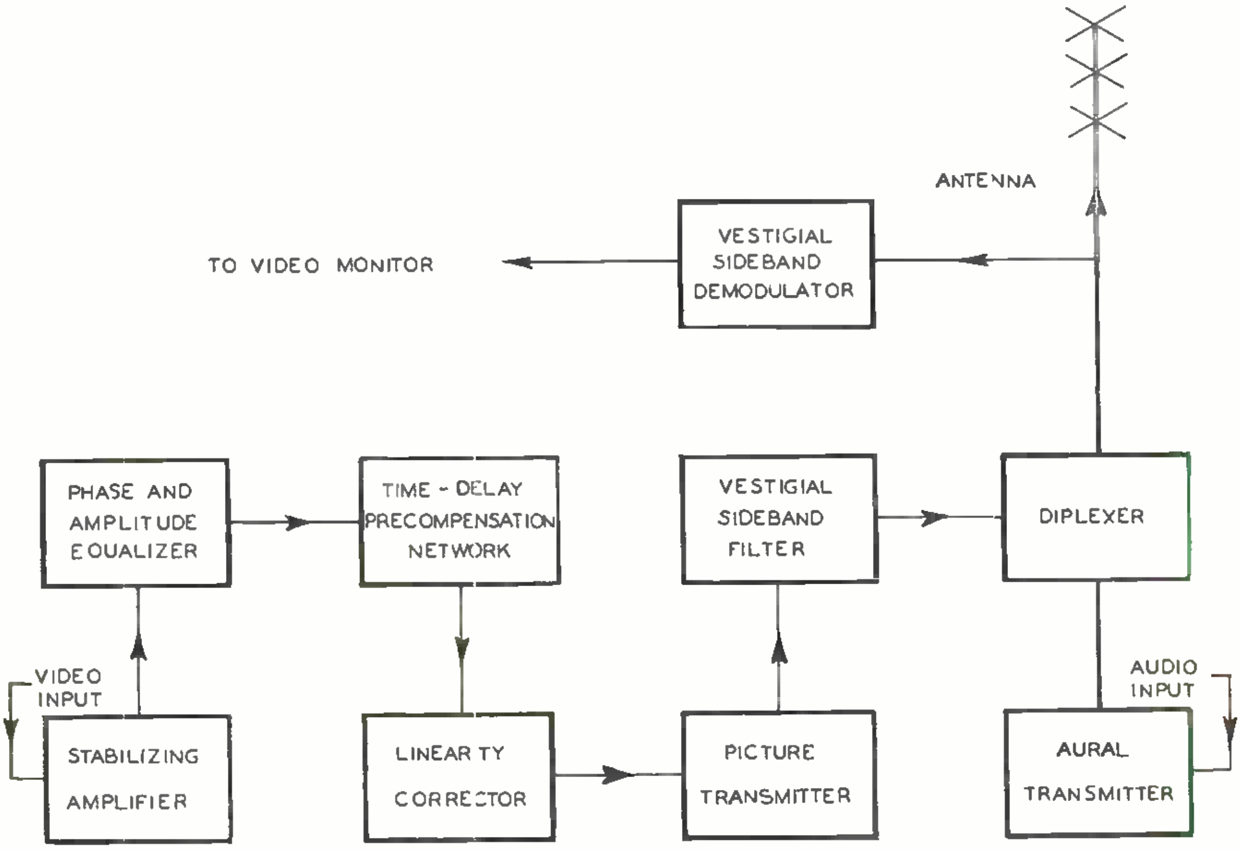

*Fig. 52—Block diagram for a color television transmitter with auxiliary equipment.**

of stabilizing amplifiers were discussed in Part II of this Exhibit. The phase and amplitude equalizer is essentially a video amplifier with adjustable frequency and phase compensation circuits. This unit is used to accomplish the first two types of phase compensation discussed in Section A above and also to provide a final trim of the overall amplitude versus frequency characteristic for the transmitter (after the transmitter itself is adjusted for optimum frequency response).

The adjustment of the amplitude and phase equalizer is made by conventional square wave techniques. The vestigial sideband demodulator must first be set up to duplicate the ideal receiver response characteristic as closely as possible. Then square waves with system-limited rise times are passed through the entire transmitter system and the waveform provided at the output of the vestigial sideband demodulator is viewed on a wideband CRO.

* The only addition required by color is the time-delay precompensation network.

The phase controls on the phase and amplitude equalizer are then adjusted to make the transients on the leading and trailing sides of each transition in the signal as symmetrical as possible. The time-delay pre-compensation network should be in the circuit when these adjustments are made.

The pre-compensation may be provided by a passive 75 ohm network which may simply be inserted in series with the 75 ohm cable connecting the phase and amplitude equalizer to the linearity corrector.

The time-delay pre-compensation network used for the RCA color television field tests consists of an eight section all-pass filter of bridged-T form. The linearity corrector is a non-linear amplifier basically similar in design to the non-linear amplifiers used for gamma correction (see Figure 21). This unit is adjusted to have a transfer characteristic which is curved in the opposite direction from the curvature in the transmitter itself.

The TT5A transmitter has a tendency to compress whites, so the linearity corrector is adjusted to provide white expansion. The linearity corrector is adjusted by passing a step signal through the combination of the linearity corrector and the transmitter and viewing the waveform at one of the diode monitoring positions. A new technique involving a subcarrier component superimposed on a step signal has been used with considerable success in making this adjustment. When using this new technique, a step-plus-subcarrier signal is passed through the equipment under test and then the step component of the signal is removed by means of a high-pass filter; any departure from linearity appears as a variation in the amplitude of the subcarrier envelope.

The linearity corrector is made adjustable over a reasonable range so that slight variations in the overall characteristic as a result of different tube characteristics and tube aging effects may be compensated for. It is necessary to use a gated clamp circuit in the linearity corrector in order to maintain the black level at a constant voltage in the non-linear stage. The linearity corrector may be built into the stabilizing amplifier, where clamp pulses are already available.

PART IV

Remote Pickup Equipment

RCA has developed and produced a remote pickup unit for color television which makes possible the origination of color television programs from points outside regular broadcast studios. A photograph of this equipment is shown in Figure 53. The mobile pickup unit consists essentially of two camera chains mounted within a truck together with a synchronizing generator, a colorplexer, and switching and monitoring facilities. A microwave transmitter is provided for the purpose of radiating a signal back to the main studio or transmitter site, and audio amplifiers are provided for the transmission of sound signals through telephone company circuits. The cameras themselves may, of course, be removed from the truck and operated at distances of up to 1000 feet.

Fig. 53 — Remote pickup unit for RCA color television.

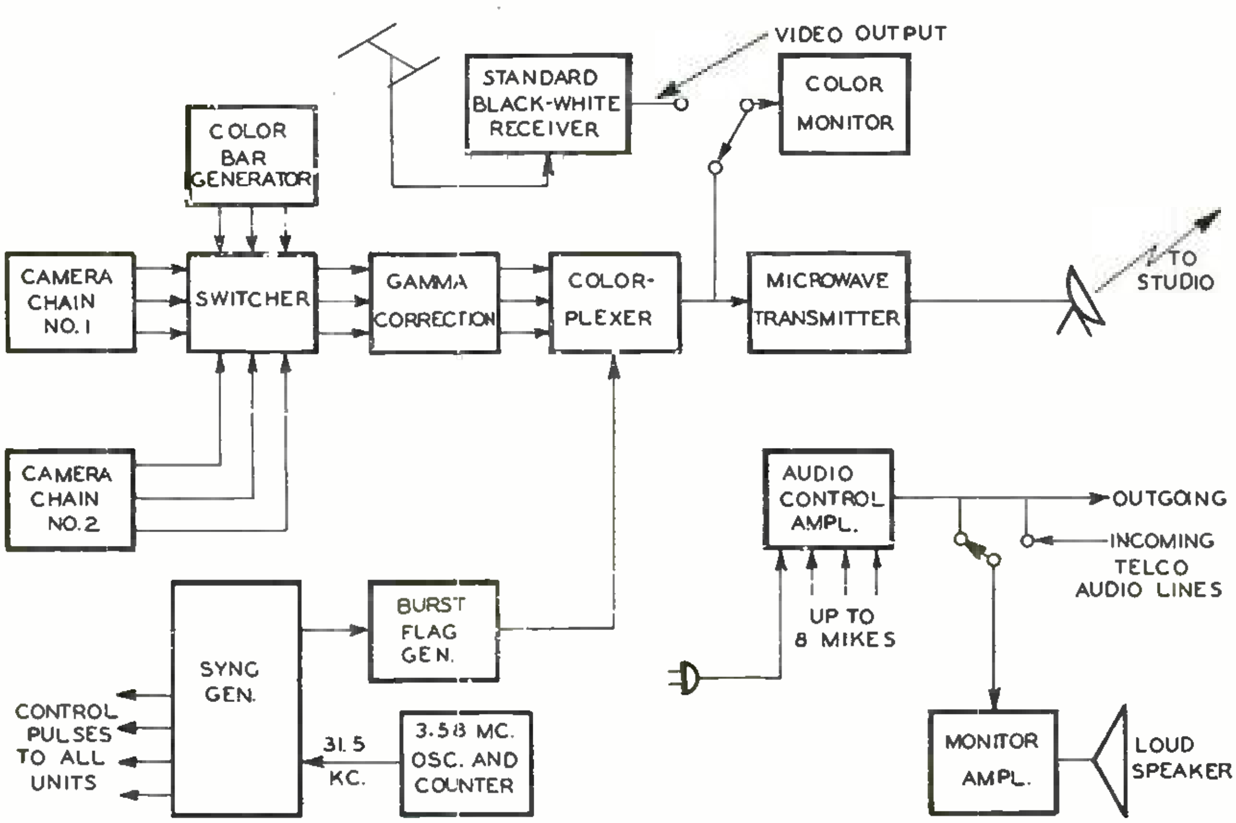

Fig. 54 — Block diagram sho~wing the major electronic equipment installed in remote pickup unit.

The major pieces of equipment used in the mobile pickup unit are shown in the block diagram in Figure 54. The two camera chains constitute the basic signal sources, but a color bar generator is also provided for the generation of special test signals. The camera chains are the same as those shown in Figure 8 and described in an earlier section of this exhibit, except that only one gamma corrector is used following a switcher for both camera chains. The colorplexer, burst flag generator, color monitor, and the oscillator and counter unit are all the same as the corresponding units previously discussed. The synchronizing generator employed is a standard RCA field synchronizing generator, which is packaged in two separate suitcase-style cases. The circuits in this field synchronizing generator are identical to those used in the TG1A studio synchronizing generator. Frequency control for the synchronizing generator is transferred from the crystal oscillator normally included in this generator to the external subcarrier oscillator and counter unit, in the manner previously discussed. The microwave transmitter is of the same type commonly used for black and white remote pickup service and for studio to transmitter links; the bandwidth of this equipment is sufficiently wide to accommodate a color television signal.

A receiver is provided in the remote pickup truck in order to permit monitoring of the signals from the station's main transmitter. As indicated on the diagram, the video output from the second detector of this receiver is brought out so that it can be applied to a color monitor during color telecasts. A black and white television receiver is useful for cueing purposes as well as for monitoring the quality of pictures actually produced by the mobile unit. Conventional audio equipment is provided to handle the sound portion of color television programs. As noted in Figure 54, up to eight microphone inputs can be accommodated. A transcription turntable is also carried as an auxiliary unit so recorded music or other sounds may be provided at the remote pickup site. It is customary to use at least two audio lines on a remote pickup. One of these is used for outgoing sound, while the other is used for a return audio line from the main studio; this second line is very useful for audio cueing.

In addition to the basic units shown in Figure 54, the remote pickup truck contains power supplies, test equipment, and a few generators for special test signals. Nine standard RCA field power supplies, supplying one ampere each at +280 volts, are mounted in a special rack at the rear of the truck. A wideband cathode-ray oscilloscope is mounted on a rotatable pedestal near the center of the truck. This oscilloscope may be used to check circuits in all parts of the truck without removing it from its mounting. A special switcher is provided to permit the oscilloscope to be connected rapidly to points that require frequent monitoring.

The test signal generators carried on the truck include a step generator for setting the gamma corrector circuit, a color bar generator for adjusting the colorplexer circuits, and a so-called "burst generator" for making rapid frequency response checks of the overall system. The last mentioned piece of equipment provides a synthetic television signal consisting of a group of

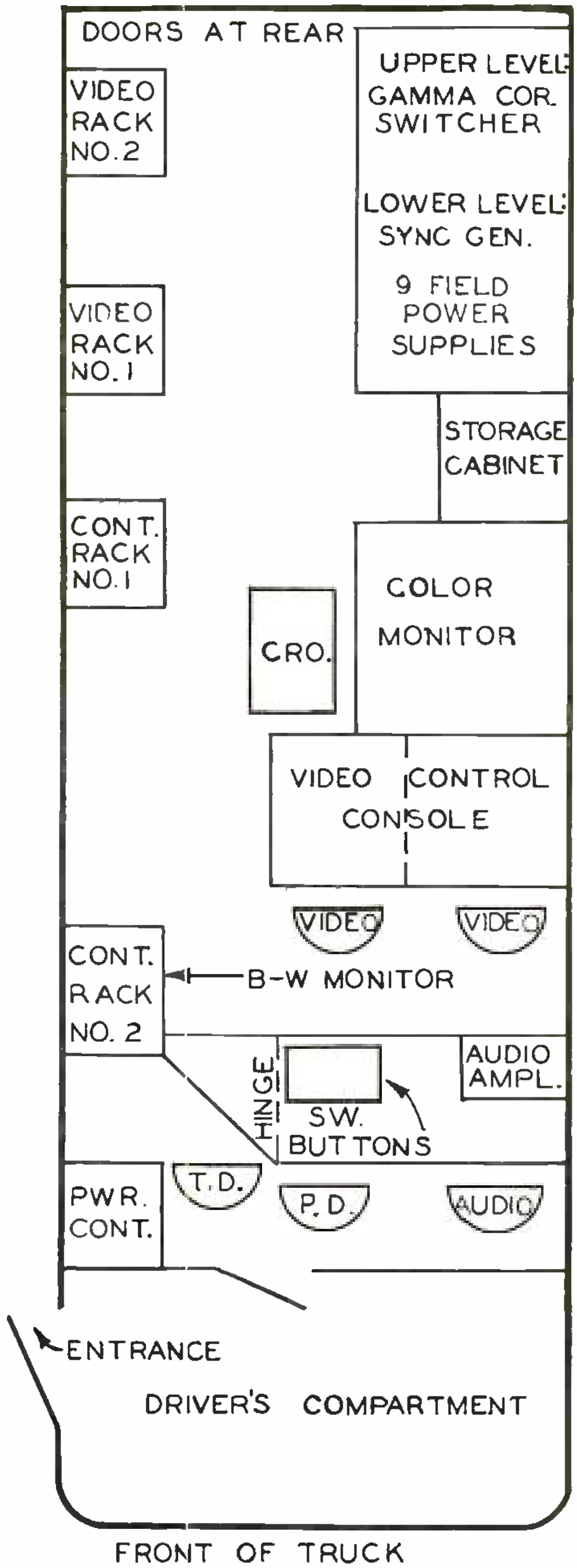

Fig. 55 — Simplified layout sketch illustrating the arrangement of equipment in the color television remote pickup unit.

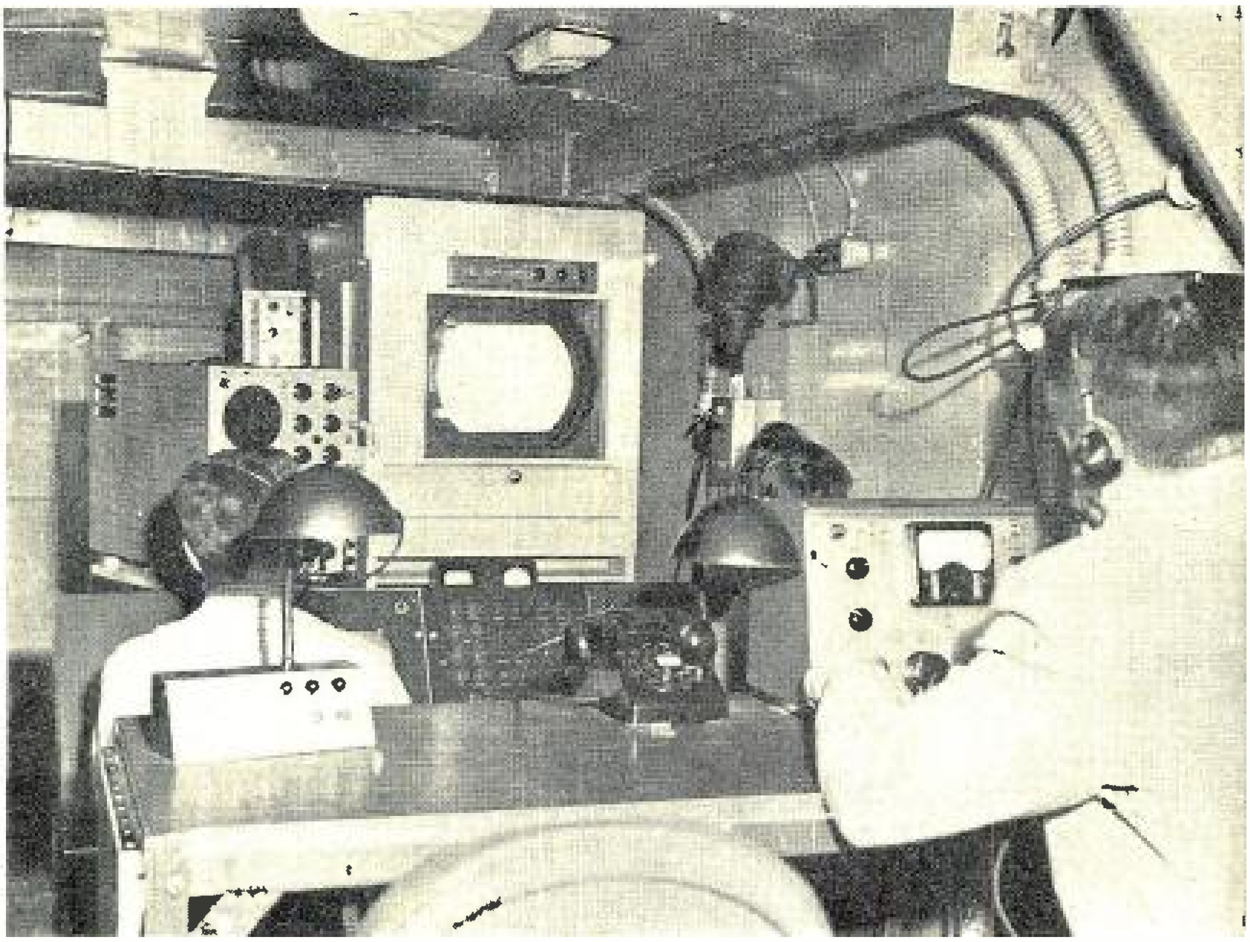

Fig. 56 — Interior view of the remote pickup unit, showing the control consoles.

five bursts in each horizontal line; each burst is of a different frequency in the range between .5 and 4.3 mc.

The arrangement of the remote pickup equipment within the truck is illustrated by the simplified layout sketch presented as Figure 55. The inside dimensions of the truck are approximately 18 feet by 7.5 feet. Two consoles — one for the program director, the technical director, and the audio engineer, and the other for the two video engineers who operate the cameras — are provided near the front end of the truck. A black and white receiver and a color monitor are mounted in positions such that they can be seen from both consoles. Standard video racks are mounted along one side of the truck and special shelves on the other side are used to hold the field power supplies, the sync generator, and the gamma corrector.

Space not actually occupied by equipment is used for storage; for example, a rack for the storage of image orthicon tubes is provided under the color monitor, and a special cabinet for the storage of microphones and other audio equipment is mounted above the monitor. The storage cabinet to the rear of the color monitor provides space for the storage of small tubes and parts, an electro-zoom lens, and small test equipment.

The two video racks for the two camera chains contain the control amplifiers, the focus coil current regulators, and the —500 volt power sup-

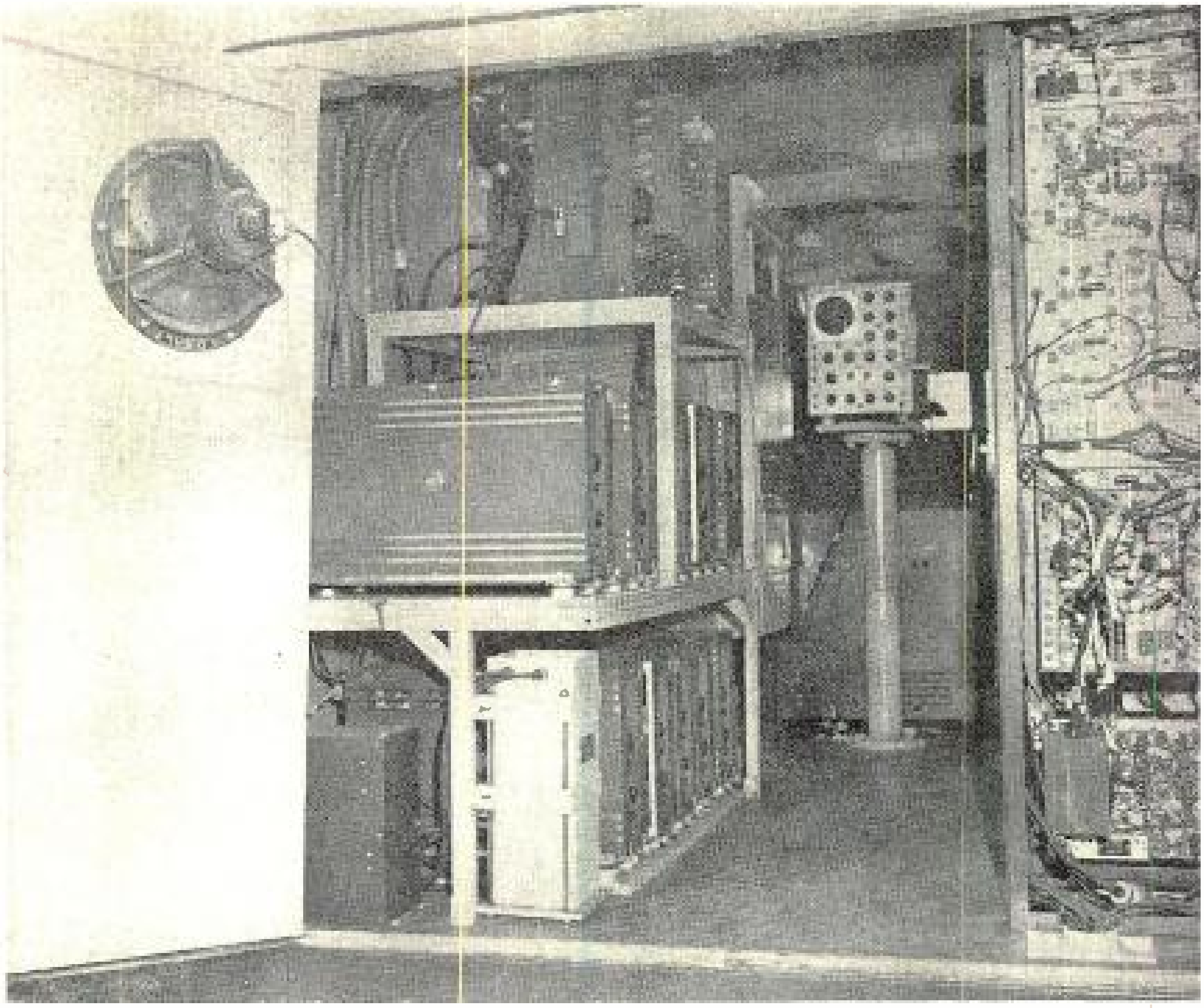

Fig. 57 — Interior view of the remote pickup unit, showing racks for electronic equipment.

plies for each camera. In the bottom of camera control rack number two is mounted a 24 volt DC power supply for the intercom system within the truck. Control rack number one provides space for the subcarrier oscillator and counter, a master jack panel permitting interconnections between the various units, the colorplexer, a power switch control panel, and the burst flag generator. Control rack number two mounted below the black and white television receiver contains the color bar generator, the step generator, the microwave transmitter control unit, and the audio monitor amplifier. Monitor loudspeakers are mounted near the front of the truck just above the audio engineer's position.

Figure 56 is a photograph of the interior of the truck showing the two control consoles. The technical director sits at the left (the shelf in front of him is hinged so that it may be lowered to gain access to the main aisle of the truck), the program director sits in the middle, and the audio engineer sits on the right hand end of the first console. Two video operators, each responsible for the operation of one camera chain, sit at the second console.

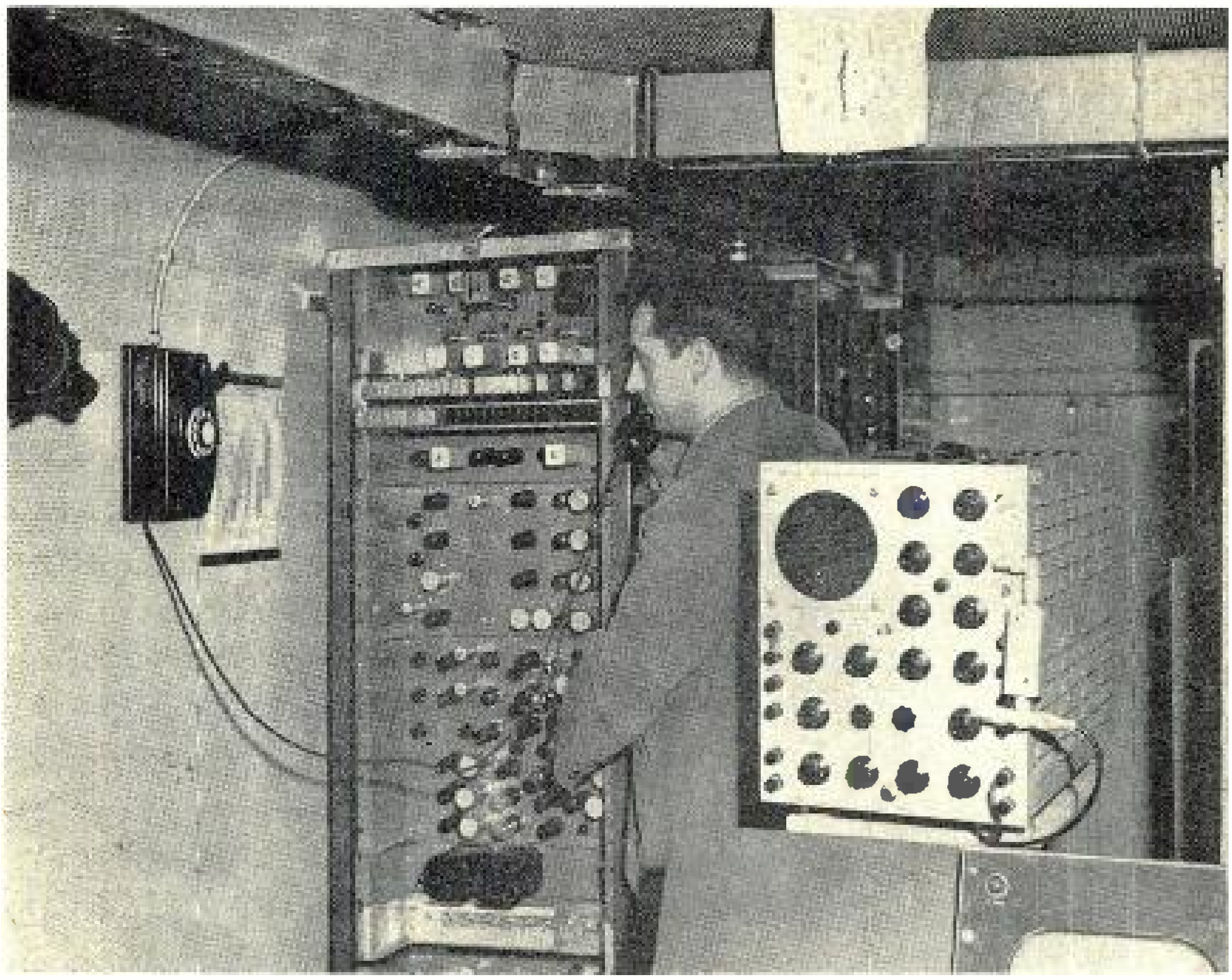

Fig. 58 — Another view of the interior of the remote pickup unit.

As noted previously, two standard console sections are used for each RCA color television camera chain. Other views of the interior of the remote pickup unit are shown in Figures 57 and 58. Four fans are provided for cooling the van and all wiring is carried in overhead ducts.

APPENDIX A

BROADCAST STATION EQUIPMENT REQUIREMENTS FOR THE RCA COLOR TELEVISION SYSTEM

Introduction

This Appendix outlines RCA's present plans with respect to the production of color equipment for broadcast stations. The introduction of commercial color television broadcasting will probably pass through four clearly defined stages for the majority of television broadcast stations. These stages may be described as follows:

Stage 1. Network Operation only. In the early days of commercial color television broadcasting, it is likely that most color programs will be originated in the studios of the major networks. The only steps that the owner of an existing television station must take to provide color service are the adjustment of his transmitter to radiate a color signal, and the provision of equipment to monitor the signal received from the network.

Stage 2. Provision for Slides. Still pictures in color may be produced at a local broadcast station by the addition of a color slide camera and the auxiliary equipment needed to produce a color signal in accordance with the proposed NTSC signal specifications.

Stage 3. Film Pickup. More intense local programming may be provided by the addition of color film scanning equipment. The auxiliary equipment needed to process the signals is the same as that already provided in Stage 2.

Stage 4. Live Pickup. Eventually, most broadcast stations will want to originate live programs in color from their own studios or from points of interest in their own communities. To do this, they will require live color cameras and more complete switching and distribution facilities to provide the programming flexibility provided in present-day black and white studios. The amount of this equipment will vary widely from station to station depending on individual requirements.

In order to facilitate the introduction of commercial color television broadcasting service, RCA's initial plans are to produce appropriate broadcast equipment on a custom basis. This program will enable interested broadcasters to proceed with color early in 1954. Meanwhile, RCA will continue its development and design activity leading toward a regular commercial production program.

The custom-made equipment contemplated for the stages delineated above is described briefly below, and an indication is given of approximate prices and delivery dates.

Equipment for Stage 1
(Network only)

The color equipment needed to supplement the monochrome facilities in an existing television station to enable it to broadcast network programs in color is as follows:

(a) New Color Equipment

Quantity	*Description*
2	*Color Stabilizing Amplifiers,* which perform the same basic functions as black and white stabilizing amplifiers and also include provisions for handling the color synchronizing bursts. Amplitude linearity correction circuits will also be included for the compensation of transmitters.
1	*Tricolor Monitor,* which produces a color picture for monitoring purposes on an RCA tricolor tube.
1	*Low Frequency Phase Equalizer,* which provides phase compensation for the cut-off region of the lower sideband of the picture carrier.
1	*High Frequency Phase Equalizer,* which provides phase compensation for the upper portion of the upper sideband, including provision for the phase compensation specified in the proposed NTSC signal specifications for receiver cut-off.
1	*Transmitter Conversion Kit,* which contains the parts needed for relatively minor modifications in existing transmitters and sideband filters.
1	*Demodulator Kit.*

Estimated total price, new color equipment: $11,500

(b) Standard Stock Items

Miscellaneous standard power supplies, racks, and associated hardware.

Estimated total price, standard items: $3,000

(c) Recommended Test Equipment (depending on individual station requirements)

Quantity	*Description*
1	*Convergence Dot Generator,* which provides a test signal capable of producing a pattern of dots on the tricolor monitor to facilitate convergence adjustments.
1	*Color Monitor Analyzer,* which provides a test signal consisting of a simplified color bar pattern.

Quantity	*Description*
1	*Linearity Checker,* which provides a test signal consisting of a staircase waveform with blanking and synchronizing pulses and superimposed subcarrier. Provision is included for adjusting the AC axis of the signal. This test signal is useful for checking amplitude linearity and, in conjunction with the color signal analyzer below, for checking phase intermodulation (phase versus amplitude).
1	*Color Signal Analyzer,* which is a piece of test equipment for making phase measurements at the color subcarrier frequency, and also provides complete analysis of color bar signals to check colorplexer adjustments, and to detect possible distortions in any transmission circuit.
1	*Burst-Controlled Oscillator,* which is useful auxiliary equipment for the color signal analyzer, in that it provides a continuous reference subcarrier signal locked in to the bursts on any composite color signal.
1	*Television Oscilloscope,* which may be the RCA type TO-524D or the equivalent.
1	*Square Wave Generator,* to provide a signal with rapid transitions for checking phase adjustments.

Estimated total price, recommended test equipment: $10,000

It is anticipated that deliveries of equipment for Stage 1 will begin during first quarter of 1954.

Equipment for Stage 2
(Provision for Slides)

The additional equipment needed by broadcast stations to enable them to originate color television pictures from slides is listed below.

(a) New Color Equipment

Quantity	*Description*
1	*Color Slide Camera,* which includes a light source, an optical system with a dichroic mirror light splitter and color correction filters, a pickup unit with associated preamplifiers, and circuits for applying aperture compensation and gamma correction to the video signals.
1	*Color Frequency Standard,* which contains a crystal-controlled master oscillator operating at the subcarrier frequency and counting circuits to provide a 31.5 kc signal for the control of the synchronizing generator.

Quantity	Description
1	*Burst Flag Generator,* which provides a keying pulse which is used in the colorplexers to gate in the bursts after each horizontal synchronizing pulse.
1	*Modification Kit for RCA Sync Generator,* which contains the parts needed to make the simple modification involved in transferring the frequency control of the sync generator from its internal oscillator to the 31.5 kc signal generated by the frequency standard.
1	*Colorplexer,* which (1) cross-mixes red, green, and blue signals provided by the color slide scanner to produce a luminance signal and two chrominance signals, (2) modulates the two chrominance signals upon two subcarriers of the same frequency but in phase quadrature, (3) adds the luminance signal and the two modulated subcarrier signals to produce a single three-variable signal in accordance with the proposed NTSC signal specifications, (4) produces the color-synchronizing bursts in the correct phase relative to the subcarrier signals, and (5) provides for the addition of sync pulses, if desired.
1	*Tricolor Monitor,* as previously described.*
1	*Master Monitor with Auxiliary Unit,* which provides facilities for viewing the three video outputs of the slide scanner in black and white (either separately or in combination) to check optical and electrical focus, and also provides for the display of the three primary-color waveforms side by side on an oscilloscope.

(b) Additional Recommended Test Equipment

Quantity	*Description*
1	*Color Bar Generator,* which provides red, green, and blue video signals capable of producing a pattern of highly-saturated color bars. These color bar signals are very useful for checking colorplexer adjustments because they produce easily recognized waveforms.

Estimated total price, additional new color equipment, including color bar generator: $29,750

(c) Standard Stock Items

A separate synchronizing generator for color is desirable in most set-ups, and miscellaneous standard power supplies, distribution amplifiers, jack panels, racks, and associated hardware are required.

Estimated total price, standard stock items for a typical slide camera installation, including synchronizing generator: $13,500

It is anticipated that delivery of equipment for Stage 2 color operation will commence during the first quarter of 1954.

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* As functions are increased, an increase in number of monitors is desirable.

Equipment for Stage 3
(Addition of Color Film Equipment)

The additional equipment that will enable a station equipped for Stage 2 operation to add programming from color motion picture film is as follows:

(a) New Color Equipment

Quantity	*Description*
1	*16mm Film Chain*, consisting of a light source and a 16mm fast pull down projector, together with a pick-up unit, preamplifiers, aperture compensators, and gamma correctors. A special power supply for the projector motor is also supplied.
1	*Colorplexer,* as described under Stage 2.
1	*Tricolor Monitor,* as described under Stage 1.
1	*Master Monitor with Auxiliary Unit,* as described under Stage 2.

Estimated total price, additional color equipment for Stage 3: $43,000

(b) Additional Test Equipment
None required above that provided for Stages 1 and 2.

(c) Standard Stock Items
Miscellaneous standard power supplies, distribution amplifiers, jack panels, racks, and associated hardware.

Estimated total price, additional standard stock items for Stage 3: $7,600

It is anticipated that equipment for Stage 3 color broadcasting will be available for delivery during the second quarter of 1954.

Equipment for Stage 4
(Provision for Live Pickup in Color)

Once a station is equipped for either Stage 2 or Stage 3 color broadcasting, it will be possible to expand operations to include simple live programs by adding the following equipment:

(a) New Color Equipment

Quantity	*Description*
1	*3-Tube Color Camera,* consisting of a lens turret, an image-dividing optical system, three image orthicon tubes with associated pre-amplifiers, and deflection and blanking circuits.
1	*View Finder and Hood,* which provides a black and white image which the camera operator may use to check focus, registration, and picture composition. The primary color channels may be viewed separately, or in various combinations.

1	*Set of Camera Control Equipment,* consisting of circuits for the control of the image orthicons and for the processing of the video signals, including aperture compensation and gamma correction, plus a shading generator and a remote control panel for mounting in a console.
1	*Master Monitor with Auxiliary Equipment,* as described under Stage 2. This equipment is mounted adjacent to the remote control panel in the console and provides for the monitoring of registration adjustments as well as picture focus and signal levels.
1	*Colorplexer,* as described under Stage 2.
1	*Tricolor Monitor,* as described under Stage 1.

Estimated total price, additional color equipment for Stage 4: $56,500

(b) Additional Test Equipment

None required above that provided for Stages 1 and 2.

(c) Standard Stock Items

Quantity	*Description*
1	Set of standard television lenses for camera.
1	Studio pedestal or tripod mounting for camera, including heavy duty friction head.

Miscellaneous camera accessories, such as cables, intercom headsets, circuit breakers, and meters.

Miscellaneous power supplies and distribution equipment.

Console housings and racks, with associated hardware.

Estimated total price, additional standard stock items for Stage 4: $13,000

It is anticipated that deliveries of live pickup color equipment will commence during the first quarter of 1954.

Additional Considerations

Although it is believed that the four stages used as a framework for this Appendix represent a logical pattern of growth for the majority of broadcast stations, it is recognized that there will undoubtedly be some broadcasters who will want to get into color activity on a complete scale right from the start. In these cases, RCA will accept orders for larger quantities of custom-made equipment, and will assist such broadcasters in the planning of switching and distribution systems capable of providing any desired degree of operating flexibility. It should be noted that the amount of color test equipment required by a broadcaster depends to some extent on his physical layout; if his studio and transmitter locations are separated, he may wish to provide some test equipment units for both locations.

The prices quoted above are all based on present equipment designs and very limited scale production. It is expected that substantial price reductions can be made when commercial product designs are finalized and the production of color equipment is placed on a standardized basis.

EXHIBIT 10

NBC OPERATING EXPERIENCE WITH THE RCA COLOR TELEVISION SYSTEM

NBC OPERATING EXPERIENCE WITH THE RCA COLOR TELEVISION SYSTEM

Index

APPENDIXES

EXHIBIT 10

NBC OPERATING EXPERIENCE WITH THE RCA COLOR TELEVISION SYSTEM

PART I

Introduction

THIS exhibit summarizes hours of operation and conditions of transmission with respect to various of the field tests of the RCA color television system conducted by the National Broadcasting Company, Inc.

Since conclusion of the color television hearings before the Commission in May, 1950, NBC has originated experimental color tests for transmission over its facilities as follows: 556 hours over its Channel 4 facilities in Washington, D. C.; 364 hours over its Channel 4 facilities in New York City; and 161 hours over its experimental UHF facility at Bridgeport, Connecticut. In addition, more than 2,000 hours of closed circuit and other technical tests have been made. Data relating to the time and programming of various of these field test transmissions have been prepared in tabular form and are attached hereto as Appendix A.

PART II

Washington Field Tests

A. Experimental Color Studio

Following the conclusion of the 1949-1950 color television hearings, RCA continued field testing its compatible color television system using experimental color television equipment set up in an NBC studio in Washington, D. C.

Experimental color television equipment installed in the Wardman Park studio of NBC included two studio cameras, a flying-spot scanner for color transparencies, and the associated control and monitoring equipment. Figures 1 and 2 are photographs of the two experimental live talent color cameras used for this studio. Figure 3 shows a view of part of the experimental color control room installation.

Color test programs originating from this studio were transmitted using NBC's Channel 4 transmitter in Washington. This studio was available for color transmissions only when it was not in use for production of black and white programs for WNBW or the NBC network. A more complete description of the technical signal specification used in the equipment of the Washington studio and of the composition of the color signal transmitted by these facilities is contained in Exhibit 4. A tabulation of the experimental programs and test transmissions made over these facilities for the period May 26, 1950 to January, 1951 is contained in Appendix A. A description of the nature of the programs used for these tests is contained in Appendix B.

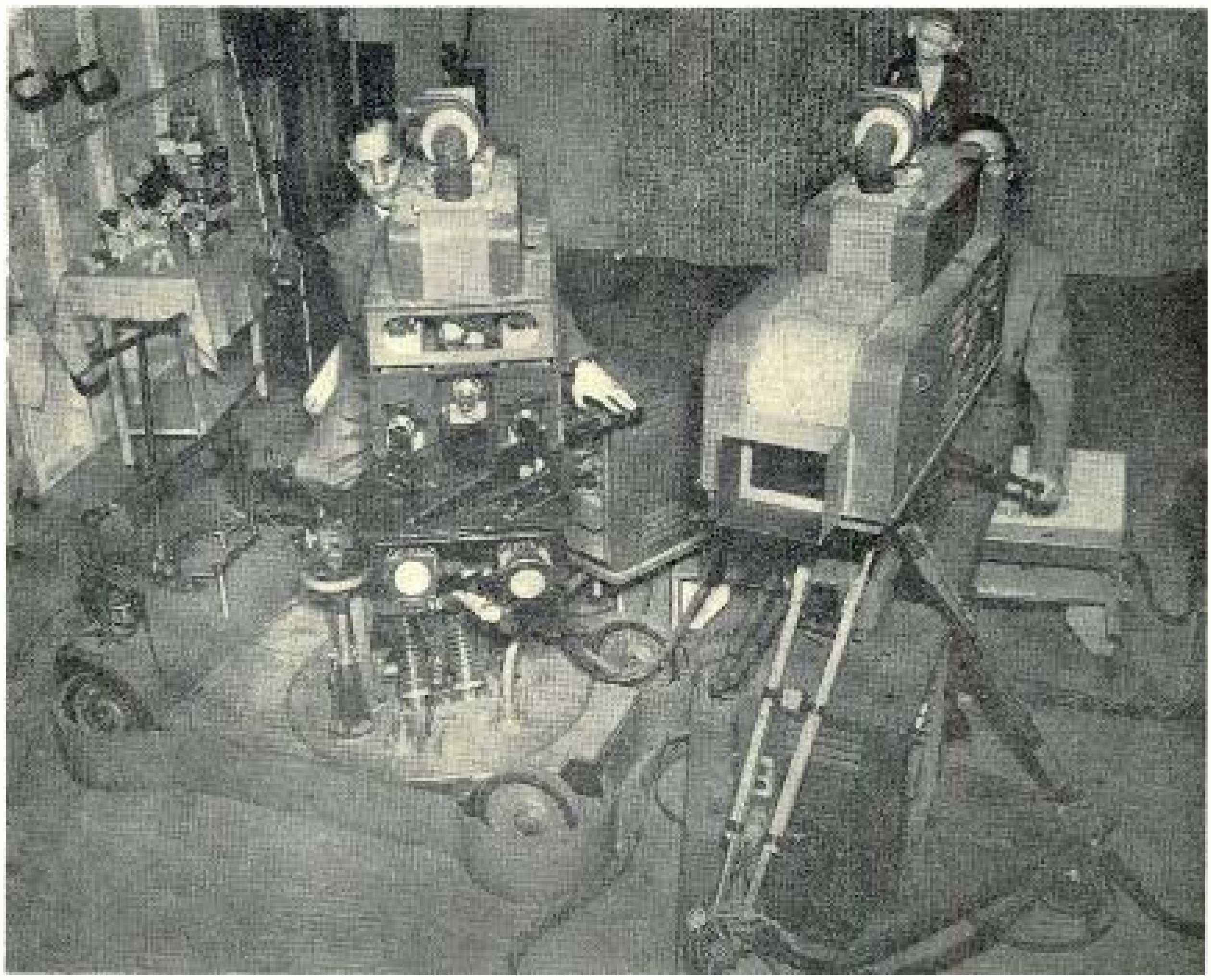

Fig. 1 — Front view of experimental color television cameras used in the Wardman Park studio at Washington, D. C., 1950.

B. December, 1950 Washington Tests

In December, 1950, a series of color television test programs was given for members of the radio-television industry. For these tests both color and monochrome receivers were located in one of the NBC sound studios in the Trans Lux Building. Color transmissions originating from the Wardman Park studio were received from our Channel 4 Washington transmitter at hours when this facility was not committed to normal monochrome program service.

During periods when the WNBW transmitter was not available, the color test signals were relayed to the Trans Lux Building over standard intracity Bell System facilities and used to modulate a miniature transmitter from which the output signal was applied to each receiver. The programs for this series of tests, which were of a variety nature, are described in Appendix B. A description of the receivers used for these tests is included in Exhibit 6.

The experimental color demonstrations in December, 1950, described above, demonstrated that the basic principles of the RCA color television system were sound. They also showed that progress in the development of compatible color television equipment had been made.

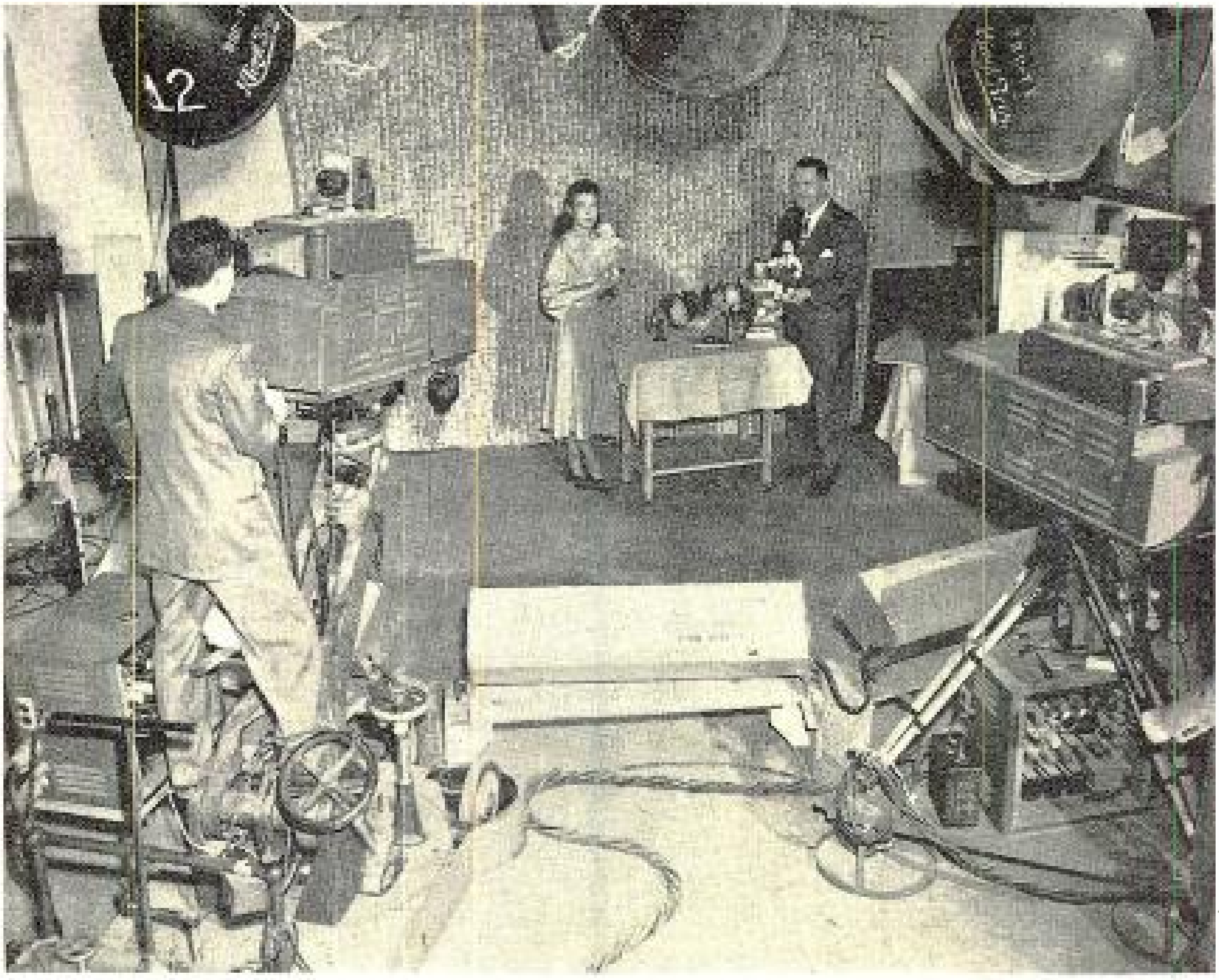

Fig. 2 — Rear view of experimental color television cameras used in the Wardman Park studio at Washington, D. C., 1950.

PART III

New York City Field Tests

A. Radio City Studio 3H

In order more extensively to field test the RCA color television system, it was decided that new equipment should be installed in one of NBC's New York City studios where there was available more complete program, production, and technical facilities with which to conduct larger scale field tests.

Conversion of Studio 3H in Radio City from a monochrome to a color studio was initiated in January, 1951, and installation of new color equipment was completed several months later. A technical description of this experimental color studio was published in the *RCA Review* of March, 1952, and is contained in Appendix C. The studio was assigned exclusively to color television use.

In contrast to the limited Washington color facility, Studio 3H was designed in such manner as to include the operational features which are generally found in a standard television studio, such as lap-dissolves or superimpositions of camera signals. The color cameras were completely redesigned and incorporated a standard lens turret, thereby providing greater operational flexibility. In addition, many circuit improvements were made in the new color cameras and associated equipment for this installation. The first color tests originating from Studio 3H took place in April, 1951. Figures 4 and 5 are photographs of the original color cameras installed in Studio 3H.

B. Mobile Unit

Also in early 1951, color television equipment similar to that in Studio 3H was installed in a motor vehicle to be used for experimental field pickups so that studio programs and programs originating at different field locations in the New York metropolitan area could be integrated into NBC field test transmission schedules. A technical description of the equipment installed in the mobile unit is contained in Exhibit 9. Figure 6 is a photograph of the mobile unit. The use made of the mobile unit in field-test activities is included in the following description of color field tests.

