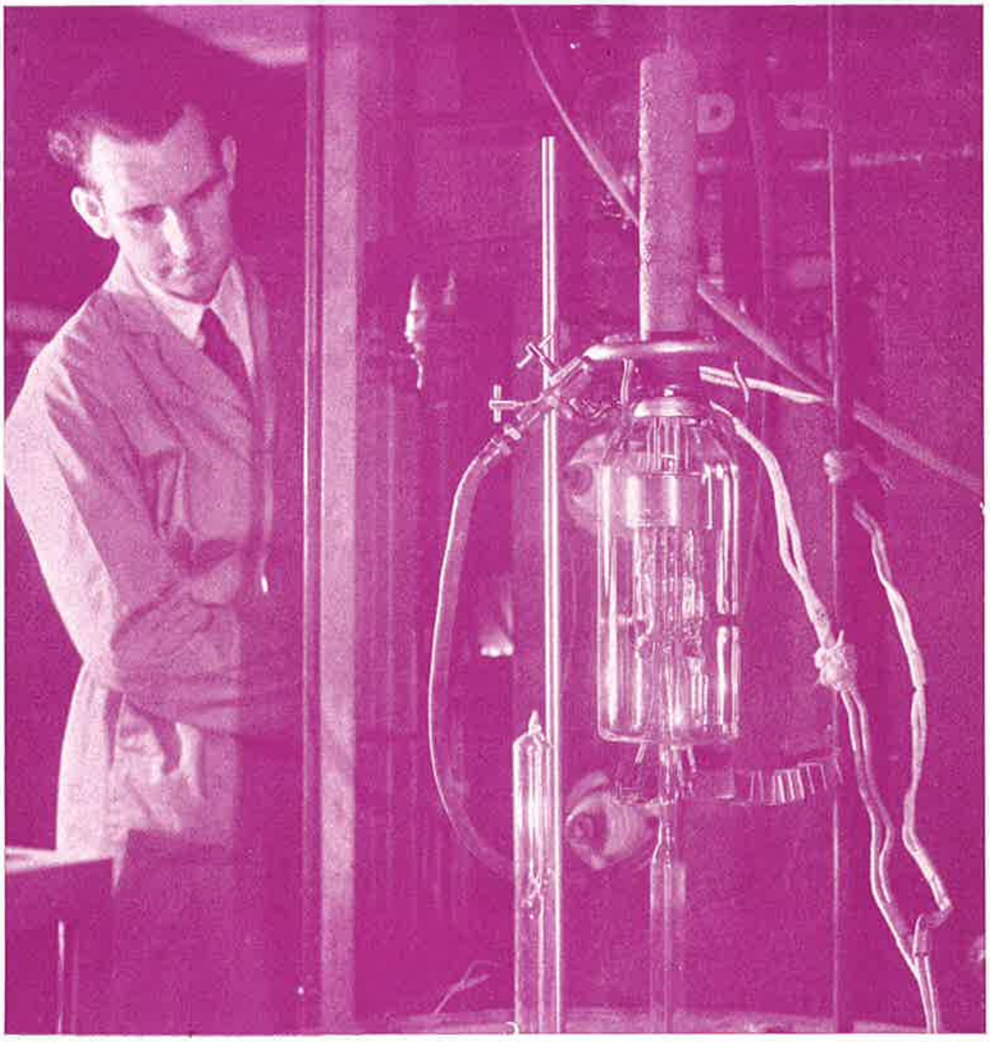
RADIOTRONICS

Vol.16 November 1951 No. 11



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RADIOTRONICS

Volume 16 **November, 1951** **Number 11**

By the way—

Small stocks of the A1714 planar triode mounted on the standard 7-pin miniature base have been received. For a full description readers are referred to Radiotronics 145, page 108.

For those interested in valves designed for computer service we would advise that we have stocks of the 5915, 5963 and 5964, which were described in Radiotronics, February, 1951, page 48.

Part two of the "Basic Description of a RCA Television Receiver" which appears in this issue is reprinted by courtesy of RCA Service Company Inc., Camden, New Jersey, U.S.A.

It is intended to hold stocks of all the germanium crystals described herein. GEX. 45/1 is expected to be the most commonly used type, followed by GEX. 00, as these will serve satisfactorily in most circuits used by amateurs and experimenters.

Information concerning new RCA releases published in Radiotronics is intended for information only, and present or future Australian availability is not implied.

Readers are reminded to complete their subscription forms, included with the last issue, and to return them with the necessary remittance.

It is recommended that constructors of amplifier A515 connect a 15,000 ohm 25 watt resistance across the filter output to avoid voltage surges when switching on.

Our cover this month shows a high-power transmitting valve undergoing a process known as "spot-knocking", 40,000 volts is applied to the valve to remove any protuberances on the grid wire which may later cause sparking in service.

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CONTENTS

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Circuit Laboratory Report **Number 12**

The Measurement of Conversion Sensitivity

The conversion sensitivity of a receiver is measured at the grid of the converter valve by applying to the grid the signal-frequency input voltage required to give standard power output from the receiver. The i-f sensitivity at the converter grid can also be measured by applying an i-f input voltage in the same way. The conversion sensitivity is usually between 0.9 and 0.6 of the i-f sensitivity at the converter grid, i.e., a greater output voltage is needed from the signal generator for the conversion sensitivity than for the i-f sensitivity. This is due to the difference between the mutual conductance and conversion conductance of the converter valve (with oscillator operating), although as explained below, different methods of measuring conversion sensitivity can introduce large differences into the values obtained and it is quite possible for the measured conversion sensitivity to be higher than the i-f sensitivity.

Conversion sensitivity measurements are not important in themselves, and their main use is that, when aerial sensitivity and i-f grid sensitivity are known, the calculation of aerial coil gain and conversion gain becomes possible. Aerial coil gain can also be measured with a signal generator and vacuum-tube voltmeter external to the receiver, and a comparison of gain figures measured by the two methods may show aerial-coil loading effects due to the converter, caused by, for example, Miller effect.

On the broadcast band, conversion-sensitivity measurements can be made by connecting the signal generator through a suitable capacitor (say 0.01 μF) to the signal grid of the converter. The grid lead is also left connected to the grid to avoid any alteration to the d.c. operating conditions of the valve.

Contributed by the Circuit Design Laboratory, Valve Works, Ashfield.

However, on the short-wave band this simple procedure introduces two possible sources of error. The first is due to the fact that, as pointed out in Radiotronics Vol. 16, No. 6, page 115, all converter valves operating on the short-wave band have some oscillator voltage developed across the signal-grid circuit and this voltage can have a considerable effect on the gain of the converter, particularly at the high-frequency end of the shortwave band. Connecting the generator to the signal grid reduces the impedance between grid and ground to a low value, which reduces the oscillator voltage on the grid and thus alters the conversion gain of the valve. This effect is eliminated in conversion-sensitivity measurements and for this reason apparent aerial-coil gain in a receiver may be greater than the gain measured with a vacuum-tube voltmeter, without regeneration occurring in the converter stage.

A second possible source of error in short-wave conversion-sensitivity measurements is that the impedance of the output cable from the generator cannot be ignored if, as is often the case, the cable is not correctly terminated at the end adjacent to the receiver. A special short output cable is provided with some signal generators for use on the short-wave band but even such a cable, in conjunction with isolating capacitor and clip connectors, is usually about eighteen inches long. This forms a section of transmission line which is an appreciable fraction of a wavelength long at 18 Mc/s (16½ metres) and the reactance of the section of line cannot be ignored.

The worst conditions exist when the impedance from signal grid to ground is that of a high capacitive

TABLE 1

Method	30″ cable and 4″ clip leads connecting generator to receiver.			15″ cable and 4″ clip leads connecting generator to receiver.		
	Value of series paper capacitor to converter grid (μF).					
	0.001	0.01	0.1	0.001	0.01	0.1
A. Correctly aligned tuned circuit between control grid and a.v.c. line.	37 μV	37 μV	37 μV	42 μV	42 μV	42 μV
B. 0.25 MΩ between control grid and a.v.c. line.	30 μV	29 μV	28 μV	37 μV	36 μV	34.5 μV
C. 1000 Ω between control grid and a.v.c. line.	33 μV	29 μV	29 μV	39 μV	39 μV	37 μV
D. 0.25 MΩ to a.v.c. line and 100 $\mu\mu$F to ground.	16.5 μV	21 μV	22 μV	10.5 μV	10 μV	11 μV
E. 1000 Ω to a.v.c. line and 50 $\mu\mu$F to ground.	14 μV	12 μV	12 μV	22 μV	19 μV	18 μV

Table 1. 18 Mc/s conversion sensitivity in microvolts measured by different methods.

reactance, as series resonance leads to a voltage step-up at the grid and consequently to an optimistic conversion-sensitivity reading.

If the tuned circuit is left connected to the grid of the valve it will affect measured sensitivity to a degree dependent on its own characteristics and the accuracy of its alignment, which makes close duplication of readings impossible.

When the tuned circuit is disconnected from the signal grid for conversion-sensitivity measurements it should be replaced by a resistor connected between the grid and the cold end of the signal-grid tuning coil. This resistor provides a d.c. return for the grid and also presents an impedance across which the output voltage from the generator is developed. If the resistor is made too large (e.g. 1 megohm) small amounts of signal-grid current in the converter will develop a voltage across it and alter the bias on the valve. Too small a resistor, however (say 10 ohms), will result in a division of the signal-generator output voltage between output-cable impedance and resistor impedance. A reasonable compromise could be taken as 1000 ohms for a signal generator with 10 ohm, or smaller, output impedance, or 10,000 ohms if the output impedance is higher.

To show the effect of different methods of measuring conversion sensitivity Table 1 has been prepared. Each of the figures in the table gives the conversion sensitivity (in microvolts) of the same receiver measured in a different way, but with the true sensitivity of the receiver remaining unchanged throughout.

The table shows in lines D and E the serious errors introduced by comparatively small capacitances between signal grid and ground. Thus, when a resistor is used to replace the coil for this measurement, the resistor should be wired as close to the grid as possible and the gang condenser must of course be disconnected from the grid.

Recommendations for measuring short-wave conversion sensitivity are:—

(1) the shortest available signal-generator output cable should be used;

(2) the tuned circuit should be disconnected from the signal grid of the converter;

(3) a resistor of 10,000* ohms should be wired with a minimum of stray capacitance between the signal grid and the cold end of the signal-grid tuned circuit;

(4) an 0.01 μF capacitor of a low-inductance type should be connected between signal-generator output and the signal grid of the converter.

