LB-962

A SIMPLIFIED HIGH-PERFORMANCE 21-INCH DEVELOPMENTAL COLOR TELEVISION RECEIVER

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION
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A Simplified High-Performance

21-Inch Developmental Color Television Receiver

Approved

Stuart Wm Seeley

Fig. 1 - Photograph of simplified developmental color television receiver.

Introduction

This bulletin describes a simplified color television receiver using the RCA developmental 21-inch color kinescope. In the evolution of this receiver, emphasis has been placed on attaining in the color circuitry the same high degree of stability which the public has come to expect in the operation of black-and-white receivers. This has been achieved through the use of color demodulators which are stable with changes in operating voltages and variations in tube characteristics. Stability of color phase is assured by the use of color sync circuitry which makes almost all tuned circuits common to both the chroma and color sync circuits, so that drift has no effect on the color stability.

In line with maximum ease of operation, circuitry is employed to provide automatic chroma control. In the same way that automatic gain control (AGC) maintains the luminance output independent of variations in picture carrier field strength, so automatic chroma control (ACC) maintains the chrominance output constant with variations in the color subcarrier. This ACC is accomplished by simple circuitry which ensures high stability.

A full-bandwidth i-f amplifier is employed to obtain flat amplitude response and constant time delay over the region occupied by the chrominance signal. In addition to the resulting improvement in color fidelity and reduction in color cross talk, tuning is made less critical.

To enhance the stability of both the gray scale and color reproduction, the high-level chrominance demodulators are coupled directly to the three kinescope grids. These demodulators provide the same high degree of stability and linearity for the chrominance channel that a high-level diode detector provides for the luminance channel.

The magnetic convergence circuitry employed has been simplified and the stability improved by the complete elimination of tubes in this section of the receiver. The power required for the wave-shaping circuits is supplied directly by the horizontal and vertical deflection circuits.

The overall degree of simplification attained is reflected in the relatively low total power consumption of 295 watts. The total tube complement is 28 tubes, including the color kinescope, three tubes in the combination VHF-UHF tuner, and three high-voltage rectifiers. Although further reduction in tube count is possible through the use of combination triode-pentode tubes, no attempt has been made to design a "minimum-tube-count" receiver.

Service accessibility is made possible by vertical chassis mounting alongside the kinescope. The top, sides and back of the cabinet comprise an integral unit which is readily removable, making accessible the complete receiver chassis and kinescope which are fastened to the base and front of the cabinet. Convergence and other set-up controls are available from the front of the cabinet behind a subpanel to simplify service adjustments.

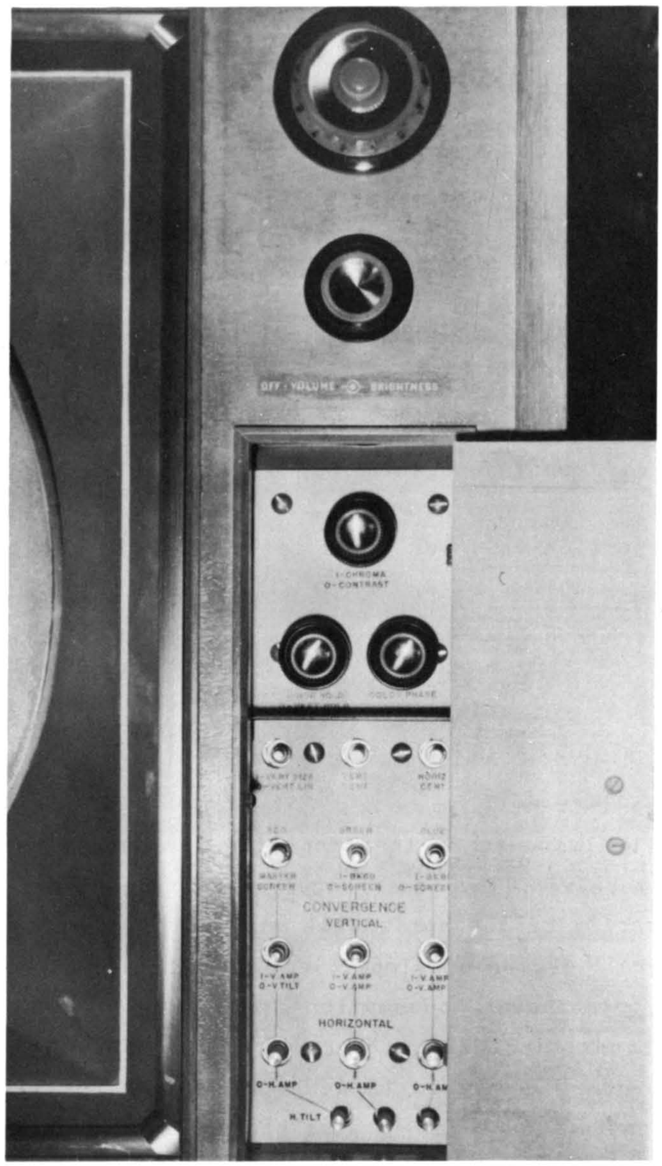


Fig. 2 - View of control panel showing both operator and service controls.

General Characteristics

A photograph of the complete receiver is shown in Fig. 1. As shown in Fig. 2, the tuner and on-off-volume-brightness controls are in the upper right hand corner. The chroma-contrast control, the color phase, and the horizontal and vertical hold controls are available behind a hinged door. Directly below these controls are the set-up controls, including vertical size--vertical linearity, vertical centering, horizontal centering, red master screen, green background-screen, blue background-screen, and the several convergence controls. The latter are grouped in three vertical lines for the red, green, and blue guns respectively. As is evident in Fig. 2, the service controls are grouped together so that they can readily be concealed from the operator by a secondary door or panel. A view of the receiver with cabinet removed appears in Fig. 3. Both the vertical chassis and the kinescope are supported from the front panel and the base of the cabinet. A view of the chassis removed from the cabinet is shown in Fig. 4. A bottom view of the chassis is shown in Fig. 5. To reduce radiation, the bottom of the chassis and the rear of the cabinet are shielded by perforated metal cover plates as shown in Fig. 6.

In Fig. 3 may be seen the color equalizer structure which is mounted on the outside of the mask. No magnetic shield is used surrounding the kinescope.

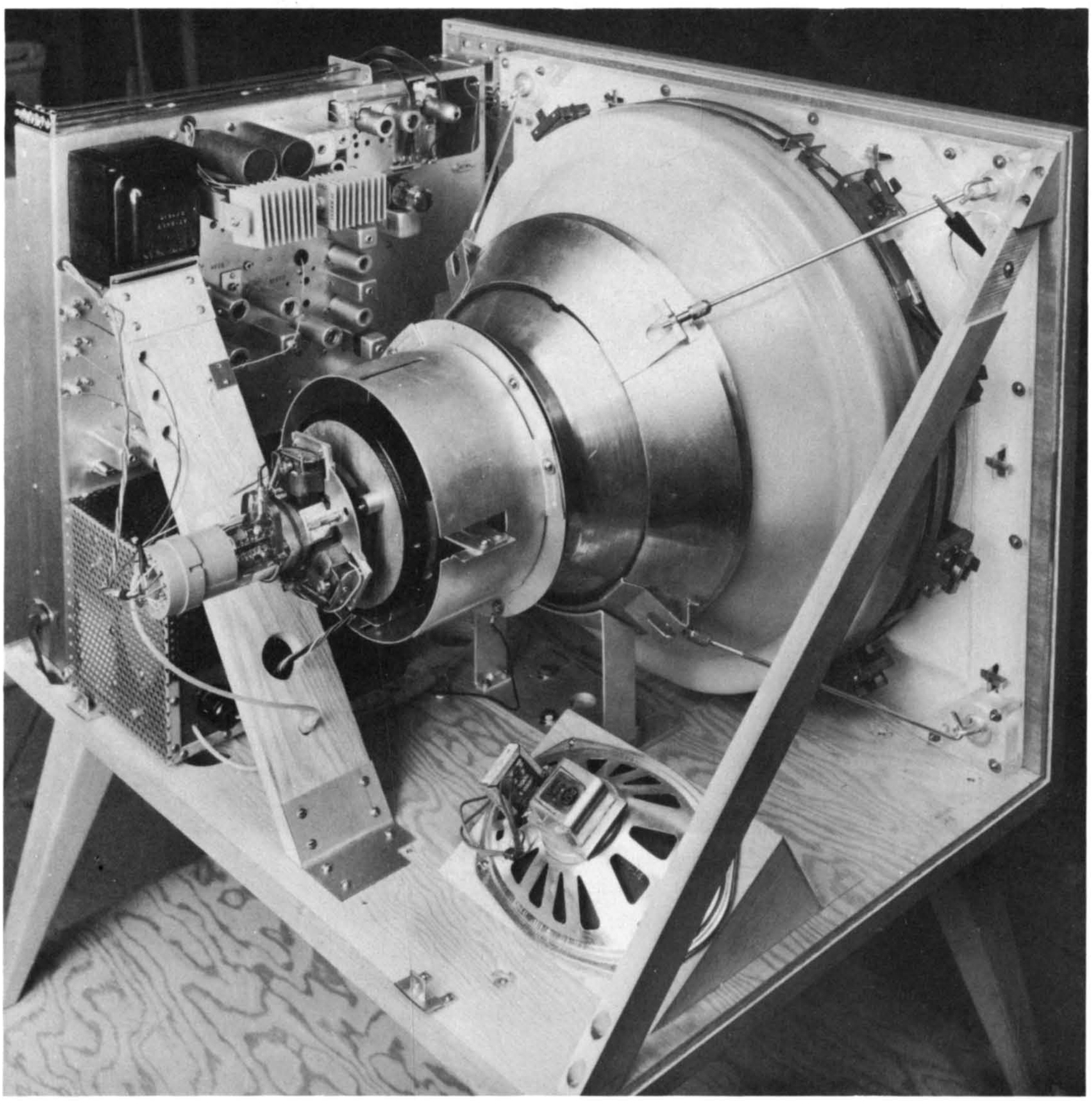


Fig. 3 - Rear view of receiver with cabinet removed.

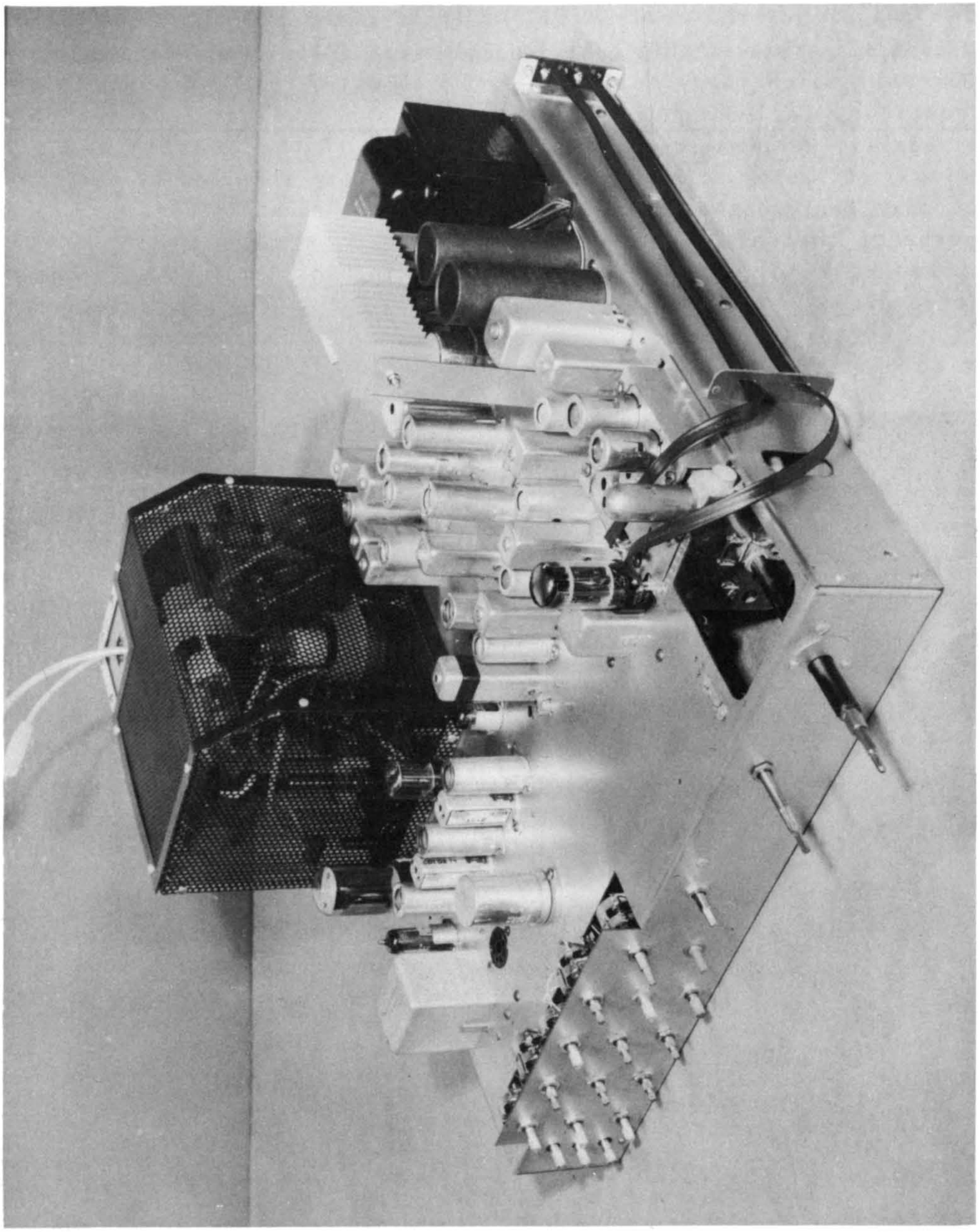


Fig. 4 - Top view of receiver chassis.

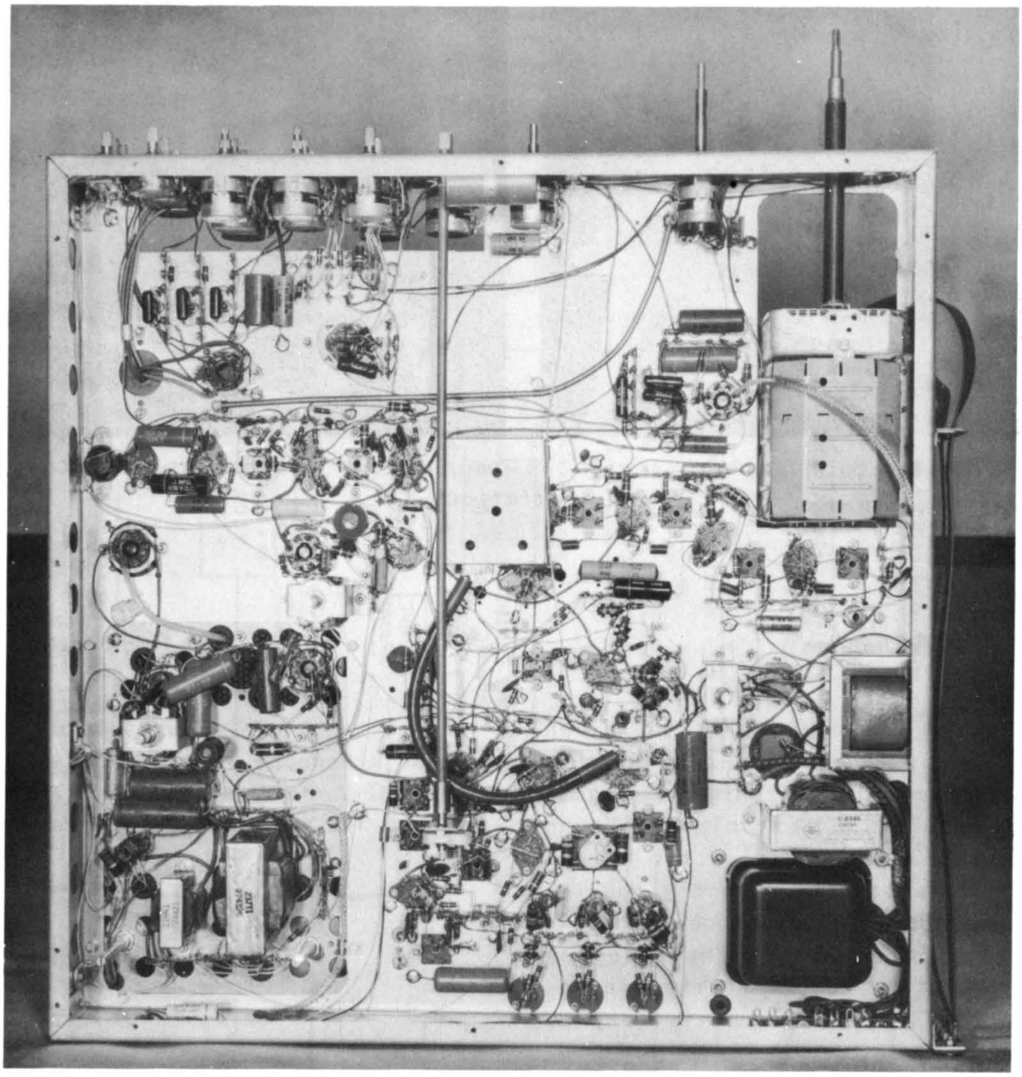
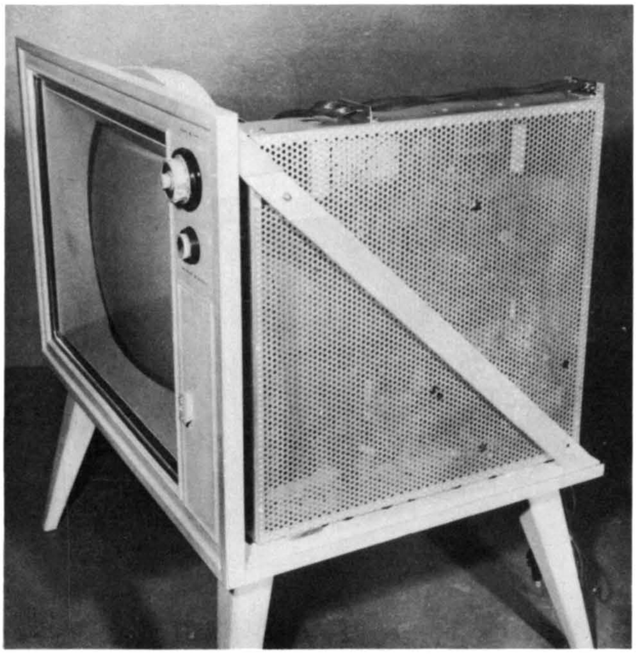


Fig. 5 - Bottom view of receiver chassis.