Fig. 3 — Experimental color television equipment installed in the control room of the Wardman Park studio.

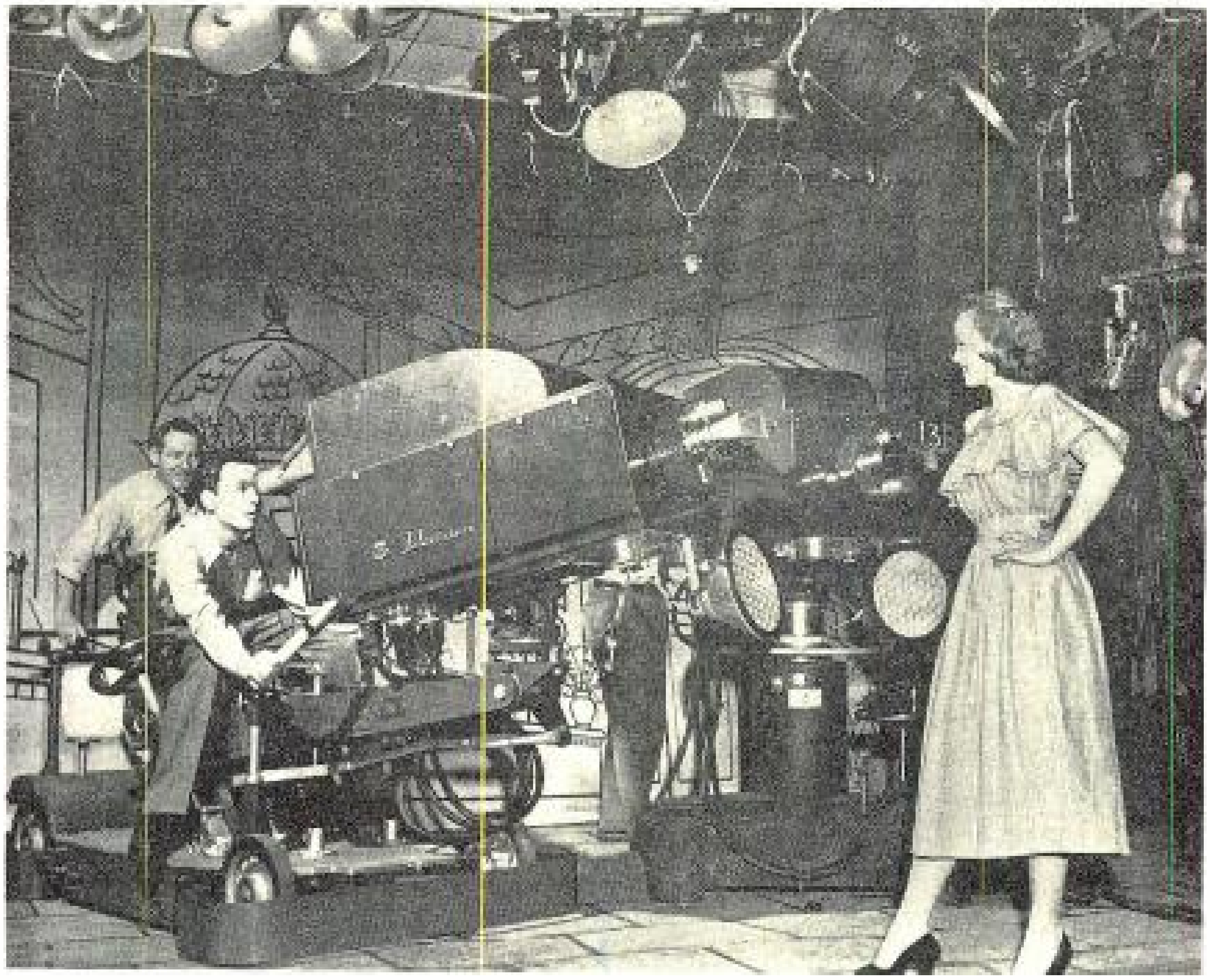

Fig. 4 — Side view of experimental color television cameras used in Radio City studio 3H for 1951 tests.

C. 1951 Field Tests

1. July, 1951 Tests

Large-scale color television field tests were transmitted over NBC's New York Channel 4 facilities, KE2XJV (WNBT), during the week of July 9, 1951. These tests consisted of live programs which originated in Studio 3H and an outdoor pickup by the mobile unit from Palisades Park, New Jersey. The purpose of this series of on-the-air transmissions was to test the quality of pictures received on black and white sets in public use from programs televised using the RCA color system. Advertisements were inserted in newspapers in the New York metropolitan area inviting the public to watch these programs and to report their reactions on how the pictures were received compared with the black and white transmissions normally received over Channel 4. A description of the programs used for these tests appears in Appendix B. A representative copy of one of the advertisements inserted in newspapers is shown in Figure 7.

A report entitled "A Report of Reactions of Television Set Owners to

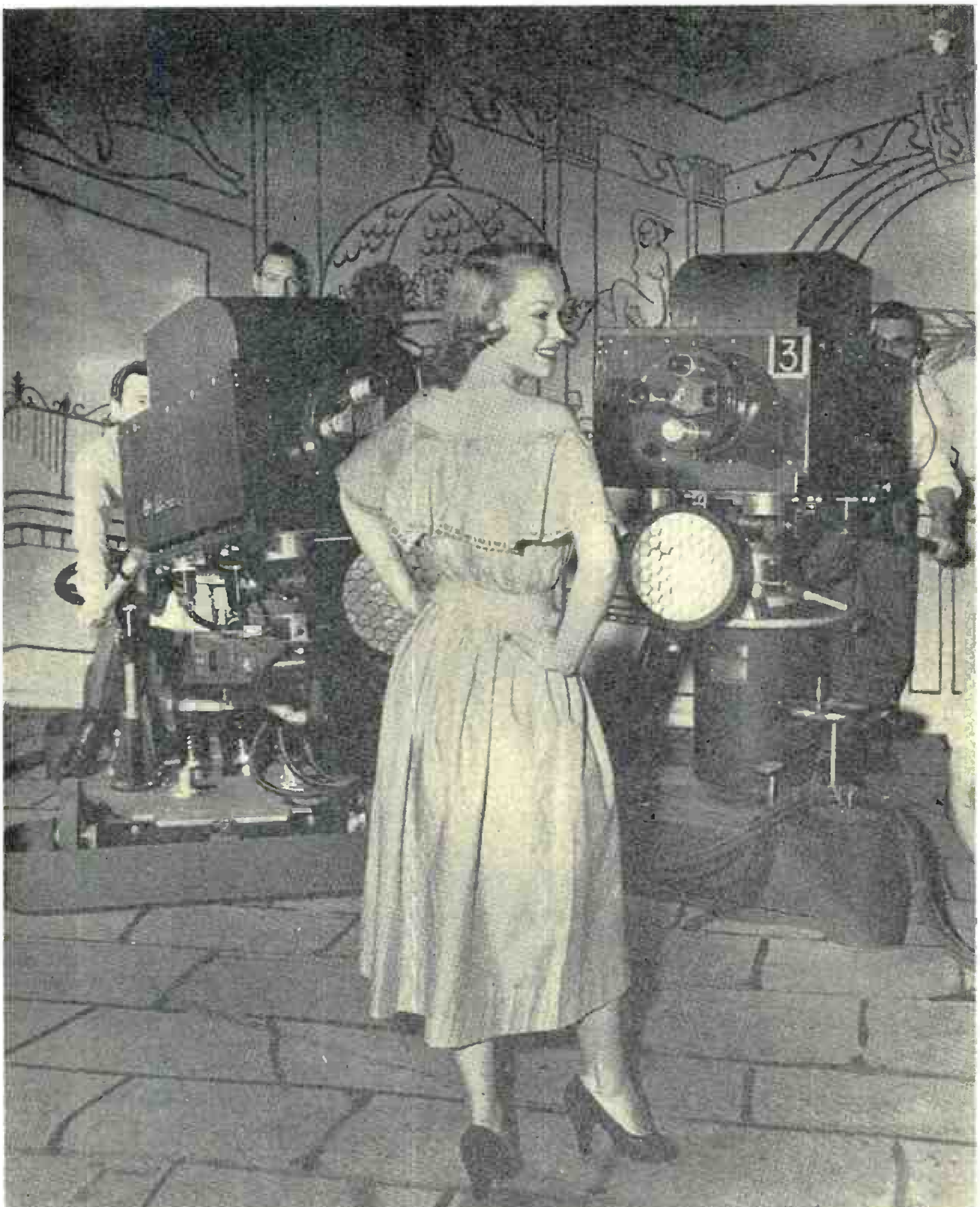

Fig. 5 — Front view of experimental color television cameras used in Radio City studio 3H for 1951 tests.

the Reception in Black and White of RCA Experimental Color Broadcasts" by Elmo Roper, dated August, 1951, analyzes the results of this series of field tests and is contained in Appendix D.

An evaluation of the data from the Roper report showed favorable reaction to the compatibility feature of the RCA color television system.

Fig. 6 — Color television mobile unit, 1952.

The color transmissions used for the compatibility tests were also observed on color receivers by technical people at several locations in the New York metropolitan area.

2. September, 1951 Tests

In September, 1951, experimental color transmissions for technical test purposes were made using live talent shows from Studio 3H and from the mobile unit at the Merchant Marine Academy at Kings Point, New York. The purpose was to further test the system, equipment and personnel under operating conditions typical of commercial broadcasting.

The morning tests were broadcast over NBC's Channel 4 transmitter in New York City using experimental license KE2XJV. The remaining tests were conducted on a closed circuit basis. The transmission of video signals from studio control point to the receiver location was by means of video cable. The programs used for these tests are described in Appendix B.

Color receivers were set up in the Johnny Victor and Center Theaters in New York and at the David Sarnoff Research Center in Princeton, New Jersey. The receivers in the Johnny Victor and Center Theaters could be fed either from signals radiated from the Channel 4 transmitter or from a local radio frequency generator (Megapix) modulated by the video signals from the cable. Receivers at Princeton received only signals radiated from KE2XJV.

You can help test

RCA COLOR TELEVISION . . . now!

This week experimental field tests of RCA's all-electronic color television system begin in the New York area.

One of the principal features of this system is its "compatibility" with the 13,000,000 receivers now in the public's hands.

This means that when a color picture is broadcast by the RCA system, it can be received in black-and-white on the set you now own.

It can be received in black-and-white *without any* change at all in your present set.

At 10 o'clock each morning for five days, beginning July 9, we will televise over Channel 4 in New York a variety television program in full color.

These programs will first be viewed by members of the press and the radio-television industry on experimental RCA color receivers . . . Later, RCA plans to place color sets where the performance of this modern all-electronic system can be seen by the public . . . so that you can give us your reactions.

But now this week, you will be able to see these color programs in black-and-white on your own television set simply by turning to Channel 4.

It will be helpful to us, in our efforts to bring good color television to the American public, if we can find out how these color broadcasts appear in black-and-white on existing television sets in the different sections of the metropolitan area.

Everybody agrees that a good "compatible" color television system is preferable: for it is estimated that an "incompatible" system would cost present set owners almost a billion dollars to adapt their sets to receive even a black-and-white picture from color broadcasts.

You can help test the "compatibility" of our system by telling us how it works in your neighborhood and on your set.

We would appreciate it if you would tune in on Channel 4 any morning at 10 o'clock, Monday, July 9, through Friday, July 13.

Then drop us a card giving your address, the age of your set, the size of its screen and type of antenna, which day you saw the program and telling us how these pictures compare with the black-and-white pictures you normally receive from NBC's regular black-and-white television programs.

Please send your reactions to RCA COLOR TELEVISION, RCA Building, New York 20, N. Y.

RADIO CORPORATION of AMERICA
World Leader in Radio — First in Television

Fig. 7 — Newspaper advertisement for July, 1951 tests.

As a result of these experimental color tests, it was decided to schedule a series of public reaction tests in October, 1951.

3. October, 1951 Tests

A series of public reaction tests of the RCA color television system was conducted in October, 1951. Three transmissions were scheduled each day during this series. The morning program was transmitted simultaneously over KE2XJV, Channel 4, in New York and KE2XDE, Channel 4, in Washington, D.C. Because of program commitments in both New York and Washington, and the Commission's prohibition of color television transmissions during regular monochrome broadcast hours, the afternoon programs were done on a closed circuit basis utilizing miniature transmitters at each receiving location. A description of the program used for these tests is contained in Appendix B.

Transmission of these test programs to Washington was successfully accomplished over standard intercity Bell System facilities. Both intercity microwave circuits and cable circuits were used during the tests. The technical quality received in Washington was good. The network facilities used during these tests are described more completely in Exhibit 11.

The programs for these tests originated from Studio 3H in Radio City and from the mobile unit located at Palisades Park, New Jersey. Color receivers were located at the Center Theater in New York and at the Trans Lux Building in Washington. Following the conclusion of each test program the public observers were requested to complete a questionnaire which had been prepared by the Opinion Research Corporation of Princeton. The answers recorded on these questionnaires were evaluated by the Opinion Research Corporation and a copy of their report is contained in Appendix E. The transmitting conditions during this and the previously described New York field tests utilized symmetrical sampling with color phase alternation and a color subcarrier frequency of 3.583125 megacycles.

D. Modification of Facilities to Proposed NTSC Color Signal Specifications

Following the October, 1951 series of tests, color encoders and associated equipment in Studio 3H and in the mobile unit were modified to conform to the proposed NTSC color field test specifications which were released on November 21, 1951 by the National Television System Committee. These modifications were accomplished by making relatively simple circuit changes in the encoder unit and in the synchronizing generator counters. A description of the composition of the color television signal as proposed at that time by NTSC is contained in Exhibit 4.

Field tests using the then proposed NTSC specifications were made by NBC in the New York City area from December, 1951 to December, 1952, inclusive. These tests included on-the-air transmissions, closed circuit technical tests, and both on-the-air and closed circuit test transmissions for NTSC Panels. A listing of various of the test transmissions of the RCA color television system for NTSC is contained in Appendix F. A description of the NBC field tests follows.

E. 1952 Field Tests

1. Saturday Morning Transmissions

A total of 31 experimental color programs of approximately 20 minutes duration each was transmitted over KE2XJV, Channel 4, on Saturday mornings prior to the start of the normal monochrome program transmission during the year 1952. A description of the types of programs used for these Saturday morning tests is contained in Appendix B. One of these programs was an outdoor pickup made by the mobile unit located in Bayside, Long Island.

Appropriate announcements were made at the opening and closing of each of these programs indicating the nature of the experimental color signal being transmitted.

2. July, 1952 Tests

In July, 1952, a special series of tests was conducted to determine the validity of an optimum relationship between the frequency of the color subcarrier and the unmodulated frequency of the sound carrier which had been proposed by the RCA Laboratories. Results of this test indicated that the optimum relationship was such that the difference between these two frequencies is an odd multiple of one-half the horizontal scanning frequency. A report relating to the transmitting conditions of this field test is contained in Appendix G. A more detailed description of the results of these tests is contained in Appendixes C and D of Exhibit 4.

3. September, 1952 Tests

In September, 1952, permission was granted by the Federal Communications Commission to conduct a series of compatibility tests utilizing the color television signals, under study by RCA engineers, over Channel 4 facilities in New York City during periods normally devoted to monochrome program transmissions. Reports concerning these tests are contained in Appendix H and Appendixes E and F of Exhibit 4.

Both the July and September, 1952 tests were also observed on color receivers installed at several locations in the metropolitan New York and Princeton areas. Comments received indicated that the technical quality of the color transmissions was very good.

4. Closed Circuit Color Television Field Test of Football Game

On Saturday, October 18, 1952, the Columbia-Pennsylvania football game played at Baker Field was telecast in color and transmitted on a closed circuit to Radio City Studio 3H for technical observation. The composition of the color signal for this field test was in accordance with the then current NTSC field test specifications.

The connecting circuit between Baker Field and Radio City was provided by the New York Telephone Company. This was a radio circuit of the type normally used for the relay transmission of monochrome signals. Measurements indicated that the technical characteristics, considering the length of this facility, would be in the average category for monochrome transmission.

The color mobile unit used for the remote pickup contained two RCA color television cameras and the associated control equipment. One camera was equipped with an Electra Zoom lens, and the other camera had the normal field complement of lenses mounted in a lens turret.

Both field cameras were equipped with recently designed turrets containing neutral filters of various densities, thereby providing a means for accommodating various light conditions such as occur for outdoor pickups. The closed circuit test program started at 1:50 PM and continued until approximately 4:45 PM.

Technical observations of this test were made on tricolor monitors located in Radio City Studio 3H. The technical quality and definition of the color signal as received from Baker Field was good. During the latter part of the game, the average illumination on the playing field was reduced to such an extent that it was necessary to operate both cameras with maximum sensitivity. The reflected light level from a white object on the field measured at this time was 50 foot lamberts.

5. Tests Using NBC Experimental UHF Transmitter at Bridgeport, Connecticut

In order more fully to test various facets of color broadcasting, NBC transmitted a total of 160 hours of color programs and technical tests over its UHF experimental transmitter located at Bridgeport, Connecticut. As a result of these transmissions, it is our belief that color broadcasts on UHF can be accomplished as successfully as on VHF and should present no particular problems.

F. Revised Method of Encoding Color Signal

1. Description

A modification in the method of encoding color information on the color subcarrier was devised by RCA Laboratories and in November, 1952, an experimental color encoder employing these new principles was installed in Studio 3H. In this unit the color information is encoded on the color subcarrier by a method whereby the two branches of the encoder produce signals of unequal bandwidths to take further advantage of the psychophysiological characteristics of the human eye. A description of this method of signal composition is contained in Exhibit 4.

2. November, 1952 Tests

In order to compare the new method of encoding the color information with that previously employed, permission was received from the Commission in November, 1952, to conduct a series of daytime on-the-air tests for this purpose. The transmitting conditions for this series of comparative tests are described in Appendix I. A description of the results obtained are contained in Appendix G of Exhibit 4.

3. Modification of NTSC Signal Specifications

On February 2, 1953, NTSC released revised color television field test specifications to incorporate the general principles described above as to the manner in which the color information is encoded on the color subcarrier. At the same time NTSC also adopted the optimum relationship between the color subcarrier and sound carrier, the value of which had been confirmed in the July, 1952 tests.

4. Modification of NBC Facilities

NBC color transmitting facilities were promptly modified to conform to the new NTSC color field test specifications.

In general, these modifications involved a change in the encoder matrix unit to obtain the proper color difference chrominance signals, and a change in the synchronizing generator counters to derive the new color subcarrier frequency.

Since January 27, 1953, all color transmissions, technical testing, and closed circuit demonstrations have been made using the modified NTSC signal specifications.

G. Field Tests During January, February and March, 1953

In order to obtain further field test data, special permission was received from the Federal Communications Commission to transmit color test programs over Channel 4 facilities in New York City during hours normally devoted to monochrome program transmissions for the months of January, February and March, 1953. Eighteen color transmissions were made during these months from 12:45 to 1:00 PM. The programs used during these experimental color transmissions are described in Appendix B.

During each experimental transmission appropriate announcements were made stating the nature of the test and requesting cooperation from the public by reporting quality of reception of the color signal on their monochrome receivers. An analysis of the reports received from viewers was made by the Opinion Research Corporation and this analysis is contained in Appendix C of Exhibit 7.

PART IV

Colonial Theater Color Television Facility

A. Introduction

Although the field tests which originated from Studio 3H and the mobile unit provided excellent facilities for operationally testing the RCA color equipment, it became apparent that a theater type studio capable of producing shows equal in scope and variety to complicated monochrome programs should be provided. Accordingly, NBC leased the Colonial Theater at 62nd Street and Broadway, New York City, and completely equipped a new color television plant employing the latest design color equipment. Figure 8 is an external view of the Colonial Theater.

The first on-the-air color transmission from the Colonial Theater occurred on March 19, 1953. A technical description of the Colonial Theater color television installation and of the programs which have originated from this facility follows.[1]

B. Design Considerations

The basic philosophy in the layout and design of the Colonial Theater facility was not one of simply more space and more equipment. Many conclusions regarding the handling of large scale productions had been reached during the operation of the previous less extensive facilities. These required verification from both the programming and technical standpoints.

Although Studio 3H and the mobile unit facilities had been constantly revised in order to keep pace with the progress of the art, it was not feasible to incorporate some newly devised improvements in both equipment and system without closing down the facilities and thereby delaying the field test program. These improvements required rigorous operational checking and field testing. This theater was to include all the latest design features, with provisions for anticipated further improvements and additions, with the ultimate goal being, among other things, the complete integration of the color facilities with those of monochrome operations.

C. Equipment

The existing Colonial Theater plant contains four live pickup color television camera chains, each complete with channel amplifier, aperture compensator, gamma amplifier, colorplexer, and control equipment. One flying-spot slide scanner is currently in use for the pickup of still color pictures and titles.

Provision is made for the ultimate addition of a second slide scanner in order to facilitate smooth transitions between a succession of stills or titles, and for color film equipment. Every piece of this equipment which is specifically color in nature had been subjected to design improvements over those previously used in Studio 3H and described in Appendix C. It should be noted, however, that many items of standard monochrome equipment such as the monitor in the control unit, regulated power supplies, camera cables, camera pedestals, dollies and cranes, etc., form an integral part of the equipment included in the phrase "color camera chain".

The camera switching system in the Colonial Theater was altered considerably from that previously used. In Studio 3H, this function had

[1] The stage of the Colonial Theater is 80 feet wide, including the wings, and 40 feet deep behind the proscenium. The technical operating area in front of the proscenium is 36 feet deep by an average of 70 feet wide.

Fig. 8 – External view of Colonial Theater.

been accomplished by switching the three primary color signals (red, blue and green) simultaneously and feeding the output of the relay system to a common encoder or colorplexer.

With the aid of newly developed circuit techniques in establishing still greater stability and uniformity of performance, it became feasible to add an individual colorplexer as a part of each camera and slide scanner chain in the Colonial Theater. The output of these colorplexers thus provided a single output complete with subcarrier modulation for each signal source rather than the three separate outputs previously used at the switching point. By so doing, it became possible to use a standard monochrome relay system with only slight modifications to accomplish the camera switching function.

In addition to the normal switching of camera signals to the on-the-air circuit, this system makes possible the use of fades, lap-dissolves, wipes and other such effects frequently seen in monochrome broadcasts. A line monitor and a preview monitor are provided for the Technical Director and the Program Director, while the video control engineers have a line monitor and two switchable preview monitors, the latter for purposes of more accurately matching camera shots. Several monochrome monitors are also furnished for adjustment purposes and in order to check the appearance of the color signal as viewed on a standard monochrome receiver.

Video distribution and line amplifiers are not unlike those used for monochrome transmission, although some new types were used in order

Fig. 9 — Colonial Theater color control room, 1953. The directors' console is in the foreground and the video control console in the background.

to evaluate their potential merit from the standpoint of improved monochrome performance as well as for color purposes.

A standard monochrome synchronizing generator and associated pulse distribution amplifiers were used. However, in this case, the generator is locked by means of a frequency divider-counter to the color subcarrier crystal frequency rather than to the 60 cycle power supply mains. Figures 9 and 10 are two views of operating positions in the Colonial Theater control room.

D. Lighting Facilities

The latest type of electronic lighting control board designed especially for television use was installed in the Colonial Theater. This "Izenour" board is capable of handling 485 kw of lighting power and contains circuitry for dimming 72 lamps either individually or in pre-selected groupings, and 24 additional circuits which can be turned on and off but without dimming facilities.

The pre-set feature has the effect of giving this board a memory, that is, once the desired light levels are established during rehearsal, the

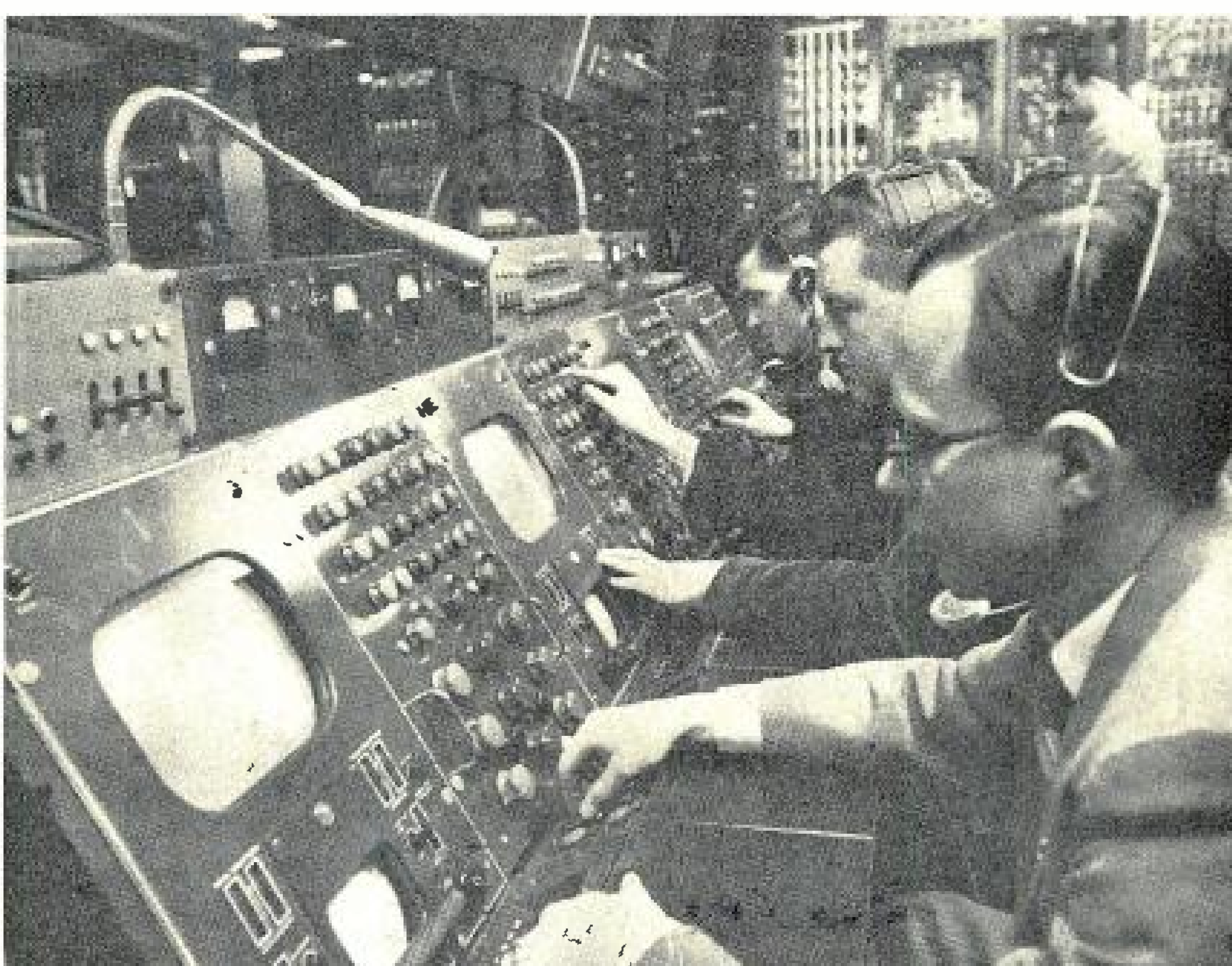

Fig. 10 — Colonial Theater color control room, 1953. Close-up of video control console.

brightness of each of the individual lamps in the grouping may be returned to precisely the same brightness by the manipulation of a single control on the lighting control console. Any given lamp may form a part of several different pre-set groupings. These control facilities materially improve the ease and precision of returning to any pre-arranged condition of lighting providing the lighting units themselves have not been physically moved.

It should be emphasized that a lighting board as elaborate as that in the Colonial Theater is not a requirement of the RCA color television system. Rather, this lighting system was installed to obtain operating experience in color television with the newest lighting facility developed for monochrome use.

There are eight pipe battens suspended from the fly loft for mounting lights. These battens may be raised and lowered in the same manner as the scenery battens. Additional light battens are suspended across each end of the stage area, and in front of the proscenium suspended over that stage area which was originally occupied by orchestra seats are three more light battens which in this case have motor driven winches for raising and lowering the lights.

Normal light levels used are such that the maximum highlight brightness in a given scene is of the order of 260 foot lamberts. An attempt is made to keep the contrast range with a 20 to 1 ratio although for effects lighting such as silhouettes, etc., the low lights are lower than this ratio would indicate.

The current required to achieve these light levels in typical scenes, such as those in the demonstration presented on May 19, 1953 for the Federal Communications Commission and its staff, ranged from 400 amperes for the small sets used by the magician and the ventriloquist, to 2200 amperes on the opening "Paris" number and 2500 amperes on the "Waltz Finale". The latter act required three different pre-set groupings to accomplish the desired lighting changes.

E. Conclusion

The Colonial Theater was not intended as a model necessarily to be copied in future theaters, but rather as a further step in the field testing program. An attempt was made to incorporate as much as possible of the mass of knowledge which has been gained through several years of operation of extensive monochrome and color facilities.

Much of the equipment included in the control room of the Colonial Theater would be normally located in a separate equipment room as is the practice for monochrome television plants. This equipment was installed in the Colonial Theater control room, however, to facilitate the developmental aspects of our color field test activity.

Fig. 11 — Colonial Theater staging area. Taken from the balcony, this photograph shows part of the opening scene of the April, 1953, demonstrations. Crane and dolly cameras, microphone boom, and foreground lights are also shown.

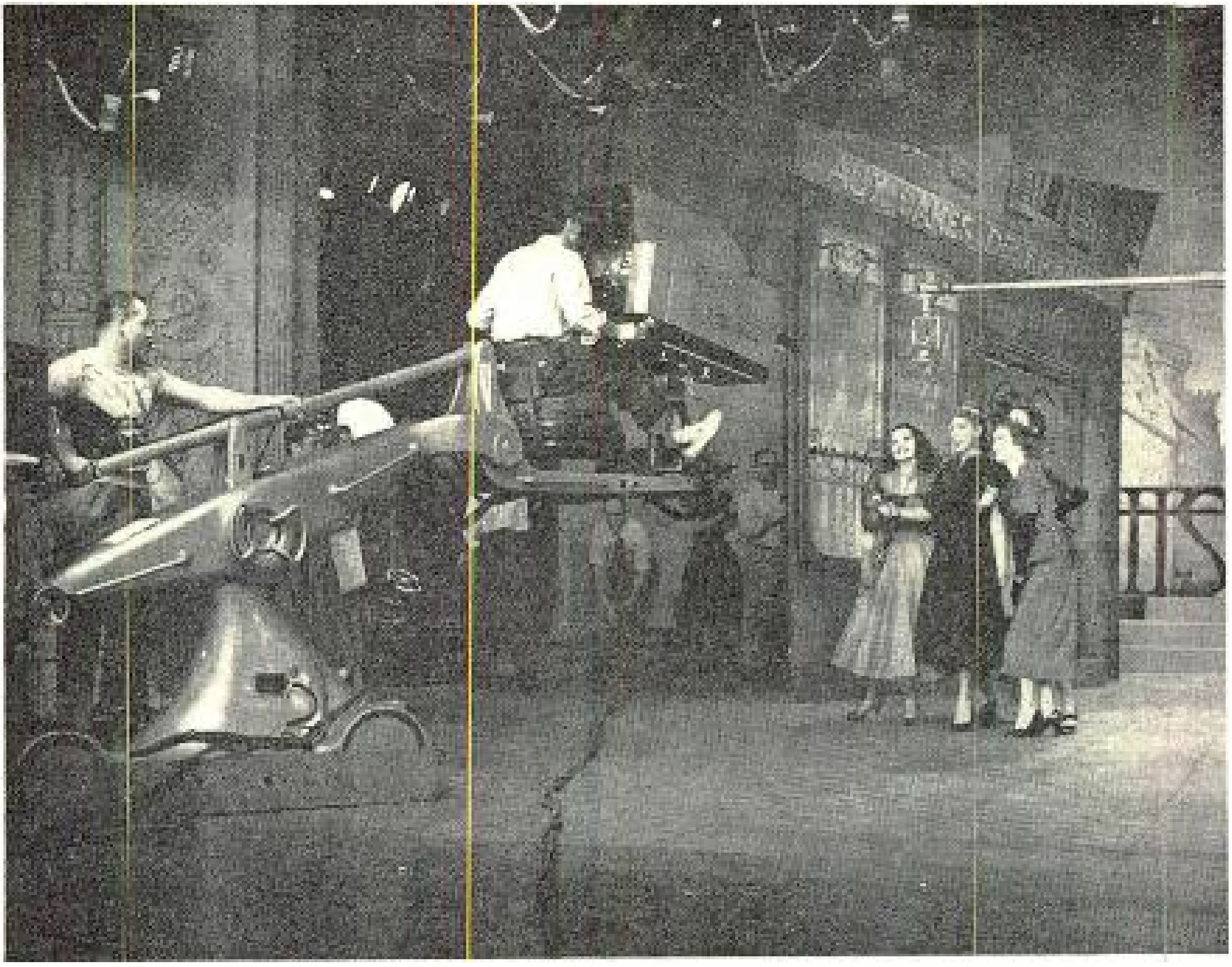

Fig. 12 — Colonial Theater staging area showing part of the opening scene of the April, 1953 tests. One of the RCA color television cameras mounted on a mobile crane is shown in the foreground.

On the basis of field test experience with the Colonial Theater it can be said that RCA color television cameras can be operated satisfactorily alongside standard monochrome cameras, using common synchronizing generator, camera switching, and video distribution facilities.

F. April and May, 1953 Tests

1. Program Tests

In April and May, 1953, eight color programs, each of approximately twenty minutes duration, were broadcast over Channel 4 in New York City using experimental license KE2XJV during periods normally devoted to monochrome programming.

All of these programs originated from the Colonial Theater Studio. A description of the programs used for the Colonial Theater originations is contained in Appendix B. Appropriate announcements were made during each program indicating the nature of the color test transmissions.

The program on April 14 was witnessed on color receivers at the

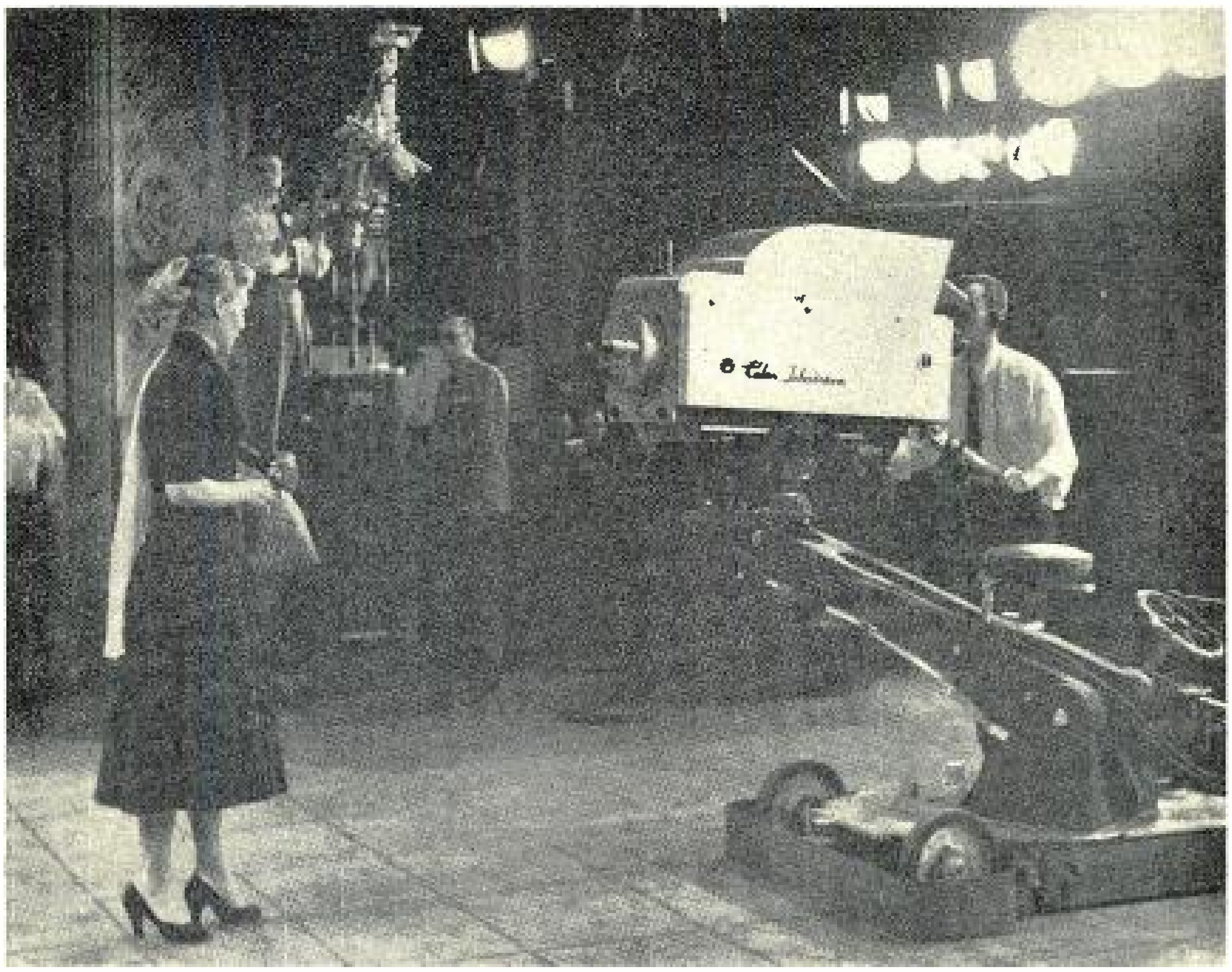

Fig. 13 — Colonial Theater staging area showing a scene from the April, 1953 tests. An RCA color television camera mounted on a camera dolly and a boom microphone are also shown.

David Sarnoff Research Center in Princeton, New Jersey, by members of the Committee on Interstate and Foreign Commerce of the House of Representatives, the press, and by staff members of the Commission.

On April 16, members of the National Television System Committee observed the color transmission. These programs were also witnessed by guests of RCA and NBC on color receivers located in the Center Theater in New York City.

On May 19, 1953, Federal Communications Commissioners and staff members of the Federal Communications Commission witnessed a color program transmission over our Channel 4 facilities in New York on color receivers located at the Princeton Laboratories.

RCA licensees and NBC affiliates viewed the color broadcasts of May 21 and 26, respectively, on the color receivers at Princeton. The same broadcasts were also viewed on color receivers in the Center Theater. Figures 11, 12, 13 and 14 were photographed during the April and May, 1953, color tests and show the staging area with performers, operating personnel, scenery, and technical equipment.

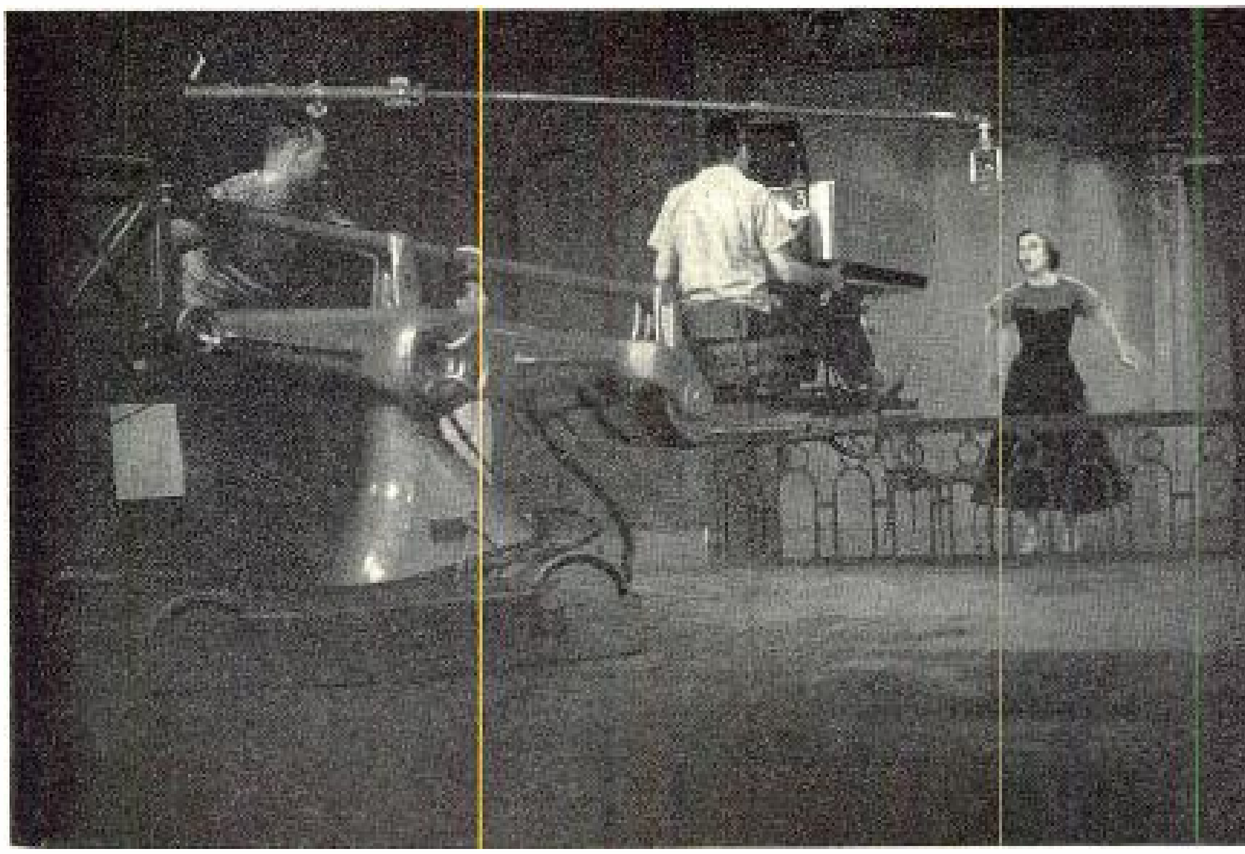

Fig. 14 — Colonial Theater staging area showing a scene from the May, 1953 tests. An RCA color television camera mounted on the mobile crane is in the foreground.

2. Technical Tests

For the past several months, late night transmissions over KE2XJV have been made on many occasions. These transmissions are tabulated in Appendix A.

A number of these transmissions were made at the request of various NTSC Panels for use in connection with official field tests requiring the transmission and reception of a color television signal in accordance with the NTSC field test specifications. A compilation of various of the experimental color television transmissions made for NTSC is contained in Appendix F.

G. Public Reaction Tests, June, 1953

A series of closed circuit color television public reaction tests under the direction of the Opinion Research Corporation was held during the first week of June. A description of the program which originated from the Colonial Theater is contained in Appendix B. Members of the general public who took NBC tours were invited to participate in these tests and viewed the program on color receivers set up in the Center Theater. Standard Bell System intracity video facilities were used between the Colonial and Center Theaters and a miniature transmitter (Megapix) energized the color receivers in the Center Theater. Three test transmissions for public reaction were made daily from Tuesday, June 2, to Friday, June 5, inclusive.

Two of the public reaction tests also included the effects of network transmission over typical intercity facilities of the Bell System. A microwave network circuit looped at Washington, D. C., was used for one of the tests on Thursday, June 4. On Friday, June 5, a coaxial cable circuit was looped at Washington, D. C., and included cable heterodyne terminal equipment designed by RCA for transmission of the compatible color signal over narrowband network facilities (Exhibit 11).

The Opinion Research Corporation prepared questionnaires to be completed by the people viewing the public reaction color test transmissions and Exhibit 2 contains an analysis of the results.

PART V

Tests of Network Facilities

In addition to on-the-air transmissions in the metropolitan New York area and closed circuit testing, a number of tests involving the transmission of the compatible color television signal over inter-city network facilities has been made. For most of these tests the network facilities have been looped at Washington, D.C., and the received signal observed in our New York studios so that quick comparison could be made of the original signal transmitted to the network with that received from the network.

There was no noticeable loss in chroma or appreciable hue shift in the received color signal after transmission over properly aligned network facilities and as observed on a color receiver. These tests further confirmed our belief that the RCA color television signal could be successfully transmitted over standard intercity network facilities with satisfactory quality. Further data on these network tests is contained in Exhibit 11.

PART VI

Use of Conventional Television Broadcast Transmitter for Color

Transmission of color signals over standard black and white television transmitters may be readily accomplished with only minor modification of the transmitter. The modifications which must be made are of a fixed nature, that is, once they have been made they have no further effect on the operating conditions. A technical description of the modifications which have resulted in improved color transmission are described in Exhibit 9.

Certain expedients which were considered acceptable for monochrome transmission must be reconsidered for the transmission of a color signal. For example, careful attention must be given to the phase vs frequency response and to the amplitude linearity characteristic of the transmitter in order to insure that degradation of the color signal will not occur. Due to the color synchronizing signal, some types of stabilizing amplifiers must be modified to accommodate satisfactorily the composite color signal.

None of these precautions should cause concern, however, since the corrective measures necessary for good color transmission will likewise substantially improve the quality for monochrome television transmission.

PART VII

Lighting for Color Television

Basically the lighting for color television is the same as that required for monochrome with one exception—the amount of incident light necessary. Color television now requires about three times the light used for black and white. This is easily accomplished by using light fixtures of higher wattage.

A show that is properly lighted for black and white, with effects, low key and mood lighting can be done in color with no changes except the substitution of light fixtures of higher output. The techniques of lighting, hanging of light fixtures and the control of the power to these lamps is the same in both media. However, the addition of color in the picture gives an apparent depth to the sets, and a separation of actors from the sets, that cannot be achieved in monochrome.

Lighting for color television does not create any new or unusual problem not present in today's black and white, but the use of colored lights opens up an entirely new field of lighting and effects that will enhance the beauty of the programs and pleasure to the viewing public. By using light neutral backgrounds, we have been able to use one set many times in a show and have a different colored background for each use by the addition of colored lights.

Using three primary colored lights (red, blue and green) it was possible to produce any color desired in these backgrounds by mixing of the colors. This mixing is accomplished by controlling the voltage supplied to each colored light at the dimmer board. This does not require the purchase of expensive equipment, but is easily done by the use of inexpensive theatrical filters (gelatin) placed in front of the standard light fixtures.

The use of colored filters on standard lighting equipment was demonstrated during the program the Federal Communications Commission viewed in Princeton and at the Colonial Theater on May 19, 1953. The opening "Paris" number had a yellow sky and the closing "Waltz" number had a blue one. This was accomplished by the use of colored filters on the same grey background.

Colored lights have been used on many field test programs, but the most striking example was the use in a recent program of an orange-red glow behind a cut-out scene of a city leveled by an atom bomb. The addition of this color transformed a rather dull uninteresting picture to one of dramatic realism.

Colored light in television will be used in many ways as the art progresses. The proper use of filters on lamps can eliminate much set painting and changing of stage curtains and still achieve the illusion of different settings. Likewise, use of filters can enhance make up, can change the color of actors on cue without long stage waits for make-up changes and can even minimize facial wrinkles when desired. An entirely new technique of theatrical production in color has been opened up for use by television producers and directors. It is believed that color television techniques provide more flexible use of color than is provided by color motion pictures.

PART VIII

Qualifications of Technical Personnel for Operation of Color Television Equipment

Members of NBC's Color Television Operating Group have been recruited from the regular Technical Operations staff on the basis of their qualifications. Also, a number of men who had participated in the experimental work in Washington were transferred to the New York group.

An important phase of our operational activity has included the training of personnel in other groups to prepare them for the eventual integration of color operations into the present NBC organization. This has been accomplished by assigning regular personnel to color operations on a rotational basis, and by the presentation of two different series of lectures covering the technical phases of color television, as well as the psychological aspects of color and the theory of colorimetry.

The operation of color television equipment is admittedly more complicated than that required for a black and white operation. The number of technical personnel assigned to a television crew, either monochrome or color, depends to a great extent upon the nature of the program material being telecast. For comparable program material, the normal technical crew for our color television operations at the Colonial Theater contains the same number of technical personnel as that assigned to a monochrome theater, except for the video control position. In monochrome television the video control technician usually handles two or three television cameras. However, in the present state of our developmental activities in color television, it has been found expedient to assign a video control technician to each color television camera, due primarily to the added complications of this function. It appears likely that future developments will simplify the color television camera to such an extent that this present practice can be modified.

It is also true that the maintenance of color television equipment used for a studio plant is more complicated than for a comparable black and white television plant due to the fact that any color television process admittedly requires additional components. The complications in any electronic equipment are usually a function of the amount of information being transmitted, and considerably more information is transmitted in a color television system than in a black and white system. At the present time, three additional maintenance men are required at our color installation in the Colonial Theater than are required in a comparable monochrome television theater.

However, even with our experimental field test equipment, it has been found that excellent pictures have been produced by technical personnel recruited from monochrome operations who have had some additional training to acquaint them with the special problems of the color television operation. It is believed that the comparison is not unlike that which existed during the rapid growth of monochrome television when technical people previously trained for sound broadcasting successfully adapted themselves to the operation of monochrome television equipment.

