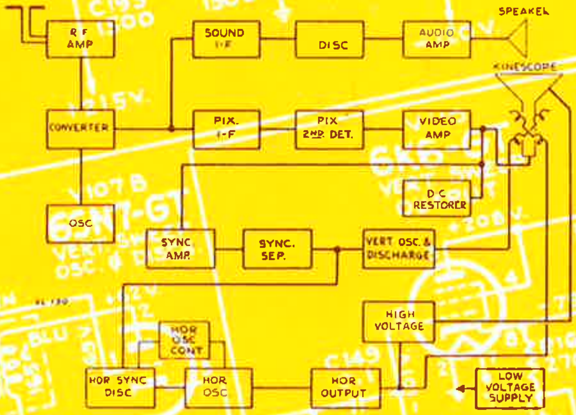
RADIOTRONICS

Vol.16 October 1951 No. 10



An AWV Publication

PRICE 1/-

Registered at the General Post Office Sydney for transmission by post as a periodical.

RADIOTRONICS

Volume 16 **October, 1951** **Number 10**

By the way—

With this issue is included a 1952 subscription form. Readers are asked to complete and return this with the necessary remittance as soon as possible. In doing so, they will assure continuity of their subscription and avoid overloading our accounting and recording staff late in December. NEW ZEALAND SUBSCRIBERS are particularly asked to note that their forms should be returned to SYDNEY and NOT WELLINGTON as formerly. All N.Z. correspondence concerning Radiotronics should in future, be addressed to Sydney.

The TV receiver description which commences in this issue is based on the U.S. TV standards, which do not differ greatly from those proposed for Australia. The article will thus be of considerable interest to local technicians. Later, the details of a 1951 model receiver will be given to illustrate the continuous improvement being made in circuitry and components. Some of the valve types for instance, in the former receiver have now been replaced, in current models, by recently developed types which will be noted in the newer set. This featured article "Basic Description of an RCA Television Receiver" is reprinted by courtesy of RCA Service Company Inc., Camden, New Jersey, U.S.A.

New RCA releases published in Radiotronics are intended for information only and present or future availability is not implied.

Stocks of the 1D21 stroboscope tube, also known as the 631P1, CV220 and NSP1, are now held. This tube and its associated circuit was described in Jan. 1951.

Editor:
Ian C. Hansen,
Member I.R.E. (U.S.A.).

Asst. Editor:
R. Ainsworth, A.S.T.C.,
A.M.I.R.E. (Aust.).

CONTENTS

Radiotronics is published twelve times a year by The Wireless Press for Amalgamated Wireless Valve Company Pty. Ltd. The annual subscription rate in Australasia is 10/-; in U.S.A. and dollar countries $1.25; and in all other countries 11/-. Price of a single copy 1/-.

Address all communications as follows:—

in Australia to:
Amalgamated Wireless Valve Co. Pty. Ltd.,
Technical Publications Department,
G.P.O. Box 2516,
Sydney.

in New Zealand to:
Amalgamated Wireless (Australasia) Ltd.,
P.O. Box 830,
Wellington, C1, N.Z.

PRINTED BY CLOISTER PRESS (D. & W. SHORT), 45-49 GEORGE ST., REDFERN.

Circuit Laboratory Report **Number 11**

RECORD-PLAYING FACILITIES FOR THE SMALL RECEIVER

Radiotron receiver RD33 (Radiotronics 140), which had a sensitivity better than 20 μV over the broadcast band, showed that a modern 4 valve straight receiver without reflexing of the i-f amplifier can provide all the sensitivity required by suburban listeners. However, a disadvantage of receivers with no a-f amplifier between detector and output valve is that there is insufficient a-f gain to allow a pick-up to be used. This disability can be overcome by a rearrangement of components by means of which the pentode i-f amplifier is used as a triode a-f amplifier.

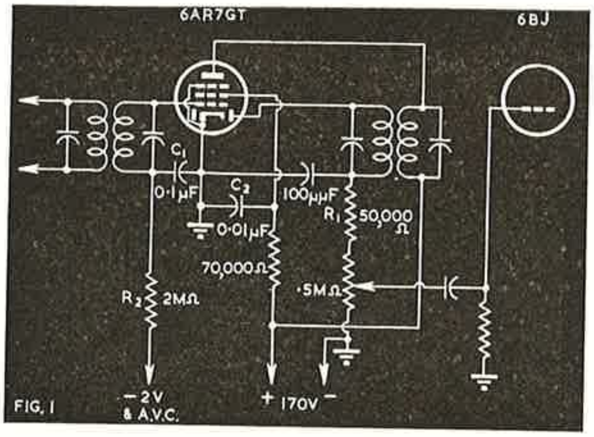


Fig. 1.

Fig. 1 shows the i-f and detector stages of a 4 valve straight receiver using a 6AR7GT. Capacitor *C*1 is the a.v.c. bypass and *C*2 the screen bypass.

In Fig. 2 the connections of the same components are modified slightly. The cold side of the a.v.c. bypass *C*1 is disconnected from ground and the capacitor used to prevent the short-circuiting of the 6AR7GT bias by the pick-up. This connection could be changed over by the use of a special socket into which the pick-up pins are plugged. In addition, the cold end of the screen bypass is disconnected from ground and connected to the top of the volume control. A switch is needed for this change-over and in a dual-wave receiver one position of the wave-change switch can be used; in a broadcast receiver a separate switch is required.

In operation, the output of the pick-up is applied through *C*1 to the grid of the 6AR7GT, which receives its normal bias through *R*2. As there is no a-f impedance in the plate circuit of the 6AR7GT there is no amplification to the plate, and instead the first three electrodes of the valve behave as a triode with the amplified output appearing at the screen. This signal is applied to the high potential end of the volume control which then operates in the normal manner.

The a-f gain available from this circuit is dependent on the amplification factor from control grid to screen grid in the valve used. In the case of the 6AR7GT a typical gain is from 10 to 12 depending on the values of the screen resistor, volume control and output valve grid leak.

The distortion from the 6AR7GT a-f amplifier varies with output, and Table 1, giving results measured in the circuit of Fig. 2, shows that sufficient driving voltage for any commonly used output valve can be obtained without the distortion exceeding a small percentage.

Table 1. Distortion vs. Peak Output Voltage

Peak Output Voltage	(V)	5	10	15
Distortion	(%)	1.6	2.1	3.2

In some receivers the decoupling resistor *R*1 is not used, and when the i-f amplifier is modified as described, its omission results in the detection diode shunting the a-f output of the 6AR7GT. This increases distortion slightly, but the effect is not serious, as shown by the following measurements.

Table 2. Distortion vs. 6BJ5 Output:
Signal applied to grid of 6BJ5

6BJ5 Output	(W)	0.05	1.0	1.5
Distortion	(%)	2.7	4.0	7.5

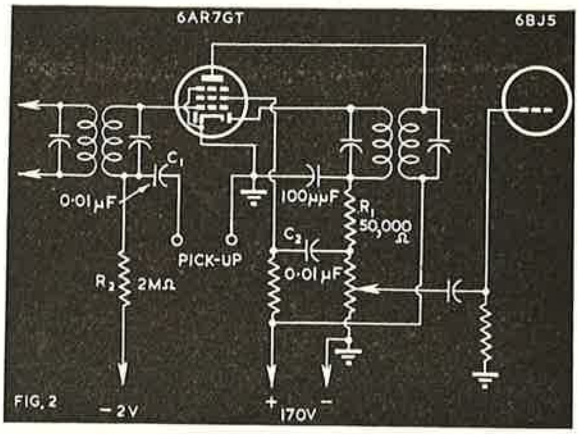


Fig. 2.

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

Table 3. Distortion vs. 6BJ5 Output: Signal applied to Pick-Up Input in Fig. 2

6BJ5 Output	(W)	0.05	1.0	1.5
Distortion	(%)	3.1	4.6	8.3

Table 4. Distortion vs. 6BJ5 Output: Signal applied to Pick-Up Input: R1 omitted

6BJ5 Output	(W)	0.05	1.0	1.5
Distortion	(%)	4.6	6.7	8.8

A limitation to the usefulness of the circuit is that when a common screen resistor is used for the i-f amplifier and converter valves, the value of the resistor may be so low that it restricts the a-f gain from the i-f amplifier excessively. Moreover, oscillation may be experienced when the bypass to the common screens is disconnected from ground. Even with separate screen supplies, parasitic oscillation may be experienced with high slope valves such as the 6AR7GT. Such problems, however, are peculiar to each individual layout and are susceptible to the usual cures. In the particular chassis from which the above results were obtained, the use of short screen and plate leads overcame the parasitics experienced.

Keying the Beam-Power Phone Final

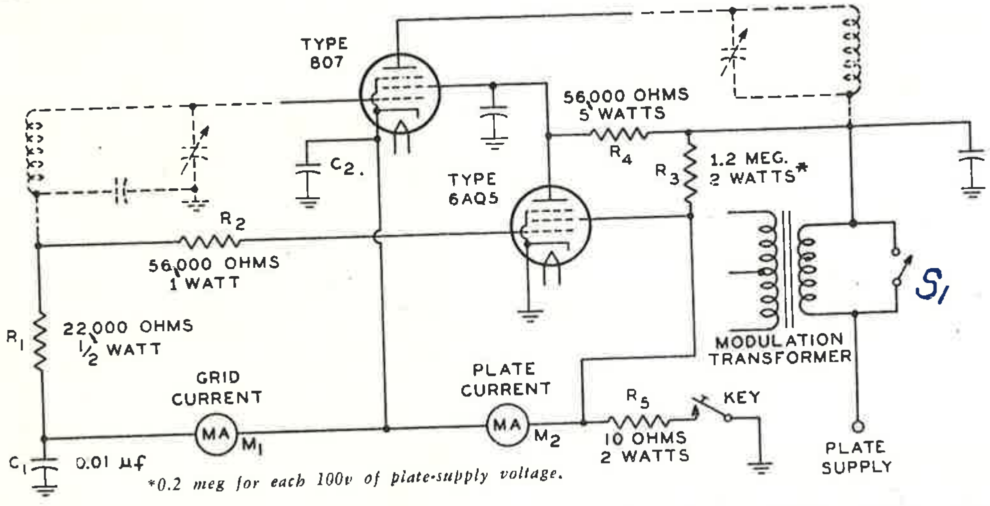
By J. H. OWENS.

