RCA
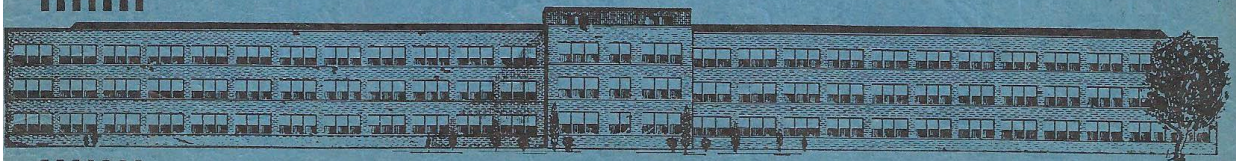
A 15 by 20-INCH PROJECTION RECEIVER
FOR THE RCA COLOR TELEVISION SYSTEM

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION

A 15 by 20-inch Projection Receiver
for the
RCA Color Television System

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Radio Corporation of America

October 1949

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Introduction

This bulletin describes two of the color television receivers which were demonstrated by RCA at the hearings before the FCC in Washington, D. C. on October 10, 1949. Some general information has been issued, particularly a brochure entitled, "A Six-Megacycle Compatible High-Definition Color Television System"[1]. More specific information on the circuitry and construction of receivers is given herewith.

The present bulletin deals primarily with the description of a projection receiver which produces a 15 x 20-inch picture. This unit is a modification of the receiver described in "An Experimental Simultaneous Color Television System"[2,3] and produces pictures of equal size and detail but with greater brightness. Modifications have consisted principally in the addition of sampler circuitry to adapt it to the new system, and the substitution of reflective optics for the refractive system previously used. Of course, r-f and i-f circuits have also been simplified to make use of a conventional black-and-white r-f—i-f system in place of the three channels necessary for wide-band simultaneous color reception.

In analyzing these receivers it should be borne in mind that they are research models which were constructed for an evaluation of the potentialities of a new system.

General Description

This receiver is one of the elements used by RCA Laboratories in research for a practical compatible color television system. To one familiar with product design of modern black-and-white television receivers, it will be obvious that no attempt has been made to economize in these models. The use of tubes, components and power in the electrical circuits has been lavish and even a first production design could result in major cost reductions. Some of the most obvious possibilities will be mentioned in connection with the discussion of the individual circuits and others will occur to the design engineer. For example, the development of a suitable sampler to operate at higher levels would obviate the necessity for a separate video amplifier for each kinescope and thus permit the use of a single amplifier in place of the three now required.

Fig. 1 is a block diagram of the receiver. The r-f, i-f and sound circuits are those of an RCA Model 9T240 television receiver. Because no modifications have been made ahead of the pic-

[1] "A Six-Megacycle Compatible High-Definition Color Television System", Radio Corporation of America, Sept. 26, 1949, furnished to the FCC and widely distributed to the industry.

[2] "An Experimental Simultaneous Color-Television System", *Proc. IRE*, Vol. 35, No. 9, pp. 861-875, Sept. 1947.

[3] "Simultaneous All-Electronic Color Television", *RCA REVIEW*, Vol. VII, No. 4, pp. 459-468, December 1946.

ture second detector and because any other such receiver having a bandwidth of 3.8 Mc or more might equally well have been used, no description of the r-f, i-f and sound circuits is included here.
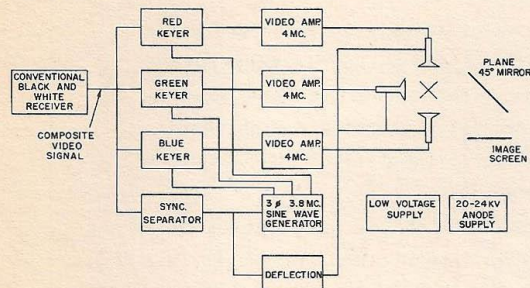

Fig. 1 – Block diagram of 3-color projection receiver.

As mentioned in the brochure[4] receiver arrangements involving by-passed highs are possible. However, this particular receiver uses the basic system without recourse to high-frequency separation.

The composite video signal is fed to the sampler and also to the sync separator chain to key the sampling pulse generator and to synchronize the deflection circuits as in a black-and-white receiver. The sampler provides three output voltages corresponding to the green, red and blue signals, each of which is amplified by a video amplifier and applied to the appropriate kinescope in the picture reproducer. It is the function of the sampling pulse generator to maintain order in the system and select the right information at the right time for transmission through the appropriate video amplifier. The sampling pulse generator derives its timing from the trailing edges of the horizontal sync pulses. Each alternate horizontal sync pulse is made slightly longer at the transmitter by the amount necessary to produce picture dot interlacing

$$\left(i.e., \frac{0.5}{3.8 \times 10^6} \ sec.\right)$$

Figs. 2, 3 and 4 are photographs of the completed receiver.

Because it was desired to compare the performance of the projection system with receivers using direct-view 10-inch kinescopes, another receiver was built to provide the same electrical performance with the same projection

[4] Op. Cit., Footnote 1.

kinescopes but with changes in the optical system to give the appearance of a 7 x 9-inch picture. Construction of this receiver permitted direct comparisons between the two types without the necessity for making allowances for differences in picture size, viewing distance, etc.
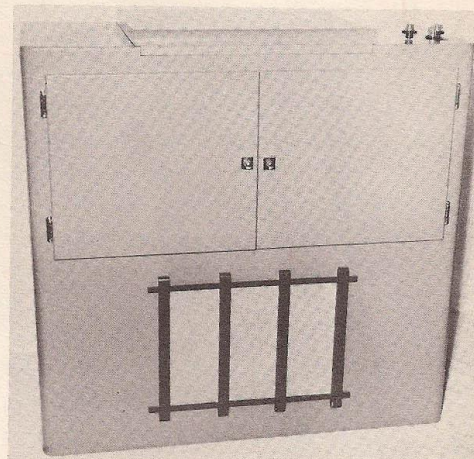

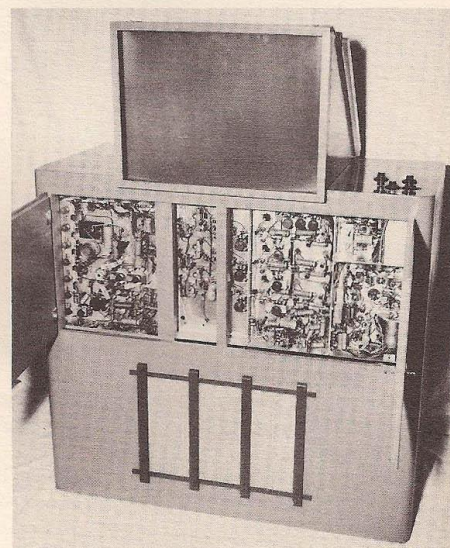Fig. 2 – Front view of 15 x 20-inch projection receiver.

Fig. 3 – Front view of 15 x 20-inch projection receiver, with screen up and doors open to show the chassis.
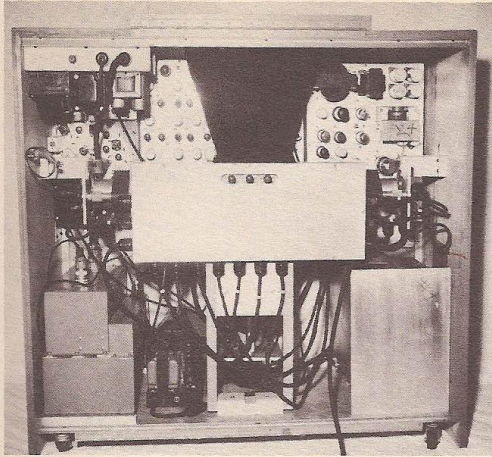
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Fig. 4 – Rear view of 15 x 20-inch projection receiver.

