Howard W. Sams

TELEVISION ANTENNAS

DESIGN, CONSTRUCTION, INSTALLATION, AND TROUBLE-SHOOTING GUIDE

By

DONALD A. NELSON

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By

DONALD A. NELSON

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Illustrative Material—Barnard Studios

First Edition—First Printing, May, 1949

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HOWARD W. SAMS & CO., INC.

INDIANAPOLIS 1, INDIANA

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PREFACE

This text is primarily intended for the guidance of service technicians in the selection and installation of proper television antennas and accessories.

Since each installation will have its own individual requirements, or limitations, it is essential that the technician have an understanding of all differing types so that the proper and least-costly system can be employed. An eventual loss of business would probably result if attempts were made to install expensive arrays in locations where simple, less-costly systems would suffice. All factors pertaining to antenna design, transmission line characteristics, etc., must be understood so that a proper evaluation of requirements can be available.

In the majority of cases, there are commercial television antenna types suited to the application, and, in the long run, it is probably more economical to install these types. However, for the benefit of those who do not have such types available in normal circumstances, complete construction information is included herein.

Every effort has been made to insure the accuracy of the material contained in both commercial and construction sections, and we wish to acknowledge a debt of gratitude to the equipment manufacturers whose cooperation has been of so much assistance in preparing this book.

We also wish to express our special appreciation to the following for their valued help:

Richard M. Purinton,
American Phenolic Corp.,
Chicago 50, Ill.

Michael Ercolino,
Telrex, Inc.,
Asbury Park, N. J.

M. J. Marcuson,
Structural Engineer,
Batavia, Ill.

Michael DePadro,
DePadro Electric,
Berwyn, Ill.

William Cihak,
Frank Jacklin,
Suburban Television,
Berwyn, Ill.

Dr. H. O. Marcy,
Rauland Corp.,
Chicago, Ill.

Valdimar Carlson,
Carlson Radio Service,
Geneva, Ill.

Bren Hawkins,
DeForest Training School,
Chicago, Ill.

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INTRODUCTION

Generally speaking, the picture that a television receiver reproduces is only as good as the antenna system that is employed to pick up the transmitted signal. It is of interest to note how history is repeating itself with respect to radio and television.

Twenty years ago the antenna system played a very important role in the reception of radio signals. A long wire antenna was placed on the highest point of the roof to "reach out" and bring in the wanted stations. With more transmitter power and increased receiver sensitivity, present day radios need only a built-in loop antenna for most locations; and thus the outside aerial has become a thing of the past. Television, on the other hand, must have an outside antenna for all but the closest locations to the transmitter for a number of reasons. A brief discussion of television principles follows so that these reasons can be better understood before launching into a detailed discussion of receiving antennas and their installation.

TELEVISION TRANSMISSION. The television transmitter is composed of three sections: the amplitude modulated video or picture transmitter, the frequency modulated sound transmitter, and the antenna system. The camera of the video transmitter views the scene and picks up millions of units of varying light potential, and converts them into electrical energy (video signal). Each portion of the viewed scene, with its varying shade of light, is picked up by the camera. The sequence in which these light units or elements are viewed is determined by the scanning system used with the camera. After conversion from light units to electrical energy, the video signal is amplified, combined with timing potentials, and transmitted to the receiver. This composite signal contains the picture signal plus all of the elements necessary for synchronization at the receiver. The sound of the viewed scene is picked up by a microphone and amplified through an audio amplifying system. After amplification, the sound is used to frequency modulate an RF carrier and is transmitted by the antenna.

The transmission of video and sound signals entails many problems that place it in a class of its own. Ordinary radio broadcasting uses a double sideband type of transmission with a channel that is 10 kilocycles wide (5 kilocycles on each side of carrier). If television were broadcast by this method, the carrier would require a space in the frequency spectrum wide enough to accomodate a carrier of at least 12 megacycles bandwidth. This would not only reduce the number of stations that could be allocat-

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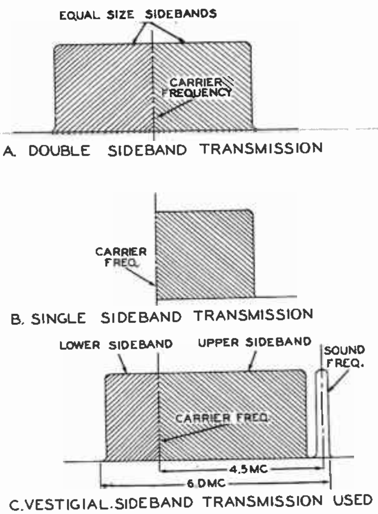

Fig. 1. Methods of Sideband Transmission.