APPENDIX A

TABULATION OF HOURS OF TRANSMISSION ON VHF CHANNEL 4 IN NEW YORK AND WASHINGTON, ON UHF EXPERIMENTAL CHANNEL IN BRIDGEPORT, CONNECTICUT, AND OVER CLOSED CIRCUIT

Table of Contents

1. Washington Field Tests Transmitted over KG2XDE

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
Call Letters—WNBW				
1950				
May 26	3:07 — 4:00 PM	:53	Rainbow Review	4:20
May 29	3:05 — 4:00 PM		Rainbow Review	3:51
	10:30 — 11:00 PM	1:25	Warner's Corner	
May 30	3:05 — 4:00 PM		Rainbow Review	3:00
	10:30 — 11:00 PM	1:25	Warner's Corner	
May 31	3:05 — 4:00 PM		Rainbow Review	3:00
	10:30 — 11:00 PM	1:25	Warner's Corner	
May Totals		5:08		14:11
June 1	3:07 — 4:00 PM		Rainbow Review	4:39
	10:30 — 11:00 PM	1:23	Warner's Corner	
June 2	3:05 — 4:00 PM	:55	Rainbow Review	4:45
June 5	3:05 — 4:00 PM		Rainbow Review	4:38
	10:30 — 11:00 PM	1:25	Warner's Corner	
June 6	3:05 — 4:00 PM	:55	Rainbow Review	4:23

1. Washington Field Tests Transmitted over KG2XDE (Cont.)

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
June 7	3:05 — 4:00 PM		Rainbow Review	4:37
	10:30 — 11:00 PM	1:25	Warner's Corner	
June 8	3:00 — 4:00 PM		Rainbow Review	4:38
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 9	3:06 — 4:00 PM	:54	Rainbow Review	5:02
June 12	3:00 — 4:00 PM		Rainbow Review	4:45
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 13	3:00 — 4:00 PM	1:00	Rainbow Review	4:53
June 14	3:00 — 4:00 PM		Rainbow Review	4:24
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 15	3:00 — 4:00 PM		Rainbow Review	5:06
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 16	3:00 — 4:00 PM		Rainbow Review	4:27
	10:45 — 11:00 PM	1:15	Warner's Corner	
June 19	3:00 — 4:00 PM		Rainbow Review	4:23
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 20	3:00 — 4:00 PM	1:00	Rainbow Review	4:21
June 21	3:00 — 4:00 PM		Rainbow Review	2:48
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 22	3:00 — 4:00 PM		Rainbow Review	3:24
	10:30 — 11:00 PM	1:30	Warner's Corner	
June 23	3:06 — 4:00 PM		Rainbow Review	3:07
	10:45 — 11:00 PM	1:09	Warner's Corner	
June 26	3:00 — 4:00 PM		Rainbow Review	4:36
	7:30 — 7:45 PM	1:15	Roberta Quinlan	
June 27			(Test Pattern only)	1:59
June 28	3:00 — 4:00 PM		Rainbow Review	4:56
	10:31 — 11:00 PM	1:29	Warner's Corner	
June 29	3:00 — 4:00 PM		Rainbow Review	3:07
	10:31 — 11:00 PM	1:29	Warner's Corner	
June 30			(Test Pattern only)	5:30
June Totals		26:04		94:28

1. Washington Field Tests Transmitted over KG2XDE (Cont.)

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
July 3	4:20 — 4:30 PM		Live portion — "Circle 4 Roundup"	4:55
	4:30 — 5:30 PM		Rainbow Review	
	10:30 — 11:00 PM	1:40	Warner's Corner	
July 4	4:34 — 5:30 PM	:56	Rainbow Review	4:46
July 5	4:31 — 5:15 PM		Rainbow Review	6:05
	10:30 — 11:00 PM	1:14	Warner's Corner	
July 6	4:31 — 5:30 PM	:59	Rainbow Review	6:13
July 7	4:31 — 5:30 PM		Rainbow Review	5:44
	10:31 — 11:00 PM	1:28	Warner's Corner	
July 10	4:21 — 4:30 PM		Circle 4 Roundup	:06
	4:30 — 5:30 PM		Rainbow Review	
	10:30 — 10:45 PM		Dateline Tomorrow	
	10:45 — 11:00 PM	1:39	Warner's Corner	
July 11			(Test Pattern only)	3:08
July 12	4:23 — 4:30 PM		Circle 4 Roundup	5:41
	4:31 — 5:30 PM		Rainbow Review	
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:36	Warner's Corner	
July 13	4:23 — 4:30 PM		Circle 4 Roundup	3:44
	4:30 — 5:30 PM		Rainbow Review	
	10:33 — 10:42 PM		Dateline Tomorrow	
	10:42 — 11:00 PM	1:34	Warner's Corner	
July 14	4:24 — 4:30 PM		Circle 4 Roundup	5:41
	4:30 — 5:30 PM		Rainbow Review	
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:36	Warner's Corner	
July 17	4:30 — 5:30 PM		Rainbow Review	6:23
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:30	Warner's Corner	
July 18	4:30 — 5:30 PM	1:00	Rainbow Review	6:16
July 19	4:30 — 5:30 PM	1:00	Rainbow Review	3:42
July 20	4:30 — 5:30 PM		Rainbow Review	6:45
	10:30 — 11:00 PM	1:30	Warner's Corner	
July 21	4:30 — 5:30 PM		Rainbow Review	6:10
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:30	Warner's Corner	

1. Washington Field Tests Transmitted over KG2XDE (Cont.)

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
July 24	4:30 — 5:30 PM		Rainbow Review	3:30
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:30	Warner's Corner	
July 25	4:30 — 5:30 PM	1:00	Rainbow Review	2:26
July 26	4:15 — 5:15 PM		Rainbow Review	2:43
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:30	Warner's Corner	
July 27	4:15 — 5:15 PM		Rainbow Review	6:46
	10:30 — 11:00 PM	1:30	Warner's Corner	
July 28	4:15 — 5:15 PM		Rainbow Review	6:01
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:30	Warner's Corner	
July 31	4:15 — 5:15 PM		Rainbow Review	6:22
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:30	Warner's Corner	
July Totals		27:42		103:07
Aug. 1			(Test Pattern only)	5:50
Aug. 2	10:30 — 10:40 PM		Dateline Tomorrow	5:01
	10:40 — 11:00 PM	:30	Warner's Corner	
Aug. 3	10:30 — 11:00 PM	:30	Warner's Corner	5:23
Aug. 4	10:30 — 10:40 PM		Dateline Tomorrow	5:45
	10:40 — 11:00 PM	:30	Warner's Corner	
Aug. 7	2:01 — 2:17 PM		Rainbow Review	5:25
	4:15 — 5:15 PM		Rainbow Review	
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:46	Warner's Corner	
Aug. 8	2:00 — 3:00 PM	1:00	Rainbow Review	4:45
Aug. 9	4:20 — 5:10 PM		Rainbow Review	6:46
	10:30 — 10:40 PM		Dateline Tomorrow	
	10:40 — 11:00 PM	1:20	Warner's Corner	
Aug. 10	10:30 — 11:00 PM	:30	Warner's Corner	5:35
Aug. 11	2:00 — 3:00 PM		Rainbow Review	2:15
	10:30 — 11:00 PM	1:30	Warner's Corner	

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
Aug. 14	10:30 — 11:00 PM	:30	Warner's Corner	5:06
Aug. 15			(Test Pattern only)	6:04
Aug. 16	3:50 — 4:04 PM		Rainbow Review	5:00
	10:30 — 11:00 PM	:44	Warner's Corner	
Aug. 17	10:42 — 10:56 AM		Rainbow Review	2:15
	11:00 — 11:05 AM		Rainbow Review	
	2:00 — 3:00 PM		Rainbow Review	
	10:30 — 11:00 PM	1:49	Warner's Corner	
Aug. 18	4:15 — 5:05 PM		Rainbow Review	5:04
	10:30 — 11:00 PM	1:20.	Warner's Corner	
Aug. 21			(Test Pattern only)	:56
Aug. 23	4:15 — 5:15 PM	1:00	Rainbow Review	3:27
Aug. 24	4:15 — 5:10 PM	:55	Rainbow Review	7:14
Aug. 25	2:00 — 3:00 PM	1:00	Rainbow Review	1:19
Aug. 30	4:35 — 5:08 PM	:33	Rainbow Review	—
Aug. 31	2:00 — 3:00 PM	1:00	Rainbow Review	1:30
August Totals		16:27		84:40
Sept. 1	2:00 — 3:00 PM	1:00	Rainbow Review	1:19
Sept. 5			(Test Pattern only)	1:21
Sept. 6	2:00 — 3:00 PM	1:00	Rainbow Review	3:35
Sept. 7	4:30 — 5:30 PM	1:00	Rainbow Review	3:50
Sept. 8	4:30 — 5:30 PM	1:00	Rainbow Review	4:36
Sept. 11			(Test Pattern only)	3:11
Sept. 12			(Test Pattern only)	5:48
Sept. 13	4:39 — 5:30 PM	:51	Rainbow Review	4:15
Sept. 14	4:30 — 5:30 PM	1:00	Rainbow Review	5:08
Sept. 15	4:30 — 5:30 PM	1:00	Rainbow Review	2:24
Sept. 18	4:00 — 5:00 PM	1:00	Rainbow Review	3:08
Sept. 19			(Test Pattern only)	:05

1. WASHINGTON FIELD TESTS TRANSMITTED OVER KG2XDE (Cont.)

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
Sept. 20	4:00 — 5:00 PM	1:00	Rainbow Review	2:28
Sept. 21	4:00 — 5:00 PM	1:00	Rainbow Review	2.38
Sept. 22	4:00 — 5:00 PM	1:00	Rainbow Review	4:01
Sept. 25	3:00 — 4:00 PM	1:00	Rainbow Review	3:57
Sept. 26	3:00 — 4:00 PM	1:00	Rainbow Review	3:32
Sept. 27	3:00 — 4:00 PM	1:00	Rainbow Review	3:53
Sept. 28	3:00 — 4:00 PM	1:00	Rainbow Review	:18
Sept. 29	3:00 — 4:00 PM	1:00	Rainbow Review	:42
September Totals		15:51		60:09
Oct. 2	3:00 — 4:00 PM	1:00	Rainbow Review	2:49
Oct. 3	3:00 — 4:00 PM	1:00	Rainbow Review	3:38
Oct. 4	12 Noon — 12:20 PM	:20	Rainbow Review	1:03
Oct. 5	12 Noon — 12:25 PM	:25	Rainbow Review	1:28
Oct. 6	12 Noon — 12:25 PM	:25	Rainbow Review	:43
Oct. 9	3:00 — 4:00 PM	1:00	Rainbow Review	2:36
Oct. 10	3:00 — 4:00 PM	1:00	Rainbow Review	2:07
Oct. 11	3:00 — 4:00 PM	1:00	Rainbow Review	—
Oct. 12	3:00 — 3:30 PM 3:30 — 4:00 PM	1:00	Nancy & Jane Rainbow Review	—
Oct. 13	3:00 — 4:00 PM	1:00	Rainbow Review	1:33
Oct. 16	1:00 — 2:00 PM	1:00	Rainbow Review	1:30
Oct. 17	1:00 — 2:00 PM	1:00	Rainbow Review	2:50
Oct. 18	1:00 — 2:00 PM	1:00	Rainbow Review	2:58
Oct. 19	1:00 — 2:00 PM	1:00	Rainbow Review	2:30
Oct. 20	1:00 — 2:00 PM	1:00	Rainbow Review	:54
October Totals		13:10		26:39

On October 31, 1950, experimental call letters KG2XDE were assigned and used for all color transmissions after this date.

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
Nov. 1	11:24 — 11:39 AM	:15	Live Test	2:57
Nov. 2	10:56 — 11:13 AM	:17	Live Test	2:35
Nov. 22	9:45 — 10:57 AM	1:12	Live Test	:33
November Totals		1:44		6:05
Dec. 4		—		3:12
Dec. 5	10:31 — 11:52 AM	1:21	Live Test	1:23
Dec. 6	10:29 — 11:18 AM	:49	Live Test	3:20
Dec. 7	10:22 — 11:26 AM	1:04	—	3:08
Dec. 8		—	—	1:33
Dec. 12	10:47 — 11:16 AM	:29	Live Test	3:57
Dec. 13	10:38 — 11:08 AM	:30	Live Test	3:24
Dec. 14	10:35 — 11:00 AM	:25	Live Test	3:06
Dec. 15	10:33 — 11:04 AM	:31	Live Test	1:02
December Totals		5:09		24:05
1951				
Jan. 11	11:20 — 11:29 AM	:09	Live Test	2:03
Sept. 26		—		1:53
Oct. 3		—		3:04
Oct. 4		—		1:25
Oct. 5		—		1:25
Oct. 8		—		1:57
Oct. 9	10:01 — 10:28 AM	:27	Live Test	:16
Oct. 10	10:00 — 10:27 AM	:27	Live Test	2:03
Oct. 11	10:00 — 10:26 AM	:26	Live Test	1:59

Washington Field Tests Transmitted over KG2XDE (Cont.)

Date	Time	Duration	Program Content	Additional Technical Color Test Transmissions, Color Slides, etc.
Oct. 12	10:03 — 10:29 AM	:26	Live Test	2:01
Oct. 15	10:01 — 10:27 AM	:26	Live Test	1:57
Oct. 16	10:01 — 10:29 AM	:28	Live Test	2:01
Oct. 17	10:01 — 10:29 AM	:28	Live Test	2:01
Oct. 18	10:02 — 10:29 AM	:27	Live Test	2:01
Oct. 19	10:02 — 10:29 AM	:27	Live Test	2:01
1951 Totals		4:11		28:07

	Programs	Technical Test Transmissions, Slides, Etc.		
May 1950	5:08	14:11		
June 1950	26:04	94:28		
July 1950	27:42	103:07		
Aug. 1950	16:27	84:40		
Sept. 1950	15:51	60:09		
Oct. 1950	13:10	26:39		
Nov. 1950	1:44	6:05		
Dec. 1950	5:09	24:05		
Jan., Sept., Oct. 1951	4:11	28:07		
Grand Total	115:26	441:31	=	556:57

2. New York City Experimental Color Program Transmissions over KE2XJV

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
7- 5-51	8:30A—10:12	1 hr. 42 Mins.	3.58 Sym. Samp.		Test Pgm. & Tone
7- 6-51	8:30A—10:14	1 hr. 44 Mins.	3.58 Sym. Samp.		Test Pgm. & Tone
7- 9-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	J. Victor, Princeton	Singers, Dancers Artist, Models, Birds, Howdy Doody & MU Palisades
7-10-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
7-11-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
7-12-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
7-13-51	9:55A—10:27	32 Mins.	3.58 Sym. Samp.	same as above	same as above
8-28-51	10:10A—10:20	10 Mins.	3.58 Sym. Samp.	Princeton Labs	Dancer, Harpist, Singers, Models
8-29-51	9:42A— 9:51	9 Mins.	3.58 Sym. Samp.	Princeton Labs	same as above
8-29-51	10:05A—10:13	8 Mins.	3.58 Sym. Samp.	Princeton Labs	same as above
9-10-51	9:04A— 9:30	26 Mins.	3.58 Sym. Samp.	Center, J. Victor, Princeton	Singers, Dancers, Birds, Flowers, MU Merchant Marine Academy
9-10-51	10:00A—10:27	27 Mins.	3.58 Sym. Samp.	same as above	same as above
9-11-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
9-12-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
9-13-51	10:03A—10:28	25 Mins.	3.58 Sym. Samp.	same as above	same as above
9-14-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
9-17-51	10:01A—10:26	25 Mins.	3.58 Sym. Samp.	same as above	same as above

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
9-18-51	10:00A—10:25	25 Mins.	3.58 Sym. Samp.	Center, J. Victor, Princeton	Singers, Dancers, Birds, Flowers, MU Merchant Marine Academy
9-19-51	10:03A—10:26	23 Mins.	3.58 Sym. Samp.	same as above	same as above
9-20-51	10:02A—10:25	23 Mins.	3.58 Sym. Samp.	same as above	same as above
9-21-51	10:00A—10:25	25 Mins.	3.58 Sym. Samp.	same as above	same as above
10- 9-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	Center, N.Y. Translux Wash. DC Colonial, J. Victor	Same except mobile unit at Palisades Park, N.J.
10-10-51	10:00A—10:27	27 Mins.	3.58 Sym. Samp.	same as above	same as above
10-11-51	10:00A—10:25	25 Mins.	3.58 Sym. Samp.	same as above	same as above
10-12-51	10:03A—10:29	26 Mins.	3.58 Sym. Samp.	same as above	same as above
10-15-51	10:00A—10:27	27 Mins.	3.58 Sym. Samp.	same as above	same as above
10-16-51	10:00A—10:28	28 Mins.	3.58 Sym. Samp.	same as above	same as above
10-17-51	10:02A—10:28	26 Mins.	3.58 Sym. Samp.	same as above	same as above
10-18-51	10:02A—10:28	26 Mins.	3.58 Sym. Samp.	same as above	same as above
10-19-51	10:02A—10:28	26 Mins.	3.58 Sym. Samp.	same as above	same as above
12-10-51	9:30A— 9:52	22 Mins.	NTSC 3.89	Princeton Labs	Artist, Fish Bowl, Painting
12-11-51	9:34A—10:00	26 Mins.	NTSC 3.89	Princeton Labs	Artist MC, Toys, Painting, Titles, Xmas Tree
12-13-51	9:30A— 9:53	23 Mins.	NTSC 3.89	Princeton Labs	Artist MC, Fish Tank, Titles, Paintings

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
12-14-51	9:30A— 9:58	28 Mins.	NTSC 3.89	Princeton Labs	Artist MC, Paintings, Fashions, Titles
1- 2-52	9:07A— 9:27	20 Mins.	NTSC 3.89	Astoria	Educational, Plastic making
1- 5-52	8:17A— 8:48	31 Mins.	NTSC 3.89	Princeton	Educational, Artist, Paintings
1- 8-52	8:15A— 8:45	30 Mins.	NTSC 3.89	Princeton	Educational, Artist, Paintings
1-12-52	8:30A— 8:47	17 Mins.	NTSC 3.89	Princeton	Variety—News, Artist MC, Meat, Fruit, Flowers, Model
1-19-52	8:30A— 8:45	15 Mins.	NTSC 3.89	Princeton	Variety—News, Artist MC, Fowl, Fruit. Vegetables, Model
1-26-52	8:30A— 8:48	18 Mins.	NTSC 3.89	Princeton	same as above
2- 2-52	8:30A— 8:45	15 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Artist MC, Fruit, Flowers, Vegetables, Meat, Model
2- 9-52	8:30A— 8:48	18 Mins.	NTSC 3.89	Astoria & Princeton	same as above
2-16-52	8:30A— 8:50	20 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Slides, Flip Cards and above
3- 8-52	8:30A— 8:54	24 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Artist MC, Plants, Food, Meat, Model, Vegetables
3-22-52	8:00A— 8:55	55 Mins.	NTSC 3.89	Astoria & Princeton	same as above and Quartette
3-29-52	8:30A— 8:51	21 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Artist MC, Plants, Flowers, Slides, Food Bar, Model
4- 5-52	8:30A— 8:48	18 Mins.	NTSC 3.89	Astoria & Princeton	Musical—Artist MC, Singers, Dancers, Flowers
4-12-52	8:30A— 8:50	20 Mins.	NTSC 3.89	Astoria & Princeton	Educational, Artist MC and Paintings

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
4-19-52	8:30A— 8:51	21 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Artist MC, Magician Flip Cards, Food, Slides, Flowers
4-26-52	8:30A— 8:51	21 Mins.	NTSC 3.89	Astoria & Princeton	Puppets—K.F.&O.
5- 3-52	8:30A— 8:49	19 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Artist MC, Magician Puppets, Dancers, Plants, Flowers, Slides
5-10-52	8:30A— 8:50	20 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Artist MC, Puppets, Dancers, Food, Crawl Titles, Announcer
5-17-52	8:30A— 8:53	23 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Slides, Singer, Models, Horse, Artist (Remote from Bayside)
5-24-52	8:30A— 8:48	18 Mins.	Sampler Modified	Astoria & Princeton	Variety—Singer, Dancers, Magician, Flowers, Plants, Puppets
6- 7-52	8:30A— 8:48	18 Mins.	Sampler Modified	Astoria & Princeton	Variety—MC Singer, Dancers, Puppets, Slides, Crawl Titles
6-14-52	8:30A— 8:50	20 Mins.	Sampler Modified	Astoria & Princeton	Variety—MC Singer, Hobbies, Wedding Gowns, Puppets
6-21-52	8:30A— 8:52	22 Mins.	Sampler Modified	Astoria & Princeton	Variety—Singer, Film, Gift Wrapping, Clay Figures, Titles, Dancer
6-28-52	8:30A— 8:54	24 Mins.	Sampler Modified	Astoria & Princeton	Variety—MC, Paintings, Clay Figures, Color Slides and Announcer
7- 5-52	8:30A— 8:52	22 Mins.	Sampler Modified	Astoria & Princeton	Variety, Announcer, Dancer, Hobbies, Billiards
7- 9-52	9:45A— 9:59	14 Mins.	Sampler Modified	Astoria & Princeton	Musical—Announcer, Singer, Ballet and Hobbies

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
7-11-52	9:45A—10:00	15 Mins.	Sampler Modified	Astoria & Princeton	Variety—Announcer, Dancers, Hobby, RCA Whirl
7-15-52	9:45A—10:00	15 Mins.	Sampler Modified	Astoria & Princeton	Variety—Announcer, Singer, Hobby, RCA Whirl, Flip Cards
8-16-52	8:30A— 8:54	24 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Announcer, Dancers, Singer, Ballet
8-23-52	8:30A— 8:53	23 Mins.	NTSC 3.89	Astoria & Princeton	Variety—Hobbies, Dancer, Singer
9- 6-52	8:30A— 8:54	24 Mins.	Sampler Modified	Astoria & Princeton	Variety—Announcer, Singer, Magician, Monkey, Title Cards
9-13-52	8:30A— 8:55	25 Mins.	3.89, 3.75, 3.58	Astoria & Princeton	Educational—Lab Equipment & Narrator, Title Cards
9-16-52	9:45A—10:00	15 Mins.	3.89, B & W, 3.58	Astoria & Princeton	same as above
9-17-52	9:45A—10:00	15 Mins.	3.89, B & W, 3.74	Astoria & Princeton	Variety—Hobby, Singer, Cards, Drama, Title Cards and Announcer
9-18-52	9:45A—10:00	15 Mins.	3.58, 3.74, B & W	Astoria & Princeton & Rm. 608	Variety—Announcer, Painting Hobby Singer, Dancers, Models
9-19-52	9:45A—10:00	15 Mins.	3.58, 3.74, 3.89	Astoria & Room 608 & Princeton	Titles, Comedian, Guitarist
9-24-52	9:45A—10:00	15 Mins.	3.58, 3.89, B & W	Astoria & Room 608 & Princeton	Puppets—K.F.&O.
9-25-52	9:45A—10:00	15 Mins.	3.75, 3.89, B & W	Astoria & Room 608 & Princeton	Puppets—K.F.&O.

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
9-26-52	9:45A—10:00	15 Mins.	3.58, 3.74, 3.89	Astoria & Room 608 & Princeton	Puppets—K.F.&O.
9-30-52	9:45A—10:00	15 Mins.	3.58, 3.89, B & W	Astoria & Room 608 & Princeton	Variety—Announcer, Singers, Dancers, Cards, Titles, Flips, Singer MC
10- 4-52	8:30A— 8:45	15 Mins.	3.89	Astoria & Room 608 & Princeton	Variety—Hobbys (football), Dancers, Singers
10-11-52	8:30A— 8:40	10 Mins.	3.89	Astoria & Room 608 & Princeton	Variety—Announcer, Singers, Comedian, Pictures, Ballet, Titles, Flowers
11-13-52	10:00A—10:15	15 Mins.	NTSC 3.89, OCW 3.58, B & W	Astoria & Room 608 & Princeton	Variety—Announcer, Dancer, Girl Trio, Singer, Dog, Farming Tools
11-14-52	10:00A—10:15	15 Mins.	OCW 3.58 NTSC 3.89, B & W	Astoria & Room 608 & Princeton	Variety—Titles, Slides, Hobby, Football, Dancers and Singer
11-18-52	10:00A—10:15	15 Mins.	same as above	Astoria & Room 608 & Princeton	Variety—Announcer, Cards, Magician, Singer, Umbrellas, Dancers
11-19-52	10:00A—10:15	15 Mins.	same as above	Astoria & Room 608 & Princeton	Variety—Announcer, Cards, Magician, Singer, Umbrellas, Dancers
11-25-52	9:45A—10:00	15 Mins.	same as above	Astoria & Room 608 & Princeton	Variety—Slides, Cards, Singers, Dancers, Comedian
11-26-52	9:45A—10:00	15 Mins.	same as above	Astoria & Room 608 & Princeton	Variety—Slides, Singer, Dancers, Cards, Park Scene
1- 8-53	12:45P—12:50	5 Mins.	OCW 3.57 mc	Radio City Room 608 & Princeton	Announcer, MC & New England Color Slides
1- 8-53	12:50P—12:55	5 Mins.	Monochrome	Radio City Room 608 & Princeton	same as above

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
1- 8-53	12:55P— 1:00	5 Mins.	Offset Carrier (Audio) OCW 3.58 mc	Radio City Room 608 & Princeton	Announcer, MC & New England Color Slides
1-13-53	12:45P— 1:00	15 Mins.	OCW 3.57 mc	Radio City Room 608 & Princeton	Variety—Dancers, Models, Singer, Announcer—Sun Valley Scene
1-15-53	12:45P— 1:00	15 Mins.	OCW 3.57 mc	Radio City Room 608 & Princeton	Announcer, Indian dances and singing
1-22-53	12:45P— 1:00	15 Mins.	OCW 3.57 mc	Radio City Room 608 & Princeton	Nat. History—Announcer, Narrator on Birds & Animals
1-27-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Variety—Dancers, Singer, Comedian, Announcer
1-29-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Stained Glass, Narrator, Model Announcer
2- 3-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Atomic Energy #1, MC and Announcer
2- 5-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Oriental Dancers, MC and Dolls, Announcer
2-10-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Atomic Energy #2
2-12-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	"Madam Butterfly" Singers, Announcer.
2-17-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Repeat of Butterfly

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
2-19-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Nat. History—MC and Cave Animals, Announcer
2-24-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Announcer, MC and Tibet Slides
2-26-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Musical—Singer, Dancer, Quartette
3- 3-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	MC on Pirate Treasure, Announcer
3- 5-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton & Center Theatre	"Farce" Singer, Dancer, Comedian, Orchestra, Announcer
3-12-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Variety—Singers, Dancers, Birds Announcer
3-19-53	12:45P— 1:00	15 Mins.	NTSC 3.57 mc	Radio City Room 608 & Princeton	Puppets, Announcer
4- 8-53	11:24A—11:44	20 Mins.	NTSC 3.57 mc	Princeton, Center Theater	Variety—Singers, Dancers, Birds, Models
4- 9-53	12:40P — 1:00	20 Mins.	NTSC 3.57 mc	Princeton, Center Theater	Variety—Singers, Dancers, Birds, Models K.F.&O., Announcer
4-13-53	12:40P — 1:00	20 Mins.	NTSC 3.57 mc	Princeton, Center Theater	Variety—Singer, Dancers, Birds, K.F.&O., Announcer
4-14-53	12:00P —12:21	21 Mins.	NTSC 3.57 mc	Princeton, Center Theater	Variety—Singer, Dancers, Birds, K.F.&O., Announcer
4-16-53	12:37P —12:58	21 Mins.	NTSC 3.57 mc	Princeton, Center Theater	Variety—Singer, Dancers, Birds, K.F.&O., Announcer

2. New York City Experimental Color Program Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
5- 7-53	1:54A— 2:09	15 Mins.	NTSC 3.57 mc	Bayside	Singers, Dancers, Novelty Act, Announcer
5- 8-53	1:48A— 2:04	16 Mins.	NTSC 3.57 mc	Bayside	Singers, Dancers, Novelty Act, Announcer
5-18-53	11:38A—12:00N	22 Mins.	NTSC 3.57 mc	Princeton, Center Theatre	Singers, Dancers, Bird Act, Announcer
5-19-53	12:00N—12:22P	22 Mins.	NTSC 3.57 mc	same as above	same as above
5-21-53	12:38P — 1:00	22 Mins.	NTSC 3.57 mc	same as above	same as above
5-26-53	12:38P — 1:00	22 Mins.	NTSC 3.57 mc	same as above	same as above
	Total	40:14			

3. New York City Technical Test Transmissions over KE2XJV

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
5- 2-51	8:45A—10:32	1 hr. 47 Mins.	Sym. Samp. 3.58	Princeton Labs	Color Bars—Slide Scanner and Tone
5- 3-51	9:03A—10:26	1 hr. 23 Mins.	same as above	same as above	same as above
5-25-51	9:43A—10:10	27 Mins.	same as above	same as above	same as above
6- 1-51	9:45A—10:18	33 Mins.	same as above	3H—4th floor Viewing Room	Artist MC Format
6- 8-51	9:45A—10:15	30 Mins.	same as above	same as above	Artist MC Format, Mobile Unit—Floral Displays & Interview
6-28-51	12:15A— 2:02	1 hr. 47 Mins.	same as above		Color Bars, Slide Scanner and Tone
6-29-51	7:01A— 9:56	2 hrs. 55 Mins.	same as above		same as above
7- 2-51	8:50A— 9:51	1 hr. 1 Min.	same as above	Center, & J. Victor	Color Bars, Slides, Program Type Material and Tone
7- 3-51	7:31A—10:00	2 hrs. 29 Mins.	same as above	same as above	same as above
7- 4-51	7:28A—10:15	2 hrs. 47 Mins.	same as above	same as above	same as above
7- 5-51	7:07A— 8:30	1 hr. 23 Mins.	same as above	same as above	same as above
7- 6-51	7:10A— 8:30	1 hr. 20 Mins.	same as above	same as above	same as above
7- 7-51	7:16A— 9:21	2 hrs. 5 Mins.	same as above	same as above	same as above
7- 8-51	7:08A— 9:55	2 hrs. 47 Mins.	same as above	same as above	same as above
7- 9-51	7:08A—10:27	3 hrs. 19 Mins.	same as above	same as above	same as above
7-10-51	7:01A—10:27	3 hrs. 26 Mins.	same as above	same as above	same as above
7-11-51	7:00A—10:00	3 hrs.	same as above	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
7-12-51	7:25A—10:00	2 hrs. 35 Mins.	sym. samp. 3.58	Center & J. Victor	Color Bars, Slides, Program Type Material and Tone
7-13-51	7:29A— 9:55	2 hrs. 26 Mins.	same as above	same as above	same as above
8-16-51	9:32A— 9:51	19 Mins.	same as above	Princeton Labs (Color Proj. Equipment)	Color Bars, Slides and Tone
8-21-51	9:08A—10:15	1 hr. 7 Mins.	same as above	same as above	same as above
8-22-51	8:59A— 9:51	52 Mins.	same as above	same as above	same as above
8-23-51	8:55A—10:10	1 hr. 15 Mins.	same as above	same as above	same as above
8-24-51	9:03A— 9:58	55 Mins.	same as above	same as above	same as above
8-27-51	9:38A—10:16	38 Mins.	same as above	same as above	same as above
8-28-51	9:45A—10:10	25 Mins.	same as above	same as above	same as above
8-29-51	9:00A— 9:42	42 Mins.	same as above	same as above	same as above
8-29-51	9:51A—10:05	14 Mins.	same as above	same as above	same as above
8-29-51	10:13A—10:15	2 Mins.	same as above	same as above	same as above
8-30-51	9:28A—10:21	53 Mins.	same as above	same as above	same as above
8-31-51	9:33A—10:15	42 Mins.	same as above	same as above	same as above
9- 4-51	8:15A—10:16	2 hrs. 1 Min.	3.58 mc subcarrier sym. sampling	Center, J. Victor, Princeton	Color Bars, Slides, Live and Tone
9- 5-51	8:41A—10:27	1 hr. 46 Mins.	same as above	same as above	same as above
9- 6-51	8:34A—10:15	1 hr. 41 Mins.	same as above	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
9- 7-51	7:35A—10:15	2 hrs. 40 Mins.	3.58 mc subcarrier, sym. sampling	Center, J. Victor, Princeton	Color Bars, Slides, Live, Gamma, Tone
9- 8-51	7:30A— 9:16	1 hr. 46 Mins.	same as above	same as above	same as above & Dots
9- 9-51	7:31A— 9:35	2 hrs. 4 Mins.	same as above	same as above	Color Bars, Slides, Live and Tone
9-10-51	12:00A— 1:20	1 hr. 20 Mins.	same as above	same as above	same as above
9-10-51	7:32A— 9:04	1 hr. 32 Mins.	same as above	same as above	same as above
9-10-51	9:30A—10:00	30 Mins.	same as above	same as above	same as above
9-11-51	8:03A—10:00	1 hr. 57 Mins.	same as above	same as above	same as above & Live
9-12-51	7:33A—10:00	2 hrs. 27 Mins.	same as above	same as above	same as above & Live
9-13-51	7:40A—10:03	2 hrs. 23 Mins.	same as above	same as above	Color Bars, Slides, Live, Gamma, Tone
9-14-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	same as above	same as above
9-17-51	7:33A—10:01	2 hrs. 28 Mins.	same as above	same as above	same as above
9-18-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	same as above	Color Bars, Slides, Live, Tone
9-19-51	7:30A—10:03	2 hrs. 33 Mins.	same as above	same as above	same as above
9-20-51	7:30A—10:02	2 hrs. 32 Mins.	same as above	same as above	same as above
9-21-51	7:31A—10:00	2 hrs. 29 Mins.	same as above	same as above	same as above
10- 4-51	8:30A—10:15	1 hr. 45 Mins.	same as above	same as above	same as above
10- 5-51	8:30A—10:15	1 hr. 45 Mins.	same as above	same as above	same as above
10- 8-51	8:30A— 9:30	1 hr.	same as above	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
10- 9-51	7:30A—10:00	2 hrs. 30 Mins.	3.58 mc subcarrier, sym. sampling	Center, J. Victor, Colonial—big screen proj., Wash. Princeton	Color Bars, Slides, Live, Tone
10-10-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	same as above	same as above
10-11-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	same as above	same as above
10-12-51	7:30A—10:03	2 hrs. 33 Mins.	same as above	same as above	same as above
10-15-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	Center, Colonial J. Victor, Princeton, TransLux, Wash.	same as above
10-16-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	same as above	same as above
10-17-51	7:40A—10:00	2 hrs. 20 Mins.	same as above	same as above	same as above
10-18-51	7:31A—10:02	2 hrs. 31 Mins.	same as above	same as above	same as above
10-19-51	7:30A—10:00	2 hrs. 30 Mins.	same as above	same as above	same as above
11- 6-51	9:00A—10:00	1 hr.	same as above	Bridgeport UHF	same as above
11- 6-51	11:45A—12:22	37 Mins.	NTSC 3.89	Bridgeport UHF (for Westport receivers)	Color Bars, Tone
11- 7-51	8:54A—10:23	1 hr. 29 Mins.	NTSC 3.89	Bridgeport	Color Bars, Slides, Live, Tone
11-28-51	8:37A— 9:57	1 hr. 20 Mins.	NTSC 3.89	same as above	same as above
11-29-51	8:12A—10:15	2 hrs. 3 Mins.	NTSC 3.89	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
12- 3-51	8:00A—10:02	2 hrs. 2 Mins.	NTSC 3.89	Astoria and Princeton	Color Bars, Slides, Live, Tone
12- 4-51	8:00A—10:00	2 hrs.	NTSC 3.89	same as above	same as above
12- 5-51	8:00A—10:00	2 hrs.	NTSC 3.89	same as above	same as above & Film
12- 6-51	8:00A—10:00	2 hrs.	NTSC 3.89	same as above	same as above
12- 7-51	8:00A—10:00	2 hrs.	NTSC 3.89	same as above	same as above
12-10-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	same as above	Color Bars, Slides, Live, Studio Audio
12-10-51	9:52A—10:00	8 Mins.	NTSC 3.89	same as above	same as above
12-11-51	8:00A— 9:31	1 hr. 31 Mins.	NTSC 3.89	same as above	same as above
12-12-51	10:04A—10:15	11 Mins.	NTSC 3.89	same as above	same as above
12-13-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above
12-14-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above
12-17-51	8:00A— 9:31	1 hr. 31 Mins.	NTSC 3.89	same as above	same as above
12-17-51	9:50A—10:18	28 Mins.	NTSC 3.89	same as above	same as above
12-18-51	7:30A— 9:30	2 hrs.	NTSC 3.89	same as above	same as above
12-18-51	9:56A—10:15	19 Mins.	NTSC 3.89	same as above	same as above
12-19-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above
12-19-51	9:59A—10:02	3 Mins.	NTSC 3.89	same as above	same as above
12-20-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Condition*	*Observed*	*Program Content*
12-21-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	Astoria & Princeton	Color Bars, Slides, Live, Studio Audio
12-21-51	9:51A—10:14	23 Mins.	NTSC 3.89	same as above	same as above
12-24-51	8:00A— 9:30	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above
12-24-51	9:50A—10:04	14 Mins.	NTSC 3.89	same as above	same as above
12-26-51	8:00A— 9:00	1 hr.	NTSC 3.89	same as above	same as above
12-26-51	9:30A—10:00	30 Mins.	NTSC 3.89	same as above	same as above
12-27-51	8:00A— 9:06	1 hr. 6 Mins.	NTSC 3.89	same as above	same as above
12-27-51	9:30A—10:00	30 Mins.	NTSC 3.89	same as above	same as above
12-28-51	8:00A— 9:11	1 hr. 11 Mins.	NTSC 3.89	same as above	same as above
12-28-51	9:30A—10:15	45 Mins.	NTSC 3.89	same as above	same as above
12-31-51	8:00A—10:03	2 hrs. 3 Mins.	NTSC 3.89	same as above	same as above
1- 2-52	8:00A— 9:07	1 hr. 7 Mins	NTSC 3.89	Astoria & Bridgeport	Color Tests & Tone
1- 2-52	9:27A—10:02	35 Mins.	NTSC 3.89	same as above	same as above
1- 3-52	8:00A—10:00	2 hrs.	NTSC 3.89	same as above	same as above
1- 4-52	8:00A—10:00	2 hrs.	NTSC 3.89	same as above	same as above
1- 5-52	7:38A— 8:17	39 Mins.	NTSC 3.89	same as above	same as above
1- 8-52	7:32A— 8:15	43 Mins.	NTSC 3.89	same as above	same as above
1- 9-52	7:15A— 8:45	1 hr. 30 Mins.	NTSC 3.89	same as above	Color Bars, Live Tests, Slide Scanner, Tone

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Condition*	*Observed*	*Program Content*
1-10-52	7:15A— 8:45	1 hr. 30 Mins.	NTSC 3.89	Astoria & Bridgeport	Color Bars, Live Tests, Slide Scanner, Tone, Burst. Gen.
1-11-52	7:15A— 8:45	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above
1-12-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Color Bars, Slide Scanner, Tone
1-12-52	8:47A— 8:57	10 Mins.	NTSC 3.89	same as above	same as above
1-19-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Color Bars, Live Test, Slide Scanner, Tone
1-19-52	8:45A— 8:46	1 Min.	NTSC 3.89	same as above	same as above
1-26-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Color Bars, Slide Scanner, Tone
1-29-52	12:26A— 2:07	1 hr. 41 Mins.	NTSC 3.89	same as above	Burst Freq., Dots, Color Bars, Slide Scanner, Live, Tone
1-30-52	12:35A— 3:00	2 hrs. 25 Mins.	NTSC 3.89	same as above	same as above
1-31-52	12:50A— 3:00	2 hrs. 10 Mins.	NTSC 3.89	same as above	same as above
2- 1-52	12:43A— 3:00	2 hrs. 17 Mins.	NTSC 3.89	Astoria & Princeton	same as above
2- 2-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Color Bars, Slide Scanner, Tone
2- 9-52	7:15A— 8:30	1 hr. 15 Mins.	NTSC 3.89	same as above	Dots, Color Bars, Slide Scanner, Tone
2-16-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Color Bars, Slide Scanner, Tone
2-19-52	12:27A— 5:56	5 hrs. 29 Mins.	NTSC 3.89	same as above	Color Bars, Slides, Flag Gen. and Tone
2-20-52	12:59A— 3:14	2 hrs. 15 Mins.	NTSC 3.89	same as above	Color Bars, Slide Scanner, Tone
2-23-52	7:45A— 8:51	1 hr. 6 Mins.	NTSC 3.89	same as above	Color Bars, Slide Scanner, Dots, Tone

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
3- 1-52	7:45A— 8:55	1 hr. 10 Mins.	NTSC 3.89	Astoria & Princeton	Color Bars, Slides, Tone
3- 8-52	7:46A— 8:30	44 Mins.	NTSC 3.89	same as above	same as above
3-12-52	12:58A— 3:18	2 hrs. 20 Mins.	NTSC 3.89	same as above	Dots, Burst Freq. Gen., Color Bars, Slides, Live, Tone
3-13-52	12:53A— 2:25	1 hr. 32 Mins.	NTSC 3.89	same as above	same as above
3-22-52	7:45A— 8:00	15 Mins.	NTSC 3.89	same as above	Color Bars, Tone, Slide Scanner
3-25-52	12:32A— 2:23	1 hr. 51 Mins.	NTSC 3.89	same as above	Dots, Burst Freq., Tone, Color Bars, Slides, Live
3-26-52	12:35A— 2:23	1 hr. 48 Mins.	NTSC 3.89	same as above	same as above
3-27-52	12:50A— 1:52	1 hr. 2 Mins.	NTSC 3.89	same as above	Dots, Burst Freq., Tone, Color Bars, Slides
3-28-52	12:38A— 1:48	1 hr. 10 Mins.	NTSC 3.89	same as above	Slide, Scanner, Color, Bars, Burst Gen., Live Camera
3-29-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	same as above
4- 5-52	7:00A— 8:30	1 hr. 30 Mins.	NTSC 3.89	same as above	same as above
4- 5-52	8:48A— 8:54	6 Mins.	NTSC 3.89	same as above	same as above
4-12-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	same as above
4-12-52	8:50A— 8:53	3 Mins.	NTSC 3.89	same as above	same as above
4-19-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	same as above
4-26-52	7:15A— 8:30	1 hr. 15 Mins.	NTSC 3.89	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
5- 3-52	7:45A— 8:30	45 Mins.	NTSC 3.89	Astoria & Princeton	Slide Scanner, Color Bars, Burst. Gen., Live Camera
5- 3-52	8:49A— 8:52	3 Mins.	NTSC 3.89	same as above	same as above
5-10-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	same as above
5-17-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Colors Bars, Live Camera
5-24-52	7:45A— 8:30	45 Mins.	NTSC 3.89	same as above	Slide Scanner, Color Bars, Burst Gen., Live Camera
5-24-52	8:45A— 8:53	8 Mins.	NTSC 3.89	same as above	same as above
5-29-52	12:53A— 2:55	2 hrs. 2 Mins.	Sampler Modified for Burst Ped. Width & Hor. Sync	same as above	same as above
6- 5-52	1:03A— 2:31	1 hr. 28 Mins.	same as above	same as above	same as above
6- 7-52	7:45A— 8:30	45 Mins.	same as above	same as above	same as above
6-14-52	7:45A— 8:30	45 Mins.	same as above	same as above	same as above
6-19-52	12:57A— 1:46	49 Mins.	same as above	same as above	same as above
6-21-52	7:48A— 8:30	42 Mins.	same as above	same as above	same as above
6-21-52	8:52A— 8:57	5 Mins.	same as above	same as above	same as above
6-28-52	7:30A— 8:30	1 hr.	same as above	same as above	same as above
7- 5-52	7:30A— 8:30	1 hr.	NTSC 3.89	same as above	same as above
7- 5-52	8:52A— 8:55	3 Mins.	NTSC 3.89	same as above	same as above
7-15-52	6:00A— 6:58	58 Mins.	NTSC 3.89	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
8-13-52	12:56A— 2:16	1 hr. 20 Mins.	NTSC 3.89	Astoria & Princeton	Slide Scanner, Color Bars, Burst. Gen., Live Camera
8-14-52	12:51A— 2:40	1 hr. 49 Mins.	NTSC 3.89	same as above	same as above
8-16-52	7:33A— 8:30	57 Mins.	NTSC 3.89	same as above	same as above
8-22-52	12:50A— 3:33	2 hrs. 43 Mins.	NTSC 3.89	same as above	same as above
8-23-52	7:30A— 8:30	1 hr.	NTSC 3.89	same as above	same as above
9- 6-52	7:30A— 8:30	1 hr.	NTSC 3.89	same as above	same as above
9-11-52	12:47A— 3:09	2 hrs. 22 Mins.	NTSC 3.89	same as above	same as above
9-12-52	1:10A— 2:56	1 hr. 46 Mins.	3.89, 3.75, 3.58	same as above	same as above
9-13-52	6:48A— 8:30	1 hr. 42 Mins.	3.89, 3.58, 3.74	same as above & Rm. 608	Color Bars, Slide Scanner, Live
9-15-52	5:00A— 6:17	1 hr. 17 Mins.	same as above	same as above	same as above & record
9-16-52	12:42A— 1:36	54 Mins.	same as above	same as above	same as above
9-26-52	8:48A— 8:53	5 Mins.	same as above	same as above	same as above
10- 2-52	12:40A— 4:47	4 hrs. 7 Mins.	NTSC 3.89	Astoria, Princeton	Color Bars, Slide Scanner, Burst Gen., Live Camera, Records, Tone
10- 3-52	12:45A— 1:39	54 Mins.	same as above	same as above	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
10- 4-52	7:30A— 8:30	1 hr.	NTSC 3.89	Princeton, Astoria, Room 608—Radio City	Slide Scanner, Burst, Live Camera, Color Bars
10- 4-52	8:45A— 8:58	13 Mins.	same as above	same as above	same as above
10-11-52	7:30A— 8:30	1 hr.	same as above	same as above	same as above
10-11-52	8:44A— 8:58	14 Mins.	same as above	same as above	same as above
10-17-52	12:49A— 2:23	1 hr. 34 Mins.	3.89, 3.58FF, 3.58IQ	same as above	same as above
10-21-52	12:00A— 3:58	3 hrs. 58 Mins.	same as above	same as above	Mono & Color Live, Slide Scanner, Color Bars
10-22-52	1:40A— 4:59	3 hrs. 19 Mins.	same as above	same as above	Transmitter Linearity Tests
10-23-52	12:37A— 5:55	5 hrs. 18 Mins.	NTSC 3.89, 3.58 mc	Princeton	Color Bars, Slide Scanner
11- 6-52	1:13A— 3:21	2 hrs. 8 Mins.	NTSC 3.89	Princeton, Astoria	Mono and Color Live
11- 7-52	1:14A— 2:38	1 hr. 24 Mins.	NTSC 3.58, OCW 3.58, 3.89 mc	Princeton	Color Live
11-13-52	6:20A— 6:52	32 Mins.	NTSC 3.89, B & W OCW 3.58	same as above	Mono and Color Live
11-14-52	12:25A— 4:37	4 hrs. 12 Mins.	same as above	same as above	Color Bars, Slide Scanner, Live
11-19-52	12:50A— 3:15	2 hrs. 25 Mins.	same as above	same as above	same as above
11-20-52	1:00A— 4:25	3 hrs. 25 Mins.	NTSC 3.58, 3.89, OCW 3.58	same as above	same as above
12-30-52	2:59A— 4:11	1 hr. 12 Mins.	3.57 mc Standard 3.58 mc offset sound	Room 608—Radio City, Princeton Lab	Fruit, Flowers, Model Color Bars, Slide Scanner, Burst Freq Records, Tone

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
12-31-52	1:25A— 4:18	2 hrs. 55 Mins.	3.57 mc Standard 3.58 offset sound	Room 608—Radio City, Princeton Lab	Color Bars, Slide Scanner, Burst. Freq., Records, Tone
2- 4-53	12:44A— 4:54	4 hrs. 10 Mins.	NTSC 3.57 mc	same as above	Color Bars, Slide Scanner, Modulated Stepwedge
2- 6-53	1:09A— 4:11	3 hrs. 2 Mins.	same as above	same as above	same as above and live camera
3- 6-53	1:32A— 4:07	2 hrs. 35 Mins.	same as above	same as above	Color Bars, Stepwedge Modulated, Burst Freq.
3-17-53	12:45A— 3:12	2 hrs. 27 Mins.	same as above	Astoria	Color Bars, Slide Scanner, Camera, Model, Fruit, Wheel, Flowers
3-18-53	12:45A— 2:55	2 hrs. 10 Mins.	same as above	Astoria	same as above
3-19-53	12:52A— 3:31	2 hrs. 39 Mins.	same as above	NTSC Panel	same as above
3-20-53	12:52A— 4:38	3 hrs. 46 Mins.	same as above	NTSC Panel	same as above
4- 8-53	12:41A— 2:32	1 hr. 51 Mins.	same as above	Princeton, Room 608—Radio City	Fruit, Flowers, Model, Color Bars, Slide Scanner Modulated Stepwedge
4- 9-53	5:53A— 6:51	58 Mins.	same as above	same as above	same as above
4-14-53	5:00A— 6:45	1 hr. 45 Mins.	same as above	same as above	same as above
4-16-53	4:43A— 6:45	2 hrs. 2 Mins.	same as above	same as above	same as above
5- 5-53	12:46A— 5:38	4 hrs. 52 Mins.	same as above	Bayside	Color Bars, Slides, Live, Tone and Model
5- 6-53	12:57A— 3:47	2 hrs. 50 Mins.	same as above	Bayside	same as above

3. New York City Technical Test Transmissions over KE2XJV (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Program Content*
5- 7-53	1:20 — 1:54A	34 Mins.	NTSC 3.57 mc	Bayside	Color Bars, Slides, Live, Tone and Model
5- 7-53	2:09 — 3:56A	1 hr. 47 Mins.	NTSC	Bayside	same as above
5- 8-53	1:19 — 1:48A	29 Mins.	NTSC	Bayside	same as above
5- 8-53	2:04 — 3:11A	1 hr. 7 Mins.	NTSC	Bayside	same as above
5-18-53	5:31 — 6:46A	1 hr. 15 Mins.	NTSC	Princeton, Center Th.	same as above
5-19-53	3:23 — 6:45A	3 hrs. 22 Mins.	NTSC	same as above	same as above
5-21-53	4:07 — 6:45A	2 hrs. 38 Mins.	NTSC	same as above	same as above
5-26-53	12:53 — 4:33A	3 hrs. 40 Mins.	NTSC	same as above and Jersey City	Slides and Music
5-26-53	4:33 — 6:45A	2 hrs. 12 Mins.	NTSC	Princeton, Center Theater	Color Bars, Slides, Live, Music and Tone
Total		323:52			

4. Color Transmissions Over Bridgeport UHF Experimental Transmitter KC2XAK

Date		Test Burst Gen. Color Bars, Slides	Live Program	Total
November	1951	8:17		8:17
December	1951	5:01	1:45	6:46
January	1952	64:14	2:03	66:17
February	1952	19:34	:38	20.12
March	1952	12:25	:55	13:20
April	1952	4:28	1:02	5:30
May	1952			
June	1952			
July	1952	23:29	:45	24:14
August	1952	16:29		16:29
Transmitter Closed August 23, 1952				
	TOTAL	153:57 hrs.	7:08 hrs.	161:05 hrs.