Two views of this receiver are shown in Figs. 5 and 6. Because the receivers are so nearly the same, the description which follows, while applying to both in most respects, will refer specifically to the one which produces the 15 x 20-inch picture.
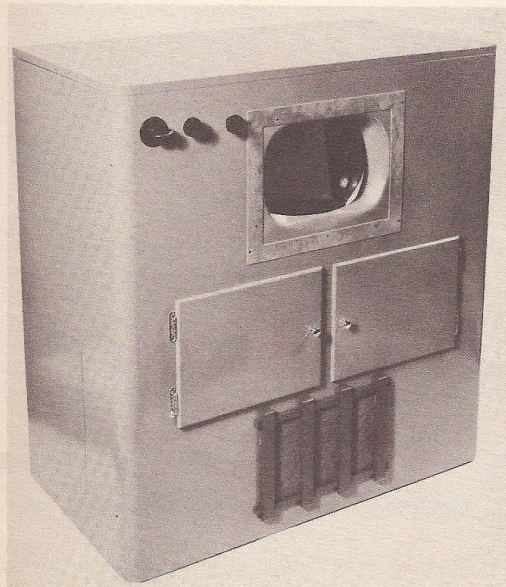
Fig. 5 – Front view of 7 x 9-inch projection receiver.
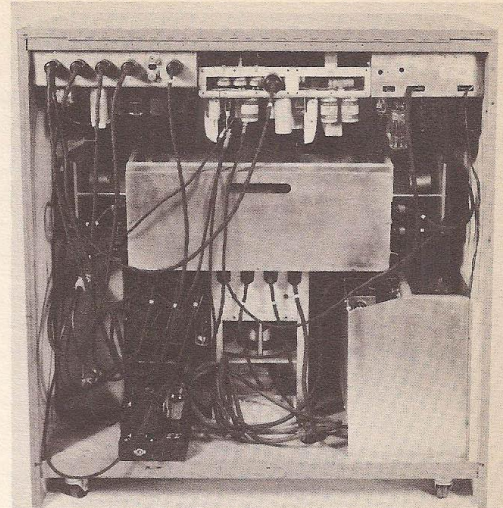
Fig. 6 – Rear view of 7 x 9-inch projection receiver.

Picture Dot Interlace Principle

As may be seen from the block diagram of Fig. 1, the composite video signal is applied to the sync clipper to derive synchronizing pulses. These are used to control the 3.8-Mc oscillator as well as the deflection circuits. The oscillator is made to start at the trailing edge of each horizontal sync pulse. It runs continuously for the duration of the visible portion of each scanned line, then stops briefly and is quiescent just before the next starting impulse. Since the oscillator will always start in the same phase with respect to the trailing edge of the sync pulse, it may be seen that systematic variation in the length of the synchronizing pulses can be made to produce picture dot interlacing. The system actually in use at the present time consists in making each alternate transmitted horizontal sync pulse longer by a time equivalent to one-half cycle at 3.8 Mc. This delays the start of the oscillator by 0.132 μsec on alternate lines and thus develops the interlaced scanning pattern illustrated in Fig. 7. The sequence of events may be understood by referring to Fig. 8. In Fig. 8A the 3.8-Mc sine wave is shown starting with a certain phase with respect to the trailing edge of

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a regular sync pulse. Fig. 8B shows the same phase relationship between the sine wave and the trailing edge of the sync pulse, but the pulse is longer by a time equivalent to a half cycle at 3.8 Mc resulting in a 180-degree phase delay (0.132 μsec) between the two sine waves. Fig. 8C shows the vector diagram corresponding to the conditions prescribed in Fig. 8A for the sampler used in this receiver. The oscillator voltage is indicated as E_o. The voltage for keying the green keyer is obtained by advancing the phase of the oscillator voltage by 60 degrees and is shown as E_G. Similarly, the voltage for keying the red keyer shown as E_R is obtained by retarding the oscillator voltage by 60 degrees. A 180-degree phase voltage for the blue-signal keying is obtained from an additional winding on the transformer connected in reverse polarity. If the vector diagram of Fig. 8C is assumed to be the instantaneous phase relationships resulting from the conditions shown in Fig. 8A, which produce the scanning and interlace pattern shown in line 1 of Fig. 7, it is apparent that the vector diagram of Fig. 8D, resulting from Fig. 8B is delayed in relative time by 180 degrees and will produce the pattern shown in line 3 of Fig. 7, first field. In Fig. 7 each letter represents the center of

a color dot area on the screen. The color dot areas, of course, overlap to a great extent.
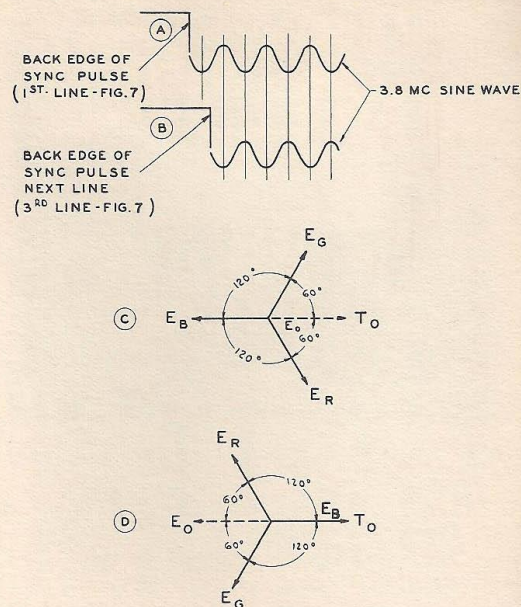
Fig. 8 – Time relationships between successive lines to obtain dot interlace.

During the first scanning field, illustrated in the upper diagram of Fig. 7, the odd numbered lines are scanned in order. Color dots are laid down in order along line 1 as shown. Next, line 3 is scanned with the displacement for each color dot as shown. The remaining odd lines are scanned in order. This scanning of the first field takes place in 1/60 of a second.

During the second field, the even lines are scanned, first line 2 with the colors laid down as indicated, then line 4, and so on. The dot pattern laid down during the third field is given by the lower diagram, where the odd lines are scanned in succession. During the fourth field, the even lines are again scanned in succession with the color dot pattern shown.

Fig. 7 - Dot interlace pattern.

Video Amplifier, Sync Separator and Sampler Circuit Chassis

Fig. 9 is a complete schematic diagram of the video amplifiers, sync separators and sampling circuits. Video output from the second

detector of the black-and-white television receiver is fed to the input of this unit. The output voltages provide green, red and blue video information to the kinescopes and sync signals for the deflection unit.

The second detector video signal is applied to one-half of a 12AU7 (V1A) for amplification. Two output voltages are taken from this tube, one for the sync separator chain via V1B, the other for the sampler circuits via the video amplifier V6.

Sync Separators

Tracing first the synchronizing-signal chain it may be seen that the composite video signal is applied to V1B with sync signal positive. The sync peaks set at zero bias and the video information is beyond cutoff on this tube which is operated at low plate voltage. In the succeeding stage the base of the sync pulses sets at zero bias and the peaks are clipped. In the third stage the sync pulses are again positive in polarity to remove any video information remaining from the first clipper V1B. The inputs of circuits V3A and V3B are connected in parallel. These tubes again clip to remove any remaining irregularities in the top of the synchronizing pulses. The trap composed of the inductance CTC5Mc and the 5 to 50-μμf capacitor is tuned for series resonance at 3.8 Mc to remove from the sync any energy at that frequency. The output of V3B is fed to the deflection chassis for deflection synchronization. To this point the system is identical to that of a black-and-white receiver except that more stages are employed than are normally used when cost is a primary consideration. The output of V3A is coupled to the grid of V4 through a small coupling condenser and the grid leak is returned to an adjustable positive voltage through the potentiometer, marked "phase control".

The sync pulses, which are positive in polarity at the plate of V3A, are differentiated by the network in the grid of V4. The phase control varies the amount of differentiation resulting in a change in the length of the output pulses from V4. The only pulse appearing in the output of V4 comes from the trailing edge of the sync pulse. The pulse resulting from the leading edge is lost because it is positive in polarity and tends to drive the grid

of V4 into grid current. However, the grid of V4 is already positive since its grid leak is returned to a positive voltage and therefore has low impedance compared to that of the coupling capacitor. This results in little change in the grid potential or the plate current. On the other hand the differential of the trailing edge of the pulse is negative. This causes V4 to be cut off, resulting in a maximum change in plate current and a positive output pulse immediately following the trailing edge of each sync pulse. The resultant pulse is applied to V5 (a phase splitter) to obtain both polarities at low impedance for driving the clamp tubes, V26, V18 and V34. These clamp tubes, which are a source of considerable and perhaps unnecessary complexity, will be discussed later, but it may be seen that since they are connected to the video output, a tube having low impedances had to be used for V5 to reduce video feedback into the sampler synchronizing circuits at this point. Use of other types of clamps or d-c restorers would permit a smaller tube drawing less plate current for V5, or perhaps its elimination.