By the installation of a single control valve and a few resistors, practically any beam-power phone transmitter can be converted for c.w. operation. And when the key is down, the final is just as suitable for plate-and-screen modulation as it was before the keying system was added.

In addition to providing a clean-cut c.w. signal that is free from chirps, thumps, and key clicks, this unique system offers worthwhile advantages over some of the keying systems presently in use.

Basically, the new method is simply an adaptation of the well-known cathode-return keying system popularly used in triode finals. It differs by the use of a unique method of preventing the screen-grid voltage from exceeding valve ratings when the key is in the up position. With this system, the screen-grid voltage is reduced below the cathode voltage, thereby completely cutting off the plate current in the final amplifier; consequently, the back-wave signal is not transmitted.

For purposes of illustration, this keying system is described here as applied to a typical low-power final employing a single 807. The circuit diagram is shown in Fig. 1. A 6AQ5 miniature beam-power tube is used in the control-valve circuit.



**0.2 meg for each 100v of plate-supply voltage.*

Fig. 1. Schematic diagram of a typical beam-power phone final and the 6AQ5 control valve which prevents excessive screen voltage on the 807 final in the key-up position.

*** The system is also applicable to both phone and c.w. transmitters employing tetrodes or pentodes. Reprinted from Ham Tips by courtesy of Radio Corporation of America.**

The d.c. plate resistance of the 6AQ5 can be made either very low or practically infinite, depending upon whether the key is up or down, respectively. Because the plate of the 6AQ5 is tied directly to the screen-grid of the final-amplifier valve, the 6AQ5 performs electronically and instantly the service of a relay without the delay, sparking, and other difficulties sometimes encountered with relays in high-speed circuits.

Key-down position

The operation can best be understood by examining the circuit in the key-down position. The cathode of the final is at ground potential, being by-passed for r-f through C_2, while the d.c. return is through R_5 (a few ohms) and the key. The plate current of the 6AQ5 is practically cut off because the screen-grid of this valve is connected to the same ground-return circuit. The control-grid of the 6AQ5 is connected through an isolating and filtering resistor to the grid side of the grid-bias resistor of the final amplifier, a negative-voltage point. The combined effects of high negative bias on the control-grid and substantially ground potential on the screen-grid raise the d.c. plate resistance of the 6AQ5 to near infinity. Thus, for all practical purposes, the 6AQ5 has absolutely no effect on the final amplifier which operates as if the control-valve were out of the circuit. Obviously, when the key is down, the final amplifier can be plate-and-screen modulated the same as before the control circuit was installed.

Key-up position

When the key is in the up position, entirely different conditions prevail. The open key removes the d.c. ground return from the final-amplifier cathode and the 6AQ5 screen-grid, and both of these electrodes become positive as a result of voltage being applied through R_3. At the same time, the control-grid of the 6AQ5 becomes slightly positive because it is connected to the final amplifier cathode through isolating resistor R_2, the grid-bias resistor R_1, and the grid milliammeter M_1. Although grid current continues to flow through the final amplifier grid-bias resistor, the negative voltage across this resistor is considerably less than the positive voltage between the final-amplifier cathode and ground; therefore, the net potential at the top of the grid-bias resistor is positive.

This voltage is applied to the control-grid of the 6AQ5 through isolating resistor R_2, but the low resistance of the positive 6AQ5 grid and the high resistance of the isolating resistor cause a relatively large voltage drop; hence the grid of the 6AQ5 is slightly positive. The combined effects of slightly positive bias on the control-grid, and the substantial positive voltage on the screen-grid reduce the d.c. plate resistance of the 6AQ5 to a low value. The plate of the 6AQ5, being tied to the final-amplifier screen grid, puts a heavier load on the screen-grid dropping resistor R_4 than does the screen grid of the final amplifier; therefore, the voltage on this screen is greatly reduced when the key is in the up position. In fact, it is reduced below the cathode voltage, and this, plus the negative bias applied between cathode and the control-grid, serves to cut off the final-amplifier plate current. The overall effect is that the screen-grid of the final amplifier is protected and the r-f signal is interrupted.

Circuit details

Note the location of the grid and plate meters in the circuit. This arrangement provides the least amount of interaction without having the plate-current meter in the high-voltage circuit. As connected, milliammeter M_2 indicates the sum of the plate and screen currents. The grid meter, M_1, indicates the d.c. grid current. (As previously mentioned, grid current continues to flow when the key is up.) The grid current is practically the same when the key is down.

The values for the three added resistors (R_2, R_3, and R_5) are given in the schematic diagram; actual values are not critical. Resistor R_2 is simply an isolating resistor to keep r-f off the 6AQ5 control-grid, Resistor R_5 is a key-click suppressor. Resistor R_3 applies positive voltage to the final cathode and 6AQ5 screen-grid; its value may be halved or doubled for experimental trials. Resistor R_4 is the screen-grid dropping resistor.

A 6AQ5 keying valve is satisfactory for an 807 or 829-B. If one or two 813's are used in the final r-f amplifier, a 6V6-GT or 6F6-G should be substituted for the 6AQ5. The actual resistance and power rating of R_3 will vary with the plate-supply voltage.

It is good practice to short out the secondary of the modulation transformer when a phone transmitter is keyed. Switch S_1 is included in the circuit for this purpose.

IMPORTANT

Enclosed with this issue is the 1952 Radiotronics Subscription Form. To ensure continuity of issues it is suggested that this form be completed and returned to this office by the last week of November.

New Zealand subscribers please note that all sub. forms and remittances (P.O. Money Order or Bank Draft ONLY) must be forwarded to: Amalgamated Wireless Valve Company Pty. Ltd., Box 2516, G.P.O., Sydney, N.S.W., Australia.

New RCA Releases

Radiotron 12SP7 is a 12-inch, directly viewed cathode-ray tube of the magnetic-focus and magnetic-deflection type intended primarily for use in radar indicator service, but it is also useful in general oscillographic applications where a temporary record of electrical phenomena is desired. It utilizes the long-persistence, cascade phosphor P7.

The faceplate of the 12SP7 is made of Filterglass to provide increased trace contrast and has so slight a curvature that it is almost a flat surface. The large, essentially flat surface facilitates the use of an external, transparent, calibrated scale.

The electron gun employed in the 12SP7 features a limiting aperture at the end of the electron gun to produce a sharper, rounder spot on the screen, especially when the tube is operated at high beam current, and hence provides greater effective resolution. Because of this feature, the 12SP7 is especially useful in those applications where pulse-modulated operation requires high grid-No. 1 drive and resultant high beam current.

-●-

Radiotron 21AP4 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 $18\frac{3}{8}''$ × $13\frac{15}{16}''$ with slightly curved sides and rounded corners.

Its design incorporates a high-efficiency, white fluorescent screen on a high-quality faceplate made of frosted Filterglass to prevent reflection of bright objects in the room and to provide increased picture contrast. Employing magnetic focus and magnetic deflection, the 21AP4 has a maximum high-voltage rating of 18,000 volts; an ion-trap gun for use with an external single-field magnet for eliminating ion-spot blemish; a diagonal deflection angle of 70°; a horizontal deflection angle of 66°; a neck length of $7\frac{3}{16}''$; and substantially less weight than a similar all-glass tube.

-●-

The new, flexible-lead, subminiature **Radiotron valve type 6026** is a high-efficiency oscillator triode designed especially for transmitting service at 400 Mc/s in Radiosonde and similar applications. In such service, it can deliver a useful power output of 1¼ watts.

The subminiature structure of the 6026 features very short transit time and low interelectrode capacitances. Furthermore, it has very small size and very light weight — design features which make the 6026 particularly useful in equipment requiring extreme compactness.

New Publications

* **"TELEVISION EXPLAINED," by W. E. Miller. Fourth Edition. Published by Trader Publishing Co. Ltd., 104 pages.**

This book, by the author of "Radio Circuits" recently reviewed here, serves as an introduction to the intricacies of television.

It describes, without mathematics, the operation of television receivers, both the T.R.F. and superheterodyne types. Also included are a discussion of TV aerials, hints on installation and adjustment of a receiver in conjunction with a broadcast test pattern.

Throughout, the emphasis is on the English low-definition system of 405 lines. However, the Australian radio serviceman will find much that is of interest in this book that will be equally applicable to the TV system it is proposed to install here.

It is an inexpensive publication that can be confidently recommended to students and others with a knowledge of radio, who wish to learn something of the workings of a television receiver.

* "RADIO VALVE DATA"

The new edition of this well-known reference book contains the main characteristics of over 2,000 types of British and American radio valves, and over 100 cathode-ray tubes. Eighteen British valve manufacturers alone are represented, all of whom have co-operated with "Wireless World" in ensuring that the tabulated information given is accurate, comprehensive and up to date.

The main tables give the electrical characteristics of each valve, and separate tables show their base connections. Sub-divisions of the main tables further classify the valves into obsolete, replacement or current types, as recommended by the makers. An index enables any valve to be found in the tables quickly and without trouble.

The following classes of valves are shown; frequency-converters, r-f tetrodes and pentodes, audio output valves, diodes, output valves and efficiency diodes for television line scan circuit, amplifier triodes, transmitting valves of various types up to 50 watts plate dissipation, valve rectifiers, E.H.T. rectifiers, tuning indicators, barretters, voltage stabilizers and thyratrons. In addition, non-thermionic diodes of the silicon, germanium and selenium types are listed, and also metal rectifiers. The cathode-ray tube section covers all British tubes for television receivers and oscilloscopes.