Even when this method is adopted the measured conversion sensitivity may be either greater or less than the conversion sensitivity when the receiver is operating normally, owing to effects mentioned above. Nevertheless the results will be consistent and as accurate as possible.

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* **Work done subsequent to the compilation of Table 1 indicates that 10,000 Ω is an optimum value.**

SUBSCRIPTION RENEWALS

Readers are reminded that subscriptions to Radiotronics for 1952 are now due. It is again stressed that supply of back issues cannot be guaranteed to late subscribers. Therefore, to ensure continuity of the series we urge that the renewal form, supplied with the October release of Radiotronics, be completed and returned to this office as soon as possible.

New Zealand subscribers please note that all correspondence, subscription forms and remittances must in future be forwarded to Sydney and not Wellington as previously.

Basic Circuit Description of a RCA Television Receiver

(Concluded from Radiotronics Vol. 16, No. 10)

The Kinescope.

The video signal is now applied to the grid of the kinescope. In some respects a kinescope is quite similar to a vacuum tube.

As in ordinary tubes, there is a cathode which emits an electron stream. However, the emitting surface of the kinescope cathode is relatively small. Since the primary function of the cathode is to emit elec-

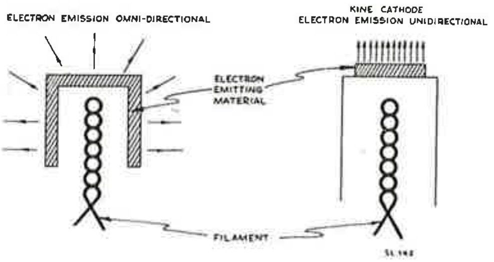


Fig. 34—Cathode Construction

trons toward the fluorescent screen of the kinescope, the emitting surface is as shown in figure 34.

The emitted electrons are formed and shaped by electrostatic or electromagnetic fields. The first influence exerted on the electron beam is the action of the control grid. Here again the action is the same as in a standard tube. The control grid determines the quantity of electrons or the density of the electron beam which is directed towards the screen of the kinescope. Since the amount of light produced on the face of the kinescope is in part proportional to the number of electrons striking the screen, the control grid can vary the intensity of the reproduced light.

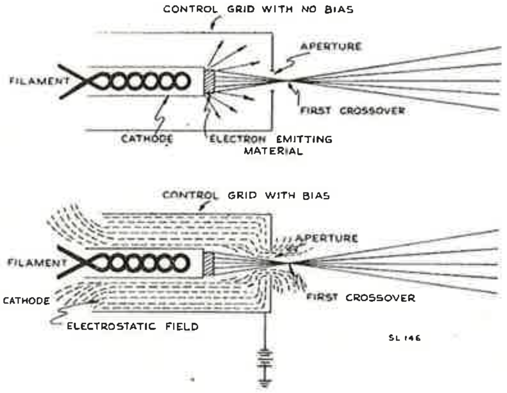


Fig. 35—Grid Construction

Note in figure 35 the effect of applying a bias on the kinescope grid. The field produced by this negative charge repels the electron beam in all directions except from the aperture. Therefore, the beam is narrowed to a fairly fine stream at this point.

Note how the beam crosses over just in front of the control grid. The action is quite analogous to the effect of a lens on a beam of light. For this reason, the section just discussed is sometimes called the "first lens" section.

Electrostatic Focus

Immediately following the control grid is the first accelerating anode. This anode has a positive charge and serves to accelerate the electron beam.

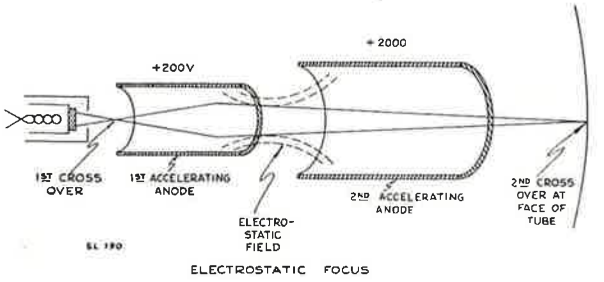


Fig. 36—Electrostatic Focus

The beam, after being in focus at the cross-over point of the first lens system, begins to diverge again. Therefore, some method of concentrating the beam must be provided.

There are two methods of focusing. In the electrostatic method a second anode with a higher potential is inserted near the first accelerating anode. Since there is a difference of potential between the two anodes there will be a difference in the electrostatic fields existing between them and of such polarity as to repel the electron beam as shown in figure 36. By varying the potential difference between the two anodes, it is possible to change the electrostatic field which exists, and thus the point at which the second cross-over occurs, so that the beam is in focus at the face of the kine.

Electromagnetic Focusing

Electromagnetic focusing functions on the following principle. The electron beam passes through the first accelerating anode on its path to the screen. Those electrons which emerge from the first cross-over point, traveling in a path which is not parallel to the axis of the tube, continue on a divergent path. Around the neck of the kinescope is placed an electromagnet. The field existing around the electromagnet will exert a force upon the divergent electrons which will cause these electrons to attain a spiral motion. By correctly choosing the position and magnitude of the magnetic

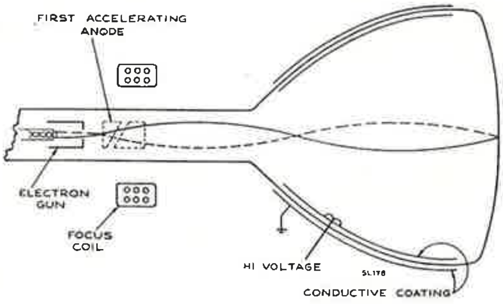


Fig. 37—Electromagnetic Focus

field, the divergent electrons complete their spiral at a point on the kinescope screen, and are at the same point as the main stream of electrons.

In tubes of the 10BP4 type, the second accelerating anode consists of a conductive coating on the inside surface of the tube as shown in figure 37. Since this coating covers the entire inside of the bell, advantage is taken of the large area used, and a similar conductive coating is placed on the outside of the bell. The two coatings form the plates of a condenser with the glass of the tube as a dielectric. This provides additional filtering to the high voltage supply.

The kinescope changes the transmitted video information into light. The electron beam producing the light must be deflected so that its motion, or deflection is the same as the electron beam at the transmitter.

Electrostatic Deflection

The two types of deflection used are electrostatic and electromagnetic. In electrostatic deflection the electron beam is deflected by two sets of parallel plates between which the beam is directed by virtue of the accelerating anodes, structures A and B, as shown in figure 38.

Assume that a positive charge were placed on one plate and a negative charge on the other. The electron beam, which has a negative characteristic, is attracted by the positive plate P_1 and repelled by the negative plate P_2. If an AC potential is applied to the deflection plates P_1 and P_2, the beam will sweep back and forth.

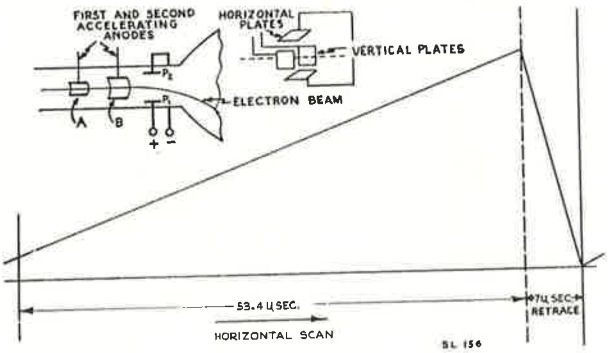


Fig. 38—Electrostatic Deflection

However, in the receiver it is necessary to have a linear scan. In scanning one horizontal line, for example, if a sine wave were used for deflection, half the picture content would be used for returning the beam from the right-hand side of the picture to the left. Also with a sine wave, the rate of scan would vary from point-to-point giving an extremely non-linear picture.

In scanning, the scan must be at a slow rate compared to the retrace. Also, the scan must be linear over the entire line.

A linear sawtooth wave will fulfill both requirements. Shown in figure 38 is a typical sawtooth produced for the horizontal scan. The time for one cycle of scan and retrace is 63.5 micro-seconds, of which the scan is 53.4 micro-seconds. The retrace cannot exceed 10.1 micro-seconds.

The magnitude of the potential on plates P_1 and P_2 will determine the distance of the swing and leave a trace on the screen of the cathode ray tube. In a typical television receiver using the electrostatic system, the plates P_1 and P_2 are connected to the output of the deflection sweep circuits. The sweep circuits are designed to provide the necessary sawtooth waveform to be applied to the plates P_1 and P_2. Vertical deflection is accomplished by a sawtooth voltage applied to a similar pair of plates mounted at right angles which function in the same manner.

Electromagnetic Deflection

In the electromagnetic deflection system the kinescope electron beam is deflected by a magnetic field produced by a pair of horizontal and a pair of vertical coils placed around the neck of the kinescope. Figure 39 shows the basic electromagnetic deflection elements that go to make up the deflection system.

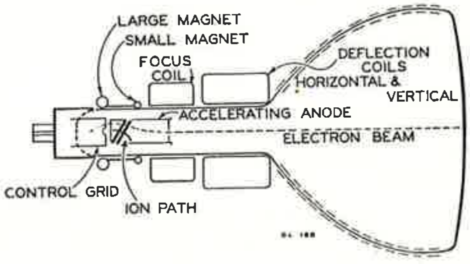


Fig. 39—Electromagnetic Deflection

The magnetic focusing coil is shown in the proper position to focus the electron beam on the screen. The magnetic focus coil is completely enclosed in a metal shell and the correct field is obtained through a small gap around the inside of the pole structure, and by an electrical adjustment of current through the coil.

Actual adjustments for individual models will be discussed later under the setup of the different model receivers.

Electromagnetic deflection imposes one restriction due to the inductance and the resistance of the deflection coils. If pure resistance were to be scanned, scanning could be accomplished by a sawtooth waveform as shown in A of figure 40.

If the deflection coils were purely inductive, scanning could be accomplished by a square wave.

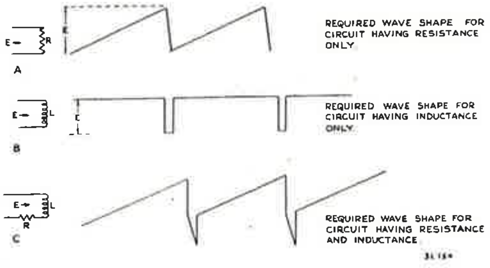


Fig. 40—Voltage Across an Inductance

However, the deflection coils have the properties of both inductance and resistance. Therefore, to obtain the proper current through the coils, the applied voltage must have the wave shape shown in C of figure 40.

