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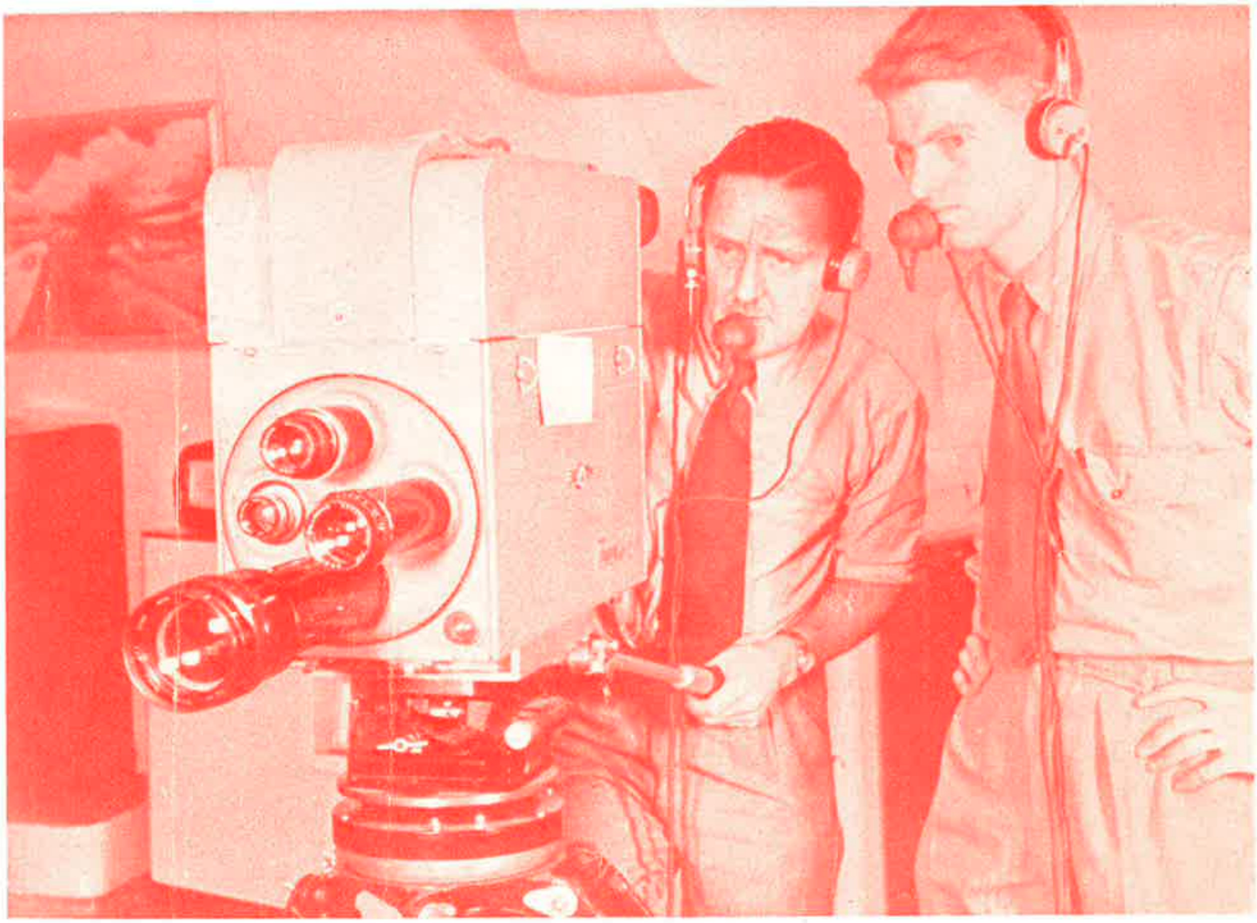
RADIOTRONICS

Volume 18 April, 1953 No. 4



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RADIOTRONICS

Volume 18 **April 1953** **Number 4**

By the way—

Our front cover this month is taken from the film "Australia Makes Radio Valves by the Million", and is reproduced here by courtesy of the Australian Diary Film Unit and shows a Marconi 625-line TV camera in action.

The second edition of the Radiotron Valve Data Book will be available immediately after Easter. An announcement will be made as soon as stocks are received; until then orders are not being accepted. Selling price will be twelve shillings and sixpence.

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

Back issues of Radiotronics prior to March, 1953, are no longer available.

The RCA Application Note dealing with "pencil triodes" is reprinted with acknowledgements to Radio Corporation of America.

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

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By K. Fowler and H. Lippert.

R-F, OSCILLATOR AND CONVERTER CIRCUITS

1. Introduction

Thus far in the course no attempt has been made to discuss any particular section of a television receiver. Instead, an attempt was made to present an over-all picture of the television system which would serve as a background for the more detailed circuit analysis of television receivers. From this point on, however, each section will be discussed in detail and probably the most logical place to start is with the r-f circuits or head-end where the television signals first enter the receiver.

2. Requirements

Before considering the actual head-end circuits, it might be well to discuss some of the important requirements of r-f circuits for television receivers.

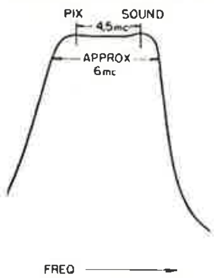

Fig. 5-1. Band width for Television.

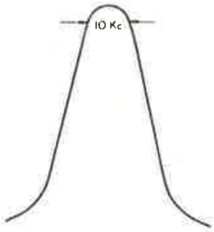

Fig. 5-2. Band width for Radio.

(1) The first of these requirements is that they must have wide-band characteristics in order to properly pass both the picture and sound carriers together with their associated side-bands. This means that the r-f circuits must have uniform response over a range of frequencies, approximately 6 mc wide, as shown in Figure 5-1, which illustrates the response curve that would be obtained if the pass-band of the r-f circuits were examined on an oscilloscope. If markers were used to locate the various frequencies on the response curve, the marker corresponding to the picture carrier would fall on the curve as shown, while the marker for the sound carrier would fall on the right side of the curve 4.5 mc away from the picture marker. The over-all band width over which uniform response is obtained is approximately 6mc. To get a better idea of the tremendous range of frequencies involved, compare the response curve of Figure 5-1 with the r-f response curve for a broadcast receiver shown in Figure 5-2. The pass-band for the television r-f circuits is approximately 600 times wider than for the broadcast r-f circuits.

(2) A second important consideration in the design of television r-f circuits is that of image rejection.

By courtesy of A.G.E., with acknowledgment to International General Electric Co. of U.S.A.

The response of the r-f tuned circuits must not only have wide-band characteristics but must also have sufficient selectivity to provide good image rejection. Using the standard RMA i-f's, it is quite possible for high powered FM stations in the spectrum from 88 to 108 megacycles to cause image interference on television Channel #2. In order to prevent image interference from this source, the tuned circuits associated with Channel #2 are often made more selective than for the other channels, providing a wide-band response with improved selectivity.

