George R. Town

HAZELTINE SERVICE CORPORATION

(A SUBSIDIARY OF HAZELTINE CORPORATION)

NEW YORK LABORATORY:
333 West 52nd Street
COlumbus 5-0793

CHICAGO LABORATORY:
325 West Huron Street
Superior 0790

BAYSIDE LABORATORY:
Bayside, Long Island.
FLushing 7-5300

This Report is the property of the Hazeltine Service Corporation and is prepared for the exclusive use of its authorized representatives.

Report No. 1877

TITLE **CHIEF FEATURES OF THE TELEVISION RECEIVER**
(*TELEVISION PRINCIPLES* — CHAPTER 6)

DATE *October 20, 1938.*

MFR. *General.*

STROMBERG-CARLSON TEL. MFG. CO.

Approved W. A. MacDonald

CHIEF FEATURES OF THE TELEVISION RECEIVER
(TELEVISION PRINCIPLES - CHAPTER 6)

By C. E. Dean

TABLE OF CONTENTS

SPECIFICATIONS SELECTED FROM THIS CHAPTER

Representative Width of Sound Intermediate-Frequency Channel	100 kc
Probable Minimum Obtainable Number of Control Functions for User to Operate	6
Usual Type of Television Antenna	Doublet
Type of Tuning for Highest Gain	Inductive
Picture Width in Terms of Normal Screen Diameter	Approx. 80%
Picture Height in Terms of Normal Screen Diameter	Approx. 60%

* * * * * *

CHIEF FEATURES OF THE TELEVISION RECEIVER

(TELEVISION PRINCIPLES - CHAPTER 6)

INTRODUCTION

The two preceding chapters describe the requirements which the television receiver must satisfy as determined by the characteristics of the transmitted wave and by the desired fineness of picture detail. The present chapter gives a general description of the parts of the receiver and a discussion of the operations by which these requirements are met.

The first six chapters give a description of a complete television system. In general only one method of accomplishing a particular operation has been described. There are, of course, a great many alternative arrangements which might be used to secure the same results. Succeeding chapters will discuss a few of the other arrangements. Following these chapters a detailed discussion of television test equipment and receiver design will be given.

GENERAL ARRANGEMENT OF RECEIVER

Figure 1 shows the general circuit arrangement of the television receiver in block form. There are a great many operable circuit combinations, the larger number of functions giving a greater variety than is possible in a broadcast receiver. The one chosen for illustration might be used in a rather high-priced television receiver. In the less expensive receivers a few of the parts, such as the separate automatic-volume-control amplifier stage, might be omitted and other parts might be combined to simplify the construction.

The small curves in Figure 1 show the transmission characteristics of various portions of the circuit. The significance of these will be apparent in the following account of the operation.

In its general plan the receiver of Figure 1 is a superheterodyne. There are two tuned circuits preceding the modulator. These are followed with intermediate-frequency amplifiers, detectors, and video-frequency amplifiers. As far as the block diagram shows, the functions of the parts in the picture channel are the same as in a broadcast superheterodyne, with the exception of the reinserter. The principal differences between Figure 1 and a conventional sound receiver are in the auxiliary channels which select portions of the incoming signals for special purposes. The radio-frequency circuit and modulator handle both picture and sound carriers, converting them to intermediate frequencies. Both of these are then amplified in a common intermediate-frequency stage. Beyond this point the circuit splits three times, providing eventually for four detectors, which are respectively for the sound, the picture, the sync signals, and automatic volume control. It will be seen that a total of two intermediate stages are included in the sound circuit and three intermediate stages in the picture circuit; there are also three such stages in the circuit for the sync signals and automatic volume control. The manual gain control for the picture channel is located in the last intermediate-frequency stage, which does not have automatic volume control; since this stage is beyond the points where the other channels separate, adjustment of the picture gain does not affect the other circuits.

The transmission curve for the radio-frequency stage, including both the tuned circuits which are in this coupling, is wide enough to accommodate both the picture and sound carriers, which have a separation of 4.5 or 4.75 megacycles.

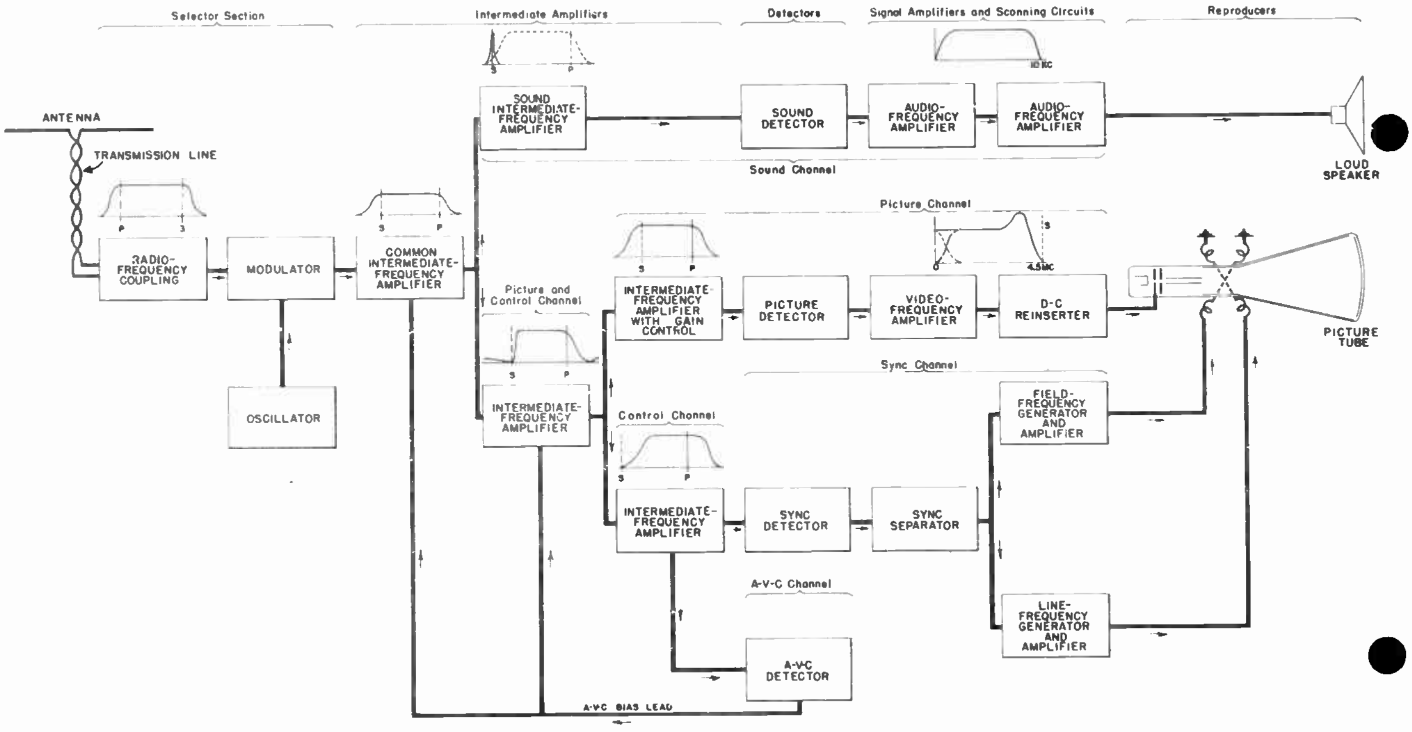


Fig. 1. Arrangement and Transmission Characteristics of Typical Television Receiver.

(The exact specification of this interval has not yet been made, the figure of 4.5 having heretofore been given as only approximate.) The oscillator of the receiver operates at a higher frequency than either incoming carrier, and therefore produces a picture intermediate frequency which is higher than the sound intermediate frequency. Both carriers are moved down in frequency by the action of the modulator.

Since the video band extends to about 4 megacycles, the chosen intermediate band must all lie above this value; otherwise the intermediate-frequency band cannot be separated from the video frequencies. It is desirable to keep the intermediate frequency below 20 megacycles because about here the input conductance of the available vacuum tubes begins to become an important factor. Difficulties from stray capacity coupling and from lead inductances are also troublesome at higher frequencies. The selection of a particular intermediate-frequency band between these limits of say 6 to 20 megacycles depends on the location of strong stations which might produce interference. The most serious danger of interference at intermediate frequency is from amateur transmitters operating in the neighborhood of 7 and 14 megacycles. At this time the range from 8 to 13 megacycles appears the best, with the range from 16 to 21 megacycles as a second choice.