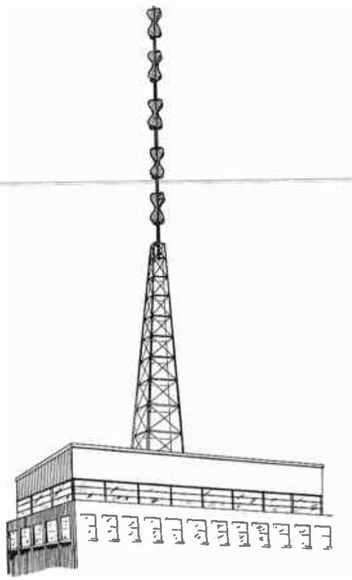

Fig. 2. Transmitter Antenna.

ed in the television band, but would also make receiver design impractical.

Single sideband transmission would allow a greater number of stations but it is not used because a sideband filter would have to be employed. This tends to produce a double or blurred image at the receiver.

A compromise between the two systems is used in television transmission. Vestigial sideband transmission transmits a carrier and the upper sideband, plus .7 megacycles of the lower sideband. Figure 1 gives a graphic illustration of why television transmissions are in the upper frequency spectrum (54 to 216 megacycle region). The bandwidth necessary for a television transmission is 6 megacycles and this width would cover the complete broadcast band (550 to 1650 kilocycles) approximately six times. There is a 4-1/2 megacycle displacement between the amplitude modulated video carrier and its accompanying frequency modulated sound carrier. To eliminate adjacent channel interference, the attenuation at each end of the carrier bandwidth must be very great, quickly reducing the regulated power to zero as shown in Figure 1.

Vestigial sideband transmission has the disadvantage of

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over-emphasizing the lower frequencies of any given channel. This over-emphasis must be compensated for in the alignment of the RF and IF amplifiers of the receiver.

While two separate carrier frequencies are used for video and sound transmission, both can be radiated from the same structure if it is especially designed for this purpose. It is essential that the radiation of the high frequency components of the sideband be equally as efficient as is that of the carrier. In some areas, it may be desirable to direct transmission in a given direction. An example of this is along a coast where transmission of the televised energy over water would be wasted. The same radiator must radiate energy over the entire television bandwidth; and, since an antenna is a tuned device, it is apparent that there is a tendency toward frequency discrimination. Special design is also required to give both the sound and video signals the same radiation pattern. Figure 2 illustrates a typical 5-bay transmitting antenna.

THE TELEVISION RECEIVER. The television receiver can be divided into three sections: the sound section, the video section, and the synchronizing section.

The RF amplifier of the receiver is designed to receive both the amplitude modulated picture signal and the frequency modulated sound signal. This is accomplished by having an RF bandpass equal in width to that of the transmitted signal.

Most television receivers have separate video and sound IF channels. Others use a common sound and video IF and separate the signals after amplification in the IF section. After IF amplification, the FM sound is detected and amplified by an audio system, and fed to the speaker. The video signal, after amplification by the video IF amplifiers, is detected and further amplified by a series of wide band video amplifiers. The composite video signal is then separated. The picture element is injected on the grid of the cathode-ray tube and is converted back into light energy in a ratio corresponding to that of the viewed scene. The synchronizing part of the composite video signal is presented to the synchronizing circuits. These pulses are composed of two general classifications; the horizontal synchronizing pulses, and the vertical synchronizing pulses. These horizontal and vertical pulses synchronize separate sweep oscillators, which scan the cathode-ray tube in exactly the same way as the camera tube at the transmitter was scanned.

FREQUENCY ALLOCATIONS. The Federal Communications Commission has, up to the present time, assigned two bands for

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television broadcasting. The frequencies in these bands are considerably higher than frequencies used in ordinary broadcasting. The low band covers a range of from 54 to 88 megacycles and the high band covers a range of from 174 to 216 megacycles. The lower band consists of 5 channels, and each channel covers the following frequency range:

Channel No.	Frequency
2	54-60 megacycles
3	60-66 megacycles
4	66-72 megacycles
5	76-82 megacycles
6	82-88 megacycles

The higher band consists of seven channels and each channel has the following frequency allocation:

Channel No.	Frequency
7	174-180 megacycles
8	180-186 megacycles
9	186-192 megacycles
10	192-198 megacycles
11	198-204 megacycles
12	204-210 megacycles
13	210-216 megacycles

The F. C. C. has re-assigned Channel 1 (44-50 megacycles) to other use due to the amount of interference present at these frequencies. The numbering of the other channels was not chang-

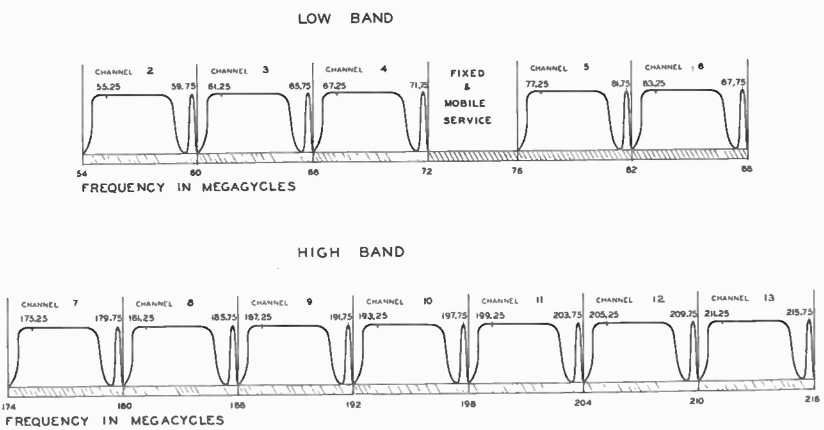

Fig. 3. Television Frequency Allocations.