(3) A third requirement is that the antenna input impedance must remain essentially constant at all frequencies to be passed. This means that the antenna input impedance must not change substantially over a range of frequencies extending from 54 mc to 216 mc. If the antenna input impedance is 300 ohms when tuned to Channel #2, it should also be 300 ohms when the receiver is tuned to any other channel.

Maintaining a constant input impedance for all frequencies to be passed is important for two reasons. First, in order to obtain the maximum transfer of signal from the antenna to receiver, the input impedance of the receiver should match the centre impedance of the antenna. If the input impedance of the receiver matches the antenna impedance on, say, Channel #2 but is considerably different when the receiver is switched to other channels, then the maximum transfer of signal will not be obtained on all channels.

The second and probably the most important reason for maintaining a constant input impedance is the prevention of reflections or standing waves on the transmission line. For reasons to be discussed in detail in the section on antennas, the transmission line between the antenna and receiver must be terminated in an impedance equal to its characteristic or surge impedance to prevent standing waves or reflections on the line. If standing waves or reflections appear on the line, they will cause a displacement of the image on the screen depending on the degree of reflections or standing waves. This displacement of the image will cause a blurring or smearing of the picture which, of course, is highly undesirable. If the input impedance of the receiver should change from channel to channel, then it is obvious that the transmission line will not be properly terminated for all channels, resulting in standing waves and a poor picture.

The antenna input impedance of many post-war television receivers is 300 ohms and remains essentially constant for all channels.

A folded dipole type of antenna having a centre impedance of 300 ohms is recommended for use with these receivers (for reasons to be brought out in a later section) and the connections from antenna to receiver, with the impedances that are involved, are shown in Figure 5-3. It will be noted that the antenna impedance is equal to the input impedance of the reciever, which provides the maximum transfer of energy when a 300-ohm transmission line is used. Also, it will be noted that the 300-ohm characteristic impedance of the transmission line is properly terminated by the receiver, the input impedance of which remains essentially constant at 300 ohms for all 12 channels.

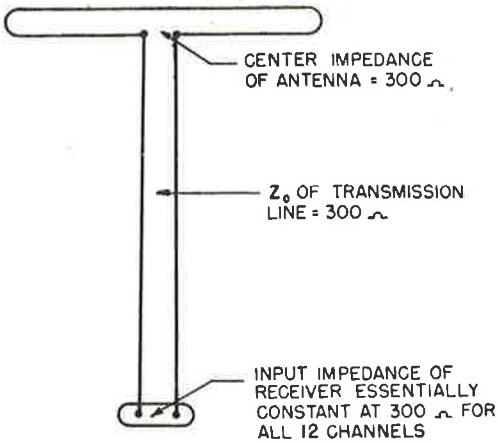

Fig. 5-3. Antenna Connections.

(4) Another consideration is that of providing maximum gain in the r-f amplifier consistent with a minimum amount of tube noise. As is generally known, the tube noise generated in a triode is lower than in pentodes and a better signal-to-noise ratio is obtained by the use of a triode r-f amplifier. However, when a triode is used, the effect of the grid-plate capacitance of the tube must be overcome, as will be explained later.

3. Antenna coupling circuits

Since a wide band of frequencies must be passed (approximately 5-6 mc), the antenna coupling circuits must be of special design to insure constant band width regardless of the operating frequency. Also, as mentioned previously, the input impedance of the antenna coupling circuit must closely match the transmission line impedance at all frequencies to be passed in order to insure the maximum transfer of signal from antenna to receiver; and, also, to prevent reflections from being set up on the line which would seriously affect the quality of the picture.

One method of coupling the antenna is to make use of a band-pass coupled circuit tuned to pass each channel in turn. This is accomplished by a suitable switching action which connects the proper pre-tuned coupling circuits for each channel. A typical antenna coupling system of this type which was used in a pre-war television receiver is shown in (A) of Figure 5-4.

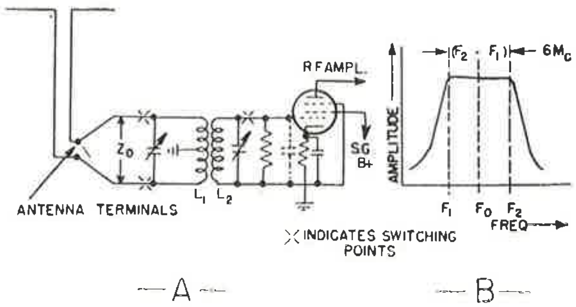

Fig. 5-4. R-F Amplifier.

It is a double-tuned, closely-coupled circuit which transfers the signal from the transmission line to the grid of the r-f amplifier. The centre tap on the primary L_1 is grounded, thus providing an antenna input circuit that is balanced to ground. The response curve for this coupling circuit is shown in (B) of Figure 5-4 where Fo represents the centre frequency of the particular channel being received, F_1 represents the lower frequency limit of the channel and F_2 represents the upper frequency limit. The band width from F_1 to F_2 should be approximately 6 mc wide in order to satisfactorily pass both carriers with their associated sidebands. Both L_1 and L_2 resonate at the same frequency and are overcoupled together with resistive loading of the secondary to obtain the desired bandwidth. The antenna input impedance was made to look like approximately 100 ohms in the early model receivers by the proper choice of L and C values of the coupling circuit since there is a definite relationship between the antenna input impedance, the bandwidth required, and the L and C values used. A small trimmer is used to tune L_1 and L_2. This sacrifices some sensitivity but the circuit is more stable insofar as the variation of tube input capacities are concerned and, therefore, replacing a tube will not upset the response of the tuned circuits as much as if L_1 and L_2 were tuned by stray capacities alone. Switching occurs at the points marked X and as the input circuit is changed from channel to channel a separate primary and secondary pretuned to the desired channel is switched into the circuit.

To prevent signals in the region below the frequencies covered by the television channels from getting through, a balanced input wave trap forming a high-pass filter between the antenna posts anad the coupling circuits was used in older receivers. This is shown in Figure 5-5. This circuit offers a high impedance to frequencies below the television channels. At frequencies below the television channels the reactance of the capacitors is very high, while the reactance of the coils is low; therefore, little or no signal voltage appears in the filter output for signals below the regular television channels. However, for frequencies within the range of the regular television channels, the reactance of the capacitors is very low while the reactance of the coils is very high, and, therefore, signals within this range of frequencies pass through without appreciable attenuation.