The sound channel, from a transmission standpoint, need only pass the frequency band required for a high-fidelity reproduction of the sound portion of the program. Such a narrow band would have the additional important advantage of being less vulnerable to automobile-ignition interference. However, the provision of an intermediate sound stage with such a narrow band would impose a severe stability requirement on the frequency of the oscillator. As a compromise between these two opposing considerations, a total width of the order of 100 kilocycles is generally provided. Some increase in this may be required to accommodate the higher-frequency television channels of the group below 108 megacycles. The occurrence of interference in the sound channel due to video components in the neighborhood of 4.5 megacycles can be prevented only by suppression of these frequencies at the transmitter.

The transmission curves shown in Figure 1 for the intermediate stages which carry the picture signals show some attenuation at the picture carrier. This attenuation is sufficient to add up to an overall of 6 decibels from the antenna to the video detector. In stating this figure it is assumed that the transmitting station does not attenuate the carrier. If some attenuation is included in the transmitter, the receiver attenuation must be reduced to make the overall system attenuation at the carrier frequency equal to 6 decibels. (The 6-decibel requirement is explained on pages 68-70 of Chapter 4, Report 1837.)

The video amplifier may connect to the picture tube either directly or by means of an alternating-current coupling and a reinserter. In the latter case the reinserter may be thought of as contributing a transmission characteristic declining with increasing frequency, as shown by the dotted line in the sketch, while the alternating-current coupling contributes the opposite characteristic shown by the dashed curve; the overall result is flat down to zero frequency as shown by the solid curve.

The intermediate stage which is located only in the sync and automatic-volume-control circuits involves different transmission considerations from the intermediate stages of the picture channel. In the absence of noise the intermediate stage for sync and automatic volume control need not transmit the full video range. However, it is advantageous here to transmit a good share of the video range because this enables the receiver to maintain synchronism under more severe noise conditions than otherwise. The reason for this is that: (1) the wider the frequency band, the steeper are the edges of the sync signals delivered to the sync detector; and (2) the steeper these edges, the less time there is in which a noise pulse of less amplitude than the sync signals can produce a false early signal. Reduction of the bandwith in this sync channel has the advantage, on the other hand, of permitting greater gain. The curve in Figure 1 represents a compromise condition.

The synchronizing and scanning circuits shown in Figure 1 include the sync detector which separates the sync signals from the intermediate-frequency input by amplitude discrimination. The inter-sync separator separates the line sync signals from the field sync signals. Each set of sync signals controls the frequency of its associated scanning oscillator . The output of each oscillator is reenforced by one stage of suitable amplification, and the resulting saw-tooth current is passed thru the corresponding winding of the scanning yoke for the deflection of the scanning spot.

RECEIVER CONTROLS

The number of controls which can be provided in a television receiver is imposing when it is realized that, from the user's standpoint, it is desirable to require as few adjustments as possible. For a further consideration of the matter, the following controls are of interest:

General:
(1) On-Off switch;

(2) Television-broadcast switch (to turn off the television portion of the receiver when receiving ordinary broadcast signals);

(3) Tuning control (buttons, one for each television channel);

(4) Vernier tuning control;

Sound Channel:
(5) Volume control;

(6) Tone control (one or two);

Picture Channel:
(7) Contrast control;

(8) Brightness control;

(9) Focus control;

Line Scanning:
(10) Synchronizing control (the "Hold" or "Speed" control);

(11) Horizontal centering control;

(12) Horizontal size control;

(13) Shaping control;

Field Scanning:
(14) Synchronizing control;

(15) Vertical centering control;

(16) Vertical size control; and

(17) Shaping control.

A few of these controls need further explanation. The main tuning control (#3) tunes the set to the desired frequency. If the oscillator drift is excessive a vernier tuning control (#4) is required. A slight oscillator drift may tune the set off the sound channel. This is very apt to happen, for instance, if the highest frequency band (102 to 108 megacycles) is being received with the oscillator operating at about 115 megacycles. If the sound channel is only 50 kilocycles wide, an oscillator frequency drift of one part in 4600 will move the sound channel from the center of the pass-band to one edge. The problem is less severe of course at the lower frequencies and with wider sound channels. Another difficulty caused by slight oscillator mistuning is that the picture carrier moves away from the point on the receiver response curve which gives the required 6 decibels attenuation. With all of the attenuation located in the receiver and with the sharp-sided selectivity curve furnished by a highly selective receiver, this problem becomes serious.

The contrast control (#7) adjusts the gain to give the desired voltage swing on the picture-tube grid. If the receiver has automatic volume control, the contrast control should be located beyond the last stage having automatic control, and preferably also beyond the point at which the synchronizing signal is taken off. If the set does not have automatic volume control, the contrast control varies the bias on the radio-frequency and intermediate-frequency tubes.

The brightness control (#8) is used to adjust the bias of the picture tube and should be set so that the black level in the picture signal coincides with the cutoff of the picture tube.

The focus control (#9) adjusts the size of the spot. It differs from most of the controls in the picture channel in that the ordinary customer has no difficulty in understanding its purpose or in adjusting it.

The controls listed for the scanning system should be located in some place where they will not be touched by the customer, at least until he has spent considerable time adjusting the other controls. The two "Hold" controls are intended to set the oscillator constants within the range over which the synchronizing signal maintains synchronism. The centering control is used to correct for variations between tubes. It ordinarily requires no adjustment except when a new picture tube is installed. In case magnetic focusing is used in place of electrostatic focusing, the beam can be centered by a slight tilt in the focusing coil, making it possible to eliminate the electrical centering controls. The size controls are needed to adjust the lengths of the scanning paths according to the mask used to frame the picture. They are adjusted only when there is a drift in the values of circuit components or a change in tube characteristics. The shaping controls are for the maintenance of linearity in the trace portion of the sawtooth scanning wave. Adjustment of these is also required only to compensate for changes in tube characteristics or drift in resistors.

As is obvious from this list of functions of the several controls, the scanning system must be made sufficiently stable so that no changes in these controls are required for long intervals. Let us consider what might happen if a customer gets a receiver having all the controls available and attempts to receive a station. Assume first that the set does not have automatic volume control. When the receiver is turned on and tuned to the desired channel, the contrast and brightness controls will probably be incorrectly adjusted. If the brightness control is set for too low a level, the screen will be black and the customer may turn up the contrast control until he sees some light on the screen. Due to the improper setting of the brightness control the set will then probably be so badly overloaded that it will not synchronize. The customer recognizes the failure to hold synchronism, so he adjusts the line-hold and frame-hold knobs without result. Assuming that these were properly set in the factory, he will have them so far off their correct position by the time he returns to the adjustment of the contrast and brightness controls that the set will not synchronize. In other words, these four knobs (contrast control, brightness control, line hold and frame hold) present an appalling opportunity for misadjustment.

If the set is equipped with automatic volume control, the interdependence of the scanning-system controls and the contrast and brightness controls is absent. The customer then has less difficulty in adjusting the receiver. But he still will have trouble in getting the right combination of the contrast and brightness controls. For example, assume that the brightness control is properly set and that the contrast control is adjusted to give too much gain. The picture tube will then overload, giving abnormally bright high lights in the picture, probably associated with severe defocusing. The customer will recognize this as too bright a picture. He may then turn down the brightness control which will bring the high lights of the picture to the correct portion of the picture-tube operating characteristic. The high lights of the picture will then show great improvement. All of the medium tones in the picture will, however, be black as a result of the faulty settings of both the contrast and brightness controls.

It is of course possible for the customer to make the proper adjustment of these two controls. Experience with the English television receivers has, however, shown that they are rarely adjusted for correct gradation of tone. The difficulty with the contrast and brightness controls has been so serious in English receivers that some of the manufacturers remove the brightness control from the front of the set and use an alternating-current coupling without reinserter between the video output stage and the picture tube. In such a system the screen always has a fixed average illumination. While this arrangement is a compromise it is fairly satisfactory in England because the British Broadcasting Corporation follows the transmitting practice of keeping the average illumination nearly constant -- that is, they never transmit a full-black or a full-white picture. The alternating-current coupling has been used only because the average customer has difficulty in correctly adjusting contrast and brightness in a receiver with direct-current coupling. Whether or not such an arrangement would be satisfactory in the United States depends on the operation of the transmitting station, that is, whether or not wide variations in average brightness are transmitted.

If the brightness control is removed from the front of the set, the customer is still left with the troublesome vernier tuning knob (#4). This difficulty may be removed by the provision of extremely stable circuits or an automatic-frequency-control system. The controls available on such a receiver would then be (1) on-off switch, (2) broadcast-television switch, (3) tuning push-buttons, (4) contrast control, (5) sound volume control, and (6) tone control. The other controls would be available to the service man only.

THE ANTENNA

Television receiving antennas will be of more standardized designs than those which are generally used for broadcast reception. A short piece of wire, such as the usual indoor antenna, will frequently pick up sufficient signal strength to operate the television receiver. The pickup of such an antenna is, however, generally too variable over the frequency range of a single television channel, so that some of the video frequencies will be far too strong or too weak. For this reason television antennas almost always have the form of a doublet, which can be made to pass uniformly a broad band of frequencies.