"Radio Valve Data" must be considered an essential part of the equipment of every receiver designer, radio serviceman, dealer and experimenter.

*** Our copy received with the compliments of the publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.**

Basic Circuit Description of a RCA Television Receiver

BACKGROUND OF TELEVISION

Carey Television System

To begin, it may be of interest to examine briefly some of the highlights of the background of television.

In 1875 an American, G. R. Carey, proposed and designed what probably was the first television system. This system attempted to imitate the human eye with a mosaic, consisting of a great number of selenium cells. Selenium, has the property of changing its resistance to the flow of electrical current in proportion to the amount of light falling upon it.

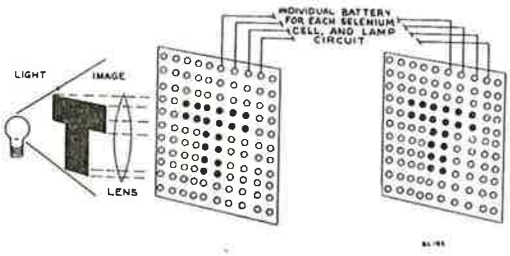


Fig. 1—Carey Television System

The scene to be transmitted was focused upon a bank of selenium cells. Consequently, if each one of these cells were connected to a corresponding lamp, in a bank, a lamp in the bank would light when sufficient light was falling upon the corresponding selenium cell. Although only a few circuits are shown in the illustration, it would be necessary to have a complete circuit for each selenium cell and its corresponding lamp. It is obvious that such a system as this could produce only crude pictures lacking in detail.

Scanning Disc

The next significant step was the development of the scanning disc by Dr. Paul Nipkow in 1884. The importance of the scanning disc was in the new conception of dissecting a picture into small segments and reassembling them at the receiver. This represented the first practical, sequential scanning system. This system, with its mechanical limitations, was superseded by the invention of the iconoscope by Vladimir K. Zworykin.

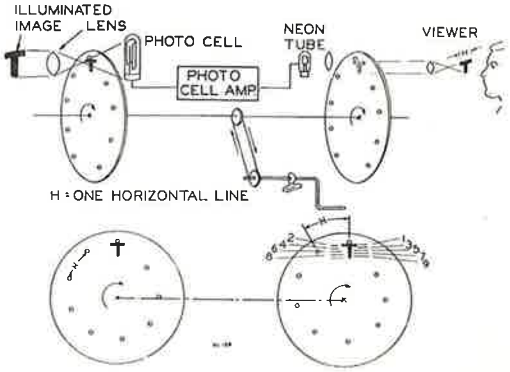


Fig. 2—Nipkow Scanning Disc

Further development of the iconoscope by Dr. Zworykin, and the announcement and demonstration of an all electronic television system by RCA in 1929, provided many of the essentials of television as it is known today.

Rapid developments followed:—in 1938 RCA announced scheduled transmissions of television programs originating from the Empire State Building. Scenes from the Broadway Play, "Susan and God," starring Gertrude Lawrence, were telecast from the NBC Studios on June 7th of that year.

TELEVISION TRANSMISSION

Electronic Television

Although this lecture is concerned primarily with the operation of the television receiver, it is first necessary to review briefly the general requirements of an electronic television system, including the transmitter.

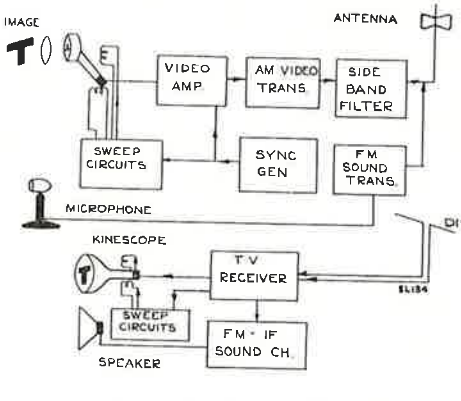


Fig. 3—Electronic Television System

Figure 3 shows the basic essentials of a television chain. The object to be televised is viewed by the camera at the studio. The camera pickup tube has the property of changing varying intensities of light into comparative changes in electrical values. This is accomplished by light falling on a plate or mosaic made up of numerous minute photo-sensitive particles. The mosaic is scanned by an electron beam, causing the mosaic to give off electrons to the collector element in the pickup tube, producing a signal having a direct electrical relationship to the light values of the object being viewed.

This signal, containing the picture information, is amplified and the necessary synchronizing pulses are added by the sync generator at the studio to synchronize the picture at the receiver. When this information has been properly combined with the picture signal, it is then transmitted much in the same manner that an ordinary radio wave is transmitted. The sound information is transmitted by a separate transmitter, which employs frequency modulation.

At the receiver the reverse process takes place. The picture signal and the sound signal are received by the antenna, and amplified. The sound signal is separated from the picture information and both signals are detected in the receiver.

The necessary synchronizing pulse information to operate the vertical and horizontal sweep circuits is extracted from the signal. The video information in the form of varying electrical potentials is changed back to visible light by the kinescope.

STANDARDS

Standards of television transmission have been established in the public interest so that a nationally coordinated television service may exist.

Scanning

In the process of forming the picture on the face of the kinescope, a single spot of light moves very rapidly in a horizontal, and vertical direction. The spot of light varies in intensity in relation to the applied video signal.

The spot of light is caused by an electron beam striking the flourescent surface of the kinescope. The beam moves under the influence of two fields. One field causes the electron beam to "scan" or move from left to right in a horizontal direction.

During the time the electron beam is scanning from left to right, the second field is moving the electron beam downward from top to bottom. The two fields which cause the beam to move or sweep are so related that the beam scans 262½ lines horizontally for every vertical scan. The spot of light on a 16-inch kinescope must move at the rate of about 97,000 miles per hour at certain times to produce the pattern or raster.

Interlaced Scanning.

The picture on the kinescope is composed of 525 lines, minus approximately 42 lines which are blanked out during the vertical retrace period. If all the lines were scanned in succession, at a rate of 30 fields per second, the picture would appear to "flicker." To overcome this, the picture content is scanned in two fields. Each field contains half of the picture information. The first field is made up of every odd line and the second field is made up of every even line.

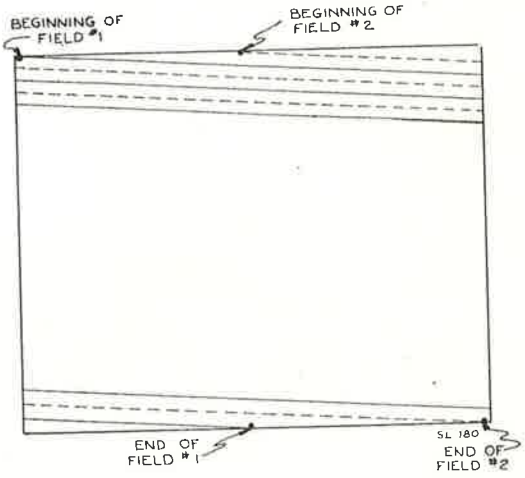


Fig. 4—Interlaced Scanning

Because of the control information contained in the transmitted signal, the second field fits in, or interlaces, between the lines of the first field. This is called interlaced scanning. A field rate of 60 times per second is used, which is high enough to eliminate flicker.

Aspect Ratio

The choice of an aspect ratio (ratio of width to height) of 4 to 3 has been influenced mainly by the aspect ratio of standard motion picture film which is 4 to 3.

The use of this ratio is due to the fact that the sides of the picture would be cut off in film subject matter, if, for example, a 1:1 ratio were used in television. However, economic, aesthetic, and artistic reasons influenced by dynamic symmetry determine the aspect ratio of the mask about the picture tube found in the various television receivers.

Voltage Output from Camera

At the transmitter, the polarity of the output from the camera is such that a black line produces a higher negative voltage than a white line. This is termed negative video polarity.

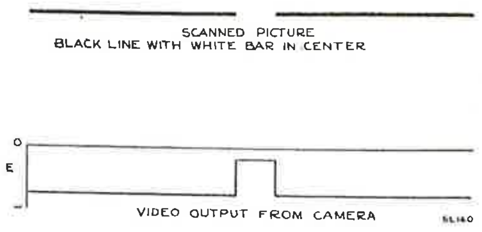


Fig. 5—Negative Video Polarity

Figure 5 shows the voltage produced by scanning a black line with a white bar in the center.

Vestigial Side Band Transmission

Amplitude modulation produces two side bands which extend above and below the center frequency by an amount equal to the maximum frequency of modulation. In vestigial side band transmission, which is the type used in television, a large portion of one side band is removed to conserve space in the frequency spectrum. For regular double side band transmission, a frequency allocation for each channel would require 10 megacycles.

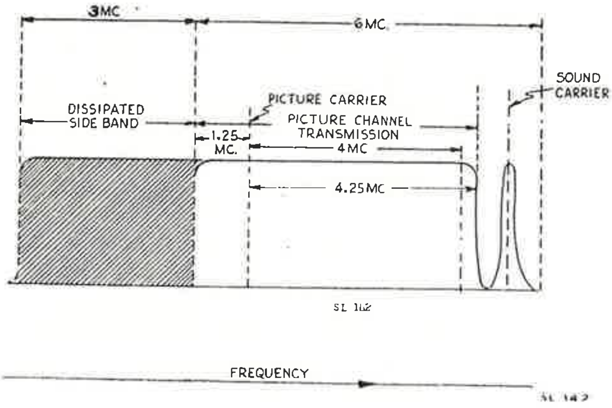


Fig. 6—Vestigial Side Band Transmission

Figure 6 shows the total frequency spectrum generated by the television video and sound transmitters. The shaded portion of the lower side band is dissipated at the transmitter and the remaining portion is transmitted. The remaining portion of the lower side band contains only the lower video frequencies. If this side band were reproduced in the receiver with no attenuation, the result would be a greater response at the low video frequency end.