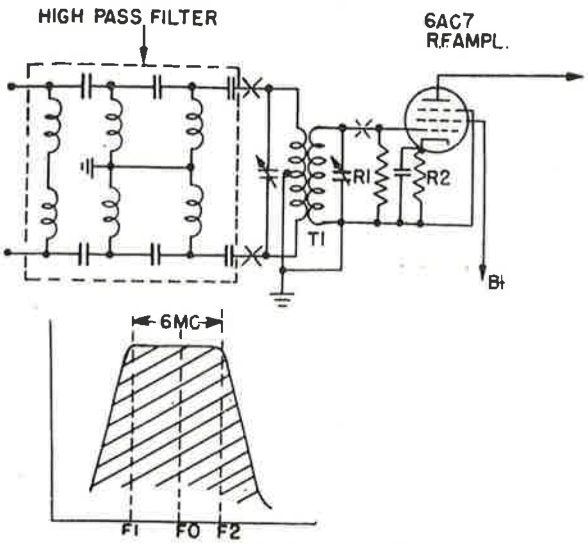

Fig. 5-5. R-F Band-pass Filter.

It should be noted that the antenna coupling circuit just described is a band-pass coupled circuit tuned to pass each channel in turn, and to attenuate all other frequencies outside the band to which it is tuned. In some pre-war receivers no r-f amplifier was used and the output of a band-pass antenna coupling circuit was fed into the converter-grid circuit, with the coupling circuit being the only r-f tuned circuit used.

Another method of coupling the antenna and the one which is used in G.E. television receivers is that shown in Figure 5-6.

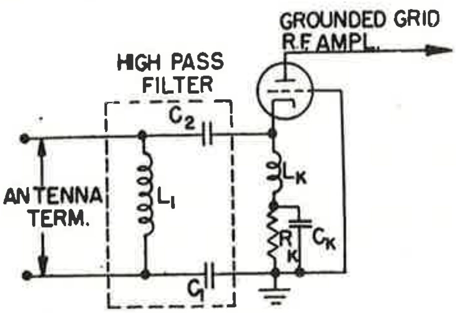

Fig. 5-6. .R-F High-pass Filter.

With this method of coupling no band-pass circuit is used. Instead, the signal is fed directly between cathode and ground of a grounded grid type of r-f amplifier after passing through the high pass filter circuit of L_1, C_1, and C_2. The input signal is applied between cathode and ground and the dynamic cathode-to-ground impedance of the r-f tube can be used to provide a substantially constant antenna input impedance over a wide range of frequencies. This dynamic cathode-to-ground impedance Z_k manifests itself only at the signal frequency and does not exist as far as d-c is concerned. The value of Z_k depends upon a number of factors among which are the a-c plate resistance of the tube, the plate load resistance, and the amplification factor of the tube.

The operating conditions of the tube are so chosen that the dynamic cathode-to-ground impedance is approximately 300 ohms, as indicated by the resistor Z_k shown in dashed lines in Figure 5-7. The dynamic cathode-to-ground impedance of the r-f tube will be discussed in more detail when the r-f amplifier itself is considered. L_k is switched every third channel from 2 through 12. Channel 13 has its own coil. Since circuit is shunted by 300-ohm input impedance, response of this circuit is broad enough to accept approximately 3 channels with each cathode inductance.

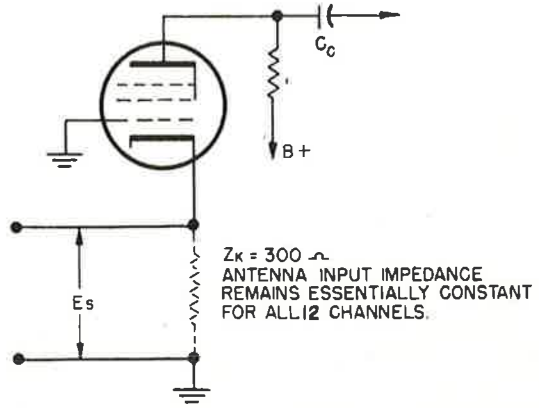

Fig. 5-7. Antenna Input Impedance.

The high pass filter circuit of Figure 5-6 shown connected between the antenna terminal board and the grounded grid r-f tube serves the same purpose as that shown in connection with Figure 5-5, i.e., to attenuate unwanted signals in the region below the frequencies covered by the television channels. C_1 and C_2 are quite small and at broadcast or short wave frequencies their reactance is high enough to block or at least greatly attenuate these signals before they reach the r-f amplifier. In addition to the blocking action provided by C_1 and C_2 these unwanted signals are further attenuated by the shorting action of L_1, which has a fairly low impedance at broadcast or short wave frequencies. At television frequencies, L_1 has a very high impedance with little or no shorting action, while C_1 and C_2 offer very little impedance, and the television signals appear between cathode and ground of the r-f amplifier with no appreciable attenuation.

This type of antenna coupling circuit is unbalanced to ground and noise picked up on the transmission line will pass through and be amplified. This may be objectionable under certain conditions of noise, and to overcome this condition the high pass filter circuit of Figure 5-6 is replaced in some models by a special wide band input transformer connected as shown in Figure 5-8.

The primary of this transformer is grounded at its midpoint and is therefore balanced to ground, which presents a balanced input for the transmission line. With the transmission line terminated in a balanced input circuit, noise voltages picked up on the line will be balanced or cancelled out in the primary of the transformer since the two wires of the line are closely spaced and noise signals induce equal voltages in the wires which cause currents that are equal and alike in polarity to flow in the primary of the transformer, thereby causing cancellation of noise voltages. The polarity of the desired signal voltages are opposite and are, therefore, not cancelled, but allowed to pass on into the receiver. To prevent any capacitive coupling of noise voltages from primary to secondary, an electrostatic shield is placed between the two windings, as indicated in Figure 5-8.

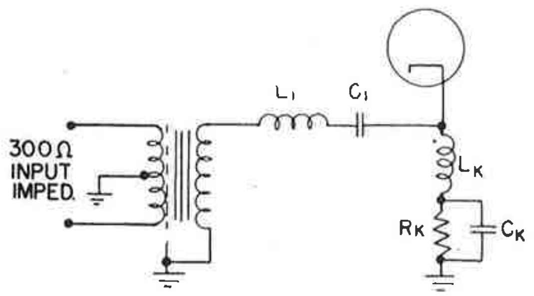

Fig. 5-8. Wide Band Input Transformer.

A powdered iron core is used to provide the necessary coupling between primary and secondary of the transformer. The transformer has a very broad response, passing all television channels equally well. It has a turns ratio of 1:1 so that the 300 ohm dynamic cathode-to-ground impedance of the r-f tube will appear as 300 ohms in the primary. L_1 is a series compensating choke, which prevents loss in gain on the high frequency channels.