A common difficulty encountered with television antennas is the reception of one or more reflected waves along with the direct wave. Such reflected waves have necessarily traveled longer distances than the direct wave, and therefore arrive later and produce on the screen repetitions of the picture displaced to the right. This causes the appearance of ghosts and echo effects. Such a condition can be prevented by the use of directivity, so as to discriminate against the undesired waves. In some cases interfering noise is more serious than multiple paths, and the directivity of the antenna can be best used to discriminate against the direction of the noise. The multiple-path effects are more common close to the transmitter, at least where the transmitter is located in a city having many tall buildings. In the case of the Empire State experimental station, reception in the suburbs at distances of fifteen or twenty miles has usually been quite free of multiple-path images. In a few locations close to a transmitter, where more than one station is to be received, it may be necessary to use a different antenna system for each station, each system having the proper directional characteristics.

In locations sufficiently far from the transmitter so that there is insufficient signal strength to override the receiver noise (thermal agitation and tube noise), directional antennas may be used to increase the signal pickup.

The great majority of television antennas will therefore be simple horizontal doublets. The rest of the antennas will be more directional types, usually consisting of two doublets of which one is the antenna proper and the other a reflector. Considerably more complicated arrangements, such as wave antennas, can be used for further improvement. They will probably be used in very few locations.

The usual doublet consists of two wires each one-quarter wavelength long (computed for a frequency near the low-frequency end of the television band), connected at the inner end to a matching balanced transmission line. Such a doublet has a total length of about ten feet and an impedance in the neighborhood of 100 ohms. A balanced transmission line with an approximate impedance match can be secured with a pair of wires carried in a weatherproof sheathing. The balanced-to-ground connection is used in order to discriminate against low-frequency interference, especially interference in the intermediate-frequency range of the television receiver.

In case the transmission line is improperly terminated at the antenna and receiver ends, the received wave may traverse the antenna system more than once; that is, it may be reflected at the receiver, return to the antenna, be reflected again, return to the receiver, and there cause a faint multiple image. Such images give the same type of distortion as that caused by multiple-path transmission. The greater the efficiency of the transmission line, the more serious the difficulty from such reflected waves will be. Therefore it is desirable to have 2 to 4 decibels attenuation in the transmission line. As a practical matter, at least this much is likely to be present in the usual length of line.

RADIO-FREQUENCY CIRCUITS

With the usual balanced transmission line, the antenna coupling system must perform the following functions: (1) provide a suitable impedance termination for the transmission line; (2) convert from balanced operation at the input side to unbalanced operation at the output side; (3) provide voltage gain; and (4) provide selectivity.

As an illustration consider the design of a double-tuned radio-frequency coupling system to be used between the transmission line and the grid of the modulator tube. One of the first questions to be decided is the choice of push-button or continuous tuning. If continuous tuning is used there will be at most seven spots on the dial where television signals may be received satisfactorily; at other points, the receiver will receive mistuned and perhaps unrecognizable pictures, or miscellaneous other signals allocated to the bands between television channels, such as amateur, aviation, etc. In addition the sound channel will pick up a distorted 60-cycle note when the sound channel is tuned to any picture carrier. These effects can be avoided if an interlock system is used which requires the presence of both the sound carrier and the picture sync signals in their proper relation to open the sound and vision channels. Such arrangements introduce some complication. The necessity for them is avoided by the use of push-button tuning; this tunes the receiver, at least approximately, for each channel.

Another disadvantage of continuous tuning, using a variable condenser, is that the total circuit capacitance at the low-frequency end of the band is large, and so gives an unfavorable L/C ratio. The total voltage which may be developed across a circuit when coupled to a given source of signal is inversely proportional to the bandwidth to be received and to the capacitance across the circuit. Consequently the variable-condenser tuning does not give the desired high voltage at the grid of the first tube in the low-frequency portion of the band.

For these reasons pre-set tuning of the push-button type with inductive tuning is selected for this example. The coupling from the transmission line to the first tuned circuit is used to transform from balanced to unbalanced operation. The coupling between the two tuned circuits is adjusted to give the desired bandwidth. The circuits are then loaded with resistance to give the necessary flatness across the broad top of the peak.

With ordinary tubes the shunt conductance of the tube input circuit is sufficient to furnish considerable damping at television frequencies. Unless special precautions are taken, this added damping is variable, especially if the bias of the tube is varied to control the gain.

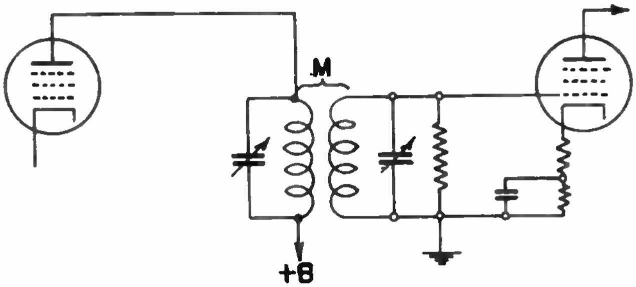
In a developmental receiver using two tuned circuits between the 100-ohm transmission line and the modulator grid, the voltage at the grid was equal to the voltage between the two sides of the balanced line for the three low-frequency television channels (44-72 megacycles). The conversion gain from the modulator grid to the first intermediate-frequency grid was 20 decibels.

INTERMEDIATE-FREQUENCY CIRCUITS

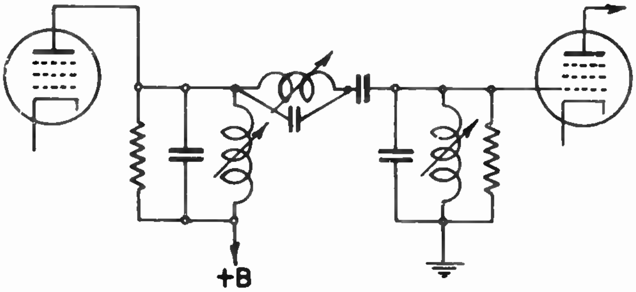
Several types of intermediate-frequency transformers are available. The simplest type, a two-circuit transformer, is suitable for use in some positions. In addition there must be intermediate-frequency transformers in the picture channel having trap circuits for the sound channel of the desired station and others having trap circuits for the sound channel of the next lower station. The trap circuit which is tuned against the sound signal of the desired station must of course be in such a stage that the sound intermediate-frequency voltage can be tapped off ahead for the sound channel of the receiver. Figure 2 shows several possible arrangements of vision intermediate-frequency circuits.

Figure 2A shows a simple double-tuned intermediate transformer with mutual-inductance coupling. In adjusting such a transformer, the same procedure is followed as described above for a double-tuned radio-frequency system. The coupling is set to give the proper bandwidth and then loading in the form of shunt resistors across one or both the tuned circuits is provided to obtain the desired flatness of response. If only one of the circuits is loaded, as in Figure 2A, the gain can be made slightly greater for a given bandwidth and flatness of response than with symmetrical loading. If only one side is loaded, the coupling must be greater than with symmetrical loading. The plate circuit is a relatively stable circuit; that is, the plate losses are lower than the grid-circuit losses and the plate capacitance does not vary with grid bias. Consequently if only one circuit is to be loaded it should be the one which is more variable, namely, the grid circuit. The small un-bypassed resistor in the cathode circuit is useful in maintaining the grid-cathode capacitance nearly constant as the bias is varied. With the mutual-inductance coupling as shown, capacitance trimming adjustments are preferable. This arrangement can be used where it is necessary to add an appreciable fixed capacitance to make the circuits more stable; that is, to reduce the change in tuning due to small changes in tube and circuit capacitance. Where the capacitance can be made about as small as the combined circuit and tube capacitance it is generally preferable to use a self-reactance coupling and inductive trimming.

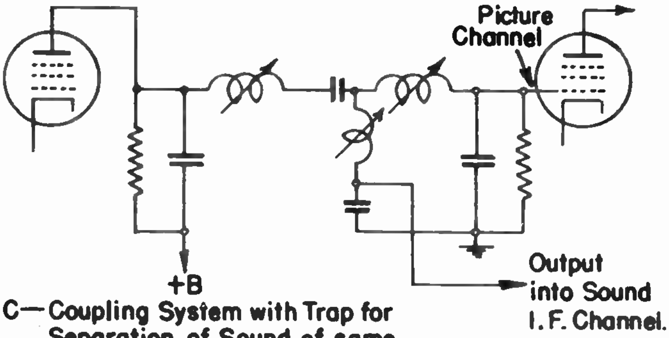
Figure 2B and Figure 2C are are circuit arrangements suitable for use where it is desired to trap out a frequency



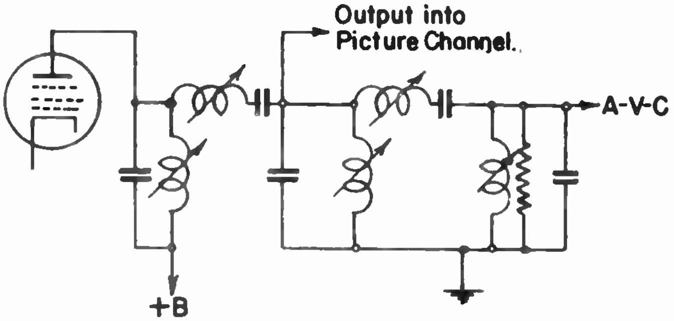
A—Simple Transformer with Mutual-Inductance Coupling.