Sampling Oscillator

A positive output pulse is taken from the cathode of V5 and fed to the grid of V8A, which has its cathode circuit shunted across the tuned circuit of V8B (the 3.8-Mc oscillator). Thus, when the positive pulse, with an amplitude of approximately 35 volts, is present on the grid of V8A the tuned circuit is loaded by the cathode impedance of V8A. This momentarily stops the oscillation of V8B. At the conclusion of the pulse V8B again begins to oscillate and the grid-leak bias developed in the grid circuit of V8A keeps that tube cut off between pulses. Oscillation is stopped for only a relatively short time. In one receiver it was found that the 3.8-Mc oscillator was stopped for 1 cycle, (of 3.8 Mc) at one end of the phase control and for 4 cycles at the other end of the control.

The 25,000-ohm variable resistor in the cathode of the oscillator tube marked "Q control" determines the amplitude of the oscillations and influences their starting and stopping characteristics. In a commercial design it might not need to be variable.

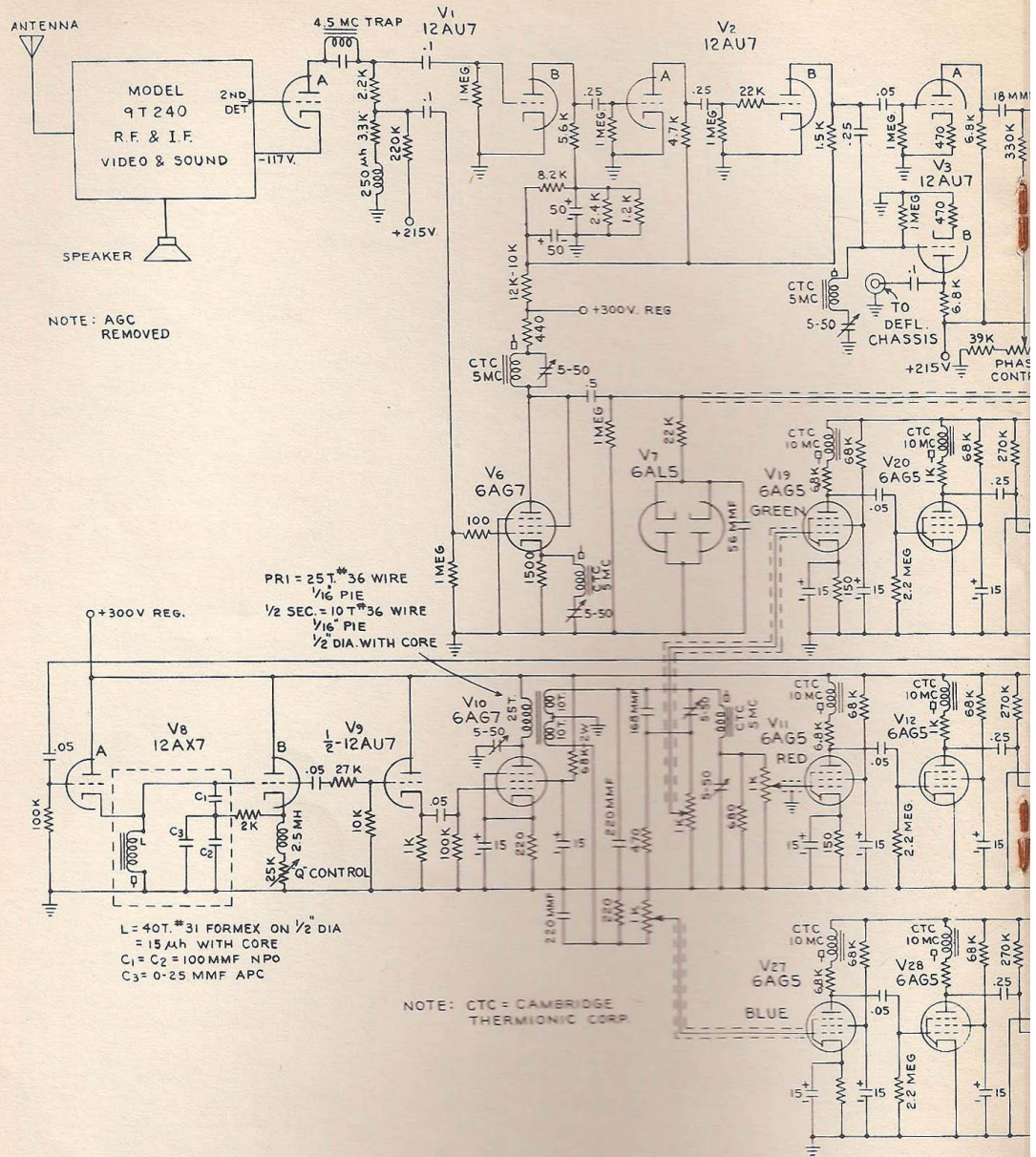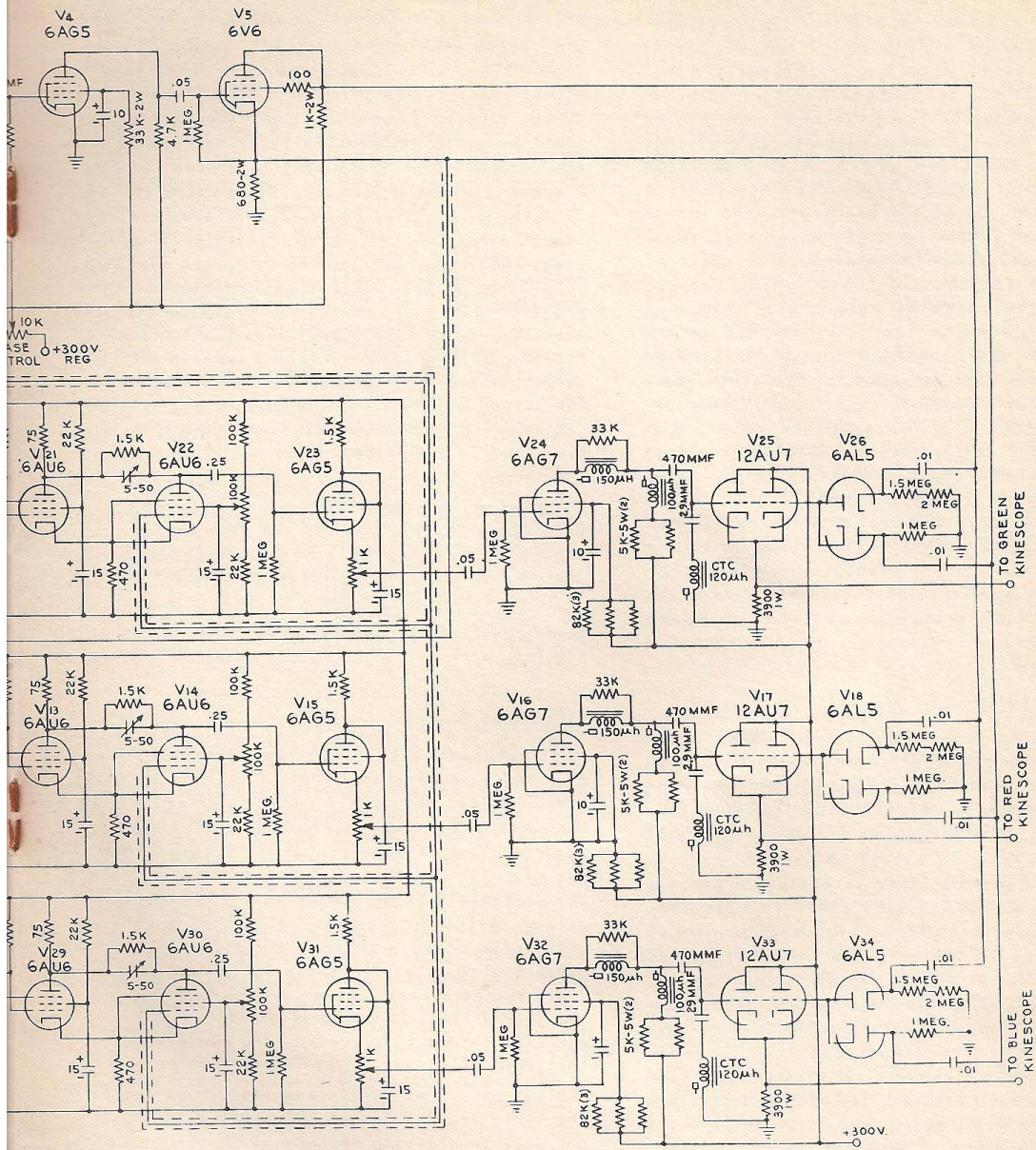V9 is a buffer to isolate the oscillator from its load circuit. The need for it is

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Fig. 9 — Video amplifier, sync separ...

arator and sampling circuit chassis.