Receiver Picture I-F Response

To prevent this, the picture I-F response is designed with a linear slope so that attenuation of the lower side band takes place in the receiver.

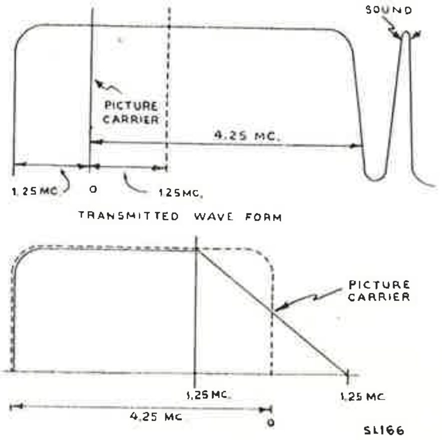


Fig. 7—Receiver Picture I-F Response

Shown in figure 7 is the overall I-F picture response of the receiver with the picture carrier at the 50% level. This reduces the amount of receiver amplification to the lower side band so that the frequency response output of the picture second detector is uniform for all frequencies as shown by the dotted line.

Evolution of the RMA Signal

Before considering the receiver, there must be a signal from the transmitter, which will produce on the face of the kinescope the same scene viewed by the camera. The electron beam which is scanning the camera tube mosaic is moving from the left side of the mosaic to the right and from the top to the bottom.

The electron beam is moved in the horizontal direction many times during the period it is moving from top to bottom. The period in which the beam moves from left to right is longer than the time in which the beam snaps back from the right side of the picture.

This is accomplished by using a scanning potential which rises at a linear rate to its peak and then drops very rapidly.

The vertical movement of the beam is similar, with the beam scanning downward rather slowly, while the return to the top of the picture is very rapid.

In the kinescope a beam of electrons produces a spot of light varying in intensity on the face of the kinescope. This spot of light must move in the identical manner to the electron beam at the camera pickup tube.

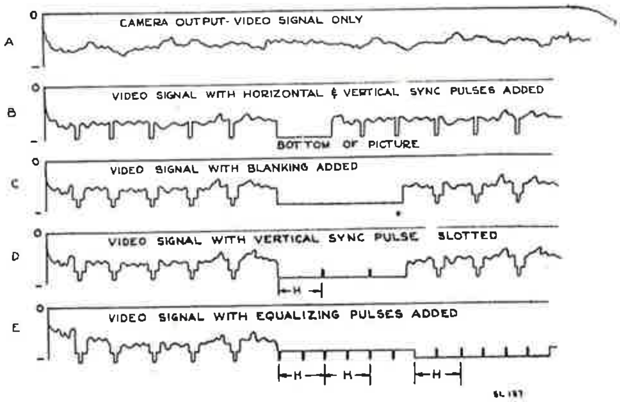


Fig. 8—Evolution of the RMA Signal

In figure 8, the first drawing A, is the video signal from the iconoscope. The signal varies in amplitude in proportion to the light values of the picture segment being scanned. The camera dissects the picture into horizontal lines which appear one after the other in the output. These lines must be reassembled at the receiver in the proper sequence.

In the receiver there are two oscillators which provide the up-and-down and side-to-side motion of the beam. If these two oscillators are locked with the corresponding oscillators which scan the camera mosaic at the studio, it is possible to reassemble the picture properly.

The second drawing B, in figure 8 shows a large pulse of voltage added at the transmitter at the end of each line. These pulses of voltage will be transmitted to the receiver. These pulses will cause both the horizontal oscillator controlling the camera scan, and the horizontal oscillator at the receiver to trigger at the same relative time.

At the bottom of the picture a pulse of voltage which is much longer in duration than the horizontal pulse is added. Certain circuits separate the longer pulses from the shorter pulses, and make use of the longer pulse to trigger the vertical oscillator in the receiver at the proper time.

This sync signal controls the oscillators and keeps the receiver in synchronization with the transmitter.

At the transmitter, more sync information is added to improve the operation of the receiver.

Since at the end of each line, and at the bottom of the picture, the spot moves very rapidly, this rapid motion, or retrace, will interfere with the picture on the screen. However, if the signal from the camera is made very negative just before the end of the line, or the bottom of the picture, and is kept negative until the beam has completed its retrace, the negative voltage will cause the beam at the receiver to extinguish or blank out during this period. These pulses, known as the blanking pedestals, are superimposed on the camera signal and are shown in C of figure 8.

During the long vertical sync pulse, it is possible for the horizontal oscillator at the receiver to fall out of step with the transmitter. This can be prevented by serrating the vertical sync pulse as shown in D of figure 8. These slots are spaced one horizontal line apart. The receiver can use this pulse information to fire the horizontal oscillator and keep it in sync during the vertical pulse.

To achieve interlaced scanning, one final modification to this wave form is made. Interlaced scanning means that the electron beam scans from the top to the bottom of the picture in 262½ lines, and then returns rapidly to the top of the picture and scans the next 262½ lines; each line of the second field falling in between the lines of the preceding field.

To do this, the vertical pulse occurs every 262½ lines. This means that the vertical oscillator triggers in the first field in the middle of a line, and in the second field at the end of a line, while the horizontal oscillator fires at the end of every line.

This is accomplished at the transmitter by superimposing additional pulses on the camera signal.

In E of figure 8, six pulses are added before the vertical sync pulse. The vertical sync pulse is serrated or slotted in six places, and six more pulses are added following the vertical sync pulse.

These pulses and serrations are spaced half a horizontal line apart. The horizontal oscillator will fire on every odd pulse or serration in the first field and on every even pulse or serration in the second field. This provides the interlaced effect. The purpose of the six pulses preceding and following the vertical sync pulse is to trigger the vertical oscillator at the proper time in each field, and achieve interlacing.

Standard RMA Signal

Figure 9 shows the standard RMA signal generated by the transmitter to control the receiver. At the left side of the figure are shown the last few horizontal lines, with horizontal sync pulses superimposed on the horizontal blanking pulses. These four horizontal lines extend from a preceding field.

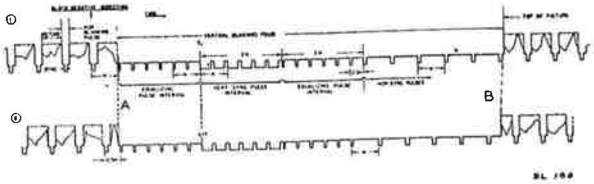


Fig. 9—Standard RMA Signal

Extending from point A to point B is the vertical blanking interval. This occupies a period equal to about 22 horizontal lines. During this blanking period the electron beam of the kinescope is blanked out. This vertical blanking interval occurs sixty times in one second and serves to start each new picture field. In this vertical blanking interval are vertical, horizontal and equalizing pulses.

Equalizing Pulses

The six equalizing pulses beginning at point A on the left, occur for a duration of three horizontal lines, are a half horizontal line apart and have a frequency twice the horizontal frequency of 15,750 cycles. Notice that one-half line horizontal spacing is provided between these equalizing pulses in order that the horizontal oscillator will be in synchronization during vertical blanking in both fields.

The equalizing pulses also serve to make the output wave shape of the integrating circuit practically identical for all fields assuring equal timing between vertical retraces.

Vertical Sync Pulse

The vertical sync pulse interval signal follows the equalizing signal interval and consists of a broad pulse with six serrations. The purpose of the serrations is to permit the horizontal oscillator to remain in synchronization during the vertical sync pulse interval. This vertical sync pulse lasts for a period equal to three horizontal lines as can be seen in figure 9. The total duration of the vertical sync pulse is seen to be sufficiently longer than the horizontal sync pulse in order to allow the pulses to be separated from each other by wave shape discrimination in the integrating and differentiating circuits in the receiver.

Following the sync pulse interval are six more equalizing pulses extending for a period of three horizontal lines. Their prime function is to keep the horizontal oscillator in sync.

Following these six equalizing pulses are the horizontal sync pulses. These horizontal sync pulses are continued in this blanking interval to allow for horizontal synchronization during vertical retrace.

THE TELEVISION RECEIVER

Block Diagram of a Television Receiver

Having examined the television transmitter and the signal it produces, it is now possible to trace this signal through the various receiver sections. Figure 10 shows an elementary block diagram of an RCA Victor 630TS television receiver.

The FM sound and picture signal occupying a band width of 6 mc. is received by the antenna and passed on to the R-F amplifier. The signal is amplified and applied to the converter grid. At this point the local oscillator beats with the incoming sound and picture carriers producing two I-F frequencies, 21.25 mc. for the I-F FM sound carrier and 25.75 mc. for the picture carrier. The sound and picture I-F frequencies are separated and fed to their appropriate I-F channels.

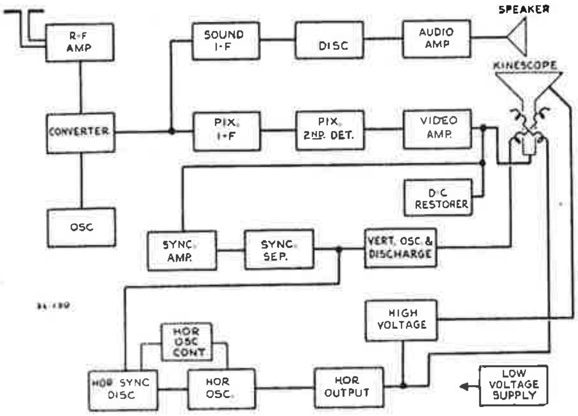


Fig. 10—Block Diagram of the 630TS Receiver

The sound I-F channel amplifies the sound carrier; the discriminator demodulates the carrier, after which the audio signal is amplified and fed to the loudspeaker.

The picture I-F amplifies the picture carrier, and the picture second detector rectifies it, producing a signal having a waveform very similar to the RMA signal just discussed.