B—Coupling System with Trap Against Frequency above Band.



C—Coupling System with Trap for Separation of Sound of same Station(Frequency below Band).



D—Coupling System for Supplying Picture and A-V-C Outputs.

Fig. 2. Intermediate-Frecuency Couplings for Picture Channel. (All coils uncoupled except in A)

fairly close to the flat-topped pass-band. The circuit of Figure 2B is useful in removing a frequency on the high side of the pass-band, such as the sound channel of an adjacent lower-frequency television station. (The order of frequencies is inverted by the modulator of the receiver.) The circuit of Figure 2C is useful in removing the sound signal of the desired station from the picture channel; that is, it traps out an undesired frequency near the low edge of the pass-band. This trap circuit supplies a convenient source of voltage for the sound intermediate-frequency channel which may branch off at this point.

Figure 2D shows a three-circuit transformer. In this case self-inductance coupling is shown. The two condensers in series in the high side of the circuit are for direct-current isolation only. The self-inductance type of coupling is used because it is difficult to get sufficient mutual inductance for this circuit. The arrangement is useful where the plate circuit of one tube must be coupled to two grid circuits. The transmission to the first of the grid circuits has better fidelity than that to the second. Such an arrangement is suitable for the dividing point between the picture channel and the control channels in the set illustrated in Figure 1.

THE DETECTOR

Figure 3 shows a detector circuit for the picture channel. In sound receivers it is possible to bypass the intermediate frequency and still retain the higher audio frequencies. In the picture channel this bypassing problem makes it desirable to use a balanced detector, with which the inherent capacitance is sufficient bypass across the video load circuit. The condenser shown in this position in Figure 3 is the circuit distributed capacitance.

SEPARATION OF SYNC SIGNALS

The sync signals are separated from the complete video wave by some form of limiting circuit such as described on pages 48-50 of Chapter 3 (Report 1822). The sync separator then separates the line sync pulses and the field sync pulses from each other. A simple circuit for accomplishing this is shown in Figure 4. The wave A having both sets of signals is differentiated by the action of the small upper condenser and the relatively small right-hand resistor to give the wave B. For the field sync signals the wave A is integrated by the action of the left-hand large resistor and large capacitor to give the wave C. Should a reference on these derivative and integral relations be wanted, pages 50-51 of Chapter 3, Report 1822, may be consulted.

The two outputs of the inter-sync separator are supplied to the respective scanning oscillators. The circuit of Figure 4 has few parts, but more complicated circuits may be used. These will steepen the slope of the field synchronizing pulse as it crosses the critical line at which the field scanning oscillator is fired; the more elaborate circuits will also serve to reduce the effects of the horizontal pulses on the field sync signal, to isolate the two scanning oscillators, and to reduce the sensitivity to noise. With the arrangement shown in Figure 4 the line oscillator is apt to supply a back signal to the sync separator which reaches the field-scanning oscillator and affects the times at which the field retrace begins and ends, with the undesirable result of upsetting the interlace. For this reason a pentode amplifier tube is sometimes used as isolation between the separator and the line-scanning oscillator.

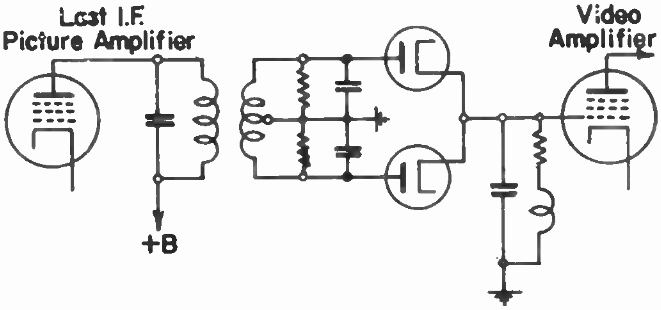


Fig. 3. Balanced Picture Detector.

SCANNING AMPLIFIERS

Figure 5 shows a scanning-amplifier circuit which has been used in the field scanning circuit. The input potentiometer is used to adjust picture height. In normal operation this is set for the scanning amplitude just to fill the picture mask vertically. The centering potentiometer adjusts the amount of direct current flowing thru the scanning coils. If the picture-tube electron gun is set so that the beam strikes the center of the tube in the absence of scanning, the centering potentiometer should be set so that practically no direct current flows thru the winding. Actually some current is almost always required. For example if the field scanning retrace is very fast, it will bring the spot to the top of the picture considerably before the end of the field blanking pulse. This would result in a black margin at the top of the picture which can and should be removed by adjusting the size and centering controls.

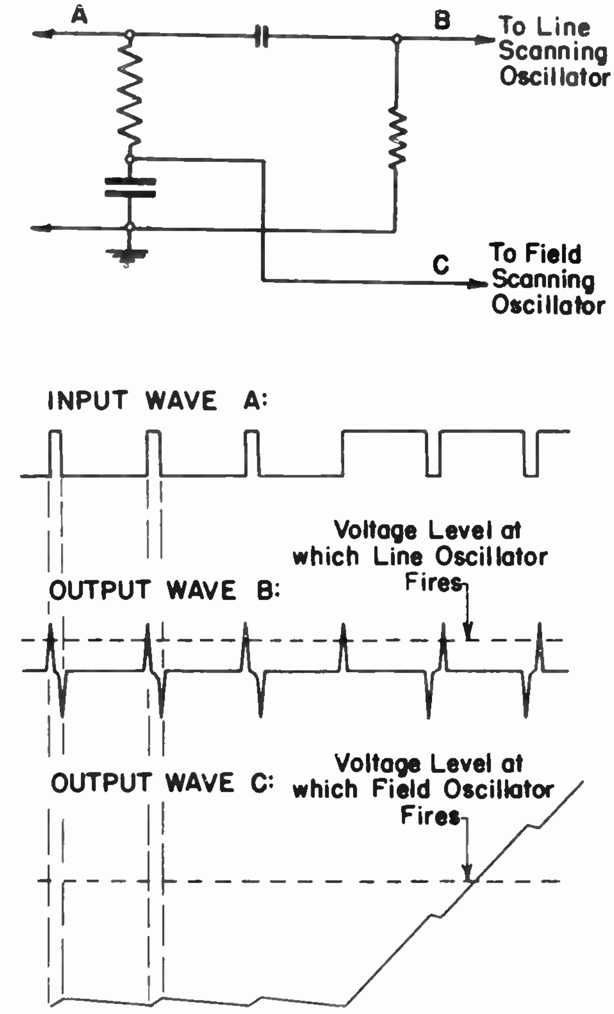


Fig. 4. Separation of Complete Sync Signal into Line and Field Components.

The line scanning amplifier is similar, except that transformer instead of choke coupling is usually used. The centering control is then a low-resistance potentiometer which supplies some of the plate-supply current to the scanning coils.

The scanning coils are mounted on a yoke around the neck of the tube similar to the arrangement used for camera-tube scanning, as described on pages 28-29 of Chapter 2 (Report 1789).

THE PICTURE TUBE

The picture tube is fundamentally similar to the tubes used in oscilloscopes. Three points of difference, however, may be mentioned: (1) the sizes of picture tubes are usually large; (2) the colors are generally an approach to white; and (3) the electron gun must include provisions for modulation, that is for controlling the intensity of the beam in accordance with the received video signals.

The present performance of picture tubes is the result of much improvement in the efficiency and color characteristics of fluorescent screens, and also in the design of electron guns. A brief discussion of the latter topic in connection with camera tubes is given on pages 27-28 of Chapter 2, Report 1789.