5. New York City Closed Circuit Color Field Tests

Date	*Time*	*Duration*	*Conditions*	*Observed*	*Guests*	*Program Content*
4-18-51			Sym. Samp. 3.58 mc	3H Viewing Room	NBC Exec	Color Bars, Pix Slides, Live Camera
4-24-51			same as above	same as above	NBC—RCA Exec.	same as above
4-25-51			same as above	same as above	same as above	same as above
4-26-51			same as above	same as above	same as above	same as above
4-27-51			same as above	same as above	same as above	same as above
5- 1-51			same as above	same as above	same as above	same as above
5-21-51			same as above	same as above	same as above	Color Bars, Live Camera, Pix from MU
5-22-51			same as above	same as above	same as above	same as above
5-24-51			same as above	same as above	same as above	Color Bars, Live Camera, Pix from Garden World, Flushing
5-31-51			same as above	same as above	same as above	same as above
5- 3-51			same as above	same as above	same as above	Jugglers, Baton Twirlers, Model, Lo Key Lights (Mag) Flowers, Fruit, Fish, Negro Dancer
5-10-51			same as above	same as above	same as above	same as above
5-11-51			same as above	same as above	same as above	same as above
5-18-51			same as above	same as above	same as above	same as above

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
6- 2-51		28 Mins.	Sym. Samp. 3.58 mc.	3H Viewing Room	NBC—RCA Execs.	Models, Singers, Parasols, Dancers, Prod. No. MU from Palisades
6- 3-51		28 Mins.	same as above	same as above	same as above	same as above
6- 4-51		28 Mins.	same as above	same as above	same as above	same as above
6- 5-51		28 Mins.	same as above	same as above	same as above	same as above
6- 6-51		28 Mins.	same as above	same as above	same as above	same as above
7- 9-51	2:30P— 2:58	28 Mins.	same as above	J. Victor	Press Represent.	Singers, Dancer, Artists, Models, Birds, Puppets, MU — Palisades
7- 9-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
7-10-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
7-10-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
7-11-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
7-11-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
7-12-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
7-12-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
7-13-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
9-10-51	2:30P— 2:52	22 Mins.	same as above	J. Victor, Center, Wash. DC, Colonial	Press, RCA-NBC Exec.	Singers, Dancers, Birds, Flowers, MU—Kings Point

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Contents*
9-10-51	4:45P— 5:07	22 Mins.	3.58 Sym. Samp.	J. Victor, Center, Wash. DC, Colonial	Press, RCA—NBC Exec.	Singers, Birds, Flowers, Dancers, MU—Kings Point
9-11-51	2:30P— 2:52	22 Mins.	same as above	same as above	Public	same as above
9-11-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-12-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-12-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-13-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-13-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-14-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-14-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-17-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-17-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-18-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-18-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-19-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-19-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above
9-20-51	2:30P— 2:52	22 Mins.	same as above	same as above	same as above	same as above
9-20-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	same as above

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
9-21-51	2:30P— 2:52	22 Mins.	3.58 Sym. Samp. & 2.4 mc Cable & Radio Relay	J. Victor, Center, Wash. D.C. Colonial	Public	Singer, Dancers.
9-21-51	4:45P— 5:07	22 Mins.	same as above	same as above	same as above	Birds, Texas Prod., MU—Palisades
10- 9-51	2:30P— 2:58	28 Mins.	same as above	same as above	Special Guests & Public	same as above
10- 9-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
10-10-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-10-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
10-11-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-11-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
10-12-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-12-51	4:15P— 4:43	28 Mins.	same as above	same as above	same as above	same as above
10-13-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-13-51	4:14P— 4:43	29 Mins.	same as above	same as above	same as above	same as above
10-14-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-14-51	4:14P— 4:43	29 Mins.	same as above	same as above	same as above	same as above
10-16-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-16-51	4:14P— 4:43	29 Mins.	same as above	same as above	same as above	same as above

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
10-17-51	2:30P— 2:58	28 Mins.	3.58 Sym. Samp. & 2.4 mc Cable & Radio Relay	J. Victor, Center, Wash. D.C. Colonial	Special Guests & Public	Birds, Texas Prod., MU—Palisades
10-17-51	4:14P— 4:43	29 Mins.	same as above	same as above	same as above	same as above
10-18-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-18-51	4:14P— 4:43	29 Mins.	same as above	same as above	same as above	same as above
10-19-51	2:30P— 2:58	28 Mins.	same as above	same as above	same as above	same as above
10-19-51	4:14P— 4:43	29 Mins.	same as above	same as above	same as above	same as above
11- 8-51	1:00P— 3:00	2 hrs.	3.89 NTSC Const. Lum.	3H Viewing Room	NBC Exec. BBC Guests	Color Bars, Slides, Camera Pix.
11-29-51	2:30P— 3:00	30 Mins.	same as above	same as above	NBC Exec. & Sir Geo. Nelson	Artist, Toys, Flowers, Models
1- 7-52	3:30P— 4:00	30 Mins.	NTSC 3.89 Const. Lum.	3H Viewing Room	NBC—RCA Execs.	Artists and Paintings
1- 8-52	3:15P— 3:45	30 Mins.	same as above	same as above	same as above	same as above
1-17-52	12:00N— 1:00P	1 hr.	same as above	same as above	same as above	Color Bars, Slides, Camera
2- 5-52	1:00P— 2:00	1 hr.	Signal Looped at Wash.	same as above	same as above	same as above
3- 3-52	4:00P— 4:45	45 Mins.	NTSC 3.89 Const. Lum.	same as above	Westing. Engs.	same as above
3-24-52	2:00P— 2:23A	12 hrs. 23 Mins.	same as above	Astoria	NTSC Panel	same as above
3-25-52	2:00P— 2:25A	12 hrs. 25 Mins.	same as above	same as above	same as above	same as above
3-26-52	2:00P— 1:50A	11 hrs. 50 Mins.	same as above	same as above	same as above	same as above

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
3-27-52	2:00P— 1:40A	11 hrs. 40 Mins.	NTSC 3.89 Const. Lum.	Astoria	NTSC Panel	Color Bars, Slides, Camera
4- 7-52	3:30P— 4:00	30 Mins.	same as above	Colonial—Large Screen	NBC—RCA Execs.	River Boat Scene Choral, Blues Song, Dance Prod.
4-11-52	?	?	same as above	same as above & J. Victor	same as above	same as above
5-23-52	3:00P— 3:30	30 Mins.	same as above	Viewing Room	NBC—RCA Execs. & Guests	Dancers, Models, Flowers, Puppets
6-17-52	12:30P— 2:45	2 hrs. 15 Mins.	same as above	same as above	Telco Eng.	Burst Freq. Gen., Color Bars, Slides Camera Pix.
6-27-52	4:00P— 4:24	24 Mins.	same as above	same as above	NBC—RCA Execs.	"Enchanted Gate" show
7- 3-52	4:00P— 4.22	22 Mins.	same as above	same as above	same as above	Dancers, Hobby, Billiards, Model
7- 8-52	4:00P— 4:15	15 Mins.	same as above	same as above	same as above	Model, Titles, Singers, Flips, Hobby, Ballet
7-14-52	4:00P— 4:15	15 Mins.	same as above	same as above	same as above	Model, Singers, Hobby, Fashions Puppets
8-15-52	4:15P— 4:30	15 Mins.	same as above	same as above	same as above	Model, Singers, Dancers, Scarves Slides
8-27-52	3:30P— 4:00	30 Mins.	same as above	same as above	Dr. Marshall	Color Bars, Slide Scanner, Fruits, Models, Flowers
9-24-52	8:30A— 8:45	15 Mins.	3.58, 3.89, B & W	same as above	NBC—RCA Execs.	Puppets—K.F.&O.

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
10-18-52	2:00P— 4:45	2 hrs. 45 Mins.	NTSC 3.89	Astoria & Viewing Room	NBC—RCA Execs.	MU—football game — Baker Field
10-21-52	3:40P— 4:00	20 Mins.	same as above	3H Viewing Room	Div. Eng. NBC	Color Bars, Slide Scanner, Fruit Model, Flowers
10-31-52	10:30A—11:00	30 Mins.	?	same as above	FCC Comm.	same as above
11-17-52	11:00A—11:30	30 Mins.	?	same as above	same as above	same as above
12-16-52	?	?	NTSC 3.89	Colonial Viewing Room	NBC—RCA Execs.	Xmas Scene, Ann. Trampoline
1-14-53	4:00P— 4:20	20 Mins.	OCW 3.57 mc	Studio 3H	Signal Corps Officers	Fruit, Model, Flowers, Slides
1-16-53	3:00P— 3:45	45 Mins.	same as above	same as above	Eastman Kodak	35mm Motion Picture
1-30-53	12:30P— 3:00	2 hrs. 30 Mins.	NTSC 3.57 mc.	3H, Room 608	AT&T & NBC Off.	Cable Tests, Color Bars, Slide Scanner, Burst Freq., Live
2- 4-53	10:30A—11:15	45 Mins.	same as above	Studio 3H	Eastman Kodak & Dev. Lab	Color Slides, Test Patterns
2- 5-53	1:00P— 3:00	2 hrs.	same as above	3H & 608	AT&T & NBC Off.	Cable Tests, Color Bars, Slide Scanner, Burst Freq., Live
2-10-53	9:15P—10:00	45 Mins.	same as above	Center	NBC—RCA Execs.	Musical — Birds, Dancers, Singers, Fruit, Flowers, Model
2-12-53	11:15A—11:30	15 Mins.	same as above	Room 608	same as above	Madame Butterfly Announcer
2-16-53	12:00N— 3:00P	3 hrs.	same as above	Signal Looped at Wash. & Room 608	NBC—Telco	Color Bars, Burst Freq. Gen.

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
2-17-53	11:15P—11:30	15 Mins.	NTSC 3.57 mc	Room 608	NBC—RCA Execs.	Madame Butterfly
2-19-53	11:15P—11:30	15 Mins.	same as above	same as above	same as above	Nat. History—MC and Slides
2-24-53	11:15P—11:30	15 Mins.	same as above	same as above	same as above	MC and Tibet Slides
2-26-53	11:15P—11:30	15 Mins.	same as above	same as above	same as above	Fruit, Flowers, Model, Slides
2-26-53	11:30A—12:00	30 Mins.	same as above	Studio 3H	British Movie Exec.	Fruit, Flowers, Model, Slides
2-27-53	3:45P— 4:00	15 Mins.	same as above	Room 608	FCC Comm. Webster	Musical-Singer Dancers, Ann.
3- 3-53	11:15A—11:30	15 Mins.	same as above	same as above	RCA—NBC Exec.	MC on Treasure and Announcer
3- 5-53	11:15A—11:30	15 Mins.	same as above	Center Room 608	same as above	"Farce", Singer Dancer, Comedy
3- 9-53	11:17A—11:34	17 Mins.	same as above	Center Thea.	same as above	Musical — Singers, Dancers, Birds, Fruit, Flowers, Model
3- 9-53	2:51P— 3:08	17 Mins.	same as above	same as above	same as above	same as above
3- 9-53	4:01P— 4:18	17 Mins.	same as above	same as above	Public Aud.—React.	same as above
3-10-53	11:08A—11:24	16 Mins.	NTSC 3.57 mc	Center Theatre	NBC-RCA Execs	Musical—Singers, Birds, Dancers, Fruit, Flowers, Model
3-12-53	11:20A—11:35	15 Mins.	same as above	Room 608	NBC-RCA Execs	same as above

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
3-13-53	12:30P— 2:30	2 hrs.	NTSC 3.57 mc	Room 608 Looped at Wash.	NBC-RCA Execs	Color Bars, Slides, Burst Freq. Gen.
3-13-53	10:00A—11:10	1 hr. 10 Mins.	same as above	Room 608	NBC Eng.	Slides, Test Pattern, Model, Camera, Ping Pong
3-13-53	3:00P— 3:50	50 Mins.	same as above	Room 608	NBC Eng.	same as above
3-13-53	4:00P— 4:50	50 Mins.	same as above	Room 608	NBC Eng.	same as above
3-16-53	2:00P—12:45	10 hrs. 45 Mins.	same as above	Astoria	Recvr. Group	Slides, Color Bars, Camera, Model, Fruit, Flowers, Wheel
3-17-53	2:00P—12:45	10 hrs. 45 Mins.	same as above	Astoria	Recvr. Group	same as above
3-18-53	2:00P—12:52	10 hrs. 52 Mins.	same as above	Astoria	NTSC Panel 16	same as above
3-19-53	2:00P—12:52	10 hrs. 52 Mins.	same as above	Astoria	NTSC Panel 16	same as above
3-20-53	6:00P—12:42A	6 hrs. 42 Mins.	same as above	Astoria	NTSC Panel 16	same as above
3-21-53	9:00A— 5:00P	8 hrs.	same as above			Variety Program Dancers, Singers
3-23-53	9:30A— 4:00P	6 hrs. 30 Mins.	same as above			same as above
3-24-53	9:30A— 3:00P	5 hrs. 30 Mins.	same as above	Colonial Theatre		same as above
3-25-53	2:12P— 2:28	16 Mins.	same as above	Colonial Theatre		same as above
3-27-53	12:00N— 2:45	2 hrs. 45 Mins.	same as above	Astoria Recr. Lab	NTSC Panel 17	Test signals, slides
4-27-53	1:30P— 2:30	1 hr.	same as above	WPTZ Control Rm		Bell System Microwave for WPTZ. Test signals, slides

5. New York City Closed Circuit Color Field Tests (cont.)

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
5-12-53	12:30P — 2:30	2 hrs.	NTSC 3.57 mc	Camden	NBC—RCA Exec.	Variety Program, Singers, Dancers
5-13-53	12:30P — 2:30	2 hrs.	same as above	Camden and Princeton	same as above	same as above
5-14-53	2:00P — 2:20	20 Mins.	same as above	same as above	same as above	same as above
5-15-53	9:00A— 4:00P	7 hrs.	same as above	same as above	same as above	same as above
6- 1-53	9:00A— 5:00P	8 hrs.	same as above	Center Theatre, Camden	NBC-RCA Exec.	Variety Program, Singers, Dancers, Magician, Ventrilo-quist
6- 2-53	9:00A— 4:00P	7 hrs.	same as above	same as above	Public-Audience Reaction	same as above
6- 3-53	9:00A— 4:00P	7 hrs.	same as above	same as above	same as above	same as above
6- 4-53	9:00A— 5:00P	8 hrs.	same as above	same as above	same as above Also included Bell System microwave to Wash., D. C., and return	same as above
6- 5-53	8:00A— 4:00P	8 hrs.	same as above	same as above	same as above. Also included Bell System cable (L1) to Wash., D. C., and return	same as above

5. New York City Closed Circuit Color Field Tests

Date	*Time*	*Duration*	*Conditions*	*Observed*		*Program Content*
6- 8-53	9:00A— 5:00P	8 hrs.	same as above	Center Theatre, Astoria	Tech. Observation NBC Prog-Prod.	same as above
6- 9-53	9:00A— 5:00P	8 hrs.	same as above	same as above	same as above.	same as above
6-10-53	8:30A— 4:00P	7 hrs. 30 Mins.	same as above	Center Theatre,	NTSC Panel 17 Comparison of Bell System microwave and cable (L1) facilities	Same as above plus technical test signals
6-11-53	8:30A— 4:00P	7 hrs. 30 Mins.	same as above	same as above	RCA Guests	Variety Program, Singers, Dancers, Magician, Ventriloquist
Total		260:31				

APPENDIX B

PROGRAMS FOR COLOR TELEVISION FIELD TESTS

WASHINGTON, D. C.

MAY 26, 1950 — JANUARY 11, 1951

"RAINBOW REVUE"—MAY, 1951—NOVEMBER, 1950

"Rainbow Revue" was an hour long combination variety and educational program. It was emcee'd by Gene Archer, baritone, and Jeanne Warner, soprano. The program was divided into four basic segments with variety and musical acts interspersed. As the show ran five days a week, it meant twenty different informational type segments were provided. Among the segments were a sewing series by the United States Department of Agriculture, a science series by National Bureau of Standards, a cultural series on South America by the Pan American Union, a weather report by the Weather Bureau, interior decorating, cooking, a golf lesson, a Mr. Fixit and other educational features. Daryl Harpa and his Latin American Band provided the music.

"MOHAWK SHOWROOM"

On June 26, 1950, Roberta Quinlan presented her regular network show to the network from the Wardman Park Studios. The program, in addition to Miss Quinlan, consisted of Florian Zabach, violinist, and an old fashioned waltz with Bob Stanton.

"WARNERS CORNERS"

"Warners Corners" was an evening musical show featuring songs by Jeanne Warner and interviews with personalities of the music world.

"CIRCLE 4 ROUNDUP"

"Circle 4 Roundup" was a follow-up of a cowboy movie with Ray Michael as host and Ed MacIntyre as commentator. This was a kid show featuring birthdays, etc.

"DATELINE TOMORROW"

"Dateline Tomorrow" showed the progress of the Korean War — featuring NBC commentator Morgan Beatty.

PROGRAMS FOR NOVEMBER AND DECEMBER, 1950

The last large series of Washington programs — those of November and December, 1950 — was based on a whirling drum built as a carousel. Featured on the show were Jeanne Warner with a food display, Inga Runvold with women's fashions and Betty Bradley with a toy display. Dr. Engstrom made the opening remarks. This show, with the exception of Dr. Engstrom, was repeated in January, 1951.

New York Operations

1951

Special Programs--March, 1951—July, 1951—Studio 3H

The Program Department in New York was formed in March, 1951. The first presentation of a closed circuit color test was April 18th. During April, May and June shows were given approximately once a week. The program material included Jon Gnagy, artist, Karl Kammann, florist, and Kajar, magician. The average length was 15 minutes.

Special Programs—Week of July 9—13, Incl.—15 Shows

The program was as follows: Nanette Fabray introduced the show. Ray Malone then opened with a fast tap number. This was followed by Howdy Doody. An artist's hand drew the setting for Miss Fabray's production number, "My Resistance is Low", sung with Rene Paul. The finale starred Ima Sumac singing "Earthquake" in an Inca setting with a dancing chorus. Following the studio program, a field pickup was shown from Palisades Park in New Jersey. This portion featured Buster Crabbe and his water ballet.

Special Programs—Weeks of September 10—14, Incl., 17—21 Incl.—28 Shows

This program starred Nanette Fabray and opened with Miss Fabray singing "It's a World of Color". This blended into the Cuban number featuring Earle Barton and Dorothy Keller, dancers. Compatibility was integrated in this particular number through a monochrome picture of the male dancer on the girl's desk. At the appropriate time in the music this picture was brought to life in the person of the boy dancer in color. Burton's Birds then made their appearance. The finale featured Nanette Fabray and the chorus in "Texas". Following the studio program a field show was presented from the Merchant Marine Academy in Kingspoint with the crack drill team from the Marine Barracks in Washington, D.C.

Special Programs—Weeks of October 9—13, Incl., 15—19 Incl.

The program for October, 1951, was the same as for September, 1951, with the addition of a Vienneze waltz production with Norwood Smith and Gail Manners and a ballet group. The field pickup for this show series was located at Palisades Park in New Jersey. This remote featured Scotch flag bearers and baton twirlers in native costume.

During the month of December, 1951, a fifteen-minute program was inserted into the hour test segment of 9:00 — 10:00 A.M. This program consisted of Jon Gnagy giving an art lesson in oil painting. The program period was 9:45 — 10:00 A.M.

NEW YORK OPERATIONS

1952

"THE CURTAIN RAISER"

Starting Saturday, January 12, 1952, and continuing through October 11, 1952, a regular Saturday morning 15-minute program was instituted. The first few months Jon Gnagy served as master of ceremonies. Among the features of this series was a section on plentiful foods, a news commentary, songs by Francey Lane and a weekly puppet program.

On May 17th a field pickup was held at Garden World, Bayside, Long Island, from 8:30 to 8:53 A.M. On the program was Joe Phillips and Smokey, the Wonder Horse, songs by Francey Lane and a spring fashion show.

SPECIAL PROGRAMS—JULY, 1952

Three special shows were presented in July, 1952. The program material was as follows: July 9th — Songs by Connie Russell, a hobby segment featuring Norman Brokenshire and a Spanish ballet featuring the Tony Bocchino Dancers. On Friday, July 11th, Ray Malone starred in a musical comedy written for him. The July 15th color test featured a ballet by Gerri Gale, a hobby segment with Norman Brokenshire and songs by Connie Russell.

SPECIAL PROGRAMS—SEPTEMBER, 1952

Eight special programs were presented during the month of September, 1952. On September 16th Dr. Roy K. Marshall lectured on basic color principles. September 19th brought Anita Ellis, soprano, a hobby segment with Norman Brokenshire and a dramatic pantomime featuring Jeffrey Lynn and Patricia Wheel. On September 18th Connie Russell and Jack Cassidy opened with a duet, Norman Brokenshire exhibited a hobby. The show closed with Mara and Her Dancers. On September 19th a musical was presented including Jana Jones, Soprano, Cliff Norton, comedian, and Eleana, Spanish dancer. On September 24th, 25th and 26th the entire program was given to Kukla, Fran & Ollie. On September 30th a short version of the Broadway musical, "Wish You Were Here", was presented with the original Broadway cast.

SPECIAL PROGRAMS—NOVEMBER, 1952

Five special shows were presented in November. On November 13th a musical story was shown based on Ben Grauer's desire to be a gentleman farmer. Included in the cast were Ray Malone, Connie Russell and the Paulette Sisters. A football musical featuring Dick Kallman and Ray Malone was presented on November 14th. Jimmy Jimae, magician, was starred on November 18th. Cliff Norton and a western revue was presented November 19th. A musical revue tracing modern songs was presented on November 25th. Anita Ellis starred in a musical November 26th.

Times for the above shows were 10:00 to 10:15 A.M., with the exception of November 25th and 26th, on which dates the programs went on at 9:45 to 10:00 A.M.

SPECIAL NOTE—OCTOBER, 1952

A closed circuit showing of the Columbia-Pennsylvania football game was held October 18th. A mobile unit equipped with two RCA color television cameras was utilized.

NEW YORK OPERATIONS

1953

1ST QUARTER 1953

During the months of January, February and the first part of March, seventeen shows were presented. These were presented every Tuesday and Thursday from 12:45 to 1:00 P.M. from Studio 3H. The shows alternated between educational features and musicals. Outstanding among the educational shows were two lectures on atomic energy and a program on caves featuring Ivan Sanderson, naturalist.

On February 12th and 17th two scenes from Puccini's "Madama Butterfly" highlighted the musical series.

On March 19th program operations shifted to the Colonial Theater with a return engagement of Kukla, Fran & Ollie.

On March 23rd, 24th and 25th a musical production was presented featuring the Ray Malone Dancers, Mara and Her Dancers and Kukla, Fran & Ollie.

2ND QUARTER 1953

On April 3rd a color test program featured Dolores Gray, Burton's Birds and Mara.

A series of color tests was held on April 9th, 13th, 14th and 16th. This program featured Dolores Gray with the Hit Parade Dancers. Also featured was George Burton and His Love Birds and Kukla, Fran & Ollie.

On May 7th and 8th a Spanish show was presented featuring Vera Barton, Jeff Clark, the Kay-dets and the Paulette Sisters. These two programs were presented after WNBT sign-off. The above show was repeated closed circuit on May 14th.

Another series of tests was held May 18, 19, 21 and 26th. Two basic elements of the April 9th show — the waltz number and the Paris number — were used. The star was Nanette Fabray. Also on this program were Burton's Birds and Jay Marshall. These were on-the-air shows.

Beginning June 1st and running through June 11th, Monday thru Friday, only — the above show was repeated with Clifford Guest appearing instead of Burton's Birds.

APPENDIX C

THE NBC NEW YORK COLOR TELEVISION FIELD TEST STUDIO*

BY

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Summary—Studio 3H in Radio City New York has been converted for use as a color television studio. The studio was used in field testing the RCA color television system. At a later date the installation was modified, and field tests using NTSC standards were conducted. Equipment and operation of the studio are described.

INTRODUCTION

After a period of nearly two years of intensive operational experience in field testing the RCA Color Television system in the Washington studio installation, it was decided to continue the activity in the NBC studios in New York. For this purpose, apparatus for a complete studio was jointly planned by engineers of RCA and NBC. The equipment was developed and built by the RCA Victor Division. The specifications for the apparatus were based upon experience from the Washington field testing and upon plans which envisaged expansion to include additional studio setups for enlarged scope of operation.

PLANNING

At the outset it was recognized that full advantage should be taken of the experience gained over the years in monochrome television operation. At the same time, however, the fundamental layout and design had to be such that it would promote the development of those new program and operating techniques which would be needed with the addition to television of the very important dimension of color. The design, therefore, was intended to be sufficiently rigid to permit a daily routine of program schedules while being flexible enough to facilitate any circuit or basic system modifications which might become advisable. A versatile design of this type would provide the advantages of facilities permitting regular daily use, but still being capable of easy changes for experimental purposes.

Figure 1 shows the basic block diagram of the color television system. It will be seen that the plan does not vary widely in its fundamentals from that used in present day monochrome plants. Chief differences lie in the switching system, where three channels are switched simultaneously for each camera, and in the multiplexer which accepts the three outputs of the switching system and combines them to form a single composite color output signal with subcarrier.

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* Published in *RCA Review*, Vol. XIII, pp. 107-124 (March, 1952).

It was thought that the greatest efficiency would be achieved by subdividing the over-all design into a number of separate, functional units. Each unit would then be assigned its relative degree of importance and position in the over-all plan and design, and would be built in accordance with it.

Selection of Studio

For a number of reasons it was desirable to locate the color studio in Radio City in New York where it would be conveniently accessible to development laboratories, program production facilities, and executive offices. Studio 3H in Radio City was selected for the conversion to color television. Designed in 1933 as a radio broadcast studio, it measures 50 feet in length, 30 feet in width, and 18 feet in height. The control booth is located at one end of the studio at a level slightly above the studio level. The installation of monochrome television equipment in 1935[1] required so much additional space that a separate video control booth was constructed on the fourth floor over the original audio booth. 3H was selected as the first Radio City color television studio because, having been previously used for monochrome television, it was equipped with many of the services that would be required for color operations. In addition to this there was some space adjacent to the fourth floor booth which could easily be converted to an equipment room. Previous use of the studio for monochrome television had required the installation of supplementary air conditioning and power supply facilities. Some additional revisions in these services were necessary with the conversion to color on account of the additional equipment installed.

Lighting

Overhead power distribution for lighting in the studio was provided by installation of five ducts running lengthwise, with outlets on three-foot centers. The individual fixtures are suspended from an overhead pipe grid, either by means of adjustable pantographs or by fixed-length rods. An ample number of power receptacles are also provided along the walls to accommodate any lighting fixtures of the portable floor-stand type which might be required to achieve low-angle lighting effects. Each lighting circuit is equipped with circuit breaker control, and additional master breakers are available for controlling lights in groups. Dimmer control is provided for maximum potential flexibility in lighting control and to determine the value of dimmer controls in color television operation. The lighting power feeders are separate from technical equipment power feeders in accordance with usual television studio design practice. The total lighting power available to the studio is in excess of 100 kilowatts and is supplied to the studio over a direct four-wire three-phase system. Thus far, the lighting levels for color television have been somewhat higher than those generally used with monochrome operation.

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[1] R. E. Shelby and R. M. Morris, "Television Studio Design," *RCA Review*, Vol. II, p. 14, July, 1937.

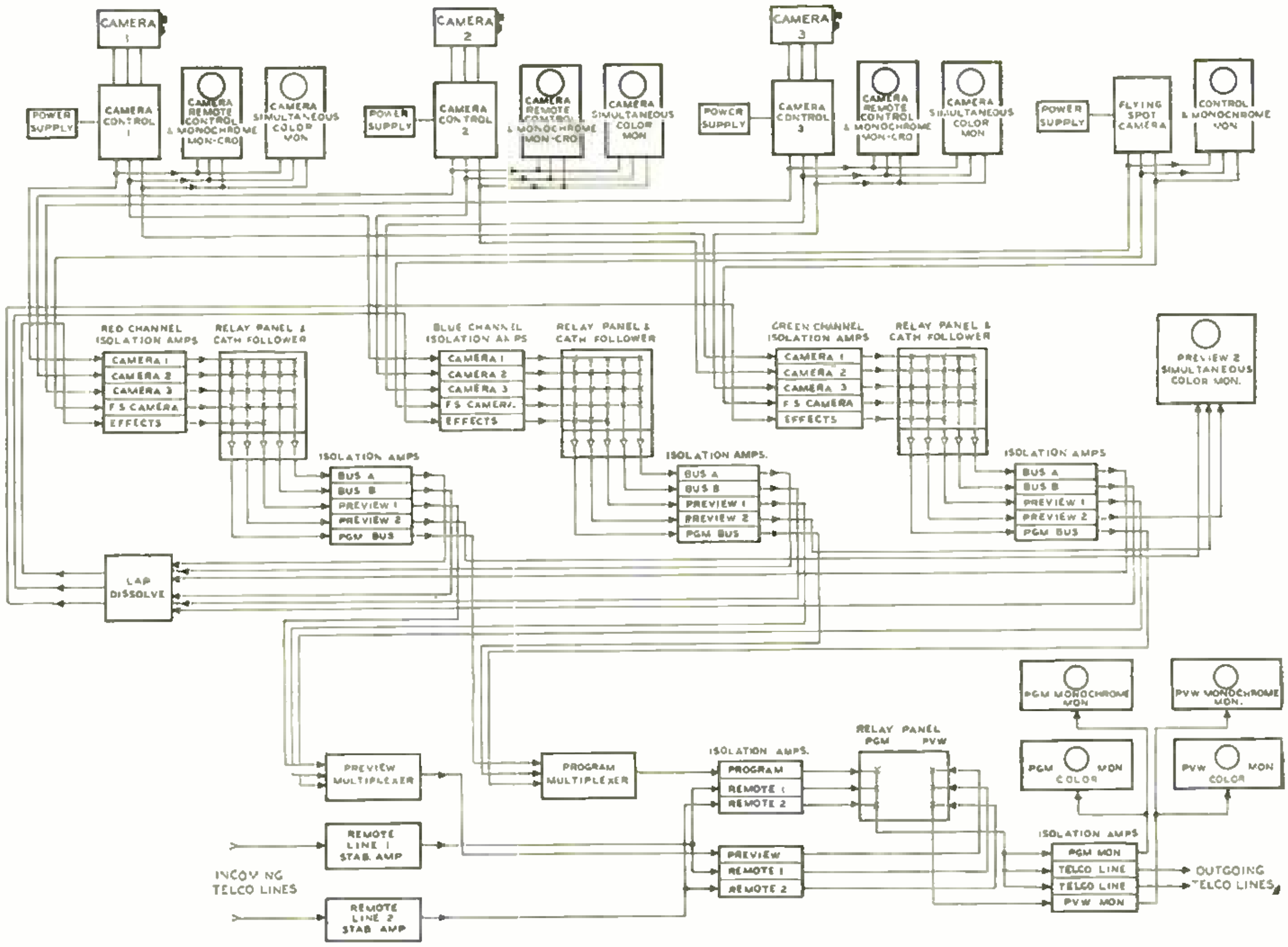

Fig. 1—Block diagram of switching system.

Experiments in color television lighting have proven that production sets with the same degree of complexity as those utilized in monochrome television can be satisfactorily handled. Figure 2 indicates the lighting plan utilized on a color production set. At present, incandescent lamps are used for lighting in this studio during all field test transmissions. Standard voltage, long-life bulbs are used and are operated at approximately 2900 degrees Kelvin. The fixtures are conventional units and are used interchangeably with the monochrome studios in Radio City.

Air Conditioning

The air conditioning system supplies the studio with 5500 cubic feet per minute of conditioned air cooled to 55 degrees Fahrenheit. This is sufficient to maintain an ambient temperature of 78 degrees Fahrenheit within the studio with all equipment operating and with 45 kilowatts of light in use. This amount of power is more than adequate to produce proper lighting levels for two average stage sets.

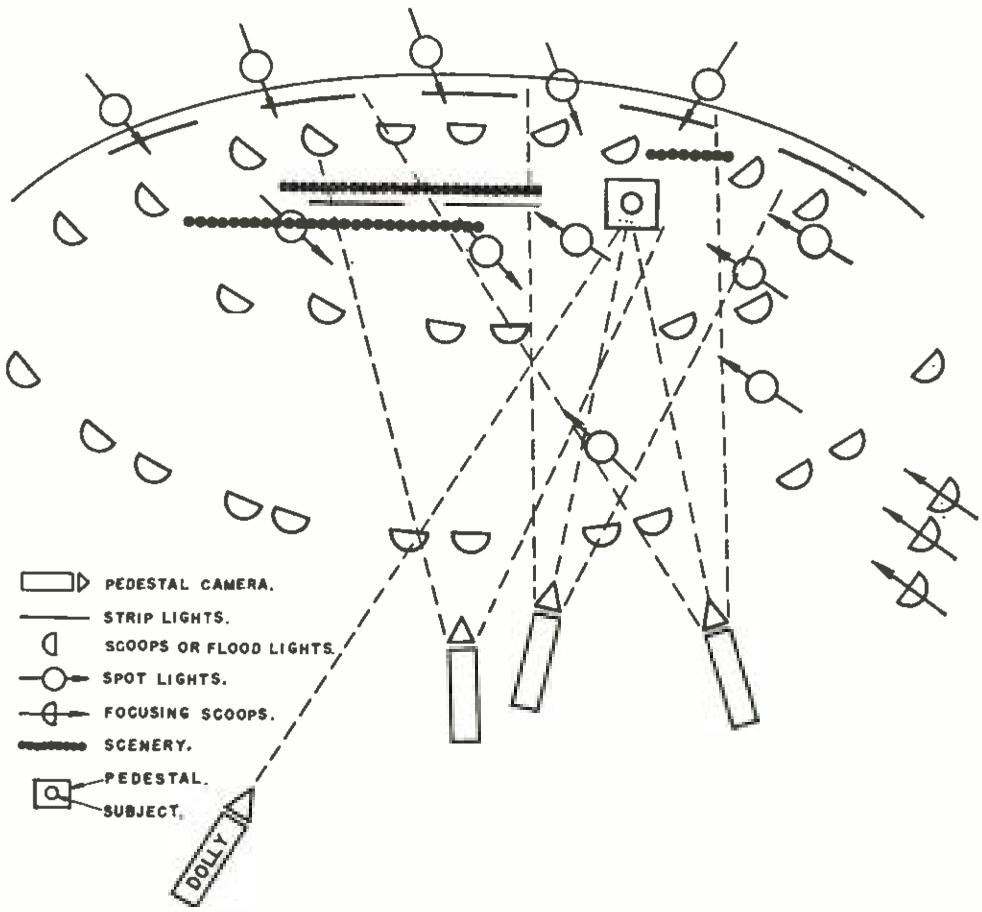

Fig. 2—Diagram of set lighting plan.

Camera Equipment

The design of the video system provided for 3 studio cameras for live pickup and one flying spot scanner for transparencies. Thus far only two of the studio cameras have been installed. The cameras are equipped with electronic viewfinders (monochrome), lens turrets, and the standard-type intercommunication system. A detailed account of the color camera design is given in an accompanying paper.[2] Following the general concept of monochrome operations, one of the studio cameras is mounted on a conventional crane-type dolly and the other on a standard studio pedestal. The transmission of film programs in color has been accomplished by the use of the rear projection screen method employing a studio camera focused on the projected image on a translucent screen.

Intercommunication System

The studio is equipped with the standard-type intercommunication system used in all of the newer NBC television installations. With this system the technical director and the program director are able to talk to studio personnel during the rehearsal by means of loud-speakers. During periods of program trans-

[2] J. D. Spradlin, "The RCA Color Television Camera Chain," *RCA Review*, Vol. XIII, p. 11, March, 1952.

mission, communication with floor personnel is by means of headphones and small "pocket ear"[3] radio receivers.

Control Booth

The control booth is divided into two separate units according to function — an audio booth and a video booth.

Audio Booth

Figure 3 is a third-floor plan of the studio and the audio control booth. The audio control booth is equipped with a studio-type console containing an eight-position split mixer with the conventional echo chamber, monitoring, and outgoing line controls. It is also provided with complete jack field facilities to permit patching of 16 microphone inputs, turntables, remote lines, and all component equipments associated with the console system. Microphone preamplifiers

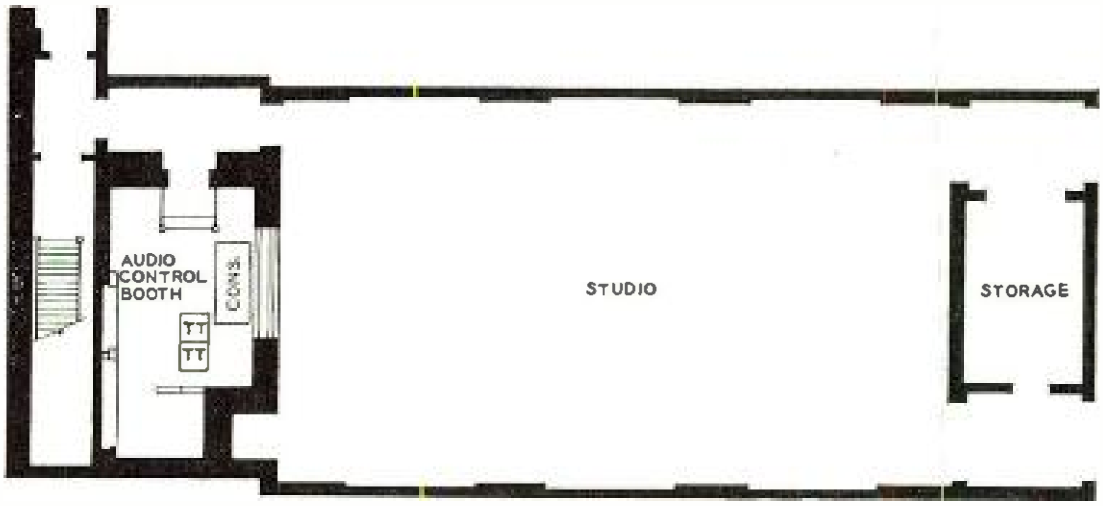

Fig. 3—Third floor plan of studio and audio booth.

and monitoring amplifiers for studio and control booth speakers are a part of the control booth assembly. Program and preview video monitors are provided so that the audio control engineer may more closely follow camera action in the studio. Intercommunication is provided with the video booth and microphone boom operator.

Video Booth

The over-all circuit plan of the video booth follows rather closely the general plan of a typical monochrome booth. However, since the color operation is not at present an integral part of the monochrome operation in Radio City, the video booth contains much additional equipment, such as complete patching and

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[3] J. L. Hathaway and W. Hotine, "The Pocket Ear," *RCA Review*, Vol. VIII, p. 139, March, 1947.

processing facilities for all incoming and outgoing video lines as well as control and patching facilities for all house monitoring and other miscellaneous video circuits. Figure 4 is the fourth-floor plan of the studio showing the video booth, equipment room, and space for future equipment expansion. This arrangement provides a complete unit of color television operations and functions as a full-scale working model from which information and experience will be gained for guidance in the future planning of multistudio color television plants.

Physically, the video control booth is basically a two-level design and is rectangular in shape measuring 18 feet in width and 30 feet in length. The equipment is arranged according to function in five basic groups: monitors, technical and program directors' console, video control console, flying spot scanner, and rack-mounted camera control units with associated patching and distribution facilities.

Generally it has been the accepted practice in video control booth design to locate camera controls and switching equipment in operating consoles so that the program director, technical director, and video engineer have unobstructed views of the studio from their normal operating positions. Ordinarily this condition is achieved by arranging the control booth so that the equipment is in

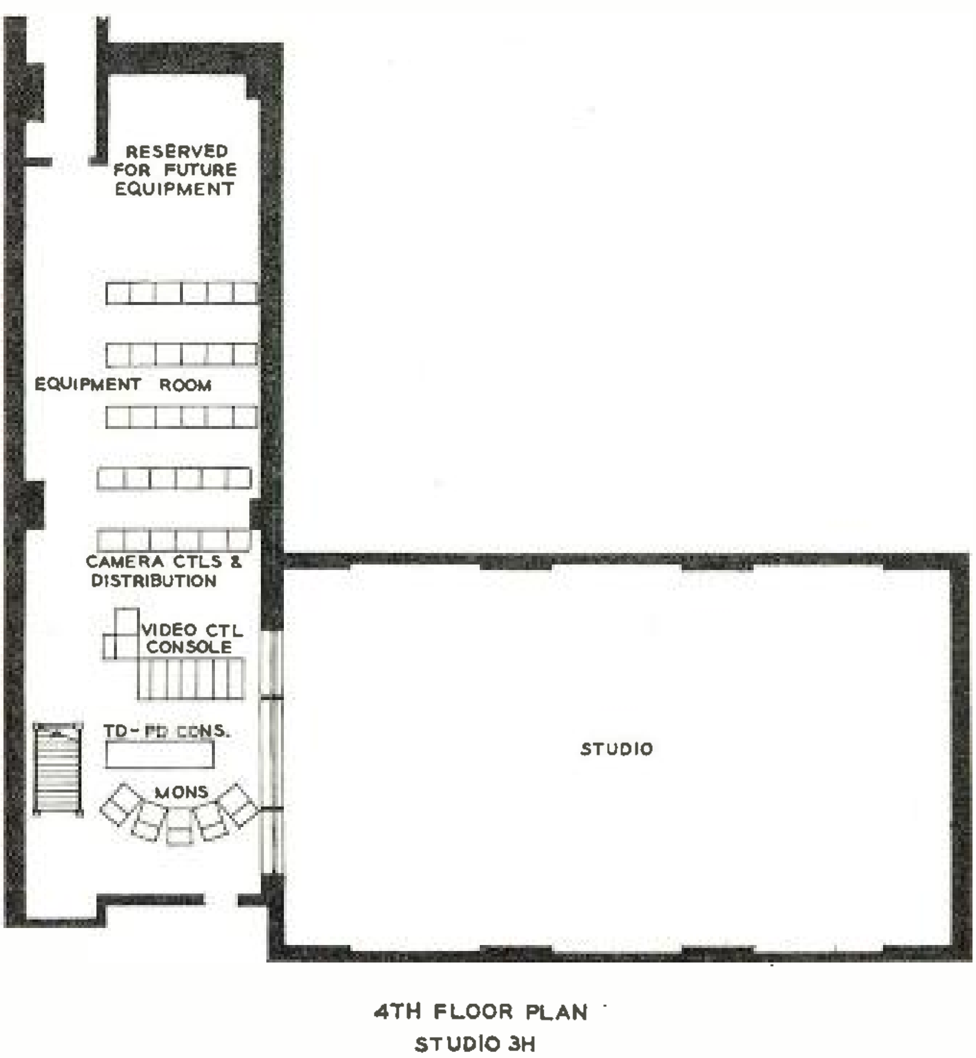

Fig. 4—Fourth floor plan of studio, video booth, and equipment room.

stepped rows parallel to the control booth window. For the design of the color video control booth it was decided to deviate from this practice by rotating the equipment plan of the booth 90 degrees, still retaining an unobstructed view of the studio with the distinct advantage of always viewing monitors against a dark background. Figures 5, 6, 7, and 8 are views showing the arrangement of control booth equipment. The major equipment groups are:

First: A total of 6 monitors, including 2 simultaneous color camera monitors plus a spare rack position for the third camera monitor, 2 three-gun kinescope color monitors for program and preview, and 2 monochrome monitors also for program and preview.

Second: Program and technical directors' console.

Third: Video engineer's console with individual camera control auxiliaries.

Fourth: Rack-type camera control units with associated jack fields for circuit patching and distribution.

Fifth: Flying spot scanner and switchable simultaneous color monitor.

The control booth floor level was raised at the point of the video control console to permit viewing of the color monitors from the video control position. This arrangement has proved satisfactory.

The normal camera switching and picture processing controls, such as lap dissolve, are located on the technical director's console. (Lap dissolve has been found to be feasible and desirable with this system of color television.)

The physical arrangement of the studio color camera chain differs from the conventional monochrome chain in that two console sections and one equipment

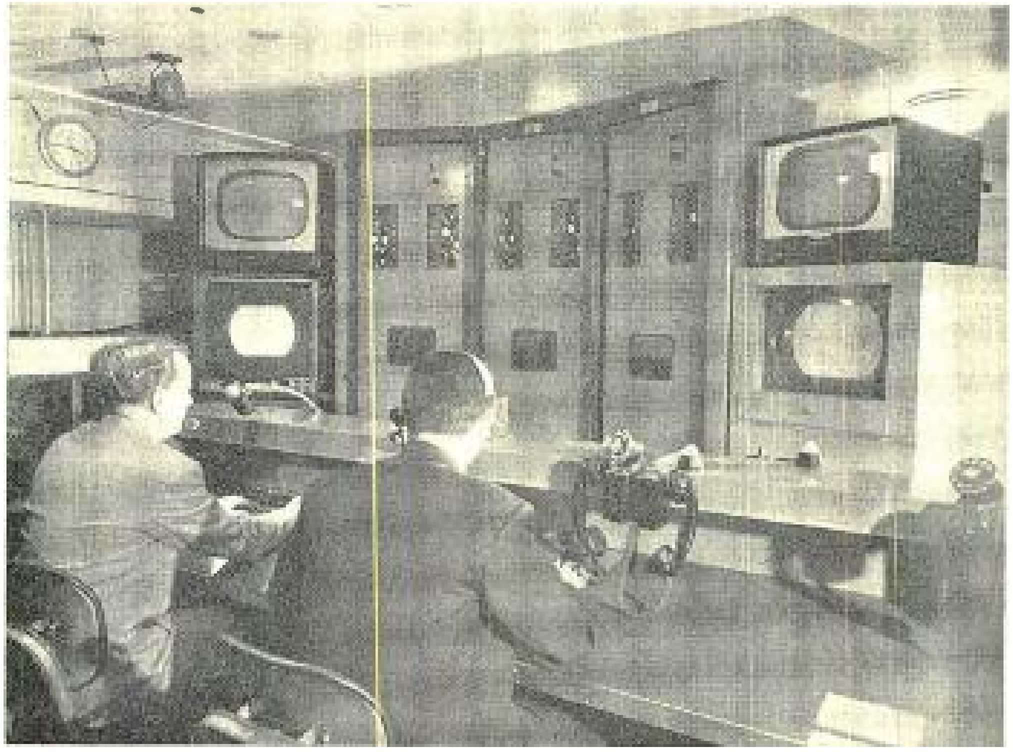

Fig. 5—Photograph of arrangement of monitors with technical and program directors' console.

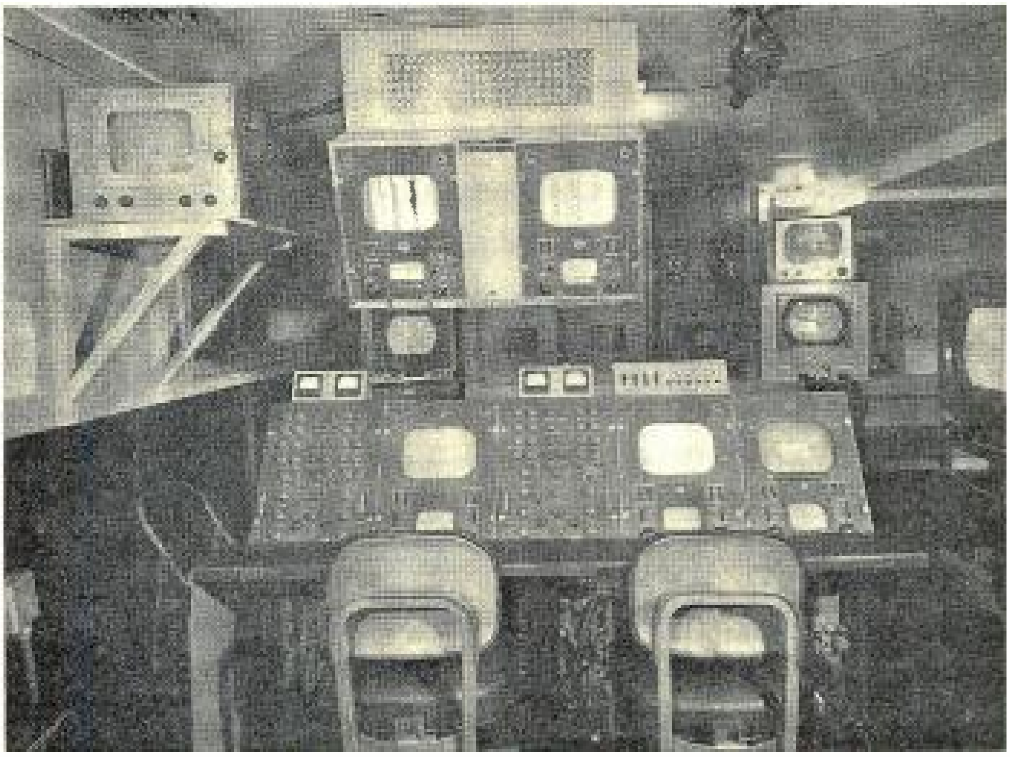

Fig. 6—Photograph of video control console.

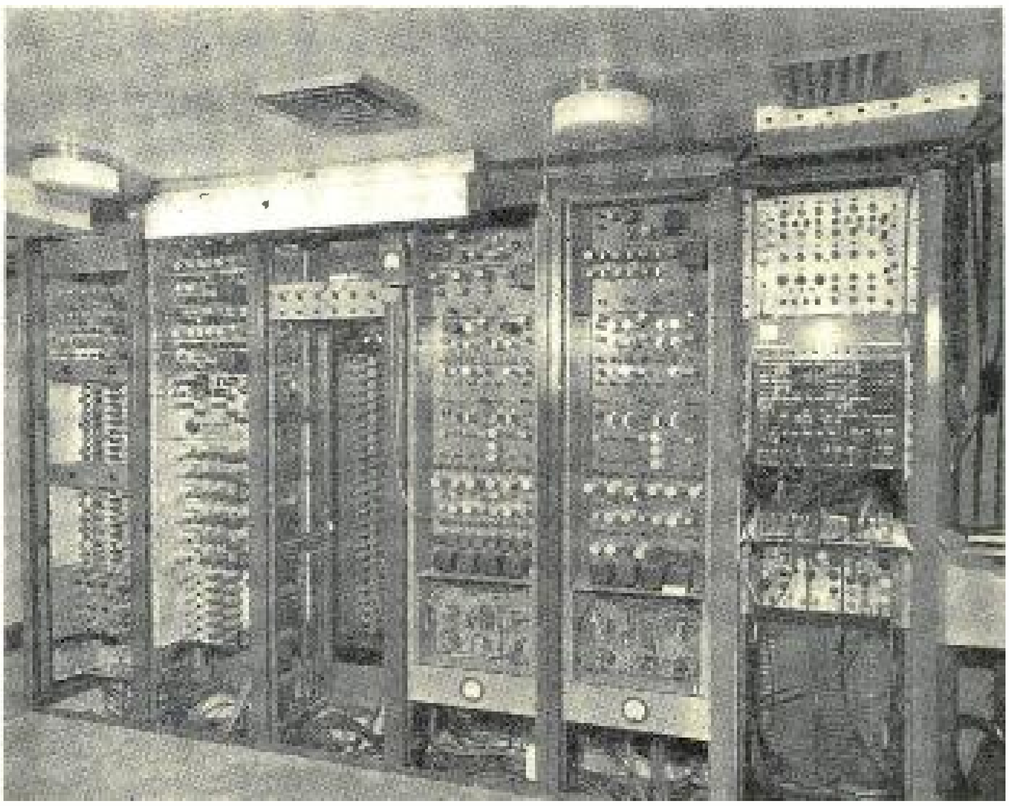

Fig. 7—Photograph of rack mounted camera control units and circuit patching rack.