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questionable since the next amplifier (V10) should serve the purpose adequately.

V10 is a 3.8-Mc amplifier, the primary of the transformer in its plate circuit being tuned to that frequency. The network in the secondary of the transformer serves to provide the three phases of 3.8-Mc voltage required for the keyers in the sampler circuits as explained previously and shown in Fig. 8. The voltages which lead or lag by 60 degrees are derived from the top end of the secondary. The inductance marked CTC5Mc in combination with the 5 to 50-μμf capacitor provides a phase delay of 60 degrees for the red channel. The 168-μμf capacitor in parallel with the 5 to 50-μμf capacitor and in series with the combination of 470 ohms and 1000 ohms in parallel provide the 60-degree phase advance for the green channel. The blue channel voltage is taken from the bottom end of the secondary to obtain the requisite 180-degree phase reversal. The potentiometers shown, to vary these output voltages do not appear to be essential. There is a critical value of voltage at which the system starts to operate and the operation continues unchanged above that level. In a commercial receiver it should suffice to provide adequate output voltage with most adverse component tolerances.

Sampler Circuits

Since the 3 keyers, one for each color, which compose the sampler are identical, only one need be examined. The blue chain, for example, is composed of V27, V28, V29 and V30.

The 3.8-Mc sine wave of the proper phase is applied to the grid of V27 which serves as an amplifier. The inductance in the plate circuit is set for maximum 3.8-Mc gain. The electrolytic capacitors shown as bypasses should not be necessary in the circuits of V27, V28 and V29. V30, however, has video signal applied and adequate bypassing for low frequencies is necessary. The output of V27 is a 3.8-Mc sine wave of relatively large amplitude. V28 is grid-leak biased so the positive tips of the sine wave set at zero bias and the negative portions of the cycle swing beyond cutoff. This produces clipped sine waves of negative polarity in the plate circuit. These are applied to the grid of V29. V29 and V30 have a common cathode resistor. The grid leak of V29 is returned to +B. This

causes V29 to draw sufficient plate current to keep V30 at cutoff except when the grid of V29 is supplied with negative cutoff pulse from V28. Thus, when V29 is cut off, V30 amplifies the video signal applied to its grid. This signal contains the information to be reproduced by the blue kinescope. During the remainder of the time, when information to be reproduced by the red and green kinescopes is present in the video signal, V30 is cut off, but due to the difference in phases of keying voltages applied to the other two chains, one of them is operative. The arrangement of the 1.5K load resistor returning to the small load resistor in the plate of V29 and shunted by the 5 to 50-μμf capacitor is to obtain neutralization so that a minimum of the keying signal appears in the output of V30. The 100,000-ohm potentiometer in the screen of V30 is effectively a d-c balance control. It should be set for minimum gating transient in the output.

It may be of interest that an experimental keyer using triodes in place of pentodes for V27, V28, V29, V30 and V31 has been assembled. Preliminary tests indicate the performance characteristics will be satisfactory.

It should again be mentioned that the development of a high-signal-level sampler would simplify some of the circuitry shown in Fig. 9.

Video Amplifiers

Following V1A, which amplifies both the sync and video signals, is V6. The gain of this stage is less than unity for most of the video range as may be seen from the fact that the degenerative cathode resistor is larger than the plate load resistor. However, it does have considerable gain at 3.8 Mc to boost this frequency. Relatively higher gain for 3.8 Mc has been found to be a desirable attribute of the video system. The LC network in the cathode of V6 is series resonant removing the degeneration and the parallel LC combination in the plate is parallel resonant increasing the plate load at that frequency.

The output of V6 is capacitance coupled to the three keyed tubes of the sampler, V30, V14 and V22. In order to restore the d-c component at this point V7 is connected from grid to ground of these tubes in customary d-c restorer fashion.

From this point to the kinescopes there are three video amplifiers, each amplifying the picture information for green, red and blue for application to the appropriate kinescope. Since all are identical, only one need be discussed. To return to the blue channel, pulses of information corresponding to the blue picture content at a 3.8-Mc rate were obtained at the output of V30. These are fed into a triode-connected 6AG5(V31) as a cathode follower. In the research stage it has been essential to have separate gain controls for each color accessible from the front panel. A cathode follower was necessary to obtain the low impedance required of a remote control with its associated capacitance if the frequency response were to be retained. In a commercial design the cathode follower may be omitted, although individual controls will probably be necessary in the original setup of a receiver because of tube and circuit component tolerances.

Following the original setup one master gain control should suffice. In this receiver, the changes made in the video and sync circuits resulted in a loss of the original a-g-c circuits. Therefore, a manual bias control on the r-f and i-f stages was installed and used as the master contrast control. A good commercial design would incorporate a.g.c. and include a contrast control to vary the gain through V6. The cathode follower V31 drives a video-amplifier stage V32 which is conventional except for the inclusion of the 29-μμf capacitor and variable inductor marked CTC120 μh which, in combination with the peaking circuits, is adjusted to attenuate frequencies above 4.2 Mc. The output of the video stage feeds a cathode follower V33 which is no more necessary in a color receiver than in its black-and-white counterpart, but it was convenient for research work to have the video response unaffected by variations in capacitance of the kinescope grid lead. The output of the cathode follower is 40 to 50 volts peak to peak which drives the kinescope.

Connected to the grid of the cathode follower is V34, a double diode used as a line-by-line clamp. When the pulses, which immediately follow the back edge of the sync pulse, are applied to the clamp from V5 the d-c level is established at the black level. A complete discussion of this type of clamp circuit is contained in a paper by K. R. Wendt, "Television

DC Component", *RCA REVIEW*, Vol. IX, No. 1, pp. 85-111, March 1948. It is important in a color television receiver that the d-c levels be maintained for proper color balance but it is problematical whether or not elaborate clamp circuits of this type are necessary. It is quite possible that simple diode d-c restorers of the type used in black-and-white receivers will suffice.

Deflection Chassis

Fig. 10 shows the circuit diagram of the deflection chassis. Sync input to this unit comes from the sync output terminal on the video-amplifier chassis (marked TO DEFL. CHASSIS on Fig. 9). The level is approximately 40 volts peak to peak and the polarity is sync positive. At the output of the first 6SN7 (V9) the sync signal is integrated for the vertical and fed to V10A and is also fed to the other half of the same tube used as a phase splitter for the horizontal a-f-c sync circuit.

The vertical circuit as shown is quite complex even though the vertical synchronization and linearity requirements are no more stringent than those for a monochrome receiver of the same type. Since all three kinescopes are deflected by the same source, they are affected identically by any non-linearity of the deflection currents. Therefore, registration is not a function of linearity. However, this receiver was built to provide the best possible vertical linearity by the inclusion of a degenerative feed-back network in the vertical deflection circuit. The network in the plate circuit of the discharge section of the 6N7 (V13A) is designed to produce a linear saw-tooth voltage which is amplified by V14A, V15 and the vertical output tube V16. The output-transformer secondary current which flows through the deflection yokes is passed through a resistance composed of the three 1.5-ohm resistors in parallel. The voltage developed across these is applied to V14B to furnish the degeneration which assures that the yoke current is essentially as linear as the original saw-tooth voltage generated by the discharge tube.