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ed, in order to avoid confusion in channel identification on receivers already produced. Figure 3 shows the channel allocation plan for the two standard television bands. The video and audio carrier frequencies for each channel are marked in the illustration.

Notice that in the lower band there is a "skip" frequency channel between channel 4 and channel 5. The F. C. C. has assigned these frequencies to either amateur or mobile radio operation. The frequency of 75 megacycles has long been used for Marker Transmitters to give aircraft their relative position with respect to airports.

The bandwidth of each television frequency allocation is 6 megacycles, and both the sound and video signals must be transmitted within this limit. The amplitude modulated picture signal is always at the low frequency end of each channel allocation and occupies approximately 5-1/4 megacycles bandwidth. The frequency modulated sound signal is always at the high frequency end of the 6 megacycle bandwidth and covers approximately 1/2 megacycle.

It is necessary to use the high frequency spectrum for television broadcasting because each station must cover a relatively wide band of frequencies in order to transmit both the sound and picture signals. This use of high frequencies, however, limits the distance of satisfactory reception of the transmitted signal to approximately 50 to 75 miles, depending upon the relative height of the transmitting and receiving antennas, and the terrain between them. For practical purposes, line-of-sight transmission must be

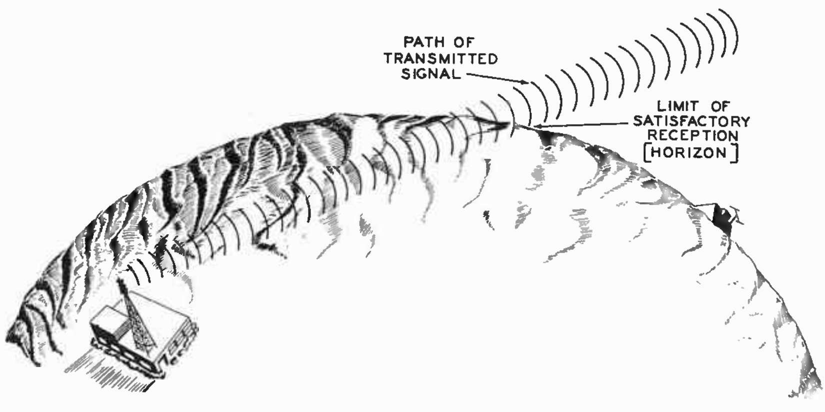

Fig. 4. Line-of-Sight Illustration Showing Horizon Limiting Distance of Transmission.

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considered. This factor not only complicates matters for the station engineer in his considerations of the transmitting antenna, but also makes more serious the problem of good receiver antenna installation. This usually means that the receiver antenna must have no large physical objects such as buildings, hills, etc., between it and the transmitting antenna. (Figure 4.)

TELEVISION NETWORKS. Due to the limited distance of television transmission, it has been necessary for the Federal Communications Commission to assign various metropolitan districts on the basic policy that stations will not be allowed to operate on the same channel unless they are at least 150 miles apart. For example, Station WBKB, located in Chicago, would not be able to transmit on channel 3, the frequency of Station WTMJ-TV, located in Milwaukee. However, a station located in Chicago could operate on the same channel as a station situated in Indianapolis, because these two cities are separated by a distance of more than 150 airline miles. (Figure 5.)

These same provisions limit each area to a maximum of

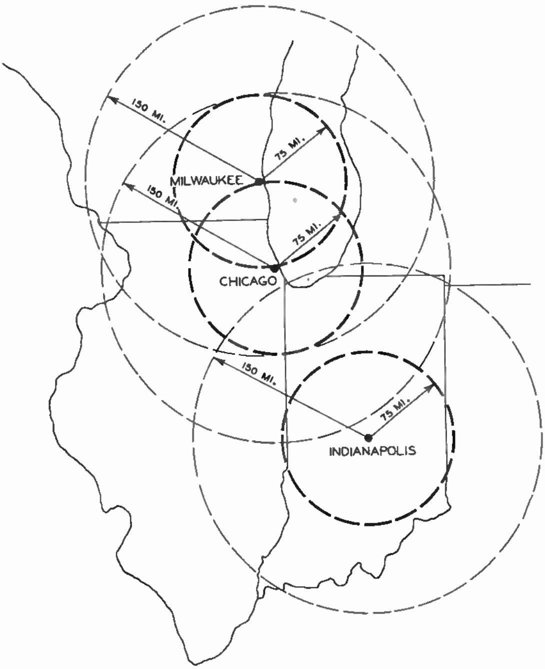

Fig. 5. Channel Allocation Plan.