At frequencies below the television channels, the efficiency of this transformer drops off quite rapidly so that little or no voltage at these frequencies appears across the secondary winding. The capacitor C_1 also tends to block out any unwanted low frequency signals because of its high impedance at low frequencies; therefore, this transformer also serves as a high-pass filter in addition to providing a balanced input circuit for the transmission line.

4. R-F amplifier circuits

Most of the gain in a television receiver is obtained in the i-f amplifier stages. However, the use of a stage of r-f amplification improves the signal-to-noise ratio considerably, and in areas on the fringe of the regular service area of the transmitter, an r-f amplifier may mean the difference between a satisfactory picture and one that is full of "snow" and noise. Also, the use of a properly designed r-f amplifier will greatly reduce radiation of the local oscillator signal through the antenna which might cause considerable interference with other television receivers in the vicinity.

Many of the early television receivers did not employ an r-f amplifier, and the output of the antenna coupling circuits was connected to the grid of the converter tube, with the band-pass characteristic of the antenna coupling circuit providing the necessary r-f selectivity for image rejection and some adjacent channel attenuation. A few of the higher priced receivers, however, did employ a stage of r-f amplification. The antenna coupling and r-f amplifier circuits used in the older G.E. Model 90 receiver are shown in Figure 5-9. The antenna coupling consists of a double-tuned circuit T_1, preceded by a high-pass filter circuit. For simplicity, only the circuits for one channel are shown, although tuned circuits were provided in this receiver to cover five television channels by switching them in at the points marked x. Individual band-pass filters are provided to couple the grid of the converter tube to plate of the 6AC7 r-f amplifier. L_1 and L_2 are tuned to the centre frequency of the particular channel being received, while the bandwidth of the filter circuit is adjusted by the common coupling provided by L_3C_3. The input of the bandpass filter is shunt-fed through the plate resistor R_3. The overall response curve from antenna to grid of the converter tube appears as in (B) of Figure 5-4 where F_1 represents the lower limit of the channel and F_2 represents the upper limit of the channel. As indicated, the acceptance frequency band of the antenna and r-f amplifier circuits is approximately 6 mc wide in order to accommodate the picture and sound carriers with their associated side bands.

To obtain the maximum possible gain at the wide bandwidths employed in the r-f section, it is necessary to use a tube having a high G_m (mutual conductance) and low grid and plate capacities. In order to keep tube noise at a minimum, the plate current of an r-f amplifier tube should be as low as possible.

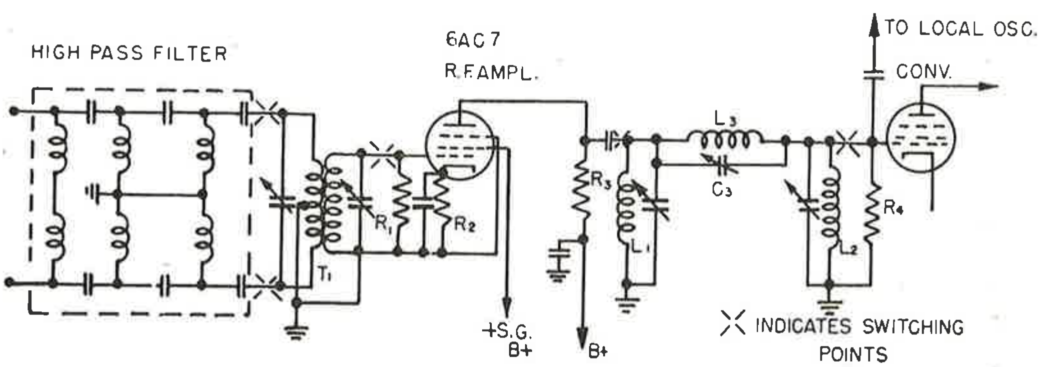

Fig. 5-9. R-F. Amplifier.

If a triode is used as an r-f amplifier, the tube noise generated in the r-f stage can be kept to a minimum, with a resultant improved signal-to-noise ratio. However, a triode cannot be used as an r-f amplifier at high frequencies if the input signal is applied to its grid in the conventional manner unless some form of neutralization is employed.

In order to make use of a triode for best signal-to-noise ratio and to eliminate the necessity for neutralization, the control grid may be grounded, with the input signal applied between cathode and ground (instead of between control grid and ground as in the conventional manner) and the tube operated as a grounded grid amplifier. With this arrangement the capacity from grid to plate which would cause regeneration in the conventional amplifier is placed at ground potential and there is practically no interaction between the input and output circuits as a result of the grid-plate tube capacity. Since the grid-to-cathode potential will still vary according to the input signal, the tube acts, as far as the output voltage is concerned, essentially the same as though it were connected in the conventional manner.

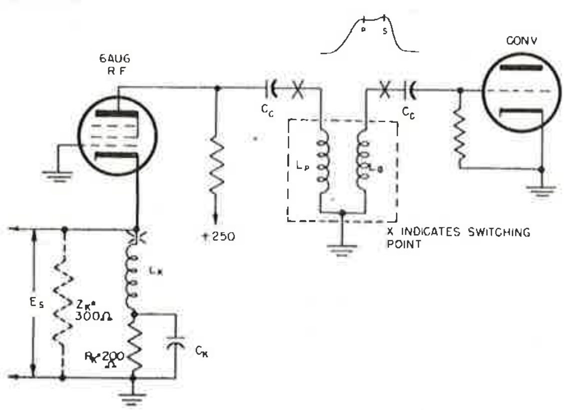

Fig. 5-10. Grounded Grid Circuit.

An r-f amplifier used in G.E. television receivers is of the grounded grid type, the basic circuit of which is shown in Figure 5-10. As indicated, a type 6AU6 is used. Although this tube is a pentode, it is triode connected with the suppressor and screen grid tied to the plate which goes to approximately 250 v. through the plate resistor. The control grid goes directly to ground and the cathode is returned to ground through an r-f choke, L_k, and bias resistor, R_k. A high-pass filter is connected between the antenna terminal board and the r-f amplifier for reasons mentioned previously, with the output of the high-pass filter applied directly between cathode and ground. In some receivers a balanced antenna transformer is used in place of the high-pass filter. Since the input signal is applied between cathode and ground, the dynamic cathode-to-ground impedance of the tube can be used to provide a substantially constant input impedance over a wide range of frequencies. The operating conditions of the tube are so chosen that this dynamic impedance is approximately 300 ohms, as indicated by the resistor Z_k shown in dashed lines, Figure 5-11.

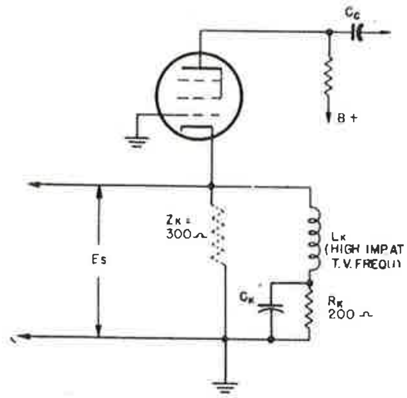

Fig. 5-11. Cathode Circuit of Grounded Grid Amplifier.