The three vertical deflection yokes are connected in parallel but each is provided with its own centering control. In addition, two of

the yokes are provided with incremental size controls to permit the deflection of each of them to be made the same as that of the third. In a commercial design it seems probable that V9 would not be required and that the tubes in the vertical chain, V10A, V12A, V13, V14, V15 and V16 could be replaced by one triode as a blocking oscillator–discharge tube and a power triode output tube. Details of the vertical output transformer are shown in Fig. 11.
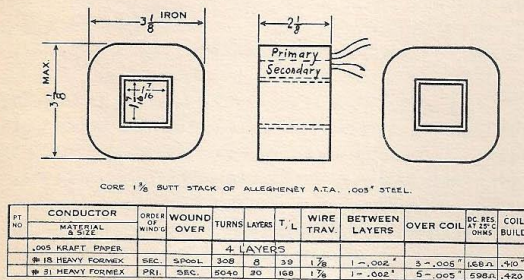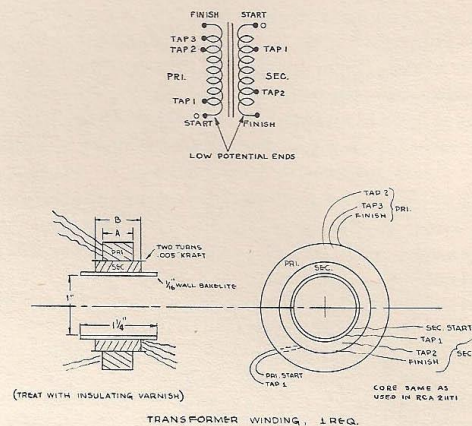

Fig. 11 – Vertical output transformer.

The horizontal a–f–c sync circuitry is conventional and is of the blocking–oscillator type described by K. R. Wendt and G. L. Fredendall, "Automatic Frequency and Phase Control of Synchronization in Television Receivers", *Proc. IRE*, Vol. 31, No. 1, pp. 7–15, January 1943. The two 6BG6G deflection tubes are coupled to the damper diodes by output transformer KW154, details of which are shown in Fig. 12. No attempt has been made to apply recent developments in deflection circuits which provide increased efficiency. Since the deflection angle of the kinescope is only about 40 degrees the deflection power requirements are not severe.

The horizontal deflection yokes are isolated for d.c. from the output transformer by a 1–μf condenser and a choke KW153 (also shown in Fig. 12) is used to provide a d–c path for the centering currents. As with the vertical yokes, the three horizontal deflection yokes are connected in parallel and each is provided with a separate centering control for registration. Individual adjustment of width is made by adjustment of the deflection yoke position on the tube neck.

The "Micro-positioner" protective relay together with the Leach 125–volt d–c relay provide protection for the cathode ray tubes in the event of horizontal deflection failure.

The deflection yokes are conventional in design but if good registration is to result, it is important that they be uniform in characteristics. In their assembly a signal should be applied to one set of windings and the other adjusted until the induced voltage is zero. This insures that the fields from the two windings are at 90 degrees. Unless this is done it is possible to obtain registration in either the vertical or horizontal direction but not both simultaneously without skew circuits to correct for yoke differences. The horizontal yoke inductance is 17 mh and the vertical 22 mh.

Fig. 12 – Horizontal output transformer and choke.

In a black–and–white television receiver a small amount of deflection from stray power line frequency fields is not objectionable. The same would be true in a color receiver using more than one kinescope if the stray fields acted similarly on all kinescopes. However, the difference in orientation of the tubes almost certainly precludes this possibility. In order to maintain registration it has been found desirable to place magnetic shields around the necks of the kinescopes.

The Bi-Reflective Optical System

Viewed as a complete unit, the bi–reflective projection optical system which reproduces the color picture consists of the green, red and
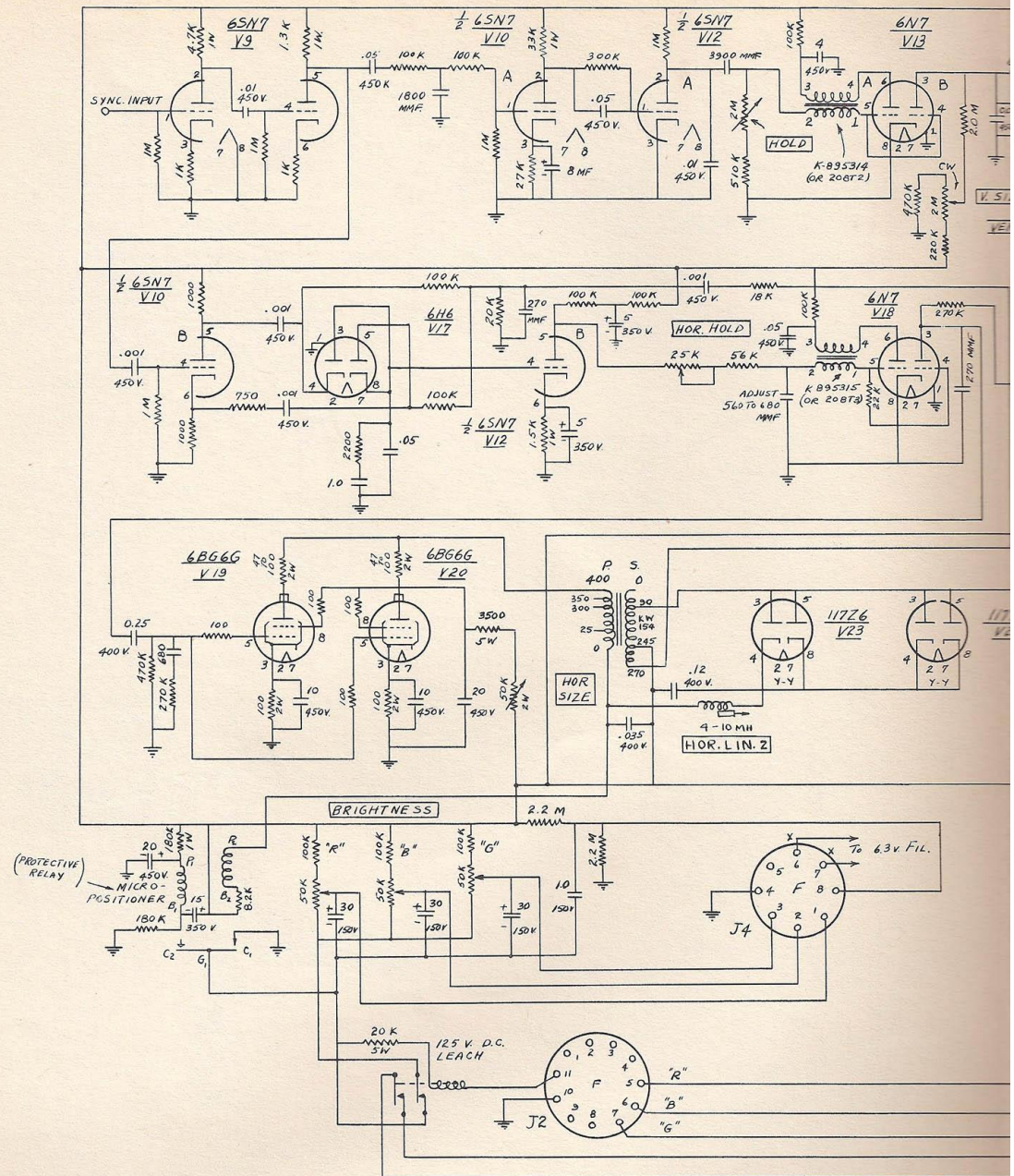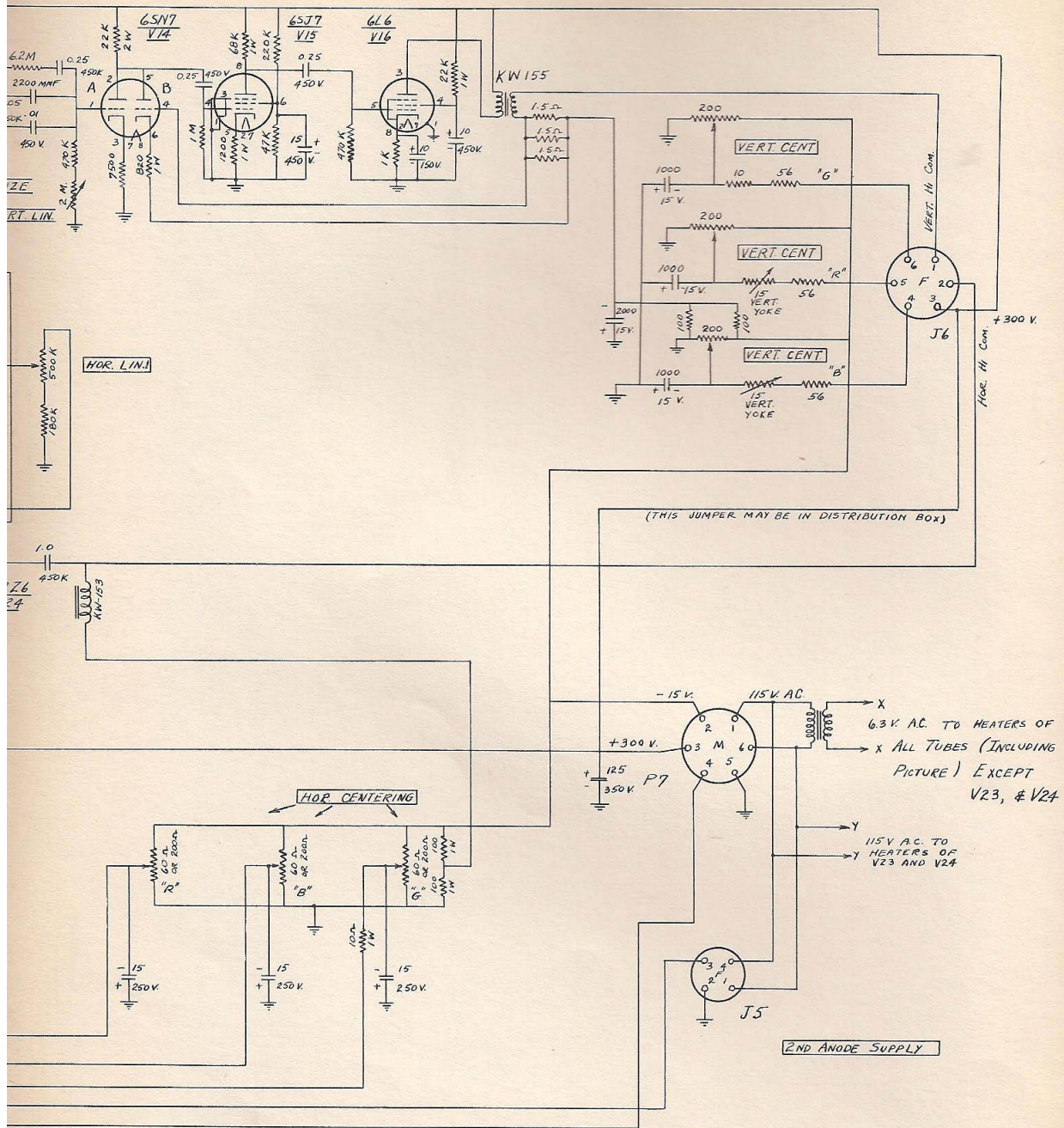
Fig. 10 —