This signal is amplified by the video amplifier and fed to the kinescope grid. A DC restorer re-inserts the proper background level.

From the kinescope grid, a portion of the signal is also fed to the sync circuits. This signal is then amplified, the video information removed, and the vertical sync pulse is separated from the horizontal sync pulses by integrating and differentiating circuits.

This vertical sync pulse will cause the vertical oscillator to trigger at the proper point to provide synchronization with the transmitted picture signal.

The horizontal oscillator is controlled by the horizontal sync pulse, and provides horizontal synchronization.

The high voltage for the kinescope is obtained in this circuit in a manner which will be described later. An examination of the various circuits and components will begin with the R-F Unit.

The R-F Unit

The head end unit used in the 630 consists of three tubes mounted on a separate sub-chassis. Three 6J6's are used. Their functions are:

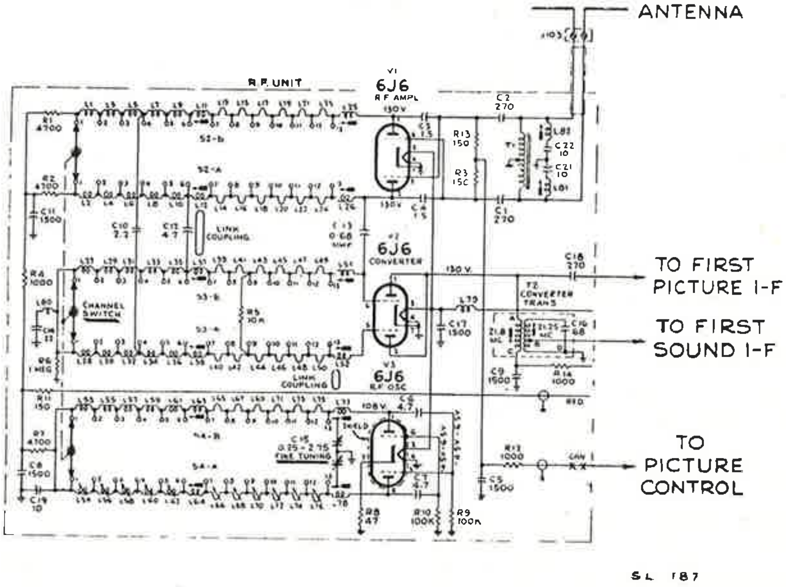


Fig. 11—Schematic of the R-F Unit (KRK-2)

1. R-F amplifier
2. Converter
3. Oscillator

This unit functions in much the same manner as in a conventional superheterodyne. The chief difference is the higher frequencies and the wider band width involved.

Figure 11 is a schematic of this head end unit.

The signal is received by an antenna and applied to pin 5 and 6 of V1, the R-F amplifier tube. Transformer T1 short circuits low frequency signals which would be applied to the grids of the R-F amplifier V1. If T1 becomes open, the lower frequency interfering signals which would normally be attenuated, may appear as interference on the face of the kinescope.

Two series tuned traps are shown across the input. These traps are tunable over the range of 92 to 136 mc., and provide sharp attenuation to the frequency to which the traps are tuned. Resistors R3 and R13 provide paths for the grid return and terminate the transmission line in its characteristic impedance of 300 ohms.

Tuning of the R-F unit is accomplished by switching small values of inductance in the tuned circuits.

Coupling between the tuned circuits in the R-F unit is comprised of three types. Capacitive coupling, link coupling, and mutual coupling which is due to the physical proximity of the tuned circuits, provides for uniform coupling over the R-F range.

The signal after being amplified in the R-F amplifier is applied to the converter grids. At this point, the oscillator signal is also injected into the converter. The signal information and the oscillator signal are fed to the grids of the converter. Again a combination of link and mutual coupling provides for uniform injection of the oscillator voltage over the entire range. Tuning of the oscillator is accomplished, as in the R-F amplifier and the converter, by means of increasing or decreasing the inductance in the tuned circuit. In the oscillator circuit provision is made for tuning each channel by means of slugs. This differs from the R-F amplifier and the converter where only two slugs are provided for the high frequency group of channels and two slugs for the low frequency group of channels. In the oscillator circuit a variable condenser provides adjustment over a limited range to permit optimum tuning of the signal.

At the plates of the converter both sound and picture I-F signals are present.

Separation of the picture from the sound I-F is accomplished by the converter transformer. The action of this transformer is as follows:

The secondary is an absorption trap which removes the sound I-F signal from the primary. The primary contains the picture signal with the sound I-F signal greatly attenuated and is fed to the picture I-F. The secondary containing the sound I-F signal is applied to the sound I-F amplifier channel.

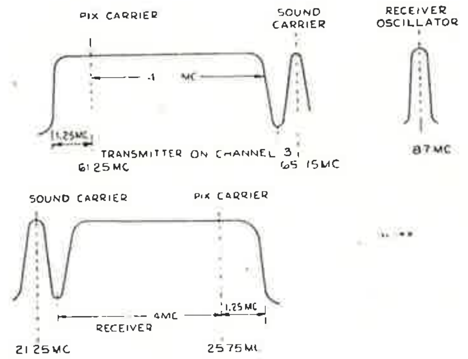


Fig. 12—Reversal of Sound and Picture Carriers

Figure 12 compares the transmitted waveform with the waveform at the converter plate. In the 630TS receiver the oscillator frequency is above the frequency of the incoming signals, consequently, the I-F response will be the reverse waveform of the transmitted signal. This is evident since the oscillator frequency is above both the sound and picture carrier and, consequently, closer to the sound carrier, and the sound carrier is above the picture carrier. The difference between the oscillator frequency and the sound carrier on any channel is 21.25 megacycles, while the difference between the oscillator and the picture carrier is 25.75 megacycles.

The sound I-F carrier at 21.25 mc. is taken from the secondary of the converter transformer and applied to the grid of the first sound I-F amplifier.

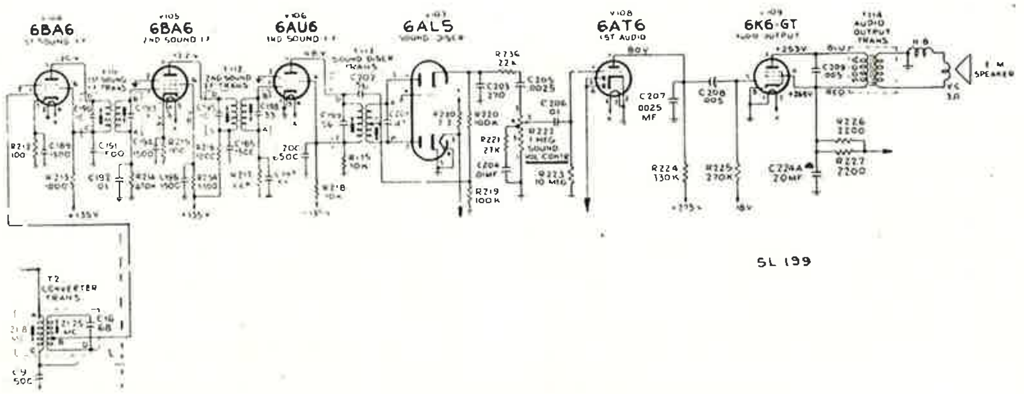


Fig. 13—Schematic of the Sound I-F

The Sound Channel

The sound I-F channel shown in figure 13 is conventional, consisting of three stages of I-F followed by a discriminator.

The sound I-F signal is detected at the discriminator, amplified and reproduced by the audio system. The sound I-F channel has the desired frequency band width of 50 kc for 100% modulation.

Since the sound channel will be covered in detail in a subsequent lecture, the picture I-F amplifier and the problems encountered therein will be considered.

Returning to the converter transformer, it will be noted that the picture carrier I-F at 25.75 mc. is applied to the grid of the first picture I-F amplifier.

The Picture I-F

Overcoupling vs. Stagger-tuning

In the picture I-F amplifier it is necessary to pass a signal occupying a band width of over 4 mc. Two methods are in common use to obtain the necessary band width of 4 mc.

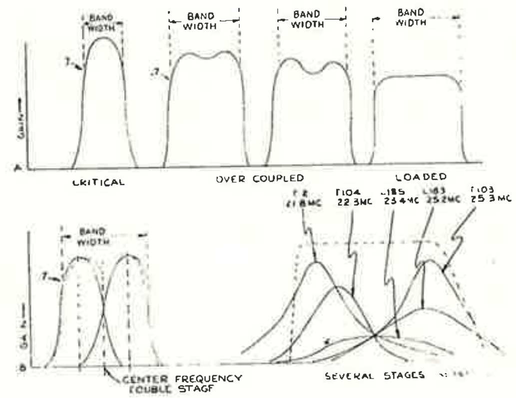


Fig. 14—Overcoupled vs. Stagger-Tuning

In one type of amplifier, both the primary and secondary of a transformer are tuned to the same frequency.

With critical coupling, the resultant curve will be just rounded on the top as shown in A of figure 14. As the coupling between the two circuits is increased, a double peak is obtained. To eliminate the double peak, it is necessary to load the circuits. Loading of the circuits can be accomplished by placing a parallel resistor in either the primary or the secondary, or both. Loading the circuits results in a lower gain per stage due to the lower Q of the circuits.

The second method is the stagger tuned system. This system utilizes the effect obtained in tuning successive stages to a different frequency. Figure B shows the frequency response curve for a double tuned staggered circuit. In actual use a greater number of stages are used to produce sufficient gain, and band width as shown in the bottom of figure 14. The Q of each tuned circuit is such as to produce the desired picture I-F characteristic. Several advantages are offered by each system. Stagger tuning offers a greater degree of freedom from regeneration, by virtue of the grid and the plate circuits of each stage being tuned to different frequencies. This makes possible the design of I-F stages with a minimum of shielding. Another important consideration in stagger tuning is the ease of alignment—each stage may be readily aligned to its center frequency without regard to other stages. A sweep generator is not necessary for alignment, and is used only for checking the over-all response

The chief advantage of over-coupled transformers in the picture I-F is that it is possible to obtain greater gain per stage. It will be found, therefore, that either method may be used with excellent results. In some cases a combination of both stagger tuning and over-coupling may be used.

