The Aerovox Research Worker

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Television Receivers

PART 2

By the Engineering Department, Aerovox Corporation

ANTENNAS

The antenna for a television receiver must be carefully designed and installed if good results are to be obtained. The practice of using any wire that is handy—so prevalent in sound reception—will be certain almost to cause unsatisfactory reception.

Essentially, the antenna for television reception is an ultra-short-wave antenna similar to those employed by amateurs and others who work below ten meters. There are, however, special precautions to be taken to prevent certain types of interference, such as that caused by ignition systems of passing automobiles, and to prevent multiple images due to reflections.

POLARIZATION

Disturbances created by automobiles consist mostly of vertically polarized waves. In order to avoid this interference the television transmitting and receiving antennas are designed to transmit and receive horizontally polarized waves. Therefore, the antennas are generally horizontal contrary to amateur practice. This does not mean that a vertical antenna would not receive any television signal. Polarized waves do not appear to stay polarized after they have travelled a considerable distance and there are reflections which may cause the polarization plane to rotate. The important point is that a horizontal antenna will pick up less of the interference from nearby automobiles.

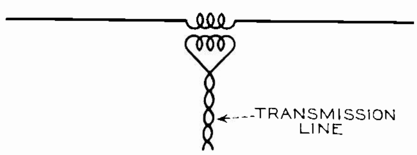


Figure 1A

THE DI-POLE

One of the simplest and most popular of antennas is the half-wave di-pole. It consists of a horizontal metal rod or tube, a half wavelength in length and connected to the receiver by means of a transmission line. Such an antenna is directional; it receives best from directions at right angles to the rod.

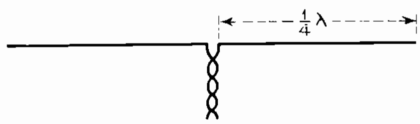


Figure 1B

The connection of the transmission line to the di-pole can be made in several ways; some of them are shown in Figure 1. The system of Figure 1A employs an r.f. transformer. Here it should be noted that the presence of the primary loads the antenna and increases its natural wavelength. Therefore it calls for a shorter antenna than otherwise would be the case.

The system shown in Figure 1B is perhaps the most popular. The half-wave antenna has simply been cut in the center while the twisted transmission line is connected to the gap so created. When the gap is as small as possible, the antenna will match a transmission line of 74 ohms surge impedance.

DIRECTIONAL ARRAYS

The above described antenna will generally be satisfactory at locations not too far from the transmitter. When greater pickup and greater directional properties are required, a second di-pole may be connected in parallel with the first one, a reflector may be used, or the two remedies may both be applied.

Pickup can be greatly improved by operating two or more di-poles in parallel. The di-poles may be arranged as in Figure 2. The two antennas should be in a vertical plane, that is, above each other. The combination receives best from a direction perpendicular to the vertical plane.

A reflector or director is an important means of increasing pickup in a desired direction. Such a reflector or director consists simply of another antenna without any connections to it and placed parallel to the receiving antenna. If this auxiliary antenna is placed farther away from the transmitting station than the receiving antenna it is called a reflector; if it is closer to the transmitting station than the receiving antenna it is a director.

Such reflectors or directors will have currents flowing in them due to the received signal and these currents cause re-radiation which is picked up in the receiving antenna. The design of the reflectors and their placing must be such that the re-radiated signal arrives in phase with the original signal at the receiving antenna for signals

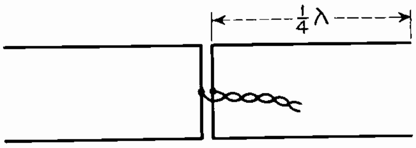


Figure 2

coming from the desired direction. Pickup from other directions is discriminated against because the re-radiated signal opposes the direct pickup at the receiving antenna.

The directive properties of an antenna and reflector both of exactly half a wavelength were described by G. H. Brown in the Proceedings of the I. R. E. for January 1937. According to his curves and experiments the greatest improvement in reception due to a reflector occurred when the main antenna and the reflector were one-tenth of a wavelength apart. Practically the same gain is also obtained when the auxiliary antenna is placed on the other side of the main antenna, making it a director; the best spacing is still one-tenth of a wavelength The maximum gain over a single antenna, according to Brown's curves, is five.

A combination antenna and reflector of this type is illustrated in Figure 3. It receives best from the two directions as shown in the diagram, since, in one case, the auxiliary antenna becomes a reflector, and in the other case a director. One of the RCA antennas consist of two such di-poles and two reflectors.

