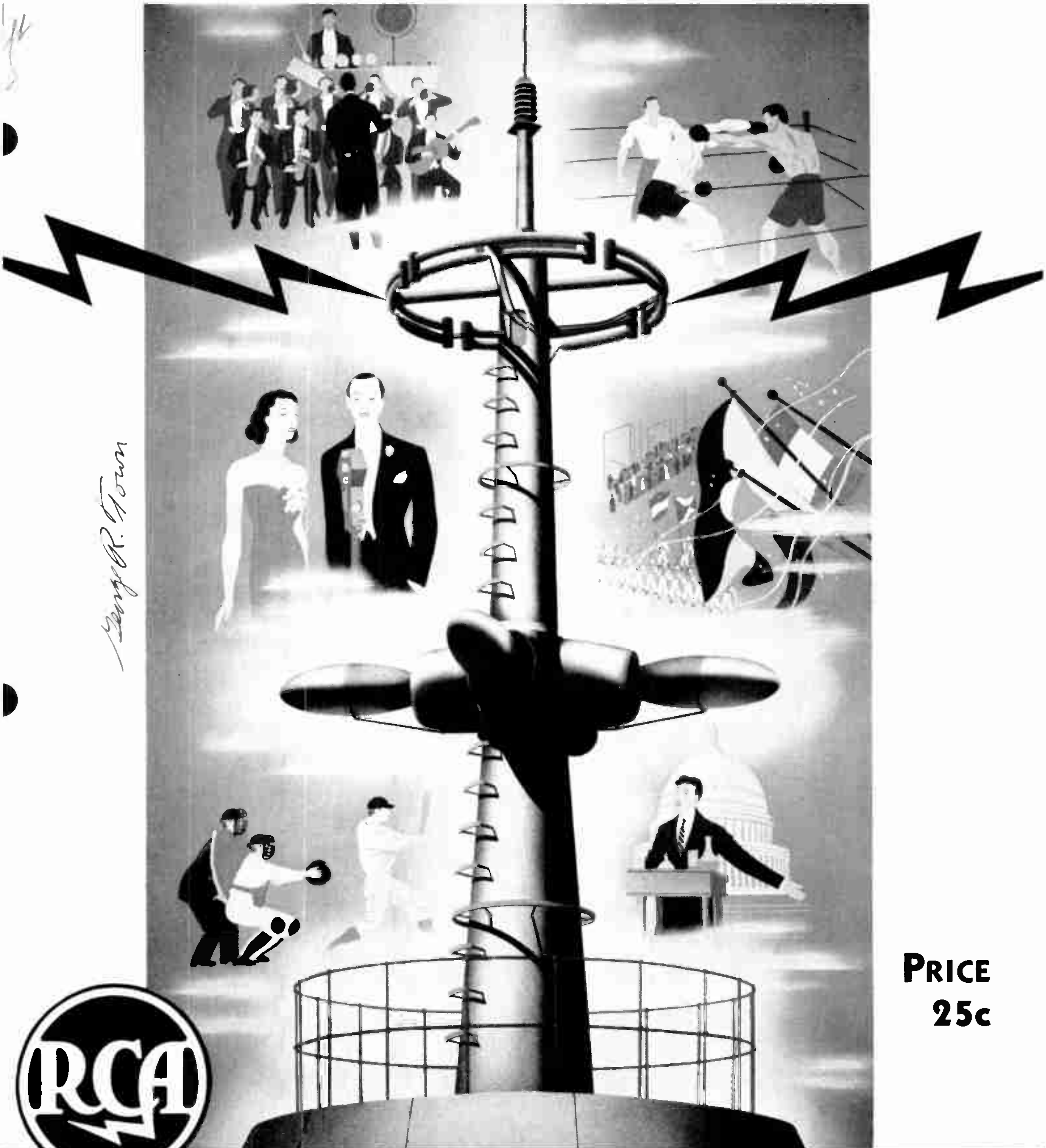

George R. Town

PRICE 25c

PRACTICAL TELEVISION By RCA

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Compiled by Service Division

RCA MANUFACTURING CO., Inc., CAMDEN, N. J.

Foreword

This booklet "Practical Television by RCA" is intended to give the RCA Victor dealer service personnel and television technicians a practical outline of the television system as a whole and television reception in particular. It is not an engineering treatise on television. It does, however, represent practical aspects of television receiver design, installation and service as gained by RCA engineers in the RCA-NBC field tests for the past seven years. The many years of field testing behind RCA Victor Television Receivers mean that they have been proven in the field under the most trying conditions — a product that will give many hours of pleasure in the home.

Technical description of a typical television receiver, as might be represented by the RCA Victor Model TRK-12, is arranged by outline circuit discussions. General installation and service information supplements existing RCA Victor publications. A group of RCA-NBC test pattern photographs under various degrees of receiver adjustment, receiving conditions and receiver faults are given herein to assist the observer interpret effects seen on the Kinescope's viewing screen.

It is recognized that this booklet does not cover all the details on television installation and service. However, it is hoped that the reader in studying it will not only gain practical knowledge but acquire the desire for further television knowledge and experience so the owner of a television receiver can be assured of expert advice and assistance. A satisfied owner of a television receiver is the best advertisement television can have.

The advent of television has created a new service field requiring more knowledge and skill, but one that brings great opportunities for all.

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INTRODUCTION

To quickly familiarize the reader with the general problems of television, it may be well to compare it with sound transmission and to analyze briefly the differences between the nature of sight and sound.

Disturbances in the air causing sound sensations arrive at the ear in successive pulses which depend upon the correct time sequence for intelligibility Sight sensations, however, depend upon a correct space arrangement of the elements of a scene for the production of an intelligible picture. An image of a scene being viewed is formed in the eye because of the variations of light intensity reflected by all of the various portions of the scene at a given instant. The image of the scene being viewed is a picture because of the space arrangement of these variations of brightness. Thus, for intelligibility of sound, orderly time arrangement must be maintained; whereas for picture definition, orderly space arrangement must be maintained. Sound transmission therefore is readily adaptable to radio broadcasting. Picture transmission and reception, however, required that the picture be subdivided into minute elemental areas so that information on the illumination of each small picture element can be transmitted in an orderly sequence and the bits of information reassembled in the correct sequence at the receiving end to form a complete picture.

A picture being reassembled or reproduced by television appears to be quite continuous because of a peculiarity of the human eye which retains an image for a short period of time. As a result, although minute portions of the scene are reproduced at different times, the whole process is completed so quickly that the eye sees the picture as a whole. The retentivity of the human eye is utilized in television in a manner somewhat similar to the manner in which it is utilized to create the illusion of motion in motion pictures. In the latter the illusion of motion is accomplished by projecting a sequence of time-related still pictures in such rapid succession that the eye retains the image of one picture until the next is projected, thereby creating an illusion of continuity. Television is complicated by the necessity of transmitting in an orderly sequence the information on minute picture elements and then rearranging the information on the screen of the picture tube of the receiver in the same sequence to form a picture of the original scene.

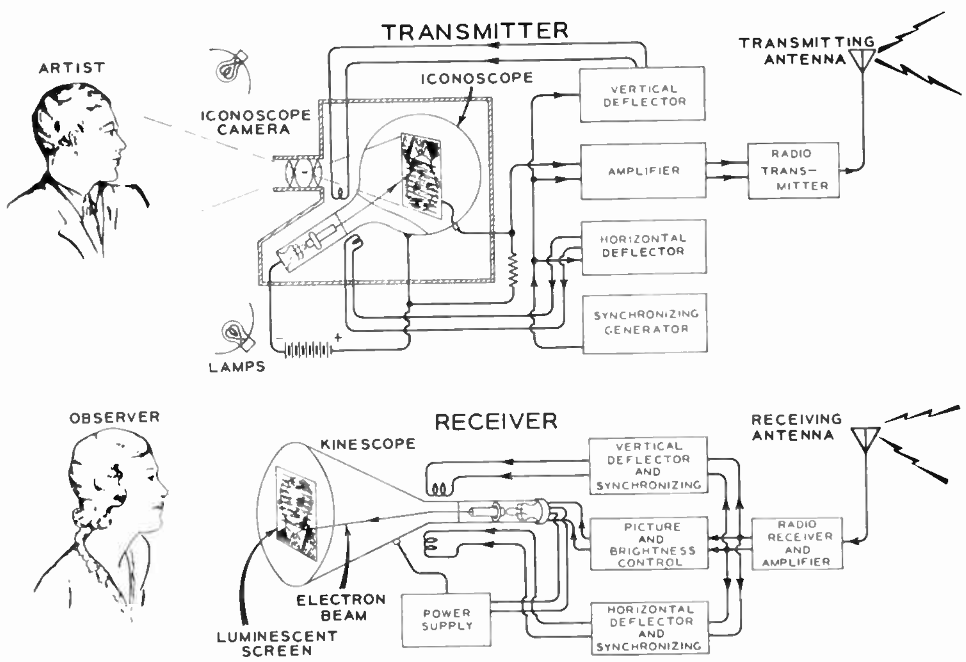


Figure 1—Schematic of RCA Television System (Sound portions not shown)

To clarify the over-all procedure, the steps required to pick up, transmit and reproduce a television picture will be discussed briefly. In the upper left corner of Figure 1 is shown an artist whose picture is to be transmitted. Light reflected from the face of the artist is collected by the lens system and focussed on the plate of the television camera tube known as the Iconoscope. This plate is covered with a material which, in effect, forms an innumerable quantity of minute photoelectric cells and is called a "mosaic." The Iconoscope also incorporates an electron gun similar to that used in a standard cathode ray tube. The scanning, in the case of the Iconoscope, is accomplished by deflecting the electron beam electromagnetically by means of coils external to the tube. These coils are excited at frequencies which cause the point of impact of the electron beam to move across the mosaic in approximately a horizontal line at a uniform speed, then fly back and scan another line, and so on until the entire mosaic has been scanned by 441 lines in the desired sequence. This complete scanning is repeated at a rate of 30 times per second. When the electron beam falls upon an illuminated portion of the mosaic, current will flow through the output circuit of the Iconoscope. When it falls on a partially illuminated portion a smaller current will flow, and when it falls on a dark portion very little current will flow. Hence, current pulses will be generated which will correspond in time sequence to the light and dark areas of the artist's image as they are scanned by the electron beam. The resulting voltage pulses, which are called video signals, are amplified and combined with special artificially manufactured signals for controlling the timing of the Kinescope (picture tube of television receiver) deflection circuits and for extinguishing (or blanking as it is usually called) the Kinescope's electron beam during the return time. The resulting composite signal is then used to modulate a high frequency transmitter.

In the receiver, the received signal is amplified and separated into its components. The picture components are amplified and applied in such a way as to produce variations in the intensity of the electron beam of the Kinescope which is similar to a conventional cathode ray tube. In the particular case under consideration, deflection is accomplished electromagnetically with coils external to the tube. The oscillators which furnish the energy for deflection operate at the same frequencies as the deflection oscillators associated with the Iconoscope and are held in synchronism by the transmitted synchronizing pulses. Thus the electron beam of the Kinescope moves in synchronism with the electron beam of the Iconoscope and the variations in brilliancy of illumination at the point of impact on the Kinescope screen correspond to variations in illumination of the respective areas of the Iconoscope mosaic. In this manner the image on the mosaic of the Iconoscope is dissected and information on each element transmitted separately in a manner which permits the receiver to take these bits of information and use them to produce corresponding variations in illumination on the Kinescope screen and thus produce a picture of the original scene.

The foregoing over-all description of the television system gave very little attention to the details of the process. It may be interesting now to go back and consider some of these details. The scanning process is not as simple as might be inferred from the previous discussion. In order to reduce flicker to an acceptable amount without needlessly increasing the band width required for high definition pictures, alternate lines are scanned successively. This type of scanning is called "interlaced" scanning. Thus scanning may start with line No. 1, then No. 3, No. 5, No. 7, etc., until line No. 441 is scanned. This is called one "field" and requires 1/60 of a second. Then the spot flys back to the top of the picture and scans the even numbered lines in order, starting with line No. 2, then No. 4, No. 6, No. 8, etc., until line No. 440 has been scanned. This also requires 1/60 of a second. The term "field" designates one scanning of either all the even or all the odd numbered lines. Two fields, or a complete scanning of all 441 lines, is called a "frame" and requires 1/30 of a second.

It has been rather common knowledge that the RMA standard for high definition television pictures designates 441 line scanning, but the reasons for the choice of this number are not so obvious. The reasons for selecting 441 lines are:

First — To obtain pictures of adequate size with best detail, as many lines as possible should be used. A limiting factor is the high picture signal frequencies involved. An analysis indicates that the number of lines should not be much less than 450 if pictures with good definition are desired.

Second—Interlaced scanning makes it very desirable that the number of lines be odd.

Third — For reasons too involved to discuss here, the number should have simple odd factors. The number 441 has the simple odd factors of 3, 3, 7, 7.

With 441 line interlaced scanning and a frame frequency of 30, the reasons for the great range of frequencies involved in television become apparent. To obtain as good picture detail horizontally as is obtained vertically, it must be possible to put picture elements into a line as close together horizontally as the vertical spacing of the lines. As the picture width is 4/3 times the picture height, there must be 588 elements in each line.

Successive black and white elements (such as in a checker board pattern) would represent the greatest possible distribution of elements. Each succession of a black and a white element represents a complete signal voltage cycle. It must be possible, therefore, to transmit 294 cycles (588 divided by 2) while one line is being traced. As 441 lines are traced during 1/30 of a second, it is apparent that the output from the Iconoscope will cover a great range of frequencies. A consideration of all factors indicates this to be approximately four million cycles per second.

Modulation considerations require that the transmitter carrier frequency be appreciably higher than the highest modulation frequency. The fact that the modulation frequencies extend up to four megacycles and above, and the lack of available space in the other portions of the radio spectrum require that the carrier frequencies be in the ultra high frequency region. For this purpose the Federal Communications Commission has assigned seven television bands in the spectrum between 44 mc and 108 mc. These are shown in Fig. 2 at A. The relation between the picture carrier and its associated sound carrier of any one channel is shown in the detail at B. The lower picture side-band is attenuated permitting a sufficiently wide spacing of 4.5 mc between picture and sound carriers to allow a wider upper picture side-band so necessary for adequate reproduction of fine detail of the original scene.

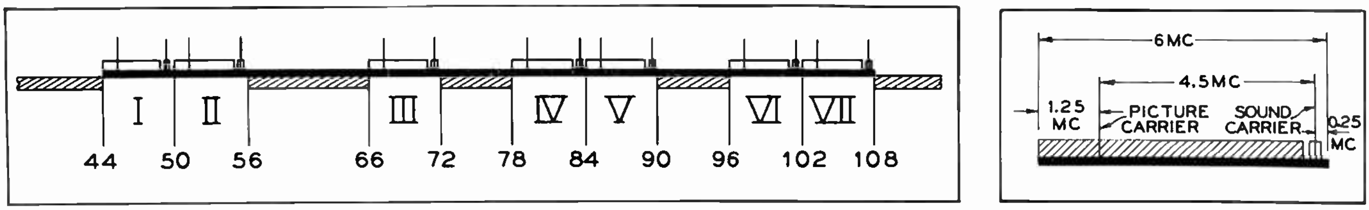
Radio transmission at these frequencies exhibits the peculiar phenomenon known as "line of sight" transmission. The radiations from the transmitting antenna evidently do not follow the curvature of the earth because they usually cannot be reliably received beyond the horizon. In order that the horizon be as far as possible from the transmitter and the service area extended accordingly, the transmitting antenna is placed as high as possible. In New York City, where RCA has conducted extensive television tests for seven years, the NBC transmitting antenna has been placed on top of the Empire State Building. This gives a service area with a radius averaging approximately 40 miles.

Other difficulties are encountered in the transmission and reception of these very short waves. The similarity of their behavior to that of light is further evidenced by the fact that they are readily reflected by buildings, hills, or other masses. The receiving antenna may pick-up reflected signals as well as those coming directly from the transmitting antenna. As these signals may arrive at the receiving antenna via routes of appreciably different lengths, they may arrive at different times and each of them, therefore, may produce an image on the Kinescope screen displaced somewhat from the others. This, naturally, produces a confused picture. This annoyance can usually be minimized by proper location and orientation of the receiving antenna or by the installation of a special directive antenna.

Of course, in order that the television program will be complete, the sounds accompanying the scene must also be broadcast. The sounds are picked up by a microphone in the usual manner and the amplified energy is used to modulate another ultra-high frequency transmitter operating at a frequency 4.5 mc above the picture carrier frequency.

Present American television receiver design practice is to use superheterodyne receivers with antenna and r-f circuits which are sufficiently broad in frequency response to accept the entire pass band covered by the two carriers and their transmitted side-bands. No separation occurs until after the first detector. The output of a single local oscillator is heterodyned with both sound and picture carrier signals to produce signals of two intermediate frequencies. By having separate picture and sound intermediate frequency amplifying systems, each of which is tuned to the correct i-f, the television picture and sound signals may be separated. The sound amplifying system from that point on is in most respects identical to that of a conventional radio receiver.

The television picture signal must be separated into its components. As previously explained, timing or "synchronizing" and extinguishing or "blanking" pulses are transmitted along with the video signals which provide the information on variations in illumination of picture elements. At the end of each scanning line, synchronizing pulses for holding the horizontal scanning oscillator at the proper frequency and blanking pulses for extinguishing the electron beam during the horizontal return time are transmitted. At the end of each field, synchronizing pulses for holding the vertical scanning oscillator at the proper frequency and blanking pulses for extinguishing the electron beam during the vertical return time are transmitted.



(A) TELEVISION BROADCAST CHANNEL ALLOCATIONS

(B) CHANNEL MAKE-UP

Figure 2—Television Spectrum and Channel Make-up

The synchronizing pulses must be separated from the video signal, and the vertical and horizontal pulses selected and applied to control the proper scanning oscillator. The video signal and blanking pulses must be applied to the control grid of the Kinescope through suitable amplifier and circuit arrangements to control the Kinescope illumination.

Although this brief over-all description of a television system may lead the reader to believe that the system is comparatively simple, such is by no means true. Much of the apparatus required to produce the conditions described is of necessity extremely complex. The development of many of the apparatus and circuit arrangements has called for unusual knowledge, skill and ingenuity on the part of the engineers responsible for our present highly advanced system. Fortunately for the television technicians who must install and service these receivers, these engineers have continually sought to evolve a system which does not utilize unnecessarily complicated receivers.

Discussion of RMA Standard Television Signals

If the television receiver is to reproduce a true image of the scene being televised, the following conditions must obtain: (1) The Kinescope scanning spot must be made to move in synchronism with the scanning spot of the Iconoscope or camera tube at the transmitter studio. (2) The Kinescope electron beam must be extinguished during the horizontal and vertical return time periods. (3) The Kinescope must be supplied with information on the relative brightness of elemental areas and on the average illumination of the complete scene. These requirements are accomplished by transmitting along with information on elemental areas such signals as are best suited to accomplish the other control functions involved.

Synchronization of the scanning at the receiver with that at the transmitter and blanking of the beam during the return periods are accomplished by transmitting at the end of each line and at the end of each field special characteristic pulses for controlling the timing of the deflection circuits and the intensity of the Kinescope electron beam. In the transmitted television signal, the synchronizing portions of these pulses are represented by excursions of voltage in the direction representative of black in the picture and where they occupy a position corresponding to what is sometimes called "blacker than black." That is, while the picture signal occupies the portion of the total signal amplitude between a voltage representative of white and a voltage representative of black, the synchronizing pulses occupy a region beginning at the black level and extending from there in a direction opposite to that representative of white.

The wave shape of the RMA Standard Television Signal for the region near the vertical synchronizing pulse for two successive fields is shown in Fig. 3. These wave shapes are for 441 lines per frame, 30 frames per second, 60 fields per second interlaced. The two wave shapes of Fig. 3 differ because of the requirements for interlacing. At the left are shown the last few lines of each field. At the end of each line is shown the horizontal blanking pulse, which biases the Kinescope grid to cut-off (black level) during the return sweep of the line deflection. During the time between the bottom of one picture field and the top of the next occurs the vertical blanking pulse which maintains the Kinescope bias at or beyond cut-off during the vertical return sweep. Superimposed on these two types of blanking pulses are the synchronizing pulses, which extend from the black level in the direction of black. The horizontal synchronizing pulses are single, nearly rectangular pulses, occupying most of the horizontal blanking period. Their positions in alternate fields are displaced by half a line, so that in alternate fields the horizontal scanning lines will be displaced by half a line, thus producing interlacing.

The horizontal synchronizing pulses are continued during the periods of the vertical blanking and vertical synchronizing pulses in order to continuously maintain horizontal synchronization. Beginning at the front edge of the vertical blanking pulses the width of each horizontal pulse is made only half the width of those preceding the vertical blanking, and in addition equalizing pulses are spaced half way between the regular pulses. This condition continues for a period equivalent to three lines after the vertical synchronizing pulse, following which the regular horizontal synchronizing pulses again occur. The purpose of the equalizing pulses is to make conditions of vertical synchronization identical for the two successive fields and still permit continuous horizontal synchronization.

The vertical synchronizing pulses for the two fields are identical. Each consists of a pulse lasting for three horizontal line periods and which has been "slotted" or shaped to provide continuity of horizontal synchronization. The leading edge of each vertical pulse corresponds in position to the leading edge of the equalizing pulses. The total duration of the vertical synchronizing pulse is sufficiently longer than that of the horizontal synchronizing pulse to allow them to be separated from each other by wave shape discrimination.

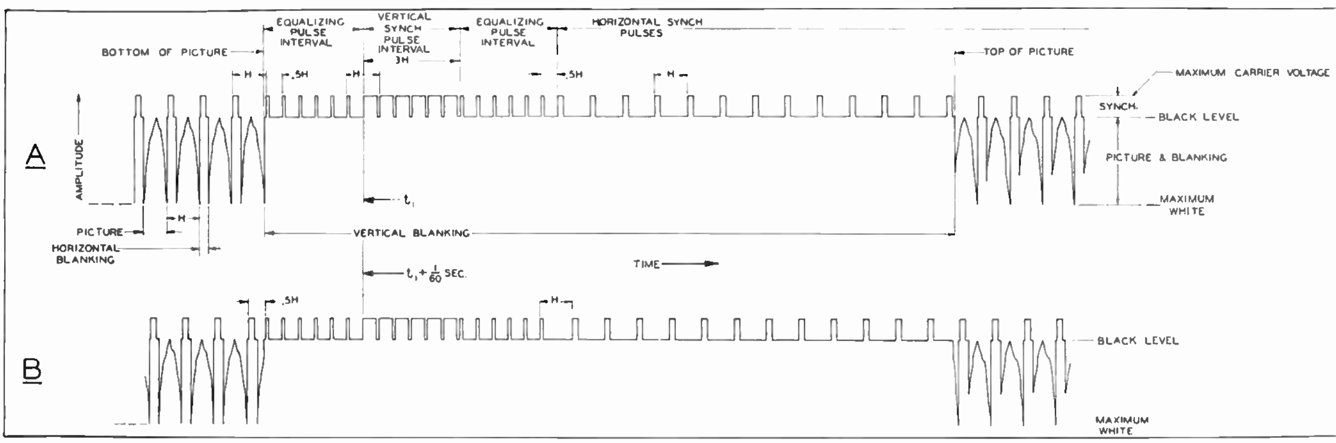


Figure 3—RMA Standard Television Signal

The signal appearing across the diode load resistor of the picture second detector is the same as that shown in Fig. 3. It is amplified as much as required and then impressed upon the control grid of the Kinescope. The signal appearing across the diode load resistor is also impressed on the synchronizing separator the action of which will be discussed with the other components in the block diagram of Fig. 4.