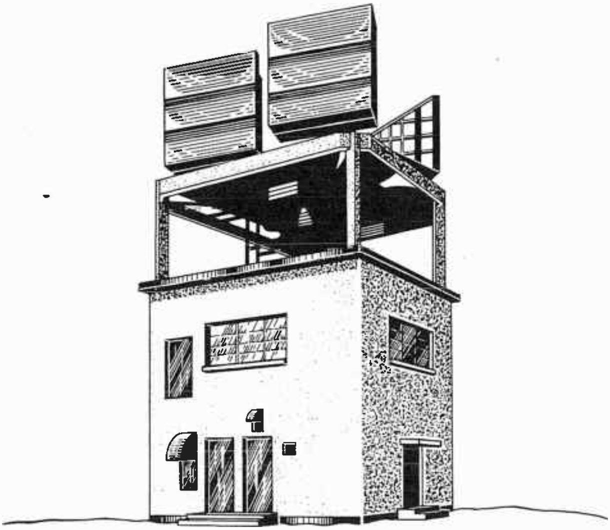

Fig. 6. Microwave Relay Station.

seven stations. Therefore, no receiver located in any one area can receive more than 7 stations. This 7-station allocation provides for at least a 4-megacycle separation between each station, thus preventing inter-station interference. An example of this is in the New York area, where channels 2, 4, 5, 7, 9, 11, and 13 have been allocated. At first glance, it would seem that channels 4 and 5 are adjacent and would cause inter-station interference. This is not the case, however, as channels 4 and 5 are separated by a difference of 4 megacycles. This separation is sufficient to prevent adjacent channel interference.

Since television transmission is limited to approximately 75 miles, an efficient relay system is necessary to link the nation into television networks. Two types of relays are now in use. One is an underground coaxial line with a wide pass-band characteristic. The other is a microwave radio relay system which requires no attention, and is automatic in operation. (Figure 6.) Such relays have two uses - one as an inter-station link, and the other as a link between a remote scene pickup and the main transmitter.

The remote pickup unit consists of an ultra-high frequency transmitter with a parabolic reflector type antenna and a complete video pickup system. Inside the mobile unit is a small self-contained television station with monitoring units, video amplifiers, and associate equipment. The remote camera and audio signals

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Fig. 7. Typical Remote Pickup Unit. (Photo Courtesy WENR)

are amplified and transmitted to the main studios. Here the ultra-high frequency RF is removed, and the remaining picture and audio intelligence used to modulate the television frequency carrier for transmission to the viewing public. A typical remote pickup truck, and camera, appears in Figure 7.

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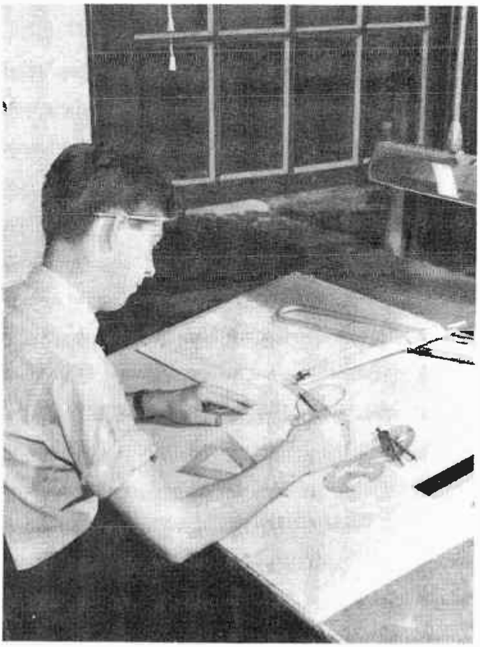

CHAPTER 1

RECEIVING ANTENNA PRINCIPLES

From the foregoing introduction it should be understandable why the receiving antenna for a television installation must be thoroughly understood from a practical as well as a theoretical standpoint.

Each metropolitan district can, for all practical purposes, be divided into three zones or areas as far as antenna installations are concerned. They are as follows:

1. The immediate zone within a 10 mile radius of the transmitter where a simple, inexpensive antenna will suffice because there is always sufficient signal strength to operate the receiver with such an antenna system.

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2. The intermediate area which covers the radius from 10 miles to 25 miles from the transmitter, requiring a more complicated antenna array to present the receiver with enough signal strength for a good picture.

3. The "fringe" area which covers a range of from 25 to 75 miles and ordinarily requires an elaborate antenna array with the highest gain possible to obtain enough signal for proper operation of the receiver. In some cases, an antenna system alone will not suffice, and an RF booster (pre-amplifier) must be used to increase the signal to a usable point.

Each installation must be considered as a separate problem that falls into one of these three categories.

Many contributing factors are involved in an installation; and, unless the basic theory of each general type of antenna is understood, it is practically impossible to know where to place each type for the best picture results. Some of the considerations encountered at television frequencies with respect to the antenna system are:

1. The television waves follow a "line-of-sight" path instead of following the curvature of the earth or being returned by the ionosphere. This limits the distance of transmission according to the height of the transmitting and receiving antennas and the terrain or intervening objects between them.