In either case, the over-all gain per stage is fairly low due to the wide band width considerations. In conventional broadcast receivers, it is not uncommon to find I-F stages with a gain of 150-200. Picture I-F amplifiers generally have a gain on the order of 5 to 10. Therefore, four stages of picture I-F are used in this chassis to provide sufficient gain.

Trap Circuits

In considering the picture I-F channel, it is necessary to consider the various wave traps and their functions. A review of the theory of the various types of traps may be helpful. The absorption trap is frequently used to attenuate undesired frequencies. It consists of a parallel tuned circuit inductively coupled to the plate load of the video I-F stage. At the resonant frequency of the trap a much lower impedance appears in the primary circuit, which is the plate load. Since the gain of the tube is equal to GM R_L, and R_L is reduced, the gain of the stage at this frequency is, therefore, greatly reduced. Traps of this type are employed in the secondary of the converter transformer and in the secondary of the first and second picture I-F transformers.

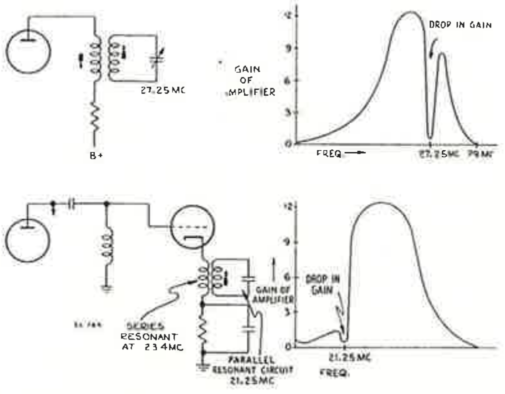


Fig. 15—Trap Circuits

The second type of trap is the cathode trap, which functions in the following manner. A parallel resonant circuit is coupled to the cathode circuit of one of the amplifier stages. At the resonant frequency of the trap, degeneration takes place and reduces the amplification of the stage.

In the 630TS chassis, the primary of the cathode trap is a series resonant circuit at 23.4 mc. Since a series resonant circuit offers minimum impedance at resonance, the effect of the primary is to permit the tube to function as a normal amplifier at the frequency of the primary, and as a degenerative amplifier at the trap frequency.

The schematic of the picture I-F is shown in figure 16. The response of each stage is shown. The effect of the traps can easily be seen. The secondary of the converter transformer, T2, and the cathode trap T105, serve to attenuate 21.25 mc. the sound I-F of the channel being received.

The secondary of T103 provides for the attenuation of 27.25 mc., adjacent channel sound, and the secondary of T104, attenuates 19.75 mc., adjacent channel video signal.

The picture control R131, sets the bias on the first, second and third picture I-F amplifier grids. Bias is also applied to the R-F amplifier grid from this control. The bias on the R-F amplifier would be positive over a large portion of the picture control, except for the presence of the diode. As long as the tap on the picture control is positive, the diode will conduct, holding the R-F bias at an effective ground potential. As

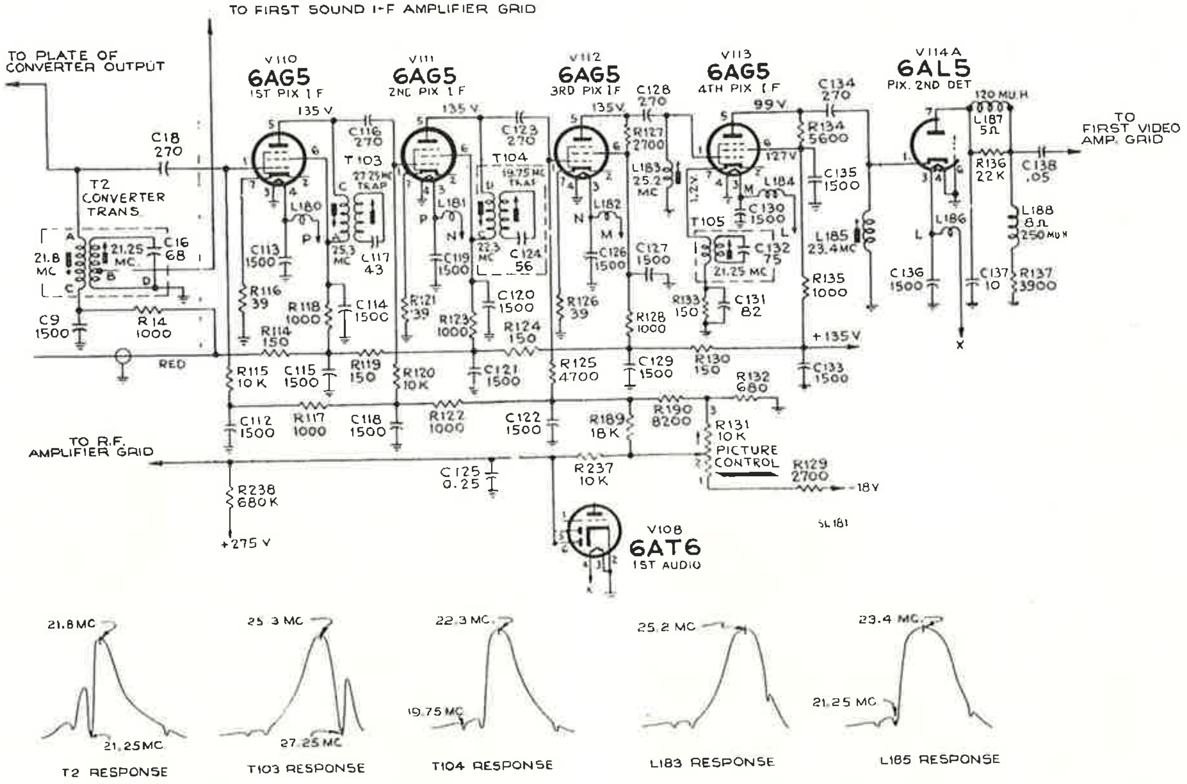


Fig. 16—Schematic of the Picture I-F

the picture control setting is reduced, the tap on the picture control becomes less positive, until the diode stops conducting. After this point, the R-F bias bus becomes negative as the picture control setting is reduced, until it is more negative than the picture I-F bias. This reduces the gain of the R-F amplifier.

Picture I-F Response

As shown in figure 17, the traps in the picture I-F channel provide for the rejection of the following frequencies: 21.25 mc. co-channel sound, 27.25 mc. adjacent-channel sound, and 19.75 mc. adjacent-channel video. With the traps inserted and properly tuned, the picture I-F response will look like that shown in figure 17.

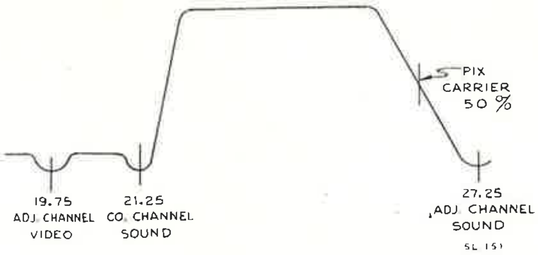


Fig. 17—Picture I-F Response

Picture Second Detector

The output from the picture I-F is then applied to the picture second detector. The picture second detector is a diode which differs from conventional AM detectors in the loading of the output circuit. Components are chosen to flatten the response over the entire video range of 30 cycles to 4 megacycles. In the output of the picture second detector, the synchronizing pulses are the most negative, and the white level

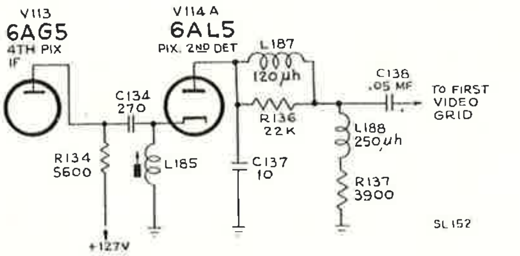


Fig. 18—Picture 2nd Detector

is most positive. The polarity of the picture at the second detector is selected by design to be correct for the number of video amplifiers following the second detector, so that the proper video signal is applied to the grid of the kinescope.

Video Amplifier

As pointed out previously, the wide band frequency response of the video signal imposes severe limitations in the design and construction of the video amplifier. Frequency response at both high and low frequencies must be considered. The frequency response of a video amplifier should extend from 30 cycles to 4 megacycles. The loss of low or high frequency response can result in smearing, poor picture detail and poor background illumination.

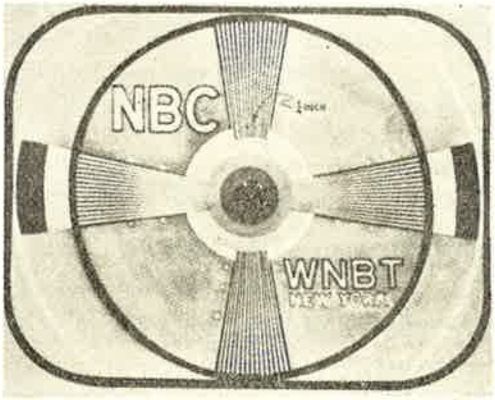


Fig. 19—Test Pattern Showing 4 mc. Response

Figure 19 is a test pattern as seen on a 16″ kine. The width of the picture is about 12″. Since each line lasts 53 micro-seconds on the face of the tube, it is possible to calibrate the face of the kinescope in increments of time. One inch equals 4.5 micro-seconds, and ¼ inch equals approximately one micro-second. Checking the test pattern at the point of maximum resolution, there are four vertical lines to each ¼ inch. This means the spot is changing from black to white 4 times in one micro-second, or 4 million times in one second. Therefore, the receiver should have a band pass of 4 megacycles to produce a clear picture.