A factor which must be considered in the action of electromagnetic deflection is the effect of ions. When the electron beam is produced, ions are also produced. Ions are much heavier than electrons and are deflected only by an electrostatic field and not by a magnetic field. Therefore, when the electron beam is deflected vertically and horizontally, the ions are not deflected but strike the center of the screen, and if they were not removed, the center of the screen would become discolored rapidly and eventually be destroyed under the bombardment of these ions.

Therefore, some method of removing the ions from the electron stream must be devised. One method is to construct the electron gun inside the tube in such a manner as to "trap" out the ions.

Ion Trap Construction

Figure 41 portrays the ion trap and shows its general construction. The large magnet bends the electron beam upward, while the ion beam continues in a straight path. Note the construction of the anode located inside the kinescope. This construction causes both the ion and the electron beam to be deflected downward towards the neck of the kinescope, because of the electrostatic field existing between the anodes. At this point, the small ion trap magnet causes the electron beam to straighten out. But since the ions weigh approximately 2,000 times more than electrons, they continue in the direction of the bent path and are not affected materially by the magnetic field. Therefore, the ions are removed from the electron beam. In making the ion trap magnet adjustment, a preliminary adjustment is first made by inspection where the rear magnet poles are placed over two small flags attached to the gun structure. The final adjustment is made by moving the magnet forward or backward with a slight rotational movement in order to give maximum illumination on the screen. This position is critical and requires careful adjustment to obtain optimum brightness.

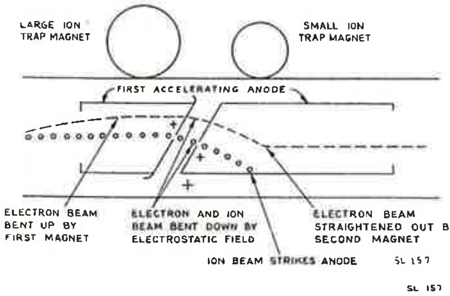


Fig. 41—Ion Trap Construction

Synchronizing Circuits

The next circuits to be considered hold the picture information in step with the picture information transmitted from the studio. These are the synchronizing circuits.

The sync information for the synchronizing control circuits is obtained from the DC restorer. As pointed out, the sync level was constant at the DC restorer and is at the proper level to provide the necessary synchronizing control information.

First Sync Amplifier

The sync pulse at the grid of the 6SK7, the first sync amplifier, is negative in polarity.

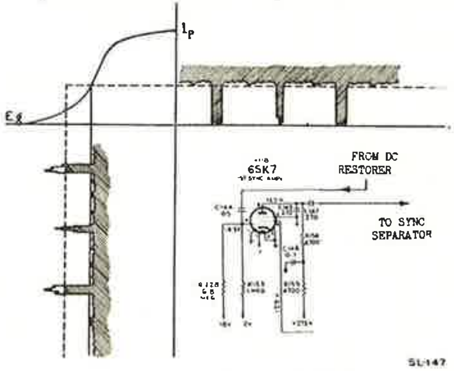


Fig. 42—First Sync Amplifier

Due to the cut-off characteristic of the 6SK7, noise excursions more negative than the sync will be compressed so that the ratio of sync to noise is further improved. The polarity of the sync signal is reversed by the 6SK7 so that the sync signal appearing on the grid of the 6SH7, the sync separator, is positive in polarity.

Sync Separator

The sync separator, the 6SH7, is biased to cut off so that only the positive portion of the applied signal, that is the sync tips, appear at the output of the sync separator. The negative portion, containing the video signal is cut off. Further clipping is accomplished in the second sync amplifier, ½ of a 6SN7. The signal

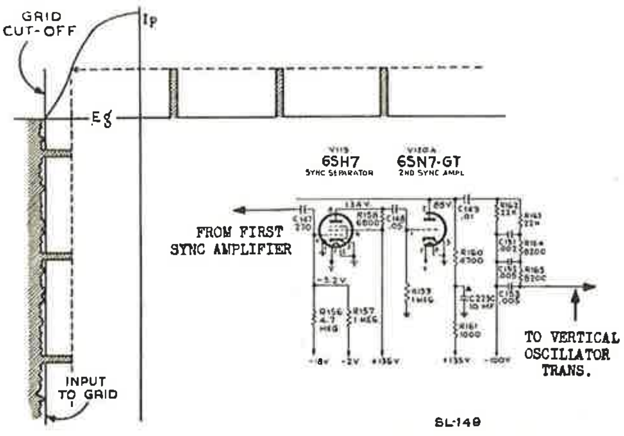


Fig. 43—Sync Separator and Second Sync Amplifier

is again inverted so that in the output of the plate of the sync amplifier, the sync signal is positive in polarity.

At this point, the horizontal sync pulses are separated from the vertical pulses, and are used to control their respective circuits. Due to the difference in duration of the vertical and horizontal sync pulses, separation is accomplished by circuits which are responsive to the difference in duration of the applied pulses. These circuits are termed integrating and differentiating networks.

RC Circuits

It may be of interest to review the properties of a resistor and condenser which make wave shape discrimination possible. Shown in figure 44 is a circuit with a curve showing the charge and discharge

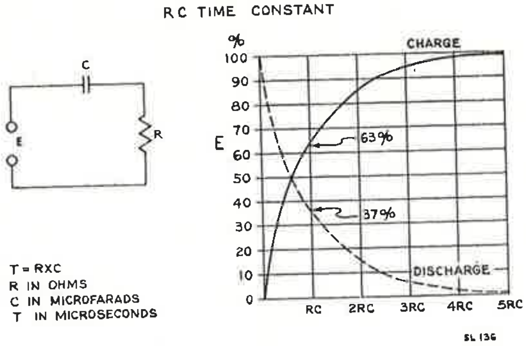


Fig. 44—RC Action

of a condenser in series with a resistor. The values of resistance R and condenser C in the circuit will determine the rate at which condenser C charges. The time in which the condenser will attain 63% of its charge is known as the RC time constant. The formula for calculating the time constant is T equals RC, where T is the time in micro-seconds, R is the resistance in ohms, and C is the capacity in microfarads.

The rate of discharge of the condenser, when the impressed voltage is removed, is the inverse of the charge curve, as shown by the dotted line on the slide. The curve shows that the condenser will charge to 85% of the applied voltage in twice the RC time, to 95% of the applied voltage in three times the RC time, and to approximately 99% of the applied voltage in five times the RC time.

Figure 45 shows an RC circuit, in which the input consists of the sync pulse output of the sync separator. The time constant is made very short—about one micro-second. Therefore, the horizontal sync pulse, point A, lasting for five micro-seconds (which is 5 RC time) will charge the capacitor up to 99% of the applied voltage. During the equalizing pulse (point B) time of 2½ micro-seconds (which is 2.5 RC time) the capacitor can charge to more than 90% of the applied voltage. During the vertical sync pulse, (Point C) which lasts 31.75 micro-seconds between serrations, the condenser will attain a maximum charge and the waveform shown will be produced. Next examine the waveform at the resistor. To determine the flow of current through the resistor, start with the waveform at the capacitor at the horizontal pulse, point A. The leading edge of the horizontal sync pulse causes a surge of current through the resistor as the condenser charges. As the condenser attains its maximum charge, the flow of current becomes smaller until it is zero when the condenser has attained its peak charge. The trailing edge of the horizontal sync pulse then follows, causing the same action to take place, but with the polarity reversed. The same condition prevails durin the equalizing pulses B. Current flows only during the period when the condenser is charging or discharging, and not during a static period.

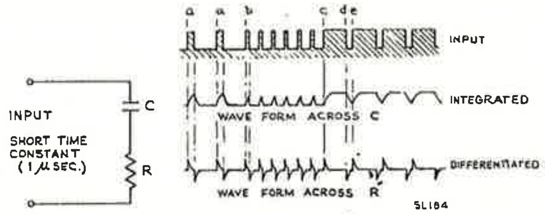


Fig. 45—RC Effect on Sync Pulse

During the vertical sync pulse, the following action occurs. The leading edge C of the vertical sync pulse charges the condenser, causing a sudden flow of current through the resistor. When the plateau of the vertical sync pulse is reached, the condenser is fully charged and no current flows through the resistor. Disregarding the minute time involved, the pulse is at a steady DC potential, and the circuit is at a static period.

The first slot D in the vertical sync pulse then occurs. The condenser discharges rapidly, causing a surge of current in the opposite direction. As the bottom of the slot is reached, a substantially static period from D to E again prevails, and current flow is again zero. At the end of the slot a rapid rise across the condenser occurs and the cycle is repeated.

Consequently, the differentiated output across R represents only voltage changes. During the vertical sync pulse, surges of current through the resistor appear only when the voltage changes, that is, when the pulse is interrupted, as is the case at each slot in the vertical sync pulse.

The vertical sync pulse is no longer apparent in the differentiated output and has little effect on the horizontal circuits. The differentiating circuit produces pips which synchronize the horizontal oscillator.

Integrating Network

The simplest form of integrating network is shown in figure 46 and consists of resistor R in series with condenser C. The incoming sync pulses are applied across the combination of R & C at the input. The output is taken across C. The time constant of the circuit is long, so that neither the equalizing pulses nor the horizontal pulses have sufficient duration to charge the capacitor to the peak voltage of the applied pulse. Note that the horizontal sync pulse, point A, charges C to a higher voltage since it is twice the duration of the equalizing pulses, point B. The vertical pulse, lasting 190 micro seconds, charges the condenser to almost sync pulse potential. The saw-tooth effect on the larger pulse is due to the slots in the vertical sync pulse. As explained previously in the discussion of the differentiating circuit, the purpose of these slots is to permit the horizontal oscillator to continue in synchronization during the vertical sync pulse.

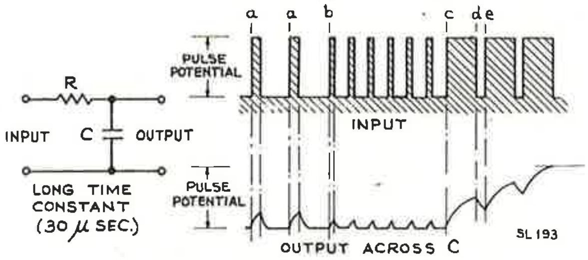


Fig. 46—Integrating Circuit

The vertical oscillator triggers only when the integrated pulse reaches a predetermined height. Therefore, the horizontal pulses, the equalizing pulses, or extraneous noise will have little or no effect upon vertical synchronization.