When a reflector is not exactly a half wavelength long, the currents flowing in it will be displaced in phase with respect to the induced e.m.f. Such a reflector will give best results when placed at a different distance from the main antenna. From this it follows also that maximum performance can be had in any given case by slight re-adjustment of the length or the location of the reflector or director.

DIAMOND ANTENNA

Another antenna which has found some use for television reception is the diamond antenna. It is made up of four wires of equal length connected so as to form a diamond, a terminating resistance and a transmission line. This antenna is placed horizontally and receives best from the direction of the terminating resistance. When the terminating resistance is removed the antenna becomes bi-directional and picks up signals from the direction of the transmission line as well.

In order to obtain these directional properties, the angle a of the diamond must bear a certain relation to the length of the sides. This relation is shown in the curve of Figure 4 which is due to Prof. Terman. The longer the sides the greater the directional properties.

This antenna is also directional in the vertical plane. If the antenna is less than a wavelength above its surroundings (the roof or the ground) it favors waves which come downward at an angle. For horizontal waves it should be at least one wavelength above the ground or roof.

A special advantage of the diamond antenna is its lack of selectivity. It will work satisfactorily over a wavelength range of two to one which is of great benefit in television where each station occupies a 6-megacycle channel.

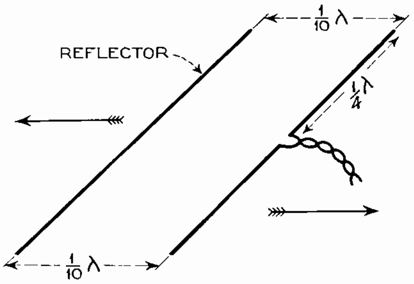


Figure 3

The antenna must be terminated in a load resistance of 800 ohms. The transmission line, if it is of a different impedance, must be matched to it by means of a transformer.

LENGTH OF ANTENNA

The correct length of a half-wave antenna is somewhat less than half a wavelength. This is so because of two reasons, the reduced velocity of a wave along a wire or transmission line and the end effect.

The velocity of propagation along an aerial or transmission line is less than that in free space. This reduced velocity varies again with the frequency. At 60 megacycles we may assume a 5 percent reduction in speed of the wave and a consequent 5 percent reduction of aerial length due to this cause.

The end-effect calls for a reduction in length of a definite fraction of a wavelength for each end. When expressed in percentage it is therefore different for a full-wave antenna and for a half-wave antenna.

The total reduction to the two causes appears to be seven percent although the figure is still in dispute. In television it is not necessary to find the length very exact because of the wide transmission-band. The following conversion factors may be used. To find the length of a half-wave antenna in inches, multiply the wavelength in meters by 18.3. Divide the frequency in megacycles into 5440 to find the length of a half-wave antenna in inches.

Since television receivers have to accept a wide frequency-band it is not desirable that the circuits or the antenna should have a high Q. Conductors of large diameters of inexpensive materials—iron pipes—have proved satisfactory. The length of the conductors can be calculated for the middle of the 6-megacycle band. This makes the proper length for the 44-50 mc. band 117 inches and for the 50-56 mc. band 102 inches.

IMPEDANCE MATCHING

Great stress has been laid on the proper impedance matching of the transmission line especially at the receiver end. The theory of transmission lines teaches us that electric waves will travel along a line and be completely absorbed in the terminating load if the load matches (or has the same impedance as) the characteristic impedance of the line. When this condition is not fulfilled there is a loss of power transmitted at the junction and this reflected power travels back along the transmission line to the other end where it may be reflected again and so on.

In the case of television, the returned wave may be sufficiently late to form a second picture on the screen which is visibly displaced from the original picture. Whether or not this happens depends on the length of the transmission line and whether a round-

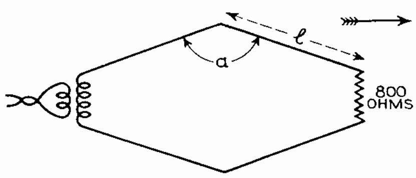


Figure 4A

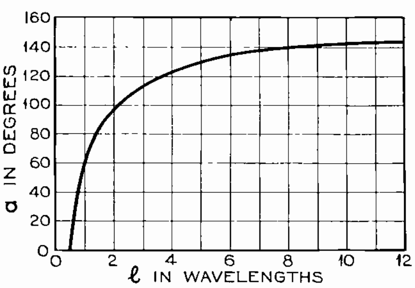


Figure 4B

trip to the antenna and back takes an appreciable part of the time required for a line scanning.

At first glance it might seem that radio waves travel too fast to cause a visible effect. Consider however, that the number of picture elements is 7 million per second. Then the effect of an echo or reflection becomes visible when the delay is more than one seven-millionth of a second. This will happen when the transmission line is longer than 20 meters or roughly 65 feet.