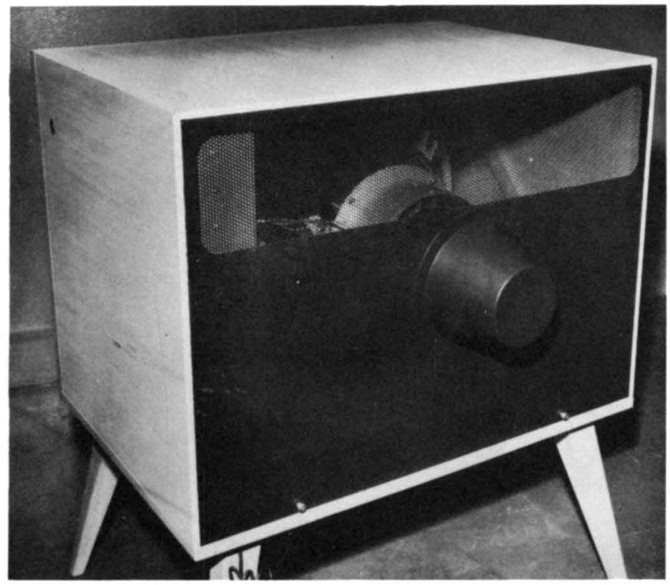


Fig. 6 - The bottom of the chassis and the rear of the cabinet are shielded to reduce radiation.

Block Diagram

A block diagram of the receiver is given in Fig. 7. (Fig. 25 is the schematic diagram of the complete receiver.) The chrominance signal is taken from a combination chrominance-sound detector and is amplified to drive the chrominance demodulators which are directly coupled to the kinescope grids. The luminance signal is delayed by a delay line between the detector and video amplifier. The output of the single-stage luminance amplifier is directly coupled to the kinescope cathodes.

Color sync is provided by an automatic-phase-control circuit which controls the frequency and phase of the reference oscillator. The output of one diode of the balanced phase detector provides automatic-chrominance-control voltage and in addition provides the sensing voltage for the color-killer circuit.

The convergence circuitry provides the necessary horizontal and vertical waveforms for dynamic convergence. No tubes are employed in this section.

Tube Complement

A total of 28 tubes is used, including the color kinescope, three tubes in the combination VHF-UHF tuner, and three high-voltage rectifiers. The tube complement is given in Table I.

Circuit Description

Tuner

A conventional VHF-UHF tuner is employed. Low-side capacitance coupling is used between the mixer and first i-f grid circuits to reduce oscillator radiation. The mixer-output circuit can readily be adapted to work out of either a pentode or triode mixer.

IF Amplifier

The four-stage i-f amplifier is composed of a mixer output network with two tuned circuits and traps at 41.25 and 47.25 Mc, a stag-

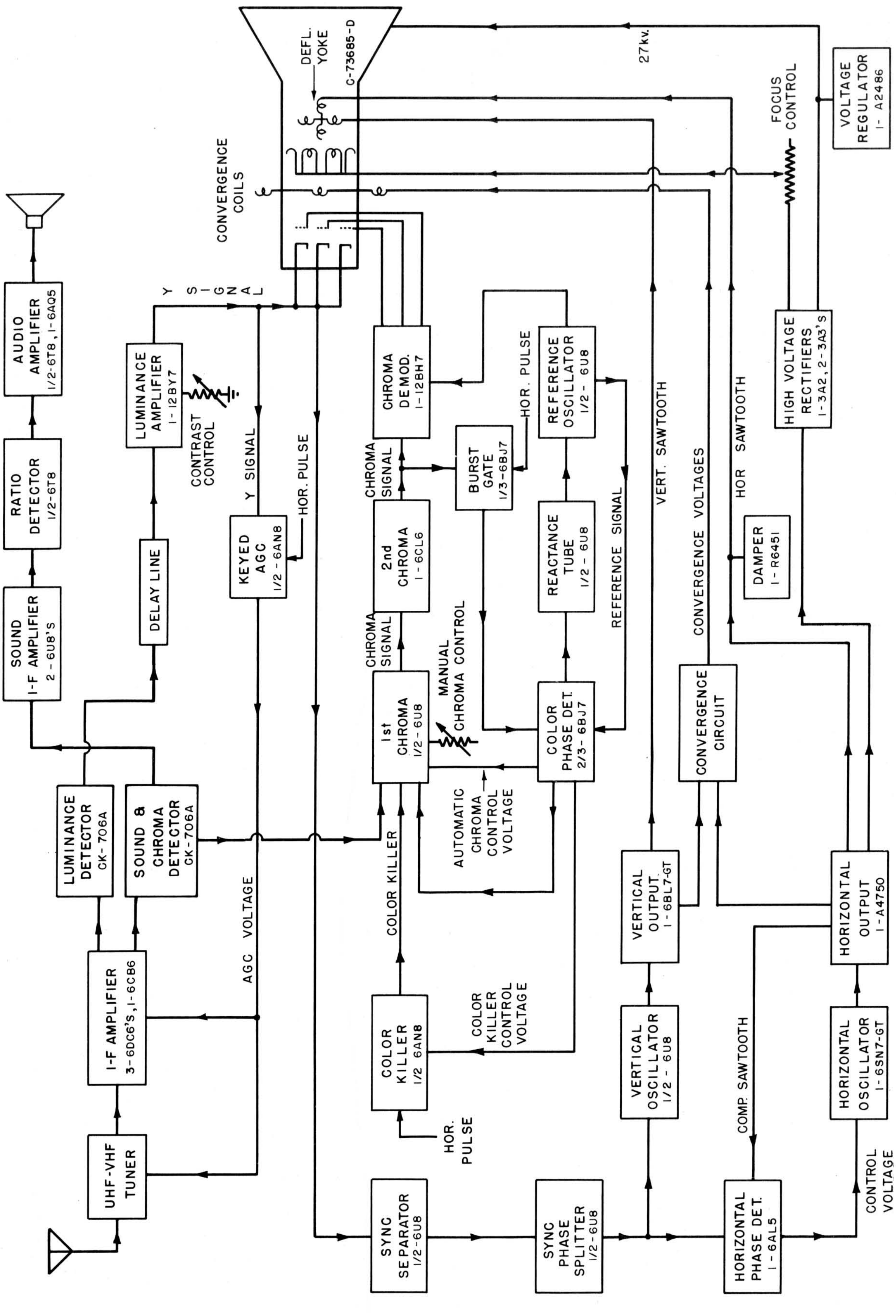


Fig. 7 - Block diagram of simplified developmental color television receiver.

Table I

Tube Complement

Tuner			
UHF mixer crystal	1N82		
UHF oscillator	6AF4		V27
VHF mixer oscillator	6U8		V26
VHF RF amplifier	6BZ7		V28
IF Amplifier			
First i-f amplifier	6DC6		V1
Second i-f amplifier	6DC6		V2
Third i-f amplifier	6DC6		V3
Fourth i-f amplifier	6CB6		V4
Luminance Detector (Crystal)	CK-706A		
Chrominance-Sound Detector (Crystal)	CK-706A		
Luminance Amplifier	12BY7		V5
Chrominance Amplifier			
First chroma amplifier	½ 6U8	(pentode)	V10A
Second chroma amplifier	6CL6		V11
Chrominance Demodulators			
R-Y, B-Y, G-Y demodulators	12BH7		V12
Chrominance Synchronization			
Subcarrier Oscillator	½ 6U8	(pentode)	V15B
Reactance tube	½ 6U8	(triode)	V15A
Phase detector	⅔ 6BJ7		V14B
Burst gate	⅓ 6BJ7		V14A
Color Killer	½ 6AN8	(triode)	V13B
Deflection Synchronization			
Sync separator	½ 6U8	(triode)	V6B
Sync phase splitter	½ 6U8	(triode)	V7B
Horizontal Phase detector	6AL5		
Keyed AGC			
AGC rectifier	½ 6AN8	(pentode)	V13A
Delay diode	¼ 6T8		V8B
Horizontal Deflection			
Oscillator and control	6SN7-GT		V17
Output	A4750	(Dev.No.)	V18
Damper	R6451	(Dev.No.)	V20
High-Voltage Supply			
Rectifier	3A2		V22
Rectifiers	2 3A3		V23, V24
Regulator	A2486	(Dev.No.)	V21
Vertical Deflection			
Vertical oscillator	½ 6U8	(triode)	V10B
Vertical output	6BL7-GT		V19
Low-Voltage Supply			
Selenium rectifier--450 ma			
Selenium rectifier--350 ma			
Sound			
First sound i-f amplifier	½ 6U8	(pentode)	V6A
Second sound i-f amplifier	½ 6U8	(pentode)	V7A
Ratio detector	½ 6T8	(2 diodes)	V8A
First a-f amplifier	¼ 6T8	(triode)	V8B
AF output	6AQ5		V9
Color Kinescope			
RCA Developmental No.	C-73685-D		V25

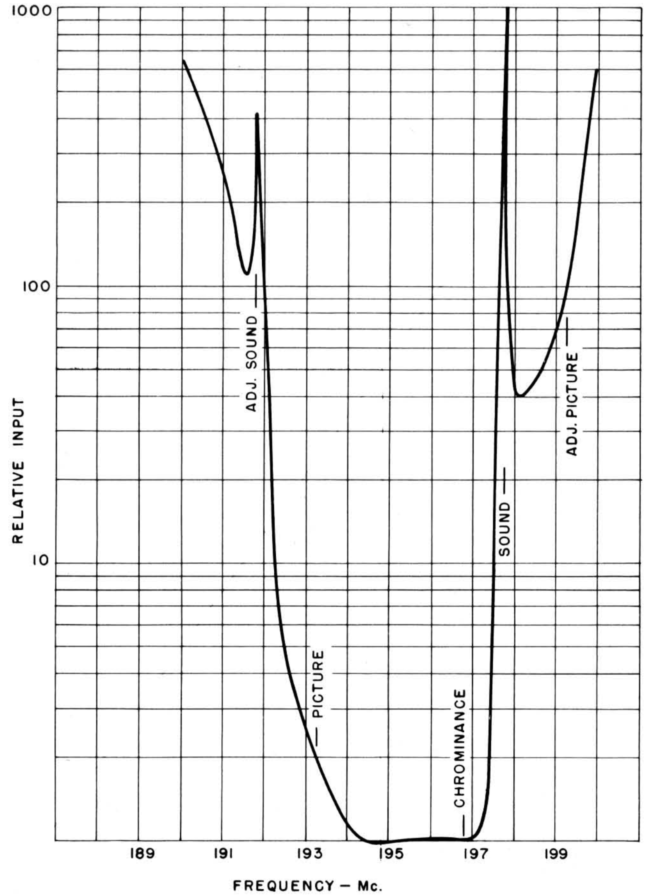


Fig. 8 - Overall selectivity to luminance detector.

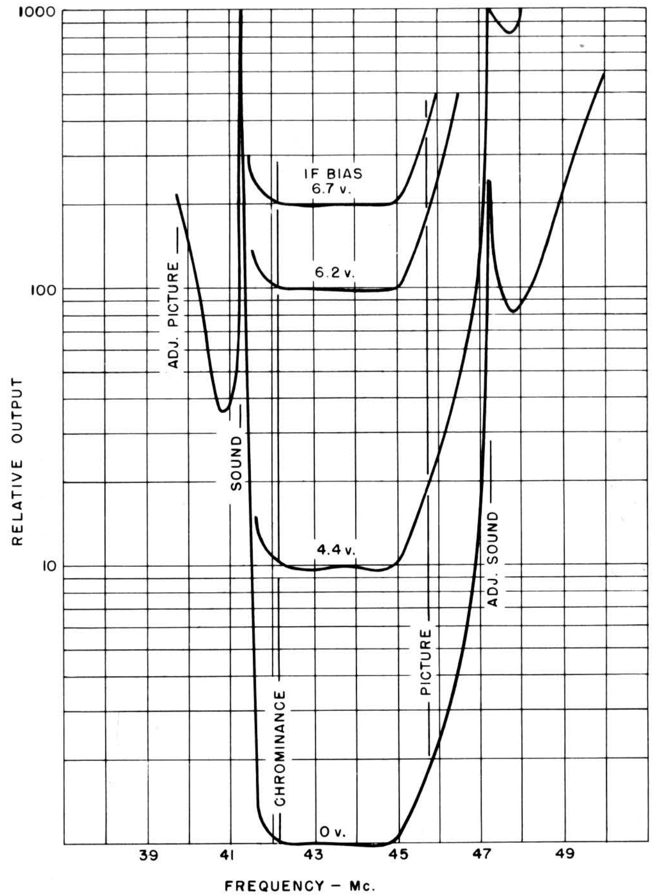


Fig. 9 - Selectivity from mixer grid to luminance detector.

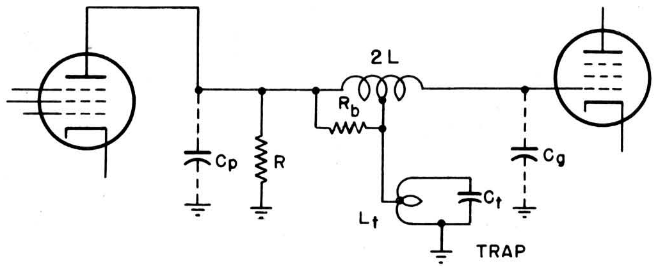
gered triple approximately 4 Mc wide, and a detector network with two tuned circuits and a trap at 41.25 Mc. The overall selectivity as measured on VHF channel 10 is shown in Fig. 8. Selectivity measured from the mixer grid is shown in Fig. 9 for several bias voltages.

Separate crystal detectors are used for the luminance signal, and the chrominance and sound signals. The chrominance and sound signals are detected prior to the final 41.25-Mc trap which precedes the luminance detector.

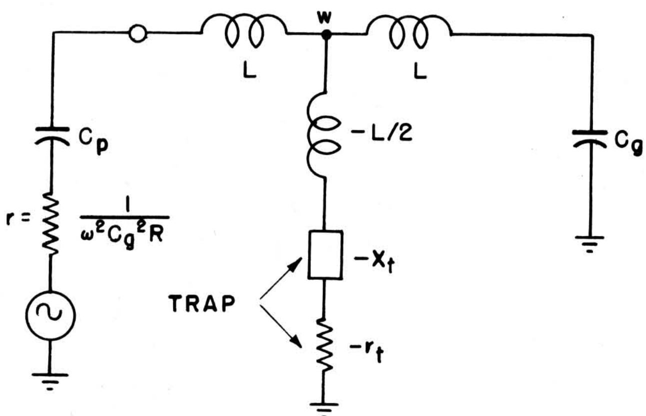
Bifilar-T Trap Circuits

Attenuation of the sound carrier in the mixer output and in the detector stages is obtained by the use of the bifilar-T trap circuit. This circuit is described in detail in an accompanying bulletin, *LB-961, An Analysis of the Bifilar-T Trap Circuit*. The basic structure of the bifilar-T trap circuit and its equivalent circuit are shown in Fig. 10. At a frequency f_0 such that the trap has a reactance equal to $\omega L/2$, the reactance of branch w-to-ground is zero. At this frequency the voltage at point w and the voltage across the output capacitor C_g is zero except for the small voltage supported by the equivalent resistance of the trap. The response of this circuit is observed to be similar to the single-tuned response (Fig. 10c) which would be obtained if the trap were removed from the circuit, except for the attenuation notch introduced by the trap. The response differs from that of conventional trap circuits in that no "after" response is introduced by the trap.

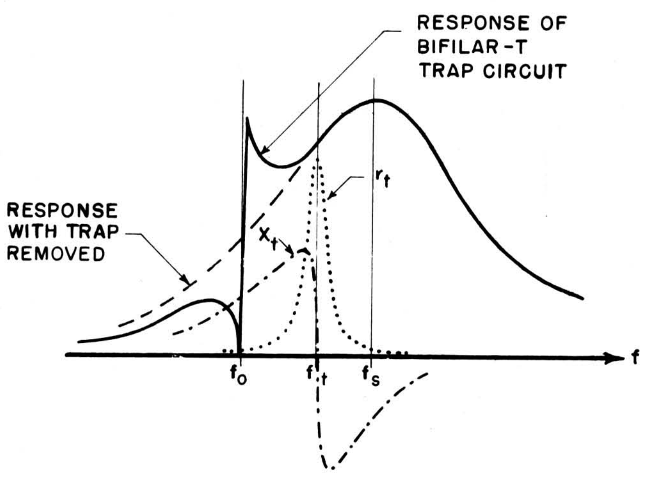
The voltage at point w due to the finite trap Q can be eliminated by bridging a resistor across one-half the bifilar transformer, as shown in Fig. 10a. This reflects a negative resistance equal to ω^2L^2/R_b into the branch



(a) Basic circuit



(b) Equivalent circuit



(c) Circuit response

Fig. 10 - Bifilar-T trap circuit.

w-to-ground and can be adjusted to cancel the effect of the equivalent series resistance r_t of the trap at the frequency of maximum attenuation f_o.