6SN7 V14 6SJ7 V15 6L6 V16

6.2M 0.25 450K 22K 2W
2200 MMF 450V 450K 68K 220K 1W 22K 1W KW 155 1.5 Ω
05 0.25 450V 0.25 1.5 Ω
5CK .01 450V 1.5 Ω
450 V. 7500 820 1M 1200 27 47K 470K 1K 10 450V 10 450V
470K 1W 15 450V 750V

ZE 2.M 470K
RT. LIN.

200
VERT. CENT
1000 10 56 "G"
15 V.
200
VERT. CENT
1000 15 VERT. YOKE 56 "R"
15 V.
2000 100 200 100
15 V. VERT. CENT
1000 15 VERT. YOKE 56 "B"
15 V.

J6 06 F 20 5 3 Q +300 V.

Vert. Hi Com. Hor. Hi Com.

HOR. LIN. 500 K 180K

(THIS JUMPER MAY BE IN DISTRIBUTION BOX)

1.0 450K
Z6 KW-153
24

-15 V. 115 V. AC.
2 1
03 M 6 0
+300 V. 4 5
+ 125 P7
- 350 V.

6.3 V. A.C. TO HEATERS OF
X ALL TUBES (INCLUDING
PICTURE) EXCEPT
V23, & V24

Y 115 V. A.C. TO HEATERS OF V23 AND V24

HOR CENTERING
60 Ω OR 200 Ω 60 Ω OR 200 Ω 60 Ω OR 200 Ω 1W
"R" 100 "B" 100 "G" 100 1W
10 Ω 1W

-15 -15 -15
+250V. +250 V. +250 V.

3 5
04 0 2
J5 0 1

2ND ANODE SUPPLY

Deflection chassis.

12

MIRROR
45°
SCREEN
10
2½ DIA
4⅛ DIA
CORRECTING LENS 4¾ DIA.
PLANE MIRROR, CENTRAL PORTION ALUMINIZED
SPHERICAL MIRROR 4½ DIA
RED REFLECTOR
RED PROJECTION TUBE
CROSSED DICHROIC REFLECTORS
BLUE REFLECTOR
YOKE
BLUE PROJECTION TUBE
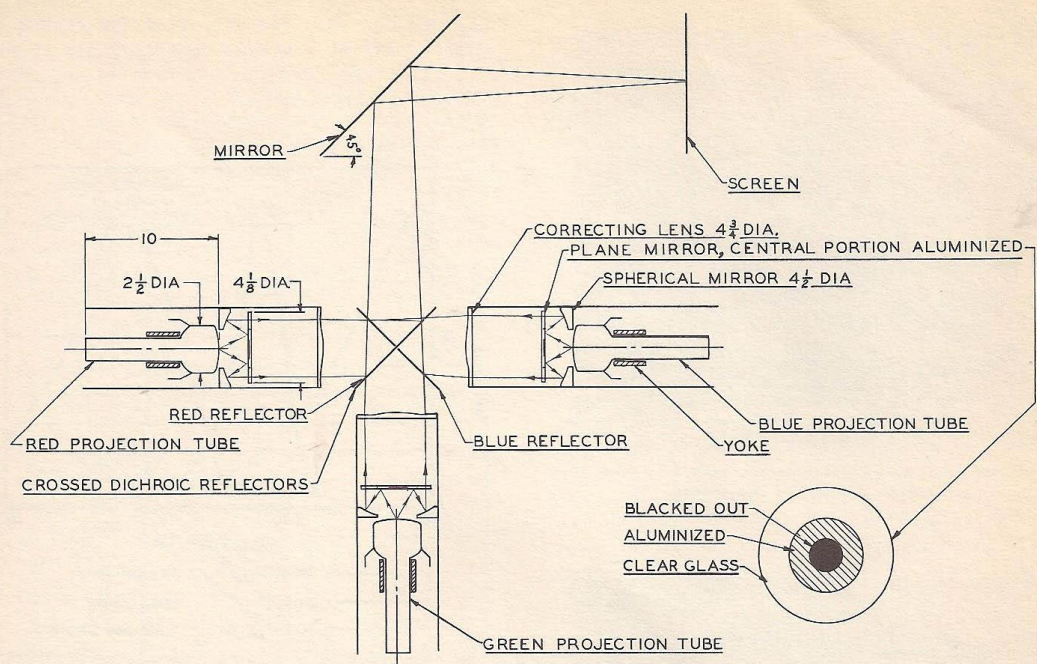BLACKED OUT
ALUMINIZED
CLEAR GLASS
GREEN PROJECTION TUBE

Fig. 13 – Diagram of bi-reflective projection optical system.
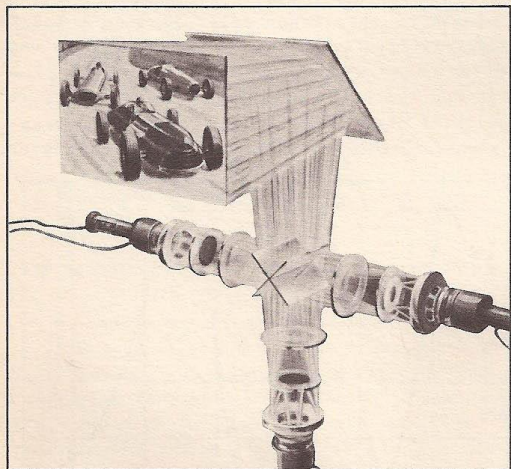

Fig. 14 – Exploded view of projection picture–reproducing system using 3 projection kinescopes, reflective optics and a pair of dichroic mirrors.

blue kinescopes each mounted in conjunction with its own reflective optics, a pair of crossed dichroic selective reflectors, a 45–degree plane mirror, and a viewing screen. Their relative positions in the entire assembly are shown diagrammatically in Figs. 13 and 14, while Fig. 15 is a photograph of the actual equipment tipped away from the cabinet to expose the components. In operation the whole unit is positioned vertically in the rear of the cabinet as in Fig. 4, thus permitting the projected image to reflect from the plane mirror in the hinged cover to the screen. For a close–up view of the optical assembly, reference is made to Fig. 16 which shows the three optical barrels, the dichroic mirrors, and some of the adjusting controls.