Discussion of Block Diagram of Typical Television Receiver

In order to better illustrate the operating principles of television receiver circuits, the circuit discussion which follows will be based on a typical television receiver. In Fig. 4 is shown a block diagram of such a typical television receiver. The antenna receives both sound and picture carrier signals. In a typical case, the picture carrier would be 45.25 mc and the sound carrier 49.75 mc. (These carrier assignments are being used by W2XBS, the NBC television transmitter in New York City.) The r-f circuits are sufficiently broad to pass both carriers with such portions of their side bands as are transmitted. These are passed on to the first detector where they are both heterodyned with a 58 mc local oscillator signal. This produces two i-f carriers, one at 12.75 mc modulated with the picture signals, and another at 8.25 mc modulated with the accompanying sound signals.

The i-f signals with sound modulation are amplified by the sound i-f amplifier, and the i-f signals with picture modulation are amplified by the picture i-f amplifier. In order to prevent cutting of the high frequency side bands in the sound i-f amplifier when the receiver is slightly mistuned, the sound i-f transformers are designed to pass a band up to 100 kc wide. As this type of transformer reduces the gain per stage, two sound i-f amplifier stages are used to obtain the necessary amplification. The sound i-f signals are impressed upon the sound second detector and are converted into audio frequencies in the usual manner. These are then amplified and reproduced as sound by a conventional audio amplifier and loudspeaker.

The picture i-f signals are amplified by a picture i-f amplifier system which is tuned to 12.75 mc and which passes a band of 2.5 mc to 4 mc depending upon the quality of the receiver. For vestigial side band transmission within the band widths allocated for television, this will allow modulation frequencies corresponding to video frequencies up to 4.0 mc. An i-f amplifier which will pass a band of this width must necessarily have a low gain per stage and consequently five picture i-f stages are used in this typical receiver to secure the desired amount of amplification. It was necessary to develop special, high mutual conductance, amplifying tubes, such as the RCA 1852, to permit the use of an economic number of amplifying stages to secure both sufficient gain and band-width.

The amplified picture i-f signal is applied to the picture second detector and converted into the television signal represented by Fig. 3. The output of the picture second detector is supplied simultaneously to the picture a-v-c system, to the video amplifier, and to the synchronizing separator. The picture a-v-c

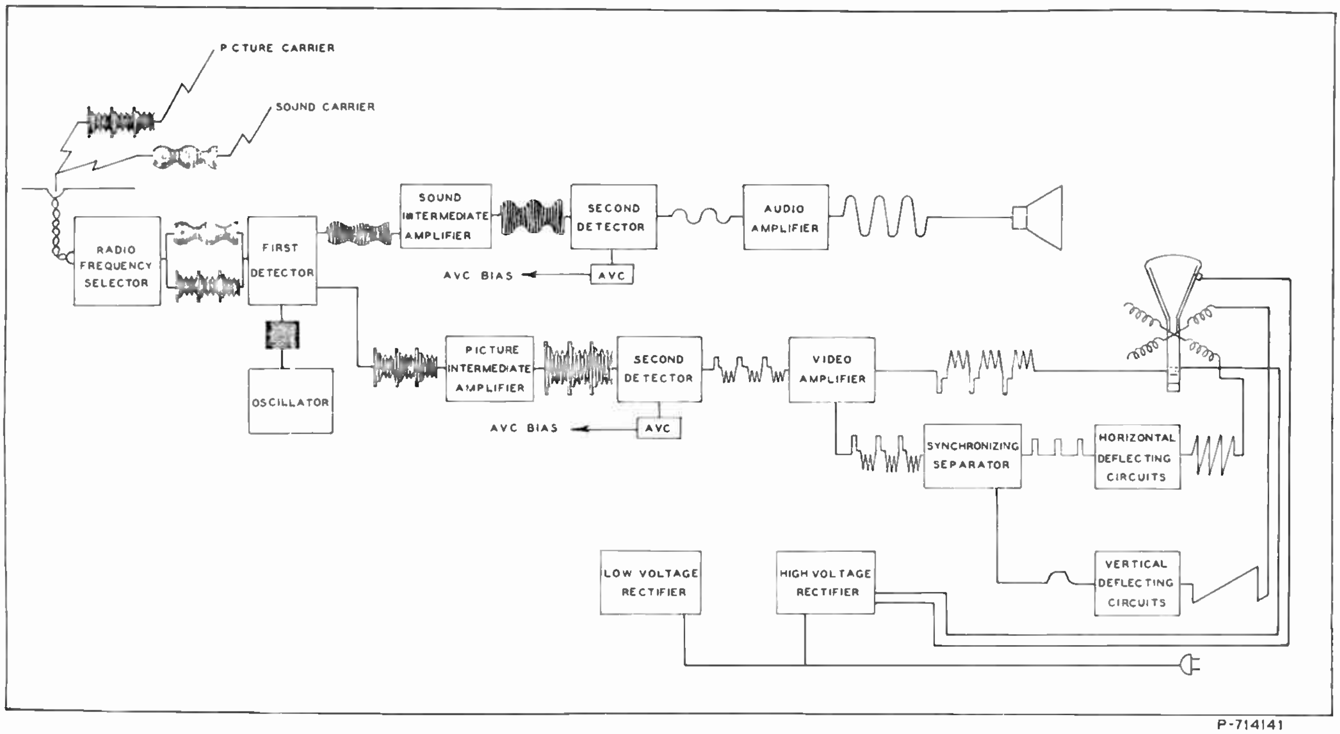


Figure 4—Block Diagram of a Typical Television Receiver

system utilizes some of the television picture signal to produce a variable d-c voltage which after suitable filtering is applied as negative grid bias to the picture i-f stages to control their gain.

The video amplifier amplifies the a-c portions of the television picture signal and applies them to the grid of the Kinescope to control the relative illumination of the elemental areas and to blank the beam during the return periods. A portion of the output of the video amplifier is rectified by a tube called the "d-c restorer" and the d-c voltage thus produced is applied as variable bias voltage to the Kinescope grid. This function is usually referred to as the automatic brightness control and is necessary when the video amplifier is not a d-c amplifier in order to reproduce correctly the average brightness or illumination of the scene being televised and to secure correct blanking during the return time.

The synchronizing separator incorporates circuits which separate the synchronizing pulses from the remainder of the signal. The horizontal synchronizing pulses are then separated from the vertical synchronizing pulses by suitable circuits and both are then applied to control the timing of the deflection oscillators with which they are associated.

Circuit Description

To facilitate a study of the details of the circuits used in the typical television receiver illustrated in the block diagram of Fig. 4, the schematic circuit diagram has been divided into sections, and each section considered separately. The circuits shown are typical of a large receiver of the superheterodyne type, but do not necessarily refer to any definite model. Only those portions of the circuit necessary for an understanding of its functioning are shown, and those portions such as the d-c connections have been omitted. A general knowledge of radio circuits has been assumed.

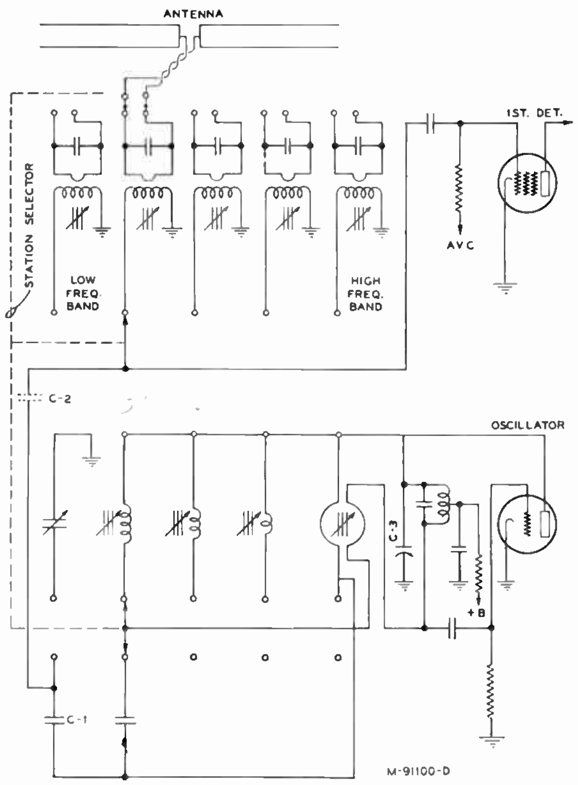


Figure 5—R.F. Input and Oscillator

Radio Frequency Circuits

The first considered is the radio frequency circuit shown in the upper portion of Fig. 5. The double dipole antenna picks up both picture and sound carriers together with their associated sidebands. A manually operated switching system permits the selection of any one of five channels by transfer of input coupler and oscillator circuit connections. This is shown diagrammatically by arrows which can be considered as being connected together mechanically by the dashed lines on the left of the illustration. The transmission line from the double dipole antenna connects to the primary of the proper r-f transformer. Each transformer is designed to be sufficiently broad in tuning to transmit one of the 6 mc television bands including sound and picture carriers with their associated sidebands. The secondary of the antenna transformer being used is connected to the first detector.

Oscillator Circuits

The lower portion of Fig. 5 shows the local oscillator necessary for superheterodyne operation. It employs a Hartley type of circuit and its frequency of operation is controlled by the range switch which changes the circuit constants. A portion of the tuned circuit is always coupled to the small inductance shown connected to the range switch position at the extreme right. This position is connected through condenser C-1 to the lower left section of the switch which is also connected through condenser C-2 to the input of the first detector. The capacity C-2 may be a capacitor or it may be obtained by utilizing the interwiring capacity. The small variable condenser C-3 provides vernier tuning for each position of the band selector switch.

First Detector
Intermediate Frequency Amplifiers

Figure 6 shows the first detector together with the picture and sound intermediate frequency amplifying systems. As the first detector receives the sound and picture carriers plus the local oscillator signals, two intermediate frequencies will be produced. Since associated sound and picture carriers are always separated by 4.5 mc, two i-f carriers with the same frequency difference will be produced. For a typical case, the picture carrier would be 51.25 mc, the sound carrier 55.75 mc, and the local oscillator frequency 64 mc. These conditions would produce a sound i-f carrier of 8.25 mc, and a picture i-f carrier of 12.75 mc. The output of the first detector is connected to a filter network where the unwanted frequencies are attenuated and the desired i-f signals are separated. The sound i-f signals are applied to an amplifying system tuned to pass the sound i-f carrier of 8.25 mc and both side bands. The picture i-f signals are applied to an amplifying system tuned to pass the i-f carrier of 12.75 mc and the usable side band.

The sound i-f amplifier system is conventional in design with the exception that the transformers are designed to pass a band up to 100 kc wide. This is done so that a normal amount of mistuning will not appreciably effect the sound reproduction. Furthermore, it also permits adjustment of the oscillator frequency for best picture results without impairing the tonal quality of the sound reproduction. The secondary of the last sound i-f transformer drives the sound second detector. A portion of the d-c drop across the diode resistor is filtered and utilized as a-v-c voltage to control the gain of the sound i-f amplifier.

In this particular example, delayed a-v-c and residual bias on the sound i-f amplifier tubes are obtained by utilizing the second section of the 6H6 duplex diode rectifier used as the sound second detector and a-v-c tube. The connections are indicated in Fig. 6. When no signals are being received, the cathode will be at a potential of –2 volts with respect to the plate. Under these conditions, the diode will be conducting and it will represent a low resistance in the series circuit including R-72, R-73. As a result most of the –2 volts from the voltage divider will appear across the resistors R-72 and R-73 and thus furnish approximately –2 volts residual bias. When a signal is received, the voltage across R-72 resulting from signal rectification will be of such polarity as to make the plate of the second diode section less positive with respect to its cathode. Obviously when the voltage across R-72 resulting from signal rectification exceeds –2 volts, the plate of the second diode section will be negative with respect to its cathode and the diode then will be non-conducting. It is evident that the bias voltage remains approximately –2 volts until the rectified signal produces a voltage in excess of 2 volts across the detector load resistance. Thus a-v-c action is delayed until the signal strength reaches the value required to accomplish this effect.

The picture i-f amplifier in the typical receiver under discussion has five stages. This number of stages is necessary because it is not possible to obtain a high gain per stage when the pass band is approximately 4 mc as in this example. As the modulating frequencies for the picture carrier will be approximately 4 mc, it is necessary that the picture i-f transformers pass a band of this width if one set of side bands only is to be amplified by the receiver. The overall response curve of the five picture i-f stages for such a selective single side band receiver is shown in Fig. 6. It is necessary that the response be very small at 8.25 mc so that none of the accompanying sound i-f signals will get into the picture. It is also necessary that the response at 14.25 mc be very small so that sound signals from the adjacent lower frequency television channel will not get into the picture. These requirements are accomplished by the use of suitable rejector circuits which must be aligned with a high degree of accuracy. For double sideband transmission and vestigial sideband transmission (where all of one set of sidebands and portions of the other are transmitted), the i-f amplifier response at the i-f carrier frequency (12.75 mc) should be 50% of the response over the flat response portion

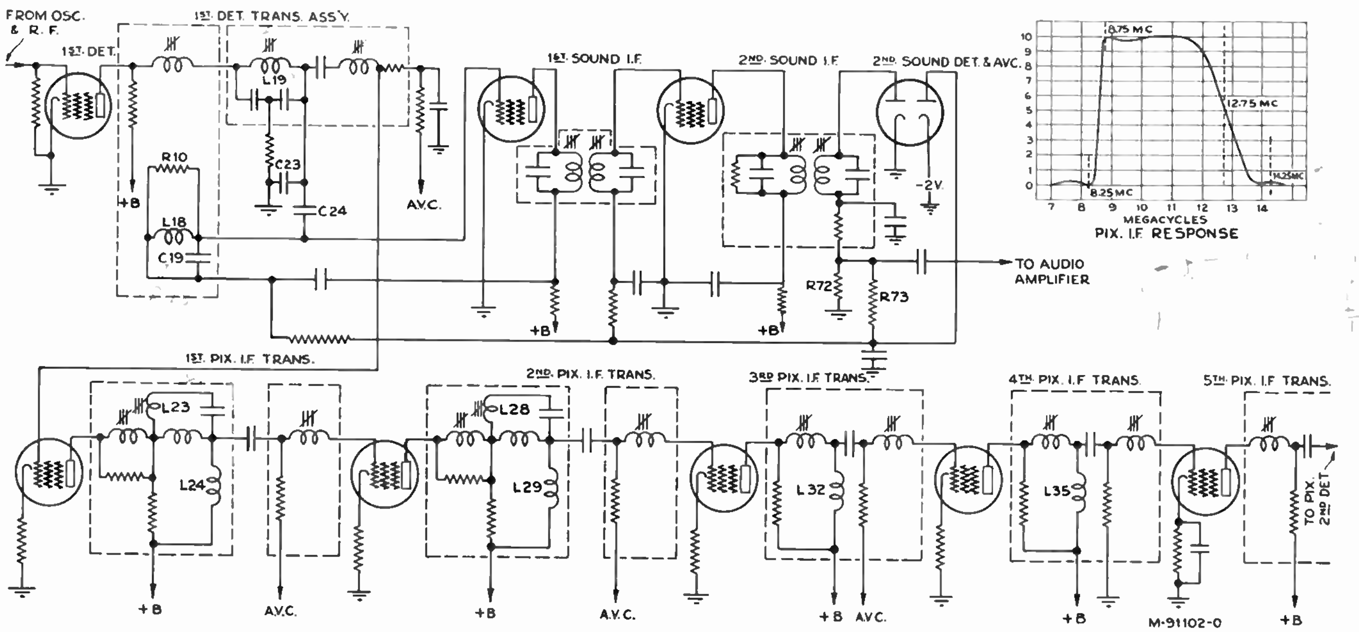


Figure 6—First Detector and Intermediate Frequency Amplifiers

covering most of the desired frequency range as shown in the overall picture i-f response curve of Fig. 6. The output of the picture i-f amplifying system is applied to the picture second detector where it is rectified or demodulated to obtain the television picture signal illustrated in Fig. 3.

It may be of interest to consider briefly the type of picture i-f coupling transformers used in this typical receiver. It will be noted from Fig. 6 that the primary and secondary sections of the first detector, first picture i-f, and second picture i-f transformer assemblies are mounted within separate shields. The primary and secondary are not coupled magnetically but are coupled through an impedance which is common to both circuits. The common impedances for the three transformers listed above are C-23, L-24, and L-29 respectively.

At the frequencies involved, stray capacities and the tube input and output capacities become very important factors. These capacities, while not shown diagrammatically in Fig. 6, are actually utilized to resonate the circuits at the proper frequencies. In the case of the first, second, third, and fourth picture i-f transformers, the signal voltage applied to the grid of the succeeding tube is in each case the voltage developed across the tube input and stray capacity connected to the grid end of the secondary inductance.

The first detector, first picture i-f, and second picture i-f, transformer incorporate rejector circuits which are resonated to offer rejection at 14.25 mc, 8.25 mc, and 8.25 mc respectively. The frequency of rejection is adjusted by varying the inductances L-19, L-23, and L-28.

L-18 and C-19 (together with a loading resistor R-10) of the first detector transformer assembly form a parallel circuit resonant at 8.25 mc. This circuit is connected to the high signal potential end of the common coupling impedance C-23 by the capacitor C-24. Since the parallel circuit is resonant at the sound i-f, 8.25 mc, a strong sound i-f signal voltage will be developed across it. This voltage is coupled to the grid of the first sound i-f amplifying tube. The circuit will not offer much impedance to the picture i-f signal currents and therefore very little picture i-f signal voltage will be applied to the first sound i-f amplifier.

Although the primary and secondary sections of the third and fourth picture i-f transformer assemblies are mounted within the same shields, there is practically no magnetic coupling between them. Most of the coupling is obtained from the common impedance offered respectively by L-32 and L-35. In the fifth picture i-f transformer most of the primary to secondary coupling is obtained from the common impedance offered between the taps A and C of the secondary as shown in Fig. 7. There is no rejector circuit in the third, fourth, and fifth picture i-f transformer.

The alignment of the picture i-f circuits involves very rigorous standards. The eye is much more critical than the ear and therefore will detect picture defections caused by relatively small deviations in electrical response whereas the ear ordinarily will not discern defects in the sound reproduction caused by deviations of the same order. The method of alignment best adapted for field use involves a special wide band frequency modulated oscillator and a suitable cathode-ray oscillograph. The response of the oscillator over the range involved must be very uniform and the calibration must be very accurate. The cathode-ray oscillograph should use a tube with a screen at least 5 inches in diameter as otherwise errors in observation may cause serious inaccuracies in alignment.

Picture Second Detector Circuit

Figure 7 illustrates the picture second detector, video amplifier, picture a-v-c, and d-c restorer circuits. Each of these will be discussed briefly. The picture second detector input coil is, in effect, a center-tapped autotransformer with its center tap effectively grounded with respect to i-f voltages by the capacitor C-1. The primary is formed by the section of the winding between the center-tap and the connection shown immediately above it. The ends of the coil connect to the plates of a double diode rectifier. This arrangement provides a balanced full wave video second detector. When the picture i-f signals are impressed on the diode, the signal appearing across the diode load resistance (in Fig. 7, this is the resistance element of the contrast control) will be essentially the same as the standard television signal illustrated in Fig. 3. Thus white in the picture is represented by minimum voltage across the resistor, and black level is always represented by an amplitude equal to 80% of the voltage range, while synchronizing pulses occupy the upper 20% of the voltage range.

One very important factor in the design of the picture second detector and subsequent circuits is the need to consider the polarity of the signal. It must of course be applied with correct polarity to the control grid of the Kinescope, as otherwise the reproduced image will be a negative rather than a positive as desired. Furthermore, as previously pointed out, the deflection circuits are controlled by means of synchronizing pulses transmitted along with the picture components. These signals must be separated from the picture signals and applied with correct polarity to their respective associated deflection oscillators. Since each amplifying tube effects a 180° phase reversal, it is necessary that the polarity of the coupling to the picture second detector load resistance and the number of stages be such that the desired output polarity will be achieved.

Picture AVC System

There are several distinct advantages obtained from use of automatic gain control on the picture channel of a television receiver. Only a few of these will be mentioned. An a-v-c will maintain the signal level at the second detector substantially constant for wide variations in signal input. While the signal from a given transmitter may not vary greatly within its service area because of natural fading, the signal sometimes may vary greatly because of moving conductors or objects nearby. When tuning from one station to another a-v-c will maintain proper level without manual readjustment of other controls. Also, with a constant signal level at the second detector the problems of synchronizing pulse separation and gain control are simplified.

The a-v-c system of the picture i-f amplifier differs considerably from that of the sound i-f amplifier. In sound broadcast receivers, it is customary to use the filtered d-c drop across the diode resistor as the source of the a-v-c voltage. This is satisfactory, because the d-c voltage thus obtained is directly proportional to the **average** carrier amplitude at the diode. If it maintains the average carrier amplitude substantially constant, then the a-v-c operates as it should. In the transmission of television pictures, however, the average carrier amplitude varies greatly with picture content, and an a-v-c system operating on the principle of maintaining a substantially uniform average carrier amplitude therefore is not suitable.

The RMA Standard Television Signal calls for a transmission system known as d-c negative transmission. Under this system, the carrier always reaches a uniform maximum amplitude during the periods when synchronizing pulses are being transmitted, and a white portion of the scene is represented by minimum or zero carrier condition. Thus, if there is no fading, the peaks of the synchronizing pulses will always represent some constant amplitude, and they, therefore, form a convenient reference for operating a satisfactory picture a-v-c system.