Equalizing Pulse Function

At this time the function of the equalizing pulses becomes more apparent. Assume an input to the integrating network of a standard signal without equalizing pulses. In figure 47, at the end of the first field, point A, the integrated pulse begins to build up. There is a full line between the last horizontal sync pulse, point B, and the start of the vertical pulse, point A. This means that the RC circuit will fully discharge before the start of the vertical pulse. Therefore, the integrated pulse looks as shown by the solid line. Now observe the output of the integrating network for the second field. At the beginning of the vertical pulse point C, the condenser has not fully discharged from the effect of the last horizontal pulse, point D, since it is separated from the vertical pulse by only half a line. Therefore, there is already a residual voltage in the integrating network, and, consequently, the trigger point of the vertical oscillator will be reached earlier as shown by the dotted line. While this time difference is very slight, it is sufficient to throw off the timing of the circuit and to affect interlacing.

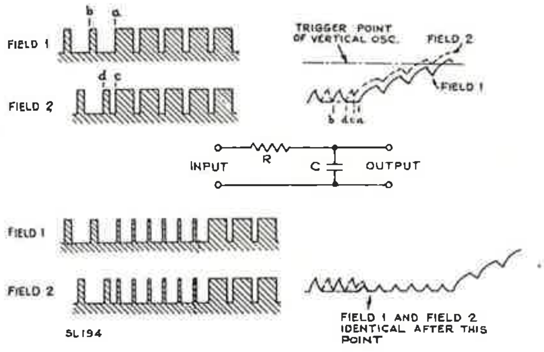


Fig. 47—Equalizing Pulse Function

Now, examine the output of the integrating network with equalizing pulses in both fields. As can be seen, the integrated pulse begins at the same point regardless of which field has been completed, and most important, reaches the trigger point of the vertical oscillator at the same time. Regardless of which field has been completed, the vertical oscillator will begin retrace at the same time.

Filter Effect on Pulse

Examining the integrating circuit as used in the 630 receiver, it can be seen that it consists of three RC cir-

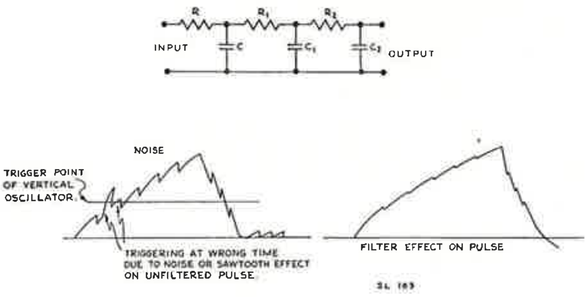
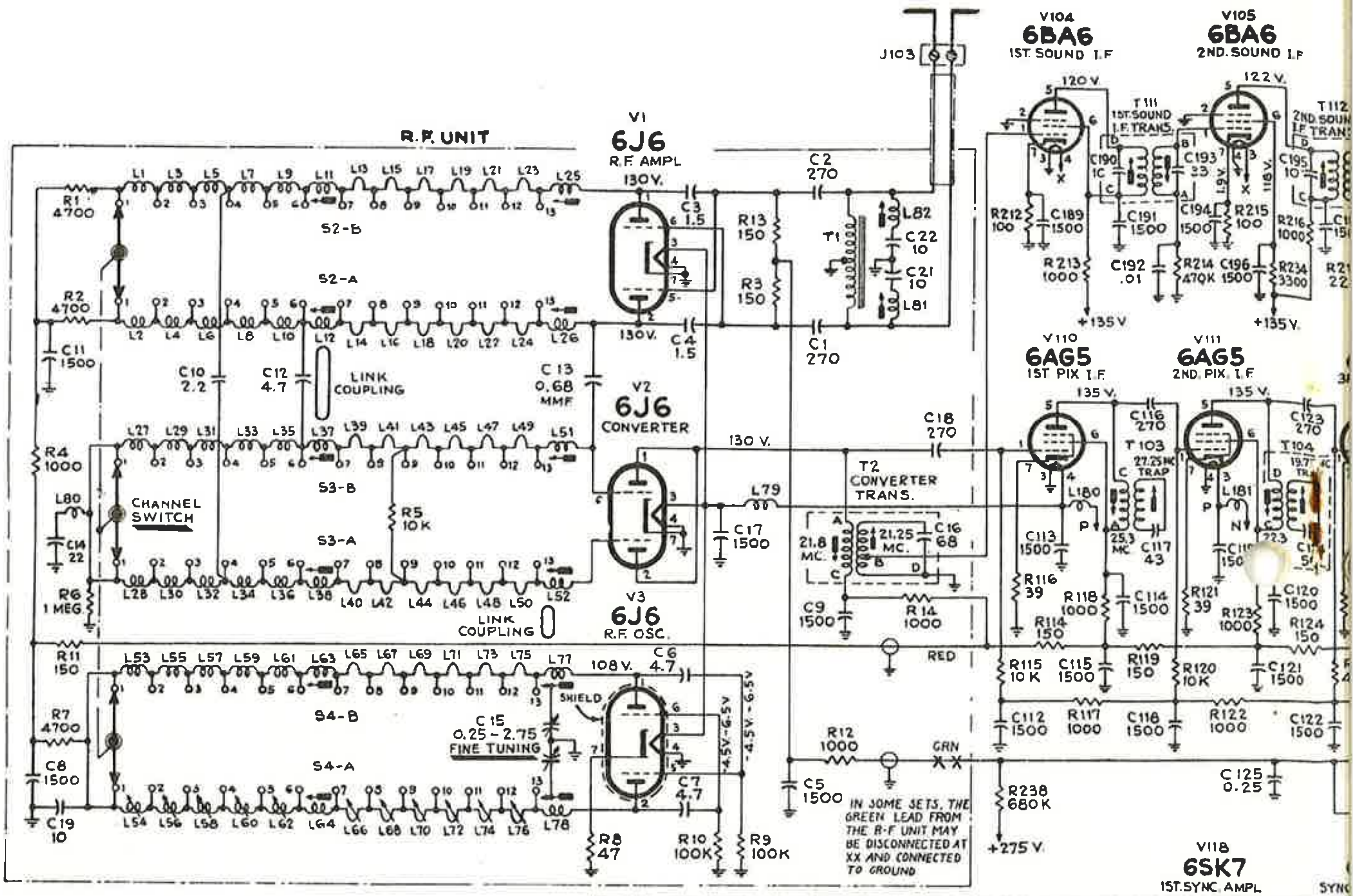


Fig. 48—Filter Effect of Cascaded RC Circuits



K = 1000

All resistance values in ohms, and capacitance values in mmfd., unless otherwise noted.

Direction of arrows at controls indicates clockwise rotation.

All voltages measured with VoltOhmyst and with picture control counterclockwise. Voltages should hold within ±20% with 117 v. a-c supply.

The schematic diagram shows the circuit with all the latest changes incorporated at the time of printing.

In some receivers C19 is omitted.

In some receivers C14 is fixed.

In some receivers R239 is omitted.

In some receivers C164 is omitted.

In some receivers R177 is 2.7K.

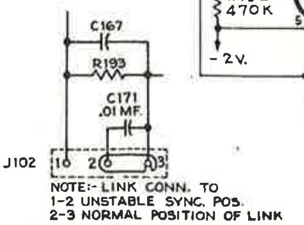
In early production receivers, R186B is employed in place of R240.

In receivers with a sub. 4 power transformer, R208 is 27K.

In some receivers L187 is 180 Mu. H and R136 is 39K.

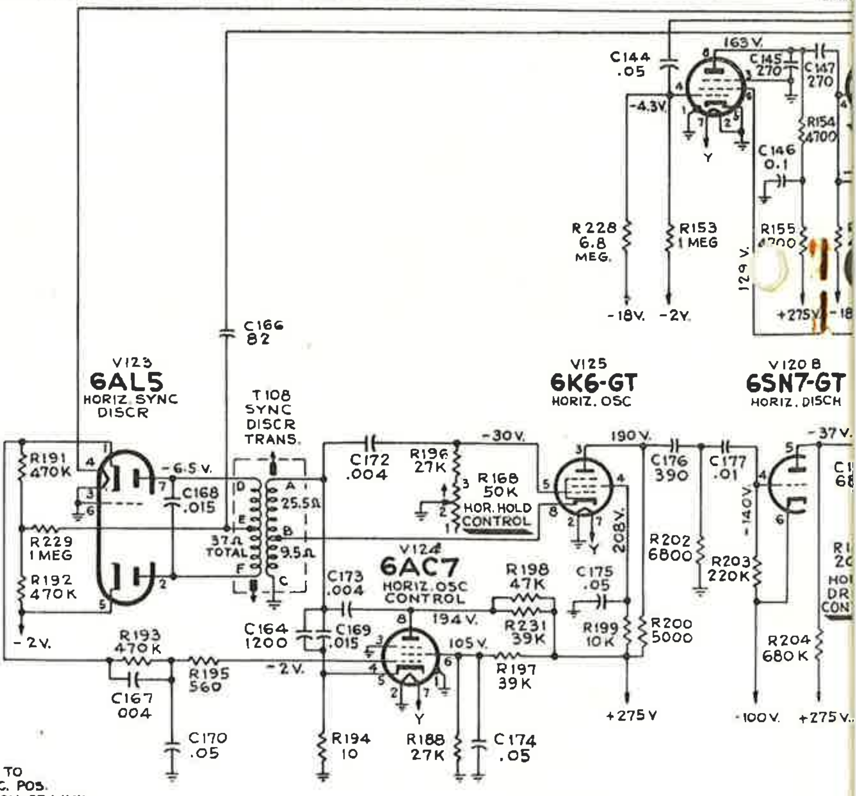
In some receivers the terminals 1 and 3 of the link, J102, are connected across R193 and a .01 mf. capacitor (C171) is connected between terminals 2 and 3.