Mixer Output Network

The mixer output network is composed of a bifilar-T trap circuit, low-side capacitively coupled to the mixer plate tuned circuit. This circuit can be considered as forming a staggered pair. The mixer plate circuit is resonant at approximately 43 Mc, while the first i-f grid circuit is tuned, by the bifilar winding, to resonate at approximately 45 Mc with the grid capacitance of the first i-f amplifier tube in series with capacitor C_1. Low-side capacitance coupling is used to reduce oscillator radiation. The two traps provide approximately 30 db rejection at 41.25 and 47.25 Mc, as shown in Fig. 11.

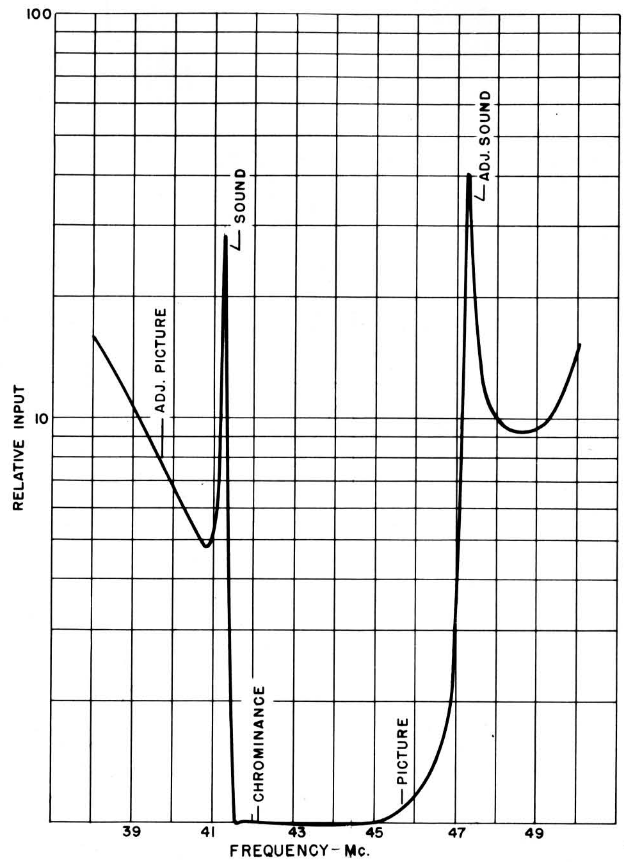


Fig. 11 - Response of the mixer-first i-f coupling.

Staggered Triple

The first, second and third i-f stages comprise a stagger-tuned amplifier. The first and second stages are high-Q circuits tuned to approximately 45 and 43 Mc. The third i-f stage is a low-Q circuit tuned near the center of the pass band. At 45.75 Mc the overall response of the staggered triple is down approximately 6 db.

Detector Stage

The luminance detector is driven by a bifilar-T trap circuit which is low-side inductively coupled to the fourth i-f plate inductance. The plate and detector input circuits are stagger tuned to approximately 46 and 43 Mc respectively. As shown in Fig. 12, the trap provides an additional rejection of 32 db in the luminance channel.

The chrominance signal is taken from the combination chrominance-sound detector which is coupled to the plate of the fourth i-f stage through a 2-μμf capacitor. To prevent 920-kc beat from appearing in the demodulated output of the chrominance channel, two 4.5-Mc traps are provided in the output of the chrominance detector. One of these is a bridged-T trap, and the other is an absorption trap coupled to the input tuned circuit of the first chrominance amplifier. This latter circuit is tuned to 4.1 Mc and forms one of the two high-Q circuits of the stagger-tuned triple chrominance amplifier. The 4.5-Mc intercarrier-sound beat is taken from a winding closely coupled to the 4.5-Mc bridged-T trap. This trap thus performs the dual function of providing a sound takeoff and rejecting 4.5 Mc in the chrominance channel.

IF Alignment

The detector stage is aligned as a staggered pair with the plate and bifilar tuned circuits adjusted as shown in Fig. 13a.

The staggered triple may be aligned by connecting an i-f sweep to the first i-f grid and observing the luminance detector output. The picture carrier position is set by adjustment of the first i-f plate tuning. The sound carrier end is aligned for the response shown in Fig. 13b by the adjustment of the second i-f plate tuning. The low-Q circuit in the third i-f plate tuning serves as a tilt control and

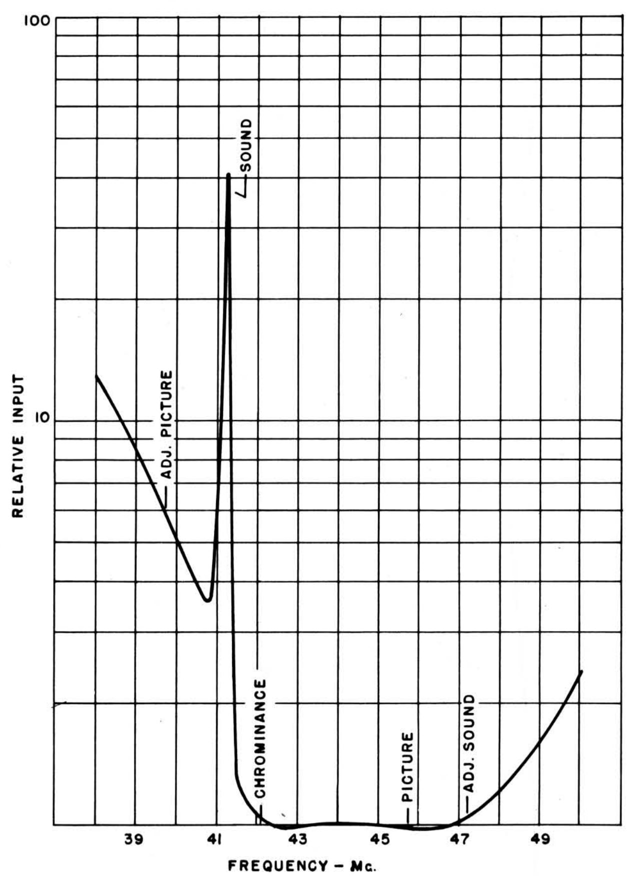


Fig. 12 - Response of detector network.

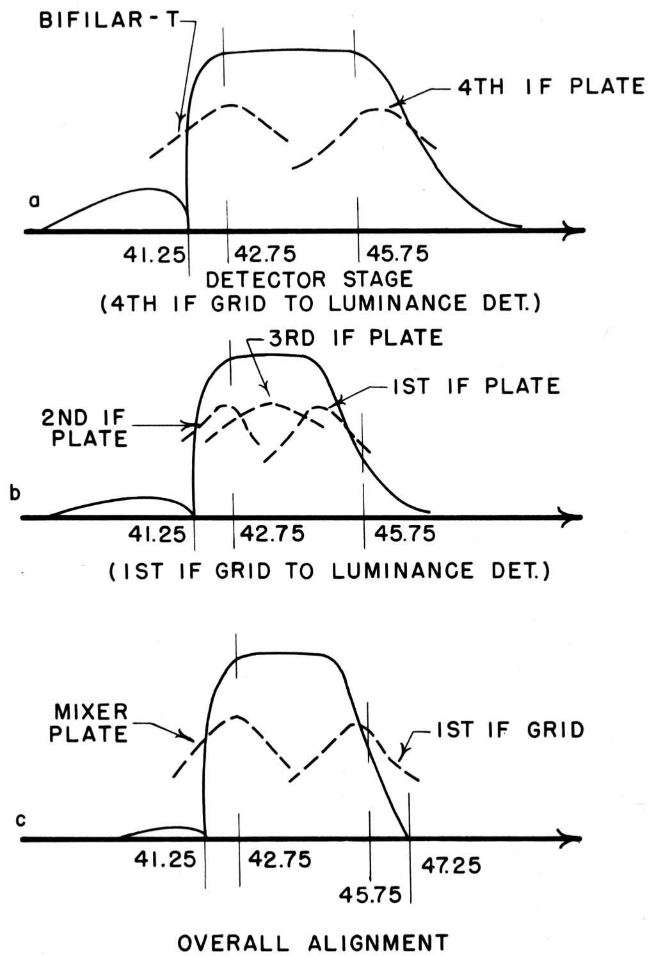


Fig. 13 - IF amplifier alignment.

is adjusted to produce a flat response over the pass band.

The mixer output network can be aligned without the use of an auxiliary detector at the plate of the first i-f tube, provided that the tuner response is approximately flat over the pass band. The first i-f grid is adjusted so that the carrier position remains at the 6-db point as previously determined by the staggered triple. The traps are aligned for minimum response at 41.25 Mc and 47.25 Mc. Alignment of the two 41.25-Mc traps is simplified if the last i-f sound trap is detuned and the first sound trap aligned; the last i-f sound trap is then realigned for minimum response at 41.25 Mc. The mixer plate tuning is then adjusted for a flat response at the low-frequency end of the pass band as shown in Fig. 13c. Small variations from optimum response can be compensated by adjustment of the staggered triple.

Sound Channel

The 4.5-Mc intercarrier beat is detected in the combination chrominance-sound detector which is driven from the plate of the last i-f amplifier tube. Sound-carrier attenuation of 30 db up to this point is provided by the 41.25-Mc trap in the mixer plate circuit. The sound takeoff is closely coupled to the 4.5-Mc bridged-T trap in the output of the chrominance-sound detector and is followed by a 4.5-Mc amplifier and ratio-detector driver using the pentode sections of two 6U8 tubes. A type 6T8 is used for the ratio detector and the first a-f stages.

The third diode of the 6T8 is used for r-f a-g-c delay. Fixed bias, available from the electrical centering control, is used for the 6AQ5 audio output tube.

Luminance Channel

The luminance detector is driven from the secondary winding of the last i-f transformer so that the 41.25-Mc rejection of the last i-f transformer is effective. The output of the detector drives a 4100-ohm delay line which delays the luminance signal by 0.8 μsecond to equalize the luminance and chrominance delays. The series peaking coil in the output of the delay line is adjustable to minimize reflections. A modified bridged-T trap in the output of the delay line provides rejection at 3.58 Mc. The 4100-ohm load resistor serves as the detector load, as a termination for the delay line, and also as the center leg of the bridged-T.

The single-stage 12BY7 video amplifier is direct-coupled to the kinescope cathodes. A potentiometer in the cathode circuit functions as the contrast control. This control is tapped at 75 ohms and partially bypassed in order to boost the high-frequency response.

A 5000-ohm video plate load is used. The kinescope anode current significantly loads this circuit during the highlights of the picture and this is taken into account in the adjustment of the video peaking. The effect of the kinescope loading can be simulated approximately by the shunting effect of a 20K load resistor.

Chrominance Channel

The chrominance section of the color receiver is shown in simplified form in Fig. 14. The output of the chrominance-sound detector is amplified in a two-stage amplifier consisting of the pentode section of a 6U8 and a 6CL6. The output of the 6CL6 drives a 12BH7 high-level triode demodulator which provides R-Y, G-Y and B-Y signals. These color-difference signals are direct-coupled to the kinescope grids.

The chrominance amplifier also amplifies the color burst which is separated from the chrominance signal by means of a diode gate as shown in Fig. 14. This separated high-level burst is fed to the phase detector where it is compared with the output of the color reference oscillator. The resulting balanced control voltage is fed to the reactance tube. Since the burst input to the phase detector exceeds the color reference oscillator input, the unbalanced negative output of the phase detector is a measure of the relative chrominance signal

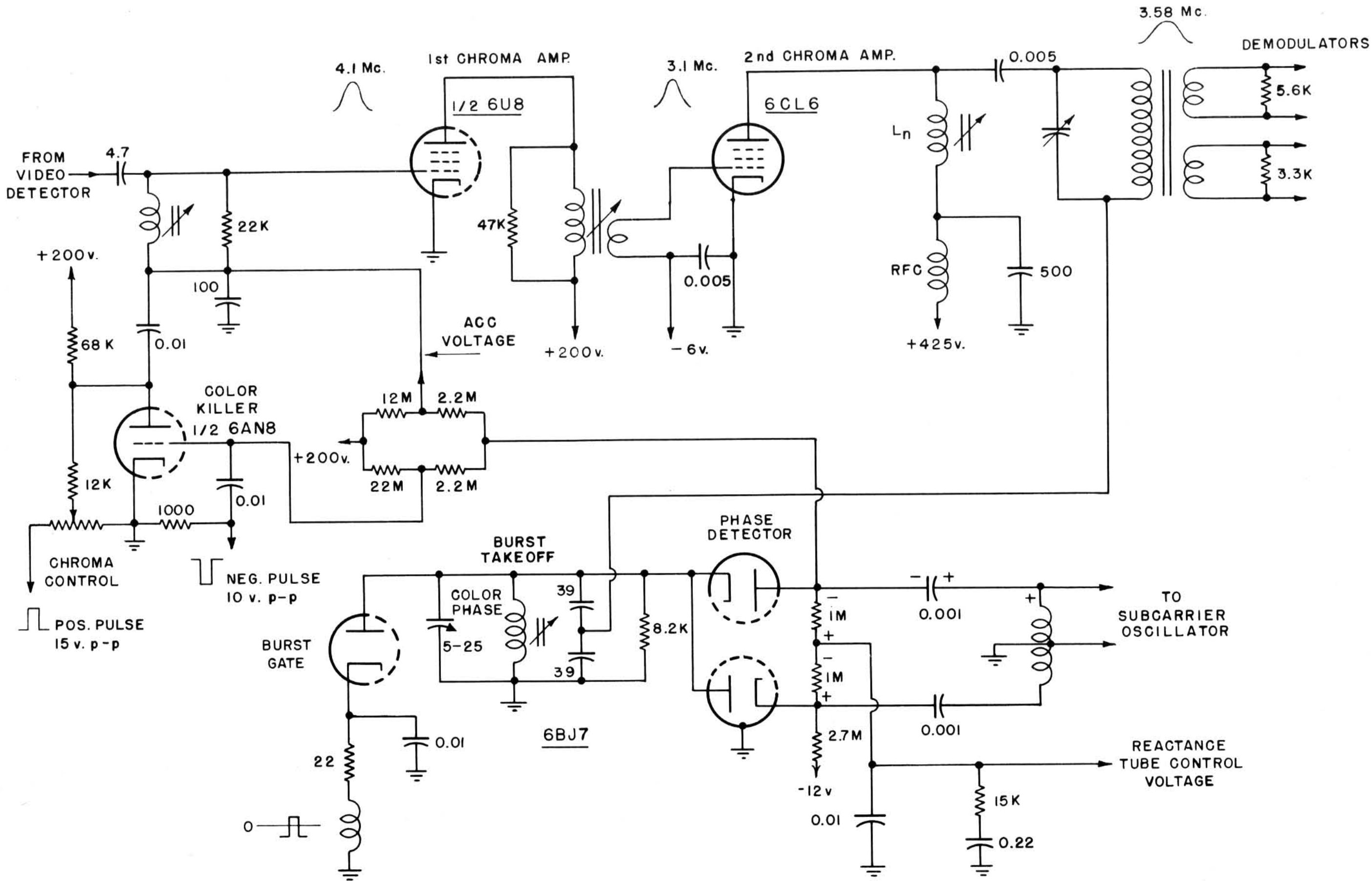


Fig. 14 - Simplified schematic of chrominance channel.

level; this control voltage is applied to the first chrominance amplifier to provide automatic chrominance control.

Manual chrominance control is accomplished by applying a positive horizontal retrace pulse to the grid of the first chrominance amplifier. This attempts to vary the burst output of the chrominance amplifier in accordance with the magnitude of the horizontal pulse, corresponding to the chroma control setting. The automatic-chroma-control action interprets this as corresponding to a weaker or stronger chrominance signal, and changes the amplification of the first chrominance amplifier so as to maintain the burst amplitude essentially constant.

The control voltage which is used for automatic chroma control is also used to provide the control voltage for the color killer tube. This tube is normally biased beyond cutoff by the unbalanced phase detector control voltage. In the absence of burst, however, the color killer conducts and amplifies the negative keying pulse to produce a positive pulse which clamps the grid of the 6U8 chrominance amplifier during the retrace interval so as to hold it beyond cutoff during the line interval.

The use of the chrominance amplifier in this manner to amplify both the chrominance signal and the burst contributes to the overall stability. This is made possible by the fact that the first chrominance amplifier is always operative during the burst interval, even when cut off during the line interval by the color killer in the absence of a color signal.

Chrominance Amplifier

The three interstage circuits in the chrominance amplifier form a staggered triple having a 1-Mc flat bandpass. The two high-Q elements are in the grid and plate circuits of the 6U8 first chrominance amplifier and are tuned to 4.1 and 3.1 Mc, respectively. These circuits have a Q of approximately 7. The plate circuit of the final 6CL6 chrominance amplifier has a Q of 3.5 and is tuned to the middle of the pass band at the color subcarrier frequency.

Low driving impedance in the grid of the 6CL6 chrominance amplifier is obtained by using a 2:1 turns ratio in the interstage transformer. This reduces feedback through the 6CL6 plate-grid capacitance.

The amplification measured from the control grid of the pentode section of the 6U8 to the plate of the 6CL6 is 1000 times at 3.6 Mc, with a bias of one volt at the 6U8 pentode control grid.

The 6CL6 chrominance amplifier is operated with a fixed bias of 7 volts corresponding to class AB operation. The screen is operated at 200 volts, while the plate is operated at 300 volts to ensure adequate chrominance signal output.

The output of the chrominance amplifier is applied to the demodulators through a tightly-coupled output transformer wound on a ferrite core. Damping is provided by resistors across each of the secondary windings driving the two demodulator triodes.

The bias of the first chrominance amplifier is derived in part from the output of the phase detector to produce automatic chroma control. This is dropped to the required d-c level by bleeding current from the 200-volt supply. Normal operating bias with a color signal input is approximately 3.5 volts. The bias rises or falls from this value, depending (a) upon the level of the chrominance signal with respect to the luminance signal (which in turn depends on the tuning of the receiver and propagation--antenna conditions); and (b) upon the setting of the manual chroma control.

The color killer pulse and the manual chroma control pulses are a-c coupled to the first chroma amplifier grid as shown in Fig. 14.