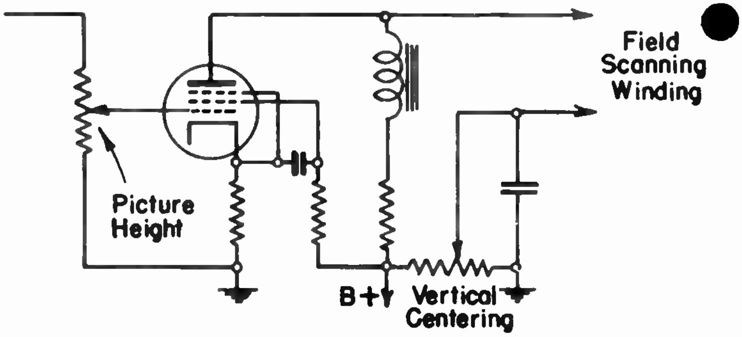


Fig. 5. Pentode Scanning Amplifier for Frame Deflection.

fairly close to the flat-topped pass-band. The circuit of Figure 2B is useful in removing a frequency on the high side of the pass-band, such as the sound channel of an adjacent lower-frequency television station. (The order of frequencies is inverted by the modulator of the receiver.) The circuit of Figure 2C is useful in removing the sound signal of the desired station from the picture channel; that is, it traps out an undesired frequency near the low edge of the pass-band. This trap circuit supplies a convenient source of voltage for the sound intermediate-frequency channel which may branch off at this point.

Figure 2D shows a three-circuit transformer. In this case self-inductance coupling is shown. The two condensers in series in the high side of the circuit are for direct-current isolation only. The self-inductance type of coupling is used because it is difficult to get sufficient mutual inductance for this circuit. The arrangement is useful where the plate circuit of one tube must be coupled to two grid circuits. The transmission to the first of the grid circuits has better fidelity than that to the second. Such an arrangement is suitable for the dividing point between the picture channel and the control channels in the set illustrated in Figure 1.

THE DETECTOR

Figure 3 shows a detector circuit for the picture channel. In sound receivers it is possible to bypass the intermediate frequency and still retain the higher audio frequencies. In the picture channel this bypassing problem makes it desirable to use a balanced detector, with which the inherent capacitance is sufficient bypass across the video load circuit. The condenser shown in this position in Figure 3 is the circuit distributed capacitance.

SEPARATION OF SYNC SIGNALS

The sync signals are separated from the complete video wave by some form of limiting circuit such as described on pages 48-50 of Chapter 3 (Report 1822). The sync separator then separates the line sync pulses and the field sync pulses from each other. A simple circuit for accomplishing this is shown in Figure 4. The wave A having both sets of signals is differentiated by the action of the small upper condenser and the relatively small right-hand resistor to give the wave B. For the field sync signals the wave A is integrated by the action of the left-hand large resistor and large capacitor to give the wave C. Should a reference on these derivative and integral relations be wanted, pages 50-51 of Chapter 3, Report 1822, may be consulted.

The two outputs of the inter-sync separator are supplied to the respective scanning oscillators. The circuit of Figure 4 has few parts, but more complicated circuits may be used. These will steepen the slope of the field synchronizing pulse as it crosses the critical line at which the field scanning oscillator is fired; the more elaborate circuits will also serve to reduce the effects of the horizontal pulses on the field sync signal, to isolate the two scanning oscillators, and to reduce the sensitivity to noise. With the arrangement shown in Figure 4 the line oscillator is apt to supply a back signal to the sync separator which reaches the field-scanning oscillator and affects the times at which the field retrace begins and ends, with the undesirable result of upsetting the interlace. For this reason a pentode amplifier tube is sometimes used as isolation between the separator and the line-scanning oscillator.

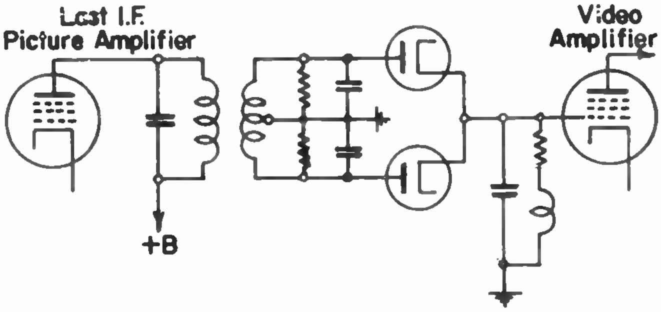


Fig. 3. Balanced Picture Detector.

SCANNING AMPLIFIERS

Figure 5 shows a scanning-amplifier circuit which has been used in the field scanning circuit. The input potentiometer is used to adjust picture height. In normal operation this is set for the scanning amplitude just to fill the picture mask vertically. The centering potentiometer adjusts the amount of direct current flowing thru the scanning coils. If the picture-tube electron gun is set so that the beam strikes the center of the tube in the absence of scanning, the centering potentiometer should be set so that practically no direct current flows thru the winding. Actually some current is almost always required. For example if the field scanning retrace is very fast, it will bring the spot to the top of the picture considerably before the end of the field blanking pulse. This would result in a black margin at the top of the picture which can and should be removed by adjusting the size and centering controls.

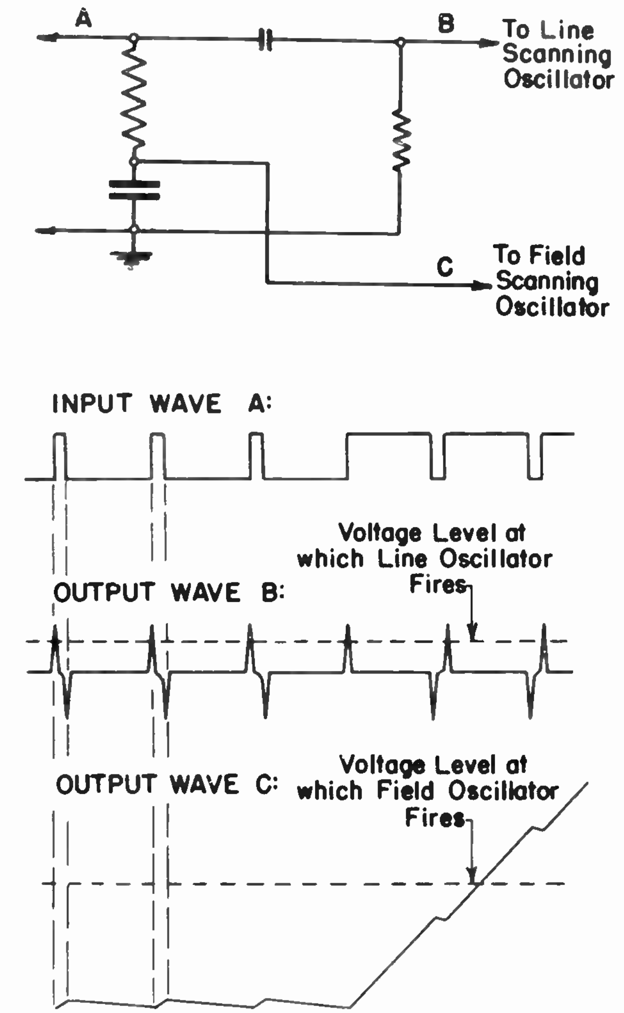


Fig. 4. Separation of Complete Sync Signal into Line and Field Components.

The line scanning amplifier is similar, except that transformer instead of choke coupling is usually used. The centering control is then a low-resistance potentiometer which supplies some of the plate-supply current to the scanning coils.

The scanning coils are mounted on a yoke around the neck of the tube similar to the arrangement used for camera-tube scanning, as described on pages 28-29 of Chapter 2 (Report 1789).

THE PICTURE TUBE

The picture tube is fundamentally similar to the tubes used in oscilloscopes. Three points of difference, however, may be mentioned: (1) the sizes of picture tubes are usually large; (2) the colors are generally an approach to white; and (3) the electron gun must include provisions for modulation, that is for controlling the intensity of the beam in accordance with the received video signals.

The present performance of picture tubes is the result of much improvement in the efficiency and color characteristics of fluorescent screens, and also in the design of electron guns. A brief discussion of the latter topic in connection with camera tubes is given on pages 27-28 of Chapter 2, Report 1789.

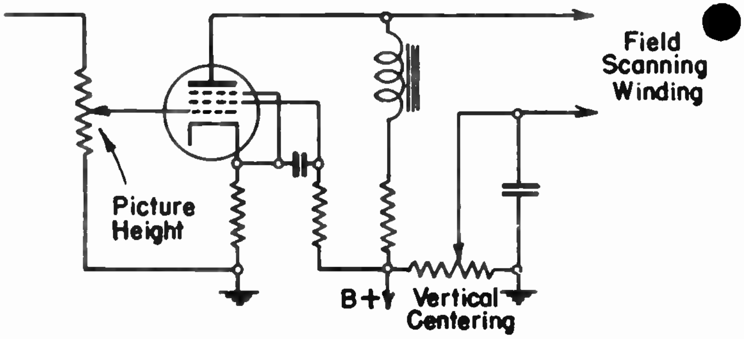


Fig. 5. Pentode Scanning Amplifier for Frame Deflection.