2. Television waves have the same tendency as radar waves to reflect from objects and the earth. This results in a double image or "Ghost" in the picture and stems from the phase difference between the original image and the reflected image.

3. Ignition noise from automobiles, and arc interference from electric motors in heavy traffic areas, are easily picked up by the antenna and can over-ride the signal, causing the picture to tear, or go completely out of synchronization.

RADIATION. The principles of radiation are based on the law that a moving electrostatic field creates a magnetic field, and that a moving magnetic field creates an electrostatic field. If the two fields are radiated in free space, they will always be in phase with each other electrically. Physically, however, they will be

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located in perpendicular planes at right angles to each other. In the past, the idea of a magnetic field producing an electric field, or vice versa, has usually been thought of as taking place in a conductor. However, the laws of field generation hold true whether a conductor is present or not.

Basically, both transmitting and receiving antennas are resonant circuits designed to tune to some particular frequency. Each antenna system possesses the tuned circuit properties of inductance and capacitance.

The inductance of the antenna is formed by the length of the conductor, while the capacity value represents the combined capacitance between various sections of the conductor. Figure 8 illustrates inductance and capacitance properties of a simple dipole. The dipole antenna is employed for analysis of radiation and reception because approximately 90% of all television antennas in use, are either dipoles or modifications of this basic type.

A dipole antenna cut to resonate at one-half the wavelength of an RF generator is shown in Figure 9. Each half of the dipole is 1/4 of a wavelength long. The output of the RF generator causes current to flow in each quarter wave section of the dipole. The center of the dipole is the point of maximum current, the current diminishing as it moves toward the ends of the conductor. This current distribution remains the same for any magnitude of current flowing in the dipole. It is important not to confuse the terms current distribution and current magnitude. Current distribution can be defined as the relative proportions of a current in an antenna, while the magnitude of current is the amount of current taken from the antenna.

For purposes of explanation, the current should not be considered as a varying charge; but, instead, it should be considered as a series of charges, each slightly different in magnitude from the preceding one. A charge is impressed on the center of the dipole and moves along the sections of the dipole toward the ends

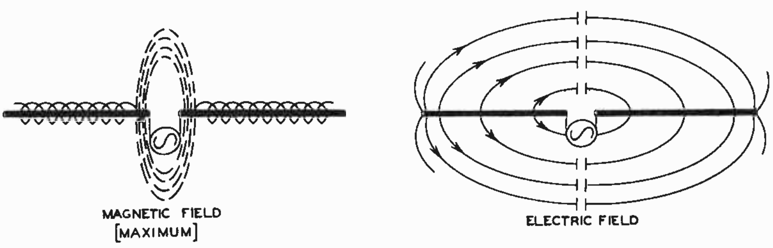

Fig. 8. Inductance and Capacity in a Dipole Antenna.

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and then reverses itself to start back toward the center. By this time, the next charge is just reaching the end of the antenna and is traveling in the opposite direction of the reversed first charge. The two currents, being approximately the same size, cancel each other; and the resultant current is zero at the ends of the dipole. The resultant current is greater toward the center of the dipole, because the magnitudes of the outgoing and returning charges are no longer the same, as they are taken from different parts of the cycle. At the center of the dipole no cancellation is present, and a full current charge exists.

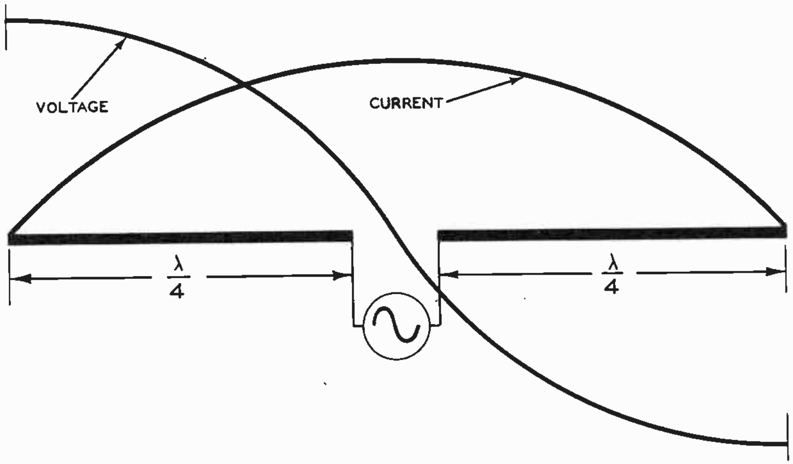

Fig. 9. Current and Voltage Distribution in a Half Wave Dipole Antenna.

The voltage variations in a half wave dipole are exactly opposite the current variations. The voltage is greatest at the ends of the dipole, because the current is zero and the two amplitudes of voltages additive. Toward the center of the dipole, where the current becomes greater the voltage becomes less. At the center or feed point of the dipole where the current is maximum, the returning charge is equal to the injected outgoing charge of the opposite phase; and voltage cancellation results. The voltage distribution remains the same, regardless of variations in voltage amplitude.