Burst Takeoff

The burst is taken off (Fig. 14) across a tuned circuit in series with the primary winding of the chrominance-output transformer. During the line interval the burst gate diode conducts and short circuits the takeoff circuit so that the full chrominance signal is developed across the chrominance output transformer. During the retrace, however, the positive gating pulse applied to the cathode of the diode stops its conduction and 100 volts peak-to-peak of burst signal is developed across the burst takeoff tuned circuit.

The Q of the burst takeoff tuned circuit is determined by the 8.2K damping resistor which provides sufficient bandwidth to prevent distortion of the burst. The 6CL6 plate circuit is tapped down on the chrominance takeoff tuned circuit in order to reduce the diode current requirements.

Feedback of color reference signal (which is amplified by the demodulator triodes and appears across the primary of the chrominance output transformer) into the burst takeoff tuned circuit is prevented by using a high-Q choke which tunes to 3.58 Mc with the plate-to-ground capacitance of the 6CL6. As a result, the 3.58-Mc reference frequency appears across the 6CL6 and the burst takeoff signal is therefore not contaminated. The residual color reference frequency across the burst takeoff tuned circuit is 1 volt which is negligible in comparison to the normal burst level of 100 volts.

Color Phase Control

Color phase control is provided by a 5-to-25-μμf capacitor across the burst takeoff coil. This varies the tuning on either side of resonance to provide a ±25-degree change in color phase. The change in burst amplitude over the range of the color phase control is negligible.

Phase Detector

The input to the balanced phase detector (Fig. 14) consists of a single-ended 100-volt peak-to-peak burst signal and a 30-volt peak-to-peak push-pull color reference signal input. In the absence of burst, approximately 15 volts d.c. is developed across each of the two 1-megohm load resistors. On a color signal, this voltage varies between 38 and 42 volts at maximum and minimum settings, respectively, of the chroma control.

In order to eliminate the need for a balance control, resistors matched to ±1 per cent are used for the load resistors which have a nominal value of 1 megohm (±10%). This is less expensive and considered more satisfactory than using a variable balance control.

The connection of one end of the phase

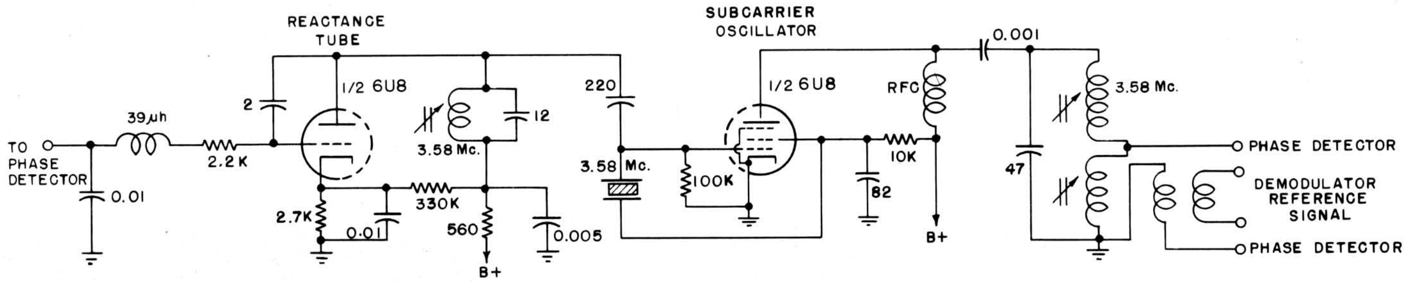


Fig. 15 - Color reference oscillator and reactance tube.

detector to provide automatic chroma control bleeds a small positive voltage into the phase detector. This is offset by bleeding a negative voltage into the opposite load resistor through a 2.7-megohm resistor connected to the -12-volt supply used for electrical centering.

The sensitivity of the phase detector is 0.18 volt per degree of phase error. The static phase error corresponding to a 100 cps frequency difference is 5 degrees.

Color-Reference Oscillator

The color-reference voltage is produced by a crystal oscillator using the pentode section of a 6U8 (Fig. 15). The crystal is connected between the grid and screen. Electron coupling to the plate produces sufficient signal in the plate circuit of the oscillator to drive the phase detector and the triode demodulators. A bifilar-wound transformer provides 30 volts peak-to-peak push-pull for the phase detector. An additional winding on the same form provides 30 volts peak-to-peak at a 300-ohm impedance level. This latter winding is isolated with respect to ground as required by the color demodulators.

Phase Shift Network

The plate tank of the oscillator drives a two-section low-pass filter having a 300-ohm characteristic impedance. This network provides the 63.6-degree phase shift required for excitation of the triode demodulators. The use of two sections makes the circuit less critical of component values and improves the stability. Alignment of the circuit to obtain the 63.6-degree relative phase shift requires adjustment of only one element. All other tuned circuits, with the exception of the color phase control, are common to both the chrominance and burst channels.

Reactance Tube

The triode section of a 6U8 is used as a capacitive reactance tube (Fig. 15). Self-bias provided by a 2700-ohm cathode resistor is used to improve the stability. The inductance in the grid circuit is used to improve the Q of the variable capacitance presented by the reactance tube.

The sensitivity of the reactance tube is 100 cps/volt. The pull-in range of the color sync automatic phase control system is approximately 275 cps.

Chrominance Demodulators

The high-level chrominance demodulator used in this receiver provides adequate output for direct drive to the kinescope grids, with good linearity, stability, and independence of tube characteristics. The principles of operation are described in detail in an accompanying bulletin, *LB-959, A High-Level Triode Color Demodulator*, and will be described only briefly here.

Fig. 16 shows the basic circuit of the triode demodulator. The chrominance signal is fed at high level to the plate through a transformer and the reference signal is applied to

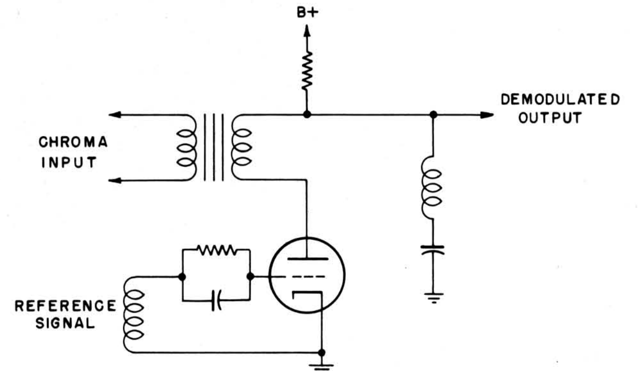


Fig. 16 - Basic triode demodulator circuit.

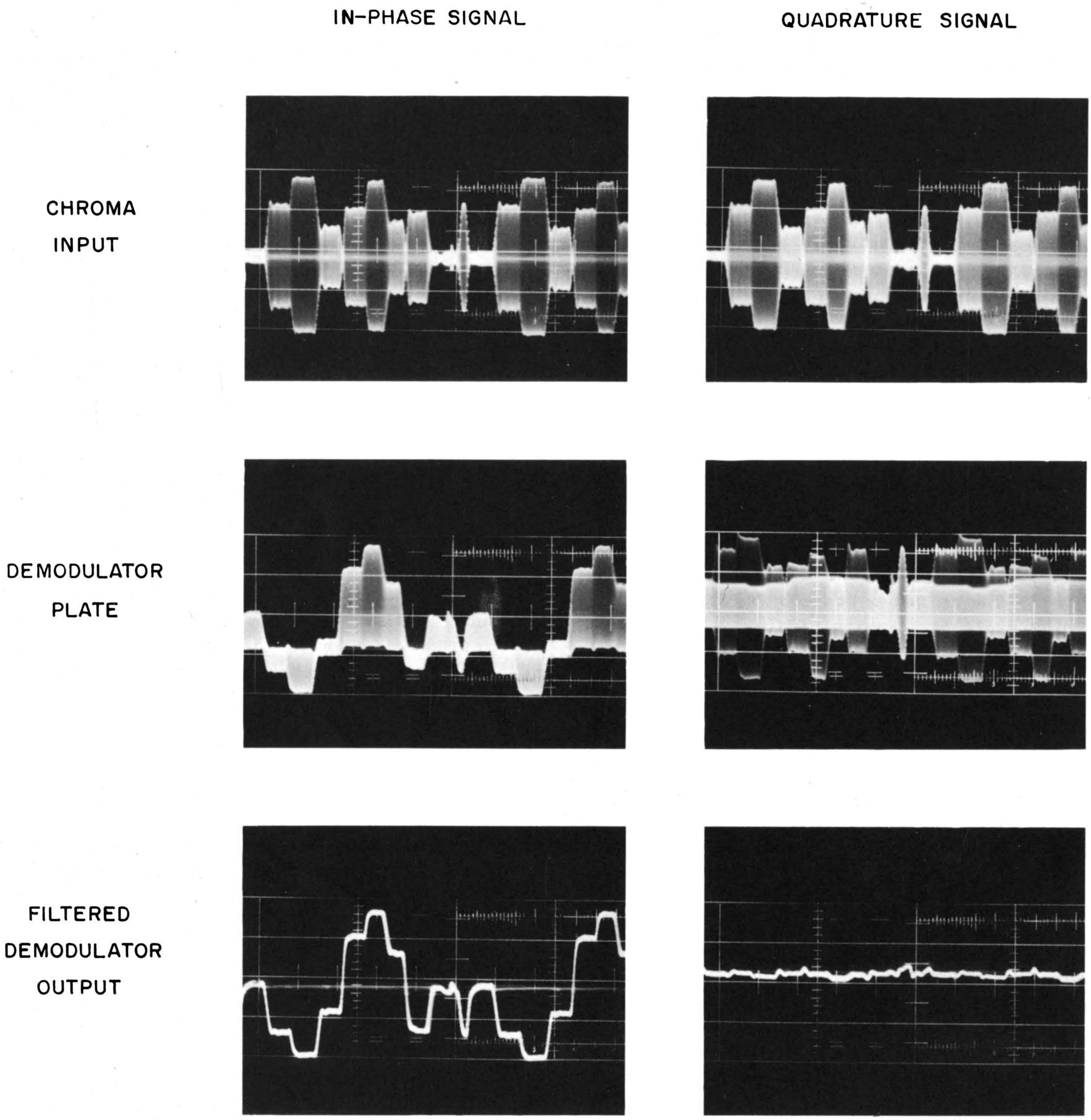


Fig. 17 - Demodulator waveforms.

the grid. The demodulator may be considered as a grid-controlled rectifier, the plate being clamped slightly above the cathode potential at the instant of plate current flow. The demodulated output voltage is therefore equal to the peak-to-peak chrominance signal as the relative phase of grid and plate signals goes from 0 degrees to 180 degrees.

The 3.58-Mc trap prevents 3.58-Mc voltage from appearing across the demodulated output. This is desirable because of the resulting improvement in rectification efficiency, as well as for the reduction of radiation.

Typical demodulator waveforms are shown in Fig. 17. This shows the input signal applied to the plates, the demodulator plate signal, and the filtered color-difference output for in-phase and quadrature signals. The essentially zero output for the quadrature signal indicates the high degree of linearity.

The demodulator circuit arrangement used in the receiver is shown in Fig. 18. A 12BH7 dual triode is used, with R-Y and B-Y being produced across the two plate-load resistors and G-Y across the common cathode resistor.

It is shown in the accompanying bulletin, *LB-959*, that the requirements for producing the color difference signals are:

(a) The chrominance drives applied to the demodulator plates must be in the ratio of 1.4 to 1.

(b) The phase of the grid drives must be separated by 63.6 degrees, (Fig. 18).

(c) The three load resistors must be in the approximate ratio of 1, 2 and 5.2.

As shown in Fig. 18 these requirements are readily met. The turns ratio of the chrominance transformer determines the 1.4-to-1 drive ratio, while the low-pass filter in the grid circuit provides the 63.6-degree phase shift in the color reference drive. No adjustments are required since the demodulators directly produce R-Y, G-Y and B-Y signals.

The maximum peak-to-peak demodulated output is about 200 volts. With no chrominance signal input, the potential at each of the demodulator plates is 125 volts, and the potential at the common cathode is 100 volts. Since the change in these voltages with a ±50 per cent change in grid drive is less than ±1 volt, the stability with changes in grid drive is excellent.

The r-f chokes and 2.7K resistors in series with the R-Y, G-Y and B-Y outputs are used to reduce radiation at harmonics of 3.58 Mc.

The effective driving impedance of the demodulators is in the order of 4000 ohms.

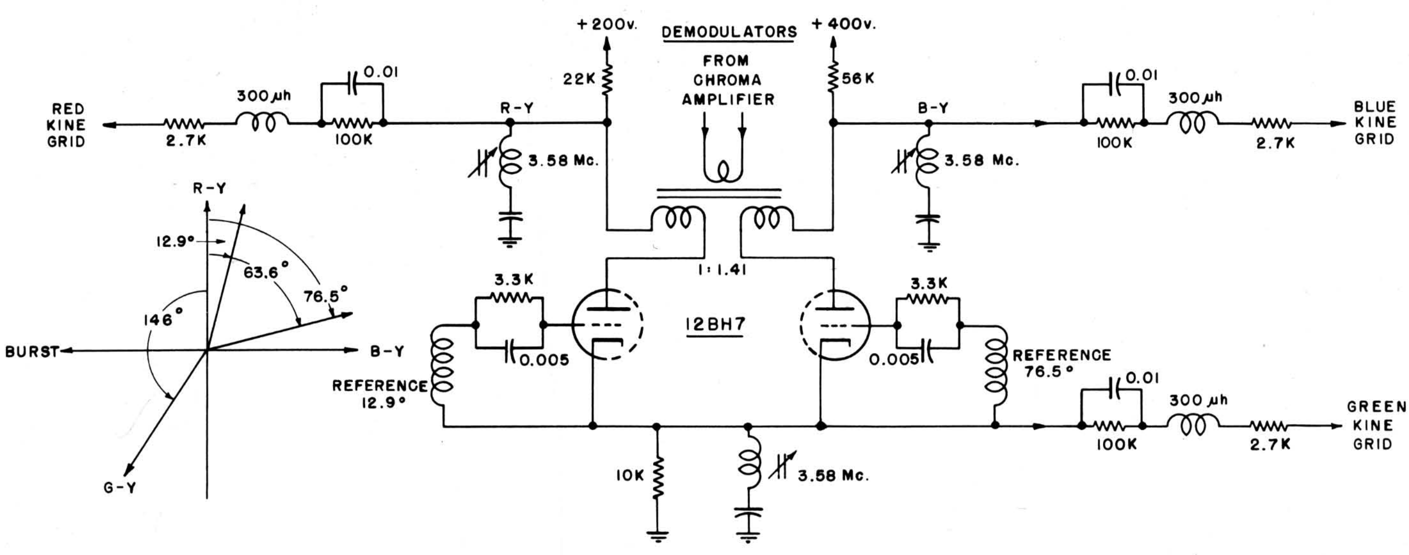


Fig. 18 - Demodulator circuit.

This is sufficiently low to require no peaking in the demodulator outputs.

Chrominance Channel Alignment

The *plate inductance of the 6CL6 chrominance amplifier* is adjusted for minimum c-w color reference frequency across the burst takeoff tuned circuit. This adjustment is made with the grid of the 6CL6 grounded.

The *demodulator 3.58-Mc traps* are adjusted for minimum 3.58-Mc output, as observed on an oscilloscope, with the receiver operating normally.

The *chrominance amplifier bandpass* is aligned as a conventional stagger-tuned amplifier. The color-reference oscillator tube is removed, the B+ supply to the demodulator tubes is removed, and the circuits aligned as follows: the chrominance takeoff at 4.1 Mc, the interstage circuit at 3.1 Mc, and the 6CL6 output circuit at 3.6 Mc (by adjusting the trimmer capacitor across the transformer primary).

The *demodulator grid phase-shift network* and the burst takeoff circuits are conveniently adjusted with a bar pattern. When these circuits are properly adjusted, the B-Y and R-Y outputs will be zero during the R-Y and B-Y bars, respectively.

The *reactance tube plate inductance* is adjusted, with a color signal applied, to bring the phase detector error voltage to zero. This adjustment tunes the oscillator accurately to 3.58 Mc.

The *oscillator output circuit* is tuned as follows: The fixed slug is set for maximum coupling between the transformer bifilar windings and the secondary winding which drives the triode demodulators. The adjustable slug is tuned to produce maximum output as indicated by maximum color reference signal at the demodulator grids.

Brightness and Screen Controls

A simplified schematic of the brightness and screen control circuit is shown in Fig. 19. The master brightness control is placed in the kinescope cathode circuit; the green and blue differential brightness controls are in the respective grid circuits, the brightness voltage being developed across 100K resistors in each of the demodulator output circuits.

A master screen control and blue and green differential screen controls are provided. The master screen control varies the cutoff voltage of the guns to make maximum use of the available drive, while the differential screen controls enable compensation for differential phosphor efficiencies. The red screen is tapped at a low point on the screen divider because of the somewhat lower red phosphor efficiency.

To eliminate a-g-c level variations with setting of the master brightness control, the cathode circuit of the a-g-c rectifier is made to vary with the brightness control in the same amount as the variation produced at the plate of the luminance amplifier. This compensation to maintain the video amplifier clipping level constant is accomplished by the 270K resistor connected between the kinescope cathode and the 4700-ohm cathode resistor of the a-g-c tube.

The 68K resistor R_1 in series with the common kinescope cathode lead results in partial degeneration of the luminance d-c component. The amount of degeneration, i.e., the degree of d-c restoration, is determined by the value of this resistance. If R_1 is changed, R_2 and R_3 (Fig. 19) should be changed proportionately in order to maintain the brightness control range and the a-g-c compensation.

Deflection Synchronization

The sync separator (triode section of a 6U8) is driven from the plate of the luminance amplifier. This insures good noise clipping since the keyed a.g.c. holds the sync peaks near plate current cutoff in the 12BY7. The sync separator is followed by the triode section of a 6U8 which provides the push-pull sync output for the horizontal phase detector and the positive vertical sync pulse to trigger the vertical oscillator. A transformer is used to provide the comparison sawtooth for the horizontal phase detector.