In the circuit diagram of Fig. 7, the a-v-c rectifier tube and its associated circuit components furnishes a d-c voltage which is amplified by a d-c amplifier stage designated as the a-v-c amplifier. The voltage drop across the plate resistor of the a-v-c amplifier is used as a-v-c bias. The a-v-c rectifier is essentially a peak voltmeter, i.e., the voltage across R-1 is proportional to the peak amplitude of the signal applied to the a-v-c rectifier. The condenser C-2 assumes a charge proportional to the peak amplitude of the applied voltage because the shunting resistance is too high to appreciably discharge the condenser during the period between successive synchronizing pulses. The operation is somewhat similar to that of the first synchronizing separator tube described in a subsequent section. It differs in the fact that the time constant of the R-1, C-2 circuit is so long that the voltage across them remains substantially equal to the peak amplitude of the synchronizing pulses as described just previously instead of following the amplitude-time characteristic of the synchronizing pulses as in the case of the separator tube. The cathode of the a-v-c rectifier is direct coupled to the grid of the d-c amplifier which in this particular illustration, is at a negative potential of 12 volts with respect to its cathode. For zero signal conditions, this effectively biases the d-c amplifier tube to cut off and no a-v-c action is therefore obtained until the a-v-c voltage overcomes enough of the residual bias on the a-v-c amplifier to cause plate current to flow. Thus, a desired amount of delayed a-v-c action is obtained. The plate of the a-v-c amplifier is connected to a potential of −2 volts through a load resistor R-2, and to the grids of the first detector and picture i-f amplifier tubes through a conventional RC filter. Thus, an increase in signal beyond the point at

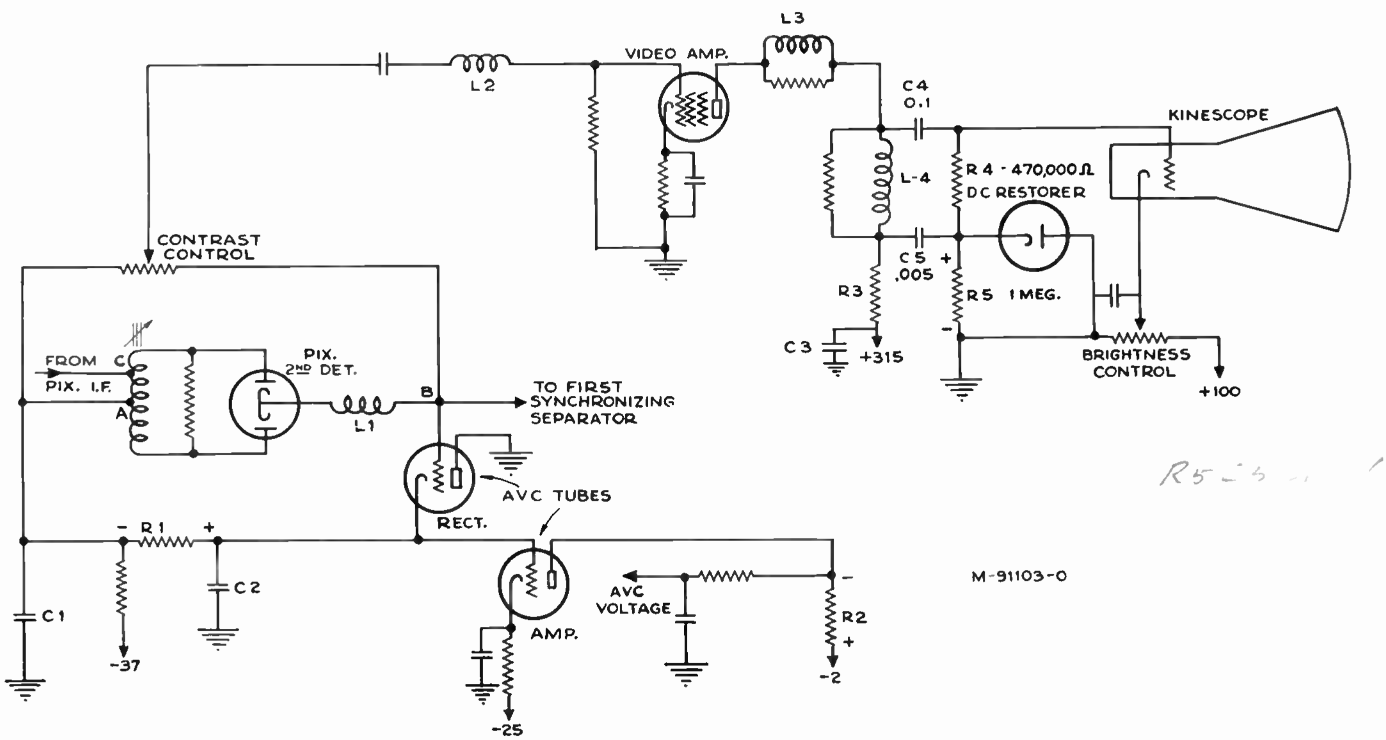


Figure 7—Picture Second Detector, Video Amplifier and D.C. Restorer

which the a-v-c becomes operative causes plate current to flow in the a-v-c amplifier tube, and the voltage developed across R-2 by this current causes the plate of the a-v-c amplifier tube, and, therefore, the grids of the picture i-f amplifier stages, to become more negative. Thus, the gain will be controlled to maintain substantially the maximum carrier amplitudes represented by synchronizing pulses.

As was previously pointed out, the gain of the sound i-f channel is controlled by an a-v-c system which derives its control voltage from the voltage drop across the sound second detector load resistor. Since the recommended standards specify that the picture and sound transmitters for any given station shall have the same power output rating, and since the two transmitting antennas are located relatively near to each other, the question might very logically arise as to why the sound a-v-c voltage is not utilized to control the gain of the picture i-f channel and thus make it possible to eliminate the special picture a-v-c system previously described. Such a system would be very practical if the sound and picture carrier voltages delivered by the receiving antenna system to the receiver input could be relied upon to be of equal magnitudes. Experimental investigations, however, have shown that a number of factors including the frequency response characteristic of the receiving antenna, location of antenna and transmission line, and others, operate to make the sound and picture input voltages vary as much as ten to one. Obviously under such conditions, the gain of the picture channel might not be correctly controlled by the sound a-v-c system.

However, the expense connected with the special picture channel a-v-c system previously described makes a cheaper alternative desirable in cases where cost is a very important factor. It has been found that one reasonably satisfactory alternative consists of applying the sound a-v-c voltage to the first detector and controlling manually the picture i-f channel gain by means of a variable resistor in the cathode circuit of the first picture i-f amplifier tube.

Video Amplifier

As previously indicated, the diode load resistor forms the resistance element of the video amplifier gain control potentiometer commonly called the contrast control. The movable connection supplies a portion of the video voltage to a single video amplifier stage as shown in Fig. 7.

It is not considered economical in design to secure directly from the picture i-f system sufficient voltage for proper operation of the Kinescope and it is necessary, therefore, to use a stage of video amplification. Since it is necessary to produce a positive picture on the Kinescope viewing screen, the video amplifier input connection at the diode load resistor is of such polarity that the synchronizing and blanking pulse portions of the signal are in the white or positive direction. The video amplifying stage inverts the signal due to the usual 180° phase reversal that takes place in any amplifying stage. This connection then insures that a positive picture signal appears on the Kinescope grid so that blacks of the original televised scene appear as blacks and not whites.

The frequency response of the video amplifier must be excellent up to 4 mc for a high quality receiver. The inductances L-1, L-2, L-3 and L-4 are commonly called "peaking" coils. These inductances in association with tube and stray wiring capacities really form a wide bandpass filter network to secure uniform response up to and beyond 4 mc. Furthermore, the video amplifier must have linear phase shift or uniform time delay if the output signals are to arrive at the Kinescope in the correct phase relationship. A study of this latter factor is beyond the scope of this booklet.

The signals after being amplified by the video amplifier are coupled to the grid of the Kinescope. The variations in video voltage produce corresponding variations in intensity of the Kinescope electron beam and therefore corresponding variations in the illumination of the elements of the scene. By varying the video amplifier gain control (contrast control) the contrast can be varied to secure best picture detail and half-tone relations.

DC Restorer or Automatic Brightness Control

Since the video amplifier is an a-c amplifier with RC coupling, the d-c component of the video signal that represents the average illumination of the original scene will not be passed. Consequently, unless some provision is made to restore it, the Kinescope will not receive any information on the average brightness of the scene and the reproduced image therefore will not have the correct average illumination even though the contrast between the illumination of picture elements may be correct. Furthermore, unless the residual bias on the Kinescope is adjusted to a point too negative for average conditions, the black portions of the original scene and the blanking pulses will not always drive the grid to cutoff as desired. The restoration of the d-c component in the typical receiver under consideration is accomplished by means of a d-c restorer tube or automatic brightness control tube as it is commonly called. Reference to Fig. 7 will indicate how the tube is applied.

It will be noted that the d-c restorer or automatic brightness control utilizes a diode rectifier. Reference to two typical conditions of transmission may best serve to illustrate how it serves the function intended. Under the recommended standards, if the scene being televised is completely black, the amplitude of the voltage representing the picture content will be equivalent to the black level. As a result, if the d-c component is removed, the only amplitude excursions from the a-c axis will be those corresponding to the synchronizing peaks which will represent comparatively small amplitudes. If these small pulses are to drive the grid of the Kinescope beyond cut-off, it is obvious that some means must be provided whereby the bias on the grid is automatically adjusted to cut-off so that the small negative synchronizing pulses can drive it beyond cut-off.

We can assume that the initial Kinescope bias as determined by the setting of the "Brightness Control" is such that with no signal the Kinescope is operating at the point of cut-off. Assume now that the condition discussed in the previous paragraph is imposed. Because the signal voltage across the video amplifier plate load resistor is small, only a small a-c voltage will be applied in the series a-c circuit represented by the plate circuit decoupling condenser C-3 the plate load resistor, R-3, the 0.005 mfd. condenser C-5, and the diode rectifier. When the plate is positive with respect to its cathode, the diode rectifier passes current which charges the 0.005 mfd. condenser. During periods when the plate is negative veloped across the picture second detector load resistor the voltage excursions from the a-c axis represented by the synchronizing and blanking pulses will represent comparatively high amplitudes. Under such conditions the Kinescope bias must be automatically reduced by a considerable amount from its correct value for a black scene if the blanking pulses are to drive the tube just to the cut-off point and the synchronizing pulses beyond cut-off. An analysis of the circuit as previously made indicates that the larger voltage excursions or peak amplitudes would cause a greater amount of rectification and therefore a correspondingly greater reduction in Kinescope bias. Thus the automatic brightness control or d-c restorer is in reality

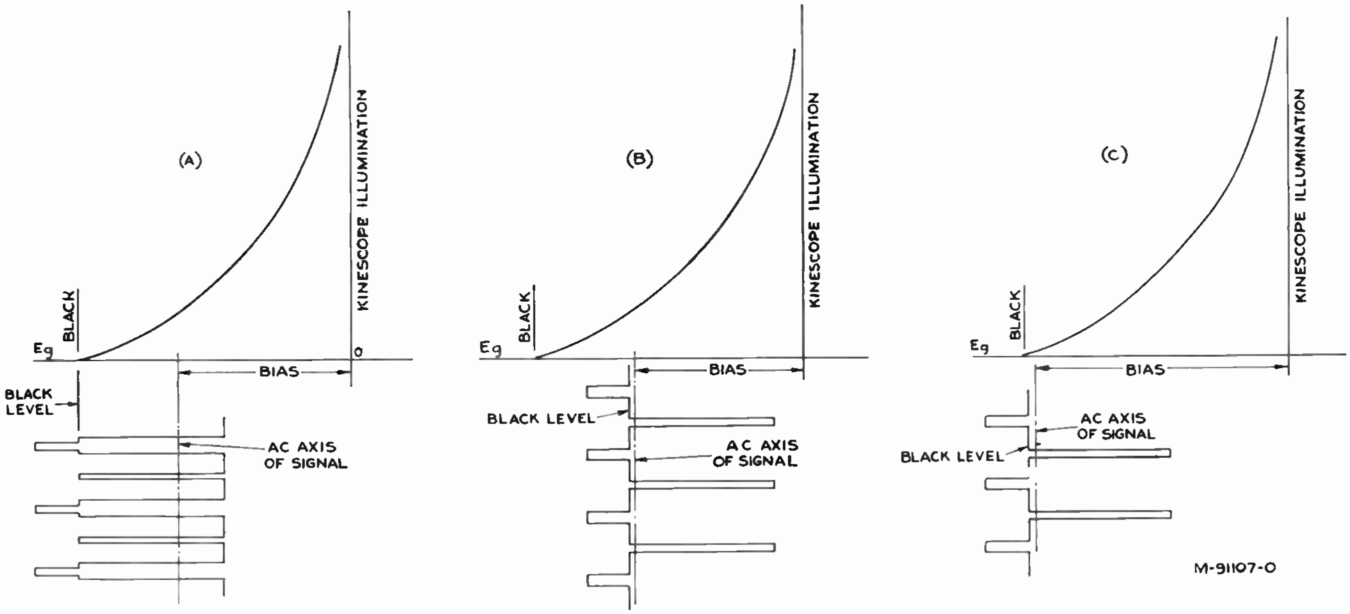


ILLUSTRATION SHOWING KINESCOPE BIAS CORRECTLY ADJUSTED FOR REPRODUCTION OF WHITE PATTERN WITH SINGLE VERTICAL BLACK LINE.

ILLUSTRATION SHOWING REPRODUCTION OF BLACK PATTERN WITH SINGLE VERTICAL WHITE LINE WITH KINESCOPE BIAS SAME AS FOR (A)

ILLUSTRATION SHOWING REPRODUCTION OF SAME PATTERN AS (B) WITH KINESCOPE BIAS CORRECTLY ADJUSTED.

Figure 8—Operation of D.C. Restorer or Automatic Brightness Control

with respect to its cathode the diode rectifier is non-conducting and the condenser discharges partially through the 1 megohm resistor R-5. If the circuit elements are correctly proportioned, the charge across the condenser (and therefore the voltage from cathode to ground) will remain substantially constant during the picture interval between successive horizontal line synchronizing pulses. The effect is to develop across the resistor R-5 a variable bias voltage which opposes the residual bias effected by the brightness control. If the constants are correctly adjusted, this reduction in bias will always be just sufficient to enable the synchronizing pulses to drive the Kinescope beyond cut-off.

Another analysis may be made using as an example an all white scene. Under such a condition, the amplitude of the voltage corresponding to the picture content will be a minimum. Consequently, after the d-c component is removed from the signal voltage de-

an automatic bias control which continually adjusts the bias so that the blanking pulses always drive the Kinescope grid to the desired cut-off point and the synchronizing pulses drive it beyond cut-off.

A reference to A, B, and C of Fig. 8 will serve to further illustrate the need for automatic brightness control. In A, the Kinescope bias has been correctly adjusted for reproduction of a pattern which is all white with the exception of a single vertical black line. In B is shown the application of a signal from a pattern which is all black with the exception of a single vertical white line under the same Kinescope bias conditions as for A. It should be noted that in B the synchronizing pulses no longer drive the grid beyond cut-off. In other words black level now occurs at a point where the Kinescope still has a considerable amount of illumination. The white line therefore will not appear as a white line on a black background but instead will be reproduced as a white line on a slightly whiter or gray background. In C is shown the reproduction of the same pattern but with the Kinescope bias correctly readjusted to make the black level occur at the correct or cut-off bias point.

The time constant of the d-c restorer circuit should be sufficiently long to maintain the bias substantially constant during the picture intervals between the horizontal or line synchronizing pulses but sufficiently short to enable the d-c restorer to follow rapid variations in the average illumination such as occur in motion picture transmission.

Another method of restoring the d-c component is by reinserting it in the signal at the grid of the video amplifier tube by operating the tube at zero fixed bias. This method is illustrated in Fig. 9. The operating bias is then determined by the d-c drop across the grid resistor caused by the grid current.

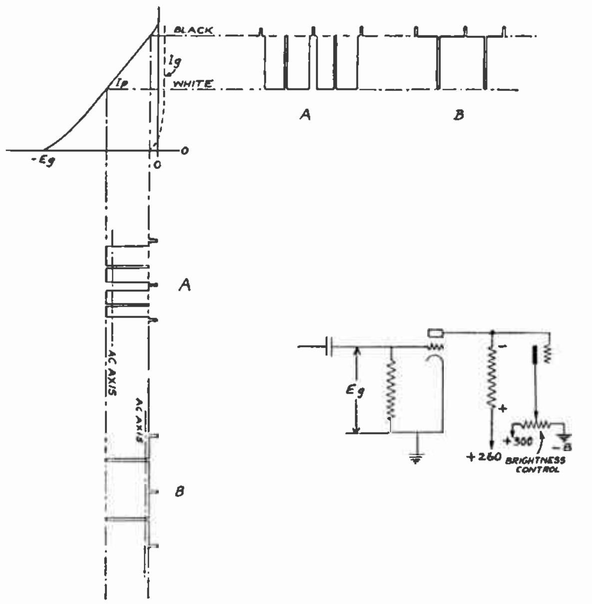


Figure 9—Typical Grid Leak—Condenser D.C. Restorer

To keep the grid current small the grid resistor should be large, a half megohm or more, depending on the tube used. The bias generated by the grid current which flows during the occurrence of the synchronizing pulses is maintained by the charge on the grid coupling capacitor. The time constant of the grid resistance-grid capacitor should be sufficiently long to maintain the bias substantially constant during the picture intervals between horizontal (line) synchronizing pulses, but sufficiently short to follow the variations introduced by the time constant of the v-f circuits preceding this point. It will be noted in this figure that grid current flows during the peaks of the synchronizing pulses, thus maintaining them at approximately the zero bias point regardless of the position of the a-c axis, and that black level therefore occurs again always at the same voltage level, as it did in the detector diode circuit before the d-c component was lost. With this method for restoring the d-c component, it is of course, necessary that the plate of the video amplifier tube be direct coupled to the grid of the Kinescope. In other words, the plate resistor IR voltage drop variation, caused by the amplifier grid bias change, will raise or lower the applied Kinescope grid bias.

Synchronizing Separator Circuits

The signal voltage developed across the picture second detector diode load resistor is also applied to the synchronizing separator circuits which filter out the synchronizing pulses used to control the timing of the deflection oscillators. The signal is applied to the synchronizing separator circuits at the point marked "Input" on Fig. 10. The first synchronizing separator tube operates with a low plate voltage and is grid leak biased to a point where only the synchronizing pulses have sufficient amplitude to cause plate current to flow. This separator tube therefore serves to eliminate most all the picture components from the signal. This type of operation is illustrated in Fig. 11.

In addition to removing most of the picture components, the first synchronizing separator also inverts the pulses or shifts them 180° in phase as in the case of any amplifying tube. The synchronizing amplifier amplifies and again inverts these pulses, and then applies them to the second synchronizing separator. The action of the synchronizing amplifier must not be confused with that of the first synchronizing separator. The amplifier uses a relatively high plate potential and, as in the case of the separator tube, is self biased. A stable operating condition will be reached when the most positive amplitude of the applied signal voltage causes just sufficient grid current to maintain bias during intervening periods. The synchronizing pulses will be in the negative direction but will not drive the grid to cut-off.

The second synchronizing separator is a tetrode operated with a low plate voltage and a relatively high screen voltage. It also is grid leak biased. Under these conditions the tube has a dynatron characteristic and effectively cuts off or clips the tops of the synchronizing pulses as well as effecting further separation of remaining picture components. This characteristic is desirable in that it removes noise components which may have become superimposed on the synchronizing pulses and limits the amplitude of other noise pulses which may have come through. The pulses in the output of the second synchronizing separator will be inverted and therefore in the negative direction.

As the horizontal synchronizing pulses are of short duration and the vertical synchronizing pulses of much longer duration, they can be separated by filters responsive to wave shape. The horizontal pulses can be selected by means of a high pass RC circuit consisting of C-1 and the grid resistor of the horizontal amplifier. The action of an equivalent circuit is illustrated in Fig. 12. The horizontal synchronizing pulses arriving at the grid of the horizontal amplifier are of negative polarity. The amplifier amplifies and inverts them, and they are then applied with correct polarity to the grid of the horizontal deflection oscillator tube to control its frequency of operation. The front edges of all the synchronizing pulses produce positive voltage peaks which serve to trip the horizontal deflection oscillator. The timing of the oscillator is thus maintained even during the period of the vertical synchronizing pulses. The type of deflection oscillator used is not tripped by the positive peaks caused by the equalizing pulses occurring between horizontal periods.

appearing across the second detector load resistor is applied to the diode as indicated. The synchronizing pulses will represent excursions of voltage in the positive direction (due to polarity of connections to detector load resistor). On positive excursions from the a-c axis of the signal, the diode will be conducting and the condenser C-1 will become charged. On negative excursions the diode will be non-conducting and

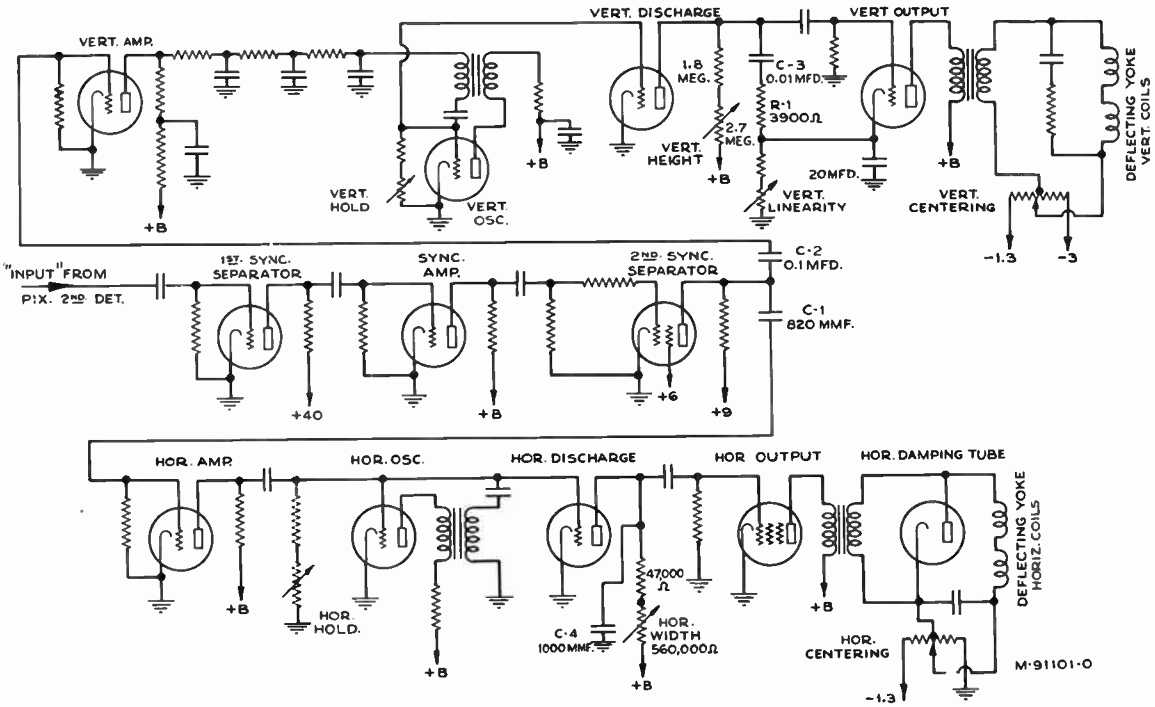


Figure 10—Synchronizing and Deflecting Circuits

Since the capacitor C-2 must be relatively large to transmit the vertical pulses, both horizontal and vertical pulses will be applied to the grid of the vertical amplifier at the top left of Fig. 10. Both are amplified and inverted, and then applied to a filter network known as an integrating circuit. In the case of the typical receiver under discussion, the vertical pulse selecting circuit has three sets of elements in cascade. The action of an equivalent circuit is illustrated in Fig. 13. This filter network allows a charge to accumulate on the condensers proportional to the time the voltage is applied. As the horizontal pulses also present are of comparatively short duration their effect will be minimized.