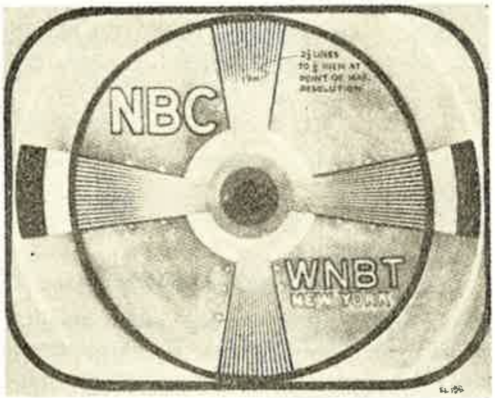


Fig. 20—Test Pattern Showing 2.5 mc. Response

Figure 20 is a test pattern with the frequency response limited to 2.5 mc. Notice the poor resolution of the vertical bars.

Another important factor in video amplifiers, is phase shift. Phase shift is the time delay introduced in a circuit which is discriminatory with respect to the frequency of applied signals. That is, when two or more different frequencies are applied to the circuit, one frequency will be delayed more than the others in its passage through the circuit.

In television many wave shapes are encountered which are complex. The sync signal pulse, for example, is a square wave which is made up of a fundamental frequency with an infinite number of odd harmonics combined in the proper amplitude.

Square Wave Distortion

For the purpose of illustration it is possible to break a square wave into its fundamental frequency and one-third the amplitude of its third harmonic.

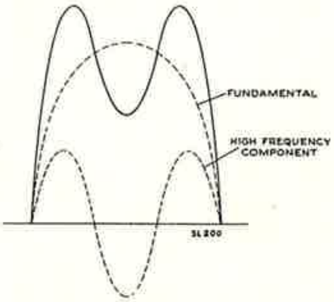


Fig. 21—Composition of a Square Wave

Consider now the shape of the reproduced waveform when phase shift is introduced.

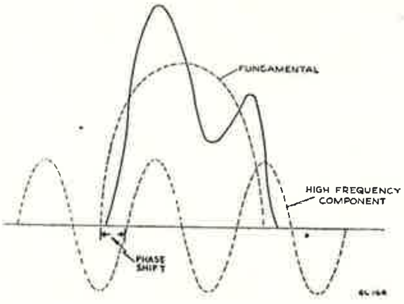


Fig. 22—Phase Shift

Figure 22 shows the effect of delaying the high frequency component. The phase shift of the fundamental would result in the wave shape shown.

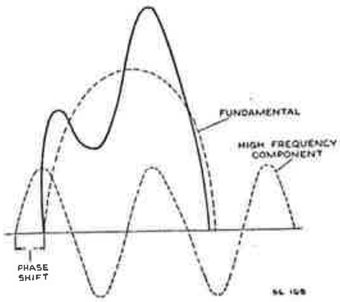


Fig. 23—Phase Shift

Conversely, a phase shift in the opposite direction would result in the curve shown in figure 23.

At the lower video frequencies, the coupling capacitor between stages introduces phase distortion. As the frequency is increased the effect of the coupling condenser decreases until the phase shift becomes negligible. Little difficulty is experienced in amplifying the middle range of frequencies, but as the higher frequencies are approached, phase shift is introduced by the distributed capacities of the tubes and associated wiring. It is desirable that in a video amplifier the phase shift be proportional as the frequency increases in the amplifier.

Video Amplifier Equivalent Circuit

Returning to the problem of high frequency response, consider for a moment, what the video amplifier looks like at the higher video frequencies, from two to four megacycles.

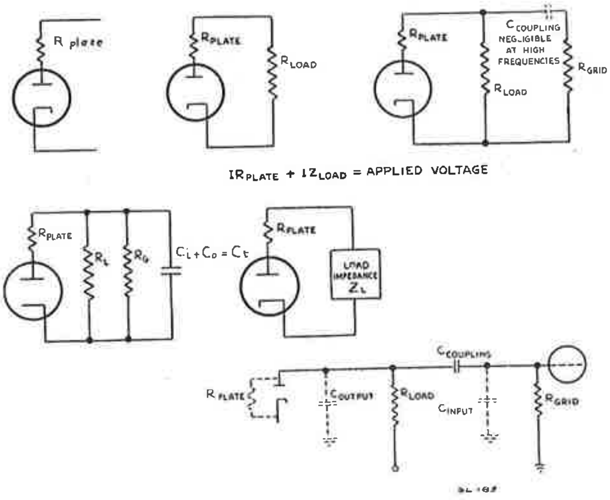


Fig. 24—Video Amplifier Equivalent Circuit

The tube can be considered as a generator, since as far as the output circuits are concerned, the tube is the source of the driving voltage.

In any generator the internal resistance of the device must be considered. In the case of a tube, this resistance is R_p, the plate resistance of the tube. This can be shown as in series with the generator.

Across the output of the generator is the load resistor of the tube R_L.

Looking at the schematic at the lower right of figure 24, the next component is the coupling capacitor C_c. In dealing with the high video frequencies, C_c, has little effect and can be ignored.

Next is R_g, the grid resistor of the following stage. This resistor is also across the output of the generator, so it can be shown in parallel with R_L.

The circuit is nearly complete, except for one important factor. Since the tube, components, and the wiring all have capacity to ground, these must be shown as being present. The output capacity to ground can be called C_o, and the input capacity to ground of the following stage C_i. Therefore, $C_i + C_o = C_t$, the total distributed capacity of the circuit. This capacity is in parallel with R_L and R_g.

Assume that the circuit is amplifying or generating a frequency of two megacycles. The voltage developed across the generator will be the voltage across the internal resistance of the generator, R_p, plus the voltage across the parallel circuit R_L, R_g, and C_t. These components have a definite impedance at this frequency. It is possible to consider C_t, R_L, and R_g as one impedance which can be called the total effective impedance of the circuit. The voltage drops developed in the circuit are IR_p and IZ_L.

Assume the frequency being amplified is increased to four megacycles. C_t now has less reactance at this higher frequency. Therefore, the parallel circuit R_L, R_g, and C_t will have less impedance. The voltage drop through the circuit must still be IR_p and IZ_L. Therefore, more of the voltage must be dropped across R_p and less across R_L, R_g, and C_t. It is therefore obvious that there is less voltage available at the higher frequency, or in effect, less gain and a consequent loss of high frequency response. The effect of the distributed capacity on the frequency response can be minimized by making R_L approach the reactance of C_t at the highest video frequency at which flat response is desired. As R_L, however, is decreased, the gain of the stage will also be decreased.

Shunt Peaking

A further improvement in the response of a video amplifier may be effected by adding an inductance in series with the load resistor. The effect of this added inductance is to make the plate load increase with an increase in frequency, thus offsetting the effect of the distributed capacity, which made the effective plate load decrease with an increase in frequency. This is termed shunt peaking.

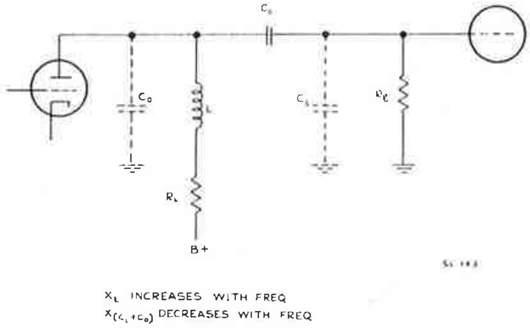


Fig. 25—Shunt Peaking

The inductance L is chosen to resonate with C_i at or above the highest frequency at which flat response is desired. At the high frequency end of the band L is resonant with C_i plus C_o, thus causing a relatively high voltage to develop across L and R_L.

Series Peaking

A second type of peaking, termed series peaking, consists of an inductance L in series with the coupling capacitor. In effect, L, C_i, and C_o are in series. This results in C_o being the only capacitive load across the output of the tube, consequently, R_L can be of a higher value, increasing the gain. Again the resonant frequency is chosen at or above the high frequency end of the video band. The advantage of series peaking is higher gain and a more linear phase response. The ideal ratio of C_i/C_o should be 2:1. To prevent a high frequency peak just before cutoff, a loading resistor R_s is shunted across the series coil. This adjusts the Q of the circuit for flat response. R_s is generally five to ten times R_L.

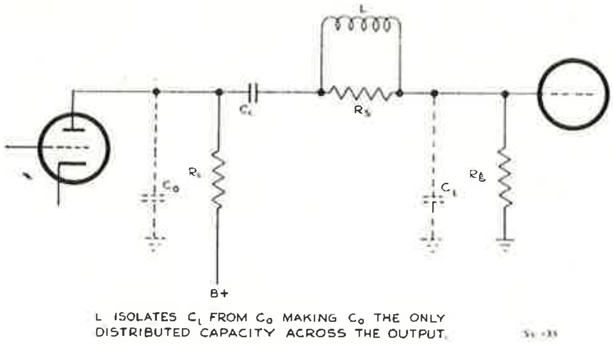


Fig. 26—Series Peaking

Combined Peaking

An extended frequency response may be obtained by a combination of both series and shunt peaking. As might be expected, this type of peaking is termed combined peaking. Combined peaking produces both higher gain and better phase response in the video amplifier.