The remedy for reflections from this cause is a careful adjustment of the matching at the receiver end. In the case of manufactured receivers this has already been taken care of in the design. No trouble should be experienced if the prescribed transmission line is used.

Those who experiment or build their own equipment may readjust the impedance either by adjusting the coupling, tapping the primary, or using a variable condenser as in Figure 5.

INSTALLATION

The above discussed reflections are not the only ones which may occur. Metal structures, buildings, etc., may cause reflections; in some cases they are more reliable than the direct signal. Experimentation is needed to determine the best position of the directional antenna. It is a two-man job; one man should be at the antenna, the other at the receiver and they should be able to communicate with each other by means of a telephone or any other suitable way. Furthermore, this adjustment must be performed while the transmitting station is on the air.

R. F. AND OSCILLATOR SECTIONS

The design of the r.f.-section is a typical problem in ultra-high frequency work. Special tubes must be used for the mixer, oscillator and r.f.-amplifier, if any. So, one finds that virtually all commercial receivers are equipped with one of the high-mutual-conductance tubes as converter while

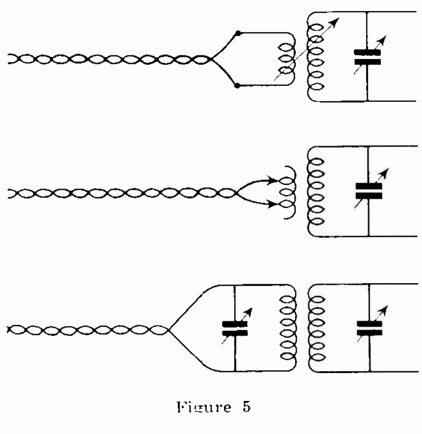


Figure 5

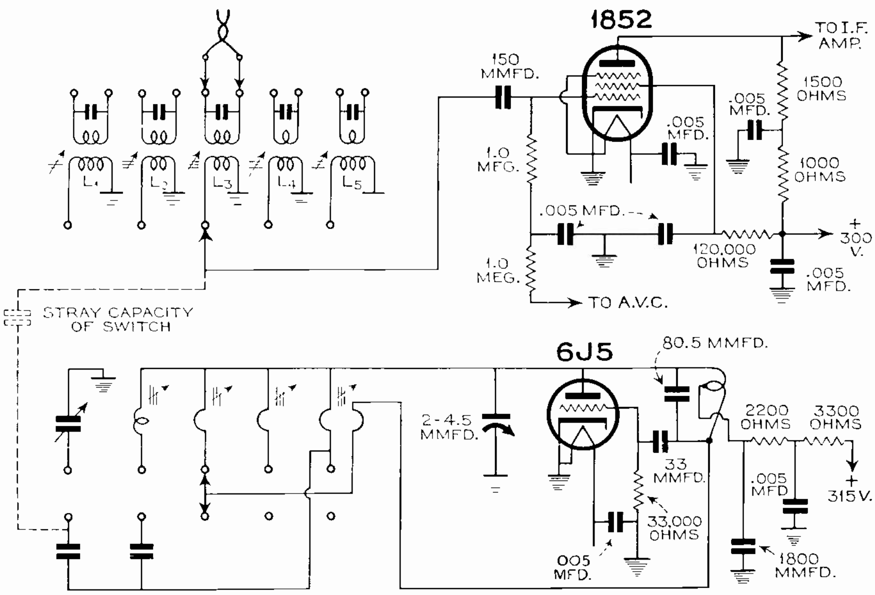


Figure 6

the 6J5 seems to be the universal oscillator. If an r.f. amplifier is to be employed it will have to be another tube of the high-mutual-conductance type or it might be an acorn.

Studies of the various possible circuits have shown that the least noise with weak signals is obtained with a separate oscillator and mixer rather than with the combination tube. The possible tubes, in the order of their noisiness are 6J5, 1852, 1853 and 6L7 while the 6SA7 is being used by some. The 1852 is the preferred tube and gives the highest gain. The coupling between oscillator and mixer is of the mutual inductance or stray capacitance type. This causes the oscillator signal to be radiated unless there is an r.f. stage. This point deserves attention since it may cause trouble in crowded locations.

The sound and picture carrier both pass through a broadly tuned antenna circuit and mixer as explained in Part 1 (August, 1939).

The design of the r.f. amplifiers requires a stable oscillator which calls for careful design of its tuned circuit. Mica trimmers are not to be used for this purpose but air-dielectric trimmers would be suitable. Another solution is the use of a fixed condenser of the silvered mica type in combination with variable inductors. The new coils with variable iron dust cores are excellent for this purpose. On the converter stage the conditions are less critical and mica trimmers may be used to tune the antenna coupler.