The equalizing pulses (refer to Fig. 3) function to make the vertical pulses for alternating fields sufficiently alike so that correct interlacing will occur. Since the pulses were inverted once more by the vertical amplifier, the pulses out of the filter will be of the correct polarity (positive) to properly control the frequency of the vertical deflection oscillator to which they are applied.

An alternative method for effecting separation of the picture signals from the synchronizing pulses utilizes a diode rectifier and is illustrated in Fig. 14. In this case only the a-c component of the voltage

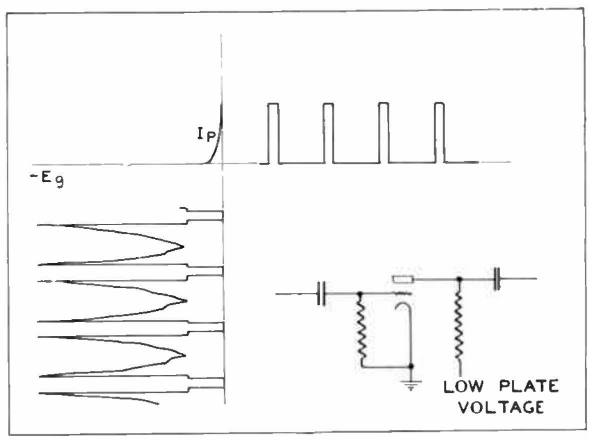


Figure 11—Operation of Synchronizing Separator

the condenser will partially discharge through the resistor R-1. The time constant of the C-1, R-1 circuit, however, is such that the condenser does not discharge appreciably during the intervals between successive synchronizing pulses and as a result currents will flow through the diode only during the periods of the synchronizing pulses. The corresponding voltage pulse developed across the diode load resistor R-2 can then be coupled to the succeeding synchronizing amplifier.

In the two successive amplifying stages of the synchronizing amplifier, the pulses are amplified and rotated in phase 360°. As a result they will be applied with correct polarity to the vertical pulse selecting circuit which precedes the deflection oscillator. Horizontal pulses are selected by the action of L-1 and R-6 and having correct polarity, control the horizontal deflection oscillator.

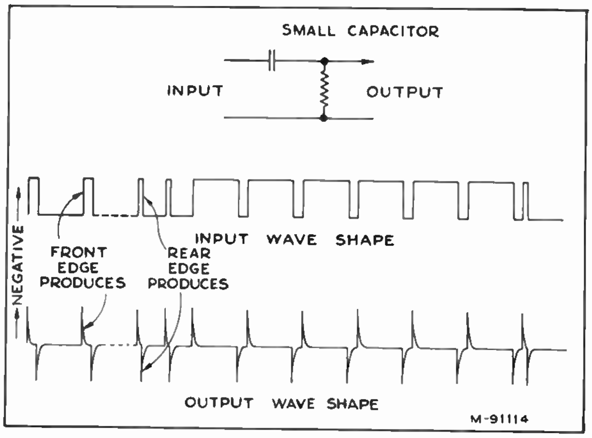


Figure 12—A Typical Horizontal Pulse Selecting Circuit and Wave-forms

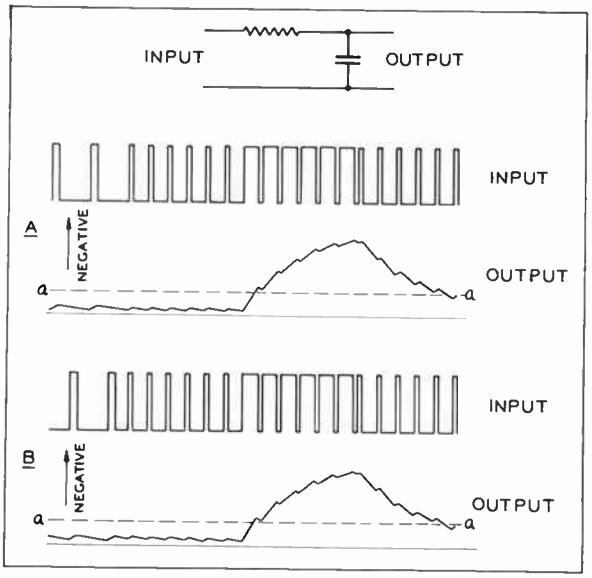


Figure 13—Vertical Pulse Selecting Circuit and Wave-forms

Blocking Oscillator and Discharge Tube Circuits

The operation of a blocking oscillator is shown in Fig. 15. It consists of a tube whose grid is transformer coupled directly to the plate. The starting of the plate current drives the grid positive causing grid current to flow. During the time grid current is flowing a negative voltage is built up across R and this charges the condenser C. When the plate current ceases increasing and begins to decrease, the transformer drives the grid very negative. The negative charge on the grid and condenser C will leak off slowly through R and no action will take place until the grid reaches a potential where plate current can again flow. Then the cycle of events is repeated. The heavy curve shows the natural sequence of grid voltage. However, if at time "S" a voltage pulse is applied to the synchronizing input which will raise the grid voltage to a point where plate current will flow,

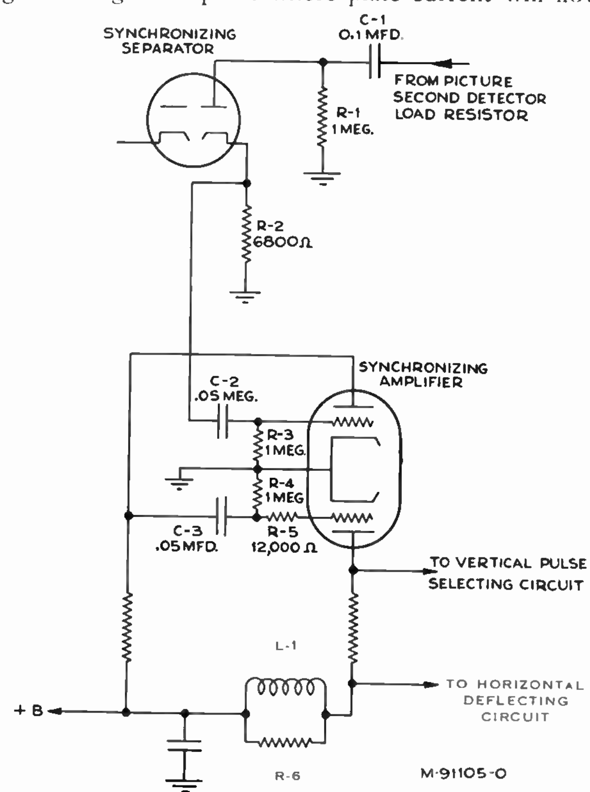


Figure 14—Typical Diode Synchronizing Separator

the sequence of operations will start at "S" as shown by the dotted line instead of later as shown by the solid line. In this manner the synchronizing pulses trigger the blocking oscillators associated with the deflection circuits. It is interesting to note that inherently the blocking oscillator provides some protection from noise pulses. Any noise pulse in the positive direction must be of sufficient amplitude to overcome the negative self-bias on the oscillator before it can interfere with synchronization. Grid resistance, R (called the Hold Control), is made variable to allow adjustment of the free running period or frequency of the oscillator.

Deflection Considerations

Before discussing the operation of the discharge tube circuit and the deflection output tubes, it is advisable to first consider the current and voltage requirements of the deflection coils shown in the diagram of Fig. 10. A study of the current wave requirements and the voltage waves required to produce the desired current waves will serve to make apparent the reasons for the arrangement of circuit components.

A deflection circuit in a television receiver performs the function of supplying the force which deflects the electron beam in the Kinescope. This force must be of such a type that it deflects the beam in the same manner and in synchronism with the electron beam in the Iconoscope at the transmitter. For rectilinear scanning this force must have a linear change while the beam is traversing one line (or field, for vertical deflection) sweep, and a rapid return to the original condition at the end of the line (or field sweep). Thus the time-amplitude wave of the deflecting force is of sawtooth wave shape with a slow linear rise and a rapid fall. The vertical deflection circuit must have a period of 1/60 second and the horizontal deflection circuit a period of 1/13,230 second.

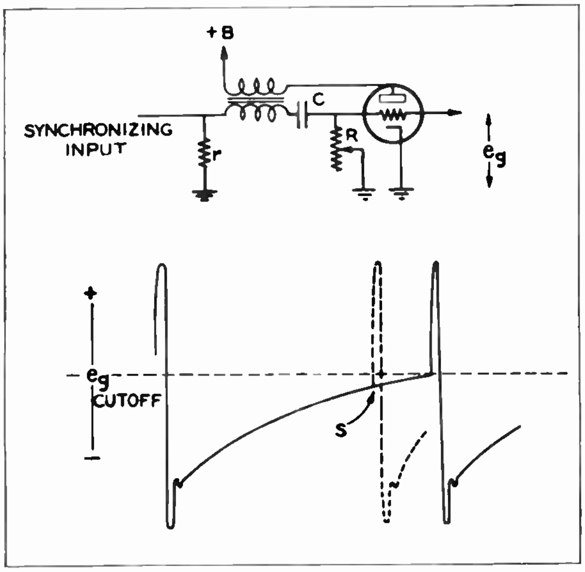


Figure 15—Blocking Oscillator and Wave-form

The force producing the deflection may be either electro-static or electro-magnetic. In the typical example selected, electro-magnetic deflection is used for both horizontal and vertical deflection.

Most technicians are familiar with electro-static deflection through its application in cathode ray oscillographs. For electro-static deflection, a sawtooth voltage wave is impressed on the deflection plates. Electro-magnetic deflection requires that a sawtooth current wave be passed through a deflection coil arranged around the correct portion of the neck of the tube. The generation of such a sawtooth current wave may require an applied voltage wave of somewhat different form as is evident from Fig. 16.

To produce a sawtooth current wave as shown by "A" through a pure inductance requires an applied voltage wave as shown in "B." To produce a sawtooth current wave through a resistance requires a sawtooth voltage wave as shown in "C." If the circuit has both resistance and inductance, the applied voltage wave must be a combination of the waves shown at "B" and "C" as shown by "D" in order to produce a sawtooth current wave.

The deflection current is produced by an output tube to the grid of which is applied a voltage of the correct wave shape to produce the desired sawtooth current wave. The vertical deflection output tube in the typical receiver under discussion is a triode. The vertical deflection coil has a considerable amount of inductance as well as resistance. The voltage wave required on the grid of the vertical output tube is therefore of the type required to drive a sawtooth of current through a resistance and inductance. The method for generating this special voltage wave will be discussed under the section "Discharge Tube Circuits."

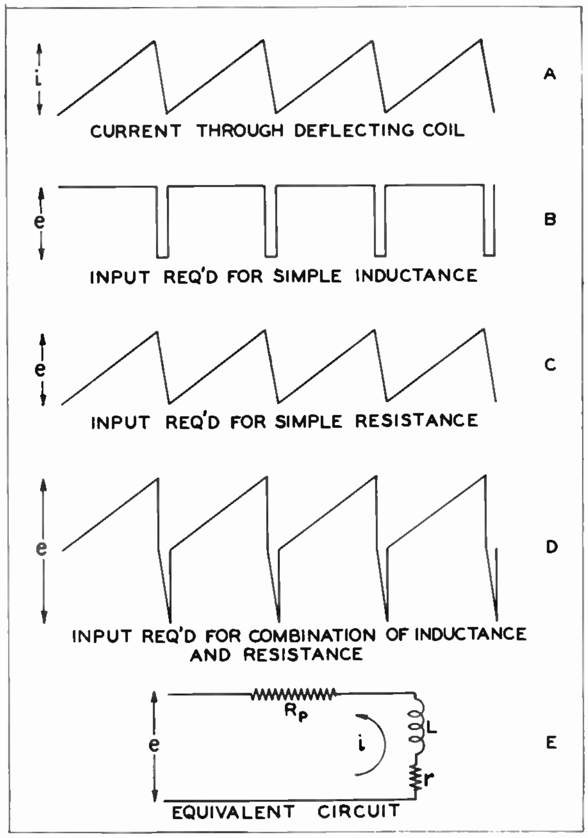


Figure 16—Wave-forms for Deflection

A pentode is used for the horizontal deflection output tube. It is usually biased by means of a cathode circuit resistor which is not by-passed in order to obtain the favorable effects of cathode circuit degeneration. Because the tube has such a high plate resistance and since the inductance of the horizontal deflection coil as compared to the tube's plate resistance is quite negligible, the voltage required on the grid is essentially a sawtooth as shown in "C" of Fig. 16. Because of the high resistance of the horizontal output tube, it offers very little damping to the inductance of the deflection coil, so that when the current changes abruptly a transient condition is set up which must be damped out. This is accomplished by a diode which acts as a switch to remove the load during the return time while still preventing the transient during the active scanning time.

Discharge Tube Circuits

The operation of a discharge tube is illustrated in Fig. 17. The grid is normally biased to cut-off, but is supplied with a positive pulse at the end of each scanning line by the associated blocking oscillator which in turn has been set off or triggered by the transmitted synchronizing pulse. The positive pulses from the blocking oscillator are shown at the left of Fig. 17. During the periods between the grid pulses, the condenser C will be charging through the resistor R. The values of R and C are such that the charge on C never exceeds a small percent of the +B voltage. Under these conditions, the rise in voltage across the condenser will be practically linear, and the wave form of this rising voltage will therefore be substantially equivalent to the rising portion of the sawtooth voltage wave shown for C of Fig. 16. When the positive impulses drive the grid to zero or positive potential, the tube becomes conducting and discharges the condenser through the tube. Thus, by alternately charging the condenser C through the resistor R and discharging it through the tube, a sawtooth voltage wave may be generated across the condenser C. This sawtooth voltage wave may be coupled to the grid of the horizontal output tube to produce a sawtooth current wave in its output circuit. In the case of the vertical output tube, however, a voltage wave equivalent to that of D in Fig. 16 is required. A wave form substantially equivalent to that of "D" may be obtained from the discharge tube circuit when a resistor (commonly called a "peaking" resistor) is placed in series with the charging capacitor and connections made to the terminals of the series combination.

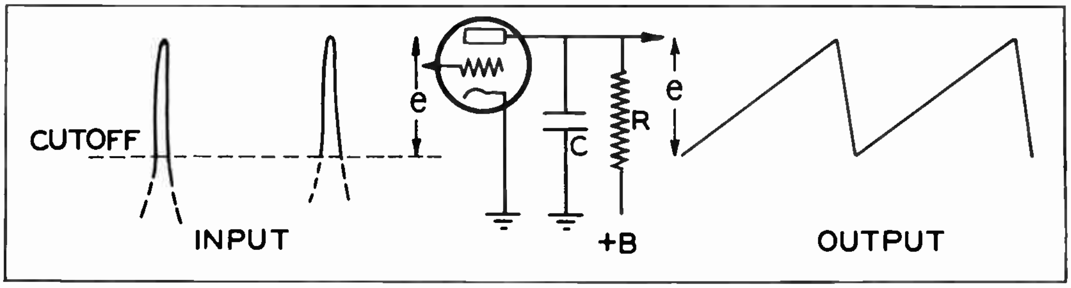


Figure 17—Operation of Discharge Tube

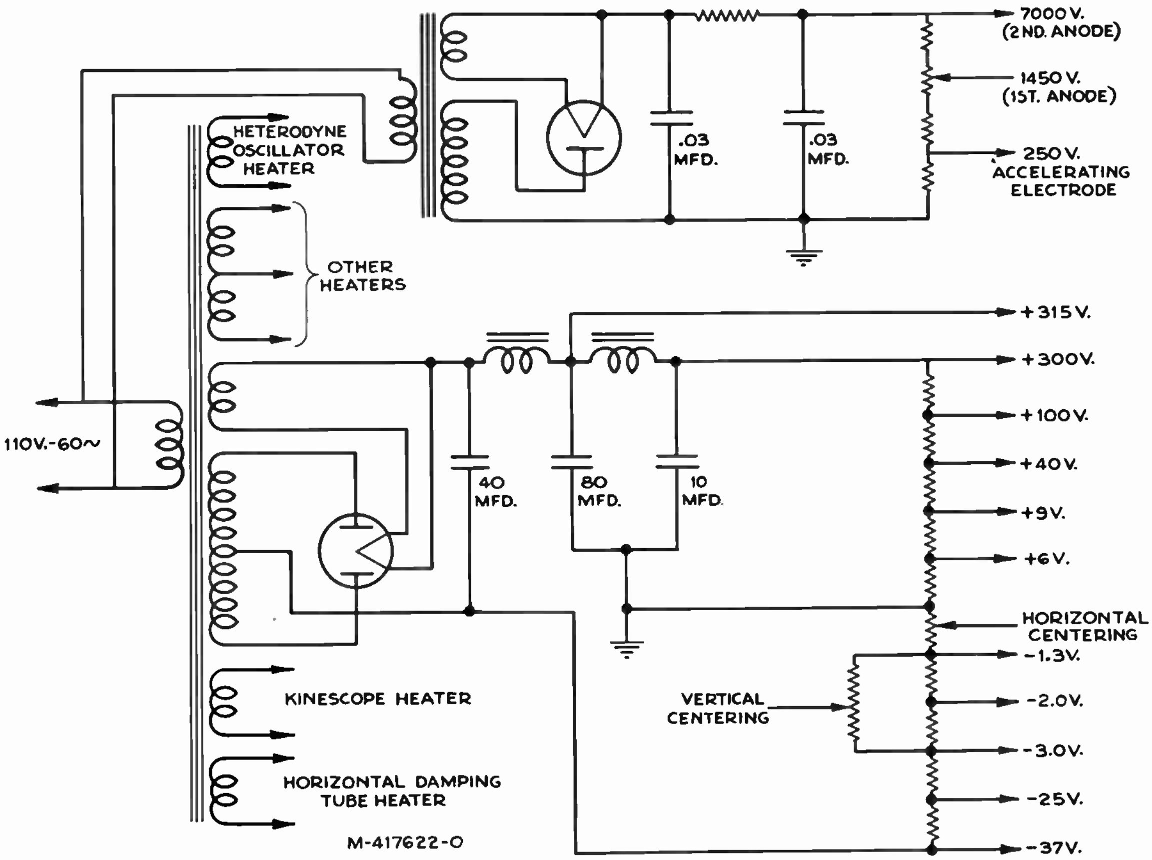


Figure 18—High and Low Voltage Power Supply

A reference to Fig. 10 will indicate that these circuits have been applied in the case of the typical receiver under discussion. It should also be noted that the discharge tube circuits include provisions for varying the height, width, and vertical linearity. The height and width controls are variable resistors in the +B supplies to the discharge tube plates. Since they control the charge which can be built up across the condensers (C-3 and C-4 in Fig. 10) during a given interval, they control the amplitude of deflection. The vertical linearity control is located in the cathode circuit of the vertical output tube and is adjusted until the desired tube operating characteristic is obtained. The vertical linearity and height controls are to some extent related and if one is adjusted, the adjustment of the other must always be checked. In the case of receivers equipped with one of the smaller Kinescopes, the vertical linearity control may be omitted.

In the typical receiver circuits illustrated in Fig. 10 provision is also made for horizontal and vertical centering of the Kinescope image. As is evident from the diagram, these controls make it possible to pass d-c through the deflection coils and thus secure correct centering of the picture.

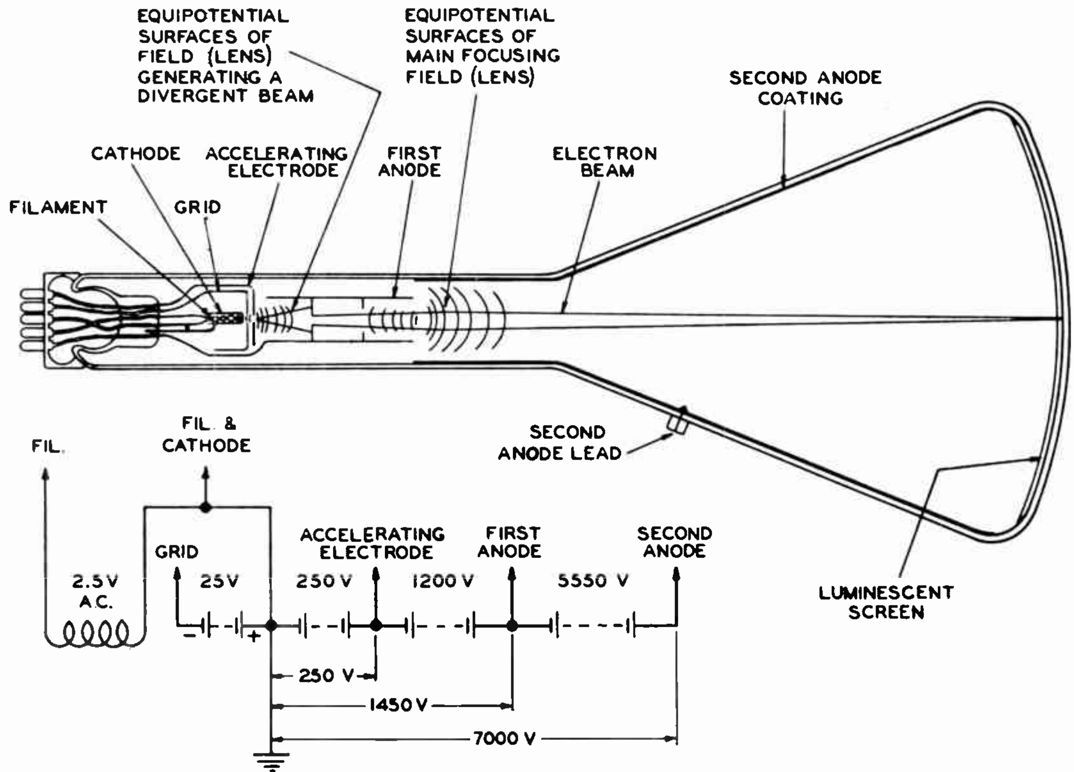


Figure 19—The Kinescope and Voltage Supply System

Power Supply

In order to supply power to operate the television receiver, two rectifiers are used, a high voltage low current rectifier for supplying Kinescope anode voltages, and a lower voltage rectifier for supplying plate voltage for the amplifying tubes. Figure 18 shows these two rectifiers schematically. At the top of the diagram is shown the high voltage rectifier which supplies voltage for the first and second anodes and the accelerating electrode. The voltage applied to the first anode is adjustable so that the electron beam can be focused to a fine point. As the current consumption of the Kinescope is very small, a resistor capacitor filter will give satisfactory filtering. A half-wave rectifier is used because of the resulting economy and because the filtering problems are not severe when only a very small amount of current is required. The low voltage rectifier is conventional except that it has unusually good filtering to insure hum free operation, and has more bleeder taps than usual.