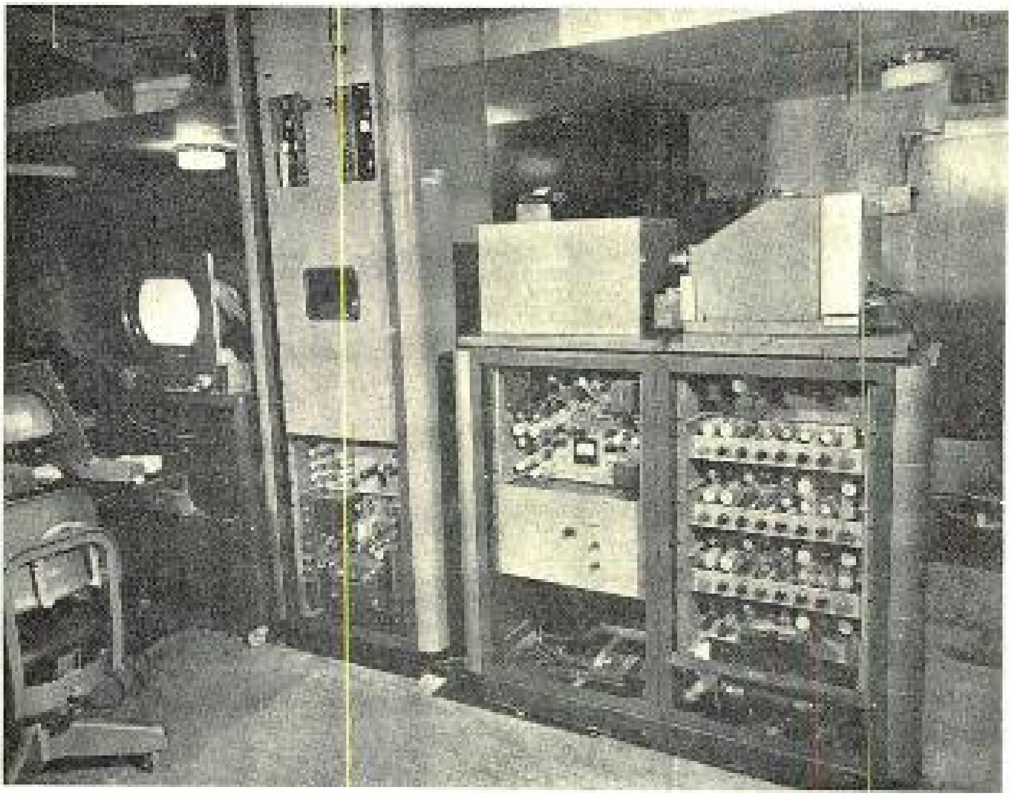

Fig. 8—Photograph of flying spot camera and switchable simultaneous monitor.

rack in addition to the power supply racks are required for each camera. The first console section contains all the normal controls for each of the three color channels (red, green and blue) and the second a TM-5A monochrome monitor with cathode-ray oscilloscope which is provided with suitable switching so that signal amplitudes of the color channels may be displayed individually or in groups as determined by the video engineer. The basic camera control unit comprises several rack-type equipments mounted on a standard rack. The major portion of the controls on the rack units do not require adjustment during normal operations. However, those controls, such as pedestal and gain, which do require operational adjustments have been extended to the video engineer's console.

Equipment Room

This portion of the studio was constructed in accordance with the over-all plan for a centralized equipment room and is located adjacent to the video control booth as shown in Figure 4. Physically, the equipment room is an extension of the video control booth; however, its function is entirely separate. In the 3H installation these two functions were combined in one space to permit further study on centralized equipment room design in anticipation of large multi-studio-type color television plants. The equipment room contains equipment such as synchronizing generators, distribution amplifiers, stabilizing amplifiers, power supplies, switching panels and all of the so-called fixed-adjustment-type equipment. It was planned that the 3H color studio installation would simulate a large color plant, with studios displaced considerable distances from the central equipment room. This condition may be achieved for experimental studies by the insertion of extra lengths of cable, thus increasing the electrical separation of the video control booth from the equipment room.

Switching System

The plan of the camera switching system is on a tri-color basis, that is red, green, and blue channels are distributed individually from the cameras to isolation amplifiers, thence through three standard monochrome relay switching panels, and are combined after processing in the multiplexer. Video signals from remote sources such as mobile field unit or network connection are inserted in the switching system at a point following the multiplexing function. The block diagram of Figure 1 shows the switching system and indicates in skeleton form the circuits and components for a complete 4-camera switching system with monitoring, lap dissolve, and facilities for incoming remote and outgoing telephone lines. Monitoring of the individual camera chain is accomplished by means of the three-tube simultaneous-type monitor. Monitoring in all other parts of the video circuit is by means of the RCA three-gun color kinescope units.[4]

Operations

The operation of a color television studio encompasses all of the routines normally included in the operation of a monochrome studio plus a few which are peculiar to the color television studio. These latter routines are those associated with the colorimetry of the system and with the multiplexing of the additional information.

The cameras in Studio 3H use the optical beam splitting system described in an accompanying paper.[5] In so far as the optical system is concerned, there are few routine operational requirements beyond keeping the camera optical system clean and protected, since the coating on the dichroic mirrors, the color temperature of the studio lighting, the spectral response of the image orthicons and the response of the phosphors in the tri-color kinescope are all integrated into the over-all colorimetry of the system, and all are assumed to remain constant under normal conditions. Gelatin filters used to supplement the dichroic mirrors in providing the spectral transmission characteristics of the three color channels of the camera must be renewed periodically.

Image orthicons vary somewhat in absolute sensitivity (microamperes per lumen from the photocathode) and in the amount of light input required to reach the knee of the light input versus electric output characteristic. Some means of equalizing these sensitivity and saturation point variations must be

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[4] H. B. Law, "A Three-Gun Shadow-Mask Color Kinescope," *Proc. I.R.E.*, Vol. 39, p. 1186, October, 1951.

[5] G. L. Allee, E. Kornstein, D. J. Parker and L. T. Sachtleben, "Image Orthicon Color Television Camera Optical System," *RCA Review*, Vol. XIII, p. 27, March, 1952.

provided. This requirement is made more positive by the fact that light transmission through the three optical paths to the image orthicons is not equal. The equalization is accomplished by the use of neutral density gelatin filters placed in the optical paths to the individual image orthicons. Those channels which reach saturation at lower light levels are attenuated until all three channels reach the knees of their respective characteristics simultaneously. Operationally, this is adjusted by televising a step wedge pattern illuminated with a standard light level. The resultant signals from the three color channels are viewed simultaneously on a cathode-ray oscilloscope, while an iris in the common optical path is alternately stopped down and opened up sufficiently to cause all image orthicons to operate above and below the knee of their respective characteristics. Neutral density gelatin filters are inserted in the individual optical paths as required until the best adjustment for tracking at the knee is obtained. The optical iris, the studio illumination, and the electrical outputs from the camera must be in an operational relationship after the insertion of the neutral density gelatin filters. That is, there must be a reasonable margin available for control settings, and light levels must be within permissible limits.

Image orthicons must be matched somewhat more critically for color television than for monochrome operation. The spurious signal (shading) output of each image orthicon must be within limits that will permit nearly complete cancellation by the shading correction circuits provided in the equipment. The requirements just described, namely the matching of image orthicons for shading and sensitivity characteristics, comprise two of the four duties which must be performed by the video control operator with more exactness in alignment than is normally exercised in monochrome operations.

The third task, while not unknown to monochrome operation, assumes a high degree of importance in the color operation and must be carried out with exactness. This is the adjustment of the transfer characteristic or "gamma" correction circuits. These correction circuits, as described in reference (1), are incorporated in each camera control unit and must be adjusted accurately against the prescribed correction. The care with which transfer characteristic correction adjustments are made will have an important bearing on the ability to match camera outputs with respect to color fidelity.

The adjustment of gamma correction is accomplished by driving the correction unit with a step wedge test voltage repeated at line frequency. This step wedge test signal is derived from a step wedge signal generator, an electronic device which produces a step voltage having increments that vary exponentially with time, as indicated in Figure 9. The exponential envelope curve for the step wedge generator is selected in consideration of several factors, including the transfer characteristics of the tri-color kinescope, the image orthicon, and other elements of the system, and it is assumed that the desired over-all characteristic for the system is linear for normal scenes. The following paragraph illustrates the method currently utilized in selecting the proper envelope curve for the step wedge generator for adjusting the transfer characteristic correction circuits.

Assume that the tri-color kinescope has a transfer characteristic which approximates a second-power exponential curve, thus requiring a one-half-power exponential curve for correction. Further assume that the transfer characteristic of the image orthicon is best represented by a 0.7-power exponential curve. If C is the power of the exponential curve or transfer characteristic required to linearize the over-all system, then

$$0.7 \times C = 0.5,$$

$$C = \frac{0.5}{0.7} \approx 0.7.$$

This relation states that an additional correction of 0.7 is required to linearize a system where the assumptions of 0.7 and 2.0 have been made for the image orthicon and the tri-color kinescope transfer characteristics respectively. Taken by itself, the correction circuits adjusted to provide a transfer characteristic represented by a 0.7-power exponential curve will linearize a transfer characteristic represented by a 1/0.7-power exponential curve, or a transfer characteristic represented by a 1.4-power exponential curve. Hence, the power of the exponential curve selected from the step wedge generator should be 1.4 and the correction circuits should be adjusted to linearize the steps (Figure 10) as viewed on a cathode-ray oscilloscope connected to the output of the correction circuits.

Use of the test voltage of Figure 9 and the adjustment of the correction unit to provide the output of Figure 10 would linearize a system with a transfer characteristic represented by a second-power exponential curve.

The fourth adjustment which requires greater attention than its monochrome counterpart is the setting up of registration in the cameras. The adjust-

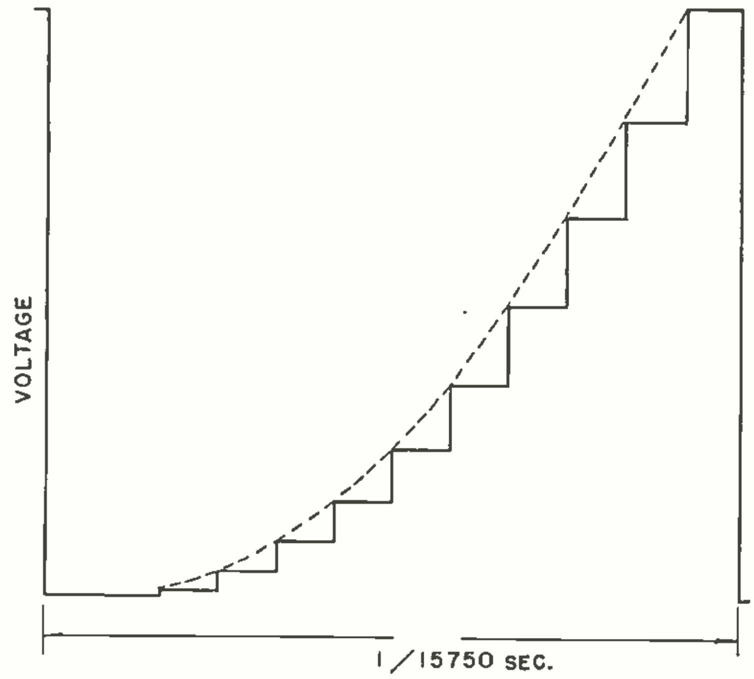


Fig. 9—Second-power exponential step wedge test voltage.

ment is a refinement of the distribution check normally made in monochrome cameras. Rough registration is automatic inasmuch as the three camera scanning yokes are driven from a common source. Precise registration is obtained by adjustment of the width, height, centering, and skew controls on the individual channels. Operationally, this is accomplished by televising a pattern of lines creating approximately 1-inch squares across an 18 × 24-inch area. The cameraman sets the above-mentioned controls while the video control engineer views the result on a monochrome monitor that permits viewing of individual channel outputs or any combination of the three channel outputs.

There are also the previously mentioned operating adjustments which have no parallel in monochrome operation. One such operation is the setting of a proper color temperature on the color monitors. One way to accomplish this is by the use of a photometer comprising a photocell meter unit with provision for inserting gelatin filters over the photocell. Relative readings of the meter with the three filters (red, blue, and green) in place (one at a time) are estab-

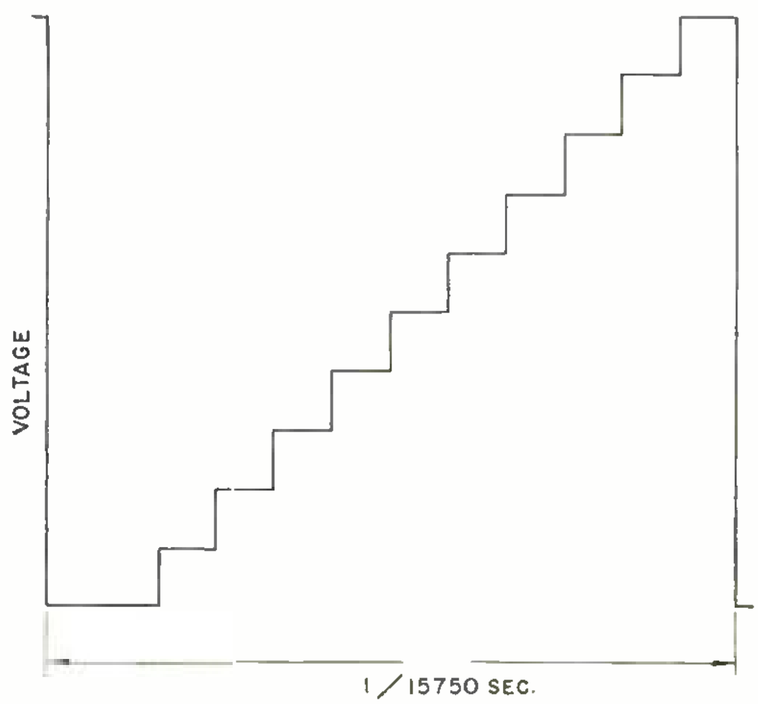


Fig. 10—Linearized step wedge test voltage after passing through the transfer characteristic correction circuits.

lished by taking readings against the white of a color monitor when that white has been set to match a standard approximately illuminant C* (6800° K). Once the three relative readings are established for the photometer, it is possible to set the backgrounds of all monitors alike.

Another operation having no counterpart in monochrome operation is the adjustment of the multiplexer. This unit can be adjusted to a standard with

* This refers to the National Television System Committee Color Field Test Specification which requires that the color signal be so proportioned that when the color subcarrier vanishes, the chromaticity reproduced corresponds to I.C.I. system of specifications illuminant C ($x = 0.310$, $y = 0.316$).

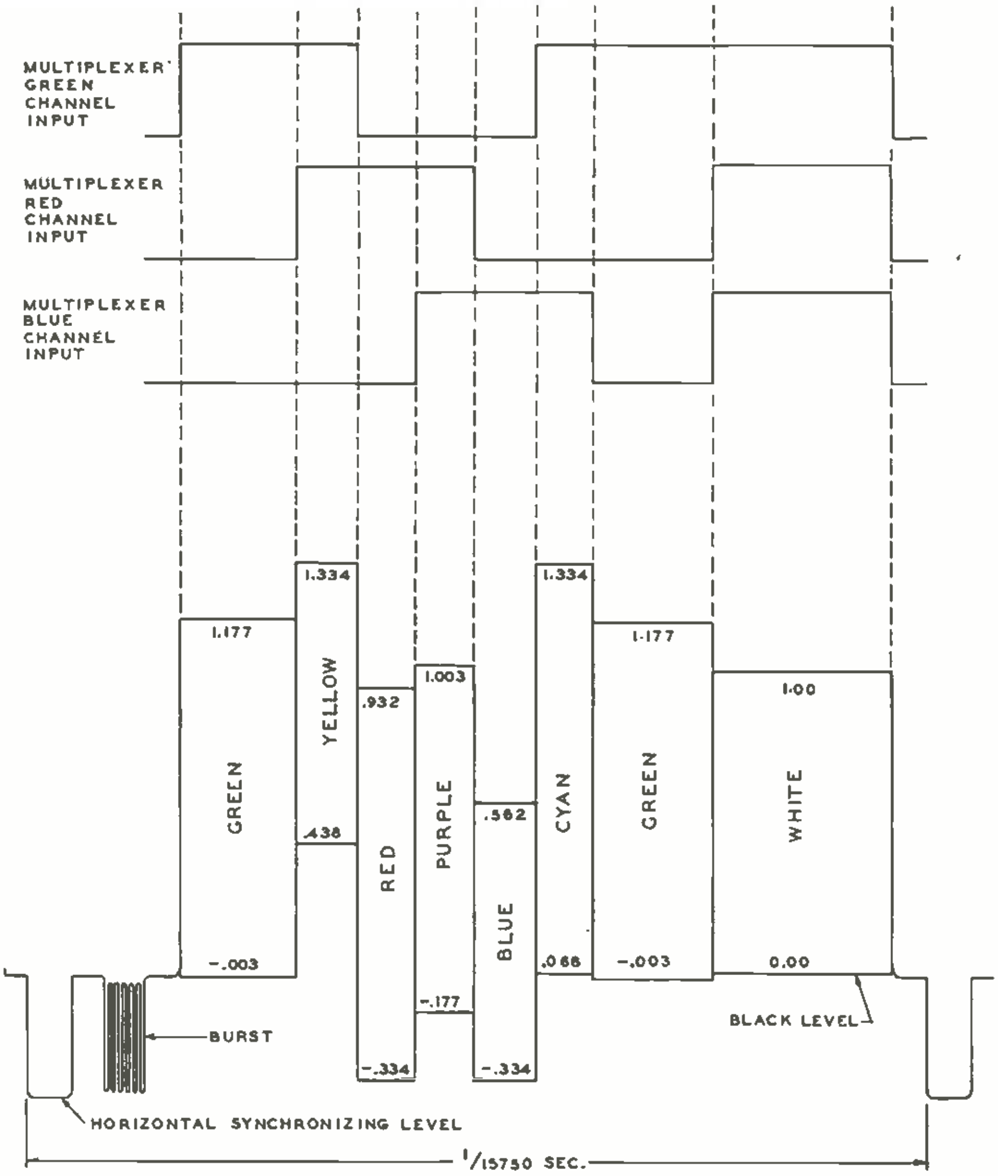


Fig. 11—(A) Inputs to the multiplexer from the synthetic color bar generator (above) and (B) resultant output signal from multiplexer (below).

exactness by the use of a synthetic signal—one that is relatively free of the residual imperfections found in the output of even the best camera. It is therefore a reference in the over-all system, and other components of the system should not be misadjusted to compensate for maladjustment or deficiencies of the multiplexer. The synthetic signal source employed in the present operations is a color bar test signal generator which produces the test signal shown in Figure 11A. With the signal from this generator, the multiplexer can be set with exactness by making prescribed inputs to the multiplexer deliver a calculated pattern as viewed on a cathode-ray oscilloscope connected to the output. In Studio 3H, the synthetic color bar generator delivers equal signals to each of the three inputs of the multiplexer. The time sequence of the signals applied to the three inputs of the multiplexer is as indicated in Figure 11A. The resultant signal on the output of the multiplexer when adjusted to the National Television System Committee (NTSC) field test standards[6] is as indicated in Figure 11B.

FIELD-TEST OPERATION

This studio and associated facilities have been in continual use since April, 1951 for purposes of the development of operating, lighting, and programming techniques, as well as over-all systems development and testing of the RCA color television system.

Many hours of field test transmissions have been made. Three sets of showings during the course of these field tests were presented during the months of July, September and October for the press, public and other interested groups. Each of these consisted of three showings a day for periods of one, two and three weeks, and included in addition to the studio portion, a short act from a remote point in the vicinity of New York. The remote pickup was accomplished by the use of a mobile unit which carried a duplicate of the studio cameras previously mentioned, working in conjunction with standard monochrome portable-type power supplies and sync generator. The signal was transmitted to the studio by means of standard 7000-megacycle link equipment.

These presentations were broadcast in New York on channel 4 (KE2XJV) from the Empire State Building whenever that transmitter was available for color experimental operation. Other points to which the color signals were fed during part or all of the periods mentioned included a viewing room adjacent to the studio, the Johnny Victor and Center Theatres in Radio City, and the Colonial Theatre on Broadway at 63rd Street, where the picture was viewed on a theatre-size screen by means of RCA color television projection equipment. The signals also were transmitted to the NBC studios in Washington, D. C., over both 2.7-megacycle coaxial cable and regular microwave facilities of the American Telephone and Telegraph Company, and portions of the field tests were also broadcast in Washington through the NBC experimental station KG2XDE, operating on channel 4.

Early in November, the studio and remote facilities were modified to operate in accordance with the Field Test Standards adopted by the National Television System Committee.[6] These modifications involved a change in the subcarrier frequency from 3.58 to 3.89 megacycles, and a change from symmetrical equal amplitude multiplexing to asymmetrical multiplexing. Field test transmissions using the NTSC signals were broadcast 5 days per week throughout the month of December and on a varying schedule during January and February. The field testing of the RCA color television system using the NTSC signal standards will continue.

ACKNOWLEDGMENTS

It is not feasible to indicate separately the contributions of the many individuals in the RCA and NBC organizations who have been active in the Color Television Systems Development project. The authors are pleased to present, in their behalf, this account of a portion of the project.

[6] "Specifications for Color Field Test," *Electronics*, Vol. 25, p. 126, January, 1952.

APPENDIX D

A REPORT OF REACTIONS OF TELEVISION SET OWNERS TO THE RECEPTION IN BLACK AND WHITE OF RCA EXPERIMENTAL COLOR BROADCASTS

PREPARED FOR

RADIO CORPORATION OF AMERICA

August, 1951

BY

ELMO ROPER

FOREWORD AND DISCUSSION

For five successive days, beginning Monday, July 9, the Radio Corporation of America conducted experimental field tests of its color television system in the New York area. The purpose was to test the quality of the pictures that would appear on black-and-white sets receiving programs televised by its color system.

For this purpose a program of the "variety" type was prepared and broadcast in color for five successive mornings. Advertisements were inserted in newspapers in the New York metropolitan area, inviting the public to watch these programs and to write in their reactions on how the pictures received compared with the black-and-white pictures normally received from the National Broadcasting Company's regular black-and-white television programs.

A total of 11,369 mail responses was received from people who reported watching one or more of the programs. It is important to keep in mind the fact that these respondents may not be a cross section of television set owners in the New York metropolitan area, nor even a true sample of viewers of these experimental color programs. It is estimated by NBC that 300,000 people saw at least one of the test programs. Therefore the total of respondents approximates four per cent of the estimated total audience—certainly a *large enough* sample—but these respondents may be atypical, or not a representative cross section of the people who viewed the test programs. On the other hand, they might well be; we have no way of knowing.

All but one per cent of the respondents included in their answers (as the company requested) a comparison of their reception of the experimental color programs in black-and-white with their reception of regular black-and-white programs. Eighteen per cent felt that they received the test programs even better than regular programs; 76% reported that the test program reception was just as good as that of regular programs, and 5% thought reception was not as good.

The high percentage who felt that they received the test programs at least as well as they received regular programs indicates that the color system used in this test is satisfactory insofar as its ability to please most owners of unadapted black-and-white sets is concerned. This is heightened by the fact that nearly one out of five respondents reported even better pictures than they usually got in black-and-white. Although most of the respondents in the latter group merely said that reception was better than usual without going into detail, those who were most explicit gave three main reasons for their favorable appraisal: the pictures were clearer and sharper, the pictures were less glaring and easier on the eyes and, there was more shading—a greater number of tones from white to black.

Five per cent of the respondents felt that the RCA electronic system needed further improvement to bring it up to equal performance with regular black-and-white television. These people gave reasons for their judgment which directly contradicted those mentioned in the previous paragraph. An answer which summed up the complaints was this one: "picture less clear than normal—slightly blurred—not sharp enough—more contrast needed." Most of the people in this small group, however, felt that the reception of the test programs was *almost* as good as the regular black-and-white programs. Their answers were in the nature of "very good but. . . ." Moreover, some of the criticisms given seem to indicate that the fault may not have been due solely to the color system. For example, some respondents mentioned "snow," "wavy interference lines," "unsteadiness," and "out of focus."

In order to determine what factors, if any, might affect the reception of color broadcasts on existing sets, the comparisons of the test program reception with regular program reception are analyzed on the following pages by:

a. The day on which the respondent saw the experimental program. Since we are interested in the reactions of individuals, the analysis is based on the number of respondents. Each respondent was counted only once even though he may have seen more than one program. Those respondents who reported seeing more than one program were included in the audience of the last day on which they watched, under the theory that last impressions were the best remembered and would either confirm the earlier opinions or, if changed, were the final ones. What we are interested in in this analysis is not how the program was received on one day as compared to another day, but how the test program was received as compared to reception of regular programs.

b. The television service contour. "A" and "B" in table 2 refer to television station WNBT's A and B service contours* around the transmitting station in New York City. Respondents under the column headed "Other" live in "fringe areas" beyond service contour B.

c. The age of the set on which the program was seen. A respondent was counted only once even if he watched on more than one set. Here, again, what we are interested in is not how the program was received on one set as compared to a second set, but how reception of the test program compared with reception of regular programs on the same set. For the few respondents who reported on more than one set, analysis was based on the newest set.

* Mapped by the NBC Engineering Department in accordance with FCC definitions.

d. The size of the television screen. "Small" includes all sizes up through 12½ inches; "medium" includes screens from 14 to 17 inches, and all larger screen sizes are included under "large."

e. The type of antenna. "Outdoor" refers to the so-called "roof" antenna. Built-in, indoor and window antennae are included in the column headed "Not outdoor."

A breakdown of the responses seems to indicate a slightly higher proportion of "better than regular black-and-white programs" reports among respondents who watched the experimental programs on Thursday and Friday than among respondents who watched on other days of the week. NBC engineers reported that to the best of their knowledge television broadcasting conditions were the same for all five days of the test. The slight percentage differences, therefore, may be due to some differences in the groups themselves.

A slightly lower than average percentage of respondents who live in "fringe areas" thought that their reception of the test color program was better than their reception of regular black-and-white programs. Apparently, however, the age of the set, screen size and type of antenna had no effect on the comparative quality of reception.

Whatever might be said about the limitations of this study, it seems clear to us that on the point of the ability of black-and-white set owners to receive RCA's color broadcasts in black-and-white to their satisfaction, RCA's color television system has received a strong vote of approval from those people who took the trouble to write in their reactions.

COMPARISON OF RECEPTION OF EXPERIMENTAL COLOR PROGRAMS WITH RECEPTION OF REGULAR BLACK-AND-WHITE PROGRAMS

	Total sample	Respondents Who Saw Experimental Broadcasts on: Mon.	Tues.	Wed.	Thurs.	Fri.
Number of Respondents	11369 (100%)	3606 (100%)	2696 (100%)	1688 (100%)	1292 (100%)	2087 (100%)
	%	%	%	%	%	%
Better than Regular Black-and-White Programs	18	15	17	20	22	22
Just as Good; the Same as Regular Black-and-White Programs ...	76	79	77	73	73	74
Not as Good as Regular Black-and-White Programs	5	5	6	6	5	4
Incomplete Answers ..	1	1	–	1	–	–

	Total sample	Respondents Who Live Within Television Service Contour: A	B	Other
Number of respondents	11369 (100%)	9917 (100%)	1090 (100%)	346 (100%)
	%	%	%	%
Better than regular Black-and-White Programs	18	18	17	14
Just as Good; the Same as Regular Black-and-White Programs	76	76	78	80
Not as Good as Regular Black-and-White Programs	5	5	5	5
Incomplete Answers	1	1	–	1

	Total sample	Respondents Who Bought Their Television Sets In: 1951	1950	1949	1948	1947 or earlier	Unknown or no answer
Number of Respondents	11369 (100%)	1313 (100%)	2768 (100%)	1240 (100%)	713 (100%)	277 (100%)	5058 (100%)
	%	%	%	%	%	%	%
Better than Regular Black-and-White Programs	18	19	18	19	16	17	18
Just as Good; the Same as Regular Black-and-White Programs	76	73	75	76	78	80	77
Not as Good as Regular Black-and-White Programs	5	7	7	5	6	3	4
Incomplete Answers	1	1	—	—	—	—	1

	Total sample	Respondents Whose Television Sets Have Screens That Are: Small	Medium	Large	Unknown or no answer
Number of respondents	11369 (100%)	3114 (100%)	3866 (100%)	830 (100%)	3559 (100%)
	%	%	%	%	%
Better Than Regular Black-and-White Programs	18	19	18	17	18
Just as Good; the Same as Regular Black-and-White Programs	76	76	75	76	77
Not as Good as Regular Black-and-White Programs	5	5	6	7	4
Incomplete Answers	1	—	1	—	1

	Total Sample	Respondents Whose Antenna Is: Outdoor	Not Outdoor	Unknown or no Answer
Number of respondents	11369 (100%)	3889 (100%)	1266 (100%)	6214 (100%)
	%	%	%	%
Better than Regular Black-and-White Programs	18	18	20	18
Just as Good; the Same as Regular Black-and-White Programs ..	76	75	74	77
Not as Good as Regular Black-and-White Programs	5	7	6	4
Incomplete Answers	1	—	—	1

Volunteered Comments

	Total Sample
Number of respondents	11369 (100%)
	%
Subject of respondents' comments:	
Compatibility	3
Electronic and/or mechanical systems	1
RCA and/or CBS systems	4
FCC	2
Difference between indoor and outdoor portions of experimental program	2
Interesting comments on experimental program	1
Requests for additional attention	1
Made no comment	88

Note: Percentages add to more than 100% because some respondents made more than one comment.

Sample Comments

Respondents who reported experimental color test reception was *better* than regular black-and-white broadcasts

"The picture quality is noticeably superior to the regular telecast. There seems to be a wider range of gray shades."

"I find that color television gives a clearer picture. The face is clearer, the hair looks better, the pattern of the cloth and the scenery is plainer, the people taking part in different acts are more natural."

"Even in black and white the scenes seem to be of more substance than regular broadcasting. The pictures have more depth."

"The picture is clearer with better shading and no glare."

"The picture came in clearer than the black and white and yet was much softer with a greater variety of shadings."

"These broadcasts came over clearer in black and white than the ordinary broadcasts. Perhaps color helps to define the lines more clearly."

"The color black-and-white appears much clearer (not so blurry) and the definition is outstanding. Your background seems so much sharper."

"Television in black and white never appeared as beautiful as when RCA televised its programs in color. We were able to see more shadings between black and white—the deeper as well as the lighter tone color shadings were visible and the over-all picture was much more restful and pleasing to the eye."

Respondents who reported experimental color test reception was *not as good as* regular black-and-white broadcasts

"The program was fairly good but not quite as good as the black-and-white pictures we usually get."

"It would have been as good as regular if it were not for some shimmering and unsteadiness that caused minor distortions."

"The reception was almost as good as black-and-white shows."

"It was less clear than normally. Pictures slightly blurred, not sharp enough, more contrast needed."

"They were very good but not as sharp as the regular."

"Had a coarser grain with some snowy effects, particularly in indoor shots."

Facts About Respondents

	Total sample
Number of respondents	11369 (100%)
	%
Day broadcast seen	
Monday	32
Tuesday	24
Wednesday	15
Thursday	11
Friday	18
Television service contours	
A	87
B	10
Other	3
Unknown or no answer	*
Year set purchased	
1951	12
1950	24
1949	11
1948	6
1947 or earlier	3
Unknown or no answer	44
Screen size	
Small	28
Medium	34
Large	7
Unknown or no answer	31
Type of antenna	
Outdoor	34
Not outdoor	11
Unknown or no answer	55

* Less than 1 per cent

APPENDIX E

A SURVEY OF AUDIENCE REACTION TO RCA COLOR TELEVISION

CONDUCTED IN NEW YORK CITY

October 9-13 and 15-19, 1951

FOR

RADIO CORPORATION OF AMERICA

BY

OPINION RESEARCH CORPORATION

Princeton, New Jersey

January, 1952

TABLE OF CONTENTS

FOREWORD

This report presents the findings of a survey conducted during field tests of the RCA color television system which were made October 9 - 13 and 15 - 19, 1951. The purpose of the survey was to obtain public reaction to RCA color television. Results are based on questionnaires from 2,898 persons.

The survey was conducted in the Lounge of the Center Theatre, West 49th Street and Avenue of the Americas, New York City. Persons participating in the survey were selected by an objective method from those who requested tickets as a result of an announcement appearing in New York newspapers October 3, 1951.

Visitors to the Center Theatre Lounge filled out their own questionnaires after instructions from a representative of Opinion Research Corporation.

The same program was presented three times a day (10:00 A.M., 2:15 P.M., 4:00 P.M.) on each of the ten days during which the survey was conducted. Total duration of the program was approximately 26 minutes. A musical variety ("It's a World of Color") took up about 22½ minutes. The remaining time (about three and one-half minutes) was devoted to a remote pick-up from an NBC mobile unit which covered the performance of a Scottish band in Palisades Park, New Jersey. The morning programs were broadcast over Station WNBT. Afternoon programs were transmitted over a closed circuit to a transmitter located in the Center Theatre building.

Survey procedures are described in detail in this report. A copy of the questionnaire is appended (Attachment 6).

PART I

SURVEY PROCEDURES

1. PUBLIC ANNOUNCEMENT

A full-page advertisement appeared in the following New York newspapers on the morning of Wednesday, October 3, 1951: *Times, Herald Tribune, Daily News* and *Daily Mirror*. (For a reproduction, see Attachment 1.)

This advertisement announced the color field tests and invited the public to request tickets by means of a coupon. Space was provided for the indication of first choice as to time and first, second and third choices as to date. The coupon also contained the following question to be checked "yes" or "no":

> "Are you, or is anyone in your immediate family, connected in any way with the manufacture, sale, servicing or broadcasting of radio or television?"

2. PROCESSING OF TICKET REQUESTS

Requests were received and processed in a room in the RCA Building by a clerical staff furnished by an independent organization not connected with RCA, NBC, or Opinion Research Corporation. This staff worked under the supervision of representatives of Opinion Research Corporation.

Requests for tickets were date-stamped as they were received. In all, about 7300 such requests were sent in, a large majority of which asked for two or more tickets.

Because of possible biasing influences, requests from the following categories were kept separate and were not honored:

> Persons indicating a connection with the radio or television industries.
>
> Those stating they were RCA stockholders.
>
> Those requesting large blocks of tickets.

Other requests (about 6300) were sorted into thirty boxes (one for each showing) according to time and date preferences. Opinion Research Corporation representatives selected by a random method the requests to be honored from each box.

Enclosed with the tickets was a printed message reading as follows:

> "In response to your request, we are happy to send you the enclosed tickets of admission to an experimental RCA color television program in the Lounge of the Center Theatre, West 49th Street and Avenue of the Americas.
>
> "The programs start promptly on schedule. For that reason, it is necessary that you be in the lobby of the Center Theatre at least 15 minutes before the time indicated on your tickets. No one will be admitted after the program starts.
>
> "We are grateful for your interest in RCA's color television and look forward to getting your reaction to our field test programs.
>
> "RADIO CORPORATION OF AMERICA
> 30 Rockefeller Plaza
> New York 20, N. Y."

3. The Viewing Situation

The Lounge of the Center Theatre contains six "booths." A detailed diagram of the Lounge is attached (Attachment 2).

Four of these booths (Booths 1, 2, 3 and 4) are identical in size, shape and seating arrangements. Each of these contains four rows of five seats, the second, third and fourth rows being higher than the preceding row. Booth 5, the capacity of which is about 26, has a level floor. Booth 6 has 28 seats arranged in four rows which are on a slope.

The television receivers in each booth were on platforms eighteen inches high. Except in Booth 5, the receivers remained at the same elevation throughout the tests. Because of the level floor in Booth 5, it was decided to elevate the receiver in that booth an additional foot so that persons in the rear rows would have a better view of the screen. This was done for the 2:15 P. M. show on October 15. The receiver remained in this position throughout the remainder of the tests. In the Detailed Tables results are shown separately for viewers who witnessed the tests in Booth 5 before and after the set was raised.

4. Remarks by NBC Representative

Immediately prior to the beginning of each show, a representative of NBC read the following script to the audience in the Center Theatre Lounge:

"Ladies and Gentlemen: On behalf of the National Broadcasting Company, it is a pleasure to welcome you here today to view one of the Radio Corporation of America's color television field tests in the New York area.

"These programs originate in the NBC studios just across the street in the RCA Building. The morning program is a regular broadcast — by that I mean that the signal goes from the NBC studio to the antenna on top of the Empire State Building. From there the signal is put out on the air waves and then picked up by antennas on this building and fed to the experimental receivers in this room. Here on these receivers the signal will be received as a color television picture, but on regular black-and-white receivers like you have in your homes, it is received as a standard black-and-white picture.

"We are only permitted to broadcast the morning program because we are operating on an experimental license which only permits experimental broadcasts outside regular broadcast hours.

"The afternoon programs originate like the morning programs, in the NBC studio, but since these programs are *transmitted only* to the Center Theatre, they cannot be received on television sets outside the Theatre. The signal is transmitted from the studio over a closed circuit to a miniature television transmitter located in this building. These radio signals, equivalent in characteristic to those which would have been radiated by WNBT, will be received in this room.

"On the stage in front of you is an experimental RCA color set which will receive these color signals. These receivers house RCA tricolor picture tubes.

"We will greatly appreciate it if after the show is over you will remain in your seats for a few minutes as we would like to have a word with you at that time.

"And now, sit back, relax and enjoy the show."

At the conclusion of each showing, the NBC representative in the Center Theatre Lounge introduced a member of the staff of Opinion Research Corporation, as follows:

"It is my pleasure to present to you at this time Mr. .... of the Opinion Research Corporation in Princeton, New Jersey, who would like to get your reaction to this color television test. . . . Mr. ...."

5. Remarks by Opinion Research Corporation Representative

An Opinion Research Corporation staff member then gave these instructions to the audience at each showing:

"Thank you.

"Ladies and gentlemen, Opinion Research Corporation has been asked by RCA to conduct a survey of public reaction to the color television test you have just seen.

"A brief questionnaire will be handed you on which we would like you to express your frank opinions. It will take only a few minutes to complete this questionnaire, and we shall be very grateful for your cooperation.

"On most of the questions, you indicate your answer by placing an "X" in the *one* box that comes closest to your opinion. Be sure to check just *one* box for each question. On a few questions, we ask you to write in your comments in your own words.

"When you have finished, please check over your questionnaire, making sure you have answered the questions on both sides of the sheet. Then please turn in your questionnaire, writing board and pencil to the attendant at your booth. The attendants will give the questionnaires to us, and we shall tabulate the results in our offices in Princeton, New Jersey.

"We want to assure you that your name will not be used in any way. Again, we would like to thank you for giving us your opinions.

"(We are pleased to have several members of the press with us at this showing. But since this is a survey of public reaction, we request you press representatives *not* to fill out questionnaires.)

"Thank you."

6. The Balloting

An NBC page was assigned to each booth to serve as usher and to distribute and collect questionnaires, writing boards and pencils. Immediately after the completion of the balloting at each showing, the pages turned over the completed questionnaires to an Opinion Research Corporation representative. At the end of each day, completed questionnaires were brought directly to Princeton, New Jersey.

At least two representatives of Opinion Research Corporation were present at each showing. Pages and other RCA and NBC personnel were instructed to refer to members of the survey organization any questions from the audience dealing with the survey and the questionnaire.

7. Receiver Monitoring

Each receiver was monitored by an engineer, who submitted a brief report (sample form attached as Attachment 3) on receiver performance for each showing. A majority of these reports show that reception was normal. A total of

477 persons, however, viewed the program on receivers which the monitor reports described as being other than normal in one or more respects. Reports covering 48 of these 477 viewers stated only that the audio was too loud. In many other cases the reports indicated that irregularities were of only momentary duration. In the Detailed Tables, the attitudes of these 477 viewers are shown separately.

8. The Receivers (Description Supplied by RCA)

The receivers used during the tests were RCA color television receivers Model C616. These were designed to receive both the RCA color television signals and standard monochrome signals. Each receiver was housed in a cabinet having the following over-all dimensions: height, 40½ inches; width, 26¾ inches; and depth, 26 inches. Each receiver was equipped with the 16-inch RCA tricolor kinescope. The receivers had one additional operating control as compared with the number of controls found on most conventional monochrome receivers. This control, called a chroma control, served to vary the color saturation of the picture.

9. The Program

The entire program, which was the same throughout the test, lasted about 26 minutes. "It's a World of Color", a musical variety, ran about 22½ minutes. A brief synopsis of this part (studio) of the program follows:

Introduction by announcer, accompanied by parade of nine models
Song: "It's a World of Color"
Song and fast-tempo dance: "Weekend of a Private Secretary"
(About one minute of this number was transmitted in black-and-white.)
Singing and dancing: Viennese waltz
Acrobatic birds: A series of tricks by small birds involving considerable high-speed wing movement
Singing and dancing: "Texas"
Closing

The remaining part of the program (about three and one-half minutes) showed the performance of a Scottish band with three baton twirlers in Palisades Amusement Park, Palisades, New Jersey, through a remote pick-up from an NBC mobile television unit.

10. Characteristics of the Audience

This report is based on ballot returns from a total of 2,898 persons who attended. It will be recalled that tickets were sent only to those whose requests stated that they and their immediate family members were not connected with the radio or television industries (Part I, 2). But, as a means of identifying any persons connected with the radio and television industries who might be present at the tests, the following question was also included in the questionnaire:

"Are you, or is anyone in your immediate family, connected in any way with the manufacture, sale, servicing, or broadcasting of radio or television?"

Of the 2,898 persons taking part in the survey, 122 answered this question in the affirmative. For purposes of tabulation and analysis, two classifications were established:

Audience (nonindustry): The 2,776 persons whose questionnaires had a negative answer to the question quoted above (2,681) or no answer (95).

Audience (industry-connected): The 122 who answered this question in the affirmative.

The table below gives the characteristics of these two "audiences":

	Audience (Nonindustry)		Audience (Industry-Connected)
	Number	Per Cent	Number
Total	2,776	100%	122
Sex:			
Men	1,548	56%	90
Women	1,212	44	31
Not reported	16	*	1
Age:			
Under 20 years	184	7%	14
20 — 29	320	11	23
30 — 39	569	20	38
40 or over	1,632	59	43
Not reported	71	3	4
Education:			
Incomplete grammar school	40	1%	1
Completed grammar school	230	8	8
Incomplete high school	402	15	15
Completed high school	789	29	30
Incomplete college	400	14	30
Completed college	353	13	15
Postgraduate college	226	8	9
Not reported	336	12	14
Previous Television Exposure:			
Own a TV set	1,947	70%	93
Do not own a set but had seen TV in preceding month	533	19	23
All others	296	11	6

* Less than ½%.

The following table gives audience distribution according to home location:

	Audience (Nonindustry) Number	Per Cent	Audience (Industry-Connected) Number
Total	2,776	100%	122
New York City	1,964	71%	87
Other New York State	273	10	8
Alabama	1	*	
California	18	1	
Connecticut	38	2	1
Delaware	2	*	
Florida	7	*	
Georgia	1	*	
Illinois	7	*	1
Indiana	1	*	
Kansas	2	*	
Louisiana	3	*	
Maine	1	*	
Maryland	7	*	
Massachusetts	28	1	
Michigan	3	*	
Minnesota	3	*	
Missouri	5	*	1
Montana	1	*	
New Hampshire	1	*	
New Jersey	273	10	8
Ohio	7	*	
Oklahoma	1	*	
Oregon	2	*	
Pennsylvania	38	2	2
Rhode Island	8	*	
South Carolina	1	*	
Tennessee	1	*	1
Texas	4	*	
Vermont	2	*	
Virginia	6	*	
Washington, D. C.	3	*	1
West Virginia	1	*	
Wisconsin	6	*	1
Canada	5	*	4
Other (Australia, Denmark, England, Mexico, Scotland, Spain, Sweden, Switzerland)	9	1	2
Not classified or not reported	43	2	5

* Less than ½%.

PART II

Findings in Brief

The findings reported in this section are based on the 2,776 cases making up the nonindustry audience.

1. A Sizable Majority (93%) of the Audience Said Color Television Is More Enjoyable Than Regular Black and White.

"Which do you think is *more enjoyable* — color or regular black and white television that you have seen before today?"

		References to Detailed Tables
Color much more enjoyable	76%	
Color somewht more enjoyable	17	
Both about the same	2	
Black and white somewhat more enjoyable	1	A-1
Black and white much more enjoyable	1	
Have never seen black and white	2	
No answer	1	

Note: On this question, 142 (5%) of the questionnaires from the nonindustry audience had more than one answer marked. Questionnaires on which "have never seen black and white television" and any other answer were checked are included only in "have never seen black and white." All other combinations of multiple answers are classified according to the answer marked that is least favorable to color television.

2. And a Large Part of the Audience Were Favorably Impressed With the Over-all Quality of the Color Television Pictures They Saw.

"How do you feel about the *over-all quality of the color television pictures* you have seen?"

Excellent	39%	
Very good	38	
Good	17	A-2
Only fair	4	
Poor	*	
Multiple answer or no answer	2	

Note: On all check-box questions except the first, not more than 1% (usually less) marked more than one answer. In this and the following tables, such cases are classified under "multiple answer" and are combined with "no answer."

3. Better Than Five People in Ten (56%) Considered the Pictures About Right in Regard to Brightness.

"How would you rate the *brightness* of the color pictures?"

Much too bright	7%

* Less than ½%.

A little too bright	33	
Just about right	56	A-3
A little too dim	3	
Much too dim	*	
Multiple answer or no answer	1	

4. Favorable Opinion on Clearness of Detail Was Widespread.

"How would you rate the *clearness of detail* in the color television pictures?"

Excellent	40%	
Very good	36	
Good	19	A-4
Only fair	4	
Poor	*	
Multiple answer or no answer	1	

5. There Was Considerable Approval of the Trueness-to-Life of the Colors.

"How would you rate the *trueness-to-life of the colors* in the pictures you saw?"

Excellent	31%	
Very good	33	
Good	24	A-5
Only fair	8	
Poor	1	
Multiple answer or no answer	3	

6. Almost Three-Fourths Said There Was a Wide Variety in the Colors.

"What is your opinion about the *variety of colors* you saw?"

There was a limited variety	11%	
A wide variety	74	A-6
Somewhere in between	13	
Multiple answer or no answer	2	

7. A Major Part of the Audience Evinced Approval of the Quality of Pictures in Scenes With Considerable Action.

"How would you rate the quality of pictures in the scenes with a *lot of action?*"

Excellent	35%	
Very good	35	
Good	22	A-7
Only fair	6	
Poor	*	
Multiple answer or no answer	2	

* Less than ½%.

8. Somewhat More Than One-Third (37%) of the Audience Thought There Were Any Defects in the Pictures.

Most of these persons, however, felt that these interfered only a little with their enjoyment of the pictures.

"Were there any defects, or anything wrong, in the color television pictures you saw, which interfered with your enjoyment of them?"

"How much did these defects interfere with your enjoyment of the pictures?"

Of the 37% who said there were defects — A-8

2% said these defects interfered a great deal with their enjoyment of the pictures

11% said they interfered somewhat with their enjoyment A-9

21% said they interfered a little

3% didn't express an opinion or gave multiple answers

No single point received outstanding mention from these 37%.

But the most frequent comments made dealt with:

Colors not being true to life (7%)
Running of color (6%)
Blurred picture (6%) A-10
Complaints about the program (5%)
Colors being too vivid (5%)

9. In Response to an Open Question Asking for Any Other Comments About the Color Television Pictures —

31% gave only favorable comments
14% gave only unfavorable comments A-11
4% gave both favorable and unfavorable comments
6% gave other comments
45% gave no comments

Among those who gave only favorable comments, the type of remark made most often (by 12%) was to this effect: A-12

Color TV is wonderful.

Among those who made only unfavorable comments, the most frequent criticisms were that:

The program content was poor (4%)
The colors were too vivid (3%) A-13
The colors weren't true to life (2%)

10. The Detailed Tables That Follow Do Not Show Wide Differences According to Personal Characteristics of the Audience.

Where differences of more than a few percentage points occur, the following broad generalizations can be made:

Previous Television Exposure: Television set owners are somewhat less favorable than are people who had seen a television program in the month preceding the demonstrations but who do not own a set.

Sex: Women are somewhat more favorable than men.

Age: Persons forty years of age or over are somewhat more favorable than are those in younger age groups.

On the whole, however, such differences as do occur among various audience subgroups are not large. Therefore, the total figures reported in this section not only reflect the opinions of the audience taken collectively but also provide a good general indication of the opinions of component groups.

PART III

DETAILED TABLES

The tables in this section present the detailed findings of the survey. The order of the tables is the same as that in which the questions appear on the survey questionnaire.

Persons taking part in the survey have been divided into two broad classifications as to whether or not their questionnaires indicated a connection with the radio or television industries (Part I, 10).

Each question has been tabulated in detail for the nonindustry audience (2,776 of the 2,898 persons taking part) according to personal characteristics and according to factors directly connected with the survey situation, as follows:

PERSONAL CHARACTERISTICS

Previous television exposure: television set owners; those who do not own a set but who saw a television program in the month preceding the tests; all others

Sex

Age

SURVEY FACTORS

Date attended

Booth attended (For a discussion of the raising of the set in Booth #5, see Part I, 3.)

Show attended

Receiver performance: Under "reception normal" are included all viewers covered by engineer monitor reports which showed no irregularity in receiver performance. Under "reception irregular" are shown those covered by reports which indicated irregular receiver performance in any respect (including audio) of even momentary duration. (See Part I, 7.)

Whether or not the program had been seen previously in black and white (See Table A-14).

Sixteen persons did not indicate their sex; these cases are included in the nonindustry audience totals but not in the sex subgroups.

Tables read across where per cent signs appear in the left-hand columns; otherwise they read down.

Some persons marked more than one answer on most questions with check-box answers. Except for the first question, such cases come to 1% or less and are classified under "multiple answer."

On the first question (Table A-1), however, two or more answers were marked by 142 members (5%) of the nonindustry audience and by 9 members (7%) of the industry-connected audience. In this instance, multiple-answer questionnaires are included in answer categories as follows:

"Have never seen black and white": all multiple answer cases involving this and any other answer.

Other combinations of multiple answers are classified according to the answer marked that is least favorable to color television.

On tables giving results to comment questions, some percentages add to more than 100 on the totals shown because of multiple answers.