The fundamental requirement is for the electron beam to produce a luminous spot of high intensity. Using the efficiency factor of the screen, this luminous effect corresponds to a given number of watts energy in the beam. This power may be obtained by means of various combinations of current and voltage. Two considerations lead to the choice of high voltage and low current as the preferred operating condition: (1) higher voltage makes the initial random velocities of the electrons a smaller percentage of their final velocity, and thus facilitates focusing; and (2) high current is difficult to obtain with practicable designs of the cathode and the small apertures of the electron gun.

As a representative picture tube the #1800, which has a screen diameter of about nine inches, may be discussed. At zero bias and 6000 volts this tube has a beam current of 450 microamperes, corresponding to 2.7 watts. With a screen efficiency of 1.6 candles per watt, this power produces an intensity of 4.4 candles. This means that the end of the tube as normally viewed is a light source of 4.4 candles intensity. However in normal operation the beam is cut off more than 20 percent of the time by the blanking signals, and also for full white a small negative bias is used to avoid defocusing. With the usual scanned area, the power of 2.7 watts corresponds to 10 milliwatts per square centimeter, which is the maximum average rating to avoid damage to the screen. Therefore the scanned area, under these and similar electrical conditions, must not be reduced.

The mask recommended for the #1800 tube has a width of 7-3/8 inches, a height of 5-1/2 inches, and corners with a radius of 1-3/4 inches. These dimensions give a useful area of about 38 square inches, or 240 square centimeters. As a rough rule applying to this and other tubes, the width of the picture is about 80 percent of the nominal diameter of the screen. The height of the picture is approximately 60 percent of the nominal diameter.

The maximum screen rating of 10 milliwatts per square centimeter is of course on a steady-state basis; that is, the average dissipation must not exceed this. The instantaneous dissipation per unit area, while a particular spot is being scanned, however, may and does very greatly exceed this value. With say 200,000 picture points, the allowable dissipation during the short time of scanning one spot may have a value which is greater in this proportion, or the equivalent of two kilowatts per square centimeter. It is for this reason that the scanning spot must be kept in motion whenever the tube is operating with normal beam current. It is essential, for example, that the scanning oscillators continue in operation in the absence of synchronizing signals, and that in general the scanning have a high degree of reliability. Otherwise, upon failure of the spot to scan a substantial portion of the screen, damage to the tube would promptly occur.

CURRENT ENGLISH RECEIVERS

Table I, which occupies pages 128-133, gives the available data on television receivers exhibited at the 1938 London Radiolympia radio and television exhibition. The information in this table is mostly from trade periodicals and sales circulars. These television receivers are fixed-tuned to the London station, which operates with a picture carrier of 45 megacycles and a sound carrier of 41.5 megacycles. It will be noted that the sound carrier is below the picture carrier, which is opposite to American practice.

In Table I the approximate list price in England of the various receivers is given in dollars; these have been computed from the English price, stated to the nearest pound, using an exchange factor of five dollars per pound. The dimensions of the picture are given in inches. The cabinet dimensions are to the nearest inch. The number of tubes is intended to include the power rectifiers, but in some cases these may be omitted; the picture tube is always included.

Some of the models listed in Table I have been recently introduced, and others carried over from last year. The most interesting recent development in English receivers has been the decrease

TABLE I. CHARACTERISTICS OF

Notation:- APh = Automatic phonograph. AW = All-wave radio. BL = Broadcast and low-
P = Projection type. Ph = Phonograph. T = Table model. VO = Vision only.

Make	Model	Approx. Price in Dollars	Picture Size	Cabinet W x D x H	General Type	Number of Tubes
Baird-Bush	T19	790	18 x 15 P	C 29x23x42	AW	-
"	T14	630	13-1/2 x 11 M	C 58x20x42	AW + APh	27
"	T21	375	10 x 8 M	C 39x20x33	AW + Ph	-
"	T18 (Cons.)	245	10 x 8 D	C 20x16x44	AW	-
"	T18 (T.M.)	230	10 x 8 D	T 18x16x25	AW	-
"	T20 (Cons.)	200	7-3/4 x 6-1/4 D	C 18x13x48	VS	-
"	T20 (T.M.)	185	7-3/4 x 6-1/4 D	T 18x13x22	VS	-
Beethoven	TR20	250	7-1/2 x 6-1/4 D	C	AW	18
Burndept	-	235	10 x 8 D	C	VS	21
Cossor	237T	475	10 x 8 D	C 21x24x51	BL + APh	21
"	137T	370	10 x 8 D	C 21x24x45	BL	21
"	1210	250	12 x 9-1/2 D	C 21x25x49	AW	21
"	437T	235	8-1/4 x 6-1/2 D	T 15x25x23	VS	20
"	54A	135	5 x 4 D	T 13x21x18	VS	16
"	54	120	5 x 4 D	T 13x21x18	VS	13
Decca	38/1	315	10 x 8 M	C	VS	27
Dynatron	E3515	865	10 x 8 D	C	AW + APh	35
Ekco	TC103	255	10 x 8 D	C 19x20x38	VS	24
"	TA201	115	6 x 5 D		VO	18
Ekco-Scophony	ES104	1155	24 x 20 M P	C 30x22x60	VS	39
Electrical and Musical Industries, ("E.M.I.") Has Marconiphone and Gramophone divisions, latter using trade mark "His Master's Voice," ("H.M.V.")	H.M.V. 906	1050	22 x 18 P	C 40x25x66	AW	37
	H.M.V. 902	630	10 x 8 M (Mirror and lens)	C 40x21x50	AW + APh	23
	H.M.V. 900	420	10 x 8 M	C 37x19x38	AW	24
	H.M.V. 901	315	10 x 8 M	C 24x17x38	VS	23

frequency bands. C = Console. D = Direct viewing. M = Mirror. MP = Mechanical projection. VS = Vision and accompanying sound.

Super or T-R-F Picture Channel	Watts Consumed	Deflection	Remarks
Super	-	Magnetic	Has 6 chassis. Also has screen of 24 x 19 inches.
-	-	Magnetic	Has 7 chassis.
-	200	Magnetic	-
-	150	Magnetic	-
-	-	Magnetic	-
Super	-	Magnetic	-
Super	-	Magnetic	-
-	120	-	Uses Mullard or Ediswan 9-inch short tube.
-	200	Magnetic	Uses Ediswan #12MH picture tube.
Super	240	Electrostatic)	Models 237T and 137T have an r-f stage, four i-f stages at 5.3 megacycles, diode picture detector, and one video stage; contrast control on second i-f stage; sound channel splits off after first i-f stage and includes individual second i-f stage at 1.8 megacycles; broadcast reception using doublet as T antenna. 1937 models.
Super	240	Electrostatic)	
Super	230	Magnetic	Has permanent-magnet focusing of picture tube; vacuum-tube scanning oscillators; one r-f stage; triode-hexode modulator; two i-f stages; one video stage. Model 1210A also offered with 24 tubes at $265.
Super	180	Electrostatic	-
T-R-F	150	Electrostatic	Like Model 54 but has additional amplifier.
T-R-F	150	Electrostatic	Takes unbalanced line deflecting voltage, balanced field voltage. For less than twenty miles.
-	250	Electrostatic	Uses Ediswan #12H picture tube.
-	200	Magnetic	Uses Baird #12MW2 picture tube.
-	265	Magnetic	Uses Ediswan #CRM121 picture tube.
-	180	-	Uses Ediswan 7-inch tube.
T-R-F	About 1000	Mirror Drums	Four r-f stages; diodes for detection and sync separation; supersonic light valve, mirror drums and pressure mercury lamp.
Super	550	Magnetic	Like Marconiphone 708. Image on projection tube is 2-1/2 x 2 inches and is projected by f/1.5 lens; color "black and light green"; has 5 chassis.
T-R-F	250	Magnetic	Like Marconiphone 703, except latter has larger tube and no lens.
T-R-F	250	Magnetic	Like Marconiphone 705. Six r-f stages; sound channel uses first two of these and is then superheterodyne with i.f. of 0.465 megacycle; high-vacuum scanning oscillators of blocking type; scanning amplifiers transformer-coupled to line and field coils of yoke. 1937 model. Like Marconiphone 701 except that latter has smaller tube with mirror and lens.
T-R-F	250	Magnetic	Like Marconiphone 702. Similar to H.M.V. 900 except without all-wave radio, one less tube, and sound intermediate frequency of 1.5 megacycles. 1937 model.

TABLE I. CHARACTERISTICS OF

Notation:- APh = Automatic phonograph. AW = All-wave radio. BL = Broadcast and low-
P = Projection type. Ph = Phonograph. T = Table model. VO = Vision only.