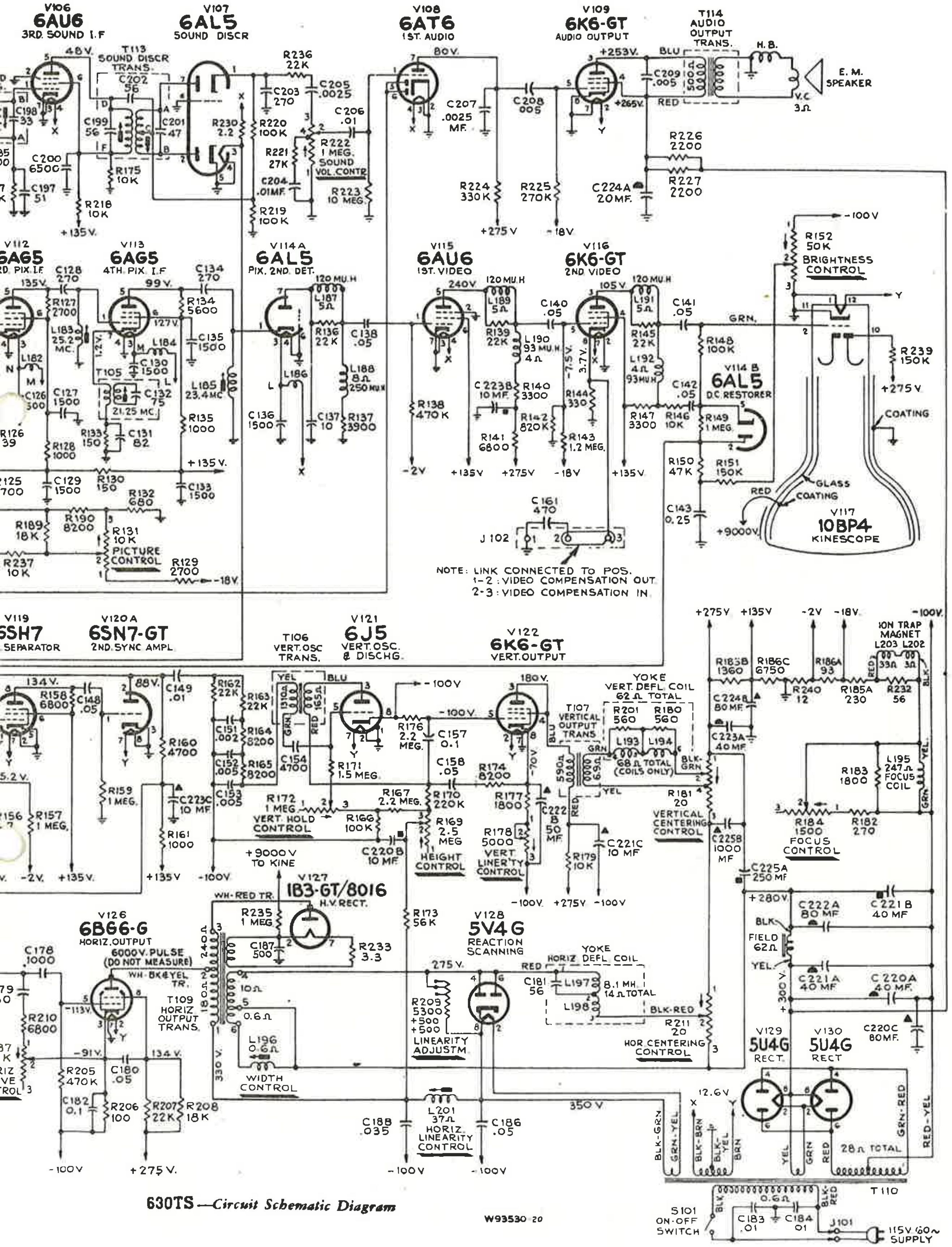
In some receivers, substitutions have caused changes in component lead color codes, in electrolytic capacitor values and their lug identification markings



NOTE:- LINK CONN. TO 1-2 UNSTABLE SYNC. POS. 2-3 NORMAL POSITION OF LINK

J102 CONNECTION IN SOME RECEIVERS





630TS—*Circuit Schematic Diagram*

W93530 20

cuits in cascade. Some measure of filter action is achieved which tends to smooth the integrated pulse and minimize the possibility of the oscillator firing on noise. Figure 48 illustrates the possible effect if the vertical sync pulse were not smooth. The time constant of each RC circuit is different, which provides better immunity to noise. The integrated pulse output is applied to the vertical oscillator.

Vertical Deflection Circuits

Vertical Blocking Oscillator

At this point it would be well to discuss briefly the theory of a simple blocking oscillator since this is the type used in the 630TS vertical circuit. Shown in figure 49 is the circuit of a typical blocking oscillator. This circuit functions as follows:

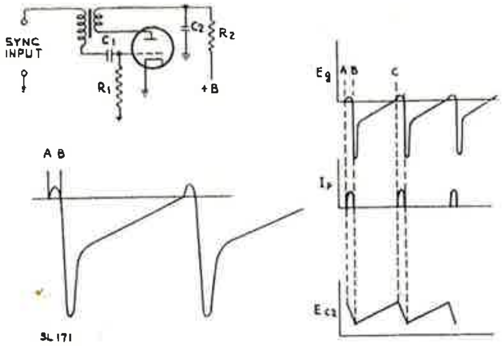


Fig. 49—Blocking Oscillator

Assume that at this moment, plate voltage is applied to the tube. Plate current will begin to flow through the transformer. The flow of current through the transformer induces a voltage in the secondary which causes the grid of the oscillator to swing positive. As the grid becomes positive with respect to the cathode, the grid draws current and electrons accumulate on the grid side of the grid capacitor C_1. The plate current continues to increase rapidly until plate saturation is approached. As plate saturation is approached the rate of change of current flow becomes less. Since the voltage induced in the secondary of the transformer depends upon the *rate of change* of current in the primary, and as plate saturation is approached, the rate of change becomes less, consequently less voltage is induced in the secondary, and the grid will swing negative. As the grid starts negative the flow of plate current in the primary is reduced, inducing a greater negative charge on the grid, causing even less plate current to flow. This action is cumulative so that the grid is driven well beyond cut-off, and plate current ceases to flow. When plate current has ceased, there is no voltage in the secondary of the transformer, and the grid ceases being driven negative. Recalling, however, that the grid capacitor has accumulated a charge of electrons, the grid will remain negative until this capacitor has discharged through R_1. If the time constant of R_1 and C_1 were short, the grid would immediately recover and the cycle would repeat at this point. However, the time constant of R_1-C_1 is made comparatively large. Due to the long time constant involved, the electron charge on C_1 does not discharge immediately, but continues leaking through R_1, keeping the grid beyond cutoff. As the condenser C_1 discharges, and the flow of electrons through R_1 becomes less, the grid becomes less negative until at a certain point, depending upon the time constant of R_1 and C_1, the grid is no longer at cutoff and plate current once more begins to flow at point C, thus repeating the cycle. Figure 49, shows the waveform of the plate current and the grid voltage during this cycle of operation. The dotted lines indicate the point at which the grid is cut off.

In the plate circuit, components R2-C2 serve to shape the output to nearly a sawtooth form. The capacitor C2 charges through R2 during the period when the tube is beyond cutoff, points B to C. The values of R2-C2 are chosen so that the capacitor attains only a small portion of the applied voltage before the tube conducts, thus providing a substantially linear charge curve.

When the tube conducts, it forms a low impedance path to ground across C2, and C2 discharges rapidly through the tube forming the proper sawtooth. The result, therefore, is a slow linear charge with a rapid discharge.

Triggering of the Vertical Blocking Oscillator

As the grid recovers from its extreme cutoff portion, if a pulse of the proper polarity were applied at the point indicated in figure 50, the grid would swing above cutoff, thus causing the cycle to begin at the point where the pulse was applied.

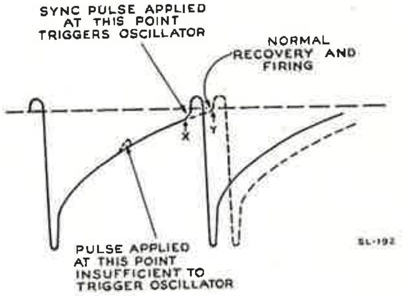


Fig. 50—Triggering of the Vertical Blocking Oscillator

Figure 50 shows the free running oscillation wave form at the grid of the blocking oscillator. Just before the oscillator is ready to fire in its natural cycle, the sync pulse output from the integrating network is applied to the grid. This pulse is of sufficient amplitude to start the cycle as shown at point X rather than at the natural period of oscillation, or point Y. Therefore, the vertical blocking oscillator is synchronized with the sync pulse of the incoming signal. This causes the picture to remain in vertical synchronization.

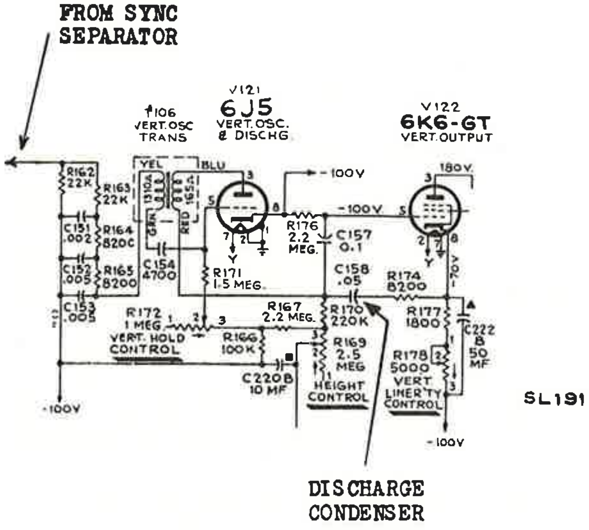


Fig. 51—Schematic of the Vertical Oscillator

Figure 51 shows the sync input from the sync separator through the integrating network to the blocking oscillator in the 630 chassis. The integrated pulse is super imposed on the grid of V121 to trigger the oscillator at the start of each field. The recovery time of the oscillator is controlled by C154 and series resistors R171 and R172. R172 is a variable resistor which functions as a hold control. C158 is the discharge capacitor, which along with R174 shapes the vertical sawtooth. R170 and R169 determine the charge rate of C158. Since R169 will vary the amplitude of the charge on C158, it will therefore vary the height of the picture.

C157 couples the sawtooth voltage developed in the vertical blocking oscillator to the grid of the output tube, V122.

The operating point of V122 is controlled by R178 and serves to control the linearity of the output. Since the gain of V122 varies as the operating point is changed, adjustment of R178, may require readjustment of R169.

Vertical Deflection Circuit

The output of the vertical output tube is applied to the deflection coils through the vertical output transformer. The vertical deflection coils are damped by means of two shunting resistors which suppress any tendency to shock excited oscillation.