The dynamic impedance manifests itself only at the signal frequency and is approximately equal to

$$\frac{R_p + Z_o}{\mu - 1}$$

where R_p is the a-c plate resistance of the tube, Z_o is the plate load resistance and μ is the amplification factor. By proper adjustment of these various factors the dynamic cathode-to-ground impedance is made to look like 300 ohms.

A grounded grid amplifier requires bias just as in the case of most other amplifiers and, therefore, a bias resistor properly by-passed is placed in series with the cathode and is of the order of 200 ohms. It will be noted that this bias resistor is not connected directly between cathode and ground since it would then shunt the dynamic cathode-to-ground impedance Z_k and the input impedance would be something less than 200 ohms instead of the desired 300 ohms. Therefore, the bias resistor is isolated from the cathode by connecting it in series with the cold end of the cathode inductance. A by-pass capacitor in parallel with this resistor is essentially a short circuit at r-f. For this reason the effect of the resistor is eliminated as far as r-f is concerned. The d-c plate current flows through the resistor and develops a bias voltage in the normal manner.

The inductance in series with the cathode bias resistor is used to compensate for the shunting effect of Z_k by the grid-to-cathode capacitance C_{gk} of the tube. As shown in Figure 5-12, this interelectrode capacity will shunt the dynamic cathode-to-ground impedance Z_k, and will cause Z_k to decrease with increasing frequency, since the capacitive reactance of this shunt capacitance decreases with increasing frequency. To overcome this undesirable shunting effect and to maintain a substantially constant input impedance, the value of L_k is so chosen as to form a broadly tuned parallel resonant circuit with this shunt capacitance, thus making it look like a fairly high impedance in parallel with Z_k which has little effect in lowering the value of Z_k. This broadly resonant condition is maintained by changing the value of inductance in series with the cathode as the various television channels are switched in.

In one model five coils are used to cover the twelve channels, gradually reducing the inductance of L_k as the receiver is switched from Channel #2 towards Channel #13. Note that the capacitor shunting the cathode bias resistor has very low impedance at r-f and so the effect on the circuit by these parts can be neglected for r-f considerations.

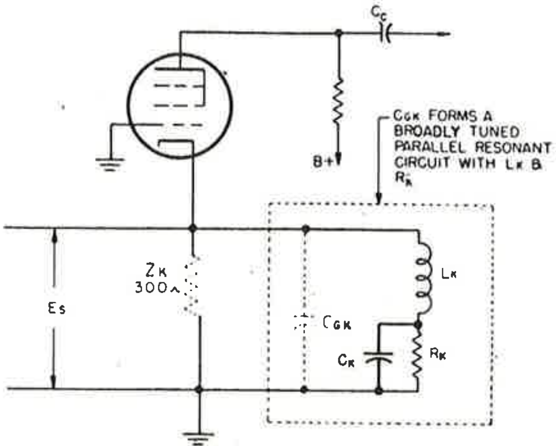

Fig. 5-12. Effect of Interelectrode Capacity.

Although the grid is grounded and the signal is applied between cathode and ground, the tube acts (as far as the output voltage is concerned) as though it were connected in the conventional manner, since the output circuit is connected in the customary way and the potential between cathode and control grid still varies according to the input signal E_s. The varying signal in the plate of the r-f amplifier is shunt-fed through a small capacitor to the primary or plate coil of a broad-band transformer. A double-tuned, closely-coupled transformer is used between the plate of the r-f amplifier and the converter grid as indicated in Figure 5-10. The pass-band of this tuned circuit is approximately 6 mc, as indicated by the curve above the transformer. The only exception to the double tuned type of transformer is the transformer associated with Channel #2, which is triple tuned so as to provide good selectivity and satisfactory image rejection for strong FM stations operating in the 88-108 mc FM band. The third tuned circuit is placed between the plate and grid windings of the Channel #2 transformer and is inductively coupled to each of them, as shown in Figure 5-13. There is practically no direct coupling between the plate and grid coils.

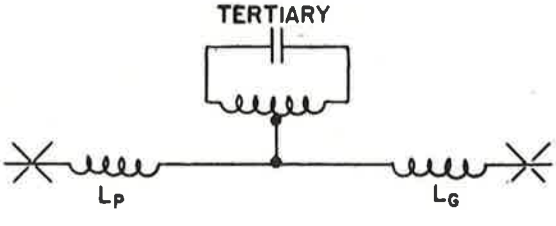

Fig. 5-13. Triple Tuned R-F Transformer.

The response of this transformer is shown in Figure 5-14, and it will be noted that the skirts of the response curve are considerably steeper than for the double tuned circuits, resulting in better selectivity and at the same time maintaining the proper bandwidth of approximately 6 mc.

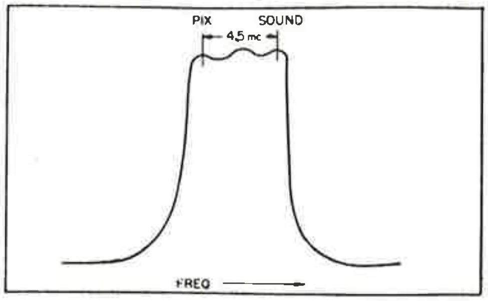

Fig. 5-14. Response Curve for Triple Tuned Transformer.

The windings of each transformer are wound on the same form and inductively coupled to each other, as indicated in Figure 5-15.

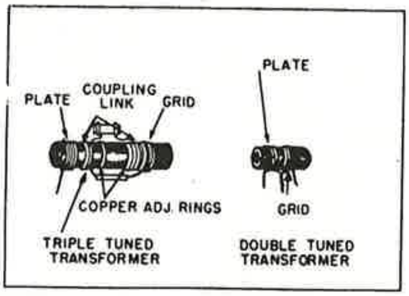

Fig. 5-15. Construction of R-F Transformers.

The plate and grid windings of each transformer are tuned to the mid-point of the particular channel for which it is to be used. The required bandwidth is then obtained by overcoupling and resistive loading of the secondary, if necessary, to prevent excessive "valley". When two circuits tuned to the same frequency are gradually coupled together, the bandwidth spreads out on either side of the frequency to which both circuits are tuned. This is shown in Figure 5-16. With close coupling, the response curve broadens out on either side of the centre frequency until the desired bandwidth is obtained.