Kinescope

The elements in the Kinescope and their connection to the high voltage power supply are shown in Fig. 19. In addition, the curvature of the electrostatic field is shown. Due to the difference in voltage between different elements, the surfaces having equal potentials will be curved as shown. The electron stream passing through this curved field will have a tendency to be deflected so that the electrons will tend to cross the equipotential surfaces more nearly at a right angle. By proper curvature of the field, the electron stream can be made to come to focus at the florescent screen on the end of the tube. In order to make the curvature of the electrostatic field the right amount for proper focus, a variable voltage control known as the focusing control is provided for the first anode. The final adjustment of this focusing control should always be made on a received picture signal.

General Information on Installation

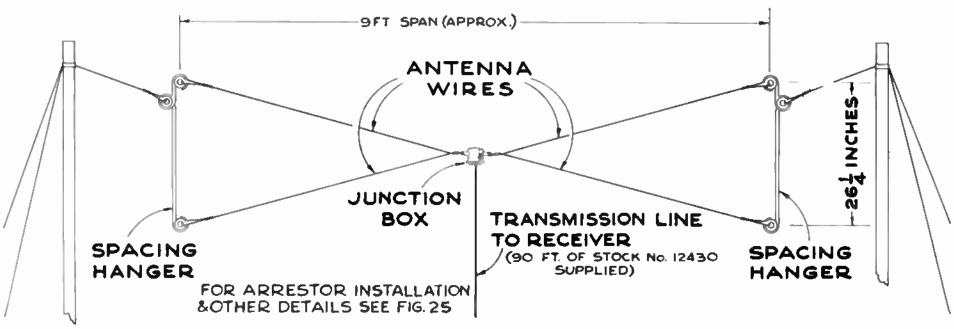
Specific installation information is given in the operating instructions accompanying each RCA Victor Television Receiver and in the installation instructions accompanying each specially developed RCA Victor Television Antenna.

In order to supplement this published information, this section has been included in this booklet.

The Receiver Location

The customer buying the receiver probably has either decided on the location for his television receiver or is awaiting a recommendation from the technician who will visit the home in the course of a survey or installation.

The receiver should be located in a room that can be darkened conveniently by drawing the window shades or curtains. A poor location for a television receiver would be a sun porch or solarium. In any case, no direct light should be permitted to fall on the viewing screen.



Assembled Length from Center of Junction Box to Center of Insulators on Spacing Hangers

Frequency Band	Inches
44-50 mc	54
50-56 mc	54
66-72 mc	39
78-84 mc	32
84-90 mc	32

Figure 20—Typical Installation of RCA Double "V" Television Antenna

At night, the room need not be in total darkness. A bridge or table lamp having a 40 or 60 watt bulb lighted and located as far as possible from the receiver will supply enough illumination to permit the viewers to move about but will not be sufficiently bright to seriously affect viewing the television program. Whenever possible all lights in the room should be controlled by a master switch which increases the convenience in darkening the room. It is an advantage to have the room as dark as possible in order to permit proper adjustment of the contrast and brightness of the viewed picture and so insure true half-tone reproduction of the received pictures.

The actual location of a receiver in a room will depend largely on the space available, the blending of the cabinet with other furnishings, the desires of the customer and availability of a 110 volt 60 cycle a-c power outlet. The location of the receiver should take into consideration the viewing by the whole family group plus a party of friends. A minimum viewing distance from the screen to the first row of chairs might be on the average of two to four feet so that the image line structure does not detract from the program. Seating might be arranged as follows, first row—3 chairs; second row, 4 chairs; third row, 5 chairs. Such an arrangement might have a bearing on the location of the receiver in the room.

The receiver should never be placed in a closet or wall recess. Accessibility for adjustments and provision for ventilation must be considered when selecting the receiver location. It must be remembered that a receiver with a viewing mirror in the lid needs sufficient clearance so the lid may be raised to an angle of 45°, the proper viewing angle. Convenience to an a-c power outlet is important as power cord extensions are to be avoided.

When a broadcast receiver is used to supply the sound output for an attachment type television receiver, the latter should be installed upon or near the broadcast receiver. This is necessary to insure that the sound accompanying the television program shall give the illusion of emanating from a location near the television screen. This arrangement will also insure that the low level audio connection from the television attachment to the broadcast receiver will be as short as possible. The lead used should be of the single conductor shielded type having low capacity. A five foot length of the correct type is supplied with each RCA Victor attachment type television receiver. If a longer length is required to reach the broadcast receiver, a lower capacity cable should be substituted as otherwise loss of high audio frequencies will result. Connection to the broadcast receiver should be to the phonograph jack or terminal board with which most receivers are now provided. If no convenient connection is available, the broadcast receiver should be modified as for record player connection. Information as to proper connections usually may be obtained from the manufacturer's service notes. On AC-DC broadcast receivers that have the power line grounded to the chassis through a capacitor, severe a-c hum may result. In these cases, isolation of the AC-DC receiver with a 1:1 line transformer for a-c operation will be necessary.

Once the receiver is located, the transmission line run and antenna location to insure maximum efficiency may be more readily determined.

The Antenna—Types and Location

As is well known, the ultra high frequency radio waves used for television broadcasting are "quasi-optical" in their propagation characteristics. In other words, they act similar to rays of light and are subject to similar reflections, diffractions, etc. in their travel through space. The transmitting antenna may be compared to a lighthouse. The latter is always built as high as possible and located on a hill, such as the Atlantic Highlands light, so the distance to the horizon is as great as possible. The NBC transmitting antenna on the Empire State Building permits sufficient height to give a horizon distance averaging about 40 miles. Under ideal conditions of the intervening earth's surface, local noise conditions, antenna type and height above sea level, etc., the reception range may be extended. The u-h-f radio waves used in American television transmission are horizontally polarized. Therefore the receiving antenna normally must be mounted so the effective pick-up sections are in a horizontal position or symmetrical to a horizontal plane.

The primary requisite for the antenna location is to place it in a "line of sight" or as near a "line of sight" as possible and broadside position to the transmitting antenna. This often means that the antenna should be placed near, or on, or above the roof of the residence or apartment house. The location on a suburban dwelling may usually be decided upon from the standpoint of roof accessibility, availability of supports, and shortest possible transmission line run. Reflection phenomena are not often present in the suburbs, so it is not likely that the antenna location need be changed once it is decided upon.

Obviously as the horizon distance from the transmitter is approached, many objects may intervene to destroy the "line of sight." Usually, the higher the antenna is erected under such conditions the greater will be the received signal. The actual received signal intensity under any conditions is a function of the receiving antenna height. Increased height may also reduce auto ignition interference, etc., resulting in a sufficiently improved signal-to-noise ratio to give satisfactory reception.

Figure 20 illustrates a typical installation of the RCA Double "V" Wire Type Television Antenna Stock No. 9870. It is suggested for use in the suburbs but is not particularly recommended for congested city areas. Obviously points of support must be either found or installed so the antenna when erected is broadside to the television transmitter location. Wherever possible the supports should be chosen or erected so the antenna is not only broadside to the transmitter but removed as far as possible from highways, hospitals and doctors' offices. Auto ignition and diathermy apparatus may cause noise interference impairing the picture.

If such supports are not available, or too costly to erect, then a practical solution is the installation of an RCA Double Dipole Television Antenna Stock No. 9871. This antenna is designed for single pole mounting. The sturdy design and corrosive protection of the metal parts provide added safety when installed in high locations. The section of four foot wood support pole supplied is round to permit rotation for the most satisfactory signal. Figure 21 illustrates its assembly.

Frequency Band	Length of Rod to Shoulder: Antenna	Reflector (See Fig. 25)
44-50 mc	63-in.	69-in.
50-56 mc	63-in.	69-in.
66-72 mc	45-in.	50-in.
78-84 mc	38-in.	41-in.
84-90 mc	38-in.	41-in.

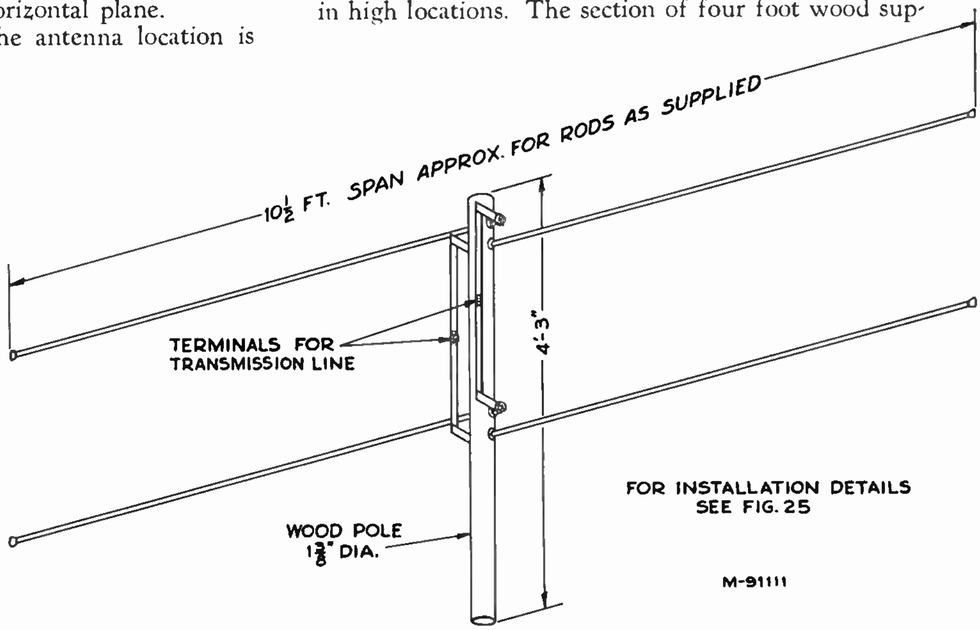


Figure 21—The RCA Double Dipole Television Antenna

Both the Double "V" and Double Dipole types are specially designed to have a sufficiently broad frequency response to cover the contemplated use of the television spectrum with good efficiency and are therefore superior to the common single dipole. Should greater efficiency be desired for any one television channel, then the wire lengths or dipole rods should be shortened in accordance with the information accompanying Figs. 20 and 21.

The RCA Victor Television Antennas when used with the RCA Victor Television Receivers and Transmission Lines provide reduction of noise picked-up by the transmission line. All RCA Victor Television Antennas, of course, receive practically no signal from the direction to which the free ends of the pick-up sections point. When positioning or rotating the antennas this characteristic should be considered in obtaining the most satisfactory reception.

In the congested city areas, the antenna should be installed permanently on the apartment or residence roof **only** after actually observing results on the television receiver. A temporary transmission line can be run between receiver and the antenna allowing sufficient slack to permit moving the antenna. Then, with a telephone system connecting an observer at the receiver and an assistant on the roof at the proposed antenna location, the antenna can be positioned to give the most satisfactory results on the received signal. *A shift of only a few feet in antenna position may effect a tremendous difference in picture reception.*

A better understanding of the multi-path or reflection phenomena can be had if the sketch of Fig. 22 is studied.

Radio wave propagation velocity is 186,000 miles per second, therefore a radio wave in traversing one mile requires $\frac{1}{186,000}$ of a second. For two miles, $\frac{2}{186,000}$ or $\frac{1}{93,000}$ of a second is required.

On a 12-inch Kinescope such as used in the RCA

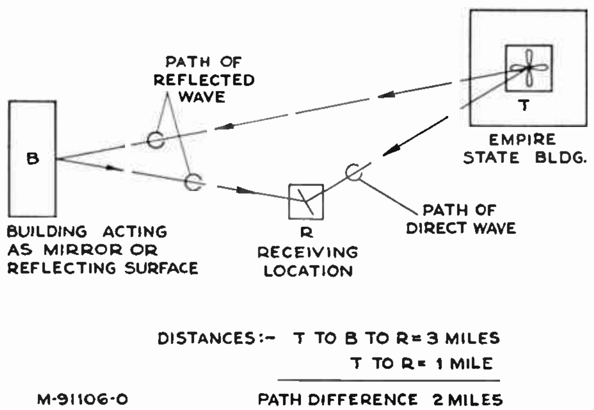


Figure 22—Direct and Reflected Transmission Paths

Victor TRK-12, the electron beam requires approximately $\frac{1}{15,000}$ of a second to travel the full horizontal screen dimension of about 10 inches. To travel one inch requires only $\frac{1}{150,000}$ of a second. As a matter of interest, the horizontal scanning speed of the electron beam is upwards of 4,500 miles per hour (depending on size of Kinescope) in traveling from left to right.

In an actual period of time, the reflected wave is delayed a difference of $\frac{1}{93,000}$ second from the direct wave because its transmission path is two miles longer. It should be apparent then that the reflected signal will cause a second image displaced $\frac{93,000}{150,000}$ of an inch or about 5/8-inch on a 12-inch Kinescope to the right of the primary or wanted image.

The reflected signal image may be white or black depending on its polarity. In intensity, it may vary from almost as intense as the primary image to a point where it is just noticeable. Any difference in relative intensities of the signals is due to the attenuation the reflected waves may encounter in their transmission path. Obviously, in any congested area there may be multiple reflection paths that may set up multiple images. In some locations, such effects may prevent satisfactory television reception. *Reflections, hardly noticeable in themselves, may cause the wanted image to appear fuzzy.*

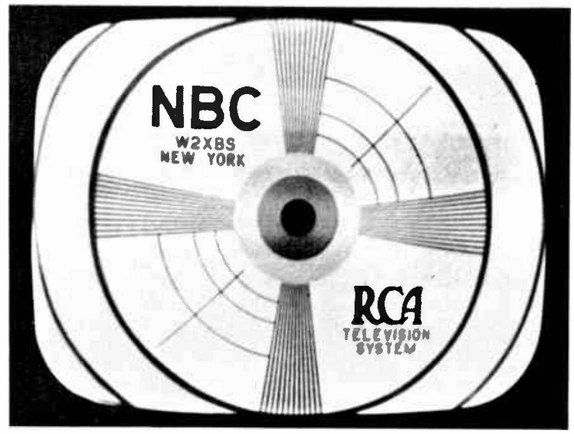


Figure 23—Normal Test Pattern

In Fig. 23 is shown the test pattern which the National Broadcasting Company will transmit at periodic intervals. This figure is an unretouched photograph of an image obtained from a signal that contained no reflections or "ghosts" due to multi-path reception.

Figure 24 shows the same test pattern seriously

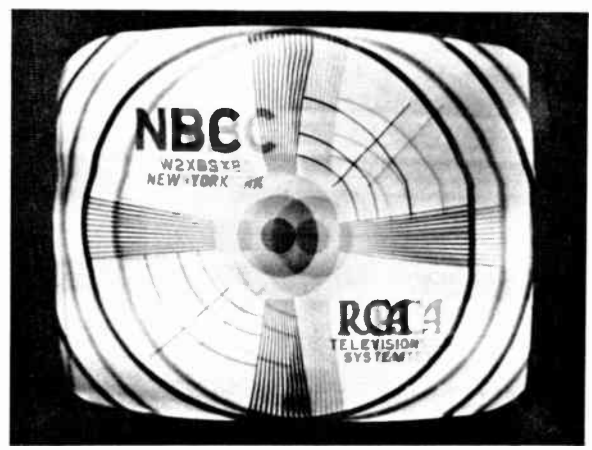


Figure 24—Test Pattern Marred by a Reflected or Multi-path Signal

marred by a reflected signal. Needless to say a televised program would be likewise impaired and would be unsatisfactory to the owner of the television receiver.

The RCA Double Dipole Stock No. 9871 with Reflector Stock No. 9872 is designed to greatly reduce pickup from the direction opposite to the transmitter location. Reflection phenomena such as illustrated in

Fig. 24 often can be reduced materially or entirely eliminated with such an antenna installation. Reflections coming from such a direction as to form a broad angle with respect to the direction of the direct wave will usually be attenuated due to this antenna having a comparatively narrow zone of reception. *The directional feature is obtained at negligible sacrifice of frequency response band, and is a function of its unique design.* In some locations, sufficient signal strength may be available to permit rotating the antenna from the normal broadside position so advantage of the antenna's directional characteristic can be taken to minimize any serious noise interference.

The RCA Double Dipole and Reflector combination, while reducing pick-up from the direction opposite to the transmitter, also increases the signal pick-up from the transmitter. Compared to a simple dipole the gain in signal strength is about 1.5 times. Reception from the transmitter location to that from the opposite location is in the ratio of about 3 to 1. Where low signal strengths are liable to be received due to distance or shielding effects, the installation of the combination RCA Double Dipole and Reflector will give an improved signal-to-noise ratio that may be sufficient to obtain satisfactory results.

Figure 25 illustrates a typical installation of the RCA Double Dipole, Stock No. 9871 and Reflector, Stock No. 9872. Assembly details and use of the RCA Mounting Bracket, Stock No. 9873, are shown. The latter provides a wide range of mounting possibilities and still permits the antenna assembly to be rotated for best receiving conditions. Other accessories such as Stock No. 9874 6-foot Mounting Pipe, Stock No. 9879 Pipe Yokes or Special "U" Bolts and Stock No. 9875 Extension Pole Coupler are also illustrated. The Mounting Pipe normally used to mount the assembly of the Double Dipole and Reflector may be used with the Extension Pole Coupler to increase the height of the Double Dipole if the latter alone is installed.

In mounting any antenna, care must be taken to keep the antenna rods or pick-up wires proper at least ¼ wave length (at least 6 feet) away from other antennas, metal roofs and gutters or any metal object. Local fire regulations may require a certain clearance between antenna and roof.

Under certain extremely unusual conditions, it may be possible to rotate or position the antenna so it receives the cleanest picture over a reflected path. If such is the case, the antenna should be so positioned. However such a position may give variable results as the nature of reflecting surfaces may vary with weather conditions. A wet surface has been known to have different reflecting characteristics than a dry surface.

In short, a television receiving antenna and its installation must conform to much higher standards than an antenna for reception of International Short Wave and Standard Broadcast signals because:

(1) Intervening obstacles have a pronounced shielding effect on the ultra-high frequency waves producing low intensity signals. Severe trouble with multi-path reception may often be experienced, especially in congested city areas.

(2) The picture signal is comprised of a very wide band or range of frequencies, all of which must be received with good efficiency.

(3) It must be continually remembered that the discernment of the eye is much more critical than that of the ear. *The finest television receiver built may be said to be only as good as the antenna design and installation.*

The Transmission Line

RCA Victor has made available two types of exterior transmission lines. One is a special low loss weather-proofed line having the correct surge impedance to match the RCA Victor Television antennas and the RCA Victor Television receivers. It is carried as Stock No. 9882 in 1,000 foot rolls. The second type is a standard weather-proofed line also having the correct surge impedance for proper matching. It is carried as Stock No. 12430 in 90 ft. rolls, Stock No. 12429 in 45 ft. rolls and is available in 1,000 ft. spools as Stock No. 9881. Use of improper lines may result in excessive loss or may lead to line reflections, resulting in multiple images or "ghosts" and thus impairing the reception.

For transmission line runs excessively long such as over 200 feet, or where the receiver is located in an area of weak field strength the low loss line Stock No. 9882 is to be recommended. It's voltage loss is about 4 db per 100 ft. at 50mc. For the average residential installation the standard line, Stock No. 12430, etc. will usually suffice. Its voltage loss is about 8db per 100 ft. at 50mc.

The standard line is also available with non-weather proof braid in two colors for interior work. The white is Stock No. 9883 and the brown is Stock No. 9884 for 1,000 ft. spools. This line should be used for all interior line runs because of its improved appearance and because it prevents marring of wood work and walls as so often happens with the weather-proofed finish. Using these interior lines in conjunction with the listed weather-proofed lines insures correct impedance matching throughout.

The Ground Connection

It is extremely important that a good ground connection be provided for the receiver. This is necessary to protect the user in case of a primary to secondary breakdown of the high voltage transformer.

Installing the Transmission Line

After the antenna and receiver locations have been decided upon, the residence or apartment should be carefully surveyed to determine the best method of running the transmission line. The most important consideration is to keep the run as short as possible consistent with other factors such as appearance and availability or accessibility of support.