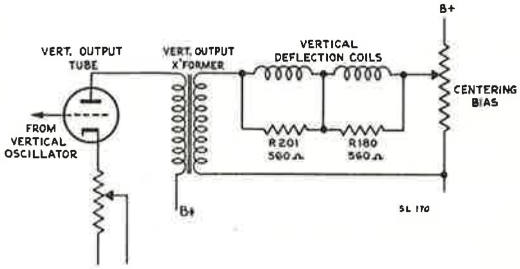


Fig. 52—Vertical Output Circuit

Horizontal Deflection Circuits

Differentiated Output

Having traced the signal from the output of the integrating network through the vertical circuits, it will be necessary to return to the second sync amplifier output and trace the signal through the differentiating circuit. Shown in figure 53 is the output of the differentiator circuit. The output consists of a series of pips or pulses which are in synchronization with the incoming signals. Before considering how these pips are used to time the horizontal oscillator, consider for a moment some applications of vacuum tubes, which differ from their normal function as an amplifier or detector.

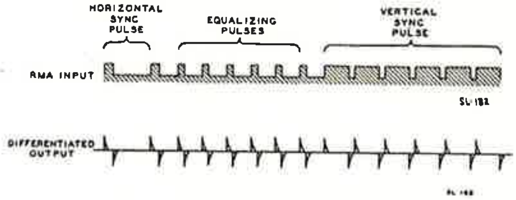


Fig. 53—Differentiated Sync

It is necessary to develop a method of controlling the frequency of the horizontal oscillator, so that it will be in synchronization with the transmitted signal. A method by which this is accomplished is as follows:

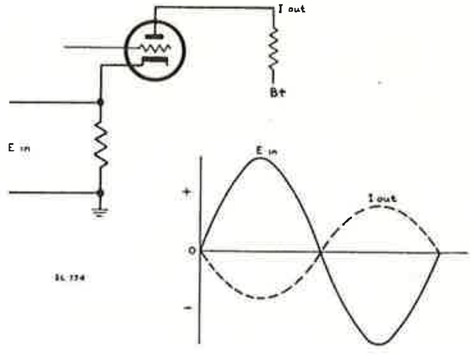


Fig. 54—Cathode Injection

Cathode Injection

Figure 54 shows a tube in which the applied signal is across the cathode resistor and the output is taken from the plate.

The effect of a signal applied to the cathode is exactly opposite to the effect of a signal applied to the grid. As the voltage on the cathode goes positive, the plate current decreases. As the cathode voltage goes negative, plate current increases, so that there is a 180° difference between the plate current and the applied voltage.

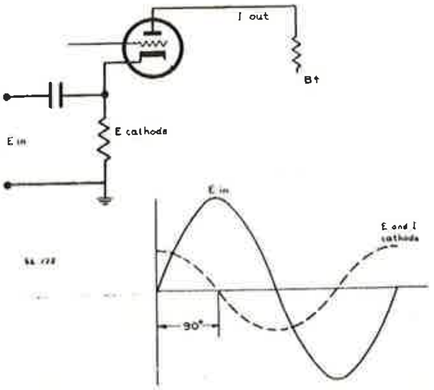


Fig. 55—Condenser Input to Cathode

Figure 55 shows a condenser having a high reactance to the applied signal, in series with the input. Because of the high reactance there will be a phase shift of almost 90° through the capacitor. The voltage drop developed across the cathode resistor will be ***in phase*** with the current through the cathode resistor. Thus the cathode voltage leads the applied voltage by nearly 90°.

Reactance Tube

From the same source, the input voltage is applied to the plate of the tube. If the tube chosen is a pentode, one of its characteristics is that a change in plate voltage will not produce a change in plate current over a fairly wide range, so therefore, the applied voltage can vary through its cycle without materially affecting the plate current.

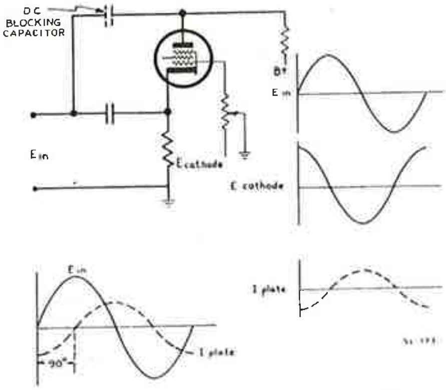


Fig. 56—Reactance Tube

However, the developed voltage on the cathode is varying 90° ahead of the applied voltage.

The plate current varies 180° out of phase with the cathode voltage. Therefore, the plate current through the tube is lagging the applied voltage by 90°. Since the current in an inductance lags the applied voltage by 90° the tube is apparently an inductance.

To an AC signal applied to this circuit the tube will exhibit the effect of an inductance.

The effect of the grid in this circuit has not been mentioned. Assume the tube working as a reactance; now if the grid voltage were varied, it would vary the amount of current through the tube. Since the current through an inductive circuit, is a function of the amount of inductive reactance, by varying the grid bias, the tube becomes a variable reactance.

Horizontal Oscillator

The horizontal oscillator is a Hartley, a simplified schematic of which is shown in figure 57. Oscillation takes place at the resonant frequency of the tank circuit. Some change in frequency can be accomplished by varying the grid bias. This is the horizontal hold control (dotted potentiometer). The resonant frequency can be changed by making L or C variable. It is also possible to vary the frequency of the oscillator by adding an inductance in parallel with L. If, therefore, a variable inductance were placed in parallel with the inductance in the tank circuit, the frequency of the horizontal oscillator can be varied.

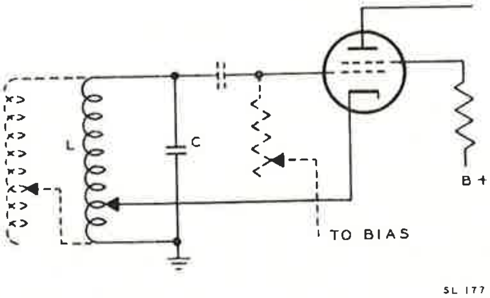


Fig. 57—Modified Hartley Oscillator

Reactance Control Tube

The circuit previously described can function as an inductance. Suppose it were substituted across the tank circuit, instead of a parallel variable inductance. The apparent inductance which the tube reflects into the tank circuit is dependent upon the amount of plate current. As explained previously, if the voltage applied to the grid was variable, the plate current through the tube would vary, which would vary the reactance of the tube, thus changing the frequency of

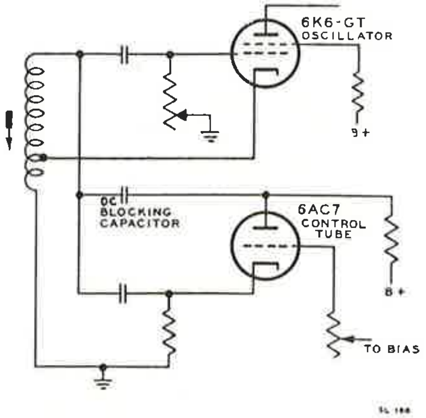


Fig. 58—Reactance Control Tube

the horizontal oscillator. The condenser shown in the plate circuit is a DC blocking condenser. Thus a method of controlling the oscillator frequency by means of an applied DC control voltage is possible. It is now necessary to determine where this control voltage is supplied from.

Sync Discriminator

Figure 59 shows a schematic of a circuit which will provide the necessary control voltage. The output from the differentiator circuit is applied to the center tap of the primary of T108. The secondary of T108 is in the grid tank circuit of the horizontal oscillator. The secondary is coupled to the primary, and consequently the sine wave voltage generated by the oscillator will appear across the primary on the plates of the diodes. The sine wave voltage will be 180 degrees out of phase at each plate. The voltage supplied by the differentiator circuit will appear *in phase* on the diode plates. The voltage developed across the diode load resistors when both the sync signal and the sine wave voltage are properly phased will be such as to oppose each other, and no output or control voltage will exist at point A.

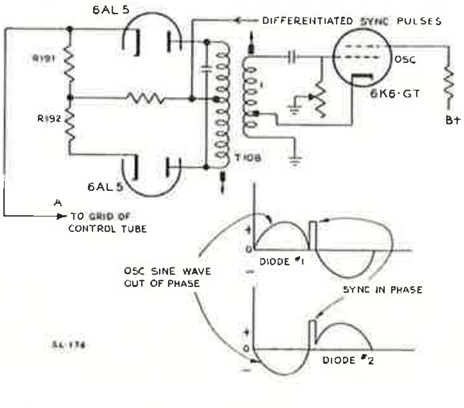


Fig. 59—Sync Discriminator

This condition is shown in A of figure 60. Since no voltage is developed, no voltage will be applied to the grid of the reactance tube, and no change will take place in the apparent inductance in parallel with the grid tank circuit. Assume now that the horizontal oscillator is operating at a frequency higher than that of the applied sync signal. The condition shown in the second figure, B will now prevail. For the condition shown, the top diode will conduct more heavily than will the bottom diode. In figure 60, the area under curve 1 is greater than the area under curve 2 in drawing B. This means that there is a greater voltage drop across the top diode load resistor, than across the bottom diode load resistor. The voltages will no longer cancel each other and a positive voltage will be produced to control the reactance tube. This will increase the current through the tube, thereby increasing the amount of reactance introduced into the circuit by the reactance control tube, and the frequency of the oscillator will decrease. Assume the opposite condition: the frequency of the horizontal oscillator is now lower than that of the applied signal. During this condition, as depicted in C of figure 60, diode #2 will now conduct more heavily developing a greater voltage drop across its load resistor. The voltage drop across the load resistor of diode #2 will be greater than the voltage developed across the load resistor, of diode #1, hence, there will be a negative voltage produced which will decrease the plate current flow of the reactance tube, decreasing the apparent reactance in the circuit, increasing the frequency of the oscillator.

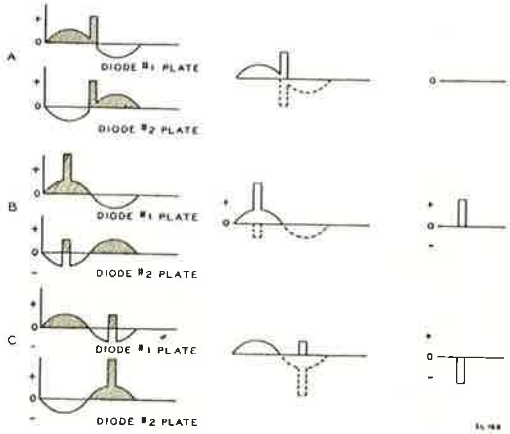


Fig. 60—Discriminator Action

The action taking place may be considered as a comparison of the oscillator frequency versus the frequency of the applied sync signal. Should any difference exist, a control voltage is developed and applied to the horizontal oscillator control tube, which will change the oscillator frequency to conform with the sync signal.