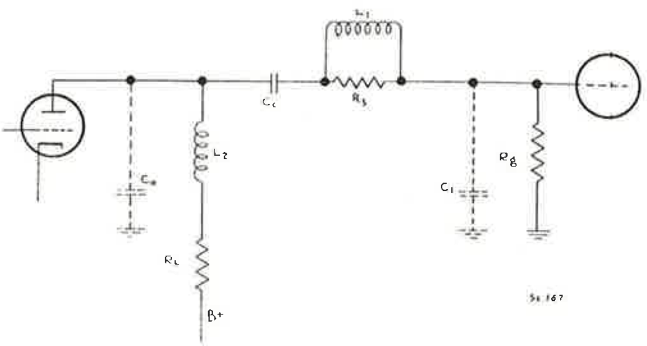


Fig. 27—Combined Peaking

Low Frequency Compensation

At the low frequency end of the video band the effect of the coupling capacitor becomes greater due to its increased reactance of the decreased frequency. The effect of this increased reactance is to decrease the voltage available at the grid of the tube, thus causing a loss in gain. Another effect of the coupling condenser at the lower frequencies is to introduce a phase shift. Therefore, to decrease the effect of the coupling condenser, the condenser should be made larger so as to offer less reactance. The grid resistor could also be made larger. However, increasing the value of the coupling condenser increases the capacity to ground, causing a decrease in high frequency response. Also a large coupling condenser may result in a leakage current from the preceding plate being applied as bias to the grid of the following stage. Oscillation might take place, were the values of the grid resistor and the coupling condenser made excessively large.

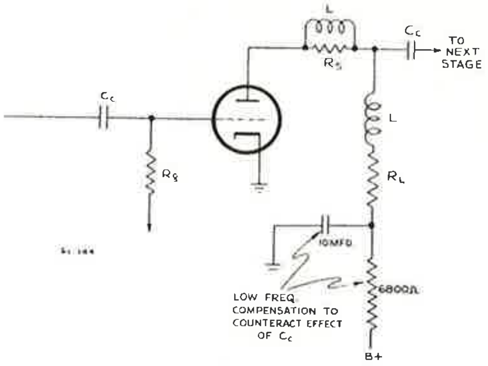


Fig. 28—Low Frequency Compensation

Improvement in the low frequency response may be accomplished by the addition of a condenser-resistor combination in the plate circuit of the tube. The effect of adding this section is to increase the output impedance at the low frequencies, thus increasing the gain and compensating for the loss across the coupling capacitor. Other components influencing the low frequency response are the cathode resistor, the cathode condenser, the screen grid resistor, and the screen by-pass condenser. Since the values of the resistive components are limited by the tube characteristics, it is possible to satisfy the circuit requirements by a proper choice of the capacitive components.

Each stage of video amplification introduces an 180 degree shift in picture polarity. Therefore, the number of amplifier stages, either even or odd, is determined by the polarity and level of the picture signal at the picture second detector.

An examination of the video amplifier in the 630 chassis and the actual components and their functions as determined by this discussion, may be interesting

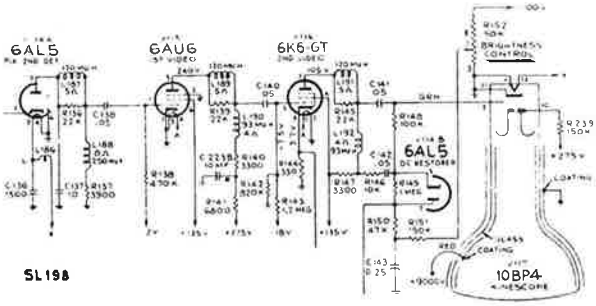


Fig. 29—Schematic of the Video Amplifier

The picture 2nd detector, ½ of a 6AL5, produces a signal of the same polarity as should be applied to the kinescope grid. Thus, an even number of video amplifiers follow the picture second detector.

In the plate circuit of the 6AL5, are coils L187, L188, resistors, R136 and R137. These can be readily identified: L187 with R136 is the series peaking coil with its shunt resistor, L188 the shunt peaking coil and R137 is the load resistor.

The coupling capacitor C138, a .05 mfd capacitor, is as large as practicable. The first video amplifier is a 6AU6. The 6AU6 is so operated that any noise excursions of greater amplitude than the sync pulses will drive the grid to cut-off, thus limiting the amplitude of the noise.

Located in the plate circuit of the 6AU6 are the series and shunt peaking coils. C223B and R141 are the low frequency compensating components.

Here again, the coupling capacitor C140 between the two stages is large. The second video amplifier is a 6K6, and has series and shunt peaking coils in the plate circuit. The output of the second video amplifier is applied to the grid of the kinescope and also to the DC restorer.

DC Restorer

DC restoration is necessary, since the average background illumination of the transmitted signal is a function of the DC component. Due to the use of coupling capacitors, the DC component is not passed, and the resultant video signal is the AC average of the impressed information.

Average Video Level

To illustrate this, consider the video signal as the result of scanning three lines, one black, one grey, and one white. The signal to provide this information to the kinescope is shown in figure 30. The blanking pedestals are of sufficient amplitude to drive the kinescope grid to cut-off, thus blanking or making invisible the retrace lines. If the DC component was removed and the AC average substituted, the resultant video signal would be as shown in B. It will be noted, that not only is most of the variation in shading gradation lost, but most important the synchronizing pulses and blanking are no longer at their proper level. Thus the sync pulse preceding the black line will be insufficient to drive the kine grid to cut-off. Therefore, with an AC coupled amplifier, it is impossible to retain the proper reference level unless some provision is made for reinserting the DC component. DC restoration, therefore, must provide a method for retaining a reference level, in order that the reproduced picture will maintain the proper values of background illumination. There are several methods of obtaining this result. One of the methods used in RCA Victor receivers utilizes a diode as a DC restorer.

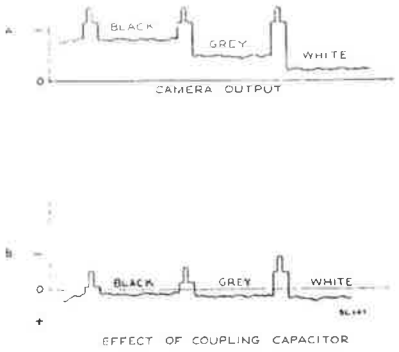


Fig. 30—Average Video Level

In the signal applied to the kine grid, the DC reference level is a function of the synchronizing pulses. Therefore, if the sync pulses are held at a constant level, the video level is then correct. In other words, if the amplitude of the sync pulses can be fixed, regardless of whether the camera is viewing an all white or all black picture, the picture content will automatically be at the proper level. A simplified schematic of the DC restorer circuit is shown in figure 31. In effect, the action of this network is as follows:

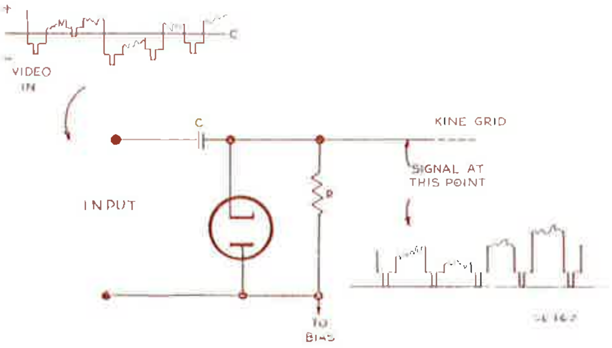


Fig. 31—Simplified DC Restorer.

A portion of the video signal is applied between the cathode and the plate of the diode. When the polarity of the applied signal is negative, the diode will conduct, charging the condenser C in proportion to the amplitude of the applied signal. In B of figure 30, the sync pulse preceding the white line will place a larger positive charge on the condenser than will the sync pulse preceding the black line. During that portion of the signal when the polarity is positive, condenser C will discharge through R since the diode is no longer conducting. The voltage drop developed across R will either increase or decrease the bias applied to the kinegrid. The time constant of R-C is sufficiently long so that the voltage across C remains constant over one horizontal line. As the AC variation of the applied video signal changes, a greater or less charge will be developed across C. Examine now the voltage developed across R for scanning several grey lines.

Effect of DC Restorer

As the sync tip preceding the first line in figure 32 is scanned, a positive charge is developed across C, causing a voltage drop across R. This voltage will cause the second sync tip to be depressed slightly. As the second sync tip is scanned, a smaller positive voltage is developed across R. This will change the bias on the kine so that the third sync tip is slightly lower than the preceding sync tips.

As the third sync tip is applied to the DC restorer, a smaller positive charge appears on C, and a smaller voltage drops across R since sync tip #3 was only slightly negative. Again, sync tip #4 will be depressed so that now no portion of the sync tip is negative. Should the signal change, the effect of C and R will oppose such a change.

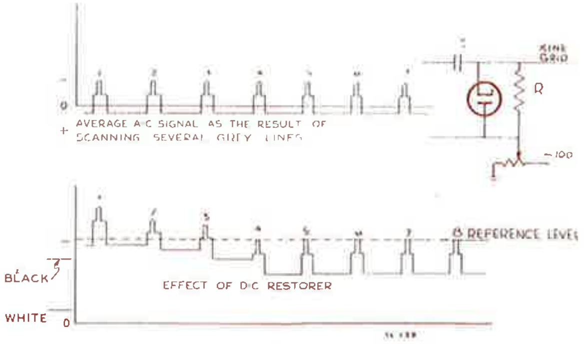


Fig. 32—Action of the DC Restorer

The effect, therefore, is that of a variable bias in series with the applied video signal. Therefore, it is possible to fix or clamp the level of the sync pulses, providing the proper DC reference level for the video signal. Effectively the diode is "clamping" the amplitude of the sync pulse, thus, automatically restoring the DC reference level.

Figure 33 shows the manner in which the diode is used in the 630TS. As can be seen, instead of the entire signal being applied across the diode, only a portion is applied. In all other respects the circuits are identical.

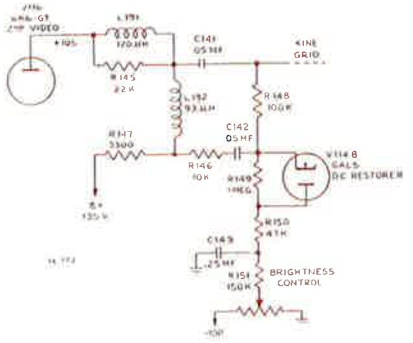


Fig. 33—Schematic of the DC Restorer

This article will be concluded in the November issue of Radiotronics.