Radiation Field. A magnetic field is created about the antenna as the current flows in the dipole. An electric field is also radiated due to the capacitive element and the varying voltage present in the antenna. Throughout the text the terms induction field and magnetic field will be used interchangeably, as will the terms electric field and electromagnetic field. The electric field

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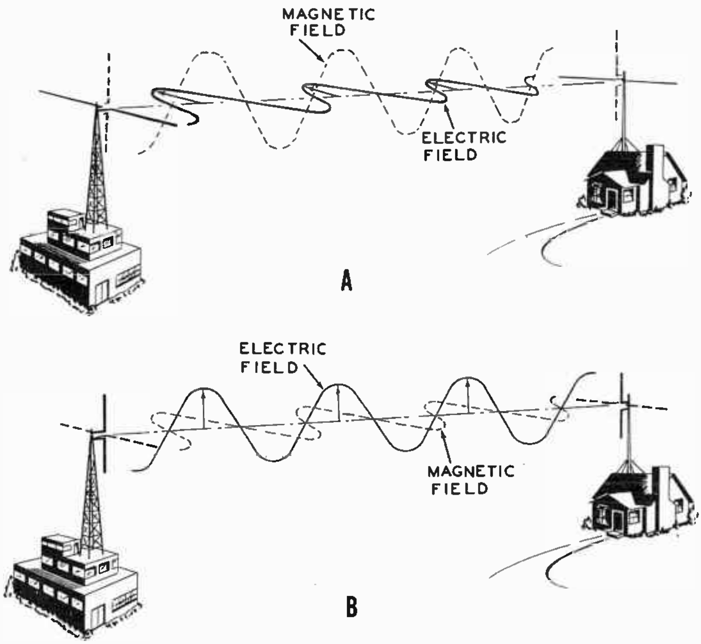

Fig. 10. The Magnetic and Electric Fields of Horizontally and Vertically Polarized Wave Fronts.

is radiated in a plane that is at 90° or right angles to the magnetic field. Only a small portion of the magnetic field created by the current variations leaves the antenna, and this energy constitutes a ground wave which is quickly absorbed by the earth, making its effects quite local.

The electric field, however, creates a field that is constantly moving away from the antenna. This movement can be basically thought of as one line of force constantly pushing out another line of force and in turn being pushed further away from the dipole by the line of force following it. The movement of this electric field creates a magnetic field, the combination of which makes up an electromagnetic field that can act upon the receiving antenna.

Wave Polarization. The plane of the electric field, or lines of force, is defined as the direction of polarization. Wave fronts of electric and magnetic lines of force are shown in Figure 10. When the electric lines of force are horizontal (Figure 10A), the wave is said to be horizontally polarized. An antenna placed in a

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horizontal plane radiates horizontally polarized signals, and one placed in a vertical plane radiates vertically polarized signals. At very high frequencies where the television bands are situated, a horizontally polarized receiving antenna will most satisfactorily receive signals from horizontally polarized transmitting antennas; and vertically polarized signals from a transmitter will be best received on a vertically polarized receiving antenna.

It has been found at very high frequencies that vertically polarized signals are best if the receiving antenna systems are employed less than one wavelength above the ground. Hence, where signals are to be received on an antenna located very close to the ground, vertically polarized systems are employed. One reason that the police radio band, located between channels 4 and 5, uses vertical polarization, is that the receiving antennas located on the radio cars are less than one wavelength above ground. Television transmitting and receiving antennas, on the other hand, use horizontal polarization; because both the transmitting and receiving antennas are usually placed several wavelengths above ground. There is a tendency for the polarization of a signal to change at very high frequencies, because the wave splits up and sometimes becomes elliptical or circular in shape. Some receiver antenna manufacturers have attempted to allow for partial wave orientation by making the dipoles of their systems adjustable so they can be varied from the horizontal plane. In this way, the

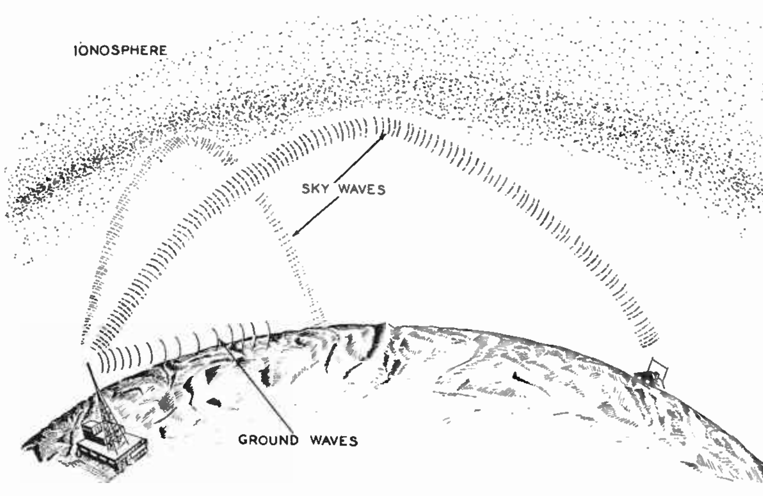

Fig. 11. Ground and Sky Waves at Frequencies below 40 Megacycles.