Make	Model	Approx. Price in Dollars	Picture Size	Cabinet W x D x H	General Type	Number of Tubes
Electrical and Musical Industries (Cont'd)	H.M.V. 903	235	7-3/4 x 6-1/4 D	C 18x25x39	VS	16
	H.M.V. 907	235	7-1/2 x 6 D	C 18x23x39	AW	19
"	H.M.V. 905	185	6-1/4 x 5 D	T 26x15x19	AW	17
"	H.M.V. 904	150	4-3/4 x 4 D	T 23x15x17	AW	17
Ferranti	T4	315	10 x 8 D	C 19x30x44	AW	17
"	T3	265	10 x 8 D	C	VS	16
General Electric Company, Ltd.	BT8161	370	13-1/2 x 11 M	C 41x22x40	AW	22
	BT9122	315	10 x 8 M	C 38x21x34	AW	21
	BT9121	195	10 x 8 D	C 20x21x38	VS	19
"	BT8090	120	7-1/4 x 5-3/4 D	T 14x20x17	VO	15
Invicta	TL5	165	7-1/8 x 5-3/4 D	T 17x14x19	VS	18
"	TL4	115	4 x 3-3/8 D	T 13x12x16	VO	13
Kolster-Brandes	790	290	10 x 8 M	C 32x18x42	AW	26
	780	230	10 x 8 D	C 21x21x38	VS	19
McMichael	800T	315	9 x 7-1/4 M	C 30x26x38	VS	28
Murphy	A42V	325	9 x 7 M	C	VS	27
"	A58V	225	7-1/2 x 6 D	C	AW	22
"	A56V	150	7-1/2 x 6 D	C 18x18x35	VS	18
Philips	Tel 61	630	18 x 14-1/2 P	C 29x21x47	AW	-

ENGLISH TELEVISION RECEIVERS (Cont'd)

frequency bands. C = Console. D = Direct viewing. M = Mirror. MP = Mechanical projection. VS = Vision and accompanying sound.

Super or T-R-F Picture Channel	Watts Consumed	Deflection	Remarks
Super	190	Magnetic	Like Marconiphone 704.
Super	180	Magnetic	Like Marconiphone 709. Has r-f stage, triode-hexode modulator, 3 i-f stages, and one video stage; sound taken off after second of these i-f stages; two-tube sync separator. New model.
Super	180	Magnetic	Like Marconiphone 707.)(These two models have
Super	180	Magnetic	Like Marconiphone 706.)(an r-f stage and 3 i-f stages; description and circuit in Wireless World, Sept. 1, 1938, pp. 218-220. New models.
Super	300	Magnetic)	Television features of both models same; r-f
Super	230	Magnetic)	stage; secondary-emission modulator; sec.-em. i-f stage; video stage; 4750 volts for second anode; viewing angle of 120°.
Super	230	Electrostatic	Has video stage; thyratron scanning oscillators.
Super	230	-	-
-	200	Electrostatic	Has 2 r-f stages and 2 i-f stages at 6 Mc; video stage direct-coupled to picture tube; thyratron scanning oscillators; single pentode scanning amplifiers coupled with push-pull transformers to deflecting plates.
-	180	-	Converts television sound to broadcast band.
-	150	Magnetic	Uses Mullard #MW22/1 picture tube.
-	110	Magnetic	Uses Cathodeon #75250 picture tube.
-	250	Magnetic)	Models 780 and 790 use Ediswan #CRM121
-	250	Magnetic)	picture tube.
Super	200	Electrostatic	Use Ediswan #12H picture tube.
Super	230	Electrostatic	Has r-f stage, triode-hexode modulator, four i-f stages at 4.25 Mc, full-wave diode detector direct-coupled to video stage, a-c coupling with reinserter to grid of picture tube; sound channel splits off after modulator and has two i-f stages at 0.750 Mc; sync separator using short-time-constant circuit to obtain opposite polarity for line and field sync signals; thyratron scanning oscillator followed by push-pull amplifier for each component. Described in paper by K. S. Davies in Journal of Television Society, December 1937, pp. 299-305. Offered in Types A and B for distances within and beyond 15 miles.
Super	260	Magnetic)	Models A58V and A56V have the following: one
Super	200	Magnetic)	r-f stage; 3 i-f stages; one video stage direct-coupled to picture tube; short picture tube with magnetic focusing; thyratron scanning oscillators followed by pentode scanning amplifiers; tube voltage 4500; sound channel splits off after converter.
Super	-	Magnetic	Has 4-inch Mullard projection tube, 18" dimension from 2", using f/1.9 lens; uses mirror and fixed screen; 25 kv on tube; has r-f stage and 4 stages of i-f picture amplification at 13.2 Mc; sound i.f. = 9.7 Mc.

TABLE I. CHARACTERISTICS OF

Notation:- APh = Automatic phonograph. AW = All-wave radio. BL = Broadcast and low-
P = Projection type. Ph = Phonograph. T = Table model. VO = Vision only.

Make	Model	Approx. Price in Dollars	Picture Size	Cabinet W x D x H	General Type	Number of Tubes
Pilot	T65	340	10 x 8 D	C	BL + Ph	25
Pye	816	1025	18 x 15 P	C	AW	-
"	4045	420	10 x 8 M	-	AW	25
"	838	340	7-1/8 x 5-3/4 D	C 30x18x32	AW + APh	23
"	843	265	7-1/2 x 6 D	-	AW	23
"	4046	225	7-1/2 x 6 D	-	VS	16
"	815	160	7-1/8 x 5-3/4 D	T 17x14x19	VS	19
"	819	150	4-1/4 x 3-1/4 D	T 17x12x23	BL	17
"	817	110	4-1/4 x 3-1/4 D	T 16x12x13	VO	12
Radio Gramophone Development	382RG	685	10 x 8 M	C 43x23x37	AW + APh	40
	382R	475	10 x 8 M	C 36x18x36	AW	36
	382	395	10 x 8 M	C 31x18x36	VS	29
Tannoy	-	445	10 x 8 D	C	APh	-
Ultra	T24	200	10-1/4 x 8-1/4 D	C	VS	18
	T22	145	7-3/4 x 6-1/4 D	T	VS	18
Vidor	-	210	10 x 8 D	C	VS	-

ENGLISH TELEVISION RECEIVERS (Cont'd)

frequency bands. C = Console. D = Direct viewing. M = Mirror. MP = Mechanical projection. VS = Vision and accompanying sound.

Super or T-R-F Picture Channel	Watts Consumed	Deflection	Remarks
-	-	Magnetic	-
T-R-F	-	Magnetic	Has video stage.
-	250	-	Uses Emiscope #6/1 picture tube.
-	200	Magnetic	Models 838 and 843 use Mullard #MW22/1 picture tube.
-	200	Magnetic	
-	150	-	Uses Emiscope #6/2 picture tube.
T-R-F	150	Magnetic	Has 5 r-f stages, no video stage; gain control by variation of suppressor potential of r-f stages; video detector direct-coupled to picture tube; two pentodes in sync separator; vacuum-tube scanning oscillators of blocking type; line scanning amplifier transformer-coupled to deflecting winding.
-	150	Magnetic	Six push buttons for normal radio reception.
T-R-F	110	Magnetic	Has 4 r-f stages; has triode-tetrode for line scanning oscillator and amplifier, and triode-hexode for field scanning; delivers sound at audio frequency for connection to phono pickup terminals of regular radio receiver.
Super	250	Electrostatic	All R.G.D. models alike in following respects: r-f stage; triode-hexode modulator; 4 stages of i.f. at 13 Mc; video stage; sound i.f. = 9.5 Mc; four-tube sync separator; thyratron scanning oscillators, followed by push-pull scanning amplifiers; Ediswan #12H picture tube; speaker flat to 8000 cycles.
Super	250	Electrostatic	
Super	250	Electrostatic	
Super	-	-	Has r-f stage, triode-hexode modulator, and 4 stages of picture i.f. at 8.2 Mc; one video stage.
Super	220	Magnetic	Both models have slow-heating mercury rectifier for extra-high tension. Model T24 uses Ediswan #CRM121 picture tube and Model T22 uses Ediswan #CRM91.
Super	220	Magnetic	
-	-	-	-

in length of the picture tubes. An example of the newer-type tubes is one with magnetic scanning, magnetic focus, and 9 inches diameter, which has an overall length of only 14 inches. These short tubes constitute an important improvement because of their reaction on cabinet design and viewing arrangements. In order to provide direct viewing of the picture and to give a good set layout for manufacture, it is desirable to mount the tube horizontally. But horizontal mounting with a long tube (20 inches or more) makes the front-to-back dimension of the cabinet too large. Most people like a table-model cabinet which can be set well back on a table, or a console which can be placed against a wall. They do not want a cabinet which has a front-to-back depth of two feet or more. With the longer tubes, therefore, it is necessary to mount the tube vertically and use an expensive hinged lid and mirror for viewing. Such a viewing system is less satisfactory than the direct viewing obtained with a horizontal tube. The new short types make it possible to mount a 9-inch tube for direct viewing in a cabinet which has a reasonable front-to-back dimension.