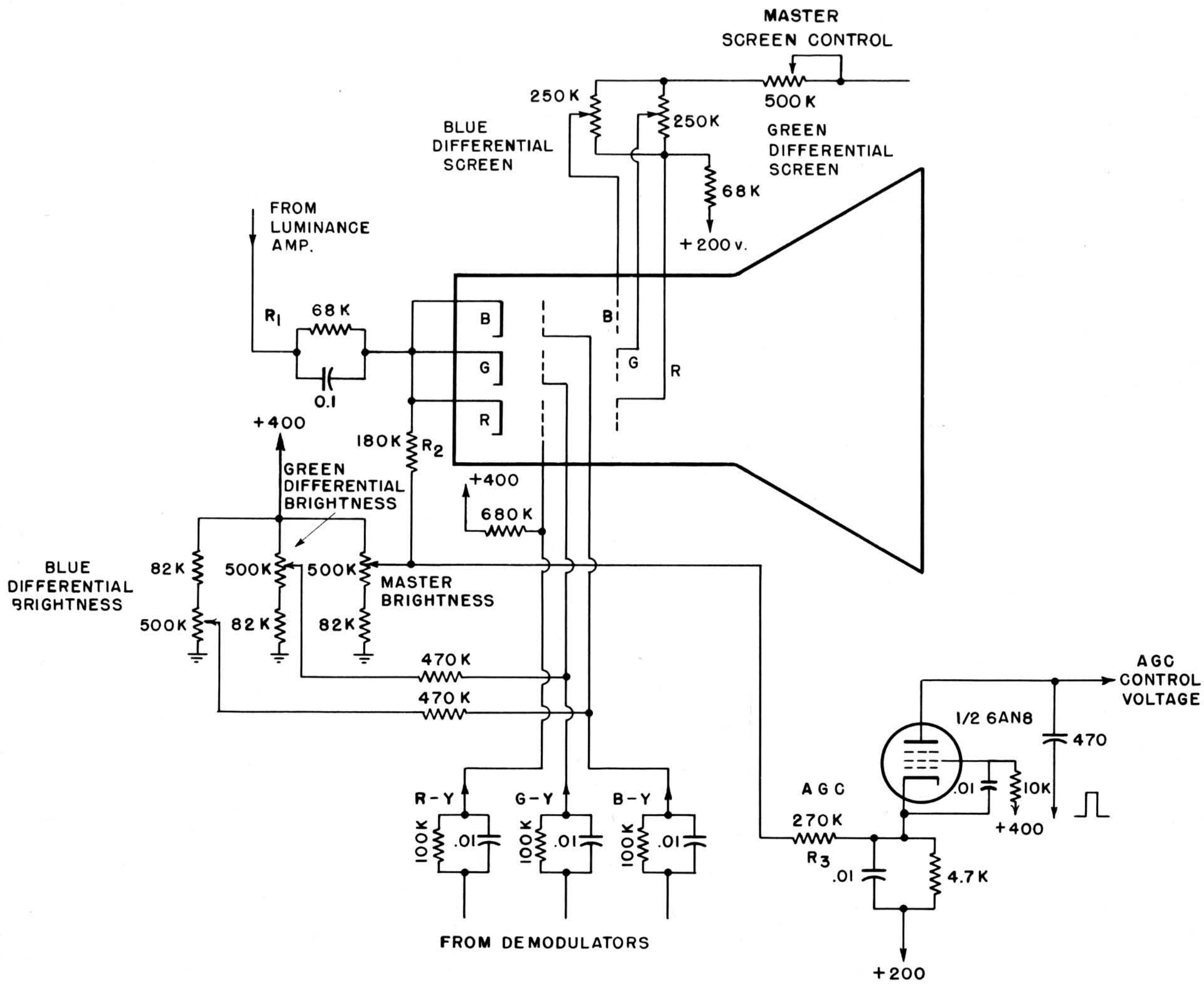


Fig. 19 - Screen and brightness circuits.

The 47K resistor and 47-μμf capacitor in the plate circuit of the sync separator are used to delay the horizontal sync pulses so as to center the horizontal-hold control range during the color burst interval.

AGC

The keyed a-g-c tube is driven from the plate circuit of the luminance amplifier, 12BY7. Full i-f a-g-c voltage is fed to the first and second i-f tubes. The a.g.c. to the third i-f tube is divided in half. AGC to the r-f tube is delayed by the 6T8 diode section. The ratio of the r-f to the i-f a-g-c voltage will depend on the particular tuner used.

The compensation used to keep the a-g-c threshold independent of the master brightness control setting is described in connection with the description of the brightness controls.

Horizontal Deflection and High Voltage

The horizontal-output tube, RCA Dev. No. A4750, is driven by a 6SN7-GT stabilized multivibrator, which supplies the required 150-to-200-volt peak-to-peak driving waveform. A fuse in the cathode of the output tube provides protection in case of loss of drive.

The ultor voltage is provided by a type 3A2 and two type 3A3 high-voltage rectifiers. A bleeder in the output of the type 3A2 rectifier supplies the 4.5 kv required for the focus electrode and another bleeder supplies the grid voltage for the RCA Dev. No. A2486 shunt regulator tube.

A separate tapped winding on the horizontal-output and high-voltage transformer, RCA Dev. No. XD-2548-J, supplies the pulses required for operation of the horizontal-dynamic convergence circuit, the color killer, the burst gate and the chroma control.

The high-voltage regulator is adjusted by means of the potentiometer in the grid circuit of the A2486. The range of the high-voltage-adjust potentiometer is determined by the value of the 1.2-megohm resistor relative to the 50-megohm bleeder resistor. The ratio of these two values, rather than the absolute values, must be maintained in order to obtain the desired range in the high-voltage adjustment control.

The vertical coils of the deflection yoke, RCA Dev. No. XD-2377-D, are isolated from ground at line frequency and centering current is fed to the vertical windings through isolation inductor transformer, RCA Type 219R1.

The horizontal windings of the deflecting yoke are a-c coupled to the horizontal-output and high-voltage transformer and centering current fed to the windings through two isolation chokes.

Normal cathode current for the horizontal output tube, A4750, is 215 ma. With the high voltage set to regulate at 25 kv, the regulator-tube cathode current is 750 μa with the kinescope cut off.

The optimum adjustment of the linearity control normally corresponds to minimum cathode current in the horizontal output tube. The horizontal drive should be adjusted just below the point at which overdrive occurs.

Vertical Deflection

The vertical deflection circuit is conventional. The triode section of a 6U8 is used as a blocking oscillator and is followed by a 6BL7-GT with the two triode sections in parallel. The drive for the vertical convergence circuit is taken from the cathode circuit of the 6BL7-GT.

Convergence

Simplified convergence circuitry is used, in which the dynamic convergence currents are obtained directly from the horizontal and vertical output circuits without additional tubes. These currents therefore tend to track the deflection with line-voltage changes. The electron guns in the color kinescope are mechanically tilted toward a common axis, to reduce the amount of static magnetic field required. Separate a-c and d-c components of magnetic field are applied to each electron gun by way of a pair of internal pole pieces attached to each gun as shown in Fig. 20. A

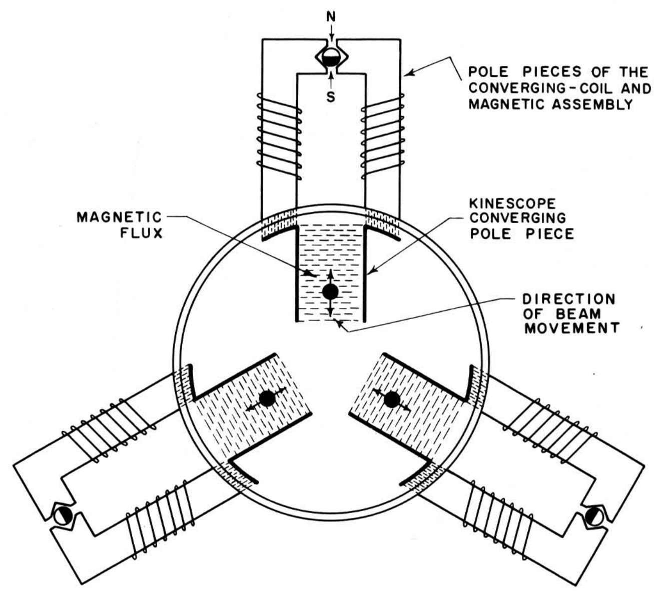


Fig. 20 - Converging-coil and magnet assembly.

converging-coil and magnet assembly, RCA Dev. No. XD-2590, which has a dual coil winding with a horseshoe-shaped ferrite core for each gun, is placed in juxtaposition to the internal pole pieces. Each ferrite core has two sections and a magnet. The dynamic component of magnetic field is produced by current flowing in the coil winding, whereas the static component is induced in the core by means of the magnet, which is a cylinder of small-diameter placed in the slot between the core sections. This cylindrical magnet is polarized perpendicular to its axis. When the magnet is rotated, a component of its field, depending upon the degree of rotation, is set up across the core sections and therefore across the internal pole pieces of the gun.

The action of the magnetic fields involved in convergence is shown in Fig. 21. The blue-positioning magnet, RCA Dev. No. XD-2373-C, is used to provide lateral movement of the blue beam so that the three beams can be made to converge at the center of the raster.

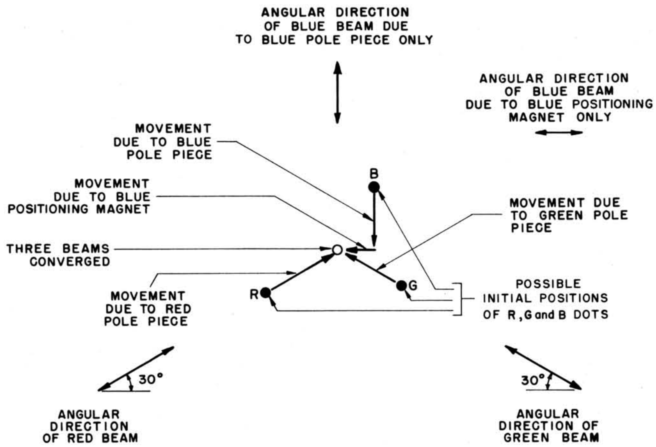


Fig. 21 - Action of the magnetic fields used for convergence.

The convergence circuit is shown in Fig. 22. The currents through each of the convergence coils are individually adjustable in amplitude and phase. The phase is adjusted by the 25-to-280-μμf variable trimmer capacitors used to resonate each coil at line frequency. Shifting the phase of the sine wave provides an effect comparable to the tilt obtained by the addition of a sawtooth to a parabola. The vertical portion of the circuit uses the readily available parabolic and sawtooth waveforms.

The converging-coil and magnet assembly, RCA Dev. No. XD-2590, is shown in Fig. 23. Two windings, one of 800 turns and one of 1200 turns, are connected series aiding on each horsehsoe core. In addition, a dynamic convergence inductor pack, RCA Dev. No. XD-2358-S, consisting of ferrite-cored chokes, each of about 400 millihenries inductance, is used. One choke of this unit is connected in series with the two converging coils for each gun.

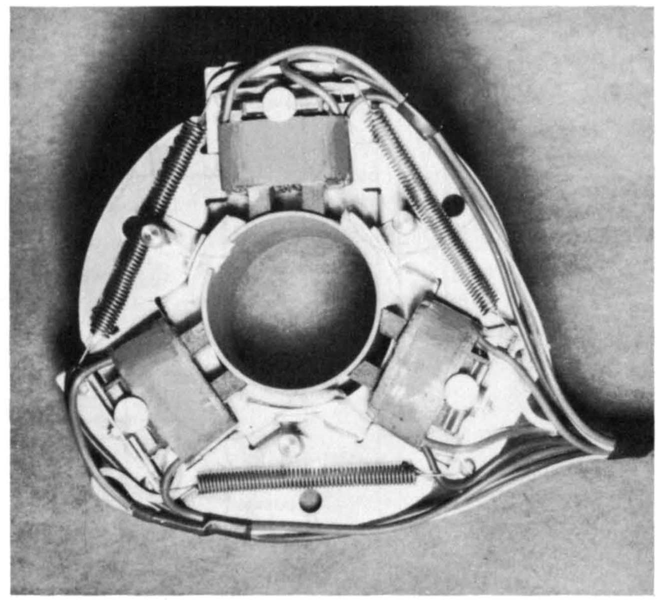


Fig. 23 - Converging-coil and magnet assembly, RCA Dev. No. XD-2590.

A parabolic voltage obtained from the cathode of the vertical output tube is fed via the blocking capacitor C_2 and the three vertical tilt controls R_1, R_2 and R_3, to capacitor C_3. The voltage across C_3 is a parabola delayed and tilted with respect to the voltage across C_1. The effect of the tilt controls on the vertical parabolic waveforms is illustrated in Fig. 24. The current in each coil is determined by the vertical amplitude controls (R_4, R_5 and R_6).

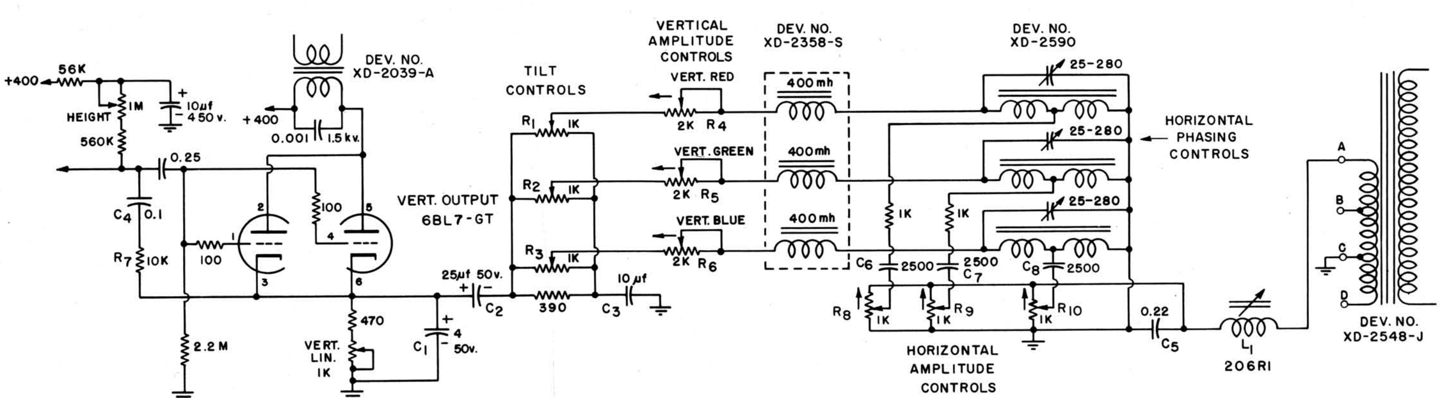


Fig. 22 - Convergence circuit.

Resistors R_4, R_5 and R_6 constitute the dominant impedance offered to the voltage, so the current will be similarly parabolic in wave shape. The vertical tilt adjustment shifts the minimum point of the parabola toward the start or finish of each cycle. In order to permit the vertical output tube to operate normally, the sawtooth charging capacitor C_4 and peaking resistor R_7 are returned to the cathode of the output triodes.

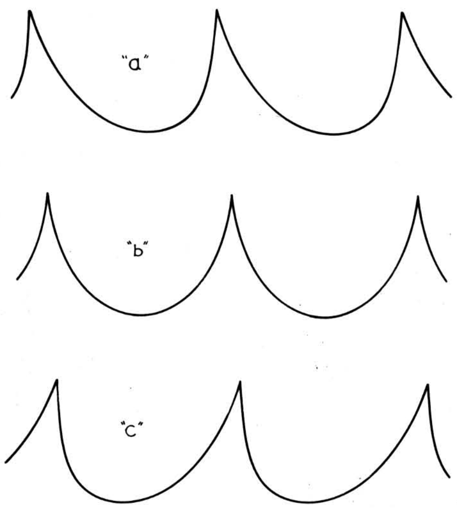


Fig. 24 - Effect of tilt on vertical parabolic waveform.

The horizontal-frequency component of voltage originates as a negative 200-volt pulse at point A in the horizontal output transformer. The sawtooth current flowing through L_1 produces a horizontal-frequency parabola across C_5; this is supplied to the three horizontal amplitude controls R_8, R_9 and R_{10}. This voltage is applied to the 800-turn coil of the converging-coil and magnet assembly via a 2500-μμf capacitor. This capacitor, the 800-turn coil, the 1200-turn coil, the 400-millihenry choke of the dynamic-convergence inductor pack, and the associated horizontal phasing capacitors, C_6, C_7 or C_8, form a series-parallel resonant circuit. The total inductance of the series-aiding coils is effectively in shunt with the 400-millihenry choke, rather than in series as it is for the vertical component. C_6, C_7 and C_8 resonate the parallel combinations. The voltage developed at the junction of the two coils is stepped up by autotransformer action at the upper end of the coils. The 2500-μμf capacitor is series resonant with the net inductive reactance seen at the junction causing the current flow to be in phase with the input parabola.

Convergence considerations are described in detail in an accompanying bulletin, *LB-960, A Convergence Circuit for the RCA Developmental 21-Inch Color Kinescope.*

Low-Voltage Supply

Two selenium rectifiers are used in the low-voltage supply to produce 200 volts and 400 volts. The current drain on the 200-volt bus is 160 ma and the load on the 400-volt bus is 305 ma. The peak-to-peak ripple on each output is approximately ½ per cent. The total power consumption is 295 watts.