Question 1: *A-1*

WHICH DO YOU THINK IS *MORE ENJOYABLE*—COLOR OR REGULAR BLACK AND WHITE TELEVISION THAT YOU HAVE SEEN BEFORE TODAY?

	Total	Color Much More Enjoyable than Black and White	Color Somewhat More Enjoyable	Both About the Same	Black and White Somewhat More Enjoyable	Black and White Much More Enjoyable	Have Never Seen Black and White	No Answer
AUDIENCE (nonindustry)	2776	76%	17	2	1	1	2	1
TV owners	1947	75%	18	2	2	1	2	*
Nonowners, viewers	533	81%	14	2	1	1	1	*
All others	296	76%	13	3	1	1	4	2
Men	1548	76%	17	2	2	1	2	*
Women	1212	76%	16	3	1	1	2	1
Under 20 years	184	84%	12	2	1	1	*	0
20-29 years	320	72%	23	1	2	*	1	1
30-39 years	569	76%	19	3	1	1	*	*
40 years or over	1632	76%	16	2	2	1	3	*
Not reported	71	58%	20	3	0	7	5	7
October 9	239	76%	18	3	1	1	1	0
October 10	272	73%	20	2	3	*	2	*
October 11	256	71%	21	1	2	2	3	*
October 12 (Columbus Day)	300	80%	15	2	1	1	1	*
October 13 (Saturday)	305	79%	14	2	2	1	2	0
October 15	285	79%	14	4	1	1	1	0
October 16	311	71%	22	1	3	*	2	1
October 17	257	71%	18	3	2	2	3	1
October 18	278	75%	17	3	1	1	2	1
October 19	273	81%	12	2	1	*	4	0
Booth #1	450	77%	16	2	2	1	2	*
Booth #2	460	72%	20	3	1	1	2	1
Booth #3	489	74%	18	3	1	1	3	*
Booth #4	430	76%	18	1	2	1	1	1
Booth #5	411	79%	14	1	2	*	3	1
Before set raised	166	81%	10	1	4	1	3	0
Set raised	245	78%	16	1	1	1	2	1
Booth #6	536	76%	17	2	2	1	2	*
10:00 A.M. show	866	76%	16	3	1	1	2	1
2:15 P.M. show	974	75%	17	2	2	1	3	*
4:00 P.M. show	936	76%	18	2	1	1	2	*
Reception normal	2299	76%	17	2	2	1	2	*
Reception irregular	477	76%	18	1	1	1	2	1
Had seen program in black and white	448	76%	16	2	2	1	2	1
Had not	2274	77%	17	2	1	1	2	*
Not reported	54	52%	28	7	0	4	4	5
AUDIENCE (industry-connected)	122	71%	18	3	2	1	2	3

* Less than ½%.

HOW DO YOU FEEL ABOUT THE *OVER-ALL QUALITY OF THE COLOR TELEVISION PICTURES* YOU HAVE SEEN?

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer	Mul-tiple An-swer
AUDIENCE (nonindustry).......	2776	39%	38	17	4	*	1	1
TV owners	1947	38%	38	18	4	*	1	1
Nonowners, viewers	533	43%	36	18	2	*	1	*
All others	296	41%	37	11	4	0	5	2
Men	1548	36%	39	19	5	*	1	*
Women	1212	44%	36	15	3	*	2	*
Under 20 years	184	35%	43	21	1	0	0	0
20-29 years	320	22%	45	24	8	0	1	0
30-39 years	569	30%	45	20	4	0	1	0
40 years or over	1632	46%	34	15	3	*	1	1
Not reported	71	51%	22	14	3	0	7	3
October 9	239	37%	40	15	5	*	3	0
October 10	272	37%	37	23	2	*	1	*
October 11	256	38%	34	22	4	0	1	1
October 12 (Columbus Day)...	300	39%	43	12	4	0	1	1
October 13 (Saturday)	305	30%	40	22	5	1	2	0
October 15	285	45%	36	15	3	*	1	0
October 16	311	44%	33	17	5	0	1	*
October 17	257	41%	36	16	5	0	1	1
October 18	278	44%	36	15	3	0	1	1
October 19	273	37%	41	17	3	0	2	*
Booth #1	450	34%	38	23	4	*	1	*
Booth #2	460	42%	35	16	5	*	1	1
Booth #3	489	44%	39	14	2	*	1	*
Booth #4	430	43%	35	16	3	*	2	1
Booth #5	411	36%	43	16	4	0	1	*
Before set raised..........	166	29%	45	19	5	0	2	0
Set raised	245	40%	41	14	4	0	*	1
Booth #6	536	38%	37	20	4	*	1	*
10:00 A.M. show	866	44%	36	15	3	*	2	*
2:15 P.M. show	974	39%	37	18	5	0	1	*
4:00 P.M. show	936	37%	40	19	3	*	1	*
Reception normal	2299	40%	38	17	4	*	1	*
Reception irregular	477	36%	38	21	3	*	1	1
Had seen program in black and white	448	49%	32	13	4	*	1	1
Had not	2274	37%	39	19	4	*	1	*
Not reported	54	54%	24	6	5	0	7	4
AUDIENCE (industry-connected).	122	26%	34	29	7	1	1	2

* Less than ½%.

HOW WOULD YOU RATE THE *BRIGHTNESS* OF THE COLOR PICTURES?

	Total	Much Too Bright	A Little Too Bright	Just About Right	A Little Too Dim	Much Too Dim	No Answer	Multiple Answer
AUDIENCE (nonindustry)	2776	7%	33	56	3	*	1	*
TV owners	1947	7%	34	54	4	*	1	*
Nonowners, viewers	533	5%	31	61	2	*	1	*
All others	296	7%	26	61	2	0	4	*
Men	1548	6%	31	57	5	*	1	*
Women	1212	8%	34	55	2	0	1	*
Under 20 years	184	5%	36	55	4	0	0	*
20-29 years	320	6%	39	51	4	0	*	0
30-39 years	569	6%	39	50	4	*	1	*
40 years or over	1632	7%	29	60	3	*	1	*
Not reported	71	6%	28	52	6	0	8	0
October 9	239	10%	33	54	2	0	1	0
October 10	272	7%	36	52	5	*	*	*
October 11	256	8%	31	57	2	*	1	1
October 12 (Columbus Day)	300	4%	33	58	5	0	*	*
October 13 (Saturday)	305	5%	31	56	8	0	0	*
October 15	285	7%	33	58	1	0	1	0
October 16	311	10%	34	54	1	0	1	0
October 17	257	5%	35	53	4	0	3	*
October 18	278	6%	30	58	4	0	2	*
October 19	273	5%	30	61	4	0	*	*
Booth #1	450	7%	31	56	5	0	1	*
Booth #2	460	7%	32	57	3	0	1	*
Booth #3	489	7%	33	56	3	0	1	*
Booth #4	430	7%	30	60	2	0	1	*
Booth #5	411	6%	37	52	3	*	2	*
Before set raised	166	5%	42	45	5	1	1	1
Set raised	245	7%	33	57	*	0	3	0
Booth #6	536	7%	33	55	4	*	1	0
10:00 A.M. show	866	6%	30	59	3	0	2	*
2:15 P.M. show	974	6%	33	55	4	*	1	1
4:00 P.M. show	936	7%	34	55	3	*	1	*
Reception normal	2299	7%	32	57	3	*	1	*
Reception irregular	477	6%	35	54	4	*	1	0
Had seen program in black and white	448	6%	25	62	4	0	2	1
Had not	2274	7%	34	55	3	*	1	*
Not reported	54	9%	20	50	6	0	13	2
AUDIENCE (industry-connected)	122	8%	37	49	5	0	1	0

* Less than ½%.

HOW WOULD YOU RATE THE *CLEARNESS OF DETAIL* IN THE COLOR TELEVISION PICTURES?

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer	Mul-tiple An-swer
AUDIENCE (nonindustry)	2776	40%	36	19	4	*	1	*
TV owners	1947	39%	37	19	5	*	*	*
Nonowners, viewers	533	39%	35	20	5	*	1	0
All others	296	43%	32	16	4	0	3	2
Men	1548	35%	37	21	6	*	*	1
Women	1212	45%	34	16	3	*	1	1
Under 20 years	184	34%	41	19	5	1	0	0
20-29 years	320	24%	41	27	7	1	*	*
30-39 years	569	34%	39	20	6	*	1	*
40 years or over	1632	45%	34	17	3	*	1	*
Not reported	71	51%	17	18	1	0	10	3
October 9	239	34%	41	19	5	0	1	0
October 10	272	38%	34	23	5	*	*	0
October 11	256	37%	31	23	7	0	1	1
October 12 (Columbus Day)	300	40%	37	16	5	*	1	1
October 13 (Saturday)	305	30%	38	24	7	*	1	*
October 15	285	46%	37	13	3	0	1	0
October 16	311	42%	33	21	4	*	*	*
October 17	257	48%	30	14	5	0	2	1
October 18	278	44%	36	16	3	*	1	*
October 19	273	38%	40	17	3	0	1	1
Booth #1	450	37%	37	19	6	0	1	*
Booth #2	460	42%	31	19	5	*	2	1
Booth #3	489	44%	35	16	4	0	1	*
Booth #4	430	40%	38	18	4	0	*	*
Booth #5	411	40%	36	20	3	*	*	1
Before set raised	166	34%	38	23	4	0	0	1
Set raised	245	44%	35	18	1	*	1	1
Booth #6	536	35%	38	20	6	*	1	0
10:00 A.M. show	866	39%	37	17	5	*	1	1
2:15 P.M. show	974	41%	34	19	5	*	1	*
4:00 P.M. show	936	39%	36	20	4	*	1	*
Reception normal	2299	41%	35	18	5	*	1	*
Reception irregular	477	36%	38	22	3	1	*	*
Had seen program in black and white	448	45%	32	16	5	*	1	1
Had not	2274	39%	37	19	5	*	*	*
Not reported	54	48%	15	15	4	0	15	3
AUDIENCE (industry-connected)	122	39%	28	21	7	3	0	2

* Less than ½%.

HOW WOULD YOU RATE THE *TRUENESS-TO-LIFE OF THE COLORS* IN THE PICTURES YOU SAW?

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer	Mul-tiple An-swer
AUDIENCE (nonindustry)	2776	31%	33	24	8	1	2	1
TV owners	1947	31%	34	23	9	1	2	*
Nonowners, viewers	533	33%	33	25	6	1	2	*
All others	296	33%	29	26	7	*	4	1
Men	1548	28%	34	25	10	1	2	*
Women	1212	36%	32	22	7	1	2	*
Under 20 years	184	34%	34	22	7	1	1	1
20-29 years	320	19%	32	34	14	1	0	0
30-39 years	569	25%	36	26	10	1	2	*
40 years or over	1632	36%	33	21	7	1	2	*
Not reported	71	34%	32	20	0	0	10	4
October 9	239	27%	34	27	9	2	1	0
October 10	272	32%	31	24	11	1	1	0
October 11	256	29%	34	22	12	*	3	0
October 12 (Columbus Day)	300	32%	35	22	9	*	1	1
October 13 (Saturday)	305	25%	38	25	9	1	2	*
October 15	285	38%	32	21	5	1	3	*
October 16	311	29%	33	26	8	2	2	*
October 17	257	32%	34	23	7	*	2	2
October 18	278	38%	30	23	6	1	1	1
October 19	273	32%	31	25	9	0	3	*
Booth #1	450	32%	29	26	10	1	2	*
Booth #2	460	36%	33	18	10	1	2	*
Booth #3	489	33%	35	22	8	*	2	0
Booth #4	430	35%	34	21	6	1	2	1
Booth #5	411	27%	34	29	7	*	2	1
Before set raised	166	24%	41	25	7	0	2	1
Set raised	245	28%	29	32	7	1	2	1
Booth #6	536	26%	34	26	10	2	2	*
10:00 A.M. show	866	33%	36	22	6	1	2	*
2:15 P.M. show	974	31%	33	23	11	1	1	*
4:00 P.M. show	936	31%	32	26	8	1	2	*
Reception normal	2299	33%	33	23	8	1	2	*
Reception irregular	477	25%	35	28	10	1	1	*
Had seen program in black and white	448	38%	32	20	7	*	3	*
Had not	2274	30%	34	25	9	1	1	*
Not reported	54	35%	24	17	4	0	16	4
AUDIENCE (industry-connected)	122	23%	35	18	19	2	3	0

* Less than ½%.

Question 6: *A-6*

WHAT IS YOUR OPINION ABOUT THE *VARIETY OF COLORS* YOU SAW?

	Total	A Limited Variety of Colors	A Wide Variety of Colors	Somewhere in Between	No Answer	Multiple Answer
AUDIENCE (nonindustry)	2776	11%	74	13	2	*
TV owners	1947	12%	74	13	1	0
Nonowners, viewers	533	11%	75	12	2	0
All others	296	12%	68	13	7	*
Men	1548	10%	74	14	2	0
Women	1212	13%	74	11	2	*
Under 20 years	184	8%	74	16	2	0
20-29 years	320	15%	71	14	*	0
30-39 years	569	13%	71	15	1	0
40 years or over	1632	11%	76	11	2	*
Not reported	71	11%	59	10	20	0
October 9	239	11%	77	10	2	0
October 10	272	13%	72	15	*	0
October 11	256	12%	73	13	2	0
October 12 (Columbus Day)	300	17%	71	11	1	0
October 13 (Saturday)	305	13%	73	13	1	0
October 15	285	7%	79	10	4	0
October 16	311	10%	72	15	3	0
October 17	257	12%	76	8	4	*
October 18	278	10%	73	13	4	0
October 19	273	11%	72	16	1	0
Booth #1	450	11%	76	12	1	0
Booth #2	460	12%	72	13	3	*
Booth #3	489	10%	78	10	2	0
Booth #4	430	12%	72	14	2	0
Booth #5	411	12%	71	15	2	0
Before set raised	166	12%	75	12	1	0
Set raised	245	12%	69	17	2	0
Booth #6	536	12%	74	12	2	0
10:00 A.M. show	866	9%	78	11	2	*
2:15 P.M. show	974	13%	72	13	2	0
4:00 P.M. show	936	12%	72	14	2	0
Reception normal	2299	11%	75	12	2	*
Reception irregular	477	12%	72	15	1	0
Had seen program in black and white	448	11%	75	11	3	0
Had not	2274	12%	74	13	1	*
Not reported	54	7%	63	11	19	0
AUDIENCE (industry-connected) ...	122	15%	74	8	2	1

* Less than ½%.

HOW WOULD YOU RATE THE QUALITY OF PICTURES IN THE SCENES WITH A *LOT OF ACTION?*

	Total	Excel-lent	Very Good	Good	Only Fair	Poor	No An-swer	Mul-tiple An-swer
AUDIENCE (nonindustry)	2776	35%	35	22	6	*	2	*
TV owners	1947	36%	35	22	6	*	1	0
Nonowners, viewers	533	33%	35	24	6	*	2	0
All others	296	34%	35	18	6	1	4	2
Men	1548	32%	35	24	8	*	1	*
Women	1212	39%	35	19	4	1	2	*
Under 20 years	184	37%	28	26	6	2	1	0
20-29 years	320	24%	35	31	8	2	*	*
30-39 years	569	29%	36	25	8	*	2	0
40 years or over	1632	39%	36	18	5	*	2	*
Not reported	71	41%	26	17	3	0	10	3
October 9	239	35%	35	19	9	2	0	0
October 10	272	33%	32	25	8	*	2	0
October 11	256	34%	33	24	7	0	2	0
October 12 (Columbus Day) ..	300	35%	35	22	5	*	2	1
October 13 (Saturday)	305	31%	33	25	9	0	2	0
October 15	285	36%	40	18	3	1	2	0
October 16	311	38%	34	20	5	1	2	*
October 17	257	37%	30	24	6	0	3	*
October 18	278	36%	40	17	5	0	2	0
October 19	273	36%	36	22	3	1	2	*
Booth #1	450	33%	37	22	7	*	1	0
Booth #2	460	35%	33	21	7	2	2	*
Booth #3	489	37%	37	20	5	*	1	*
Booth #4	430	34%	34	25	6	*	1	*
Booth #5	411	36%	33	24	4	*	3	*
Before set raised	166	33%	32	28	5	0	2	0
Set raised	245	38%	34	21	3	*	4	*
Booth #6	536	36%	35	20	7	*	2	0
10:00 A.M. show	866	36%	36	20	6	*	2	*
2:15 P.M. show	974	35%	35	21	6	1	2	*
4:00 P.M. show	936	34%	34	24	6	*	2	*
Reception normal	2299	36%	34	22	6	*	2	*
Reception irregular	477	33%	38	19	8	1	1	0
Had seen program in black and white	448	41%	31	20	5	*	3	0
Had not	2274	34%	36	22	6	1	1	*
Not reported	54	24%	35	18	0	0	17	6
AUDIENCE (industry-connected) .	122	30%	34	25	7	2	2	0

* Less than ½%.

WERE THERE ANY DEFECTS, OR ANYTHING WRONG, IN THE COLOR TELEVISION PICTURES YOU SAW, WHICH INTERFERED WITH YOUR ENJOYMENT OF THEM?

	Total	Yes	No	No Answer
AUDIENCE (nonindustry)	2776	37%	61	2
TV owners	1947	40%	59	1
Nonowners, viewers	533	33%	65	2
All others	296	25%	69	6
Men	1548	43%	56	1
Women	1212	29%	69	2
Under 20 years	184	55%	44	1
20-29 years	320	51%	48	1
30-39 years	569	46%	53	1
40 years or over	1632	29%	69	2
Not reported	71	29%	58	13
October 9	239	40%	58	2
October 10	272	36%	63	1
October 11	256	36%	62	2
October 12 (Columbus Day)	300	39%	59	2
October 13 (Saturday)	305	40%	58	2
October 15	285	28%	70	2
October 16	311	36%	62	2
October 17	257	39%	59	2
October 18	278	34%	63	3
October 19	273	40%	60	*
Booth #1	450	37%	62	1
Booth #2	460	37%	60	3
Booth #3	489	34%	64	2
Booth #4	430	34%	65	1
Booth #5	411	40%	58	2
Before set raised	166	41%	57	2
Set raised	245	40%	58	2
Booth #6	536	37%	61	2
10:00 A.M. show	866	33%	65	2
2:15 P.M. show	974	38%	60	2
4:00 P.M. show	936	39%	59	2
Reception normal	2299	36%	62	2
Reception irregular	477	41%	57	2
Had seen program in black and white	448	36%	62	2
Had not	2274	37%	62	1
Not reported	54	22%	58	20
AUDIENCE (industry-connected)	122	52%	48	0

* Less than ½%.

HOW MUCH DID THESE DEFECTS INTERFERE WITH YOUR ENJOYMENT OF THE PICTURES? (Asked only of those who said there were defects in the color television pictures they saw.)

	Total Respondents	Those Who Said There Were Defects (Per Cent of Total)	A Great Deal	Somewhat	A Little	No Answer	Multiple Answer
AUDIENCE (nonindustry)	2776	37%	2%	11	21	3	*
TV owners	1947	40%	2%	13	22	3	*
Nonowners, viewers	533	33%	1%	10	19	3	0
All others	296	25%	2%	7	12	4	0
Men	1548	43%	2%	13	25	3	*
Women	1212	29%	3%	9	15	2	0
Under 20 years	184	55%	1%	11	42	1	0
20-29 years	320	51%	3%	17	29	2	0
30-39 years	569	46%	1%	15	27	3	0
40 years or over	1632	29%	2%	9	15	3	*
Not reported	71	29%	3%	5	14	7	0
October 9	239	40%	3%	12	21	4	0
October 10	272	36%	2%	13	20	1	0
October 11	256	36%	3%	12	19	2	0
October 12 (Columbus Day)	300	39%	2%	10	26	1	0
October 13 (Saturday)	305	40%	3%	11	25	1	0
October 15	285	28%	1%	10	15	2	0
October 16	311	36%	2%	12	18	4	0
October 17	257	39%	4%	12	18	5	0
October 18	278	34%	1%	11	18	4	0
October 19	273	40%	1%	13	23	2	1
Booth #1	450	37%	1%	14	20	2	*
Booth #2	460	37%	3%	10	22	2	0
Booth #3	489	34%	2%	10	20	2	0
Booth #4	430	34%	2%	11	19	2	0
Booth #5	411	40%	1%	12	25	2	0
Before set raised	166	41%	1%	9	29	2	0
Set raised	245	40%	1%	15	21	3	0
Booth #6	536	37%	3%	12	18	4	0
10:00 A.M. show	866	33%	2%	10	19	2	0
2:15 P.M. show	974	38%	2%	13	20	3	0
4:00 P.M. show	936	39%	2%	11	23	3	*
Reception normal	2299	36%	2%	11	20	3	*
Reception irregular	477	41%	2%	13	23	3	0
Had seen program in black and white	448	36%	3%	12	19	2	0
Had not	2274	37%	2%	12	21	2	*
Not reported	54	22%	4%	2	9	7	0
AUDIENCE (industry-connected)	122	52%	5%	10	32	5	0

* Less than ½%.

WOULD YOU PLEASE WRITE IN BELOW WHAT DEFECTS YOU NOTICED? (Asked only of those who said there were defects in the color television pictures they saw.)

	Audience	
	Non-industry	Industry-connected
Total respondents	2776	122
Those who said there were defects (per cent of total)	37%	52%
Color Factors:		
COLORS NOT TRUE TO LIFE: a little off true color; poor red in American flag; flesh tones unnatural; teeth seemed unnatural	7%	8%
RUNNING OF COLOR: bleeding of color; colors seem to blur off; colors run together; colors spilling over edges; misregistration of color; fringing of color; haze or halo around faces	6	11
COLOR VARIATION: color change from time to time on same object; the colors faded or darkened at times; changes in shades of color; changing of tones of facial features	3	4
COLORS WRONG	1	0
POOR COLORS IN LONG SHOTS	1	2
POOR COLOR IN ACTION SHOTS	1	3
ENTIRE PICTURE TINGED	1	1
COLORS NOT UNIFORM IN AREA OF SAME COLOR	*	1
COLOR BREAK-UP	*	0
Miscellaneous	1	4
Definition Factors:		
PICTURE BLURRED: out of focus; details fuzzy; facial expression not in focus; slightly out of focus on close-ups	6	9
PICTURE BLURRED IN ACTION SCENES: blurs in motion; outdoor picture not too clear in movement; loss of focus in vertical movement	2	6
FOCUS IN LONG SHOTS: lack of clarity in long shots; picture blurred in outdoor shots	2	4
UNCOMPLIMENTARY TO ACTORS: seems to accentuate person's complexion and skin irregularities	1	0
FORMS DISTORTED	*	1

* Less than ½%.

Question 8c (continued):

	Audience Non-industry	Industry-connected
Production and Program:		
PROGRAM COMPLAINTS: not enough gestures in first song; in group scenes too many colors tend to give picture muddled, busy effect; only brilliant colors used in costumes; would like to see more pastel colors used	5	5
TECHNICAL AND PRODUCTION: lighting not uniform; pictures blur once in a while when cameras are changed to long shots; limited field of action	2	4
MAKE-UP POOR	1	2
PICTURE FLICKERS OR FLUTTERS	*	1
Miscellaneous	*	0
Brightness Factors:		
COLORS TOO VIVID: colors too strong; primary colors too definite	5	7
COLORS NOT VIVID ENOUGH	1	1
PICTURE BRIGHTNESS	1	0
Miscellaneous	*	0
Receiver Characteristics:		
DIFFERENCE OF COLOR AT EDGE OF SCREEN	2	3
SCREEN TOO SMALL	1	0
Other Factors:		
COLORS TIRE THE EYES	2	2
Miscellaneous	*	2
No comment	1	2

Question 9: *A-11*

PLEASE WRITE BELOW ANY OTHER COMMENTS YOU WOULD LIKE TO MAKE ABOUT THE COLOR TELEVISION PICTURES YOU SAW.

	Audience Non-industry	Industry-connected
Respondents	2776	122
TYPE OF COMMENT		
No answer	45%	46%
Favorable only	31	27
Unfavorable only	14	16
Both favorable and unfavorable	4	8
Questions about system	2	1
Qualified	4	3

Most of the questions raised were along these lines:

"When and where can I get it and what will it cost?"

"When can we get it in our home?"

* Less than ½%.

Question 9 (continued):

Of the remaining questions, a large part dealt with technical points; for example:

"Will a color set work on DC current?"

"Would a fringe area and other interferences make for blur and distortion?"

"Will it work on a twenty-inch screen?"

Most of the qualified comments are of two broad types. The first of these includes remarks dealing with *one* factor in a favorable and an unfavorable way; for example:

"The outdoor pictures were true to life, but the inside pictures were slightly off true color."

"The sunlight was all right on the faces and mouths but not so good on the garments."

The other principal type of qualified answers reflected approval with reservations; for example:

"They are on the right track, but there is still room for improvement."

A-12

	Audience	
	Non-industry	Industry-connected
Favorable Comments	31%	27%
COLOR TV WONDERFUL: color TV amazing; better than expected; very fine entertainment; excellent; very interesting and enjoyable; wonderful; enjoyed it very much	12%	12%
WANT COLOR TV NOW: will purchase as soon as possible; will wait for color before buying TV set; would like to have color television	4	3
BEST COLOR SYSTEM I HAVE SEEN UP TO NOW: better than CBS; more enjoyable than CBS; no flickering like CBS; prefer it over CBS	3	7
GENERALLY MUCH BETTER THAN BLACK AND WHITE TV: now dissatisfied with black and white; color television is far superior to black and white; will never be satisfied with black and white	2	2
COLOR MAKES TELEVISION MORE ENJOYABLE: pictures more enjoyable to watch than black and white; holds more interest than black and white; more intriguing	2	0
DETAILS AND TEXTURES CLEARER IN COLOR THAN IN BLACK AND WHITE: pictures more realistic; more true to life than black and white	2	2

Question 9 (continued):

	Audience Non-industry	Industry-connected
PICTURE CLEAR: details impressive; picture quality good; very distinct; pleasantly pleased with clarity; outstanding in clearness; detail and clearness very good; agreeably surprised with clarity; not blurred; no running of color	1	0
COLORS TRUE TO LIFE: natural; skin tones were excellent	1	0
COMPARES FAVORABLY WITH TECHNICOLOR OR KODACHROME: better than motion picture color; no worse than technicolor movies; more real than technicolor	1	0
COLOR LESS TIRING ON EYES THAN BLACK AND WHITE: less strain than black and white; didn't hurt my eyes	1	1
SHOULD BE IN PRODUCTION: see no reason why it shouldn't be marketed immediately; think they are ready for commercial broadcasting; should put the tubes on the market; don't see how it can be improved; perfect right now	1	0
LIKE THE COLORS: colors were beautiful; colors a joy to behold	1	0
LIKE COMPATIBILITY FEATURE: prefer compatible electronic system; public entitled to compatible system; RCA system is compatible	1	2
Other favorable answers	2	1

A-13

	Audience Non-industry	Industry-connected
Unfavorable Comments	14%	16%
PROGRAM CONTENT POOR: could have used better colors; too much color used; too many colors; programming could be improved; should have been less striving for very colorful effects	4%	1%
COLORS TOO VIVID: colors too bright; colors were too strong	3	5
COLORS NOT TRUE TO LIFE: some faces were red while other were too white; color rendition of flesh slightly faulty on occasion; color should be more natural	2	3

Question 9 (continued):

	Audience Non-industry	Audience Industry-connected
SCREEN TOO SMALL: would like to see it on a larger screen; picture too small	1	1
COLOR TIRED THE EYES	1	1
PICTURES BLURRED: black and white picture was sharper; would like to see it as clear as Kodacolor	1	2
RUNNING OF COLORS: haze or halo around faces or objects; smearing; colors seem to run into each other	1	0
TECHNICAL AND PRODUCTION CRITICISMS: most of faults observed could be corrected in the studio; would like to see whole figure; outdoor shots confined to too small an area; staging could be improved; camera angles could have been better	1	0
ONE-COLOR PREDOMINANCE: too much of a green element; presence of too much blue in the over-all picture; seemed a bit yellowish	1	0
MAKE-UP POOR: make-up on girls during close-ups not flattering; make-up should be made to look more natural	*	1
COLORS NOT BRIGHT ENOUGH: colors on pastel side; some colors not bright enough	*	0
COLOR VARIATION: colors change from time to time on same subject	*	0
BLURRING IN ACTION SHOTS	*	0
COLORS WRONG: white was blue; bluish cast to the whites	*	0
FORMS DISTORTED: distorted at edges	*	0
DEMONSTRATION INADEQUATE	*	0
COLORS NOT UNIFORM IN AREA OF SAME COLOR	*	0
Other unfavorable answers	2	5

* Less than ½%.

NBC HAS BROADCAST THIS SAME COLOR PROGRAM ON A TEST BASIS AT 10:00 A.M. SEVERAL TIMES DURING THE PAST MONTH. DID YOU HAPPEN TO SEE THIS PROGRAM IN BLACK AND WHITE BEFORE YOU SAW IT IN COLOR TODAY?

	Total	Yes	No	No Answer
AUDIENCE (nonindustry)	2776	16%	82	2
TV owners	1947	21%	78	1
Nonowners, viewers	533	3%	95	2
All others	296	6%	86	8
Men	1548	17%	82	1
Women	1212	15%	83	2
Under 20 years	184	27%	73	0
20-29 years	320	15%	85	0
30-39 years	569	19%	80	1
40 years or over	1632	14%	84	2
Not reported	71	18%	52	30
October 9	239	9%	90	1
October 10	272	14%	84	2
October 11	256	18%	81	1
October 12 (Columbus Day)	300	17%	81	2
October 13 (Saturday)	305	17%	82	1
October 15	285	24%	75	1
October 16	311	17%	80	3
October 17	257	15%	81	4
October 18	278	13%	84	3
October 19	273	16%	82	2
Booth #1	450	14%	85	1
Booth #2	460	17%	81	2
Booth #3	489	19%	79	2
Booth #4	430	18%	80	2
Booth #5	411	15%	83	2
Before set raised	166	18%	80	2
Set raised	245	13%	85	2
Booth #6	536	14%	84	2
10:00 A.M. show	866	18%	80	2
2:15 P.M. show	974	17%	81	2
4:00 P.M. show	936	14%	84	2
Reception normal	2299	17%	81	2
Reception irregular	477	13%	84	3
AUDIENCE (industry-connected)	122	28%	71	1

HOW DID THE BLACK AND WHITE RECEPTION OF THE COLOR BROADCAST WHICH YOU SAW AT HOME COMPARE WITH REGULAR BLACK AND WHITE BROADCASTS YOU HAVE SEEN ON THAT SAME SET? (Asked only of those who said they had seen the 10:00 A.M. test program in black and white before they saw it in color.)

	Respondents: Number	Per Cent	Much Better Than Regular Black and White	Somewhat Better Than Black and White	About the Same	Somewhat Poorer Than Regular Black and White	Much Poorer Than Regular Black and White	No Answer	Multiple Answer
AUDIENCE (nonindustry)	448	100%	42%	16	33	5	1	3	*
TV owners	412	100%	41%	16	34	6	1	2	*
Nonowners, viewers	18**								
All others	18**								
Men	268	100%	43%	16	34	5	1	1	0
Women	179	100%	41%	15	32	5	1	5	1
Under 20 years	49	100%	27%	22	37	10	2	2	0
20-29 years	47	100%	34%	21	34	7	0	2	2
30-39 years	106	100%	39%	17	35	7	0	2	0
40 years or over	233	100%	47%	13	33	3	1	3	0
Not reported	13**								
October 9	22	100%	27%	23	45	5	0	0	0
October 10	39	100%	54%	13	28	3	0	2	0
October 11	45	100%	35%	7	49	7	0	2	0
October 12 (Columbus Day) ..	50	100%	46%	16	30	6	0	2	0
October 13 (Saturday)	52	100%	40%	33	13	4	6	4	0
October 15	67	100%	52%	8	33	4	0	3	0
October 16	53	100%	36%	17	30	9	2	4	2
October 17	40	100%	45%	15	35	0	0	5	0
October 18	37	100%	43%	11	43	0	0	3	0
October 19	43	100%	32%	19	35	12	0	2	0
Booth #1	64	100%	48%	8	36	5	2	1	0
Booth #2	76	100%	53%	12	24	6	0	5	0
Booth #3	93	100%	41%	18	34	3	1	2	1
Booth #4	79	100%	34%	14	38	6	1	7	0
Booth #5	61	100%	41%	20	33	6	0	0	0
Before set raised	30	100%	43%	10	44	3	0	0	0
Set raised	31	100%	39%	9	42	10	0	0	0
Booth #6	75	100%	38%	21	35	4	1	1	0
10:00 A.M. show	157	100%	39%	11	35	9	1	4	1
2:15 P.M. show	163	100%	46%	15	31	3	1	4	0
4:00 P.M. show	128	100%	41%	22	32	4	0	1	0
Reception normal	388	100%	42%	16	33	5	1	3	*
Reception irregular	60	100%	41%	12	37	8	0	2	0
AUDIENCE (industry-connected).	34	100%	41%	18	23	6	0	12	0

* Less than ½%.

** Cases too few for analysis.

Attachment 1

Advertisement Announcing the Field Tests

Now You Can See

RCA Color Television

YOU ARE cordially invited to view a television program in color which will be broadcast experimentally by RCA-NBC in the New York area each weekday from Tuesday, October 9 through Friday, October 19.

The programs will be received on experimental RCA color receivers set up for your convenience in the Lounge at the Center Theater on West 49th Street, Rockefeller Center. Admission will be by ticket only.

These programs will be presented at 10:00 a.m., 2:15 p.m. and 4:00 p.m. every day except Sunday.

The morning programs will be broadcast on Channel 4 and can be seen in color on the Center Theater sets or in black-and-white on your own home receivers.

The afternoon programs will be transmitted only to the Center Theater where all three daily programs can be viewed in color.

These programs are part of the field tests RCA is conducting with its fully compatible all-electronic color television system.

You helped us test the "compatibility"* of RCA's color television system during the field tests we conducted in July and in September. At that time you told us how our color broadcasts were received in black-and-white on your own television sets.

Now we would like to get your reaction to our color pictures when you see them at the Center Theater.

The number of seats available for each performance is limited, so if you would like to see a program on RCA's all-electronic "compatible" color system and help us in this second phase of our field tests, please send the attached coupon immediately for tickets to RCA COLOR TELEVISION, RCA Building, New York 20, N. Y.

*The RCA color television system is "compatible" with the nearly 14,000,000 receivers now in the public's hands. This means that when a color picture is broadcast by the RCA system it can be received in black-and-white on the set you now own *without any change at all in your present set.*

Since the color television show will be broadcast in New York over Channel 4 at 10 o'clock each morning beginning October 9, you can help us further test the "compatibility" of our system by telling us how it works in black-and-white in your neighborhood and on your set.

Please send your reactions to RCA COLOR TELEVISION, RCA Building, New York 20, N. Y.

Please fill in and mail this coupon for tickets. We regret that we shall be unable to handle telephone requests.

RCA COLOR TELEVISION
RCA BUILDING, NEW YORK 20, N. Y.

Name ______________________

Address ______________________

____

1st Choice ____ 2d Choice ____ 3d Choice ____
(date) (date) (date)

Check preferred time:
☐ 10 a.m. ☐ 2:15 p.m. ☐ 4 p.m.

Number of tickets ☐ one; ☐ two

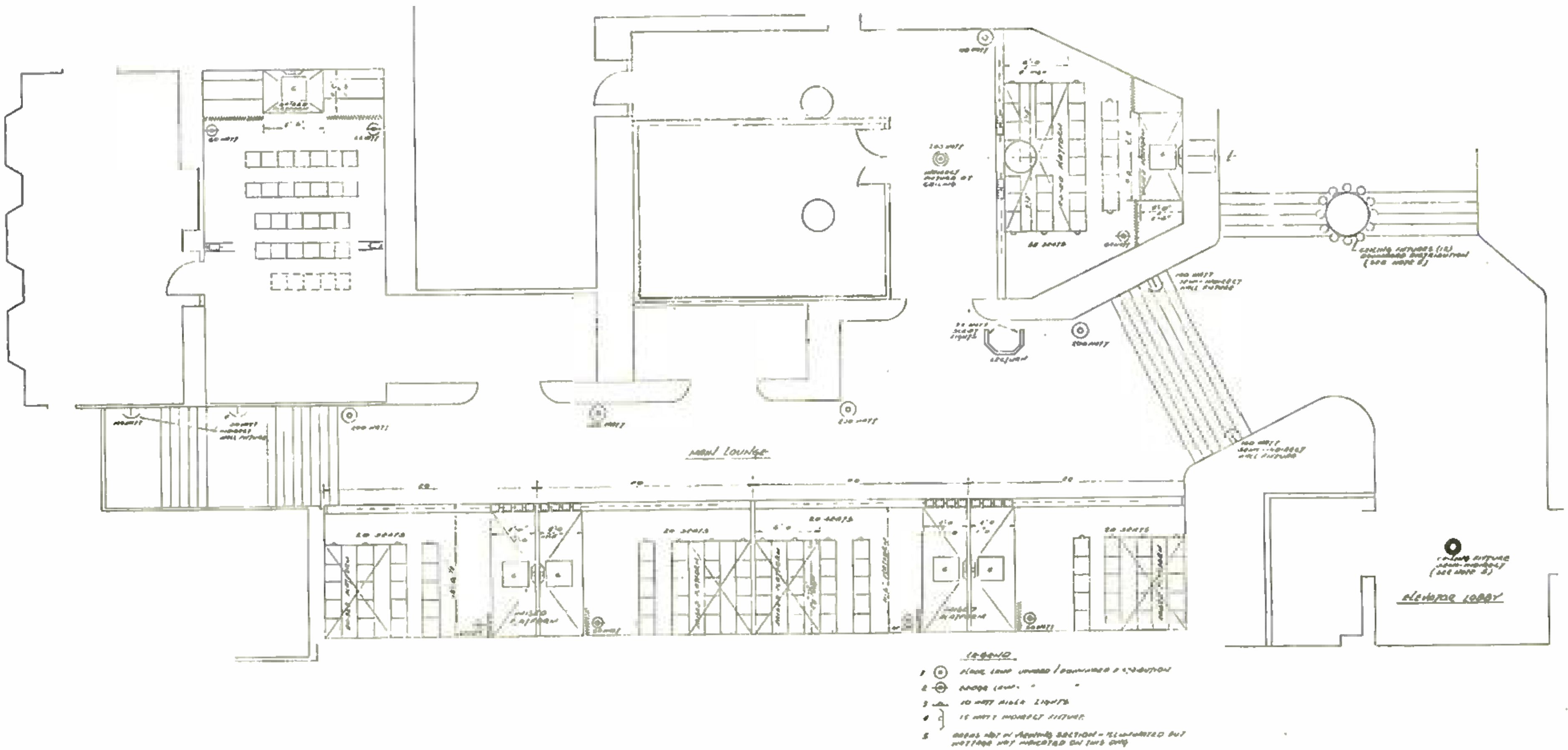
Are you, or is anyone in your immediate family connected in any way with the manufacture, sale, servicing or broadcasting of radio or television. Yes ☐ no ☐

RADIO CORPORATION of AMERICA

World Leader in Radio—First in Television

ATTACHMENT 2

REPRODUCTION OF DIAGRAM OF CENTER THEATRE LOUNGE



ATTACHMENT 3

ENGINEERING MONITOR REPORT FORM

Filled out for Each Receiver at Each Showing

Time____________________ Date____________________

Receiver #__________________ Booth____________________

Resolution__________________

Registration_________________

Brightness__________________

Color Fidelity________________

Contrast Range_______________

Sound______________________

Comments____

____

____

____

____

Checked by__________________

The above items should be checked (√) when normal. If not normal, indicate in what regard under Comments.

ATTACHMENT 4

SCRIPT OF "IT'S A WORLD OF COLOR"

COLOR DEMONSTRATIONS

OCTOBER 9-13, 1951

OCTOBER 15-19, 1951

RCA COLOR — AT YELLOW
ANNOUNCER: BEN GRAUER
ANNOUNCER: ON CAMERA
MODELS: COSTUMES
FABRAY: IT'S A WORLD OF COLOR
FABRAY: INTRO CUBAN NUMBER
CUBAN NUMBER
FABRAY: INTRO VIENNA NUMBER
VIENNA NUMBER
FABRAY: INTRO BIRDS
BURTON'S BIRDS
FABRAY: INTRO TEXAS NUMBER
TEXAS NUMBER
FLOWERS — GRAUER: CREDITS
FABRAY: SIGN OFF
RCA SIGN
REMOTE

OPENING

ON-THE-AIR SHOW

GRAUER:

RCA SIGN—MONO (at yellow)

The Radio Corporation of America and the National Broadcasting Company present Color Television!

RCA SIGN—CHROME

MUSIC: FANFARE

You are about to view another in a series of field tests of RCA's compatible, all-electronic color television system. These tests will be on Channel 4 from 10:00 to 10:25 AM except Saturday and Sunday through October 19th.

Ladies and gentlemen, greetings to you. This is Ben Grauer speaking to you over Channel 4 of the National Broadcasting Company's experimental station KE2XJV in New York and experimental station KG2XDE in Washington.

SEGUE: MODELS

1. PARASOL (Marie Dube)

While these lovely girls parade before our color cameras, this transmission is being viewed in color on experimental color receivers in the Center Theater in Radio City, New York and in the NBC studio in Washington, and in addition at the Colonial Theatre on a theatre screen. However, all owners of television sets in the New York and Washington areas can see this same test program in black-and-white. This is made possible because RCA color broadcasts can be received on your black - and - white television sets without any changes in the sets.

2. SKIING (Joy Bennett)

3. PARASOL (Betty Carson)

4. RIDING (Mary Heath)

5. PARASOL (Annelle Tice)

So that we may test how our color system receives and

6. SWIMMING (Jacki Loughery)

reproduces standard black-and-white pictures, during one of the numbers in this program we will switch from color to black-and-white and then back to color. The tri-color tube which reproduces the full color pictures was designed to produce black-and-white pictures, too.

7. PARASOL (Dolores Michaels)

8. COCKTAILS (Eve Lynn)

9. PARASOL (Dawn McInerney)

It must be emphasized that today's color broadcast and those scheduled at this hour each day this week except Saturday and Sunday are experimental.

MUSIC: FANFARE

Now, on with the show! RCA and NBC present—"It's A World Of Color"—starring Broadway's darling, lovely Nanette Fabray!

SEGUE: IT'S A WORLD OF COLOR

OPENING

ON-THE-LINE TESTS

GRAUER:

RCA SIGN
(at yellow)

The Radio Corporation of America and the National Broadcasting Company present Color Television!

MUSIC: FANFARE

Ladies and gentlemen, this is Ben Grauer speaking, it is my pleasure to welcome you to another in a series of field tests of the RCA compatible, all-electronic color television system.

SEGUE: MODELS

1. PARASOL (Marie Dube)

As these lovely girls parade before our color cameras you will see this program on a color receiver equipped with the RCA direct view tri-color tube.

2. SKIING (Joy Bennett)

3. PARASOL (Betty Carson)

This test program is being transmitted from NBC's studio in Radio City, New York, direct to the Center Theater in New York, and by coaxial cable or micro-wave relay to Washington where the program is being viewed on color receivers in the NBC studio, and in addition at the Colonial Theatre on a theatre screen.

4. RIDING (Mary Heath)

5. PARASOL (Annelle Tice)

When the RCA color system is broadcast on Channel 4 at 10 o'clock each morning except Saturday and Sunday through October 19, all owners of existing television sets in the New York and Washington areas can see this same performance in black-and-white.

6. SWIMMING (Jacki Loughery)

7. PARASOL (Dolores Michaels)

So that we may test how our color system receives and reproduces standard black-and-white pictures, during one of the numbers in this program we will switch from color to black-and-white and then back to color. The tri-color tube which reproduces the

8. COCKTAILS (Eve Lynn)

9. PARASOL (Dawn McInerney)

full color pictures was designed to produce black-and-white pictures, too.

MUSIC: FANFARE

And now, on with the show! RCA and NBC present—"It's A World Of Color"—starring Broadway's darling, lovely Nanette Fabray!

SEGUE: IT'S A WORLD OF COLOR

IT'S A WORLD OF COLOR

NANETTE:

A—It's a world of color 8 Bars
So look around you
Just open your eyes
A happy surprise is yours

B—It's a world of color 8 Bars
That will astound you
A rainbow's about
That's inside and out of doors

C—The golden sun 8 Bars
The tall green tree
The bright blue sky
The even bluer sea

D—It's a world of color 12 Bars
So look around you
The colors go by
And worries all fly away
It's a world of color today

E—It's a world of color 8 Bars
So don't be gloomy
A flower's a gem
'nd blooms on a stem for you

F—It's a world of color 8 Bars
So listen to me
Skies overhead are dressed
Up in red and blue

G—Your sweetheart's smile 8 Bars
Her golden hair
Her blue blue eyes
There's color everywhere

H—It's a world of color 12 Bars
So just be happy
The clouds disappear and
Rainbows are here to stay
It's a big wide wonderful
world of color
It's a world of color today.

TAG

INTRO TO CUBAN NUMBER — REVISION 1

NANETTE:

We have a little friend, a private secretary, who leads one of those dull, dreary lives as an office worker. Nothing original ever seems to come into her life. But once a year comes the magic of a "vacation". To get the story first-hand, let's look in on our heroine pounding away on the typewriter in her drab and dreary surroundings. In fact, her existence, just before a vacation, is so dull that we have to show it to you in black-and-white and tones of gray . . .

CUBAN NUMBER

"Weekend Of a Private Secretary"

INTRO 4 Bars

A—FEMALE VOCAL 13 Bars
I went to Havana
On one of those cruises
For forty-nine fifty
To spend a few days;

I went to Havana
To look at the natives
To study their customs
Their picturesque ways.

B—CHOIR 2 Bars
In searching for some
local color

B_3—CHOIR 16 Bars
Color!
She ran across a Cuban gent
And he was such a big sensation
She forgot the population;
He showed her the city
He taught her the customs;
Her trip to Havana
Was quite a success

C—MALE SOLO DANCE
16 Bars

D—MALE SOLO DANCE
16 Bars

E—MALE SOLO DANCE
6 Bars

F—DUET AT TABLE
16 Bars

E_1—MAMBO DANCE—DUET
8 Bars

F_1—MAMBO DANCE—DUET
6 Bars

G—SOLO FEMALE DANCE
30 Bars

H—SOLO FEMALE DANCE
6 Bars

I—FINAL DUET DANCE
41 Bars

SEGUE TO OFFICE

X—FEMALE VOCAL 5 Bars
I'm back in the office

I'm punching the time clock
But you can bet my mind
Is not on my work;

Y—CHOIR 8 Bars

Instead of Bacardies
She's ordering Bromos
Instead of a Cuban
She's really stuck with a clerk

Z—FEMALE VOCAL & CHOIR
16 Bars

But when I get married
And settle in Brooklyn
He may be a slicker
He may be a hick
Or a Ruben
But you can - bet -
That - he'll - be - Cuban!

TAG

INTRO TO VIENNA NUMBER

NANETTE:

Standing apart with a charm all its own is the city of Vienna. The picturesque flavor of that colorful city has been expressed in the music of Johann Strauss and people the world over dance the Viennese waltz to his immortal melodies. In the old days Vienna provided a stimulating atmosphere for romance and to young lovers and their intimate friends an engagement party was something long to be remembered.

VIENNA LIFE

2—INTRO 16 Bars

GLASSES

HANDS & RING

WALTZ

3—ART 8 Bars

Tell the breeze passing by
Tell the moon tell the stars
We're in love

4—ART 8 Bars
Tell the earth and the sky
Spread the word 'til they've heard
We're in love

5—ART 8 Bars
Here you are in my arms
Cling to me like the sea
To the shore

6—ART 8 Bars
Tell the moon tell the stars
You are mine I am yours evermore

7—GAIL 8 Bars
Hum—we want the world
To hear when we sigh
To know when we kiss

8—GAIL 12 Bars
Hum—we're so in love
Why should we deny
The happiness of this

9—ART & GAIL 8 Bars
Tell the birds (DANCERS IN)
On the wing tell the moon
Tell the stars we're in love

10—GAIL 8 Bars
Tell the rose (DANCERS IN)
Why we sing

(10) ART
Let them know that we're
So much in love

11—ART & GAIL 8 Bars
When your lips meet with mine
They impart what my heart
Waited for

12—GAIL 8 Bars
Tell the moon tell the stars
ART & GAIL
You are mine I am yours evermore

16—CHOIR (DANCE) 8 Bars
Hearts are young (DANCERS IN)
And it's spring again
Let the bells be rung
Love is king again

17—CHOIR 8 Bars
DANCERS—BOW

17_A—CHOIR 8 Bars
DANCE

18—ART 8 Bars
Deep in your eyes I found a dream
Lighting my life with loveliness

19—ART & GAIL 8 Bars
Deep in your arms I found a home
Where I could lose my loneliness

20—GAIL & ART 8 Bars
Deep in my heart I hear a song
Here where no music dared to be

21—GAIL & ART 8 Bars
Deep in your eyes embers of love
Seem to declare you care for me

22—ART & MALE CHOIR 8 Bars
Tell the breeze passing by
Tell the moon tell the stars
We're in love

23—ART & CHOIR 8 Bars
Tell the earth and the sky
Spread the word 'til they've heard
We're in love

24—ART & GAIL 8 Bars
Here you are in my arms
Cling to me like the sea
To the shore

25—ART & GAIL & CHOIR 8 Bars
Tell the moon tell the stars
You are mine I am yours evermore

26—TAG 4 Bars
DANCE TWIRL

INTRO BURTON'S BIRDS

NANETTE:

Today we have with us some real troupers. And, I might add, these little fellows have literally flown in from the coast to be with us for these programs.

In their own name they have world wide fame as great lovers too. But by their actions you will see their talents go far beyond the realm of romance.

So, now, we are delighted to welcome back to the RCA color television screen the amazing accomplishments of George Burton's Love Birds. Featuring those stars of stage and screen . . . Bill and Coo.

1. LOVE BIRDS
2. MUSCLE GRIND
3. SOMERSAULT
4. SINGLE RING
5. ROMAN RING
6. WIRE WALKERS
7. BALL
8. BOWS

INTRO TO TEXAS NUMBER

NANETTE:

Our next presentation concerns one of the most talked about things in the U. S. A. I know you will be delighted to hear . . .

MALE VOICE:

Telephone for Miss Fabray!

NANETTE:
Telephone? For me?

FEMALE VOICE
Miss Fabray, Texas calling

NANETTE:
Texas? . . .

INTRO—VAMP 8 Bars
Hello, Nanette, we're all down here in Texas, and we're having lots of fun. Come on down, Nanette!