In the residence, a neat installation of the transmission line can be made by entering the basement through a porcelain tube in a window frame and terminate the outside line at a doublet type lightning

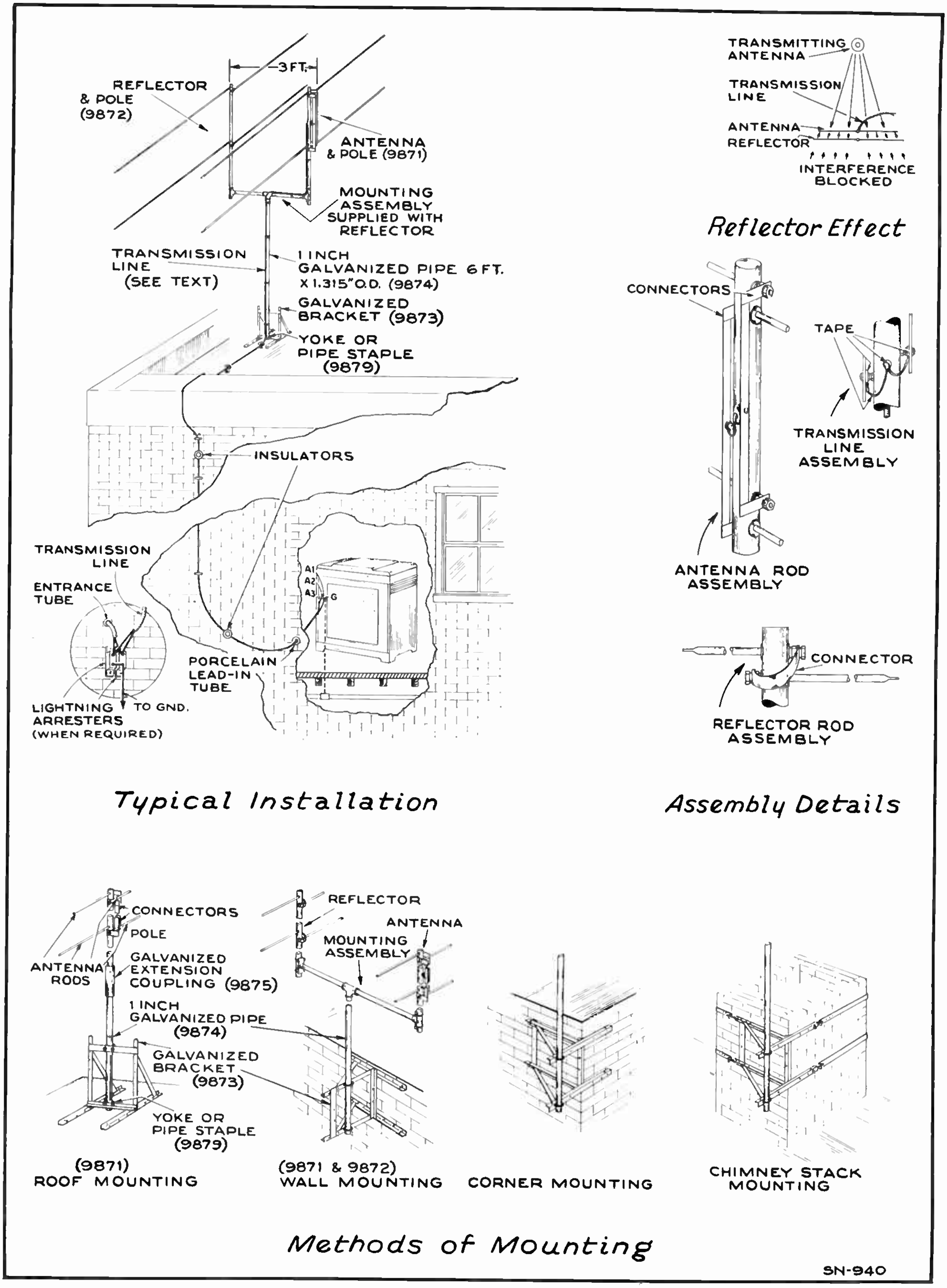


Figure 25—Typical Installation Details of RCA Double Dipole—Reflector Antennas

arrestor. The latter may be located near the cold water pipe for a convenient connection, if local ordinances permit. From the arrestor the interior line can be run along the beams to the receiver location. Here a 5/16 inch hole can be inconspicuously drilled, with the owner's permission, through the floor adjacent to the base board. The necessary ground line for the receiver may be taken through the same hole for connection to the cold water pipe. The ground line should not be kept adjacent to the transmission line except in passing through the floor.

Entrance to the receiver location in an apartment usually presents more of a problem. A common means of entrance is to drill a hole through the window frame or sill. Where walls are rather thick, an 18 inch long—3/8 inch diameter electrician's bit will be found invaluable. Instead of using a porcelain tube as an entrance protection for the line, rubber tape can be formed at the entrance hole. Interior line should be spliced, or connected, through a lightning arrestor, to the outside line.

Outside runs of transmission line should be supported every 8 to 12 feet. Telephone bridle rings are a convenient and inexpensive means for line support. Number 14 Rawl or similar plugs should be used for support of the rings when masonry is encountered. Clearing rain gutters may easily be done by using 6 inch, 8 inch or 12 inch screw eye insulators. Slack should be taken up on the line wherever a turn in the run is made and appropriately secured by tape. When the line has to be subjected to abrasion due to lack of anchorage for screw eye insulator or ring, 1/2 inch loom should be used, and secured to the line by tape. Whenever rubber tape is used it should be covered with friction tape to prevent deterioration by the elements. The line should always be carried down the antenna support pole so it is kept clear of the antenna field for at least a 1/4 wave length.

Interior runs should be secured by insulated tacks or staples of the color to match the line. When using tacks the line should not be pierced to avoid possibilities of shorts. Interior runs may usually be concealed behind picture molding or run along tops of base boards to make a neat installation. The line should be kept off the floor to prevent damage.

Obviously all splices should be soldered with rosin-core solder and properly taped. Soldering lugs should be used for arrestor and receiver connections to avoid fraying of wires and possible loose or shorted connections.

In order to maintain proper impedance relations at the receiver, at splices, etc., the individual wire lengths protruding from the braid of the line should be kept as short as possible and never fanned apart. Two separate lightning arrestors are shown installed in Fig. 25, in order to minimize the fanning of transmission line leads. In low signal strength areas careful attention to such details will insure maximum signal at the receiver input. Tape should be used to dress the frayed ends of the line braid. *At the conclusion of the line installation it should always be checked for continuity and short circuit.*

Multiple Receiver Installation

In order to operate more than one receiver from a single antenna installation, as may be desired for store demonstration, an RCA Distribution Transformer, Stock No. 9885 is available. The transformer is designed to normally operate four receivers having an input impedance of approximately 100 ohms. Mechanically it is arranged to mount in a standard four inch wall box and cover at least 2½ inches deep over-all. The transformer provides excellent frequency response covering the contemplated use of the television spectrum. This feature causes an unavoidable sacrifice in signal level so that the signal voltage to each receiver is reduced to one-half of that if no transformer was used. Assuming a relatively noise free location, a minimum signal voltage of 2 millivolts at the end of the transmission line before connection to the transformer is recommended. By using four additional transformers as many as 16 receivers may be operated. In the latter case a further sacrifice in signal level to each receiver is unavoidable and such an arrangement should not be installed unless there is at least 4 millivolts at the end of the transmission line before connection to the first transformer. Interaction of receiver r-f oscillators may occur to produce a beat frequency interference pattern (illustrated in Fig. 46) which may be objectionable. Use of H pad attenuators at each receiver (see page 31) may be necessary to minimize this unavoidable condition. The H pads used should be those having the least attenuation that removes the interference pattern. It must be remembered that the H pad used for any receiver attenuates the signal so a proportionate increase of signal level at the end of the transmission line must be available for proper operation of receivers.

Receiver Installation and Adjustments

After uncrating the receiver, all shipping supports should be removed. The Radiotrons packed in a separate carton should be installed in accordance with the tube layout label of the cabinet.

Installing the Kinescope

The Kinescope should next be installed following the particular instructions specified for the receiver as given in the service notes.

A general procedure should be undertaken as outlined in the following paragraphs. The receiver should be made ready for the installation of the Kinescope. The inside surface of the receiver's protective glass viewing window should be wiped clean, using "Windex," or similar cleaning agent, and a soft cloth.

All RCA Kinescopes are shipped in special cartons and should always be left in the cartons until ready for installation in the receiver.

The RCA 1803-P4 (12 inch) Kinescope is equipped with protective lid and shield.

CAUTION

Upon opening the shipping carton, *do not* remove the protective lid unless *shatter-proof goggles and gloves are worn.* People not so equipped should be kept away while handling Kinescopes. Keep Kinescope away from body while handling.

Do not at any time remove the close-fitting cone-shaped section of the protective carton or shield from the Kinescope. This section is to be installed with the tube in the cabinet and is designed to protect the user while handling the glass bulb. The bulb encloses a high vacuum and consequently, due to its large surface area, is subjected to considerable air pressure. For these reasons, these Kinescopes must be handled with more care than an ordinary receiving tube.

The large end of the Kinescope bulb—particularly that part at the rim of the viewing surface—must not be struck, scratched or subjected to more than moderate pressure when the tube is being inserted into it's socket. If the tube sticks, or fails to slip into its socket or deflecting yoke smoothly, investigate and remove the cause of trouble. **Do not** force the tube.

When the Kinescope is in place, the viewing screen surface should be wiped clean of all finger marks, dust, etc. by using "Windex" or similar cleaning agent, with a soft cloth.

After the Kinescope is installed, the rubber mask, if supplied should be set in place and oriented so its edges are parallel with the protective glass window aperture. Properly replace and fasten any removable protective glass window of the receiver.

The Kinescope must fit flush against the mask. Should the Kinescope be found not to fit properly due to the nature of the glass envelope and neck an adjustment of the Kinescope support has to be made.

In the RCA Victor TRK-12 and TRK-9 Television Receivers, the Kinescope is held up against the mask by means of the deflecting yoke. The latter in turn is secured by a clamp assembly that permits rotation and placement against the bulb. This assembly is in turn secured to a cabinet support by four screws. In setting the Kinescope flush against the mask, these four screws may have to be loosened. Over-size screw holes permit movement of the yoke assembly. With the screws loosened the Kinescope should be grasped at the neck and gently moved about until the face or screen fits snugly against the mask all around. When the correct position has been found, the screws should be tightened. **Extreme care** must be used to prevent breaking the Kinescope. To improve the Kinescope screen edge masking, it may be necessary to rotate the Kinescope within the limits permitted by the second anode high voltage lead in the TRK-9. In the TRK-12 this may be done by rotating the mask with respect to the Kinescope. This adjustment may have disturbed the mask position with respect to the glass cover aperture and if so the mask should be re-aligned by using the fingers in the space between the protective shield and glass cover or by rotating the protective shield.

In the RCA Victor TRK-5 and TT-5 Television Receivers, the Kinescope is held in place by the special metal shield supplied with the receiver. This shield should never be dropped or struck as its shielding properties will be changed and it may then require demagnetization. The shield in turn is supported by a threaded stud on a mounting bracket fastened underneath the top panel of the cabinet. The vertical shield position can be adjusted by means of the wing and lock-nuts provided. The horizontal position can be adjusted by loosening the screws that hold the bracket and then moving the latter as required. The bracket on the shield is slotted to permit flush setting against the glass cover cushion.

In removing Kinescopes from TRK-12 Television Receivers the high voltage second anode lead must be first removed and the yoke released to avoid forcing and possibly breaking Kinescope.

The protective carton lid and the shipping carton should be preserved. The lid particularly should be kept available for immediate replacement on the Kinescope whenever the tube is removed from the receiver and should be kept on the carton during all subsequent handling of the tube.

With the Kinescope socket in place and the second anode high voltage connection made, the rear cover should be replaced which closes the safety inter-lock power supply switches.

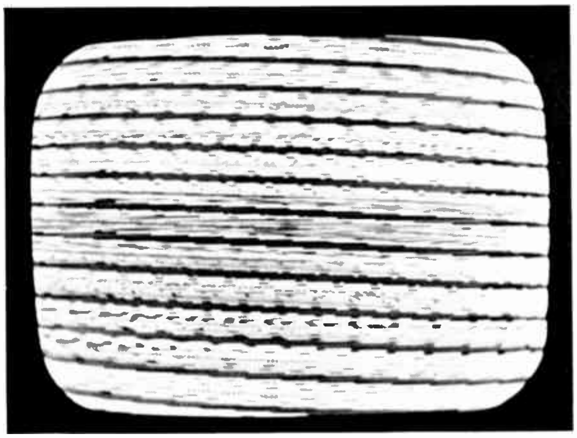


Figure 26—Horizontal Hold Control Incorrectly Set

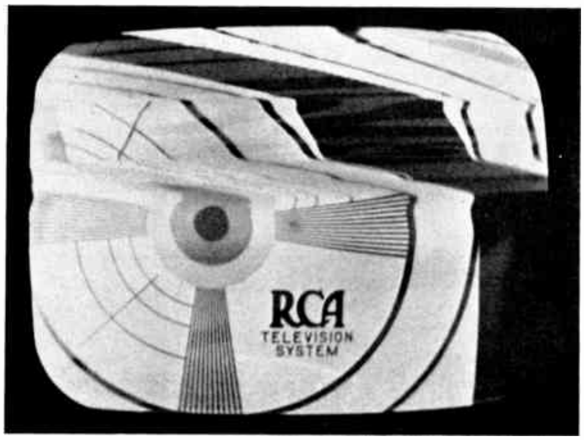


Figure 27—Horizontal Hold Control Incorrectly Set

The receiver may now be connected to the transmission line and ground lead, and plugged into an a-c 110 volt—60 cycle outlet. The desired television station may be tuned in by following the procedure outlined in the operating instructions for the receiver. Typical operating instructions are outlined in the next section.

Typical Operating Procedure

For illustrative purposes, operating procedure arranged and condensed from the owner's instructions for the new RCA Victor TRK-12 Television Receiver are outlined.

Open the lid of the cabinet to the correct viewing angle, usually 45°, and:

1. Turn the Fidelity-Selector Control on the radio panel to "Television," fully clockwise. It is good practice to turn the Brightness and Contrast Controls on the television panel fully counter-clockwise to reduce spot illumination when power is applied.
2. Turn Power-Volume Control on radio panel clockwise and advance about half way. Allow a warm-up period.
3. Set the Station Selector on the television panel to the desired television station.
4. With the Contrast Control fully counter-clockwise, turn Brightness Control slowly from a clockwise position until illumination of the screen almost disappears. Advance the Contrast Control until the picture appears at its best as viewed in the mirror on the lid. The Contrast Control turned too far clockwise causes blurring. In the course of these adjustments it may be found that the received picture is out of synchronism. If the Horizontal Hold Control is incorrectly set the resulting picture may appear as shown in Figs. 26 or 27. It should be turned until the picture "locks-in" horizontally. With this adjustment completed, the resulting picture may be unstable in the vertical direction and may appear as shown in Fig. 28. The Vertical Hold Control should be turned until the picture "locks-in" vertically.
5. With the picture stabilized, the Focus Control should be adjusted to give the best detail observable, or the sharpest picture. Figure 29 illustrates an out-of-focus picture.
6. Make final adjustment for the best picture by adjusting both the Contrast and Brightness Controls. Figures 30 and 31 illustrate various conditions of adjustment. Too much contrast gives blurred details, lack of half-tones and too black in the dark sections, while too much brightness makes the picture appear

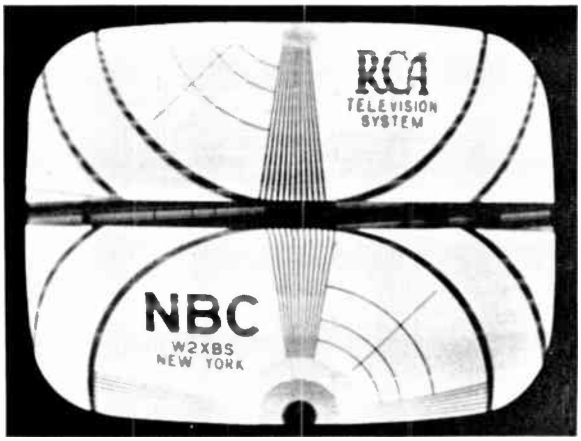


Figure 28—Vertical Hold Control Incorrectly Set

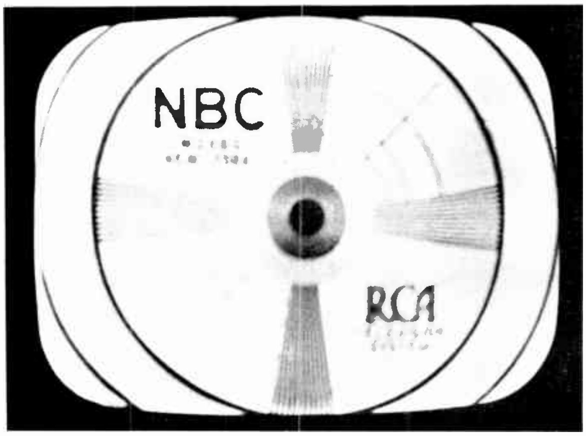


Figure 29—Focus Control Incorrectly Set

Figure 30—Contrast Control Advanced Too Far

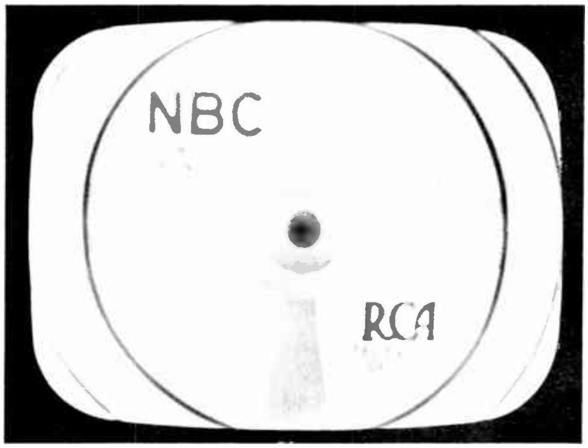


Figure 31—Brightness Control Advanced Too Far

too white or "washed out." Figure 32 illustrates a poor adjustment of Brightness and Contrast Controls as the vertical return lines can be seen.

7. Adjust the Fidelity Control and Volume Control for best sound reception.

8. If a moving ripple (horizontal black and white bars—interfering sound in picture) is observed moving across the picture adjust the Fine Tuning Knob for an elimination of the condition. Figure 33 illustrates a serious condition of sound "cross talk" in the picture.

Figure 32—Contrast & Brightness Controls Incorrectly Set Showing Vertical Return Lines

Figure 33—Sound Modulation in Picture

9. An occasional resetting of the Hold Controls may be necessary due to selecting a different station, and to the gradual ageing of the tubes.

Line Voltage Check

With the receiver controls set for television reception, the line voltage should be checked at the outlet supplying a-c power to the receiver. If a duplex outlet supplies the power, the a-c voltmeter should be plugged into the vacant receptacle, thus enabling the line voltage to be measured with full receiver load. If no duplex outlet is used, a multi-tap may be temporarily installed for convenience in measuring the line voltage with receiver load. The line voltage, as measured, should be within the limits specified for the particular receiver installed.

Picture Orientation and Size Adjustment

When the transmitted picture or test pattern is first observed on the viewing screen, it is likely that the picture or pattern will be "out-of-square" with the mask aperture.

In the case of receivers equipped with Kinescopes having magnetic deflecting yokes, the latter will need rotation. In order to better observe the orientation, the horizontal width and vertical height should be decreased by adjusting the respective controls until the

Figure 34—Picture Incorrectly Oriented

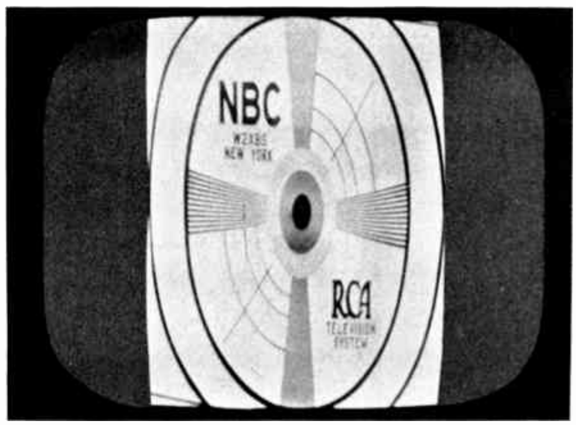


Figure 35—Horizontal Width Control Incorrectly Set

margins of the picture can be seen. The yoke should then be rotated until the picture margins are essentially parallel with the mask edges. The vertical height and horizontal width can then be increased until the mask aperture is just filled by the received picture or pattern.

In the case of receivers equipped with Kinescopes having static deflection, the Kinescope itself must be rotated until the picture is orientated correctly with respect to the mask aperture. The same technique in adjusting width and height, as for magnetic deflecting Kinescopes, should be used. Obviously, it may be necessary to adjust the vertical and horizontal centering controls during the routine of orientation. Figures

34 to 38 inclusive illustrate improper picture orientation and maladjustment of size and centering controls which are usually screw driver adjustments located at the rear of cabinet. Changes in receiver location or ageing of tubes may necessitate readjustment of these controls.

The foregoing procedure of orientation requires a transmitted signal for observation and is the one recommended for making any adjustments. However, the orientation may also be accomplished with reasonable accuracy by observing the scanning pattern or "raster" without a picture signal. In order to prevent

Figure 36—Horizontal Centering Control Incorrectly Set

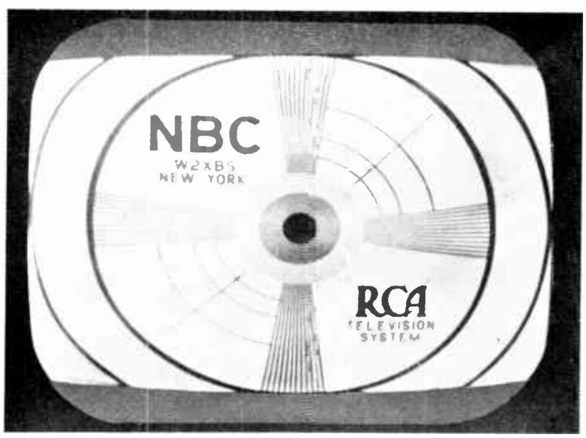


Figure 37—Vertical Height Control Incorrectly Set

noise pulses from causing rough and moving edges on the raster, the picture second detector or a synchronizing amplifier tube may be removed.

A correctly oriented raster is shown in Fig. 39. Note that the vertical return lines, normally blanked out when the picture signal is applied, slope upwards from left to right which indicates that scanning is in the right direction to give a proper related picture. When the picture signal is applied the picture dimensions are decreased due to the action of the blanking impulses. Figure 40 illustrates such a condition. Obviously when the scanning raster only is used for orientation, the picture width and height cannot be accurately adjusted unless a picture or test pattern transmission is available.

If the focus is adjusted to give a sharp reproduction of the scanning lines of the raster only, it will probably need readjusting on the received picture signal.

Vertical Linearity Adjustment

When the picture has been adjusted for orientation, size and centering, the picture may appear to be crowded toward the bottom or the top. Such a condi-

Figure 38—Vertical Centering Control Incorrectly Set

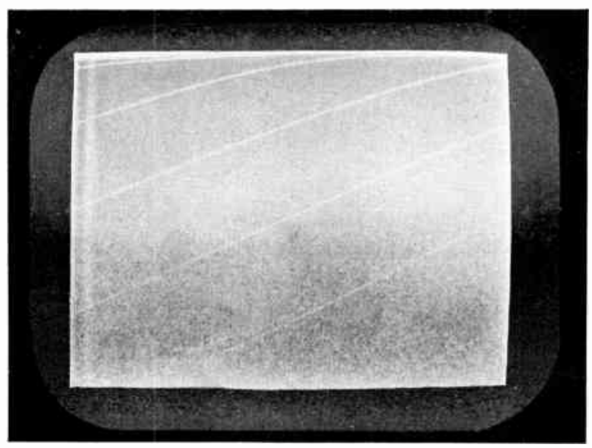


Figure 39—Scanning Raster Correctly Oriented

tion is shown in Fig. 41. The cause will usually be found to be a maladjustment of the vertical linearity control. An adjustment of the vertical linearity control will affect the adjustment of the vertical height control, and vice versa. If the picture fills the mask aperture but is crowded near the top, the vertical linearity control should be turned clockwise and the height control counter-clockwise. If crowded towards the bottom, these two controls should be turned in the reverse directions. A slight readjustment of the vertical centering control may also be necessary.