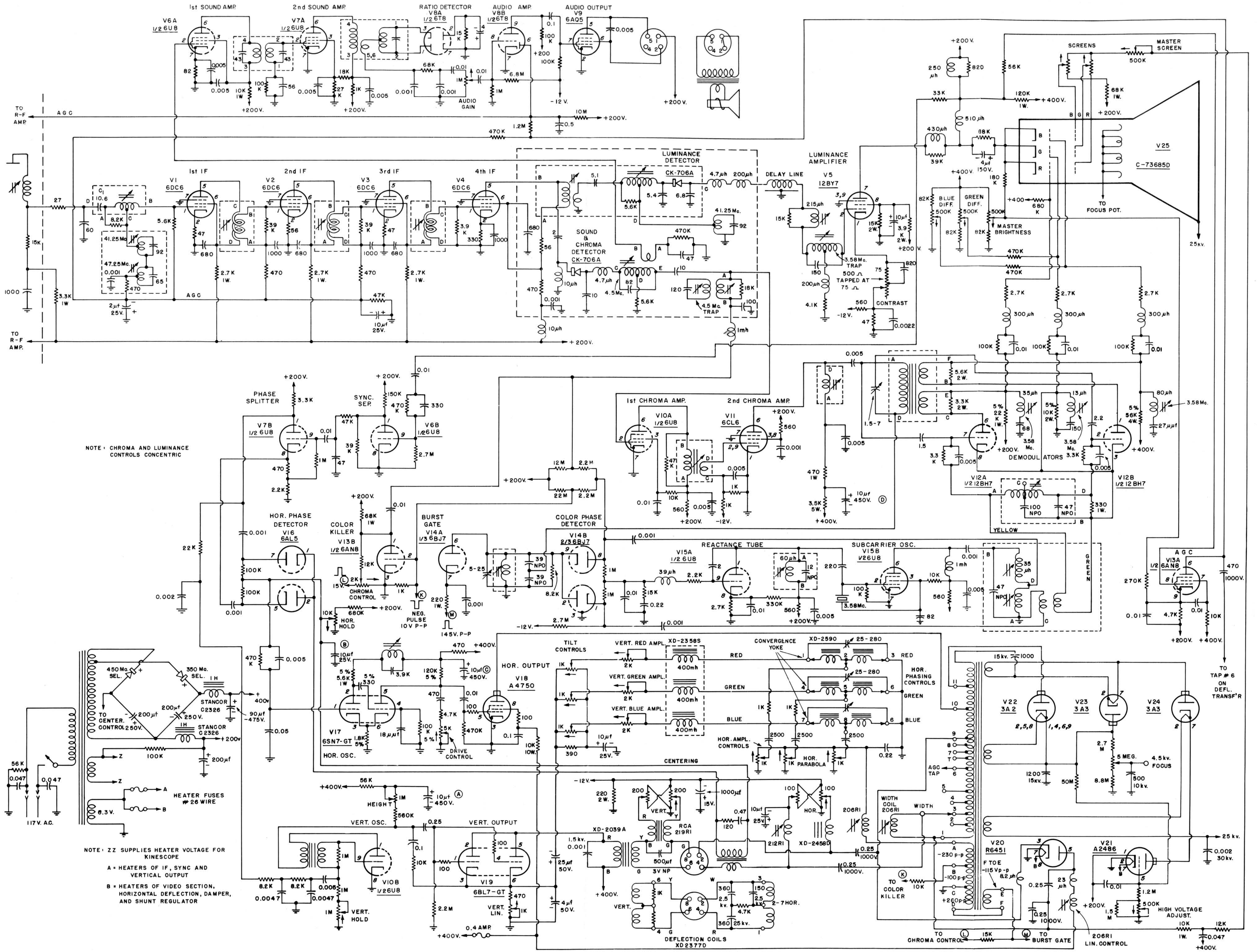


Fig. 25 - Schematic diagram of simplified developmental color television receiver.

COIL DATA

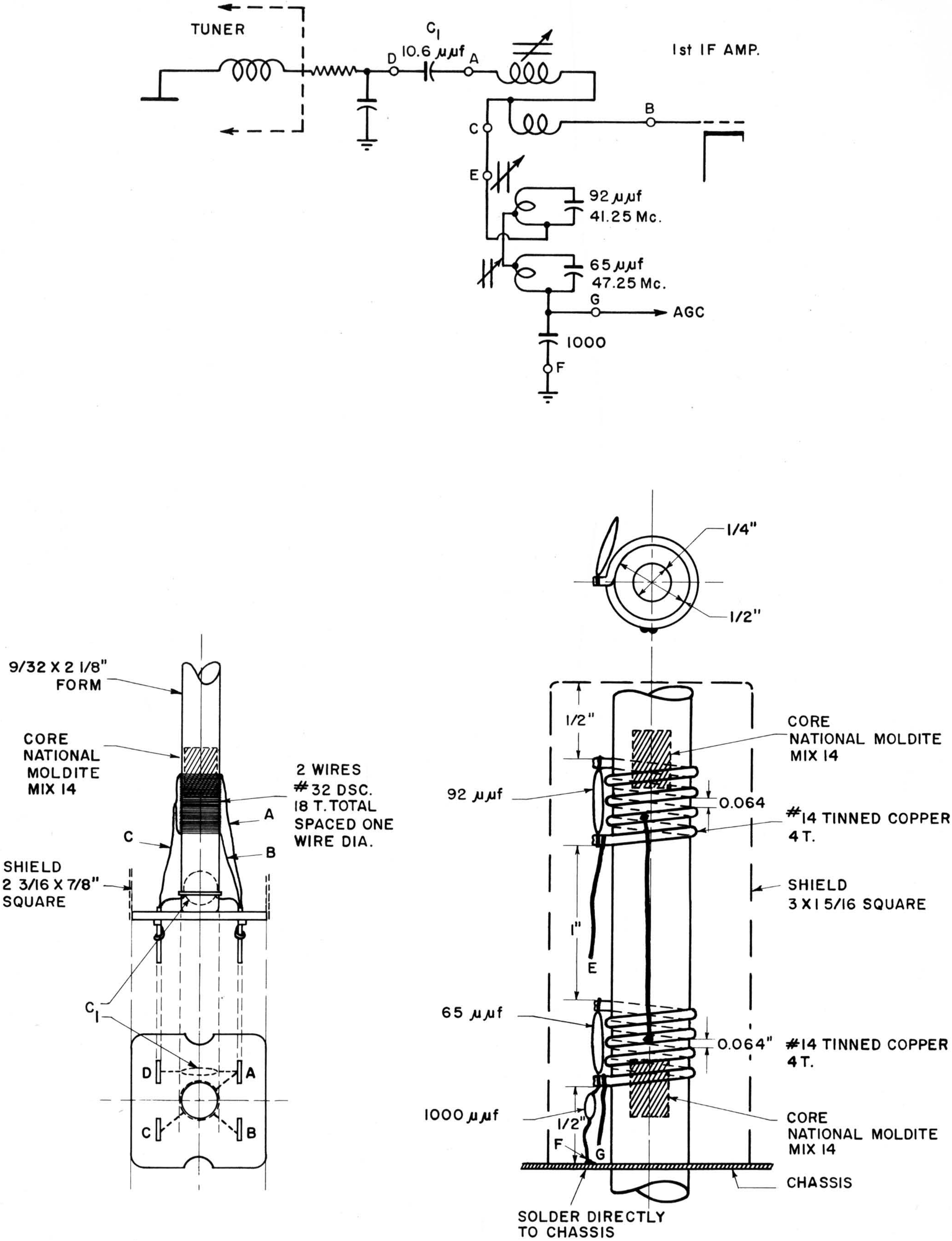


Fig. A-1 - Mixer-to-first i-f coupling.

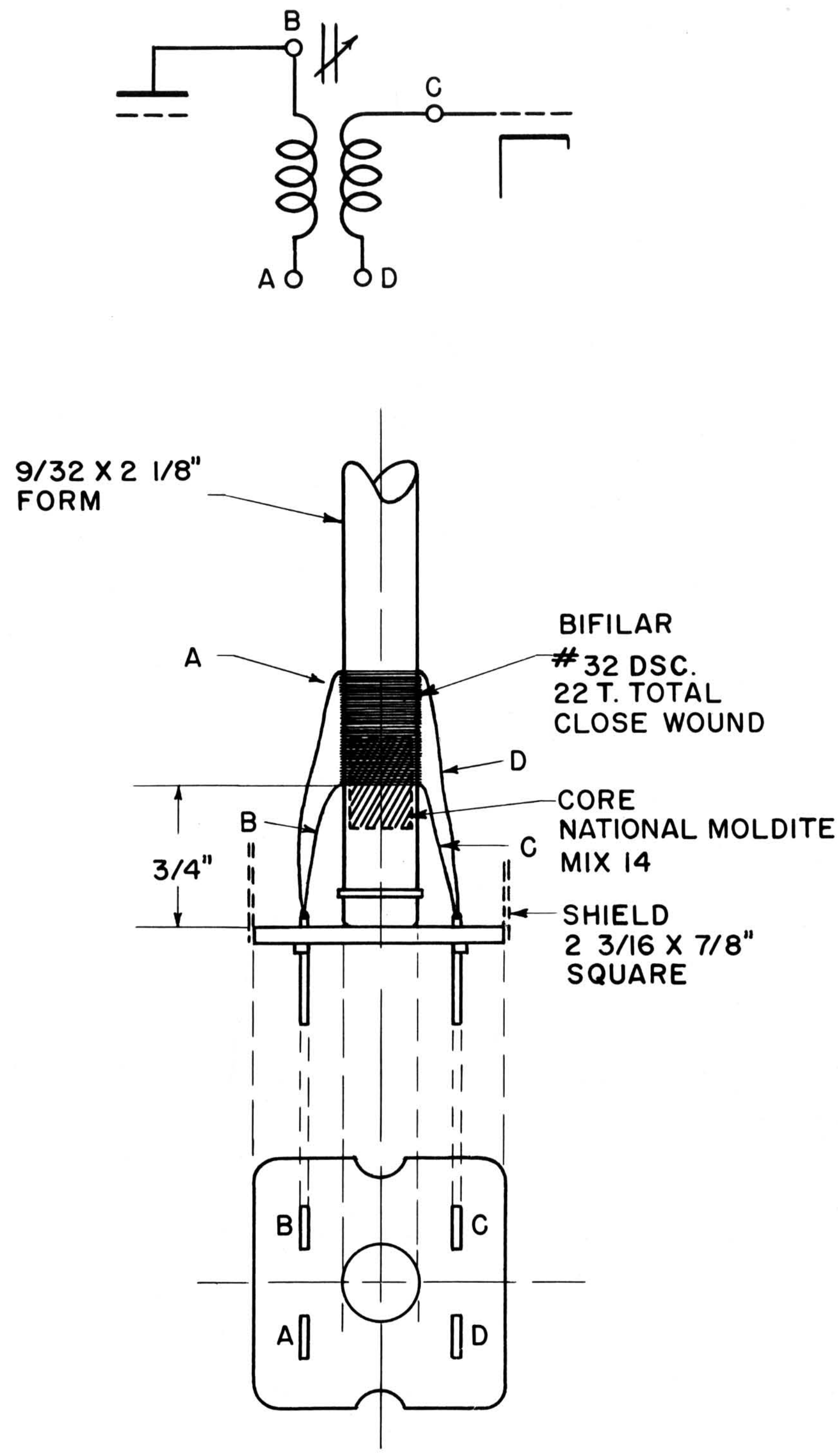


Fig. A-2 - Bifilar transformers in first, second, third i-f plate circuits.

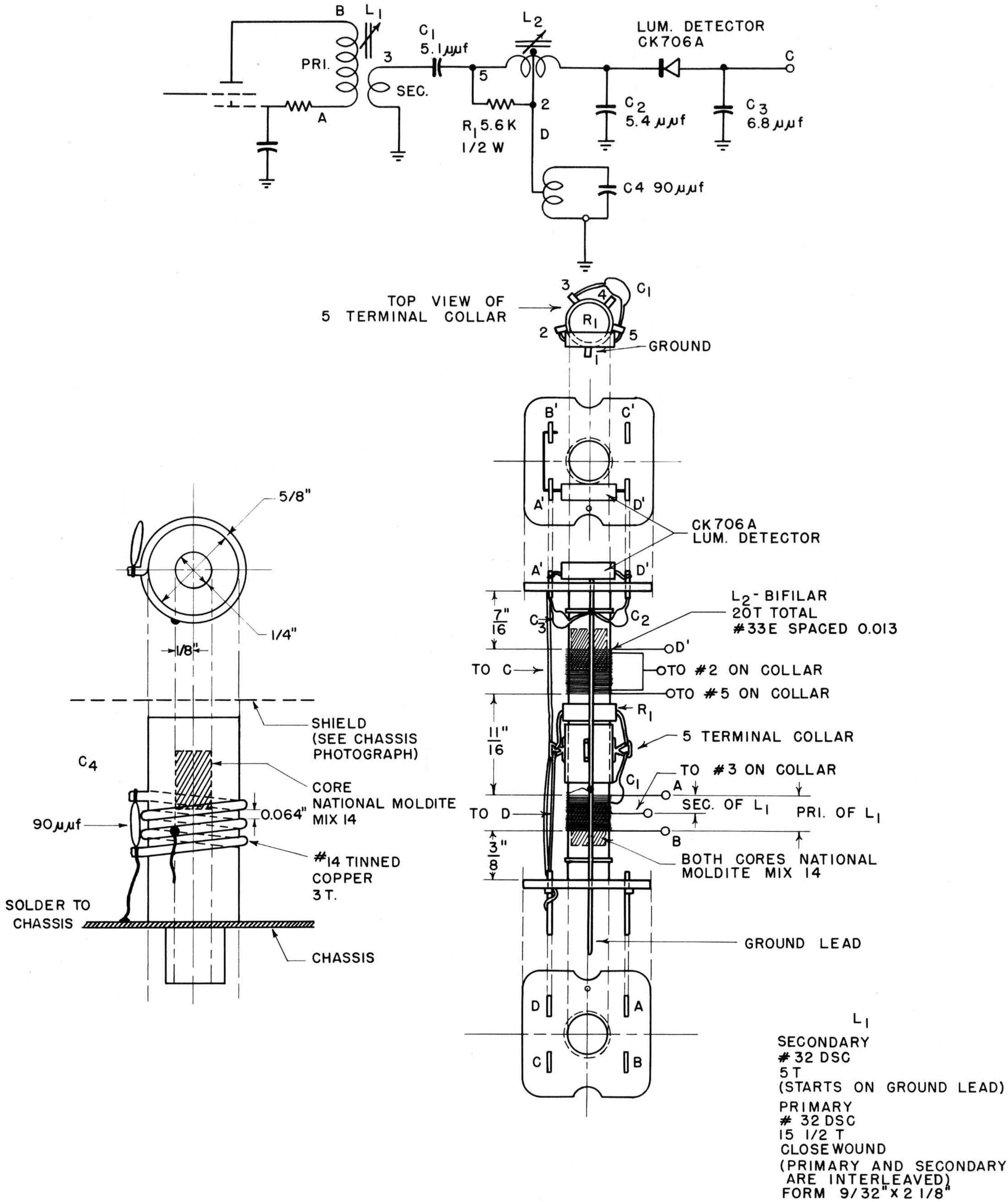
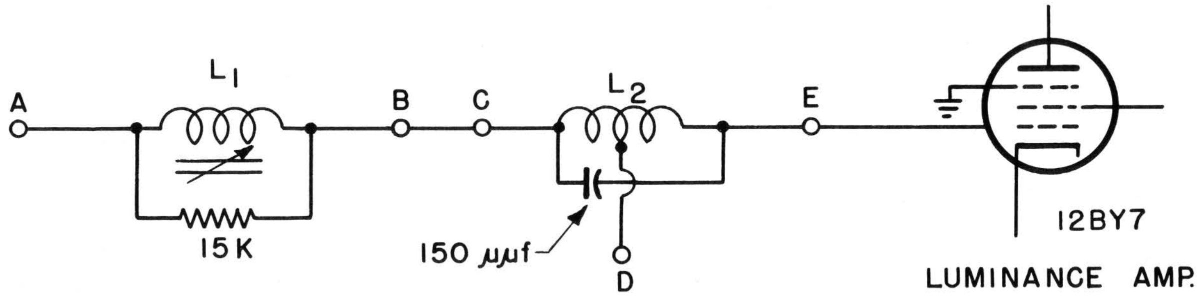


Fig. A-3 - Detector transformer and trap.