Figure 60 shows the actual voltage resulting across the load resistors for the conditions just mentioned. That is, figure B shows the developed voltage as a result of the oscillator being higher in frequency than the applied sync signal. Figure A shows the voltage result when the oscillator and incoming signals are in synchronization, and Figure C shows the voltage developed when the oscillator frequency is lower than that of the incoming sync signal. The developed voltage is not pure DC, but DC with a ripple at 15,750 cycles per second, which is the frequency of the horizontal oscillator.

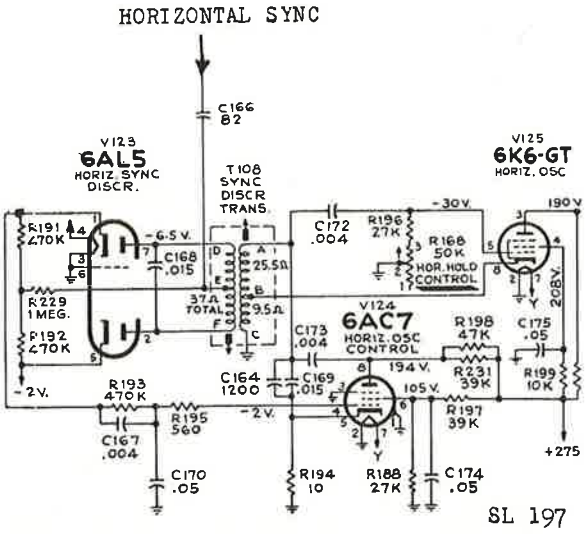


Fig. 61—Schematic of the Horizontal Control Circuits

Figure 61 is the schematic of this circuit as used in the 630 chassis.

Capacitor C167 and capacitor C170 on the schematic in figure 61 serve as filters to smooth the ripple and apply the control voltage as a DC voltage to the grid of the horizontal oscillator control tube. C167 and C170, due to their filter action, also serve to prevent rapid changes of voltage from reaching the grid of the control tube. Therefore, noise excursions have little effect on the horizontal oscillator.

It should be evident at this point how the RMA signal provides the proper synchronizing information to lock both the horizontal and vertical oscillators in the receiver with the transmitted signal.

Horizontal Oscillator Output

Returning to the horizontal oscillator momentarily, it will be recalled that the voltage on the grid of the horizontal oscillator was a sine wave. The amplitude of the sine wave is fairly large, being of sufficient magnitude to drive the tube beyond plate saturation and grid cut-off. Therefore, the waveform output at the plate of the horizontal oscillator instead of being a sine wave is essentially a clipped square wave, that is, only a portion of the sine wave on the grid appears on the plate of the oscillator due to the limiting action of plate saturation and grid cut-off. This square wave output from the horizontal oscillator plate is applied to the horizontal discharge tube. The function of the horizontal discharge is somewhat similar to the action of the vertical discharge tube.

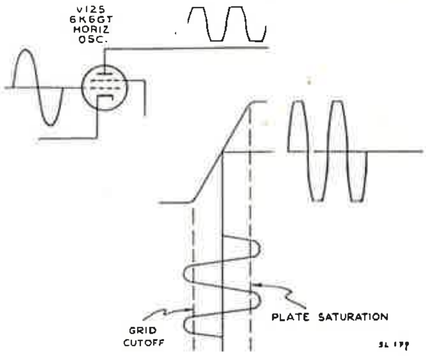


Fig. 62—Output on Plate of the Horizontal Oscillator

Horizontal Discharge Tube

The square wave output from the plate of the horizontal oscillator is applied to a differentiating circuit R1-C1. The output of the differentiating circuit will consist of a series of pips. The pips are then applied to the grid of the horizontal discharge tube which is one half of a 6SN7. The grid develops a bias well beyond cut-off, so that only the positive peaks of the differentiated pulses drive the tube out of cut-off. While the tube is cut-off, C2 is charging from the B+ supply through R2. R2 is made extremely large so that the charge on C2 will be fairly slow. As the positive peak of the differentiated pulse drives the grid out of cut-off, the tube conducts heavily, forming a low resistance discharge path for C2. C2 partially discharges through this low resistance path, but because of the comparatively long RC time constant, the tube again goes into cut-off before the charge has completely discharged from C2. Consequently, the plate voltage immediately rises to the level of the potential remaining on C2, which has not completely

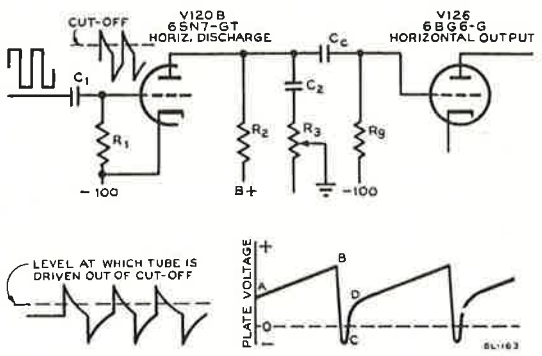


Fig. 63—Horizontal Discharge Tube

discharged. The wave form of the output voltage will appear as shown in figure 63. From point A to B the condenser is charging. As the condenser attains its charge, the flow of current through R2 becomes less, until at point B the plate voltage has risen to its highest point. At point B, however, the tube begins conducting, placing a load on the plate supply. This causes the plate voltage to drop very rapidly. The drop in plate voltage is from B to C. During this same time, B to C, the condenser is attempting to discharge also. Since the condenser cannot discharge completely, at point C when the tube is once more driven to cut-off, the plate voltage immediately rises to the potential remaining on C2 which is point D. The condenser again charges allowing the plate voltage to rise as explained before. This cycle is then repeated.

The purpose of this discharge action will be easier to understand after discussing the function of the horizontal output. The discharge circuit will produce a wave form having a very steep slope on the trailing edge. The value of resistor R3 governs the discharge rate of C2. It also determines the amount of voltage remaining on C2, thus changing the point at which the sawtooth will begin after its rapid negative excursion.

Horizontal Output

The output of the horizontal discharge tube is applied to the grid of the horizontal output tube, the 6BG6. The 6BG6 is driven well beyond cut-off. The tube will conduct only during the positive portion of the sawtooth output of the horizontal discharge tube, which is above the dotted line in figure 64. As the grid is driven positive by the applied signal, plate current flows through the coil L, creating a magnetic field around the coil. The lines of force generated by this field induce a voltage in L1, L2, and L3. This field continues to increase until point B of the applied wave of figure 64. At this point, the grid is driven negative causing the field around L to collapse almost instantly.

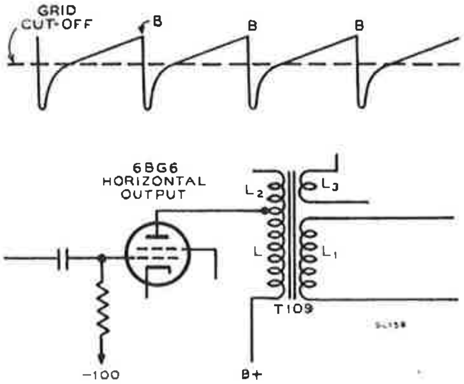


Fig. 64—Horizontal Output Tube

The secondary of T109 and the inductance of the horizontal deflection coil, L197 and L198, form a resonant circuit. The resonant frequency of the circuit is about 71 kilocycles. This frequency was chosen since ½ cycle of oscillation at 71 kilocycles is equal to 7 micro seconds, the time in which the horizontal retrace must be accomplished. The effect of the sudden collapse of the field around L, is to shock excite the resonant circuit for a half cycle of oscillation. Therefore, during the half cycle of oscillation, the current through the horizontal deflection coils has been reversed in the very short time of 7 micro-seconds. Thus retrace is accomplished in less than the ten micro-seconds established by the RMA blanking. Since the beam has been returned to the lefthand side of the screen in the required time, the next line must be scanned in a linear fashion.

It can be seen from figure 62 that if the shock excited oscillation which produced retrace was not stopped in some manner, the oscillation would continue over several cycles. This would be extremely undesirable, so the circuit must cease oscillating after one half cycle of operation. This is accomplished by the horizontal damping tube, the 5V4.

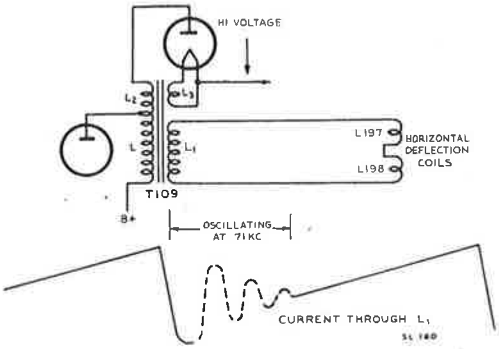


Fig. 65—Undamped Oscillation

Damping

The action of this tube on the circuit is as follows:

When the 6BG6 goes into cut-off, and plate current ceases, and the field existing around L suddenly collapses, the induced voltage in coil L1 will be such as to make point A, in figure 66 the plate of the diode negative. Since the plate is negative it will represent no load across the resonant circuit, permitting oscillation to take place. Since in an inductance the current lags the voltage by 90 degrees, when the current reaches its negative peak, the voltage at point A will be starting positive. As soon as point A becomes positive, the diode will conduct, forming a low resistance path across the tuned circuit, thus damping any further oscillation. The current in the coil does not stop immediately but falls slowly approaching

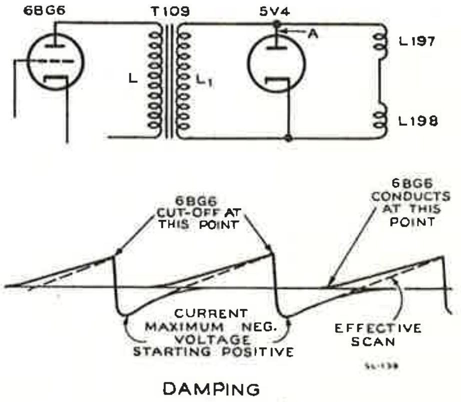


Fig. 66—Damping

zero in the manner shown. Before the current reaches zero, however, the 6BG6 is again driven out of cut-off, thus continuing the scan. Although the waveforms of the two currents shown are not linear, the effect of the combined waveforms is to produce a current through the deflection coils which will provide linear scanning of the horizontal line.