Laboratory–model 2½–inch color kinescopes, as shown in Fig. 17, provide the green, red and blue images for the picture. Their electron guns are of the type used in the 5TP4 projection kinescope. Approximate spectral characteristics for the different color phosphors are plotted in Fig. 18, the peak intensity being arbitrarily set at 100. Note should be taken of the fact that while the green and blue phosphors
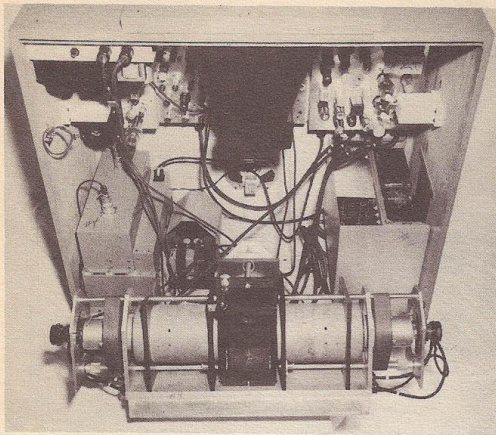
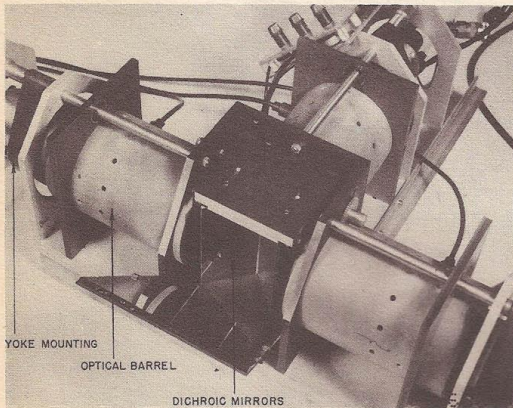Fig. 15 – Projection optical system tipped away from the cabinet to expose the components.

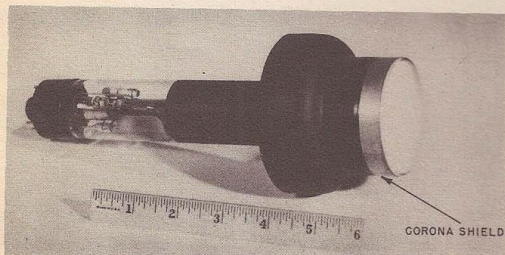Fig. 16 – Close-up view of optical assembly.

Fig. 17 – Two and a half inch projection kinescope.

have good chroma, the output of the yellow-red phosphor of the red kinescope requires the use of a red filter, such as the Wratten No. 26, to provide better chroma.
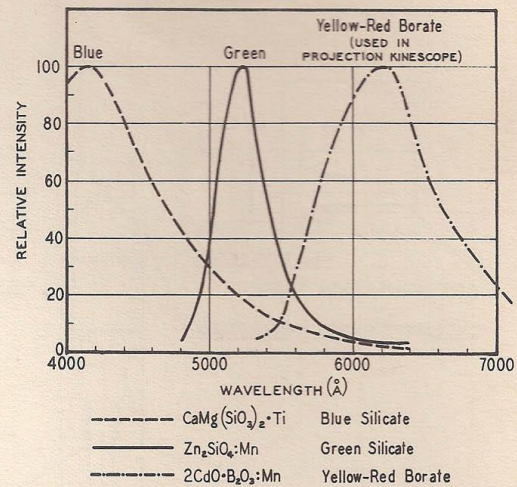

-------	CaMg(SiO₃)₂·Ti Blue Silicate
———	Zn₂SiO₄:Mn Green Silicate
—·—·—	2CdO·B₂O₃:Mn Yellow-Red Borate

Fig. 18 – Approximate spectral characteristic of color phosphors.

By way of comparison, Fig. 19 shows the final spectral distribution of the three colors as viewed on the screen after passing through the optical system and dichroics. Fig. 20 gives the location of these green, red and blue colors on the ICI[5] color diagram. From this it is evident that practically all of the ordinarily useful colors are included in the triangle.
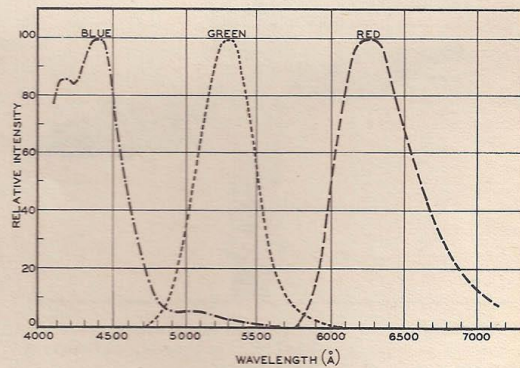

Fig. 19 – Spectral distributions of green, red and blue colors on the viewing screen.

[5] ICI = International Commission on Illumination.

Before taking up the other elements of the optical system it might be well to mention that the deflection yoke on each kinescope is so mounted mechanically within the housing that it may be both rotated and moved axially for adjustment of picture size and to assure proper registration even though there may be slight differences in tubes and yokes. Furthermore, the tubes are supported by the necks and tube-face corona shields in such a manner that when pushed up against the shields and clamped by the neck, they are automatically aligned with the optical system.
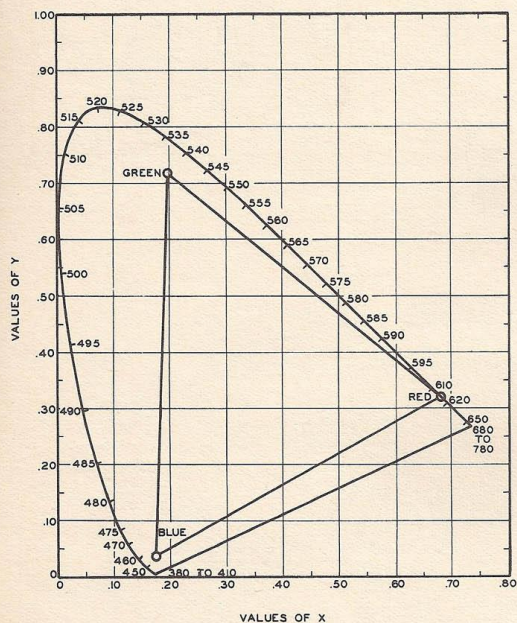

Fig. 20 — Coordinates of red, blue and green colors as seen on the viewing screen.

Situated in front of each kinescope are the spherical mirror, the plane glass disk and the correcting lens which, together with the crossed dichroic mirrors, complete the optics of the system. The plane glass disk has its center blacked out, a portion around the center alumi- nized, and the outer section clear, as shown in Fig. 13. Light from the faces of the red and blue tubes is reflected from the aluminized portion of the plane disk to the spherical mirrors, back through the clear outer section

of the disk, through the correcting lens which serves to correct for the aberrations of the spherical mirror, and thence is reflected by the red or blue dichroic mirrors. Light from the green tube takes much the same course except that it passes directly through the dichroics without reflection. For a more complete des- cription of the principle of these reflective optics, see "Projection Television" by D. W. Epstein and I. G. Maloff, *Jour. SMPE*, Vol. 44, No. 6, pp. 443-455, June 1945.

An excellent discussion of the theory and principles of operation of dichroic reflectors has been given by G. L. Dimmick, "A New Dichroic Reflector", *Jour. SMPE*, Vol. 38, pp. 36-44, January 1942. As used in the present system the arrangement consists of two crossed dichroic mirrors, or, more accurately, three, because one of the plates is divided in half at the line of junction. One dichroic reflects red and passes blue and green, while the other reflects blue and passes red and green. Such mirrors are made by vacuum deposition of multiple metallic films on glass, arranged in alternate layers having different indices of refraction. They operate at high efficiency and at the same time have a desirable filtering action which improves the chroma of the light from the three kine- scopes.