Miscellaneous Procedure

1. SETTING-UP BROADCAST STATIONS

If the television receiver is equipped for broadcast reception with push-button tuning, the desired stations should be set-up in accordance with the operating instructions accompanying the receiver.

2. CLEANING VIEWING SURFACES

The outside surface of the protective glass window should be cleaned with "Windex," or similar cleaning agent, and soft cloth.

If the receiver is equipped with a viewing mirror, it should also be cleaned, using "Windex," or similar cleaning agent and soft cloth. Very often hair marks, finger prints, etc., are found on the mirror as a result of adjusting receiver and, of course, should be carefully removed.

3. POLISHING CABINET

The unavoidable handling of the cabinet in making receiver adjustments will leave finger marks that should be removed. The entire cabinet should be polished using a good grade of furniture polish and a soft cloth. A recommended polish is the standard RCA Victor Cabinet Polish. Care should be used to keep polish off any viewing surface.

4. INSTRUCTING OWNER

The care and time taken in explaining in simple terms the television system of "Pictures Through the Air," correct operating procedures to secure best results for picture brightness, contrast and synchronizing stability will go a long way in assuring a satisfied customer. Each operating adjustment should be demonstrated and explained to the owner. To insure his knowledge of the proper technique, the owner should be encouraged to repeat the adjustments in your presence. In this manner, the owner can be advised as to the errors in operation and he can become familiar with all adjustments.

If any interfering signals, such as diathermy, auto ignition, etc., are observed despite the best possible installation, these should be carefully explained.

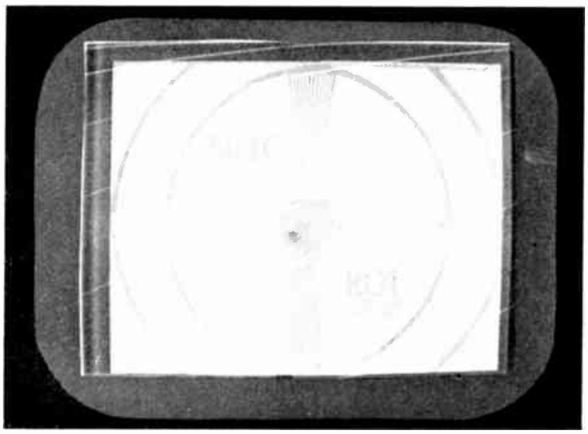


Figure 40—Action of Blanking on Picture Size

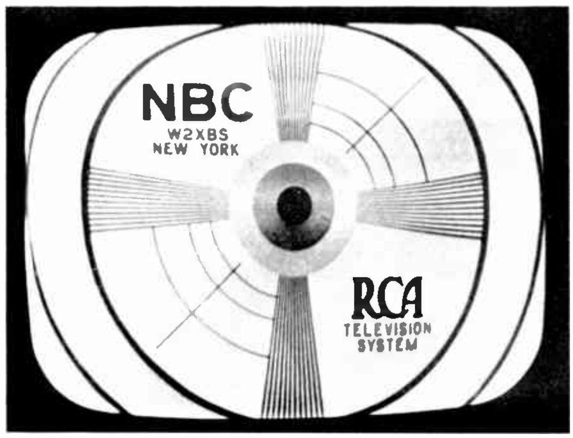


Figure 41—Vertical Linearity Control Incorrectly Set

General Service Information

The new circuits and the many tubes and parts required in a television receiver may, at first glance, readily discourage even the experienced technicians. However, with a basic knowledge of television circuit design and common sense methods of service no real difficulties should be encountered.

The RCA Victor Television Receivers for 1939 are the result of many years of design experience. Furthermore, the RCA-NBC field tests in the New York City area for the past seven years widened the practical aspects on component unit design so that all parts such as i-f transformers, high voltage transformers, etc., have been built with field experience knowledge. For instance, all i-f (and also r-f) coil assemblies are formed on the new "Styrol" plastic which is used to maintain stability of alignment under varying humidity and temperature conditions. The second anode transformers, method of wiring, etc., are designed to exhibit no corona discharge that would cause noise in the picture and sound. The r-f oscillator circuit has been carefully designed to assure unusual stability, or freedom from frequency drift. The synchronizing and deflecting circuits are arranged for utmost stability enabling good interlacing. The component parts on the television chassis have been laid out in orderly signal path fashion so the circuit may be readily followed with the aid of the service data diagrams.

The human element necessary in the manufacture of any product is, as yet, not infallible and troubles, therefore, may be experienced that will require service. Service problems will fall into two classes. First, those due to the nature of the received signals. These difficulties will of course be observed in the course of the installation. Second, those due to faults in the receiver itself.

In any case, the television technician has in the receiver Kinescope itself the best means ever of seeking a clue to the trouble. Literally, the location map of the difficulty appears on the viewing screen. When one can **actually see** the effect of a receiver fault, rather than having to listen to it, the fault can usually be more easily located provided, of course, the technician properly interprets the observed condition.

In order to assist the technician in more readily diagnosing receiver observations, some photographs of the NBC test pattern, as seen on a receiver under different receiver conditions and faults, are included in this booklet and will be discussed.

The only positive check of television receiver operation is to use the test pattern signal from the television transmitter. Field strength and interference conditions will be different at every location. Even though the antenna and receiver installation might be tested with a local r-f oscillator, there is no assurance that the antenna and receiver installation will be satisfactory until the received test pattern is actually observed on the receiver's Kinescope.

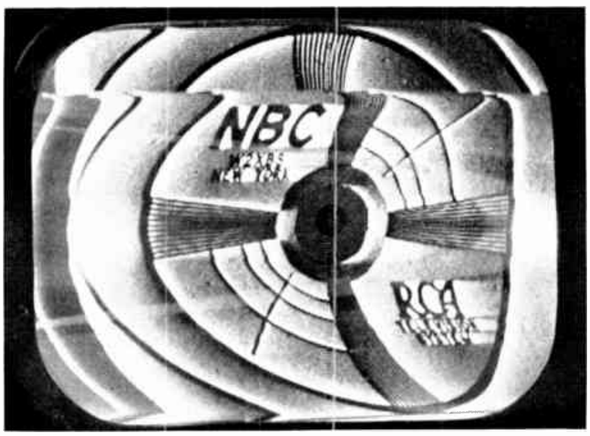


Figure 42—Effect of Too Strong a Signal

It is earnestly recommended that the television receiver be tested before shipment to a customer's home. Since the antenna installed for dealer use should give proper signal pick-up and reproduction the receiver can thus be checked under known satisfactory antenna receiving conditions.

If any doubt exists as to stability of synchronization, etc., at any customer location, it is recommended that a telephonic check be made back to the dealer's store where a normal receiver should be kept operating. In this manner, the condition of the transmitted signal can be checked in order to eliminate a possibility that would cause wasted time and effort.

In the first class of difficulties, there may be experienced:

1. Too Strong a Received Signal

If the voltage at the receiver input terminals exceeds 50 mv. (50,000 microvolts) overload may occur. First indication may be a loss of synchronization and then a picture that appears like that of Fig. 42. Some overload conditions may cause the sound modulation to appear in the picture as shown by the dark and light rippled bands in Fig. 33.

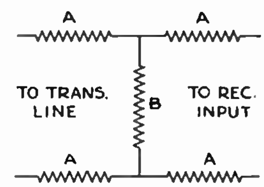
Obviously the remedy is to reduce the signal input. Care must be used since too severe reduction in signal strength at the receiver may not allow a sufficient signal-to-noise ratio. The signal input should be measured and then a proper H pad attenuator inserted between the receiver input terminals and the transmission line, so the received signal is below the overload value of 50 mv. The H pad attenuator maintains proper impedance match between line and receiver input while giving the desired signal attenuation.

The following table and sketch should be used in making up the required H pad. Carbon rod resistors (1/4 watt size) should only be used and their values checked before assembly on a suitable mounting board.

TABLE

APPROX. ATTEN.	VALUE A IN OHMS	VALUE B IN OHMS
2:1	18	82
4.5:1	27	47
9:1	33	33

SKETCH



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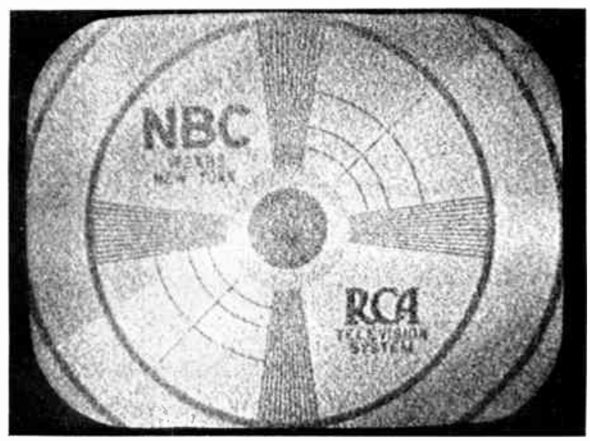

Figure 43—Effect of Too Weak a Signal

If proper measuring equipment is not available, it is suggested that the various H pads be tried and the one with least attenuation that removes the overload condition be used.

2. Too Weak a Signal

In outlying locations (near the limits of the transmitter service area) and in any location shielded by a hill or congested building construction, the signal reaching the receiver input terminals may be too weak. With this condition the receiver's sensitivity is, of course, "wide open" and receiver hiss (snow in the picture) and external noise interference may appear in the picture making it generally unsatisfactory. Figure 43 illustrates receiver hiss which might result from too weak signal input. The signal may be too weak even to insure stable synchronism as noise pulses may be strong enough to override the signal and so trip the deflection oscillators at the wrong times.

The remedy is to install the antenna at greater height or in an unshielded location, provided increased transmission line loss does not offset the increase in signal strength due to the higher or clearer locations. It may be necessary to install a special low loss transmission line or special antenna. There may be no alternative except the installation of a special r-f amplifier to offset increased transmission line loss if the location of the antenna causes such loss.

3. Interfering Signals

A. Reflections. This phenomenon has already been discussed in the installation section. In very strong signal areas, the transmission line, particularly if long and in a horizontal plane, may pick up sufficient signal so that regardless of antenna type and location reflections may not be removed by positioning the antenna. Special shielded transmission line, such as lead covered cable of the correct surge impedance of approximately 100 ohms and appropriate loss may have to be used.

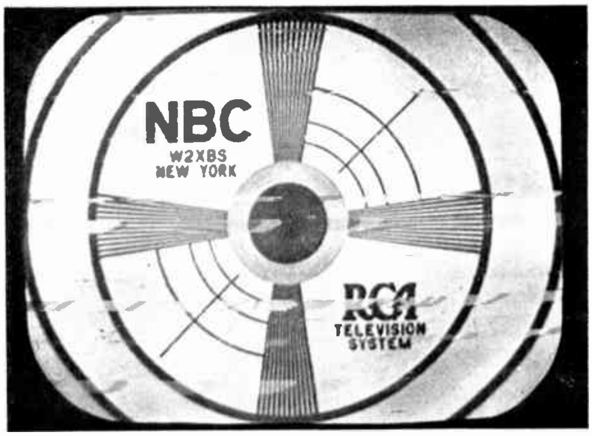

Figure 44—Excessive Auto Ignition Interference

B. Auto Ignition. The interference caused by ignition systems appears somewhat as shown in Fig. 44. Obviously, there is no ready remedy if the antenna has been installed as far as possible from known sources such as heavily traveled streets. Auto ignition may be strong enough to override the received signal in outlying locations to cause not only the speckles as shown in Fig. 44 (or white spots) but streaks of noise with accompanying loss or instability of synchronization.

C. Diathermy. The interference caused by this type of therapy equipment, usually found in hospitals and doctors' offices, appears as shown in Fig. 45. Again there is no ready remedy if the antenna installation is as efficient as possible. However, if the offending machine can be located, the owner may cooperate by seeking to reduce the interference. Some diathermy apparatus operate on a fixed frequency in the u-h-f spectrum while in others the frequency shifts with body electrode lengths and positions. In some cases the interference pattern may drift up and down the viewing screen. In most modern diathermy equipment radiation into the power supply system is reduced by appropriate r-f filters.

D. Carrier Beats. If another service carrier should drift so a heterodyne beat occurs between sound or picture carriers the resulting beat frequency may be seen as a series of fine vertical or slanting lines that drift across the screen. In fact, the receiver may be mistuned by an adjustment of the fine tuning control to see the beat of 1.5 mc. between the unwanted sound and wanted picture carriers of adjacent channels. Figure 46 illustrates the apparent cross-hatching caused by a carrier beat.

4. Hum or Ripple Pattern

If the receiver is located so its power supply is non-synchronous with the transmitters supply (the NBC

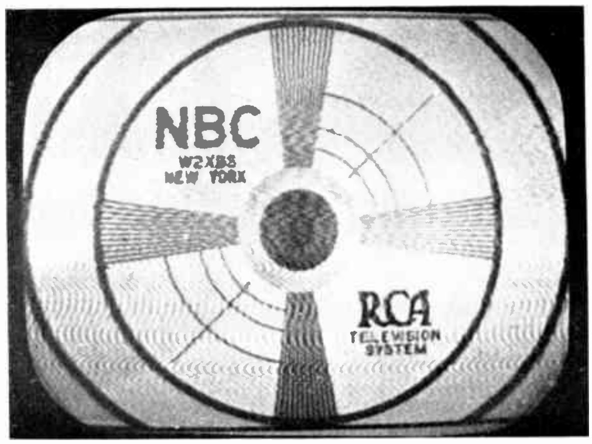

Figure 45—Excessive Diathermy Interference

transmitter is supplied by the Consolidated Edison Co. of New York) residual hum in the receiver deflecting circuits may cause a slight weaving of the picture. This motion is most readily seen by reducing the horizontal width and observing the moving or drifting ripple or wavy effect on the edges of the picture. A very exaggerated condition of 60c hum or ripple in the horizontal deflection circuits is shown in Fig. 47. The effect of 120c ripple would appear as a doubling of the wavy edges shown for 60c ripple

The residual hum in the receivers is always kept as low as the economics of design permit. Past experience has indicated that at normal viewing distances the slight weaving of the picture, when the receiver is operated on a central station non-synchronous supply, is hardly noticeable. Consult your local power company to determine if its power supply is synchronized with the Consolidated Edison Company so any slight ripple condition can be explained to the owner.

In the New York City d-c power supply areas, a-c service may be arranged for by contacting the Consolidated Edison Company for further information.

Where costs of a-c wiring become prohibitively high, the receiver may be operated by a motorgenerator, or rotary converter. The frequency of the rotating machine should be adjusted by accurately controlling its rotational speed. A conventional reed type frequency meter may be used to check the frequency at 60 cycles. The market affords converter type machines having governor control of the speed which when once adjusted *may* give satisfactory results in so far as a moving ripple pattern is concerned.

The second class of difficulties to be outlined are those that may be due to receiver faults. Obviously, it would not be possible to list and describe all the possible faults that may occur. Since the sound portions of a television receiver are similar to any high quality sound broadcast receiver, service suggestions on the audio system will be omitted.

General Suggestions

It is recommended that any failure of normal operation be traced by first replacing tubes that have a bearing on the effect observed. For instance, a microphonic first detector or picture i-f tube might cause a sound in picture condition or unstable synchronization. If such replacement fails to remedy the fault, then checks of circuit continuity and voltages at tube sockets should be made. **CAUTION: All television receivers have high voltage supplies that may cause a lethal shock. Do not make any high voltage circuit checks, other than continuity with power off. Carefully read service notes before making any voltage measurements.** Socket adaptors should never be used as lead changes may cause oscillation and erroneous voltage readings. Loose or poorly soldered connections may be more easily found by lightly tapping the chassis and parts with a rubber headed mallet. A defective joint will usually be evidenced by noise in the loudspeaker. Critical circuit components such as the oscillator inductances however should never be displaced in any service work. If any parts are replaced in the i-f, video or horizontal and vertical synchronizing and deflection circuits, the lead lengths, part placement and lead dress should be maintained as originally found. All alignment adjustments are sealed at the factory with a special cement, or spring-locked in place. There is little likelihood that they will need readjustment and they should therefore never be tampered with. **No alignment of any nature** should be attempted without proper cathode ray oscilloscope and oscillator sweep equipment.

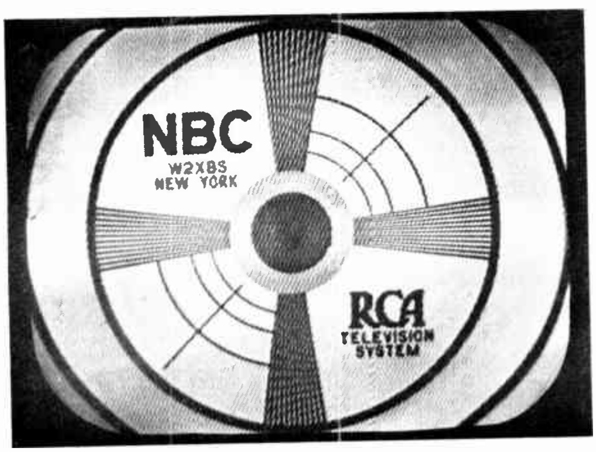

Figure 46—Beat Frequency Interference

Tools and Test Equipment

At this time no attempt will be made to list all the possible tools and test equipment that a television technician might desire in the course of installation and service work. Instead an outline of **minimum requirements** as based on RCA field test experience is given in the following paragraphs:

The usual service tools such as soldering iron, long nose, side-cutting, diagonal and slip-joint pliers, small, medium, large and off-set screw drivers, hack-saw, claw hammer, 6 inch adjustable end wrench, center punch, ½ inch cold chisel, round and half round smooth and bastard files with handles, 5/16 inch and ¼ inch socket wrenches, hand drill, hand brace, electrician's knife, ½ inch wood chisel, assorted emery cloth, friction and rubber tape, rosin core solder, safety flashlight, etc.

Figure 47—Excessive Ripple in Horizontal Deflection

In addition the following suggested items will be found useful: A set of twist drills (at least numbers 9, 10, 18, 21, 27, 29, 35 and ¼ inch), 8-32, 6-32, 10-32 and ¼-20 hand taps with wrench, No. 5 taper reamer, ⅜ inch bit stock drill, ⅜ x 18 inch electrician's drill, No. 14 Rawl or similar drill and handle, 11/16 inch x 18 inch wood auger bit, folding work lamp, extension cord, washed cheese cloth (for cleaning and polishing), 5 inch scissors, canvas work cloth (for protection of floors, etc.), 50 ft. skin tape (for measuring transmission line runs), 6 ft. tape rule (for measuring antenna rod lengths), good pocket compass, "Windex" or similar spray bottle, black cloth (for viewing images under light conditions), set of test leads with clips and rubber insulated grips, area map, two-way telephone set and sufficient line (see Fig. 48), etc.

Spare tubes, miscellaneous resistors, capacitors and controls besides installation materials should also, of course, be carried for field work.

A volt-ohmmeter, such as the Weston 663 or 772 or similar, will be found very necessary. **It is not recommended** that the high voltages be checked with a voltmeter. A safer practice is to check circuit continuity with the **power off.**

An a-c voltmeter for checking supply line and receiver unit heater voltages is recommended.

A reed type frequency meter may be needed for rotary converter installations.

A test oscillator such as the RCA Stock No. 153 is invaluable for checking i-f signal failure, horizontal distribution, etc.

The RCA Stock No. 154 Beat Frequency Oscillator may be used to check the sound system, speaker rattle, vertical distribution, etc.

For instance, horizontal linearity or distribution may be checked by tuning the RCA No. 153 Test Oscillator to a high enough frequency to give a sufficient number of vertical black and white stripes or bars on the Kinescope screen when the oscillator very near "round" circles of the reproduced test pattern thus indicating good commercial horizontal distribution.

Note: In checking distribution the sweep oscillator speed or frequency must be very close to the correct value to secure a proper sawtooth wave-form. To insure this condition, the receiver should be tuned to a test pattern transmission and the hold controls adjusted with as weak a signal input as possible. In the case of the RCA Victor TRK-5 and TT-5 models the signal is readily controlled by the contrast or sensitivity control. With the RCA Victor TRK-9 and TRK-12, an attenuator pad at the receiver input terminals should be used. With the hold controls adjusted, remove the received test pattern signal, and **adjust the test oscillator only** to produce a desired number of bars.

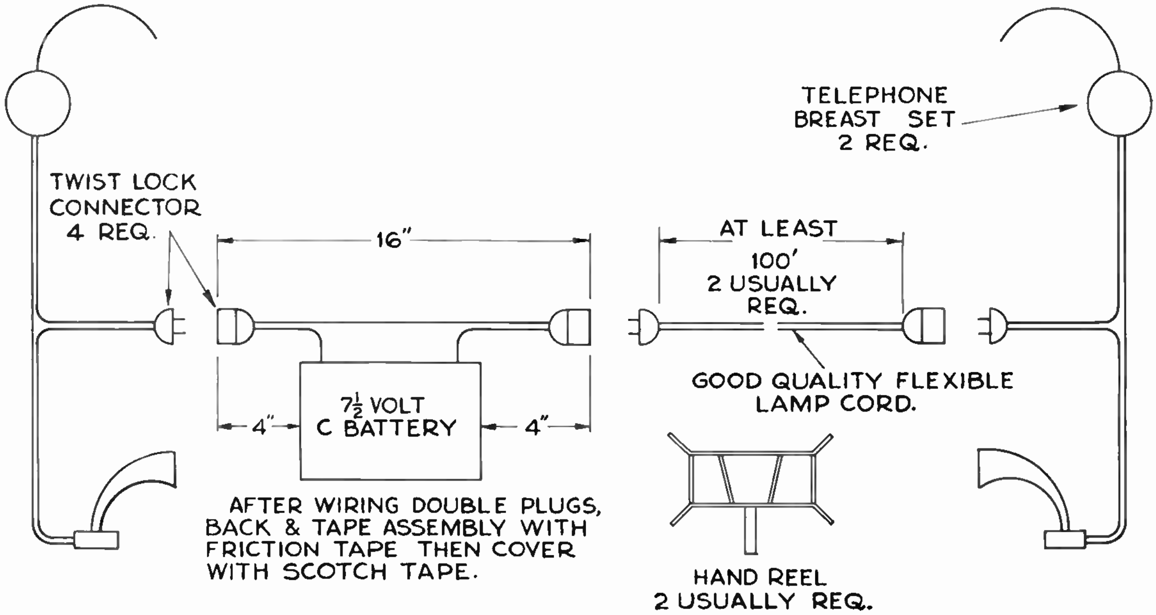

Figure 48—Typical Portable Telephone System

output is connected through a 0.1 mfd. condenser to the high side of the video second detector signal load resistor. By using full output from the test oscillator sufficient signal is available that will not only give good video indication but will synchronize the deflection oscillator to give a stationary pattern of vertical bars. Figure 49 illustrates bars caused by 250 kc sine wave signal superimposed on the received test pattern. A low amplitude sine wave signal was used for purposes of illustration. A higher frequency such as 660 kc will give about 50 bars. This is due to 660 kc being about the fiftieth multiple of the horizontal scanning frequency of 13,230 cps. Distribution can be checked with a pair of dividers or a scale. With linear or perfect distribution there must be the same number of bars per unit length at the right and left sides as there is in the center. Perfect distribution is not economically possible so limits are usually established for production purposes. Figure 49 illustrates the production of bars with the test pattern. Obviously, no test pattern signal is necessary for checking distribution if the test oscillator is used. However, it will be noted that the bars are essentially equal spaced resulting in

Vertical linearity or distribution may be checked by setting the RCA No. 154 Beat Frequency Oscillator to a suitable frequency, such as 1,000 or 2,000 cycles, but preferably a multiple of 60 cycles such as 940 or 1,800 cycles. By connecting the output of the oscillator to the high side of the video detector signal resistor horizontal black and white bars will be produced similar to those shown in Fig. 33. The same procedure as mentioned in checking horizontal distribution can be used to check vertical linearity or distribution.