A—NANETTE 8 Bars
I've heard of Texas
It sounds terrific
But I suppose I shouldn't
Try to get specific

B—NANETTE 8 Bars
'Cause all I go by
Are those scenes
That they show on TV screens
And the pictures that they
Print in magazines

C—DOROTHY & CHOIR 8 Bars
It may sound silly
But you should rilly
Give almost anything
To be a real hillbilly

D—NANETTE 8 Bars
But I suppose I'll never see
A pampas or prairie
Unless you take pity on me

E—LARIAT BUSINESS 16 Bars

F—NANETTE 8 Bars
Take me back to Texas with you
Yell! Yell!
I'll be such a good buckaroo

G—NANETTE 8 Bars
Want to wash my hand and face
In that Rio Grande Basin
Let me stay in Texas with you

CHOIR: Stay with us

H—NANETTE 8 Bars
I will help fight Indians too
And I'll bet I'll scalp quite a few

I—NANETTE 8 Bars
And each day I'll take out grazin'
The coyotes I'll be raisin'
If you keep me in Texas with you

J—CHOIR 8 Bars
You'll be happy as a lark
When you're lying in the dark
And you hear a doggie bark
At the sky—Bark, bark

K—NANETTE 8 Bars
And if I'm a lucky gal
There will be a big corral
To sing me a lullaby—Yippyi

L—CHOIR & NANETTE 8 Bars
When the desert moon starts
to beam
I'll sit on a cactus and dream

M—NANETTE 12 Bars
I won't mind if I am stranded
I'll let myself be branded
If you'll keep me in Texas with you
Let me stay in Texas with you

EXTENTION 4 Bars

N—CHOIR 4 Bars
Now you're out in Texas with us

NANETTE 4 Bars
Can I chew tobacca and cuss

Q—CHOIR 4 Bars
'Stead of Nanette you'll be Nannie

NANETTE 4 Bars
That's as good a name as any

CHOIR 4 Bars
You can stay in Texas with us

EXTENTION—YODEL 4 Bars

R—CHOIR 4 Bars
It's a place to have lots of fun

(R) NANETTE 4 Bars
Can I have a duel in the sun

S—CHOIR 2 Bars
You can shoot a total stranger

NANETTE 2 Bars
Hey there Texas Ranger—Whistle

CHOIR 4 Bars
With your trusty six shooter gun

EXTENTION 4 Bars

T—CHOIR 4 Bars
By gosh you sure look cute
In your brand new cowboy suit

NANETTE 4 Bars
Would you teach me how to
Shoot from the hip—ha, ha

U—NANETTE & CHOIR 8 Bars
Oh, a Texas life is grand
If you don't mind eating sand
So, run don't walk to take a
Texas trip—Let her rip!

V—ENSEMBLE 8 Bars
So let's all ferget our mistakes
In the land of spiders and snakes

W—NANETTE 4 Bars
I'll ferget those eastern codgers
When I see Monsieur Roy Rogers

ENSEMBLE 8 Bars
So we'll all toast Texas today
Right away!
Texas—U. S. A.!

X—DANCE 16 Bars

J_1—NANETTE & CHOIR 8 Bars
On a Sunday afternoon
We will visit the saloon
And we will harmonize a tune
Out of key

K_1—NANETTE 8 Bars
We'll enjoy a stroll through town
To watch the natives get shot down
'Til somebody aims at me—Yippee

L_1—ENSEMBLE 8 Bars
So if we go back to the soil
Let's be sure the soil has got oil

M_1—NANETTE 8 Bars
And if some one makes a pass at me
I'll be saved by Hop-a-long Cassidy

N_1—ENSEMBLE
So we'll stay in Texas
So we'll stay—never stray
From Texas—U .S. A.!

NANETTE
Texas!

CLOSING
AFTER STUDIO SHOW

FLOWERS

GRAUER:
"It's A World of Color" features Dorothy Keller, Earl Barton, the Clef Dwellers, Gail Manners, Norwood Smith, George Burton and his Love Birds, with David Terry as Musical Director, and starring lovely Nanette Fabray!

FABRAY IN

NANETTE:
For the entire company of "It's A World of Color"—Thank you for watching.

MUSIC: FANFARE

RCA SIGN

ATTACHMENT 5

SCRIPT FOR REMOTE PICK-UP

OPENING

PALISADES PARK REMOTE PICK-UP

GRAUER:
And now a special added feature to our color demonstration. The program you have been seeing thus far

has been coming to you from the NBC Studios in the RCA Building, now we are going to switch our controls to Palisades Park, New Jersey. There we are and an RCA Color Television Unit is picking up the scene. The next voice you will hear will be that of Fred Collins . . .

MOBILE: VIDEO

ON-THE-AIR CLOSING

AFTER PALISADES PARK REMOTE PICK-UP

FROM PALISADES PARK—COLLINS:

. . . and now we return you to Ben Grauer at the NBC Studios in Radio City . . .

RCA SIGN (at yellow)

GRAUER:

Ladies and gentlemen you have been viewing a field test of the RCA all-electronic color television system: coming to you from the Palisades Amusement Park high above the Hudson River in Palisades, New Jersey, and from the studios of NBC in Radio City, New York.

These broadcasts are sent to Washington by coaxial cable or microwave relay. They can be received over Channel 4 as black-and-white broadcasts on existing television sets in both the New York and Washington areas.

It must be emphasized that today's color broadcast and those scheduled at this hour each day this week except Saturday and Sunday are

experimental.
And now, for the Radio Corporation of America and the National Broadcasting Company, this is Ben Grauer saying—Good Morning.

MUSIC: FANFARE

ON-THE-LINE CLOSING

AFTER PALISADES PARK REMOTE PICK-UP

FROM PALISADES PARK—
COLLINS:

. . . and now we return you to Ben Grauer at the NBC Studios in Radio City.

RCA SIGN
(at yellow)

GRAUER:

Ladies and gentlemen you have been viewing a field test of the RCA all-electronic color television system coming to you from the Palisades Amusement Park, high above the Hudson River in Palisades, New Jersey and from the studios of NBC in Radio City, New York.
And now, for the Radio Corporation of America and the National Broadcasting Company, this is Ben Grauer saying—Good Afternoon.

MUSIC: FANFARE

Attachment 6

The Survey Questionnaire

Color Television Survey, New York City

Based on your own experience in the color television demonstration you have just seen, would you please answer *each* of the following questions as completely as possible? For each question, please check one box.

1. Which do you think is *more enjoyable*—color or regular black and white television that you have seen before today?
   - ☐ Color *much more* enjoyable than black and white
   - ☐ Color *somewhat more* enjoyable than black and white
   - ☐ Both *about the same*
   - ☐ Black and white *somewhat more* enjoyable than color
   - ☐ Black and white *much more* enjoyable than color
   - ☐ Have never seen black and white television

2. How do you feel about the *overall quality of the color television pictures* you have seen?

   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

3. How would you rate the *brightness* of the color pictures?
   - ☐ Much too bright
   - ☐ A little too bright
   - ☐ Just about right
   - ☐ A little too dim
   - ☐ Much too dim

4. How would you rate the *clearness of detail* in the color television pictures?

   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

5. How would you rate the *trueness-to-life* of the colors in the pictures you saw?

   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

6. What is your opinion about the *variety of colors* you saw?
   - ☐ There was a *limited* variety of colors
   - ☐ There was a *wide* variety of colors
   - ☐ Somewhere in between

7. How would you rate the quality of pictures in the scenes with a *lot of action*?

   ☐ Excellent ☐ Very good ☐ Good ☐ Only fair ☐ Poor

8a. Were there any defects, or anything wrong, in the color television pictures you saw, which interfered with your enjoyment of them?
   - ☐ Yes
   - ☐ No

(IF "YES" TO 8a)

8b. How much did these defects interfere with your enjoyment of the pictures?

- ☐ A great deal
- ☐ Somewhat
- ☐ A little

(IF "YES" TO 8a)

8c. Would you please write in below what defects you noticed?

....

....

....

....

9. Please write below any other comments you would like to make about the color television pictures you saw.

....

....

....

....

10a. NBC has broadcast this same color program on a test basis at 10 A.M. several times during the past month. Did you happen to see this program in black and white before you saw it in color today?

- ☐ Yes
- ☐ No

(IF "YES" TO 10a)

10b. How did the black and white reception of the color broadcast which you saw at home compare with regular black and white broadcasts you have seen on that same set?

- ☐ *Much better* than regular black and white
- ☐ *Somewhat better* than regular black and white
- ☐ *About the same* as regular black and white
- ☐ *Somewhat poorer* than regular black and white
- ☐ *Much poorer* than regular black and white

And now, just a few facts about yourself—

11. Sex: ☐ Male ☐ Female

12. Age: ☐ Under 20 ☐ 20 - 29 ☐ 30 - 39 ☐ 40 and over

13. Please circle the last year in school that you attended.

Grammar School	High School	College
1 2 3 4 5 6 7 8	1 2 3 4	1 2 3 4 5 6

14a. Do you have a television set in your home?

☐ Yes
☐ No

(IF "NO" to 14a)

14b. Have you seen any regularly broadcast television programs in the last month or so?

☐ Yes
☐ No

15. Are you, or is anyone in your immediate family, connected in any way with the manufacture, sale, servicing, or broadcasting of radio or television?

☐ Yes
☐ No

Your name: ....

Address: ....

That's all. Many thanks for your cooperation!

Opinion Research Corporation
Princeton, New Jersey

Booth................. Time.......... .... Date.................

APPENDIX F

RCA-NBC COLOR TELEVISION TEST TRANSMISSIONS FOR NTSC

A compilation of various of the experimental color television tests furnished by RCA-NBC to NTSC for field testing of the NTSC signal specifications.

Date	Observation Place	NTSC Committee
May 16, 1953	RCA Laboratories, Princeton, N. J.	Main Committee
Aug. 8, 1951	RCA Laboratories, Princeton, N. J.	Panel 13 (Color Video Standards)
May 16, 1952	RCA Laboratories, Princeton, N. J.	
June 12, 1952	RCA Laboratories, Princeton, N. J.	
June 18, 1952	RCA Laboratories, Princeton, N. J.	
July 9, 1952	RCA Laboratories, Princeton, N. J.	
July 11, 1952	RCA Laboratories, Princeton, N. J.	
July 15, 1952	RCA Laboratories, Princeton, N. J.	
Aug. 13, 1952	RCA Laboratories, Princeton, N. J.	
Aug. 26, 1952	RCA Laboratories, Princeton, N. J.	
Aug. 27, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 16, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 17, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 18, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 19, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 24, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 25, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 26, 1952	RCA Laboratories, Princeton, N. J.	
Sept. 30, 1952	RCA Laboratories, Princeton, N. J.	
Oct. 22, 1952	RCA Laboratories, Princeton, N. J.	
Oct. 23, 1952	RCA Laboratories, Princeton, N. J.	
Nov. 13, 1952	RCA Laboratories, Princeton, N. J.	
Nov. 14, 1952	RCA Laboratories, Princeton, N. J.	
Nov. 18, 1952	RCA Laboratories, Princeton, N. J.	
Nov. 19, 1952	RCA Receiver Laboratories, Astoria, L. I.	
Nov. 20, 1952	RCA Receiver Laboratories, Astoria, L. I.	
Jan. 30, 1952	RCA Receiver Laboratories, Astoria, L. I.	Panel 14 (Color Synchronizing Standards)
May 20, 1952	RCA Laboratories, Princeton, N. J.	
May 26, 1953	Emerson Plant, Jersey City, N. J.	Panel 15 (Compatibility)
May 27, 1953	RCA Laboratories, Princeton, N. J.	

Sept. 17, 1951	RCA Exhibition Hall, New York City	Panel 16 (Field Testing)
Mar. 26, 1952	RCA Receiver Laboratories, Astoria, L. I.	
May 7, 1952	RCA Laboratories, Princeton, N. J.	
May 8, 1952	RCA Laboratories, Princeton, N. J.	
Mar. 17, 1953	RCA Receiver Laboratories, Astoria, L. I.	
Mar. 18, 1953	RCA Receiver Laboratories, Astoria, L. I.	
Mar. 19, 1953	RCA Receiver Laboratories, Astoria, L. I.	
Mar. 20, 1953	RCA Receiver Laboratories, Astoria, L. I.	
May 5, 1953	Sylvania Laboratories, Bayside, L. I.	
May 6, 1953	Sylvania Laboratories, Bayside, L. I.	
May 7, 1953	Sylvania Laboratories, Bayside, L. I.	
May 8, 1953	Sylvania Laboratories, Bayside, L. I.	
May 27, 1953	RCA Laboratories, Princeton, N. J.	
Oct. 18, 1951	Trans Lux Building, Washington, D. C.	Panel 17 (Broadcast System)
Mar. 27, 1953	RCA Receiver Laboratories, Astoria, L. I.	
June 10, 1953	Center Theater, New York City	

Broadcasts offered to NTSC for technical observation.

1951
Aug. 27 thru Aug. 31
Sept. 4 thru Sept. 7
Sept. 10 thru Sept. 14
Sept. 17 thru Sept. 21
Oct. 9 thru Oct. 12
Oct. 15 thru Oct. 19
Dec. 3 thru Dec. 7
Dec. 10 thru Dec. 14
Dec. 17 thru Dec. 21
Dec. 24, 26, 27, 28, 31

1952
Mar. 24 thru Mar. 28
Sept. 16 thru Sept. 19
Sept. 24 thru Sept. 26
Nov. 13 thru Nov. 14
Nov. 18 thru Nov. 19
Nov. 25 thru Nov. 26

1953
Jan. 22
Jan. 27 and Jan. 29
Feb. 3, 5, 10, 12
Feb. 17, 19, 24, 26
Mar. 3, 5
Mar. 12
May 19, 21, 26

APPENDIX G

BROADCAST CONDITIONS FOR TESTS TO EVALUATE A "PREFERRED" RELATIONSHIP BETWEEN AURAL CARRIER AND COLOR SUBCARRIER IN THE RCA COLOR TELEVISION SYSTEM

Special permission was received from the FCC in July, 1952, to transmit the RCA color television signal using proposed NTSC specifications over Channel 4 in New York City during periods normally devoted to monochrome transmissions. The purpose of the tests was to evaluate the effectiveness of a "preferred" relationship between the sound carrier and the color subcarrier frequencies to reduce the amount of heterodyne interference resulting from the color subcarrier signal in some monochrome receivers. This "preferred" relationship will exist if the aural carrier is adjusted so that the separation between the aural carrier and visual carrier is 4.5 kc greater than the normal 4.5 mc separation.

Color transmissions were made on July 9, 11 and 15 for 15-minute periods each starting at 9:45 AM. Some of these transmissions utilized normal carrier separation while others utilized the proposed "preferred" frequency relationship. Non-technical observers witnessed these tests at the Princeton Laboratories where monochrome receivers of various representative manufacturers were installed. Their response to questionnaires which were circulated has been evaluated and reported in Appendix C of Exhibit 4. In addition to these formal observations, the viewing public was also requested to submit their comments comparing the two methods of transmission, as well as comparing the test transmissions to the monochrome programs immediately preceding and following the color program. An analysis of the public's response to these tests is contained in Appendix D of Exhibit 4.

The color test transmissions originated from NBC Studio 3H, which is equipped with two RCA color cameras and associated apparatus necessary to produce a color signal in accordance with the proposed NTSC field test specifications, and were transmitted over normal NBC facilities on Channel 4 by the WNBT transmitter operating under experimental license KE2XJV. The broadcast conditions for these three test periods were as follows:

July 9th transmission—The "preferred" relationship between aural carrier and color subcarrier was maintained throughout the program. Progam material consisted of a vocal number by Connie Russell, Norman Brokenshire describing and showing various hobbies, and a ballet dance entitled "Serenata".

July 11th transmission—The aural carrier was maintained at normally assigned frequency throughout the transmission. Program consisted of tap dancer Ray Malone and Norman Brokenshire.

July 15th transmission—During the first portion of this transmission, from 9:45 to 9:52 AM, the "preferred" frequency relationship between sound carrier and color subcarrier was maintained. At 9:52 AM the aural carrier was shifted and restored to the normally assigned aural carrier frequency and this condition was maintained until the end of the test transmission. Program material consisted of Connie Russell, Norman Brokenshire and Gerri Gale.

APPENDIX H

TRANSMISSION CONDITIONS USED FOR THE SUBCARRIER COMPATIBILITY TESTS OF THE RCA COLOR TELEVISION SYSTEM IN SEPTEMBER, 1952

The National Broadcasting Company, Inc. received special permission from the FCC in September, 1952, to transmit test programs originating from color television Studio 3H over Channel 4 facilities in New York City during periods normally devoted to monochrome program transmissions. The purpose of the tests was to obtain data which could be used as a basis for evaluating and comparing the effects of various color subcarrier frequencies on monochrome receivers in public use. Test transmissions were made between 9:45 and 10:00 AM on September 16, 17, 18, 19, 24, 25, 26 and 30. For these tests each program was divided into three segments, each of approximately five minutes duration. The composition of the transmitted signal for each program segment was different and was in accordance with one of the following signal specifications:

(1) The transmitted color signal was in accordance with the proposed NTSC specifications (color subcarrier frequency—3,898,125 cps). RCA color cameras were used.

(2) Same as (1) except that a color subcarrier frequency of 3,740,625 cps was used.

(3) Same as (1) except that a color subcarrier frequency of 3,583,125 cps was used.

(4) Same as (1) except that the colorplexer modulators were disabled and reference burst was removed thereby providing a black and white picture from the color cameras.

(5) Standard black and white transmission using RCA monochrome cameras, each utilizing an 1854 image orthicon tube which is a selected 5826 studio type pickup tube. Use of this type of pickup tube results in a monochrome picture somewhat superior with respect to noise and tonal rendition to that obtained from the average monochrome studio.

(6) Same as (5) except that the monochrome camera outputs were applied to the red and green inputs of the colorplexer (encoder) adjusted in accordance with the proposed NTSC signal specifications (subcarrier frequency was 3,898,125 cps).

(7) Same as (6) except that a subcarrier frequency of 3,740,625 cps was used.

(8) Same as (6) except that a subcarrier frequency of 3,583,125 cps was used.

All transmissions were made using the optimum relationship between the frequency of the color subcarrier and the unmodulated frequency of the sound carrier. This optimum relationship is such that the difference between these two frequencies is an odd multiple of one-half the horizontal scanning frequency. The value of this relationship was confirmed in the tests which the Commission authorized us to conduct in July, 1952.

The transmitting conditions for the three segments of each test program were as follows:

SEPTEMBER 16TH TRANSMISSION

Part I (9:45-9:50 AM). Signal specification (5). Standard RCA black and white cameras were used. Color reference burst signal was *not* transmitted.

Part II (9:50-9:55 AM). Signal specification (3). RCA color cameras were used.

Part III (9:55-9:59 AM). Signal specification (1). RCA color cameras were used.

Program material for this transmission consisted of Dr. R. K. Marshall explaining the fundamentals of color perception and elementary colorimetry.

SEPTEMBER 17TH TRANSMISSION

Part I (9:45-9:50 AM). Signal specification (1). RCA color cameras were used. The program material for this segment of the transmission consisted of an announcer with card titles and a female vocalist.

Part II (9:50-9:53:40 AM). Signal specification (4). RCA color cameras were used to transmit monochrome picture information only. Program material for this segment of the transmission consisted of a hobby display.

Part III (9:53:40-9:59 AM). Signal specification (2). Program material for this segment consisted of a short drama and announcer with card titles.

On this date the noise level produced by one of the two live talent color cameras was higher than normal. Both cameras were used equally for Part I. During Part II, although both cameras shared approximately equal time on the air, the camera with high noise level was used primarily for medium wide angle shots. During Part III the camera with high noise level was used exclusively for closeup shots and was on the air approximately 20 percent of the period.

SEPTEMBER 18TH TRANSMISSION

Part I (9:45-9:50:15 AM). Signal specification (3). Program material for this segment consisted of announcer with card titles and vocal duet.

Part II (9:50:15-9:54 AM). Signal specification (2). Program material for this segment consisted of a hobby display.

Part III (9:54-9:59 AM). Signal specification (4). RCA color cameras were used to transmit monochrome picture information only. The program material for this segment consisted of a dancer and announcer with card titles.

SEPTEMBER 19TH TRANSMISSION

Part I (9:45-9:48:50 AM). Signal specification (2). Program material consisted of the announcer with card titles and a female vocalist.

Part II (9:48:50-9:54:20 AM). Signal specification (1). Program material consisted of a variety act.

Part III (9:54:20-9:59 AM). Signal specification (3). Program material consisted of a dancer and announcer with card titles.

SEPTEMBER 24TH TRANSMISSION

Part I (9:45-9:51 AM). Signal specification (8). Standard RCA monochrome cameras were used.

Part II (9:51:10-9:55:45 AM). Signal specification (5).

Part III (9:55:45-9:59:15 AM). Signal specification (6).

Program material consisted of the Kukla, Fran & Ollie set and cast.

SEPTEMBER 25TH TRANSMISSION

Part I (9:45-9:50:30 AM). Signal specification (7). Standard RCA monochrome cameras were used.

Part II (9:50:30-9:54:30 AM). Signal specification (6).

Part III (9:54:30-9:59:15 AM). Signal specification (5).

Program material for this transmission was the same as that for the September 24th transmission.

During the test on this date, modulation levels at the transmitter were higher than normal, thereby resulting in excessive white saturation for the major portion of the transmission. This condition was partially corrected during the latter half of Part III.

SEPTEMBER 26TH TRANSMISSION

Part I (9:45:15-9:50:40 AM). Signal specification (8). Standard RCA monochrome cameras were used.

Part II (9:50:40-9:55:45 AM). Signal specification (6).

Part III (9:55:45-9:59:15 AM). Signal specification (7).

Program material was similar to the programs of September 24 and September 25.

SEPTEMBER 30TH TRANSMISSION

Part I (9:45-9:49:45 AM). Signal specification (8). Standard RCA monochrome cameras were used. The program material for this date was a musical revue, this segment consisting of an announcer with card titles and a set which consisted of house, woodland scene, and cyclorama.

Part II (9:49:45-9:54:35 AM). Signal specification (5). The sets for this segment consisted of that described above and a campfire set.

Part III (9:54:35-9:59:15 AM). Signal specification (8). This segment consisted of the main set described above and announcer with card titles.

APPENDIX I

TRANSMISSION CONDITIONS USED FOR TESTS OF THE RCA COLOR TELEVISION SYSTEM IN NOVEMBER, 1952

The National Broadcasting Company, Inc. received special permission from the Federal Communications Commission in November, 1952, to transmit test programs over Channel 4 facilities in New York City during periods normally devoted to monochrome program transmissions. These programs originated in NBC's color television Studio 3H in Radio City. The purpose of the tests was to obtain data from the viewing public for use as a basis for evaluating and comparing the compatibility on black and white receivers of two conditions of color transmission, wherein somewhat different methods of encoding color information on the subcarrier were employed, together with black and white transmissions.

Test program transmissions were made on November 13, 14, 18 and 19 between 10:00 and 10:15 AM, and on November 25 and 26 between 9:45 and 10:00 AM. During these transmissions the programs were divided into three segments, each of approximately five minutes duration. The composition of the transmitted signal for each program segment was different and the viewing public was requested to submit comments comparing their reception under the three conditions of each day's transmission. An analysis of their response has been evaluated by the Opinion Research Corporation.* This report describes the signal specifications and program content used for each program segment.

The composition of the transmitted signal for each program segment was different and one of the following signal specifications was employed:

(1) The transmitted color signal was in accordance with the proposed NTSC specifications as of November, 1952. The color subcarrier frequency was 3.898125 megacycles.

(2) The transmitted color signal was modified with respect to the manner in which color information was encoded on the subcarrier. Unequal bandwidths for the two chrominance signals were employed in an effort to take further advantage of the psycho-physiological characteristics of the human eye. This method of encoding the chrominance signals also eliminates the need for using color phase alternation, as specified by the proposed NTSC standards. The transmitted color signal for this condition was essentially in accordance with the field test Specifications attached hereto as attachment 1, except that a color subcarrier frequency of 3.583125 megacycles was used.

(3) The colorplexer modulators (encoders) were disabled, thereby producing a black and white picture from the color cameras.

All color transmissions were made using the optimum relationship between the frequency of the color subcarrier and the unmodulated frequency of the sound

* This analysis is contained in Appendix G of Exhibit 4.

carrier. This optimum relationship is such that the difference between these two frequencies is an odd multiple of one-half the horizontal scanning frequency. The value of this relationship was confirmed in the tests which the Commission authorized NBC to conduct in July, 1952.

The program material for this series of tests intentionally included many saturated colors so that the maximum possible effect from the chrominance component of the received signal would be evident on monochrome receivers.

The transmitting conditions for the three segments of each test program were as follows:

NOVEMBER 13TH TRANSMISSION

Part I (10:00:07 to 10:04:05 AM). Signal specification (1).
The program material for this segment consisted of the opening announcer's set and a farm scene.

Part II (10:04:05 to 10:11:45 AM). Signal specification (3).
The colorplexer modulators were disabled and reference burst was removed, thereby producing a black and white signal from the RCA color cameras. Program material for this segment consisted of a farm scene and a greenhouse scene.

Part III (10:11:45 to 10:14:15 AM). Signal specification (2).
Program material for this segment consisted of a farm scene and the closing announcer's set.

NOVEMBER 14TH TRANSMISSION

Part I (10:00:05 to 10:04:30 AM). Signal specification (2).
The program material consisted of the opening announcer's set and a locker room scene for a football sketch.

Part II (10:04:30 to 10:11:15 AM). Signal specification (1).
The program material consisted of an apartment scene and a porch scene with a football field background.

Part III (10:11:15 to 10:14:12 AM). Signal specification (3).
The colorplexer modulators were disabled and reference burst was removed, thereby producing a black and white signal from the RCA color cameras. Program material consisted of the porch scene of Part II, the locker room scene of Part I, and the closing announcer's set.

NOVEMBER 18TH TRANSMISSION

Part I (10:00:05 to 10:03:20 AM). Signal specification (3).
The colorplexer modulators were disabled and reference burst was removed, thereby producing a black and white signal from the RCA color cameras. Program content for this segment consisted of the opening announcer's set and magician's set.

Part II (10:03:20 to 10:07:35 AM). Signal specification (2).
Program material for this segment consisted of a female vocalist and the magician's set.

Part III (10:07:35 to 10:14:20 AM). Signal specification (1). Program material for this segment consisted of a street scene with dancers, magician's set, and closing announcer's set.

NOVEMBER 19TH TRANSMISSION

Part I (10:00:06 to 10:07:00 AM). Signal specification (2). Program material consisted of opening announcer's set and a western scene with sky background.

Part II (10:07:00 to 10:10:40 AM). Signal specification (3). The colorplexer modulators were disabled thereby providing a black and white signal from the RCA color cameras. However, reference burst was transmitted during the black and white transmission segment on this date only. The program material for this segment consisted of a Western comedy sketch.

Part III (10:10:40 to 10:14:08 AM). Signal specification (1). Program material consisted of an interior cabin scene for ballet dancers, western set, and closing announcer's set.

NOVEMBER 25TH TRANSMISSION

Part I (9:45:00 to 9:50:30 AM). Signal specification (1). Program material consisted of the opening announcer's set and a stage door scene for a vocal group.

Part II (9:50:30 to 9:54:50 AM). Signal specification (3). Due to a technical switching error, the technical change to this condition occurred 35 seconds after the announcement which advised that a change in transmitting conditions was being made. The technical change was accomplished at the above indicated time. The colorplexer modulators were disabled and reference burst was removed, thereby producing a black and white signal from the RCA color cameras. Program material consisted of an Army barracks scene for a comedy sketch.

Part III (9:54:50 to 9:59:14 AM). Signal specification (2). Program material consisted of a modernistic set for vocal and dance group.

NOVEMBER 26TH TRANSMISSION

Part I (9:45:00 to 9:49:25 AM). Signal specification (2). Program material consisted of the opening announcer's set and an interior carnival scene for vocal group.

Part II (9:49:25 to 9:55:30 AM). Signal specification (1). Program material consisted of an outdoor park scene for vocal and dance group.

Part III (9:55:30 to 9:59:13 AM). Signal specification (3). Due to a technical switching error, the technical change to this condition occurred 45 seconds after the announcement which advised that a change in transmitting conditions was being made. The technical change was accomplished at the above indicated time. The colorplexer modulators were disabled and reference burst was removed, thereby producing a black and white signal from the RCA color cameras. Program material for this segment consisted of the exterior of a carnival scene for a female vocalist and the closing announcer's set.

Unfortunately, due to an alignment error which occurred during a routine maintenance measurement of the KE2XJV transmitter, the characteristics of the transmitter facilities for the November 13th and 14th test transmissions emphasized the high frequency portion of the video spectrum in such a manner that the tests on these two dates were not representative of normal transmitting conditions. This characteristic was corrected prior to the transmission of November 18th. For this reason, the transmitting conditions used on November 13th and 14th were repeated on November 25th and 26th.

ATTACHMENT 1

FIELD TEST SPECIFICATIONS

(1) The image is scanned at uniform velocities from left to right and from top to bottom at 525 lines per frame, nominally 60 fields per second, interlaced 2-to-1.

(2) The aspect ratio of the image is 4 units horizontally and 3 units vertically.

(3) The black level is fixed at 75% (± 2.5%) of the peak amplitude of the carrier envelope. The maximum white (brightness) level is not more than 15% of the peak carrier amplitude, and the minimum white level is not less than 10% of peak carrier.

(4) The horizontal and vertical synchronizing pulses are those specified in Appendix 1 of the FCC Standards of Good Engineering Practice Concerning Television Broadcasting Stations (for black and white transmissions, dated December 19, 1945, as amended October 19, 1950), modified to provide the color synchronizing signal described in Specification 20.

(5) An increase in initial light intensity corresponds to a decrease in the amplitude of the carrier envelope (negative modulation).

(6) The television channel occupies a total width of 6 mc. Vestigial-sideband amplitude-modulation transmission is used for the picture signal in accordance with Appendix II of the FCC Standards of Good Engineering Practice.

(7) The sound transmission is by frequency modulation, with maximum deviation ± 25 kilocycles, and with pre-emphasis in accordance with a 75-microsecond time constant.

(8) The radiated signals are horizontally polarized.

(9) The power of the aural-signal transmitter is not less than 50% nor more than 70% of the peak power of the visual-signal transmitter.

(10) The color signal has the following composition:

$$E_m = E_y' + \{E_Q' \sin \omega t + E_I' \cos \omega t\}$$

where

$$E_y' = .59\, E_G' + .30\, E_R' + .11\, E_B'$$
$$E_Q' = -.61\, E_G' + .28\, E_R' + .33\, E_B'$$
$$E_I' = -.28\, E_G' + .56\, E_R' - .28\, E_B'.$$

Notes: In this expression the symbols have the following significance:

E_m is the total video voltage, corresponding to the scanning of a particular picture element, applied to the modulator of the picture transmitter.

E_y' is the gamma-corrected voltage of the monochrome (black and white) portion of the color signal, corresponding to the given picture element. This signal carries all of the luminance information.

E_Q' and E_I' are two gamma-corrected orthogonal components of the color signal.

E_G', E_R', and E_B' are the gamma-corrected voltages corresponding to the green, red and blue signals intended for the color picture tube, during the scanning of the given picture element.

ω is 2π times the frequency of the color carrier. The phase reference of this frequency is such that the color synchronizing signal (see Specification 20 below) corresponds to an amplitude modulated signal of the form $\cos \omega t$. t is the time.

The portion of the expression between brackets represents the color subcarrier signal which carries the chromatic information.

(11) The primary colors referred to by E_R', E_G' and E_B' have the following chromaticities in the I.C.I. system of specification:

	x	y
Red (R)	0.67	0.33
Green (G)	0.21	0.71
Blue (B)	0.14	0.08

The color signal is so proportioned that when the color subcarrier vanishes, the chromaticity reproduced corresponds to illuminant C(x = 0.310, y = 0.316).

(12) Gamma correction is such that the desired pictorial result is obtained on a display device having a transfer gradient (gamma exponent) of 2.75. The equipment used is capable of an overall transfer gradient of unity on a display device having a transfer gradient of 2.75. The voltages E_y', E_I', E_Q', E_R', E_G' and E_B' in the expression in Specification 10, above, refer to the gamma-corrected signals.

(13) The color subcarrier frequency is 3.579545 mc ± .0003%, with a maximum rate of change not to exceed 1/10 cycle per second per second.

(14) The horizontal scanning frequency is 2/455 times the color subcarrier frequency. This corresponds to nominally 15,750 cycles per second.

(15) The bandwidth assigned to the monochrome signal E_y' is in accordance with the FCC standard for black and white transmissions, as noted in Specification 6 above.

(16) The bandwidth assigned to the chromatic signals E_Q' and E_I' is for E_Q' not less than 400 kc at 2 db attenuation and not more than 600 kc at 20 db attenuation; and for E_I' not less than 1.2 mc at 2 db attenuation and not more than 3.5 mc at 20 db attenuation, and with the envelope delay constant $\pm$ 0.5 μsec.

(17) E_y', E_Q', and E_I' are all matched to each other in time to within $\pm$ .05 μsec.

(18) The bandwidth assigned to the modulated color subcarrier extends to at least 1.5 mc at 2 db attenuation below the color subcarrier frequency and to at least 0.6 mc at 2 db attenuation above the color subcarrier frequency and with the envelope delay constant $\pm$ 0.5 μsec between the 6 db points.

(19) A sine wave introduced at those terminals of the transmitter which are normally fed the color picture signal shall produce a radiated signal having an envelope time delay, relative to 0.1 mc, of 0 μsec up to a frequency of 2.5 mc; and then linearly decreasing to 4.3 mc so as to be equal to -0.26 μsec at 3.579545 mc. The tolerance on all these delays shall be $\pm$ 0.05 μsec relative to the delay at 0.1 mc.

(20) The color synchronizing signal is that shown in Figure 1. This signal corresponds to amplitude modulation of a continuous sine wave of frequency $\omega/2\pi$.

(21) Signals outside the assigned channel shall be attenuated at least 60 db below the peak visual signal amplitude.

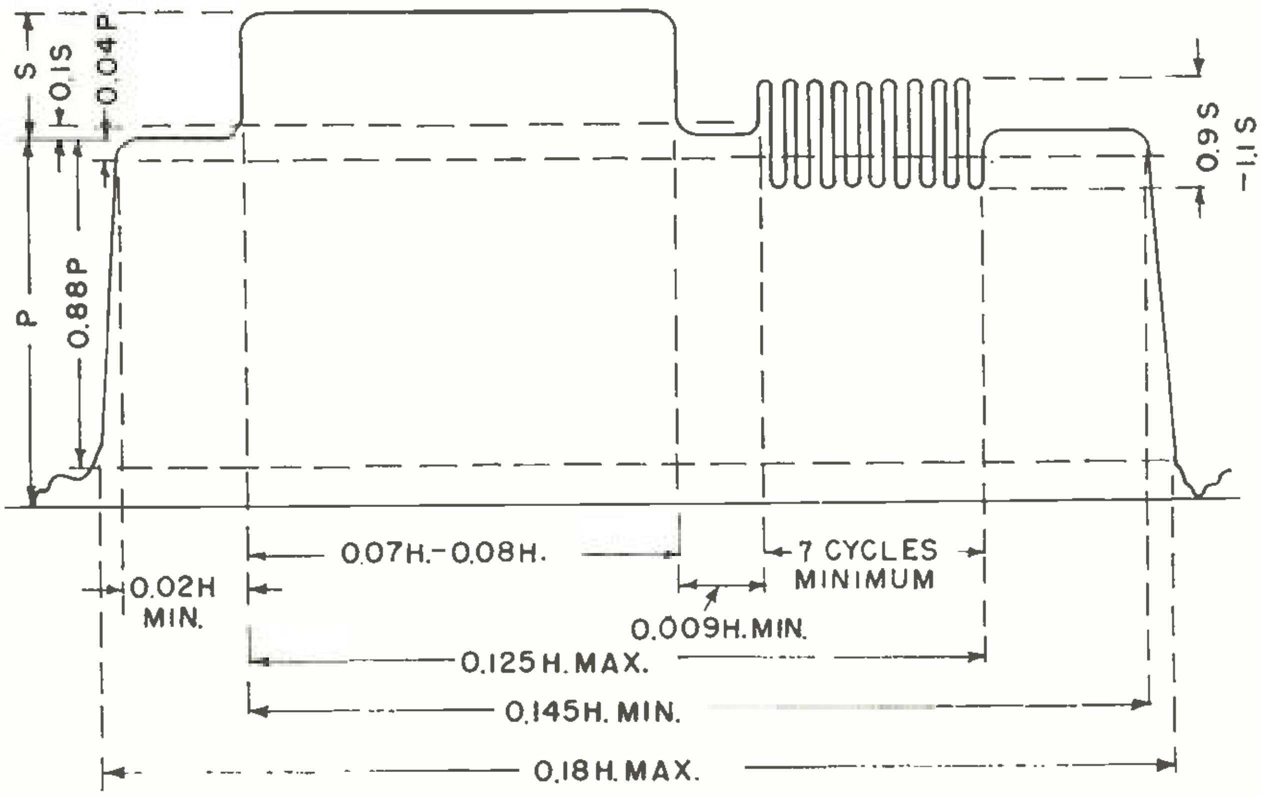


Fig. 1—Proposed field test synchronizing wave form.

Notes on Figure 1

1. The radio frequency signal, as radiated, shall have an envelope as would be produced by a modulating signal in conformity with the above figure, as modified by the vestigial transmission characteristics of the transmitter.
2. The burst frequency shall be 3.579545 mc ± .0003% with a maximum rate of change of frequency not to exceed 1/10 cycle per second per second.
3. The horizontal scanning frequency shall be 2/455 times the burst frequency.
4. Burst follows each horizontal pulse but is omitted following the equalizing pulses and during the broad vertical pulses.
5. Vertical blanking 0.07 to 0.08V.
6. Burst time interval shown indicates start and stop of burst but not necessarily the existing phase angle of burst.

EXHIBIT 11

NETWORKING RCA COLOR TELEVISION

NETWORKING RCA COLOR TELEVISION

INDEX

EXHIBIT 11

NETWORKING RCA COLOR TELEVISION

PART I

Introduction

ANY color television system to be acceptable must be capable of transmission over available networking facilities. The American Telephone and Telegraph Company normally provides two distinct types of long-distance television transmission; the microwave relay system designated as TD2 and the coaxial cable system designated as L1. The microwave circuits have a bandwidth of somewhat more than 4 megacycles and are capable of transmitting good quality pictures either in black and white or in compatible color.

As the signals from the RCA color television system contain more energy at the high frequency end of the band than regular black and white signals, due to the use of a color subcarrier, particular attention must be given to the preservation of the amplitude, phase and linearity characteristics at the higher frequencies. These tolerances are likewise necessary for the transmission of high-quality monochrome signals although quality degradation as a result of departure therefrom is not as readily perceptible to the public in monochrome pictures as in color pictures.

The bandwidth of the coaxial cable system (L1) is limited nominally to 2.7 megacycles, thus limiting the amount of information which can be transmitted over it either in monochrome or in color.

In monochrome television transmission the energy content of the higher-frequency components of the picture signal is relatively small compared to that of the lower-frequency components. A loss of these higher-frequency components results in a picture of reduced detail, but the picture is acceptable. However, a color signal has all of the chrominance information at the high end of the video spectrum. A loss of these components results in a picture with little or no color. The bandwidth of a network transmission path, therefore, becomes of major importance.

While it is anticipated that microwave relay circuits and coaxial cables capable of carrying a signal having 4 mc bandwidth will serve most areas in the future, it is also expected that some areas will continue to be served for a long time only with L1 cable facilities. It is therefore essential to provide equipment that will transmit color signals over a 2.7 mc bandwidth system.

When a standard monochrome television signal containing information out to 4 mc is passed over the 2.7 mc cable, the picture definition is reduced accordingly.

This exhibit discusses the utilization of standard networking facilities by RCA-NBC for the transmission of color television signals and describes the terminal equipment used with L1 cable circuits.

PART II

TRANSMISSION TESTS USING MICROWAVE FACILITIES

Numerous tests have been made over the past few years to evaluate the performance of regular intercity Bell System television transmission facilities for color transmission. Field tests of the RCA color television system were held in Washington, D. C., three times a day on October 9, 10, 11, 12, 13, 15, 16, 17, 18, and 19, 1951. The standard intercity Bell System microwave facilities were used for these tests.[1] The color television signals originated in New York City and were transmitted to Washington, D. C., where they were viewed by a number of persons. The demonstrations consisted of both studio and remote field pick-up programs. The color subcarrier frequency used in these tests was 3.583125 megacycles per second.

Other technical transmission tests of compatible color television signals have been made between New York and Washington, D. C., on several occasions over the past two years. Nominal color subcarrier frequencies of 3.583125 and 3.898125 and 3.579545 megacycles per second have been used. Some of these observations were made one way, viewing the signal in Washington, D. C., while others were made by viewing the results in New York employing a looped circuit between New York and Washington, D. C.

A transmission test of the RCA color television system on May 18, 1952, included the viewing in New York of color signals after a round trip to Toledo, Ohio.

Some of the more recent transmission tests and demonstrations using a color subcarrier frequency of 3.579545 megacycles included the following:

1. January 30, 1953. New York to Washington and return. Test was observed by NBC, RCA, and Bell System engineers.

2. February 16, 1953. New York to Washington and return. Test was observed by NBC, RCA, and Bell System engineers.

3. March 21, 23, and 24, 1953. Several New York originated color programs were viewed on each of three days in Washington, D. C. The program transmissions were witnessed by engineers and officials of NBC, RCA, and the Bell System.

[1] Simultaneously, color signals were also transmitted to Washington over L1 cable facilities using terminal equipment to be described later.

4. March 27, 1953. Members of Panel 17, NTSC, witnessed at Astoria, Long Island, a test transmission to Washington and return.

5. May 19, 21 and 26, 1953. Special demonstrations of the RCA color system for members of the Federal Communications Commission and others were given in Princeton, New Jersey. The program originated in New York and was transmitted to Princeton over two types of Bell System microwave facilities in tandem.

All of the above tests which have been made included the use of one or more local video loops in addition to the regular intercity microwave facilities. Thus they simulated the conditions which would be encountered in normal commercial network operations.

PART III

Terminal Equipment for Use with Cable Facilities

It has been pointed out that the color information in signals using the NTSC signal specifications is contained, to a very large extent, in frequencies near the color subcarrier. If a color signal is to be sent over a network facility with restricted bandwidth and still produce a color picture at the remote point, the signal must be modified so as to locate the color information within the passband of the system. Two basically different methods for transmitting RCA color television signals over the presently used coaxial cables, which retain color information and accept the loss of resolution corresponding to that suffered by a monochrome signal over the same transmission medium, will be described.

PART IV

Sampler Type Equipment

Figure 1 shows a diagram of the first method of transmission used in 1950. The normal color system components are shown with dashed lines at the left. The components added for the low-frequency cable transmission are shown with solid lines at the right.

For transmission over the coaxial cable the subcarrier was lowered so that frequency components around it, containing color information, could be passed over the cable. This means the frequency must be lower than 2.7 mc. In addition, the frequency must be related to the normal color subcarrier frequency by a ratio of integers, so that circuit elements can multiply and divide to arrive at the cable subcarrier frequency. Thus for any given normal color subcarrier frequency the proper factors must be found to arrive at an acceptable lowered carrier for coaxial cable transmission.

The crystal oscillator which provided the sampling signal of 3,583,125 cycles[2] fed into a regenerative multiplier which produced a sampling signal which is exactly two-thirds the frequency of the normal sampling signal, namely, 2,388,750 cycles. This latter signal, together with the synchronizing signals and the simultaneous green, red and blue signals from the camera were fed to a transmitter-type sampler especially provided at the originating station. The output of this sampler then was fed into the coaxial cable. A color synchronizing burst with a frequency of 2,388,750 cycles was placed on the back porch of the horizontal synchronizing pedestal for transmission over the cable. At the receiving end of the cable, a receiver-type sampler was provided, with sampling of each color taking place at a rate of 2,388,750 times per second. Low-pass filters, with cutoff below this sampling frequency, were placed in the green, red and blue outputs of this sampler. These three signals were then used to feed a normal transmitter sampler at the station which was being programmed by the coaxial cable transmission. The 2,388,750-cycle burst over the cable was multiplied up to 3,583,125 cycles to provide the sampling control for the latter station.

Equipment operating in the manner just described was built early in 1950. After testing it was used on April 6, 1950, for a demonstration for the Federal Communications Commission. Except for the expected loss of resolution, the pictures were equivalent to the wideband pictures. Because of the time at which the demonstration was held, it was impossible to use actual A.T. & T. cables; therefore a filter (supplied by A.T. & T.) that simulated the cable was used. The earlier tests had shown a nice correlation between signals sent over actual cables and those sent through a filter.

PART V

Sampler Type System Using Mixed Highs

The method shown in Figure 1 is a direct approach to the problem of transmitting the color information over the limited bandwidth coaxial cable. A second method is shown by the block diagram of Figure 2. This version applies mixed highs to utilize more effectively the bandwidth available for transmission. Color information is transmitted with detail up to 0.3 mc, with signal mixing to apply mixed highs extending upward from 0.3 mc.

Equipment following this design was built and tested in the laboratory and gave satisfactory results. The system was never demonstrated because

[2] Color subcarrier frequencies referred to here and later are those in experimental use at the time the equipment was built.

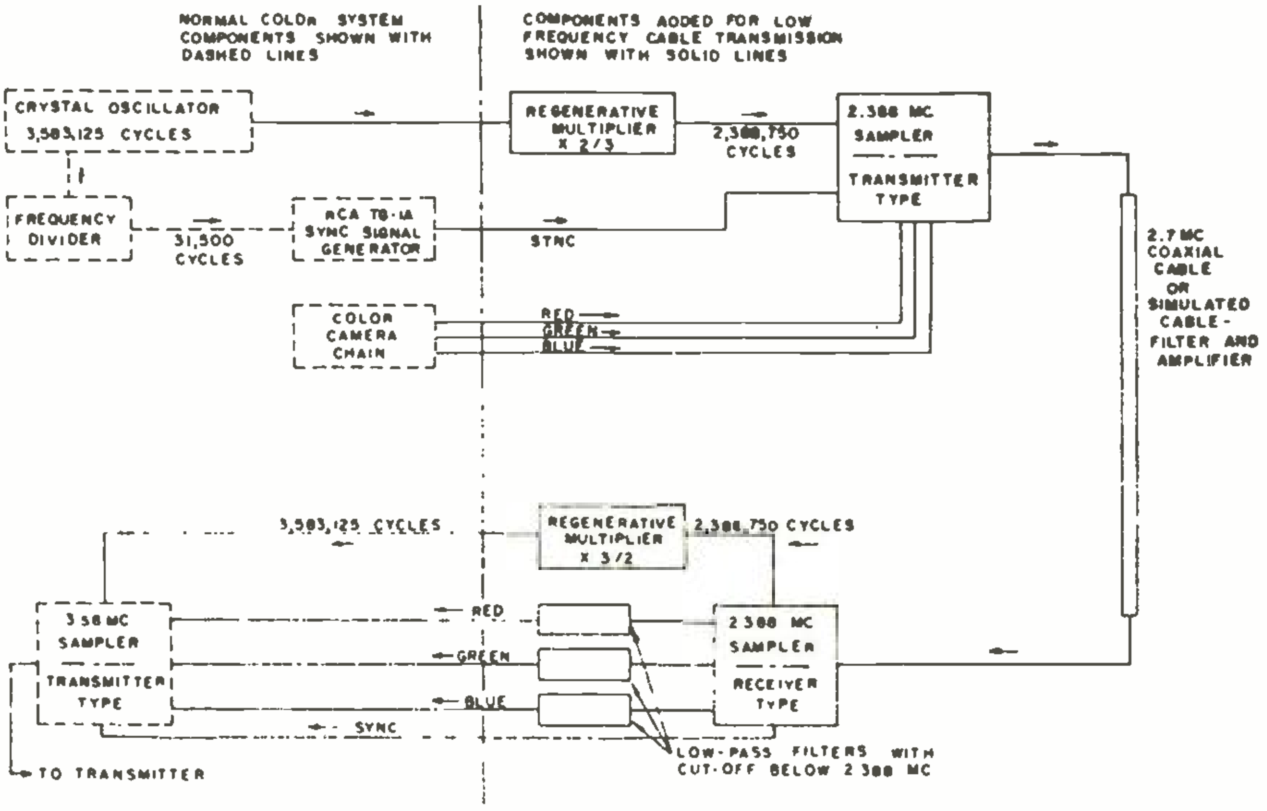


Fig. 1 — Block diagram of the equipment used to transmit color television signals over coaxial cables of restriced bandwidth.

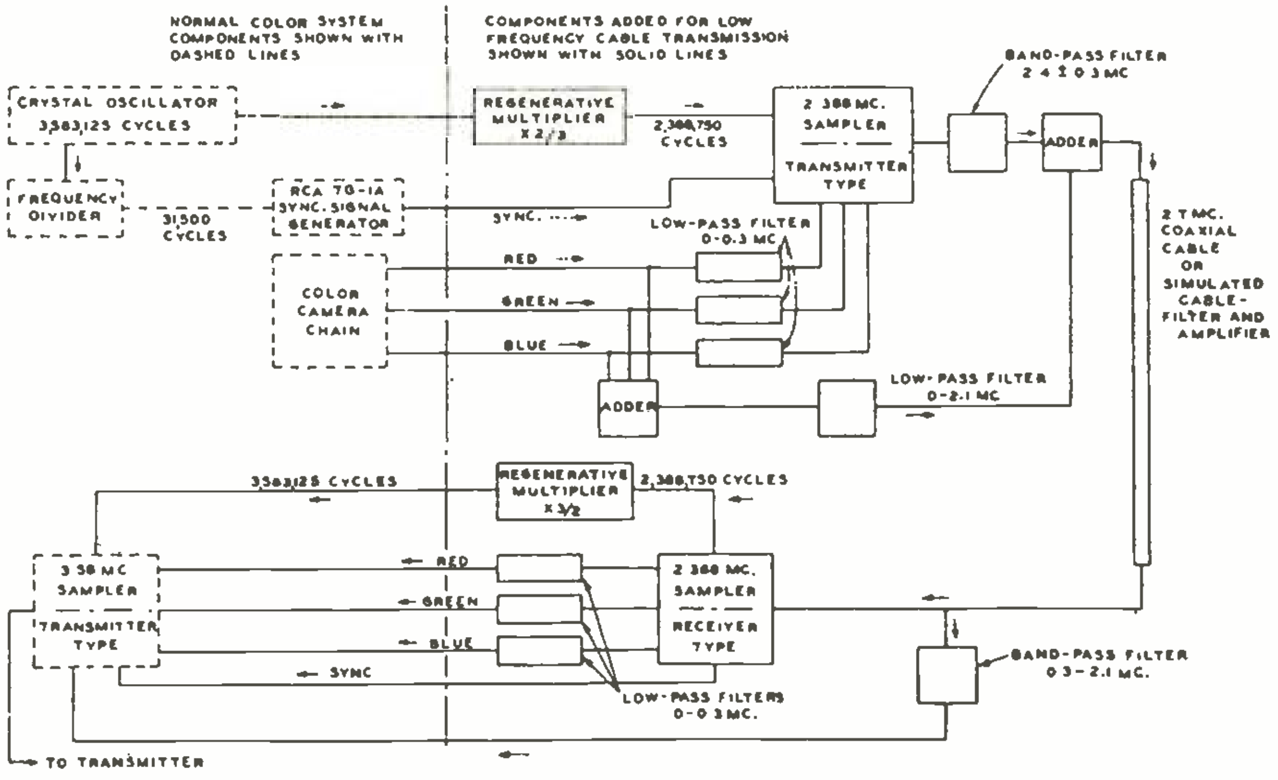


Fig. 2 — A modification of the cable equipment which makes more effective use of the available band.

a different and much more attractive approach was proposed about the time this equipment was completed. The transmit portion of this equipment was used, however, for a demonstration which will be described later.