FRONT:
CAM 0.093
CAM GEAR 40
CAM DRIVER 42

BACK:
CAM GEAR 24

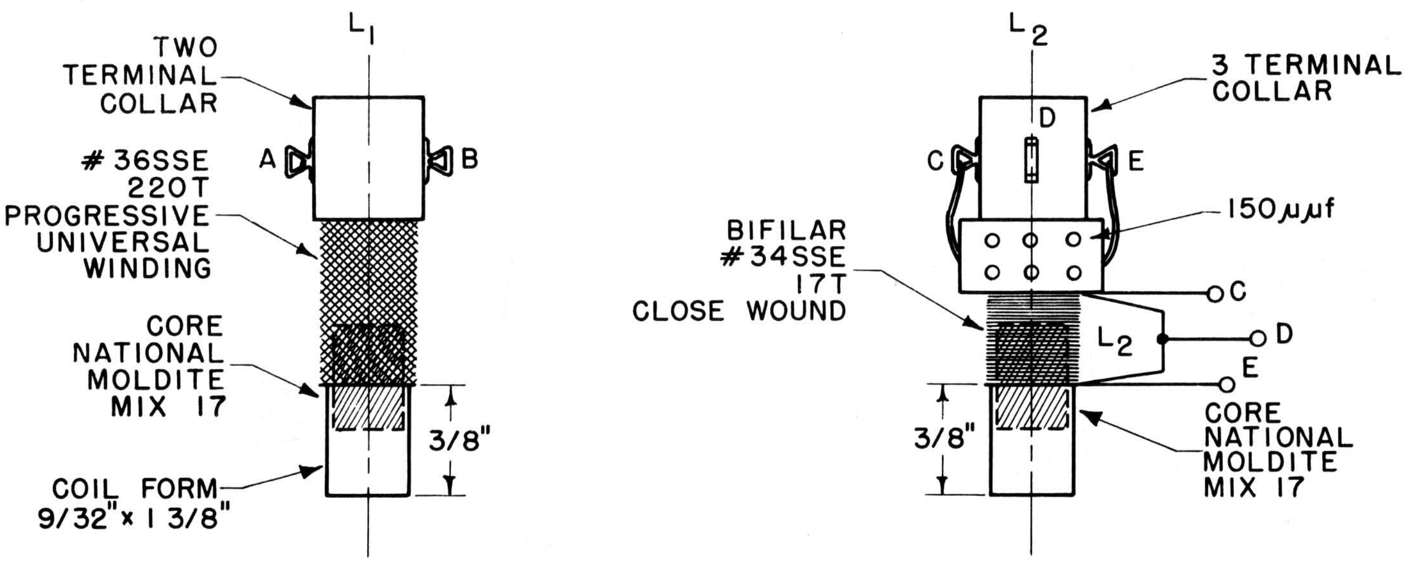
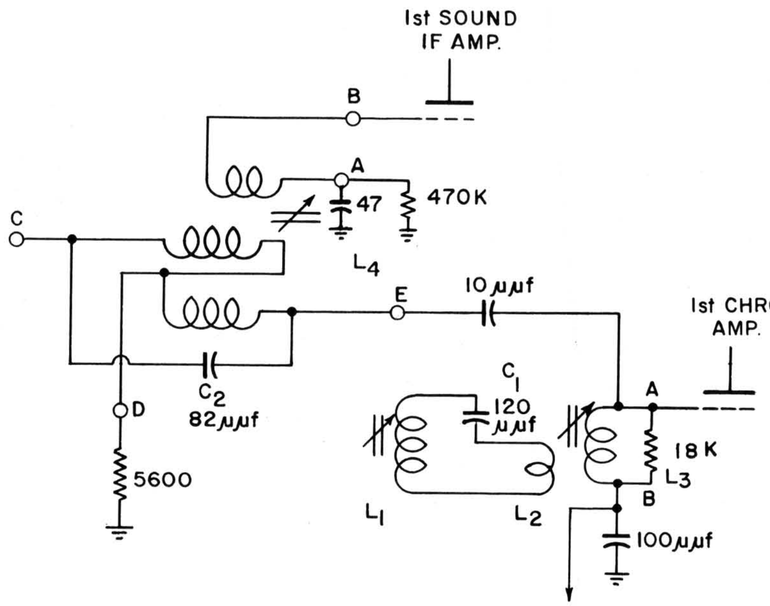
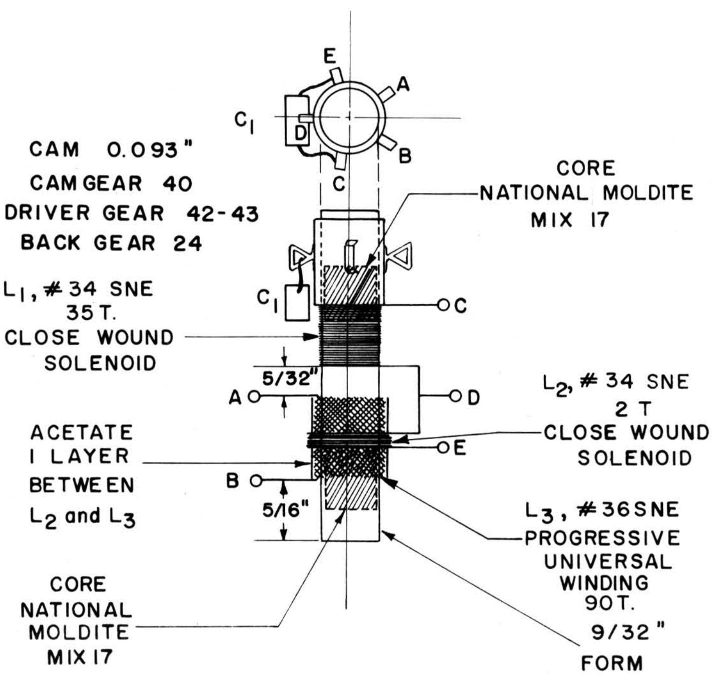


Fig. A-4 - 3.58-Mc video trap.





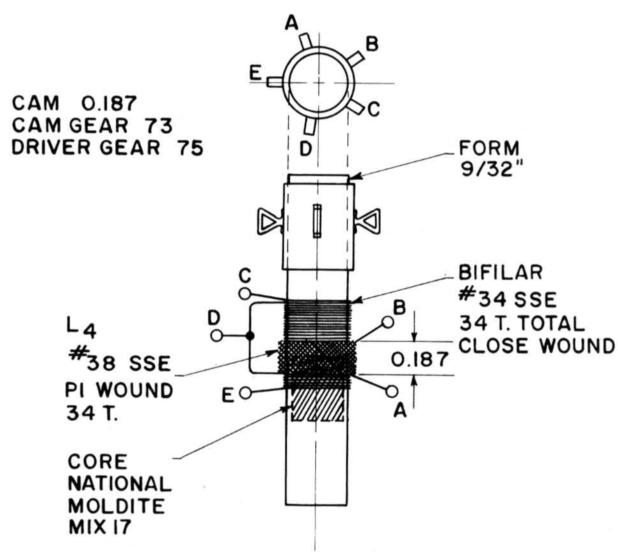


Fig. A-5 - Sound takeoff transformer, first chroma amplifier grid coil, and 4.5-Mc absorption trap.

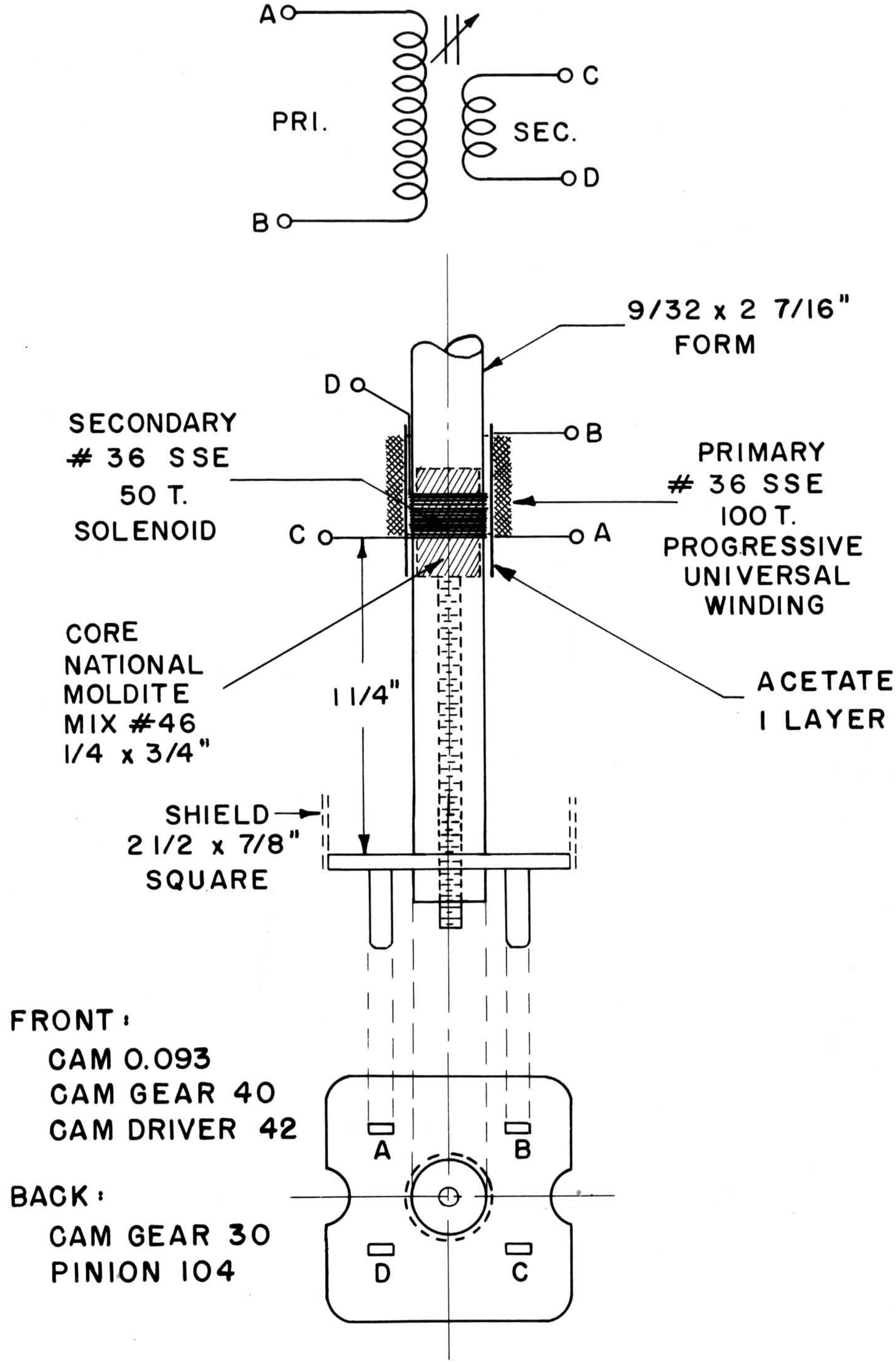


Fig. A-6 - Chroma amplifier transformer (6CL6 grid).

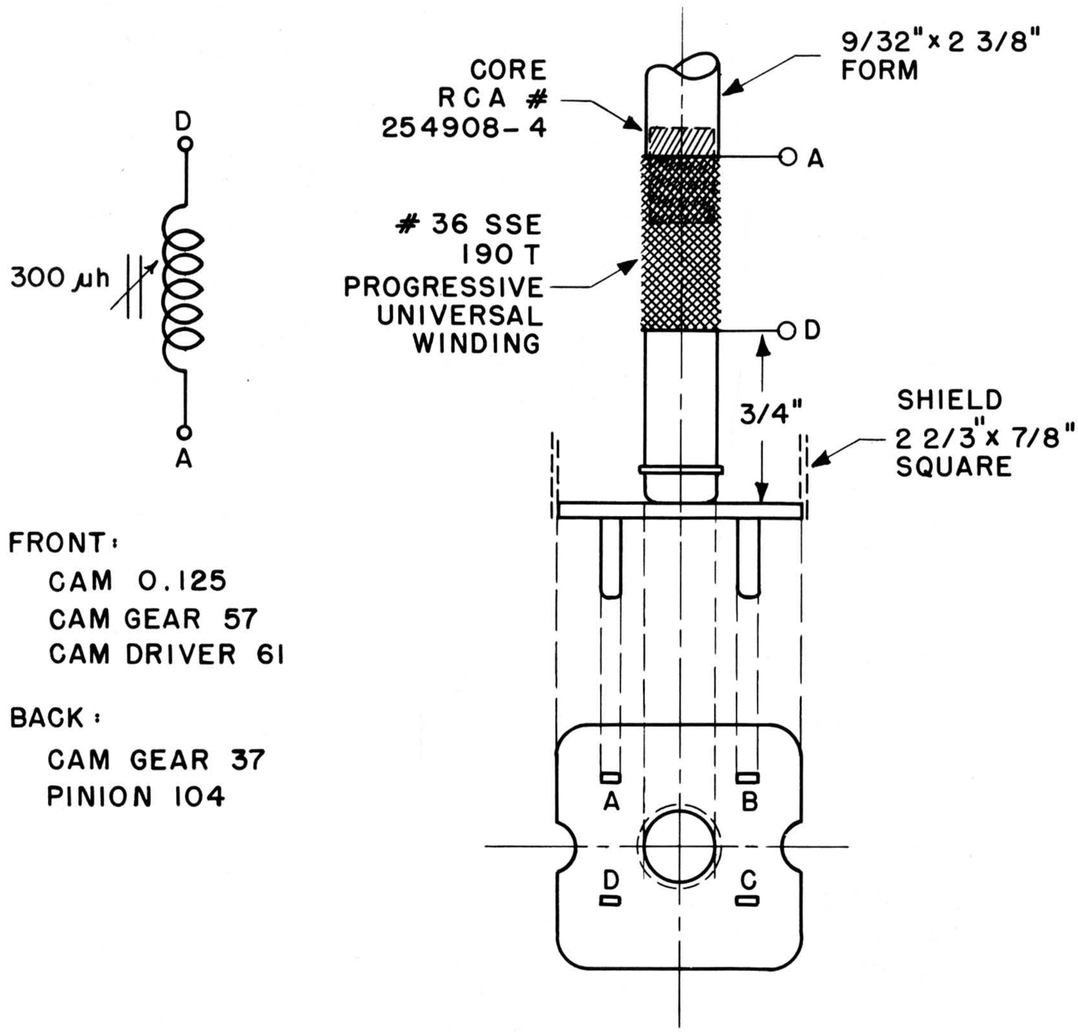


Fig. A-7 - Chroma amplifier plate inductance (6CL6 plate).

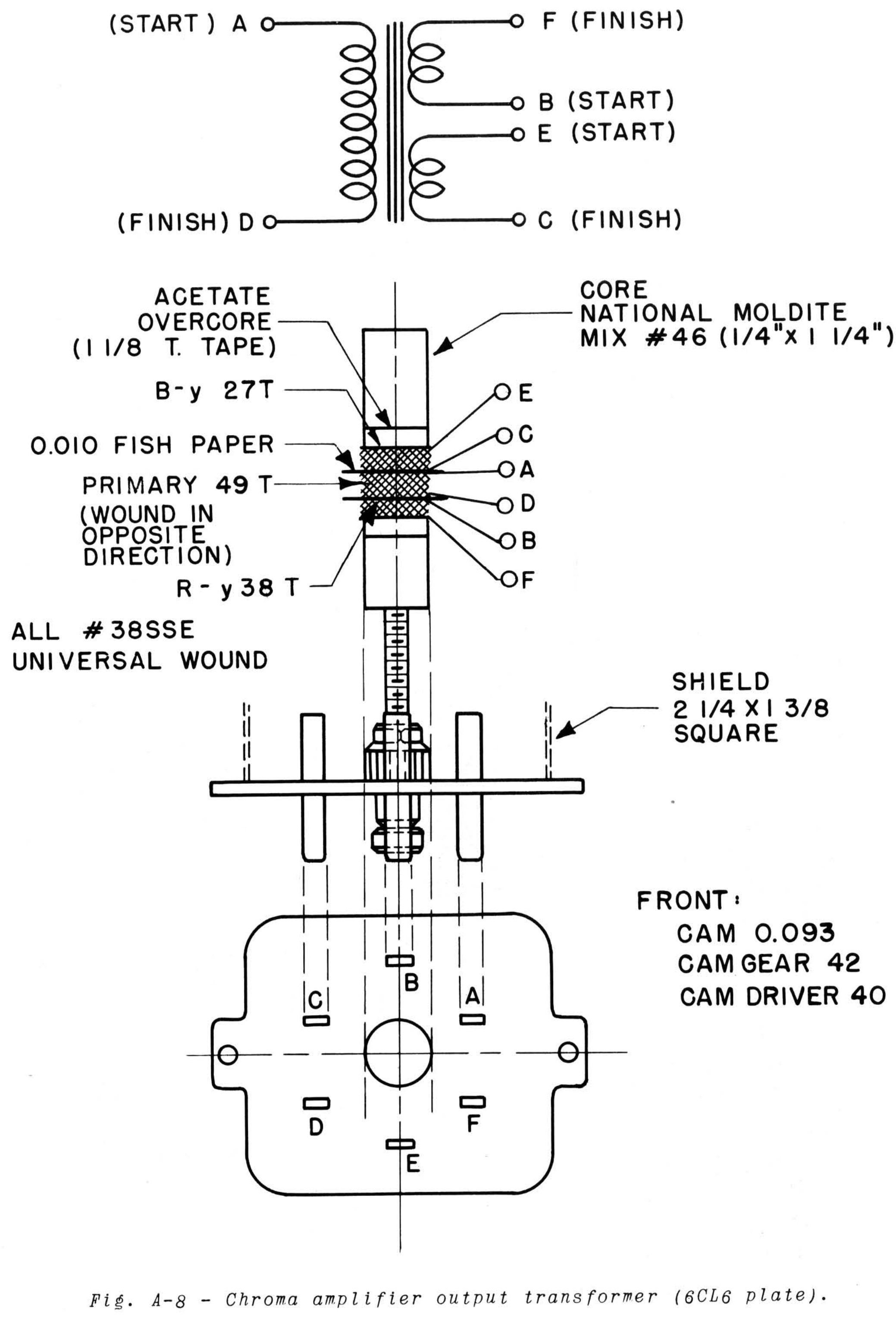


Fig. A-8 - Chroma amplifier output transformer (6CL6 plate).