Plate Supply for the 6BG6

The DC voltage on the plate of the 6BG6 flows through coil L, coil L4, the 5V4G during its conduction period, and coil L1. The 5V4G is conducting during the time that the voltage applied to the diode plate is positive. The voltage appearing on the plate of the 6BG6 then, will be the supply voltage plus the rectified voltage recovered from the damping of the deflection circuit. The supply voltage applied to the plate of the 6BG6 is 280 volts plus the voltage developed in coil L1. This is generally on the order of 50 volts or so and the resultant voltage on the plate of the 6BG6 is about 330 volts. Since the tube is conducting during the major portion of the trace when the diode is not conducting, condenser C1 and C2 will have stored sufficient charge to supply plate voltage to the 6BG6.

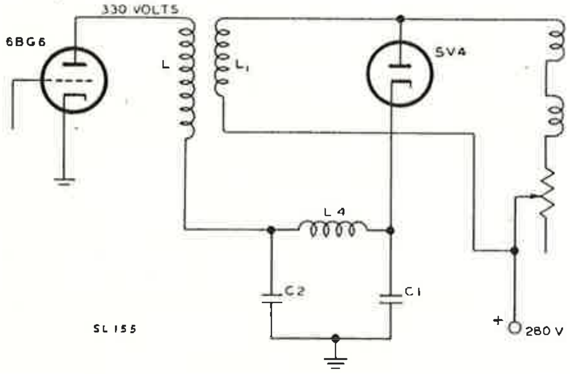


Fig. 67—Plate Supply for the 6BG6

Coil L4 shifts the point at which the 5V4G conducts permitting some compensation for linearity.

At this point the path of the signal through the entire receiver has been covered. The two functions of the receiver which have not as yet been covered are the high voltage supply and the low voltage supply. Since the high voltage supply is a function of the horizontal sweep circuit, it might be well to discuss it at this point.

High Voltage Supply

Coil L3 forms part of an auto transformer in the primary of T109. When the 6BG6 is suddenly driven into cut-off by the waveform from the horizontal discharge, the collapsing magnetic field around L will induce a high voltage at the plate of the 8016 which will be of positive polarity. The induced e.m.f. in a coil is such as to oppose any change of voltage across the coil.

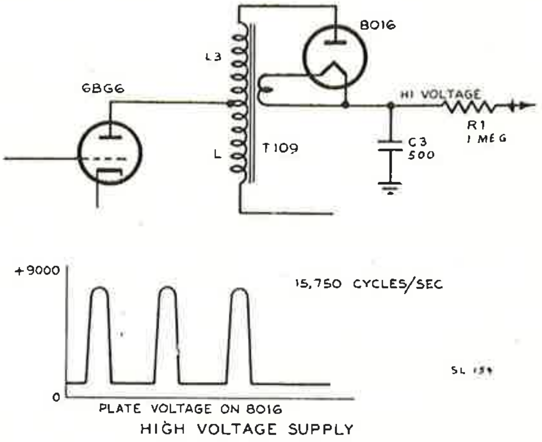


Fig. 68—High Voltage Supply

The voltage appearing on the plate of the high voltage rectifier will be very large in amplitude, approximately 9,000 volts. This voltage is rectified by the diode and supplies voltage for the accelerating anode.

It is interesting to note that the filament supply for the diode rectifier is also taken from transformer T109. Filtering is accomplished in the condenser C3, resistor R1, and by the capacity between the coatings on the kinescope bell. The filtering capacity can be very small due to the high ripple frequency, 15,750 cycles. Therefore, high voltage has been obtained at this point in an economical manner. One important advantage of this type of power supply is the reduced shock hazard it affords.

Although only small current is produced, shocks from this high voltage are still dangerous. Extreme caution must be observed when working on the high voltage section.

Low Voltage Supply

The low voltage supply is conventional in nature consisting of two 5U4's in parallel to provide the required potentials to the various circuits throughout the receiver.

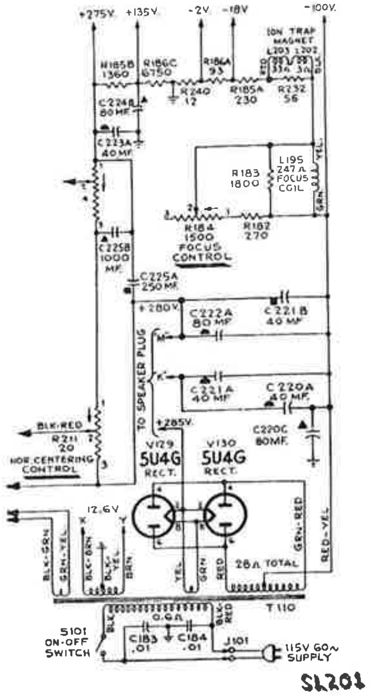


Fig. 69—Schematic of the Low Voltage Supply

New RCA Release

Radiotron 21DP4 is a new, short, directly viewed, rectangular picture tube of the metal-shell type for use in television receivers. It has a picture size of $18\frac{3}{8}''$ x $13\frac{15}{16}''$ with slightly curved sides and rounded corners.

Utilizing electrostatic focusing, the 21DP4 features an electron gun of improved design to provide good uniformity of focus over the entire picture area. Furthermore, focus can be maintained automatically with variation in line voltage and with adjustment of picture brightness. Need for alignment of a focusing coil or focusing magnet is eliminated and therefore tube installation and adjustment for optimum performance are simplified. The electron gun is designed so that the focusing electrode (grid No. 4) takes very low current and, as a result, the design of the focusing-electrode voltage supply is simplified.

Providing pictures having high brightness, the 21DP4 has a relatively flat, high-quality face made of frosted Filterglass to prevent specular reflection and to provide increased picture contrast.

CINTEL G-M TUBES

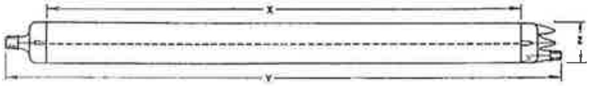
'Cintel' G-M Tubes are of the borosilicate/copper type with an argon-alcohol filling and are self-quenching in operation. This enables them to work with a low series resistance which may have a minimum value of the order 10^4 ohms.

Efficiency. The probability of an argon-alcohol G-M Tube responding to an ionising particle crossing the sensitive volume is greater than 99%.

"Plateau" or voltage region where the number of counts per minute is sensibly constant, is of the order of 200 volts, each tube being marked with a recommended operating range of voltage lying in this region. The working voltage of 'CINTEL' G-M Tubes is in the region 1100-1500 volts.

Insensitive Time. A G-M Tube is insensitive to ionising particles for a definite time after each discharge, this time, for an argon-alcohol tube being of the order 10^{-3} seconds.

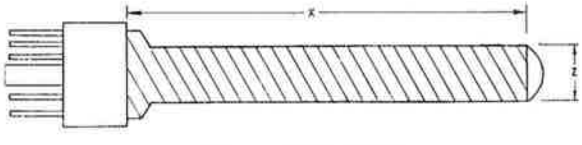
Application. Types G-M 1-10 are suitable for gamma detection. Types G-M 11-12 are suitable for beta detection.



Types G-M 1-10

TABLE OF SIZES

Type	X cm	Y cm	Z mm
G-M 1	65.0	72-74	36-38
G-M 2	45.0	52-54	29-31
G-M 4	11.5	14-15	21-23
G-M 5	23.5	26-28	21-23
G-M 6	32.0	39-41	36-38
G-M 7	32.0	39-41	21-23
G-M 8	16.0	22-23	22-25
G-M 9	51.0	58-59	36-38
G-M 10	41.0	48-50	36-38
G-M 11	140.0	—	17-0
G-M 12	80.0	—	17-0



Types G-M 11-12

Additional Details of Types G-M 11 and 12.

WINDOW THICKNESS	35 mg/cm^2.
CATHODE	Graphite.
FILLING	Argon-alcohol or Low Temperature.
OPERATING VOLTAGE	1300 ± 100 volts.
PLATEAU	Not less than 200 volts.
SLOPE	Not greater than 0.1% per volt.

Germanium Crystal Rectifiers

All the original rectifiers have now been superseded by improved types as follows:—

Old	New	Old	New
GEX. 33	GEX. 34 & GEX. 35	GEX. 45	GEX. 45/1
GEX. 44	GEX. 44/1	GEX. 55	GEX. 55/1
		GEX. 99	GEX. 00

SPECIFICATIONS.

GEX. Types	**34**	**44/1**	**45/1**	**55/1**	**66**
Forward Current					
at + 0.5 V.	—	—	—	—	6 av. mA.
+ 1 V.	1	1	5	1	— min. mA.
Reverse Current					
at — 1 V.	—	—	—	—	10 av. μA.
— 10 V.	100	100	—	—	— max. μA.
— 50 V.	—	2	0.8	0.2	— max. mA.
Turnover Voltage	30	60	75	75	— min. V.

APPLICATIONS.

GEX. 34	Sound detector and low-level noise limiter. Tested for efficiency at 50 Mc/s for an output of 5.5 volts across 7000 ohms as equal to an average low-impedance diode.
GEX. 35	Video rectifier type. Turnover voltage greater than 30. Tested similarly to GEX. 34.
GEX. 44/1	Noise limiter and spot limiter.
GEX. 45/1	Medium impedance rectifier for all purposes.
GEX. 55/1	High impedance rectifier for all purposes.
GEX. 66 (New)	For mixer use to 1000 Mc/s. Up to 100 Mc/s the mixer noise is no greater than a silicon crystal. Efficiency good and noise fairly low to 1000 Mc/s and there is considerable response at 10,000 Mc/s.
GEX. 69 (New)	Similar to GEX. 66 but capacitance up to $2\mu\mu$F. Mainly for TV mixer use.
GEX. 00	Intended for inexpensive crystal sets or video work where utmost sensitivity is not required. Functional test only.

GENERAL.

The first two of the above types are intended primarily for TV applications. In general, price will preclude the use of GEX. 45/1 and GEX. 55/1 for this purpose. The possibility of using GEX. 69 for superhet TV receivers is worthy of the set designer's consideration.