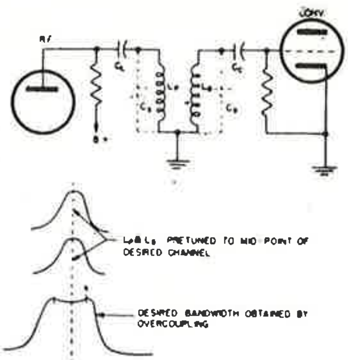

Fig. 5-16. Coupling of R-F Transformer.

Tuning of the coils and adjustment of the bandwidth is made on each transformer at the factory before the head-end assembly is placed in the receiver chassis. In some G.E. television receivers, the only capacity across the plate and grid windings is the distributed and tube capacities, as indicated in Figure 5-16. Each winding is tuned by the distributed and tube capacities existing across it by varying the inductance of each coil by either spreading or squeezing turns. In other G.E. receivers, the Model 810, for instance, a small trimmer is used in conjunction with the distributed and stray capacities to facilitate alignment and to compensate for differences in tube capacities when changing tubes.

In most G.E. television receivers a separate transformer is used for each of the twelve television channels. Switching occurs at the points marked X in Figure 5-10, and as the receiver is switched from channel to channel, a new primary and a new secondary winding pretuned at the factory with the proper degree of coupling for the particular channel is connected at the points indicated. The ground connection of the transformers remains fixed.

It should be noted that these transformers between the plate of the r-f amplifier and the converter grid provide a considerable amount of the necessary selectivity for good image rejection and adjacent channel attenuation. Since the tuned circuits for each channel are pretuned at the factory, no tuning of the r-f circuits is required by the operator. The operator merely switches in the correct transformer for the desired channel. The only tuning done by the operator is in the local oscillator circuit which will be discussed in following paragraphs.

The r-f circuits of some G.E. television receivers vary somewhat from those just discussed, but fundamentally they are the same, and reference to the service notes for each individual receiver will point out these differences.

5. Converter and oscillator considerations.

(a) The converter circuit.

The converter and oscillator in a television receiver perform the same functions as in a regular broadcast receiver, and that is to convert or change the higher (r-f) radio frequencies to lower or (i-f) intermediate frequencies. Only one converter and one oscillator is used to simultaneously change both the sound carrier and the picture carrier with associated sidebands into corresponding intermediate frequencies which appear in the output of the converter. The oscillator operates on the high side of both carriers.

The prime considerations governing the choice of a converter tube are high conversion conductance, low input and output capacities, and good signal-to-noise ratio. Good signal-to-noise ratio is obtained by keeping the converter plate current as low as possible and by proper adjustment of the amount of oscillator voltage coupled into the converter. In order to obtain the highest possible conversion gain, a separate triode oscillator is usually used.

Figure 5-17 illustrates the basic converter circuit used in G.E. television receivers.

A triode is used, usually one half of a dual triode such as a 12AT7, for best signal-to-noise ratio. As indicated, the cathode goes directly to ground, and there is a grid resistor-capacitor combination, R_G-C_c, in the grid circuit. The r-f amplifier is coupled to the converter grid by means of the r-f transformer which connects to the converter grid through the small coupling capacitor C_c. Bias is provided by rectification of the signal in the grid circuit which develops a negative voltage across R_G.

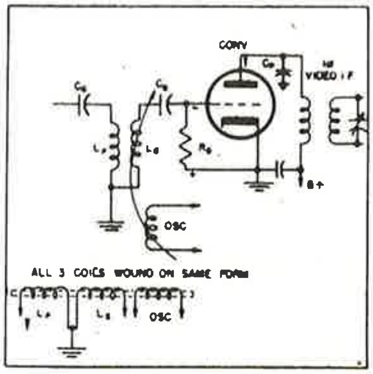

Fig. 5-17. Converter Circuit.

The oscillator signal is injected into the converter grid either by capacitive or inductive coupling. Inductive coupling of the oscillator signal is shown in Figure 5-17 and is used in several post-war models. The oscillator coil is wound on the same form and adjacent to the secondary or converter grid winding of the r-f transformer, as indicated in Figure 5-17. The coupling of the oscillator signal is carefully adjusted at the factory to provide the best signal-to-noise ratio.

The primary of the first video i-f is connected to the converter plate, and since a triode converter is employed, the inductance of the lead running between this transformer and the converter plate will have some effect on the loading in the converter grid circuit. This condition is undesirable and is corrected by placing a small capacitor, C_p, on the order of 8 $\mu\mu$F directly from the converter plate to ground. This by-passes r-f to ground and minimizes the effect of this lead inductance as far as the loading of the converter grid circuit is concerned. C_p is small enough so as not to by-pass the i-f signal and is also used to tune the primary of the first video i-f transformer. Tuning is accomplished by varying the primary inductance so that it resonates with C_p.

(b) The oscillator circuit.

As mentioned previously, only one local oscillator is used, and it operates on the high side of both carriers. The two important requirements for the local oscillator are:

1. Its ability to supply a large enough signal voltage to the converter over the entire range of frequencies at which it is to be used so as to produce a strong i-f output, but not so great as to cause excessive oscillator radiation with resulting interference to other receivers.

2. The oscillator circuit should have good stability with respect to temperature changes, supply voltage changes, and freedom from any tendency to develop a microphonic condition due to mechanical vibrations.

It has been found that the most desirable type of oscillator for television receivers is some form of Ultraudion, a modified Hartley circuit, or a modified Colpitts circuit. A typical oscillator circuit used in one of the earlier G.E. television receivers is shown in Figure 5-18.

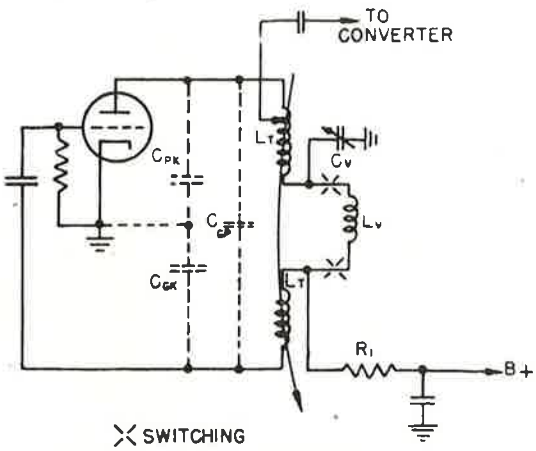

Fig. 5-18. Oscillator Circuit (pre-war).

The circuit is that used in a pre-war G.E. television receiver (Model 225), and is a form of ultraudion oscillator circuit. This oscillator is tuned over the various television channels by switching different values of inductance L_V in-between the grid and plate sections of the tank coil L_T as shown, with the inductance of L_V becoming smaller for the higher television channels. For simplicity, switching for only one channel is shown. The capacitor C_V serves as a vernier tuning control and provides about a 3 mc variation.