PART VI

Filter and Heterodyne Equipment for 3.58 MC Subcarrier

Reference to Figures 1 and 2 will show that the first method of producing a color signal suitable for cable transmission is satisfactory if the cable translating equipment is located where the three simultaneous color signals are available. If the equipment were to be used at the end of a microwave link (at a point remote from the origin of the signals) to feed a coaxial link, considerable equipment would be required to re-create the three simultaneous signals to feed the 2.388 mc sampler. This difficulty, as well as much of the complexity of the equipment, is eliminated by utilizing a "filter and heterodyne" method.

The RCA color signal in use at that time could be considered as consisting of a brightness component extending from zero to 4.1 megacycles and a color component made up of a color subcarrier at 3.58 megacycles[3] and sidebands extending out approximately 2 megacycles. The upper sideband is restricted by overall bandwidth limitations of the television system so that the upper sideband is cut off above 4.1 megacycles.

In order to transmit this color signal over a 2.7 megacycle coaxial cable, it is necessary to change the color subcarrier frequency from 3.58 megacycles to a lower value which is within the passband of the cable.

Basically, the terminal equipment selects the color carrier and a limited number of its side bands from a composite color signal. The selected carrier and its side bands are then heterodyned to a frequency low enough to be passed by the band-restricted circuits. Another network, containing a low-pass filter, selects the low-frequency components or brightness information from the composite signal.

The newly derived color subcarrier is combined with the selected brightness information to form a composite color signal for cable transmission.

At the receiving location, the color carrier and its side bands are again selected, by means of a band-pass filter. These are then heterodyned back to their original values. At the receiver another low-pass filter removes the brightness information from the composite signal. The brightness components are then added to the re-created color carrier to produce the color signal for normal transmission and reception. A detailed description of this type of conversion equipment follows.

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[3] Nominal frequencies are used to avoid repetition of the more exact figure, such as 3.583125 mc.

A. Transmitting Terminal Equipment

A block diagram of the transmitter is shown in Figure 3. The composite signal is passed through a Bode-type, low-pass filter having its first infinite rejection at 2.0 megacycles. This provides the brightness information. The composite signal is also passed through a band-pass filter centered about 3.58 megacycles with a flat response from 3.28 megacycles to 3.88 megacycles and having infinite rejection points at 2.4 megacycles and 4.8 megacycles.

This color information (3.58 ± .3 mc) is heterodyned with a 5.96-mc signal and the difference frequency of of 2.38 ± .3 mc is selected by another band-pass filter to provide the color signal components for the cable. Thus the color signal which is transmitted over the cable is composed of a brightness component with a frequency band from zero to 2.0 megacycles and a color signal extending from 2.08 to 2.68 megacycles.

In the heterodyning process, certain signals result in addition to the wanted ones and these could produce beats within the wanted signal band. It is necessary, therefore, to include several high-rejection traps throughout the system. In the channel where the narrowband color information is selected from the composite signal, traps are placed at 2.38 and 4.8 megacycles. The 2.38 mc trap eliminates components falling on and around the new color subcarrier. The 4.8 mc trap eliminates components which would beat with the second harmonic of the 3.58 mc subcarrier (produced in the hetero-

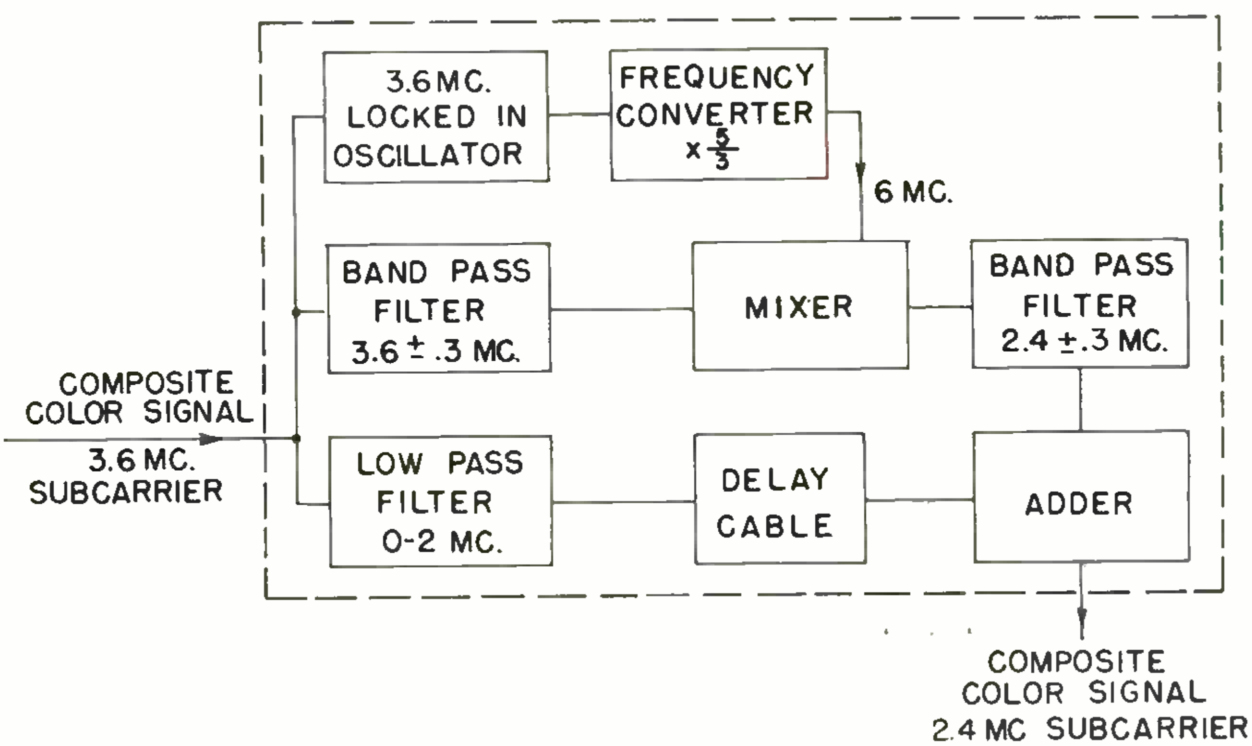

Fig. 3 — Cable transmitting heterodyne system.

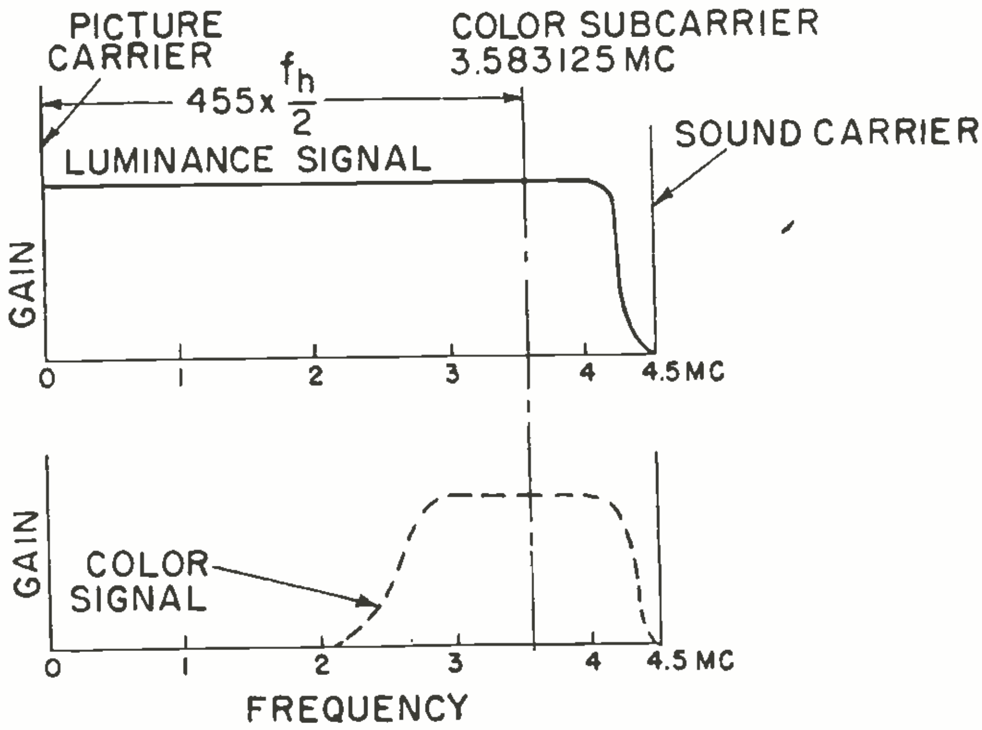

Fig. 4a — Composite signal.

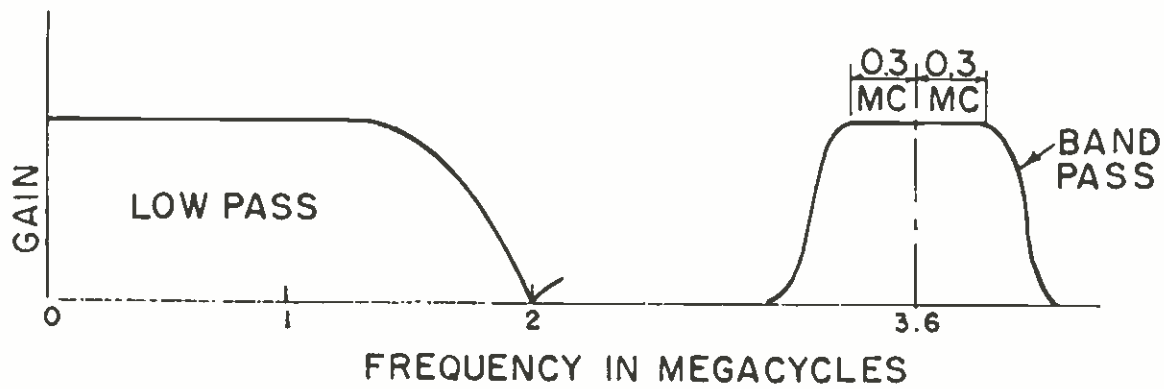

Fig. 4b — Filtered signal.

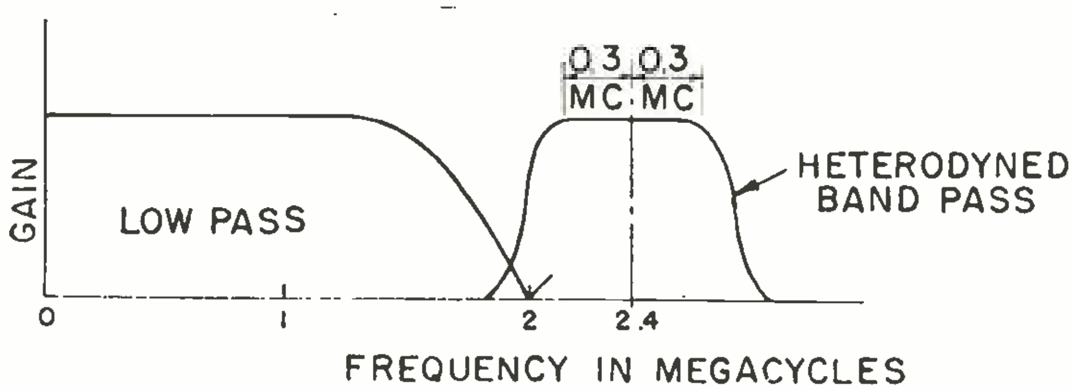

Fig. 4c — Heterodyned signal.

dyning stage) and produce undesirable components near the 2.4 mc subcarrier frequency. In the section which selects the difference frequency (2.38 ± 0.3 mc) two traps are employed; one at 1.2 megacycles to eliminate signals having a second harmonic near the color subcarrier; and one at 3.58 megacycles to eliminate the incoming color subcarrier. An additional trap, tuned to 5.96 megacycles, removes the injected heterodyning signal from the output.

B. Receiving Terminal Equipment

A block diagram of the receiver terminal equipment is shown in Figure 5. The receiving equipment contains a 0-2 mc, Bode-type, low-pass filter which selects the brightness component from the composite cable signal and a 2.08 to 2.88 mc band-pass filter which selects the color components.

The selected color components are heterodyned with a 5.96 mc signal and the difference frequency (3.28 to 3.88 mc) is selected by another band-pass filter.

As in the transmitter, traps must be employed to eliminate frequencies which would produce undesired beats in the final picture.

The 3.28 to 3.88 mc band-pass filter contains four such traps. One is set to reject 1.2 megacycles which is produced as a result of the second harmonic of 2.38 beating with the 5.96 mc heterodyning signal. Another is set to reject 5.96 mc which is the heterodyning signal. A third trap is set at 2.4 megacycles which rejects the cable-signal color-carrier frequency and the fourth trap is set to reject 4.8 mc which is the second harmonic of the cable 2.4 mc subcarrier. The low-pass filter contains a 2.4 mc rejection trap to eliminate the 2.4 mc subcarrier from the filter output.

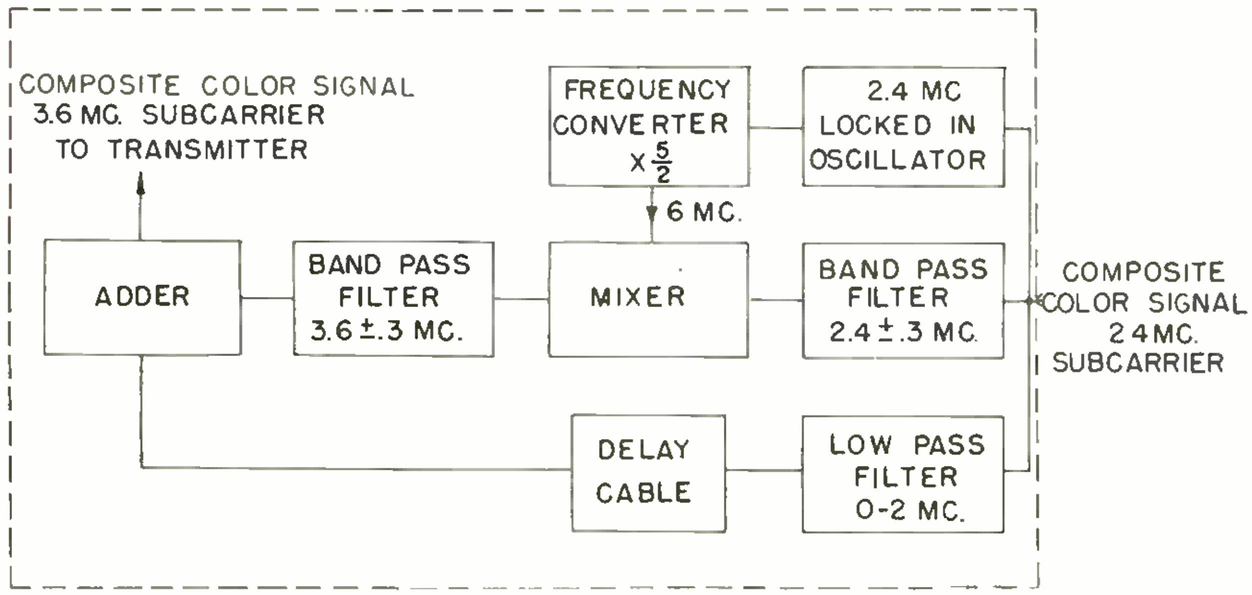

Fig. 5 — Cable receiving heterodyne system.

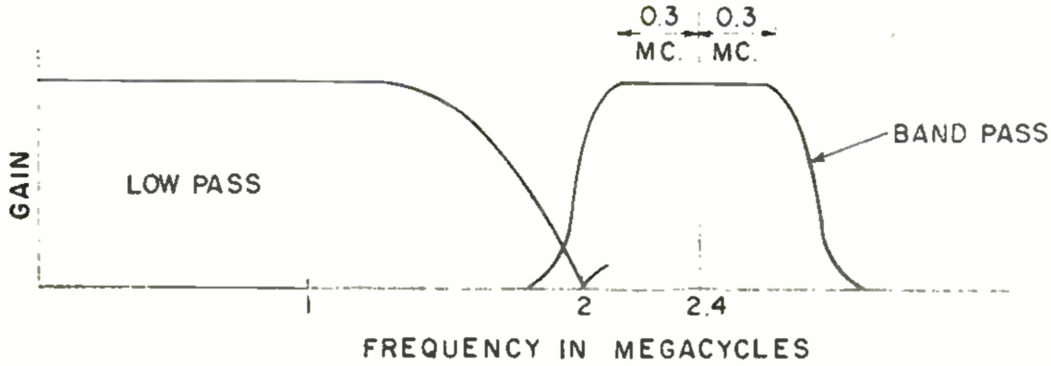

Fig. 6a – Cable signal.

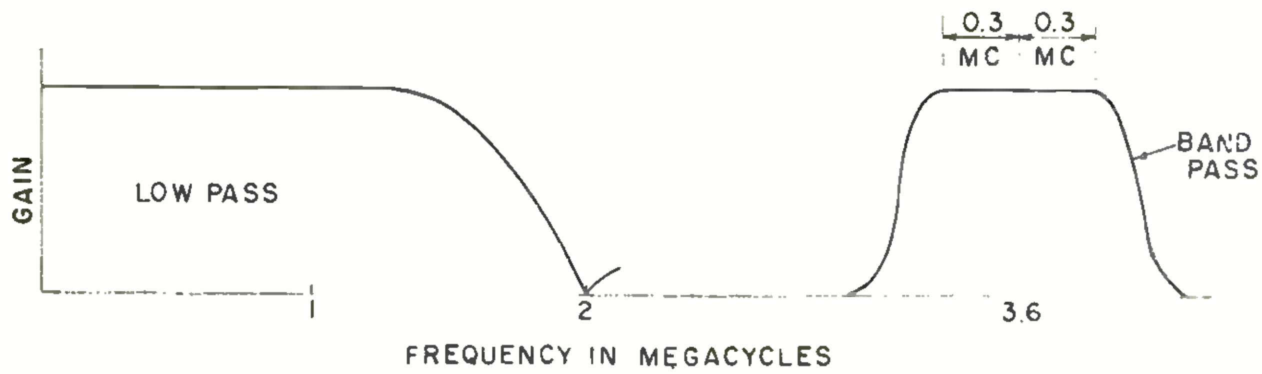

Fig. 6b – Heterodyned signal.

In order to provide an interlaced picture in the final receivers, it is necessary to lock in the 5.96 mc heterodyning signal with the 3.6 mc sampling signal employed at the color signal source.

In the cable transmitting portion of the system, a burst selector, operated from the horizontal synchronizing pulses, selects the burst and uses it to lock in a 3.58 mc oscillator. The 3.58 mc signal is divided by 3 and multiplied by 5 to produce the 5.96 mc heterodyning signal.

At the receiving terminal, a similar burst selector selects the 2.38 mc burst and uses it to lock in a 2.38 mc oscillator. The output from the 2.38 mc oscillator is divided by 2 and multiplied by 5 to produce the 5.96 mc receiver heterodyning signal.

This heterodyning process is shown by Figure 6.

C. 1950 Cable Tests

The first equipment built that utilized the "filter and heterodyne" method was a receiving unit. It was constructed in July, 1950, and on August 1, 1950, it was first used for an actual cable test in New York City.

The transmitter portion of the system shown in Figure 2 was set up in Washington, D. C., and pictures generated there were sampled at the 2.38 mc[4] rate and fed to the cable. At NBC in New York City, the heterodyne

[4] See note 3 *supra*.

type receiving equipment converted the cable signal received from Washington to a picture using a 3.58 mc subcarrier. This was radiated using the facilities of WNBT (KE2XJV) and observed at both New York and at the RCA Laboratories in Princeton. The results were considered very satisfactory.

The same set-up was used on August 7, 1950, to radiate color signals in New York that were generated in Washington. In addition, the wideband signal was carried by microwave to Bridgeport, Conn., and radiated from KC2XAK, the NBC experimental UHF station located there.

Between the summer of 1950 and the fall of 1951, color operations were moved for the most part from Washington to New York. During this interim, a heterodyne type transmitting equipment was built so that this method could be used at both ends of a 2.7 mc bandwidth system. This meant that it was no longer necessary to feed the three simultaneous color signals to the transmit conversion equipment. A composite signal, either from a local or a remote source was all that was needed.

D. Cable and Microwave Relay Tests in 1951

A complete heterodyne type system was first used for actual cable relays in September, 1951. In the period September 10 to 20, 1951, the receiving equipment was installed in Washington, tests were made using both microwave and cable network facilities, and preparations were made for a series of demonstrations to show the progress made with the RCA color television system.

The heterodyne type cable equipment in use at that time operated from a composite color signal utilizing a 3.58 mc subcarrier frequency. It produced a 2.7 mc signal for transmission over the cable in which the color subcarrier was 2.39 mc.[5] The reconstructed signal at the receiving terminal contained brightness detail up to 2 mc and color detail up to 0.3 mc.

A series of demonstrations was given in the Trans-Lux Building, Washington, D. C., October 9, 10, 11, 12, 13, 15, 16, 17, 18, and 19, 1951. The same signals were used in New York for additional field testing.

The programs in color originated in the NBC Studio 3H in Radio City, New York. In the morning hours, the program was radiated on Channel 4 in New York using the facilities of WNBT and operating under the experimental call letters KE2XJV.

The color programs were sent simultaneously to Washington, D. C., over standard intercity networking facilities of the Bell System by two separate and distinct methods; the unmodified color signal by the TD2 microwave relay and the color signal, modified by the transmitting terminal cable equipment, by the L1 coaxial cable.

In the morning hours the signal was radiated in Washington on Channel 4, using the facilities of WNBW and operating under the experimental call

[5] See note 3 *supra*.

letters KG2XDE. The signals were received on color receivers and on conventional black and white receivers located in the Trans-Lux Building. During the afternoon hours, when the facilities of WNBW were not available, the signals arriving in Washington via microwave or coaxial cable were used to modulate small transmitters which in turn fed a radio frequency signal directly to the demonstration receivers. During each day the network facilities were switched many times from microwave to cable and vice versa.

A block diagram of the New York-Washington system is shown in Figure 7.

Results were very satisfactory. Observers were pleased with the pictures received by microwave and quite surprised at the small degradation of the pictures recovered from the coaxial cable signals.

PART VII

Filter and Heterodyne Equipment for 3.89 MC Subcarrier

On November 26, 1951, the NTSC released for publication color field test specifications. These specified a change in the color subcarrier frequency from 3,583,125 cycles to 3,898,125 cycles. This, of course, necessitated a change in the heterodyne type cable equipment. Since the equipment had to be revised for the new subcarrier, it also was an opportune time to investigate certain other modifications, particularly in the method for obtaining the required heterodyning frequencies. The first equipment, as previously described, employed frequency dividers. The equipment built for the 3.89 mc subcarrier utilized an oscillator operating at the lowest required frequency. The oscillator was multiplied by one factor which brings the frequency up to that of the subcarrier. This then was used for comparison in a phase detector with the output controlling the original oscillator. By multiplying the oscillator frequency by a different factor the required heterodyning frequency was obtained.

A. Transmitting Terminal Equipment

At the transmitting terminal, the 3.898125 mc subcarrier and sidebands extending ±300 kc were selected from the composite color signal by means of a band-pass filter. Also a portion of the brightness components extending from 0 to 2.0 mc was selected by means of a low-pass filter. A 6.237000 mc signal was obtained from the 3.898125 mc synchronizing burst by circuits set to divide by 5 and multiply by 8. The 6.237000 mc signal was then heterodyned with the selected color subcarrier and the difference frequency of 2.338875 ± .3 mc was selected by means of another band-pass filter. This subcarrier was then added to the 0-2 mc brightness information to form the composite cable color signal. Thus, the cable signal consisted of two components, a brightness or black and white signal with frequencies extending from 0 to 2.0 mc, and a color signal with frequencies extending from 2.039 to 2.639 mc.

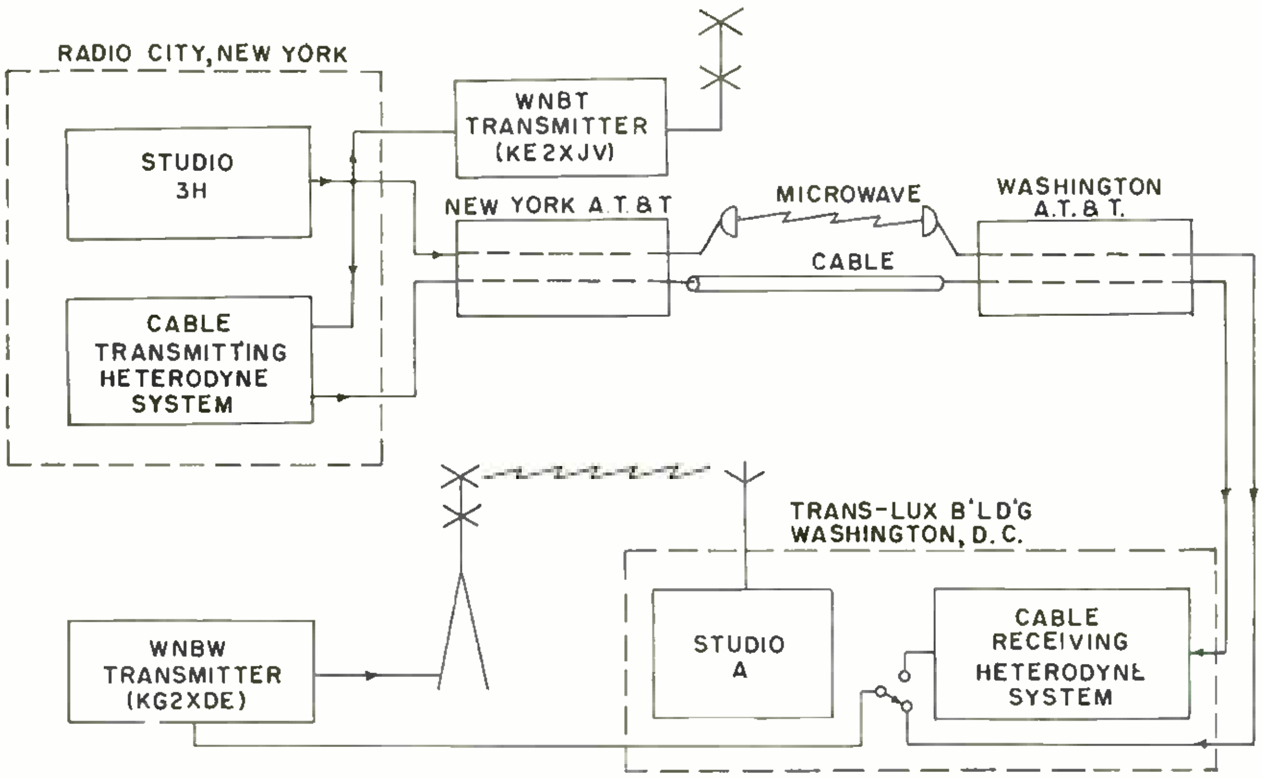

Fig. 7—New York to Washington network system.

B. Receiving Terminal Equipment

At the receiving location, the 2.039 to 2.639 mc components were selected by a band-pass filter similar to that in the transmitter. Also, the 0 to 2.0 mc components were selected by a low-pass filter identical to that used at the transmitter. The 2.338875 mc synchronizing burst, which was selected from the composite cable signal, was divided by 3 and multiplied by 5 to produce a 6.237000 mc heterodyning signal identical to that produced at the transmitter. The 6.237000 mc signal was heterodyned with the $2.338875 \pm .3$ mc color carrier and the difference frequency of $3.898125 \pm .3$ mc selected by another band-pass filter. The 0 to 2 mc brightness signal was then combined with the $3.898125 \pm .3$ mc color subcarrier to form the composite color signal. Thus, the frequency components of the re-created signal consisted of a brightness signal extending from 0 to 2.0 mc and a color signal extending from 3.598 to 4.198 mc.

A photograph of this equipment is shown in Figure 8. The transmitting rack is on the right and the receiving rack, complete with stabilizing amplifier, is on the left. These units are typical of each of the versions of heterodyne type cable translating equipment.

C. Cable and Microwave Tests in 1952

The equipment just described was used in tests carried on in collaboration with A.T. & T. representatives on February 4 and 5, 1952. The pictures produced were about as expected from previous tests with the heterodyne type equipment. It was noted that defects existing in the picture

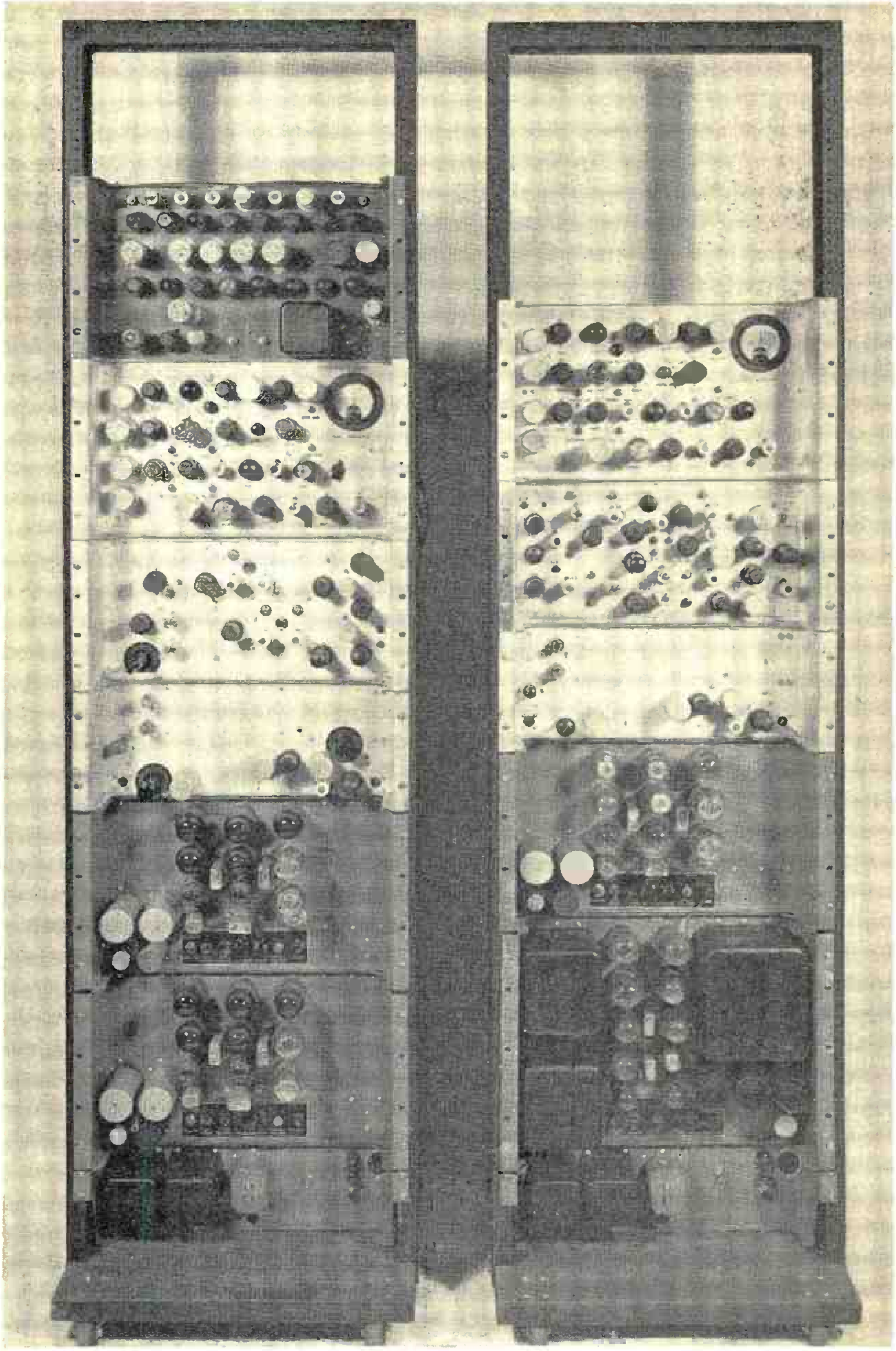

Fig. 8 — Receiving terminal equipment.

fed to the transmitting terminal were somewhat exaggerated by the heterodyning and narrow band transmission.

On February 26, 1952, tests were again conducted. Results were not entirely satisfactory because of high noise level and poor frequency response of the cable facilities. One important defect was noted, particularly on monochrome receivers. A rather weak fixed frequency beat pattern was noted in pictures received through the conversion equipment. It was discovered that this beat was a result of the choice of the cable subcarrier frequency. As has been shown in interference tests, frequencies that are even multiples of one half line frequency are most visible in a television picture. For the cable subcarrier frequency used in this equipment, the beat between the two subcarriers was such a multiple. By generous use of traps, this beat was minimized.

The equipment was used again on June 18, 1952, in a demonstration for NBC and A.T. & T. groups. The cable facilities were in good condition and the pictures produced were very good.

PART VIII

Present Filter and Heterodyne Equipment

In the fall of 1952, the trend was toward a return to the 3.58 mc subcarrier frequency. Accordingly, during October and November of 1952, new heterodyning equipment was built and tested in the laboratory. This equipment utilized the same basic design as the 3.89 mc equipment with only

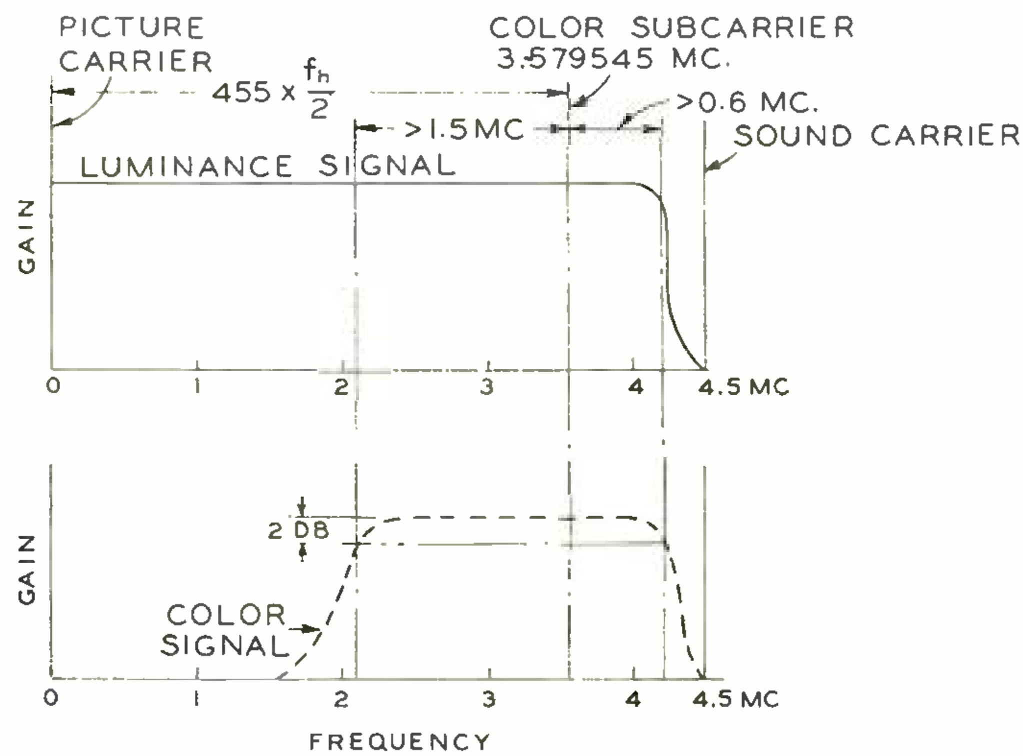

Fig. 9 — Video spectrum of the color television signal.

minor circuit modifications to simplify and improve the operation. A subcarrier frequency was used this time for the cable signals which did not produce a visible beat thereby eliminating this problem.

The complete video spectrum of a color signal, based on the NTSC field test signal specifications as published February 2, 1953, is shown in Figure 9; f_h is the horizontal scanning frequency of nominally 15,750 cycles.

Figure 10 shows a block diagram of the transmitter terminal equipment which alters the color signal for narrow band transmission. First, a linear-phase-shift low-pass filter selects the luminance components extending out to 2 mc. An m-derived band-pass filter selects the components which extend .3 mc on each side of the subcarrier frequency f_s, 3.579545 mc. This band is then lowered by heterodyning in a mixer with a sine wave voltage whose frequency is 5/3 times the color subcarrier frequency, f_s, or 5.965909 mc. A second m-derived band-pass filter follows the mixer. This filter selects only the difference frequency components, which extend .3 mc on each side of 2/3 f_s, or 2.386364 mc. This band around 2.386364 mc is then added to the low-pass band to give a spectrum as shown in Figure 11. All components which were originally near 3.579545 mc are now near 2.386364 mc. In effect, the subcarrier has been lowered. The synchronizing burst is now a burst of 2.386364 mc. The spectrum of Figure 11 can now be transmitted over a system limited to about 2.7 mc.

Figure 12 shows the block diagram of the receiver terminal equipment which must translate the 2.386364 mc subcarrier back to 3.579545 mc. Another linear-phase-shift low-pass filter selects the luminance components extending out to 2 mc. An m-derived band-pass filter selects the components extending .3 mc on each side of 2.386364 mc. This band is then heterodyned in a mixer with a signal whose frequency is again 5/3 f_s, as in the trans-

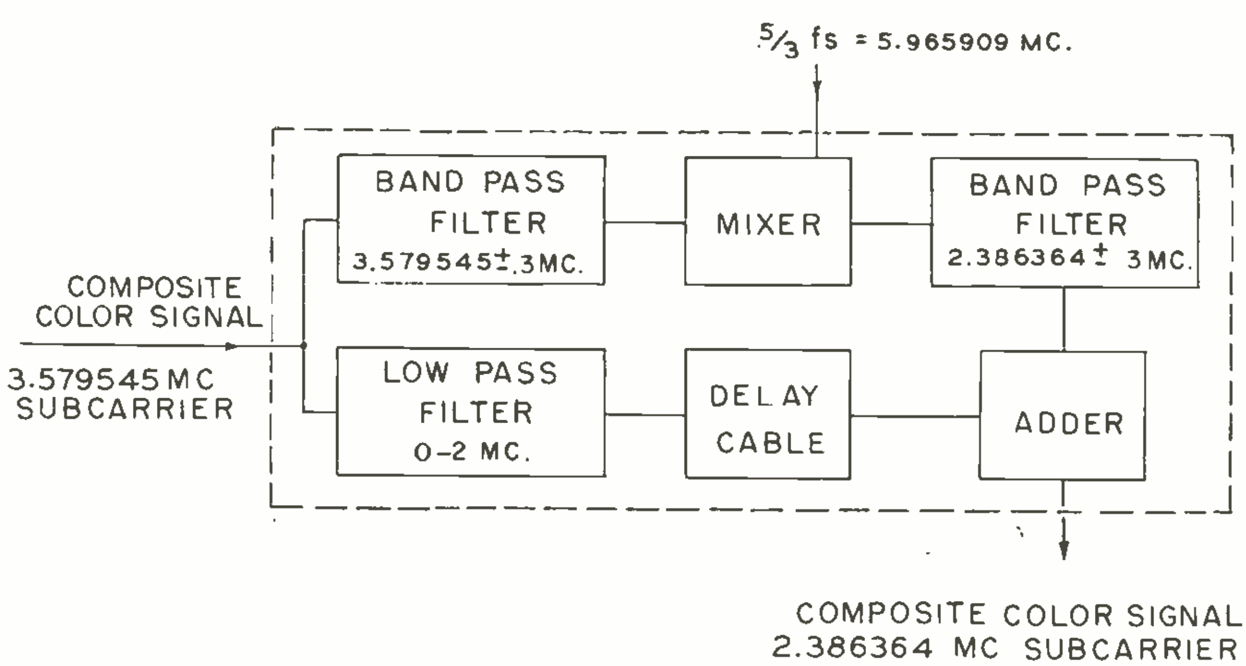

Fig. 10 — Cable transmitting heterodyne system.

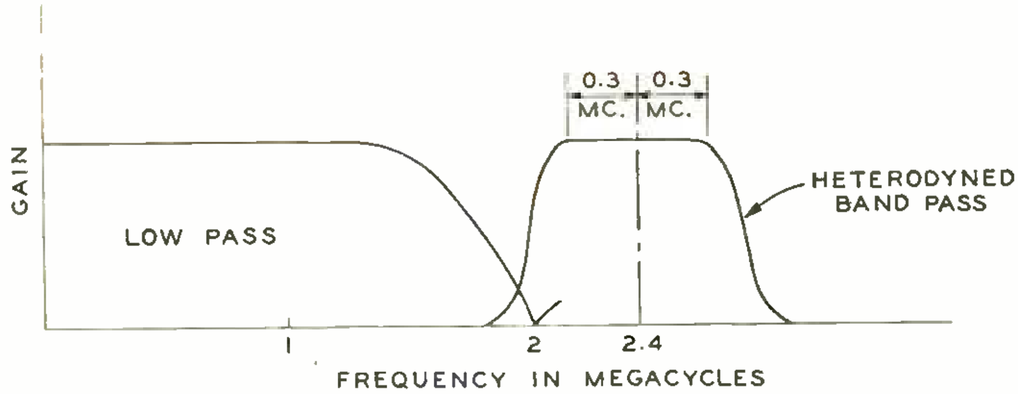

Fig. 11 – The cable signal.

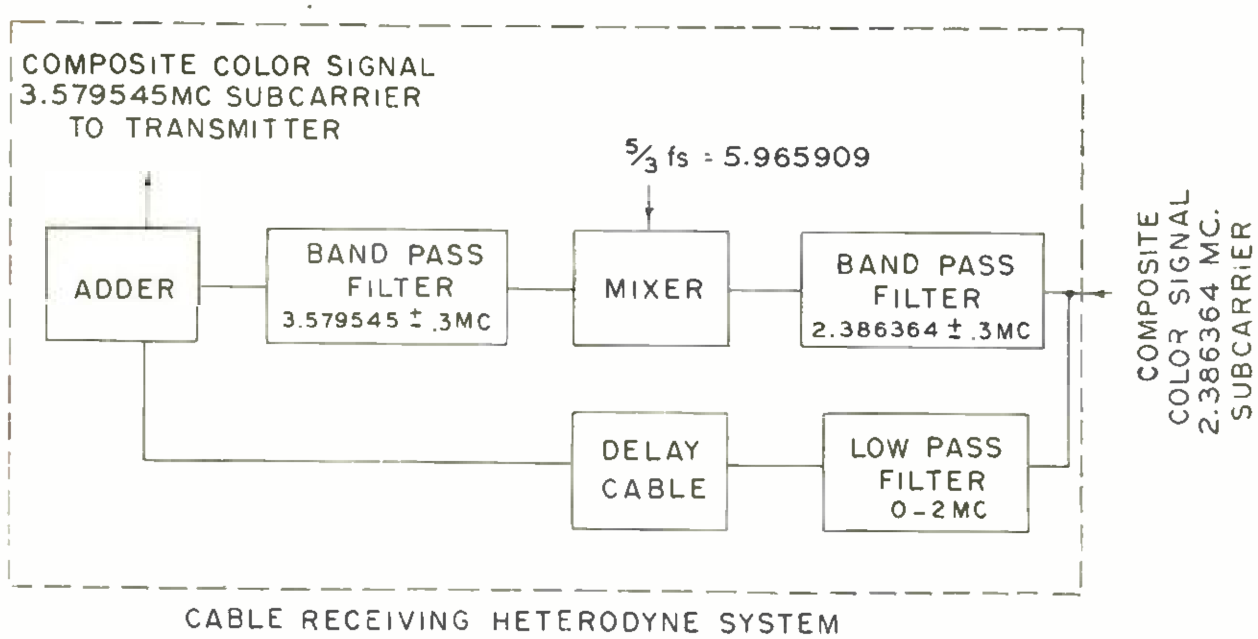

Fig. 12 – Cable receiving heterodyne system.

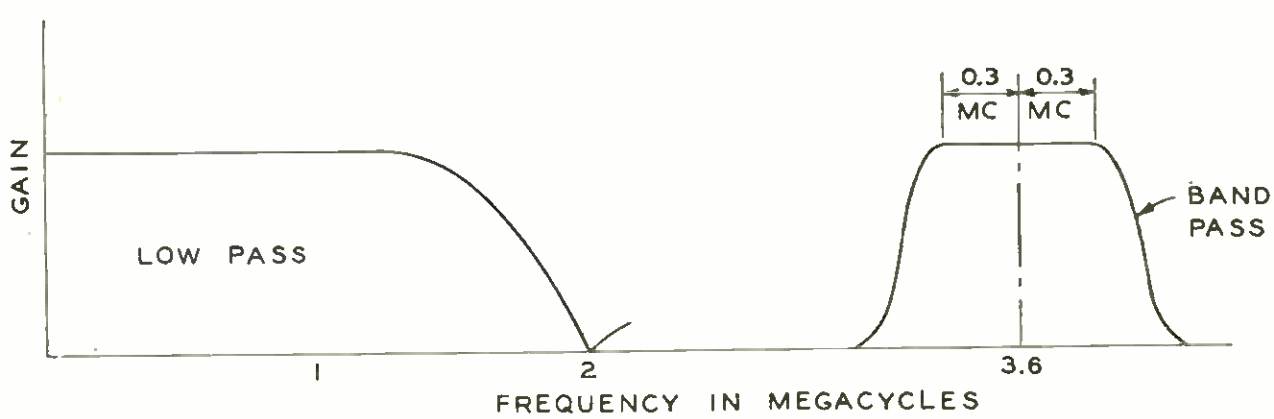

Fig. 13 – The reconstructed signal.

mitting terminal. Another m-derived band-pass filter following the mixer selects only the difference frequency components, which extend .3 mc on each side of f_s. Thus the color subcarrier is moved back to its original value. The band around 3.579545 mc is added to the low-pass band. The spectrum of Figure 13 is recovered and the signal is ready for transmission in accordance with the NTSC signal specifications but with reduced detail.

This translating equipment was installed in New York and on January 30, 1953, was used to send signals over a coaxial system to Washington, D. C., and return. The results were excellent. Detail was reduced in the color pictures just as in monochrome pictures transmitted over an equivalent circuit; however, except for test patterns, the pictures were difficult to distinguish from those carried by microwave except by direct comparison.

The translating equipment has been used a few times since the above date for rather short tests. On February 16, 1953, signals were sent to Garden City, Virginia, (Washington, D. C.) and return. This test was made in collaboration with A.T. and T. representatives for comparison with microwave signals and for circuit adjustment purposes.

On March 27, 1953, signals were again sent to Garden City and return and then viewed by Panel 17 of the NTSC for an evaluation of the results.

On May 19, 21, and 26, 1953, demonstrations were given at RCA Laboratories in Princeton, New Jersey, that consisted principally of viewing an on-the-air show over the facilities of WNBT (KE2XJV) in New York City. However, one scene was repeated for each demonstration and the signals for this were brought to Princeton by a standard microwave circuit. No cable transmissions were attempted at this time.

On June 2, 1953, the coaxial cable receiving-end terminal equipment was modified to simplify the operation and improve the results. The heterodyne-frequency generator chassis, which first produces a continuous wave locked to the 2.386364 mc burst used on the cable, by means of an A.F.C. controlled oscillator, was replaced. The new unit selects the 2.386364 mc component of the burst by means of a quartz crystal filter. This eliminates a rather difficult adjustment in the system.

PART IX

Conclusions

Based on the results of tests and observations to date, it is not believed that distance represents a serious problem in transmitting compatible color television signals from one city to another on conventional A.T. & T. microwave relay facilities without modification and over coaxial cable facilities using the signal conversion equipment just described. Good picture quality has been observed in the above-mentioned tests and an acceptable reproduction of the original signal wave form has been maintained. When the circuits were properly equalized and otherwise lined up and functioning normally the results have been very satisfactory from the point of view of over-all picture quality in the reproduced image.

APPENDIX A

LIST OF COMPATIBLE COLOR TELEVISION TRANSMISSIONS OVER STANDARD TELEVISION NETWORKING FACILITIES

A catalogue of various demonstrations of the RCA color television system using standard television networking facilities follows:*

Facility	*Between*	*Date*
Coaxial Cable	Simulated Cable	April 6, 1950.
Coaxial Cable	Washington to New York City	August 1, 1950.
Coaxial Cable	Washington to New York	August 7, 1950.
Microwave and Coaxial Cable	New York to Washington	September 10 to 20, 1951.
Microwave and Coaxial Cable	New York to Washington	October 9, 10, 11, 12, 13, 15, 16, 17, 18, and 19, 1951.
Coaxial Cable	New York to Washington and return	February 4, 5, and 26, 1952.
Microwave	New York to Toledo, Ohio, and return	May 18, 1952.
Coaxial Cable	New York to Washington and return	June 18, 1952.
Microwave and Coaxial Cable	New York to Washington and return	January 30, 1953.
Microwave and Coaxial Cable	New York to Washington and return	February 16, 1953.
Microwave	New York to Washington	March 21, 23, and 24, 1953.
Microwave and Coaxial Cable	New York to Washington and return	March 27, 1953.
Microwave	New York to Princeton, New Jersey	May 19, 21, and 26, 1953.
Microwave	New York to Washington and return	June 4, 1953.
Coaxial Cable	New York to Washington and return	June 5, 1953.

* In addition, many networking tests were made by RCA-NBC at times other than those shown for the demonstrations listed in this Appendix.