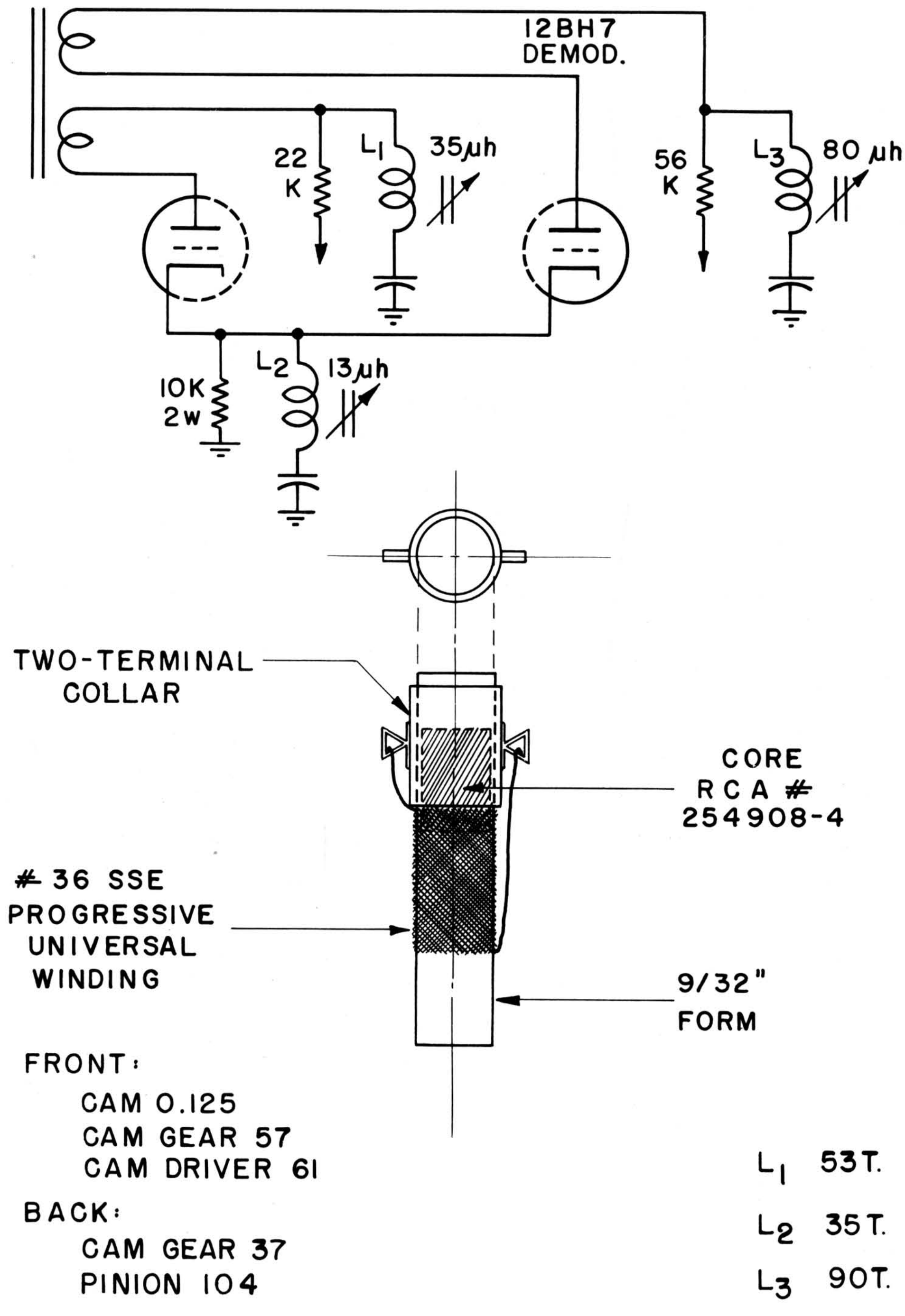


Fig. A-9 - Chroma demodulator 3.58-Mc traps.

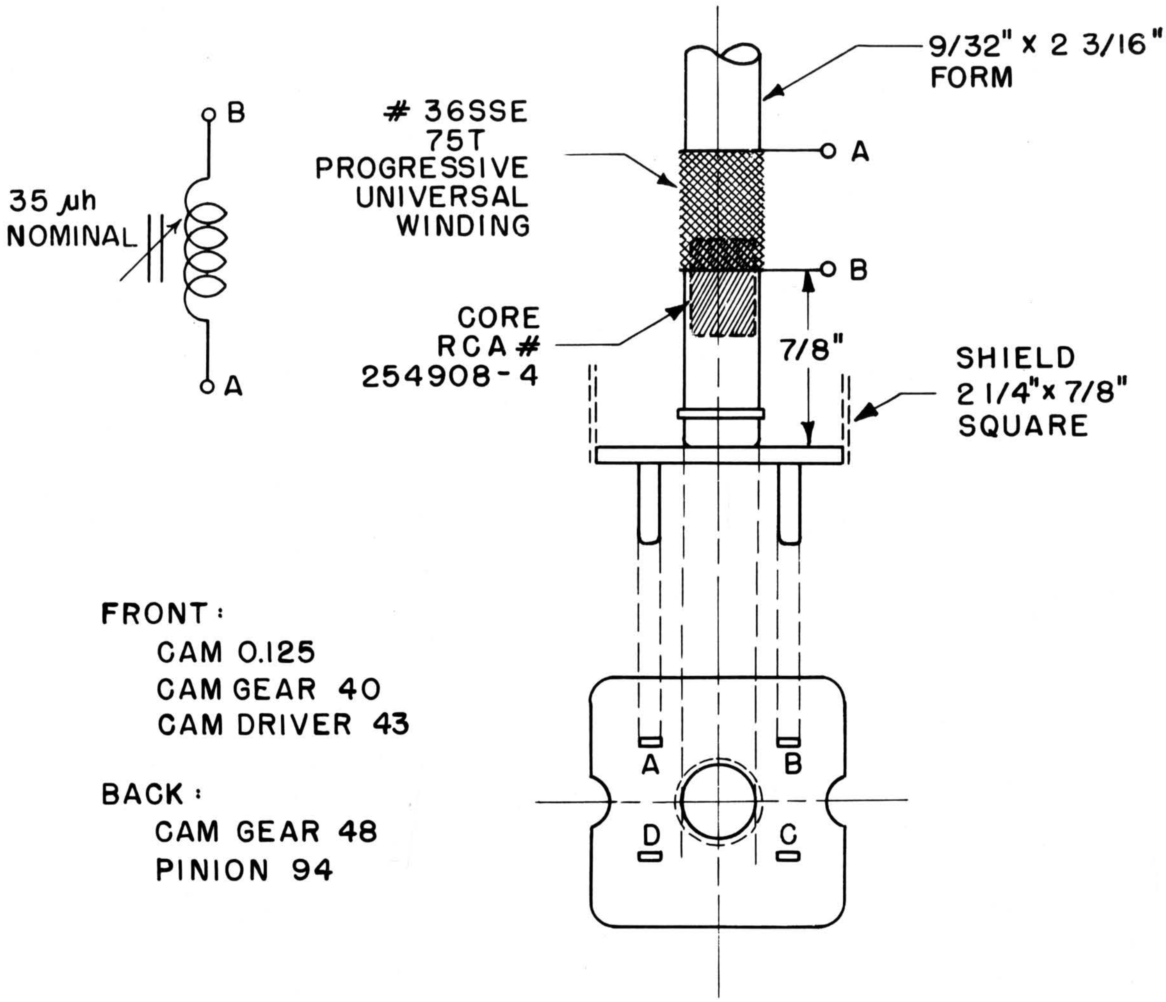


Fig. A-10 - Burst takeoff inductance.

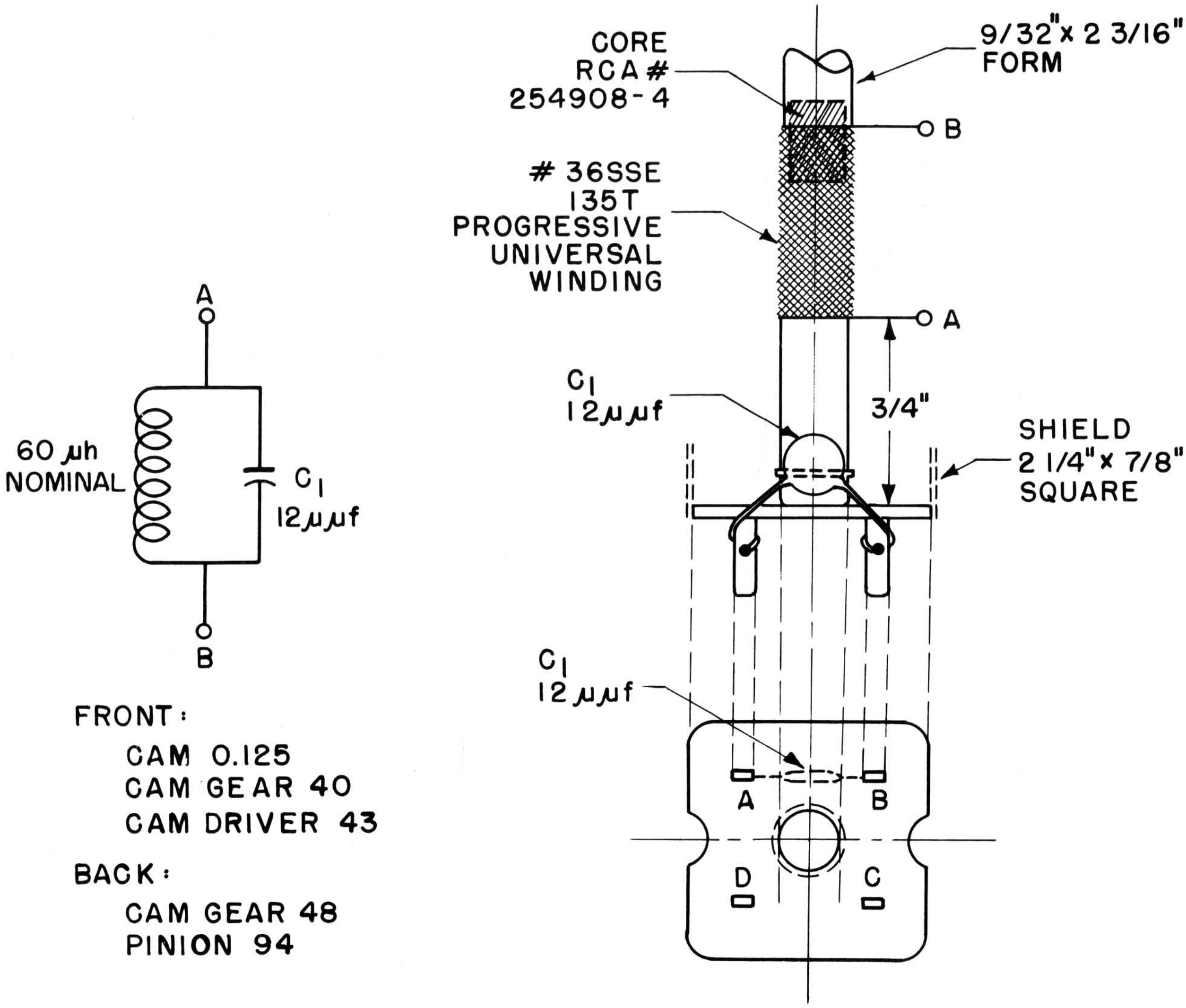


Fig. A-11 - Reactance-tube plate inductance.

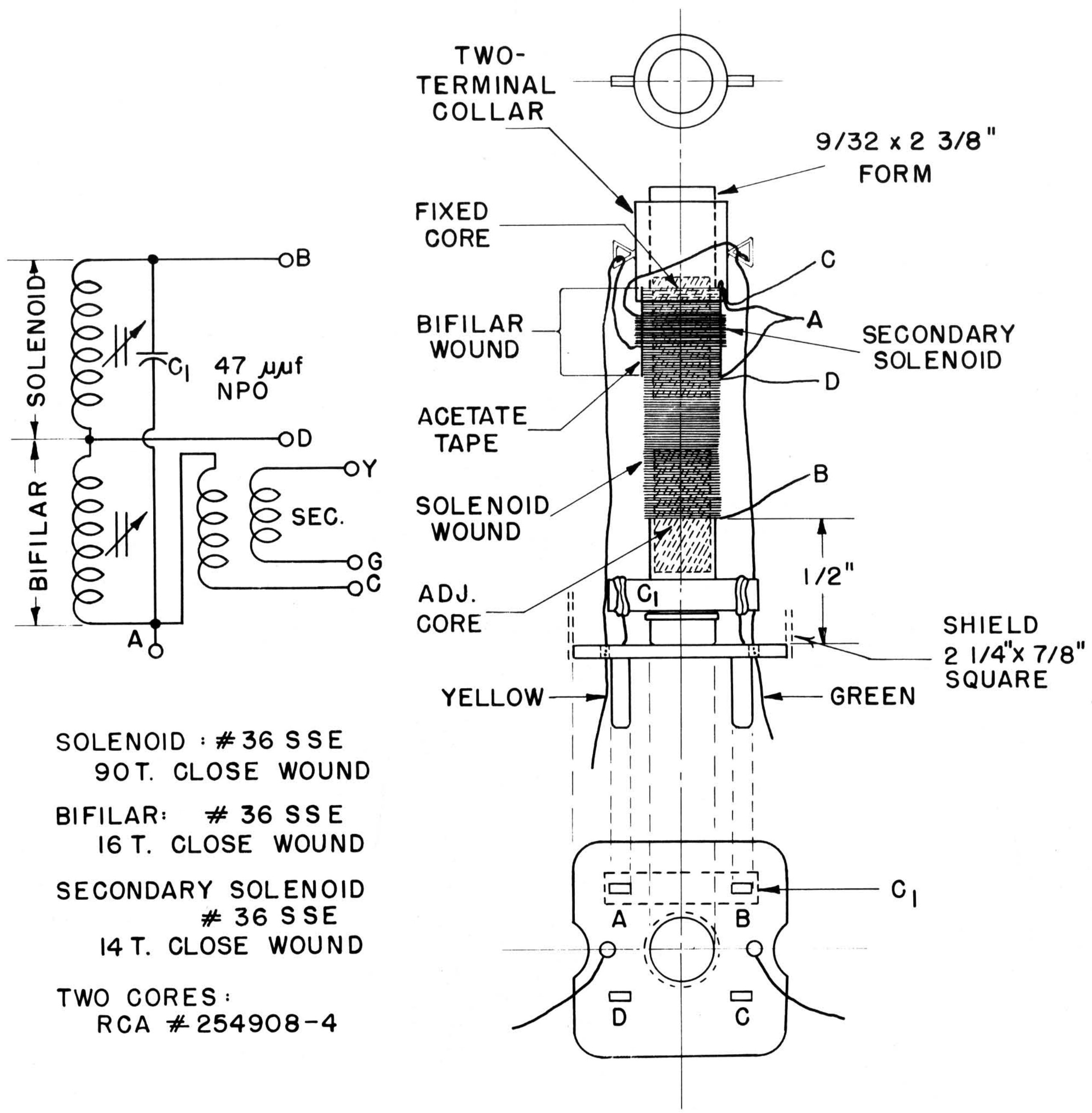


Fig. A-12 - Color reference oscillator transformer.

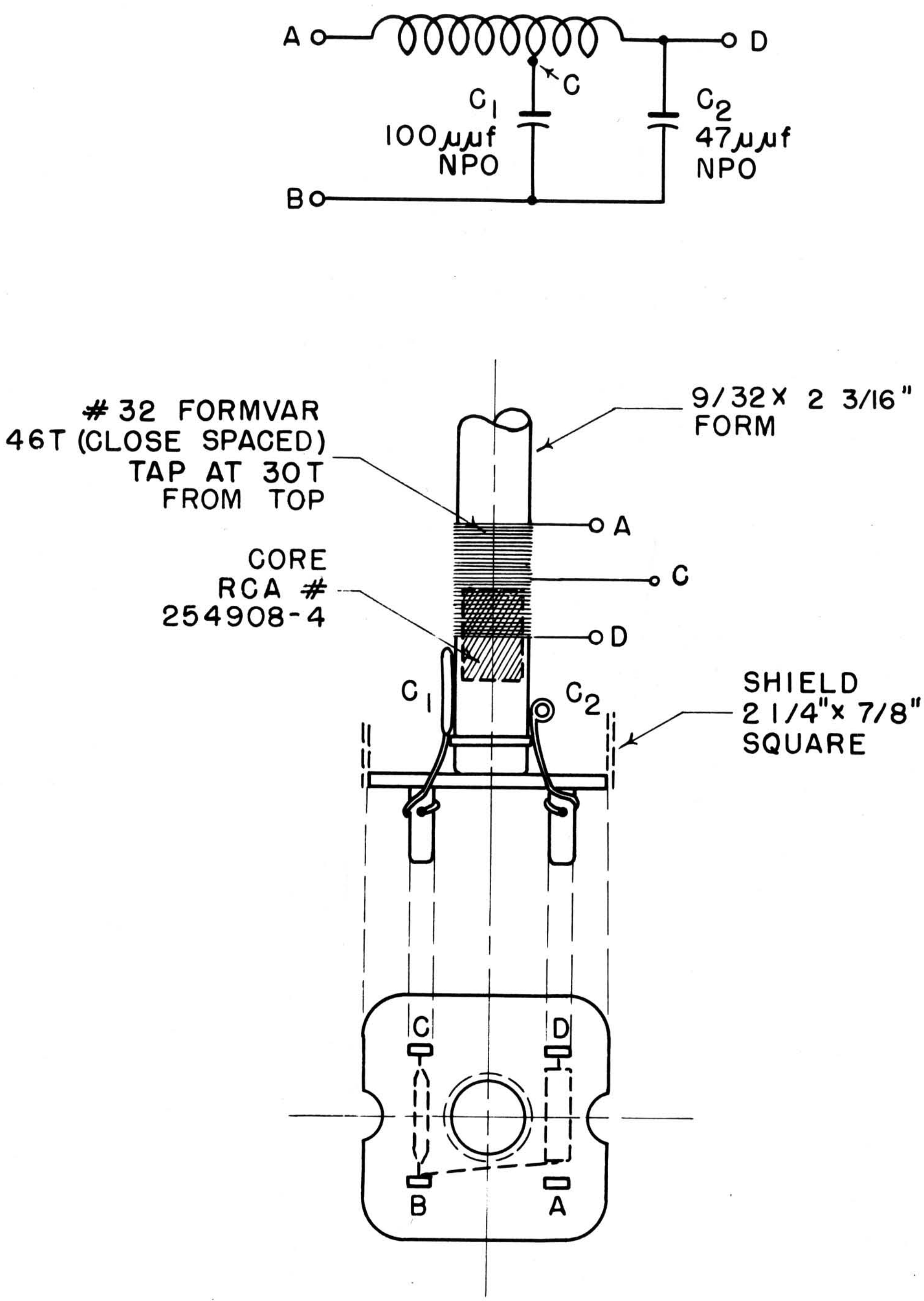


Fig. A-13 - Phase shift network.

Fig. 25 - Schematic diagram of simplified developmental color television receiver.