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antenna can be adjusted for maximum signal reception with regard to polarization.

Line-of-Sight Factors. At lower and medium radio frequencies, up to 40 megacycles, the ionosphere plays a very important role in the distance that a signal can be transmitted, because it effectively refracts or bends the signal path back to the earth if the angle of radiation is not too great. (Figure 11.) The magnetizing effect of the earth also "bends" the radio waves along the surface of the earth so that the ground wave can be received at a great distance.

At television frequencies, the angle of refraction at the ionosphere becomes so small that the waves pass completely through the ionosphere instead of being refracted back to the earth. The earth also has very little bending effect on the ground wave, especially on the higher television bands in the 174 to 216 megacycle range. Thus only the direct waves from the transmitter antenna ever reach the receiver antenna, and "line-of-sight" propagation results. (Figure 12.) Due to the curvature of the earth and intervening terrain, the reception of television signals is limited by the height of the transmitting and receiving antennas above the earth. Of course the higher the transmitting antenna, the farther away the signal can be received with good results.

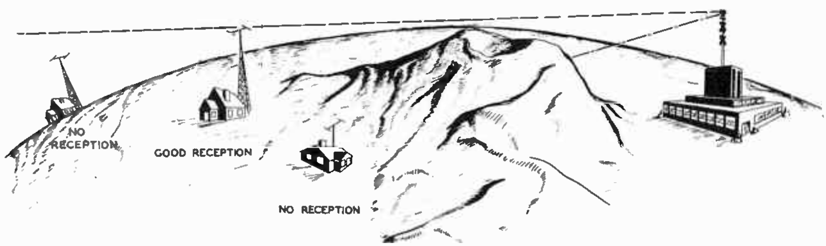

Fig. 12. Line-of-Sight Transmission.

Westinghouse Electric Corporation has developed a new system called Stratovision that increases the relative area of transmission many times compared to an ordinary transmitting antenna placed on a skyscraper or tower. Essentially, it consists of having the main television transmitter installed in an aircraft flying at a very high altitude (20,000 to 30,000 feet) over a metropolitan area. The televised programs are relayed from the studio by an ultra-high frequency transmitter to the aircraft where they are re-transmitted at television frequencies. (Figure 13.)

The effective range of reception, therefore, is dependent

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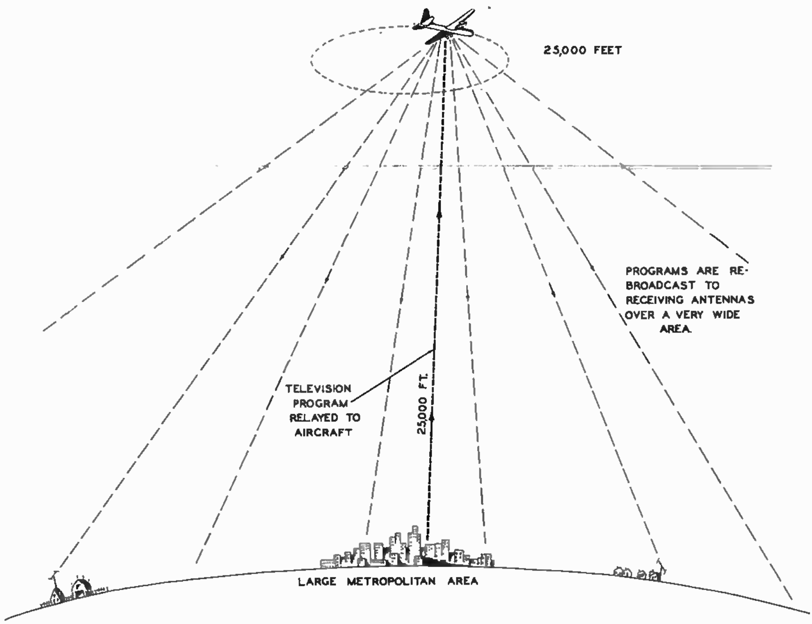

Fig. 13. Stratovision Method of Transmission.

upon the effective height of the transmitting and receiving antenna systems, and on their ability to overcome the intervening terrain and curvature of the earth. (Figure 14.) It should be remembered that in weak signal or fringe areas, better reception can be obtained by elevating the receiving antenna to a higher level than originally employed. Figure 15 is a graph illustrating the average number of miles reception that can be obtained with respect to the height of the transmitting antenna. This graph is set up to depict ordinary countryside and is not necessarily accurate if the intervening terrain between the two antennas is exceptionally hilly or mountainous. It is advisable to consult topographical or airport maps if there is any doubt that a line-of-sight path does not exist, due to rough terrain, between the receiver and transmitter.