As an example of an r.f. section, Figure 6 shows that of the RCA receiver TRK12. Instead of the double purpose converter tube, this receiver is equipped with a 6J5 oscillator and an 1852 as converter while the coupling between the circuits is capacitive.

A multiple switch completely changes the antenna transformer for each station while it connects a different variable inductor across the oscillator inductor at each position of the switch. This parallel inductor is then coupled to the proper antenna transformer.

When inductances are connected in parallel while there is no coupling between them, the resultant inductance of the combination is found by the same law as that for resistances in parallel.

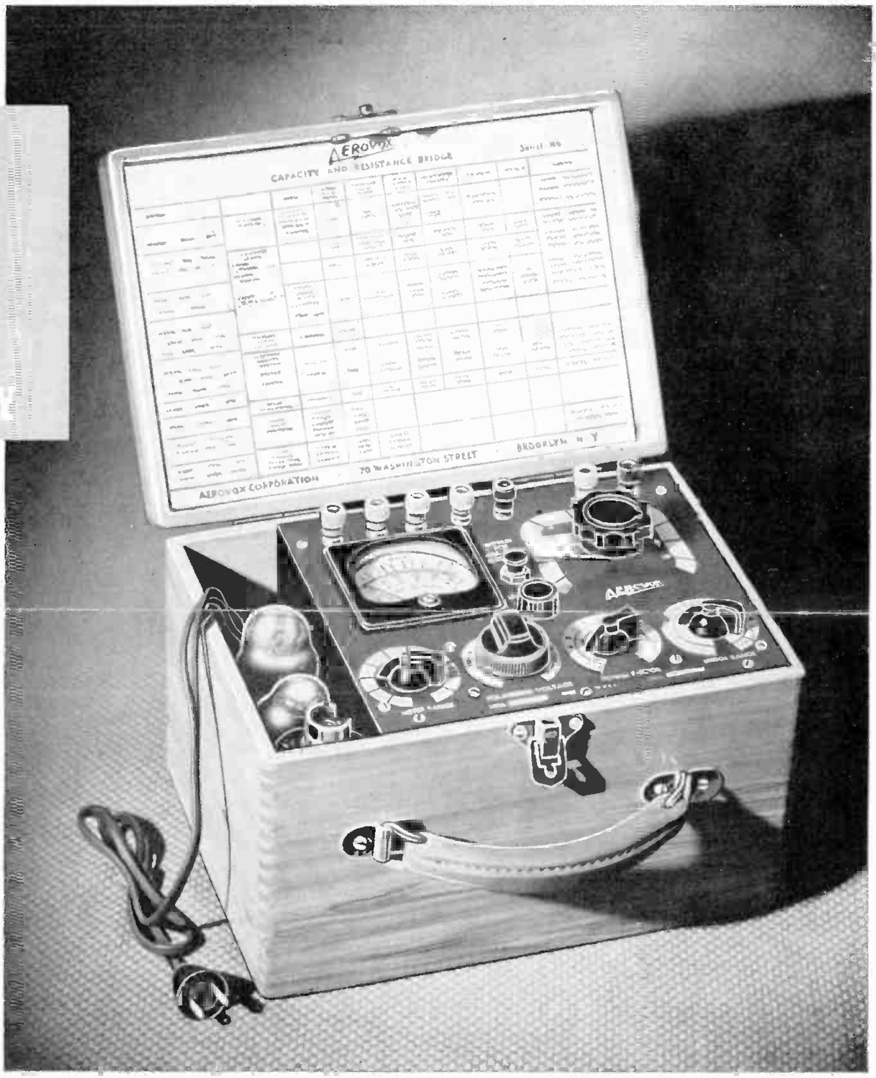
$$L = \frac{L_1 L_2}{L_1 + L_2}$$

The 6J5 oscillator circuit is a series-feed Hartley. Most of the capacity of the tank circuit is stray capacity of the wiring and the internal capacity of the tube. The variable inductors L1, L2, L3, etc., are the ones to be adjusted in alignment.

A small variable air-dielectric trimmer is also present for precise re-adjustment at all channels if it may be found necessary.

The adjustment of the oscillator frequency must be made accurately when the receiver is aligned on installation. The two i.f. amplifiers will have been aligned previously; the oscillator frequency can then be adju ted by means of a signal generator or the incoming signal. Set the oscillator trimmer so that the sound carrier is properly received. The video carrier should then also be correct if the i.f. alignments were made properly. The adjustment of the antenna stage is very broad and should offer no difficulty.

The *Yardstick* for measuring CONDENSER QUALITY



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