From the dichroic mirrors the light travels to a front-surface plane mirror located in the hinged cover of the cabinet and oriented at a 45-degree angle to reflect the picture to the rear-projection viewing screen of the type described by R. R. Law and I. G. Maloff, "Pro- jection Screens for Home Television Receivers", *Jour. Optical Society of America*, Vol. 38, No. 6, pp. 497-502, June 1948.

Kinescope Anode Supply

The circuit diagram of the kinescope anode supply is shown in Fig. 21. Construction details of the oscillator coil are given in Figs. 22 and 23 and of the filament transformers in Fig. 24.

As may be seen, this is a laboratory-type regulated supply which with appropriate changes in the filament transformer capacitors will provide voltages between 20 and 40 kv. For the 20 to 24-kv operating potential range the values as shown are used.

VIEW OF 1B3-GT SOCKETS SHOWING
METHOD OF MOUNTING FILAMENT
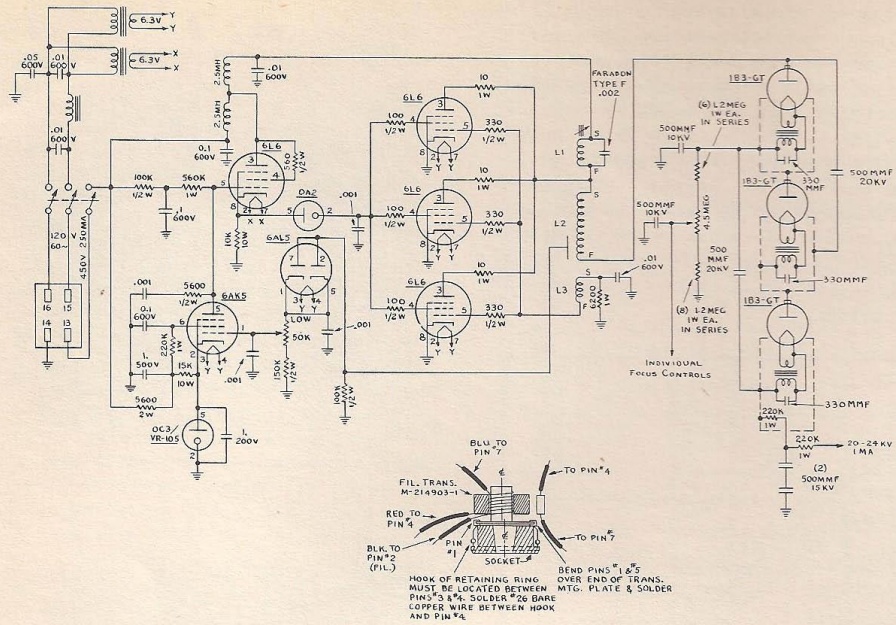TRANSFORMERS AND CONNECTIONS
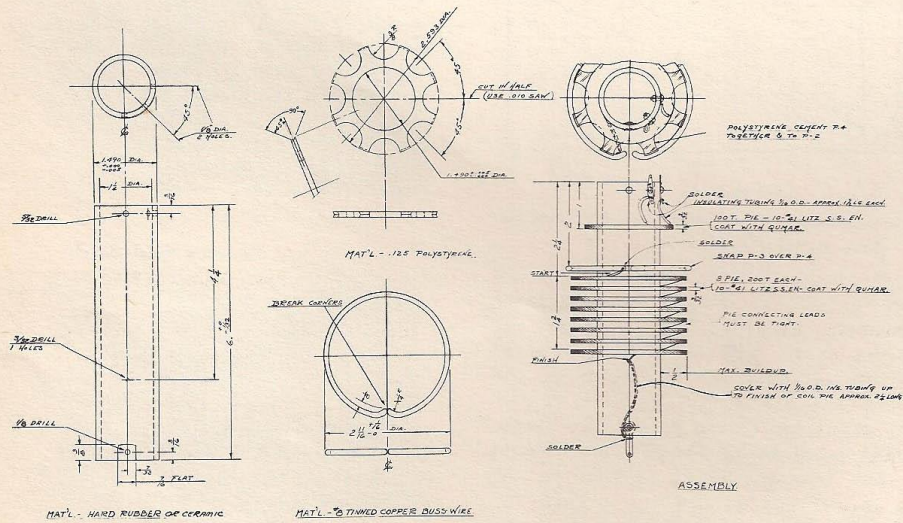TO PINS.

Fig. 21 — Regulated r-f power supply.

Fig. 22 — R-F power supply coil.

This particular receiver was built with a regulated r-f power supply. However, there is no reason for believing that a flyback power supply, deriving the anode potential from the horizontal-deflection circuits might not be just as satisfactory here as in a monochrome receiver even though the current required is higher. For example, the combined anode currents of the three kinescopes may be as much as 1 milliampere on a maximum brightness white picture.
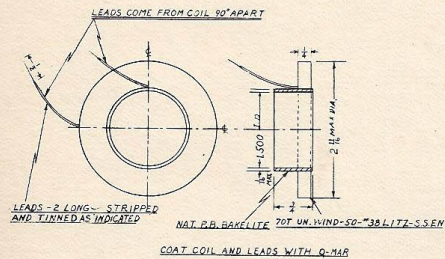

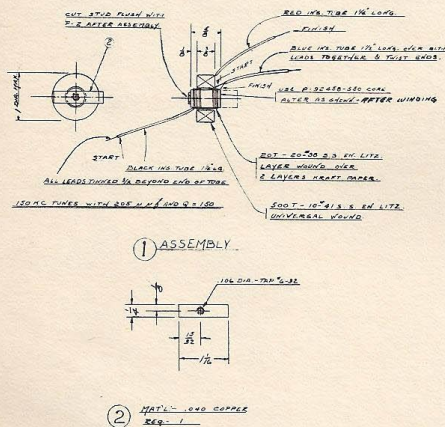Fig. 23 — Primary of r-f high voltage oscillator.

Fig. 24 — Rectifier filament transformer.

The general subject of r-f power supplies has been covered by R. S. Mautner and O. H. Schade, "Television High-Voltage R-F Supplies", *RCA REVIEW*, Vol. VIII, No. 1, pp. 43-81, March 1947. In the present source the regulation is accomplished by applying some of the r-f potential across the oscillator coil to a 6AL5 rectifier. A selectable portion of the diode-developed d-c voltage is applied to the grid of a 6AK5 voltage amplifier, the output of which is connected to the grid of a 6L6 which con-

trols the screen voltage of the oscillator tubes. The system is degenerative in that an increase in oscillator voltage results in a decrease in oscillator screen voltage to buck the effect.

Low-Voltage Power Supplies

The portion of this receiver in the block marked "R.F. & I.F. VIDEO & SOUND" in Fig. 9 is operated from the original power supply of the Model 9T240 chassis. This unit is less heavily loaded than originally because of the removal of the video and deflection circuits.

Three other low-voltage supplies furnish the power for the balance of the receiver. The principal source is an RCA commercial regulated unit WP33A which is rated at 600 ma maximum. It operates at close to its maximum rating in supplying current to all circuits except those of the output video stages and the r-f power supply. The three output video stages are fed from an unregulated power supply delivering approximately 45 ma at 300 volts d.c. A third unregulated power supply was designed to operate the laboratory-type regulated second-anode potential source. Its output is 400 volts d.c. and the current drain is about 200 ma with a maximum brightness white picture.

No attempt has been made to replace the regulated supply with an unregulated one as a cost reduction measure. However, the gains at low frequency are about the same as in a conventional monochrome receiver. It seems reasonable to assume that the techniques which minimize the effects of line-voltage variation in a well designed black-and-white receiver would yield equally good results here.

Power Distribution Panel

Across the back of the receiver shown in Fig. 4 may be seen the power distribution panel. Its function is obvious, and would need no comment except for the fact that the focus controls, one for each kinescope, are mounted on this panel. Focus voltage is obtained from the potentiometer as shown in the r-f power supply diagram, Fig. 21. The top ends of the 2-megohm focus controls are connected to this point and the bottom end of each is connected to ground through 22 megohms.

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