A basic oscillator circuit used in post-war G.E. television receivers is shown in (A) of Figure 5-19. The plate is by-passed to ground by capacitor C_p, which is large enough to place the plate at ground potential as far as the r-f is concerned. The cathode choke L_k maintains the cathode above ground at r-f. A single coil, L_T, is used as the tuning inductance.

As the receiver is switched from channel to channel, different values of tuning inductance are switched in at point X. When inductive coupling of the oscillator signal to the converter grid is employed, the tuning inductance L_T is coupled to the converter grid coil of the r-f transformer, as in Figure 5-17.

Fine tuning of the oscillator is provided by a small variable capacitor, which varies the total capacity of the circuit a small amount and provides approximately a 3 mc variation for the first six channels, and a correspondingly greater change for the higher frequency channels.

A temperature compensating capacitor is connected across the tuned circuit in some receivers

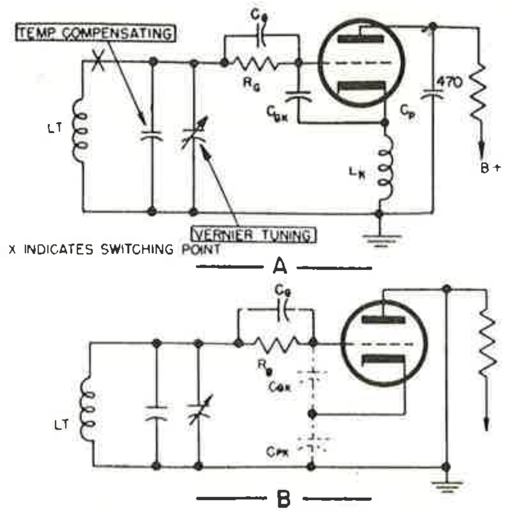

Fig. 5-19. Oscillator Circuit (Post-war).

to compensate for frequency drift as the oscillator warms up. Oscillator frequency drift is also reduced by making the physical size of the oscillator circuit as small as possible by the careful placement of parts, such as mounting the coils directly on the band changing switch. The use of low-loss materials in the oscillator circuit also tends to make the oscillator more stable from the standpoint of temperature and humidity variations. In some receivers a mycalex stator and polystyrene rotor is used on the band-switch; only ceramic or air dielectric capacitors are used. A polystyrene socket is used, and the tube is so constructed that the element connections are brought out directly through the glass of the tube.

The operation of this circuit may not be too apparent from examination of (A), Figure 5-19. It is a modified form of Colpitts oscillator with oscillation taking place due to feedback obtained across the split capacity formed by the inter-electrode capacities of the tube.

Operation of this circuit becomes much clearer if an equivalent circuit, as far as r-f is concerned and ignoring d-c, is drawn as in (B) of Figure 5-19. The split capacity formed by the grid-to-cathode capacity C_{GK} and the plate-to-cathode capacity C_{PK} is shown in dashed lines. It will be noted that the cathode is connected to the centre of this split capacity, with the grid and plate connected to the opposite ends. A feedback voltage of the proper phase is thus obtained, as in the conventional form of Colpitts circuit. It has been found advantageous to add an additional capacitor C_{GK} to assist in producing strong oscillations. The plate capacitor C_p is a short circuit as far as r-f is concerned, and effectively places the plate at ground potential, as indicated in the equivalent circuit. The purpose of the cathode choke L_k is to isolate the cathode from ground as far as r-f is concerned and to provide a d-c path to ground for the oscillator plate current. If the cathode were returned directly to ground, the plate-to-cathode section C_{PK} of the split capacity would be shorted out and oscillations would cease. The tank inductance L_T is tuned by the total capacitance appearing across it, which includes the tube capacitance, the vernier tuning capacitor, and a temperature compensating capacitor. Bias is provided by the grid leak resistor-capacitor combination, R_G and C_G.

The basic converter and oscillator circuits discussed in connection with recent G.E. television receivers are fundamentally the same in most receivers. As mentioned in connection with the antenna coupling and r-f amplifier circuits, reference to the service notes for each individual receiver will point out any slight differences.

The antenna coupling, r-f amplifier, oscillator, and converter sections of the post-war receivers, together with the necessary band-switching arrangement and coils to cover all 12 television channels are mounted on a sub-assembly which can be removed from the main chassis for convenience of servicing.

A type 6AU6 is used as the grounded grid triode connected r-f amplifier and a type 12AT7 dual triode is used for the oscillator and converter. The placement of the r-f transformers and oscillator coils around the rotary type selector switch is shown. It will be noted that the coils are mounted directly on the switch lugs, which contributes to the efficiency and compactness of this unit.

(c) Over-all action of the head-end circuits.

The complete circuit of a typical head-end unit from antenna to converter output is shown in Figure 5-20. The switching arrangement and coils for only one channel are shown for simplicity.

A brief description of the over-all action is as follows: The antenna picks up both the sound and picture carriers with associated sidebands, and, after passing through the high-pass filter or balanced input transformer, as the case may be, the signal appears between cathode and ground of the r-f amplifier; after amplification by the r-f amplifier, which provides a gain of approximately four, the signal is coupled to the grid of the converter tube by means of the r-f transformer, which is tuned to the desired channel and has wide-band characteristics as brought out earlier; the local oscillator which is inductively coupled to the converter grid operates at a frequency that is higher than the sound carrier by an amount equal to the i-f; the converter input thus consists of the local oscillator signal and the sound and picture carriers with their associated side-bands; by means of the heterodyning action of the oscillator signal on the two carriers, two intermediate frequencies with their associated side-bands are produced; the difference between the frequency of the picture carrier and that of the local oscillator is the video i-f corresponding to the picture carrier; the difference between the frequency of the sound carrier and the local oscillator produces the television sound, or audio i-f; the frequency separation between the two i-f's is the same as between the two r-f carriers (4.5 mc) with the picture i-f being the higher of the two, since only one oscillator is used and operates on the high side of either r-f carrier; both i-f signals with associated side-bands appear in the first video i-f transformer since its primary is connected to the converter plate.

The over-all gain of the head-end (including r-f and converter gain) varies from approximately 8.5 to 10.0 on the low frequency channels, and from approximately 3.5 to 7.5 on the high frequency channels.