Special RCA Television Test Equipment such as a Wide Band Sweep Oscillator, 5-inch Oscillograph, etc. will be available. These units are necessary for:

1. Checking or aligning the wide band r-f input circuits, wide band i-f amplifying stages, critical rejector adjustment, and oscillator alignment.
2. Checking condition of synchronizing signal and separated pulses, deflection circuit wave-forms, etc.

Specific instructions will be available with the units so details of the special RCA Television Test Equipment will not be given at this time.

Specific Troubles and Possible Causes

1. NO KINESCOPE ILLUMINATION

CAUTION: The high voltages (up to 7,500V) used for second anode supply may cause a lethal shock. All work on the high voltage circuits should be performed with POWER OFF by removing the power supply cord from the power supply outlet. Always discharge the high voltage condensers by connecting to ground while working on receiver. Use a high voltage insulated lead and always connect to ground first. It is good practice to use only one hand, keeping the other hand in the pocket.

Do not tamper with or eliminate the protection provided by the safety interlock switches.

Continuity checks of the high voltage circuits should be sufficient to locate any suspected trouble.

No Kinescope illumination may be due to any one

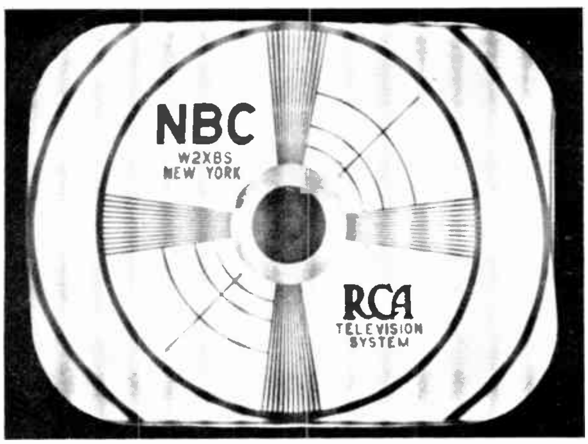

Figure 49—A 250 K.C. Sine Wave Signal with Test Pattern

of the following: Defective Kinescope — Defective high voltage rectifier tube — high voltage bleeder — defective power transformer — shorted high voltage condensers — defective brightness control — or d-c restorer circuit placing too high a bias on control grid — second anode lead disconnected — defective wiring.

A shorted or gassy high voltage rectifier tube may cause the filter resistor between the high voltage condensers to burn up, causing no illumination.

2. NO DEFLECTION OR SCANNING

If only the electron scanning spot is seen, **turn the receiver off as the stationary spot may damage the viewing screen.** Investigate continuity of deflection circuits as yoke leads or plug may be disconnected or open. Replace the deflection circuit tubes. Check supply voltages.

If only a vertical line is seen, **turn the receiver off as the stationary line may damage the viewing screen.** Observing only a vertical line indicates immediately that there is no horizontal deflection which isolates the trouble to the horizontal deflection circuits. Similarly if only a horizontal line is seen, the trouble lies in the vertical deflection circuits. In any of these observed faults the prompt manipulation of the centering controls will determine if the deflecting yoke is in operation.

3. NO PICTURE

If the transmitter is known to be on the air and no picture is seen the trouble may be anywhere between

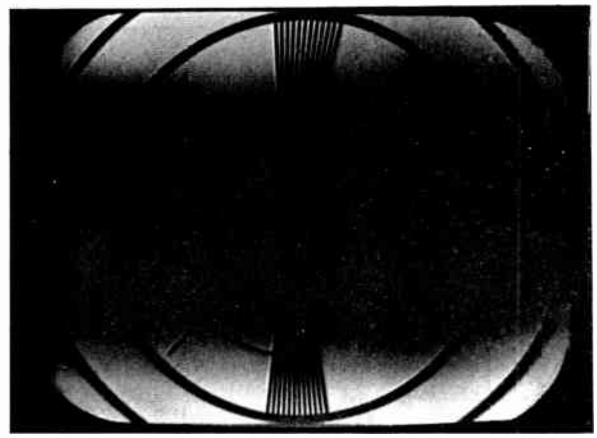

Figure 50—Excessive Ripple in Video Amplifier

Figure 51—Same as Figure 50 Except Opposite Phase

the antenna and the Kinescope grid. Assuming that the antenna and transmission line are OK, the fault may be traced to:

A. Defective tube in r-f oscillator, first detector, picture i-f, second detector or video amplifier.
B. Open grid cable to Kinescope or defective Kinescope.
C. Defective contrast control.
D. Defective part or connection.

The loss of the picture signal may be quickly isolated by a step by step procedure.

(a) Apply through a 0.25 mfd condenser some a-c voltage from any heater to the control grid of the video amplifier tube. An a-c hum pattern similar to that shown in Figs. 50 or 51 should be seen if the video amplifier to Kinescope grid is in normal operation. The RCA Stock No. 153 Test Oscillator may be used, using an unmodulated frequency around 1,000 kc with the oscillator output connected to the high side of the video second detector output resistor. This should give vertical bars on the scanning raster similar to those shown in Fig. 49.

(b) Apply to the grid through a coupling condenser of the last picture i-f stage a 400c modulated i-f signal of around 11 mc from a test oscillator such as the RCA Stock No. 153. The sound modulation

Figure 52—Unstable—"Tear-Out"—Horizontal Synchronization

Figure 53—Loss of Interlacing

will appear as a series of black and white horizontal bars or stripes on the Kinescope screen if all circuits are OK. By going toward the first detector in successive stages, the faulty stage may be located and circuit checked. The output of the test oscillator should be reduced as successive stages are checked to prevent over-load.

4. NO SYNCHRONIZATION

Assuming a proper signal at the receiver input, loss of synchronization may be due to:

(a) Defective synchronizing separator or amplifier tubes.

(b) Circuit defect such as loss of supply voltages, open circuit, etc.

5. UNSTABLE SYNCHRONIZATION

A slight "tearing" at the top of the picture such as shown in Fig. 52 may indicate a microphonic or noisy tube or loose connection in the r-f or i-f system, the horizontal synchronizing separator or synchronizing amplifying circuits.

A "bounce" in the picture may indicate unstable vertical synchronization due to a circuit defect or microphonic tube. Unstable synchronization also may, of course, be due to a loose antenna or lead-in connec-

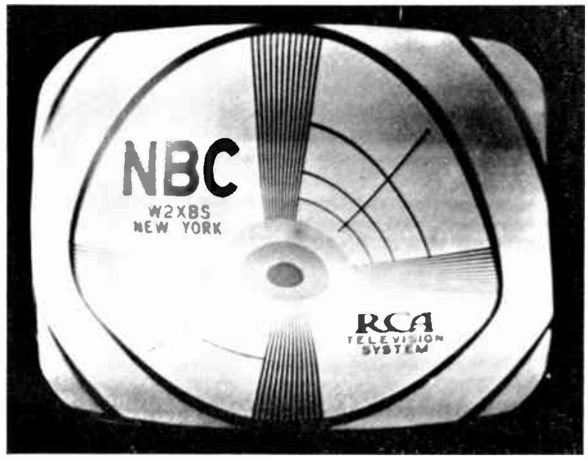

Figure 54—Excessive Ripple in Vertical Deflection

Figure 55—Vertical Distortion Caused By Defective Peaking

tion. Momentary loss of synchronization may be due to line voltage surges caused by switch operation.

Severe noise pulses or loss of interlacing with resulting lack of detail may be caused by improper vertical hold control adjustment. Figure 53 illustrates the condition of no interlacing. The line structure becomes easily visible (inspect Fig. 53 closely) as instead of 441 lines only 220½ lines scan the screen. Defects in the vertical integrating filter may cause unstable interlacing. Circuit defects to cause excessive coupling of the horizontal deflection circuits to the vertical circuits may cause a loss of interlacing.

Under any unstable synchronization condition, it is recommended that a telephone check be made with a receiver location known to be operating normally.

6. HUM OR RIPPLE IN PICTURE

(a) Excessive ripple in the picture is readily discernible as uneven illumination. Hum voltage, (60c) appearing in the video amplifier is illustrated in Figs. 50 and 51 which is an exaggerated condition.
(b) Excessive 60c ripple in the horizontal deflection circuits is illustrated in Fig. 47.
(c) Excessive 60c ripple in the vertical deflection circuits is shown in Fig. 54.

Figure 56—Transients in Test Pattern

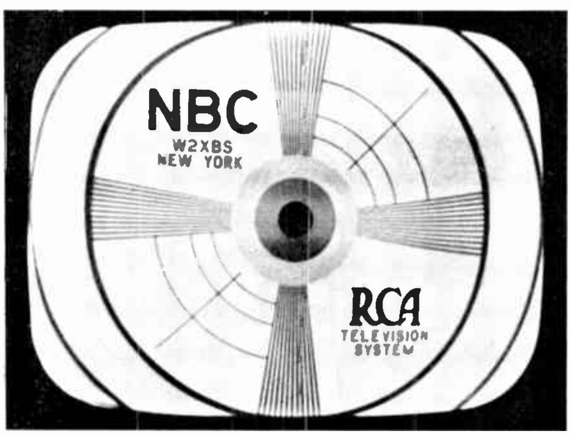

Figure 57—Normal Test Pattern

The effect of 120c ripple would appear as a doubling of the wavy edges, dark and light bands, etc. as shown for 60c ripple. Any hum effect may be due to a circuit or tube defect. Replacing tubes and checking circuit continuity should readily locate the trouble.

7. VERTICAL DISTORTION

Besides the vertical linearity adjustment, the vertical discharge circuit of a condenser and resistor in series for magnetic deflection systems will cause a crowding or even over-lapping of lines at the top if the resistor or condenser is defective.

The effect is illustrated in Fig. 55.

8. TRANSIENTS

In Fig. 56 is illustrated a test pattern containing transient reproduction of sections of the pattern. Such a condition may be caused by an improper alignment of the r-f oscillator, a wrong type i-f response curve or open peaking coil circuits in the video amplifier. If continuity testing the video circuits discloses no trouble, then the r-f, oscillator and picture i-f stages will need an alignment check.

9. LOSS OF HIGH VIDEO FREQUENCIES

The higher video frequencies when present assure sharp reproduction of detail. The extent to which the

Figure 58—Loss of High Video Frequencies

Figure 59—Phase Shift and Loss of Low Video Frequencies

divisions of either vertical wedge of the NBC test pattern can be clearly seen is an indication of the over-all video response. In the normal test pattern reception of Fig. 57, divisions of the wedge can be clearly seen to the first "bull's-eye" circle. This picture was taken on a typical high quality receiver with a 12 inch Kinescope. Such a receiver has approximately linear response to 4 mc. The divisions of the wedge are clearly seen along its entire length as the bull's-eye end of the wedge represents detail as would be produced by a response of 3.5 mc. Lower priced receivers, such as those using smaller Kinescopes, do not require as high a response as 4 mc for satisfactory results. Hence in normal test patterns seen on these smaller receivers, the wedge divisions will be clearly seen only about two-thirds down the top wedge or two-thirds up the bottom wedge.

The loss of high video frequencies will be apparent by a blurring or a lack of sharpness in most parts of the test pattern, but more particularly by the nature of the vertical wedge. Figure 58 indicates a serious loss of high video frequencies. Such a loss may occur due to open or shorted peaking coils in the video amplifying circuit or too narrow r-f, i-f, or antenna frequency response band.

10. LOSS OF LOW VIDEO FREQUENCIES

The loss of low frequencies will usually be accompanied by a phase shift of these frequencies. This results in a smearing of the picture by the low frequency elements such as large letters, etc. In Fig. 59 such a condition is shown.

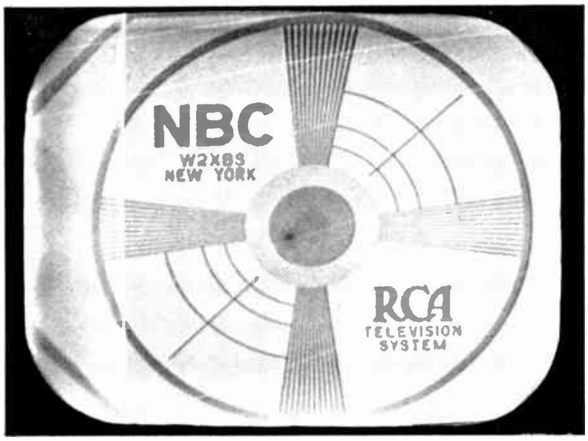

Figure 60—Effect of Damping Tube Failure

Figure 61—Non-Linear Horizontal Deflection

Such a condition might be caused by a shorting-out of video amplifier load resistors or an open by-pass condenser in the plate or screen supply circuit. An improper i-f response curve may also introduce this low frequency smear. Blurring of the horizontal wedges of the test pattern indicates a loss of low video frequencies.

11. HORIZONTAL DISTORTION

(a) Failure of Damping Tube.

Receivers using magnetic deflection use a rectifier or damping tube to eliminate a transient condition that occurs during the return line portion of the scanning sawtooth wave. This tube is subjected to high inverse voltages. If it should fail the effect on the pattern may be as shown in Fig. 60.

(b) Non-Linear Horizontal Deflection—Poor Distribution

Any horizontal deflection circuit component such as the charging resistor in the discharge sawtooth generator circuit, etc., that may be off-value or defective may lead to a non-linear condition as illustrated in Fig. 61.

More often such a condition will be caused by the horizontal output tube and this tube should first be changed. Low line voltage or off-value output tube plate load resistors can cause poor horizontal distribution. Since component parts of such circuits necessarily are a result of design and production economics, all resistors and capacitors have values within certain plus or minus tolerances. Should the tolerances add up in the wrong direction, circuit values may be changed to produce such a non-linear sawtooth deflecting voltage that horizontal or vertical crowding or stretching of picture elements may occur.

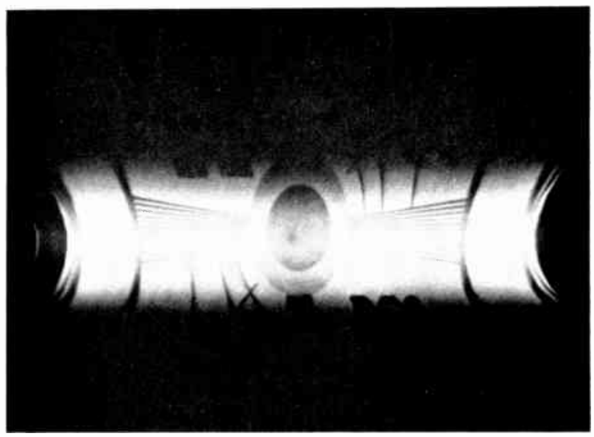

Figure 62—Effect of Open H.V. Filter Condensers

12. OPEN HIGH VOLTAGE FILTER CONDENSERS

The general effect of an open high voltage filter condenser is similar to the combined effect of ripple in the video amplifier and ripple in the deflection circuits. Figure 62 illustrates the worst possible condition in that both high voltage filter condensers were open.

Television Definitions

Aspect Ratio: The Aspect Ratio of a frame is the numerical ratio of the frame width to frame height.

Audio (Latin, "I hear"): Pertaining to the transmission of sound.

Automatic Brightness Control: Automatic Brightness Control is a device for automatically controlling the average illumination of the reproduced image.

Automatic Volume Control: A self-acting device which maintains the output constant within relatively narrow limits while the input voltage varies over a wide .

Band-Pass Filter: A filter designed to pass currents of frequencies within a continuous band limited by an upper and a lower critical or cut-off frequency and substantially reduce the amplitude of currents of all frequencies outside of that band.

Blanking Pulse: Pulses produced during the return time of the cathode-ray beam to "blank out" the undesirable signals produced by the return lines in both the Iconoscope and Kinescope. Sometimes referred to as the "pedestal."

Brightness Control: Brightness Control is the receiver control which varies the average illumination of the reproduced image.

Carrier: A term broadly used to designate carrier wave, carrier current, or carrier voltage.

Carrier Frequency: The frequency of a carrier wave.

Coaxial Cable: Special telephone cable suitable for conveying television signals.

Contrast Control: A knob on the receiver for adjusting the range of brightness between highlights and shadows in a picture.

Cycle: One complete set of the recurrent values of a periodic phenomenon.

D.C. Transmission: D.C. Transmission means the transmission of a television signal with the direct current component represented in the picture signal.

Distortion: A change in wave form occurring in a transducer or transmission medium when the output wave form is not a faithful reproduction of the input wave form.

Electron Emission: The liberation of electrons from an electrode into the surrounding space. In a vacuum tube it is the rate at which the electrons are emitted from a cathode. This is ordinarily measured as the current carried by the electrons under the influence of a voltage sufficient to draw away all the electrons.

Fidelity: The degree to which a system, or a portion of a system, accurately reproduces at its output the signal which is impressed upon it.

Field Frequency: Field Frequency is the number of times per second the frame area is fractionally scanned in interlaced scanning.

Focus: Adjustment of spot definition.

Frame: One complete picture. Thirty of these are shown in one second on a television screen.

Framing Control: A knob or knobs on the receiver for centering and adjusting the height and width of pictures.

Frame Frequency: Frame Frequency is the number of times per second the picture area is completely scanned.

Fundamental Frequency: The lowest component frequency of a periodic wave or quantity.

Ghost: An unwanted image appearing in a television picture as a result of signal reflection.

Harmonic: A component of a periodic quantity having a frequency which is an integral multiple of the fundamental frequency. For example, a component the frequency of which is twice the fundamental frequency is called the second harmonic.

Horizontal Centering: Adjustment of the picture position in the horizontal direction.

Horizontal Hold: Adjustment of the free-running period of the horizontal oscillator.

Height: Adjustment of the picture size in the vertical direction.

Iconoscope: A type of electronic cathode-ray pickup tube which has been developed by RCA.

It serves the dual purpose of analyzing the visible picture projected on its mosaic into elements and produces electrical impulses for each of these picture elements.

Interference: Disturbance of reception due to strays, undesired signals, or other causes; also, that which produces the disturbance.

Interlacing: A technique of dividing each picture into two sets of lines to eliminate flicker.

Kinescope: A type of electronic cathode-ray receiver tube which has been developed by RCA.

It converts electrical impulses into picture elements which are visible to the eye.

Line: A single line across a picture, containing highlights, shadow, and half-tones; 441 lines make a complete picture.

Linearity Control: Adjustment of scanning wave shapes. May be qualified by the adjectives "Top," "Bottom," "Right," "Left."

Megacycle: When used as a unit of frequency, is a million cycles per second.

Modulation: Modulation is the process in which the amplitude, frequency, or phase of a wave is varied in accordance with a signal, or the result of the process.

Mosaic: Photo-sensitive plate mounted in the Iconoscope. The picture is imaged upon it and scanned by electron gun.

Negative Transmission (Modulation): Negative Transmission (Modulation) occurs when a decrease in initial light intensity causes an increase in the radiated power.

Panning: A horizontal sweep of the camera. (From "panorama.")

Polarization: The particular property of an antenna system which determines its radiation characteristics.

i.e.—Vertical or horizontal polarization.

Positive Transmission (Modulation): Positive Transmission (Modulation) occurs when an increase in initial light intensity causes an increase in the radiated power.

Progressive Scanning: Progressive Scanning is that in which the scanning lines trace one dimension substantially parallel to a side of the frame in which successively traced lines are adjacent.

Radio Channel: A band of frequencies or wave lengths of a width sufficient to permit of its use for radio communication. The width of a channel depends upon the type of transmission.

Return Line: Trace of the cathode-ray beam in returning from bottom to top of the picture. (Return trace from right to left between lines usually not visible.)

Sawtooth: A wave of electric current or voltage employed in scanning.

Scanning: Scanning is the process of analyzing successively, according to a predetermined method, the light values of picture elements constituting the total picture area.

Scanning Line: A Scanning Line is a single continuous narrow strip which is determined by the process of scanning.

Side-Bands: The bands of frequencies, one on either side of the carrier frequency produced by the process of modulation.

Signal: The intelligence, message or effect conveyed in communication.

Spot: The visible spot of light formed by the impact of the electron beam on the screen as it scans the picture.

Spottiness: Spottiness is the effect of a television picture resulting from the variation of the instantaneous light value of the reproduced image due to electrical disturbances between the scanning and reproducing devices.

Television: Television is the electrical transmission and reception of transient visual images.

Tilting: A vertical sweep of the camera.

Vertical Centering: Adjustment of the picture position in the vertical direction.

Vertical Hold: Adjustment of the free-running period of the vertical oscillator.

Vestigial-Side-Band Transmitter: A Vestigial-Side-Band Transmitter is one in which one side band and a portion of the other are intentionally transmitted.

Video Frequency: The Video (Latin, "I see") Frequency is the frequency of the voltage resulting from television scanning.

Width: Adjustment of the picture size in the horizontal direction.

Yoke: Produces magnetic deflection of an Iconoscope or Kinescope when supplied with sawtooth currents of proper voltage and phase.