Although there are certain exceptions, the general trend in England appears to be from tuned-radio-frequency to the superheterodyne circuit for the picture channel, and from electrostatic to magnetic deflection. Gas-filled scanning oscillators are used in a larger portion of the models than appears likely in the United States. During the last year the chief developments have been the introduction of small models priced below the normal range and of large projection models priced above.

The projection type of television receiver is indicated by the letter "P" following the picture size. This variety uses a small cathode-ray tube operated at very high voltage so as to produce an intense picture on the tube screen; this picture is suitable for projection on to a viewing screen by means of a lens. A translucent viewing screen is used with the projection from the back.

Types listed in the table with the letter "M" following the picture size have a mirror in the lid with the picture tube in a generally vertical position so that the picture is seen in the mirror. A suitable hinge is provided to hold the lid at a proper angle in the neighborhood of 45 degrees.

Models listed in Table I with the letter "D" following the picture size provide direct viewing, which means that the screen of the picture tube is seen directly by the user.

The Ekco-Scophony model is a mechanical projection type operating as follows: (1) a pressure-type 300-watt mercury lamp produces an intense light; (2) this is modulated in a special liquid light valve; and (3) mirror drums project this on a screen. The field drum has a diameter of 12 inches; the line drum is small and rotates at 30,375 revolutions per minute for the English line frequency of 10,125 lines per second, there being 20 mirror faces on the drum. The picture signals actuate a piezoelectric crystal at one end of the light valve, causing the propagation thru the liquid in the valve of waves representing a "history" of points recently transmitted. The velocity of these waves in the liquid is suitably related to the line scanning process so that more than one point is projected on the screen at a time; it is reported that nearly 200 points are simultaneously projected -- this is about half a line.

The column "General Type" in Table I indicates what facilities the particular model offers in addition to the reproduction of the television picture. In case no other facilities are offered, the abbreviation "VO" is used indicating vision only, and a conventional sound receiver is required for the reproduction of the television sound channel. Such a television receiver includes provision for converting the television sound channel from the English sound carrier of 41.5 megacycles to some point in either the skip or broadcast bands, or to audio frequency for connection to the phonograph pickup terminals of the sound receiver. Receivers designated "VS" reproduce the vision and sound channels of the television station, but do not provide any ordinary radio reception. Receivers designated "AW" provide for both vision and sound television channels and also include an all-wave radio receiver. The meaning of the abbreviations representing other arrangements will be clear upon consulting the alphabetical list of abbreviations which is given.

REFERENCES

The references given below are in addition to those included in previous chapters on the subject of receivers. For convenience the arrangement below is by groups according to subject matter, with a chronological order in each group.

General Discussion and Description of Receivers

Book, "Television Reception Technique", by Paul D. Tyers of Watford, England, published in 1937 by Isaac Pitman and Sons, Ltd., at 12s 6d, a volume of 144 pages devoted entirely to electronic methods.

"The Cossor Television Receiver", by L. H. Bedford in JOURNAL OF THE TELEVISION SOCIETY, Volume 2, pages 226-229, March 1937.

"The E.M.I. Television Receiver", by T. H. Watson of Marconi-E.M.I. Ltd. in the JOURNAL OF THE TELEVISION SOCIETY, Volume 2, pages 230-234, March 1937; this describes the t-r-f design of this company which has since been followed by superheterodyne designs.

"Television Receivers", by D. C. Espley and G. W. Edwards of General Electric Co. Ltd., England, in two issues of the G.E.C. JOURNAL, May and August 1937; the paper totals 22 pages.

Book, "Television Engineering", by J. C. Wilson, to which reference has been made in preceding chapters; the following sections discuss subjects of the present chapter: intermediate-frequency amplifiers, pages 204-216; video amplifiers, pages 156-180; picture tube, pages 258-286 and 299-312; synchronization, pages 344-353; and scanning, pages 286-299.

Book, "Fernsehen: Die Neuere Entwicklung insbesondere der deutschen Fernsehtechnik" ("Television: Recent developments especially in German television practice"), edited by Fritz Schroeter, a volume of 260 pages published by Julius Springer in the latter part of 1937; this volume includes chapters on various branches of television, of which chapter 7 on receivers is by Manfred von Ardenne; this chapter occupies pages 185-227; the book will be found a useful reference for engineers acquainted with German.

"Some Considerations in the Design of the Murphy Television Receiver", by K. S. Davies in the JOURNAL OF THE TELEVISION SOCIETY, Volume 2, pages 299-305, December 1937.

"H.M.V. Model 904, a Receiver for Television and All-Wave Broadcast Reception at 29 Guineas", in WIRELESS WORLD, September 1, 1938, pages 218-220; includes circuit of this recent low-priced design.

Antenna and R-F Circuits

"Effect of the Receiving Antenna on Television Reception Fidelity" by S. W. Seeley, in the RCA REVIEW, April 1938, pages 433-441.

"Television Receivers" by E. W. Engstrom and R. S. Holmes of the RCA Manufacturing Company in ELECTRONICS, April 1938, pages 28-31 and 63-66.

Carrier and Video Amplification of Picture Signals

"Theoretical Notes on Certain Features of Television Receiving Circuits" by G. D. Robinson of the United States Naval Academy in the PROCEEDINGS OF THE I.R.E., June 1933, pages 833-843.

"The Steady-State Response of a Network to a Periodic Driving Force of Arbitrary Shape, and Application to Television Circuits", C. W. Carnahan of the

Hygrade Sylvania Corporation in the PROCEEDINGS OF THE I.R.E., November 1935, pages 1393-1404.

"Video Amplifier Design", R. L. Freeman and J. D. Schantz, both at that time with the Farnsworth organization, in ELECTRONICS, August 1937, pages 22-25, 60 and 62, and also extended in the issue of November 1937, pages 52 and 54.

"Analysis and Design of Video Amplifiers" by S. W. Seeley and C.N. Kimball in the RCA REVIEW, October 1937, pages 171-183; also published in TELEVISION, Volume II, the bound volume of RCA reprints, pages 241-255.

"Amplification Problems in Television" by F. A. Everest of Oregon State College in COMMUNICATIONS for January 1938, pages 15-19 and 38; this author has also published "Wide-Band Television Amplifiers" in ELECTRONICS for January 1938, pages 16-19, and "Wide-Band Television Amplifiers - II" in ELECTRONICS for May 1938, pages 24-27.

"Some Notes on Video Amplification Design" by Albert Preisman in the RCA REVIEW, April 1938, pages 421-432.

"Television I-F Amplifiers", by E. W. Engstrom and R. S. Holmes of the RCA Manufacturing Company in ELECTRONICS, June 1938, pages 20-23.

"Wide-Band Amplifiers for Television" by H. A. Wheeler of the Hazeltine organization, issued as Hazeltine Report 859b-W; presented before the New York convention of the Institute of Radio Engineers in June 1938, and to be published shortly in the PROCEEDINGS OF THE I.R.E.; this paper gives methods for obtaining optimum performance within the indicated fundamental limitations.

"Television V-F Circuits", E. W. Engstrom and R. S. Holmes of the RCA Manufacturing Company in ELECTRONICS for August 1938, pages 18-21.

Optics and Electronics

Book, "Television Optics", by L. M. Myers of the Research Department of Marconi's Wireless Telegraph Company, Ltd., a volume of 338 pages published by Isaac Pitman and Sons, Ltd., selling in the United States at $8.50; this volume gives an advanced description of optical matters of interest in both mechanical and electronic television systems.

Book, "Fundamentals of Engineering Electronics", by W. G. Dow, Assistant Professor of Electrical Engineering, University of Michigan, a volume of 604 pages giving an advanced treatment of the subject; published by John W. Wiley and Sons, Inc., at $5.00.

"Theoretical Limitations of Cathode-Ray Tubes", by D. B. Langmuir of the RCA Radiotron Division in the PROCEEDINGS OF THE I.R.E. for August 1937, pages 977-991; also in TELEVISION, Volume II, the bound RCA reprints, pages 256-270.

Book, "Electron Optics in Television", by I. G. Maloff and D.W. Epstein of the RCA Manufacturing Co., a volume of 299 pages published by McGraw-Hill Book Company, at $3.50; this book presents both theoretical and practical material on the subject.

Scanning

"Scanning in Television Receivers", by Frank J. Somers of Farnsworth Television, Inc., in ELECTRONICS for October 1937, pages 18-21.

"Distortion of Saw-tooth Waveforms" by Manfred von Ardenne in ELECTRONICS for November 1937, pages 36-38 and 84.

Chapter 13 of the above-mentioned book by Maloff and Epstein discusses oscillators for the production of saw-tooth waves.