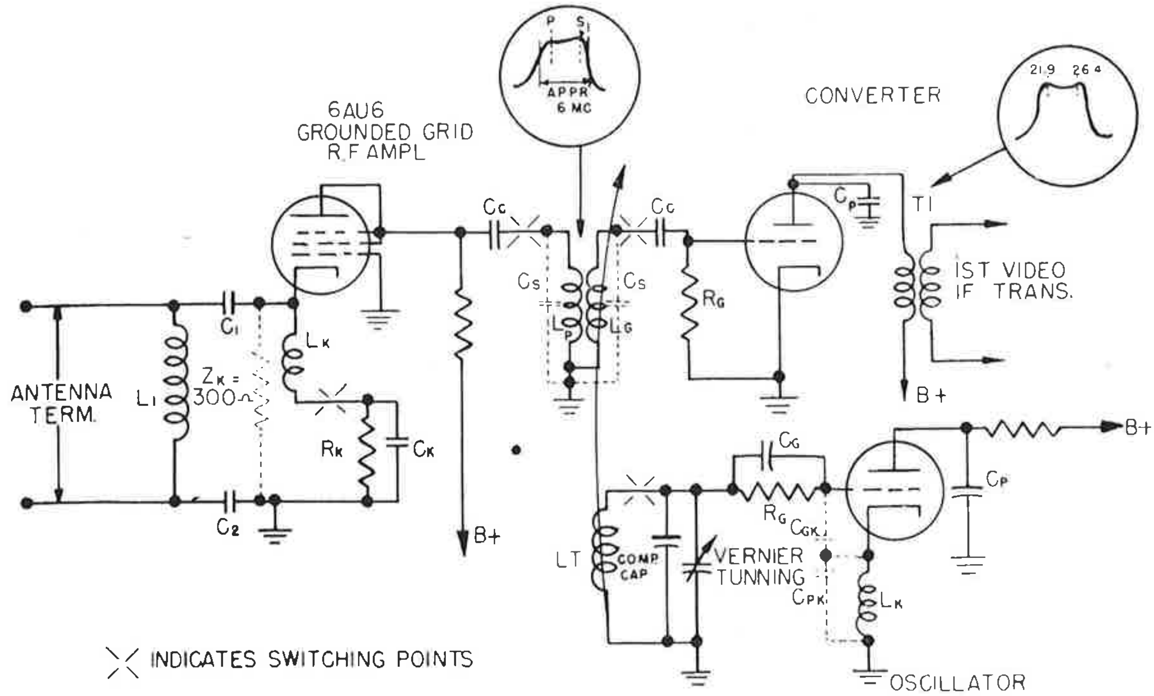

Fig. 5-20. Circuit of Head-end Unit.

New RCA Releases

Radiotron — 6AX4-GT is a half-wave vacuum rectifier tube of the heater-cathode type. It is intended particularly for use as a damper tube in horizontal deflection circuits of television receivers.

Designed to withstand negative peak pulses between heater and cathode of as much as 4000 volts with a dc component up to 900 volts, the 6AX4-GT provides flexibility in choice of deflection circuit.

Radiotron — 6BQ7-A is a medium-mu twin triode of the 9-pin miniature type intended for use as the first r-f amplifier tube in tuners of vhf television receivers or as a low noise high-f pre-amplifier tube in uhf television receivers employing a crystal mixer. This tube has high transconductance, low input capacitance, low input loading and low plate-to-cathode capacitance. These features make the 6BQ7-A especially useful in the direct-coupled r-f grounded-grid amplifier circuit or the cascode type of circuit. Use of the 6BQ7-A in such circuits provides a reduction in noise with resultant improved receiver sensitivity.

The transconductance value of 6400 micromhos obtainable at a plate current of only 9 milliamperes permits high gain and reduced equivalent noise resistance. The low input loading minimizes induced grid noise and makes practical a high input-circuit gain even in the high-frequency channels. For example, a gain of 2 on channel 13 is realized when the receiver has a 300-ohm input impedance. Furthermore, variation of the gain-control bias voltage produces a relatively small change in input loading so that the antenna termination is substantially constant. The low plate-to-cathode capacitance contributes to stability in r-f grounded-grid service.

The two triode units of the 6BQ7-A are effectively shielded one from the other with the result that either unit will give stable performance when used in high-frequency applications such as push-pull grounded-grid amplifiers, driven r-f grounded-grid circuits, and counter circuits.

Radiotron — 12V6-GT is a beam power tube of the heater-cathode type intended primarily for use in the output amplifier of automobile radio receivers operating from a 12-volt storage battery.

The application of directed electron beam principles in the design of this tube makes it capable of producing relatively high power output with high power sensitivity. For example, a single 12V6-GT operated with a plate and Grid-No. 2 voltage of 250 volts can deliver a maximum-signal power output of 4.5 watts with a driving voltage of only about 12 volts. These features, together with relatively low plate-current drain, make the 12V6-GT especially suitable for use in the output stage of automobile receivers.

Radiotron-12DP7-B is a 12-inch, directly viewed, cathode-ray tube of the magnetic-focus and magnetic-deflection type. It is intended primarily for those applications, such as radar indicator service, where grid No. 1 is pulse-modulated at low frequency to provide a temporary record of electrical phenomena, but it is also useful in general oscillographic applications where a temporary record of electrical phenomena is desired. The long-persistence, cascade (two-layer) screen used in the 12DP7-B exhibits bluish fluorescence of short persistence and greenish-yellow phosphorescence which persists for several minutes under conditions of adequate excitation and low ambient light. Because of its long persistence, the 12DP7-B is particularly useful where either low-speed non-recurring phenomena or high-speed recurring phenomena are to be observed.

Featured in the 12DP7-B is a limiting aperture in the electron gun to produce a sharper, rounder spot on the screen, and hence greater effective resolution, especially at high values of beam current. This feature makes the 12DP7-B particularly useful in those applications where pulse-modulated operation causes high grid-No. 1 drive and resultant high beam current.

The faceplate of the 12DP7-B is made of Filterglass to provide increased contrast between the trace and the background. The Filterglass faceplate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the faceplate itself in a much higher ratio than it reduces the directly viewed light of the trace. As a result, improved trace contrast is obtained.

The 12DP7-B with Filterglass faceplate supersedes and is directly interchangeable with the 12DP7-A which utilized a clear-glass faceplate.

Radiotron — 6217 is a head-on type of vacuum multiplier photo-tube intended for use in color densitometers, spectrometers, color comparators, flying-spot signal generators, and other applications where good red sensitivity is desired.

The spectral response of the 6217 covers the range from about 3000 to 8000 angstroms, and has a maximum response which is essentially flat over the wide spectral range from 3700 (violet) to 5600 (yellow) angstroms and good response through 6700 (red) angstroms.

Design features of the 6217 include a semi-transparent cathode having a diameter of $1\frac{1}{2}$ inches on the inner glass surface of the face end of the bulb, and ten electrostatically focused multiplying stages. The relatively large cathode area permits very efficient collection of light.

The 6217 is capable of multiplying feeble photoelectric current produced at the cathode by an average value of 600,000 times when operated with a supply voltage of 1000 volts. The output current of the 6217 is a linear function of the exciting illumination under normal operating conditions.

The frequency response of the 6217 is flat up to a frequency of about 50 megacycles per second, above which the variation of electron transit time becomes the limiting factor.