Reflections of Radiated Energy. It is possible to have two or more signals simultaneously present at the receiver due to the main signal reflecting from some object such as a tall building, as illustrated in Figure 16, and striking the receiving antenna with a phase delay with respect to the directly transmitted signal path. Also a signal transmitted at a low angle from the transmitting antenna may hit the earth and be reflected to the receiving antenna to cause a reflected signal path in addition to the direct signal path.

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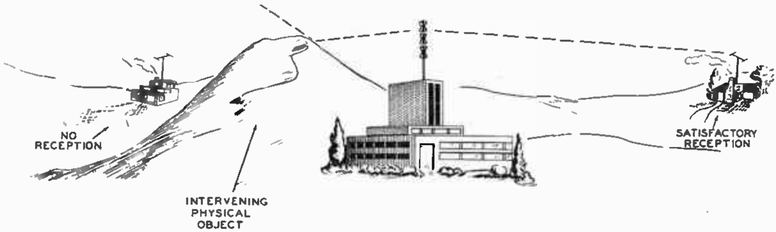
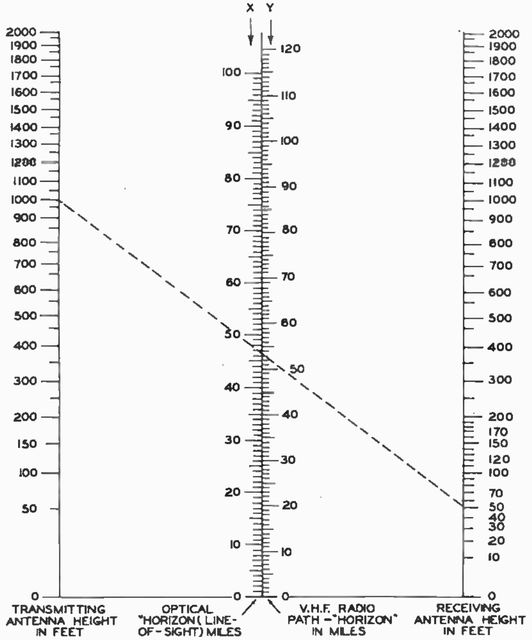


Fig. 14. Effects of Terrain upon Reception.



EXAMPLE: TRANSMITTING ANTENNA - 1000 FT. HIGH - RECEIVING ANTENNA-50 FT. HIGH - OPTICAL HORIZON - 48.5 MILES - V.HF. PATH - 53.5 MILES.

Fig. 15. Distance of Reception with Respect to Antenna Height.

The ear cannot detect the phase difference between the multiple signals; and, consequently, it cannot be noticed in the audio circuits. The multiple signal, however, is very evident in the picture; because ghost images, more or less delayed in time from the main signal, appear on the viewing screen. The reflected ghost signal is displaced from the main signal on the television screen; because the direct waves come to the receiver via the shortest possible route, while the reflected wave must travel a longer distance, and arrives slightly later than the direct signal.

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Unwanted reflected ghost signals are delayed with respect to the desired direct signal by 1 microsecond for each 1000 feet that the reflected signal detours. In terms of picture displacement, the ghost signal is displaced 1/60th of the total picture width, for each 1000 feet detour of the reflected signal.

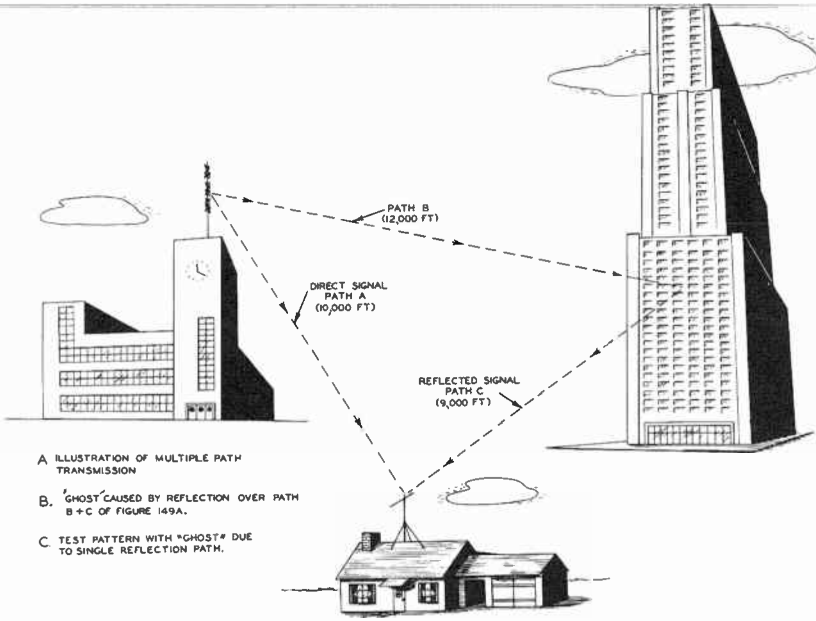

Fig. 16. Reflected Signal Paths.

It is possible to have either positive or negative ghosts, depending upon the phase of the unwanted signal. A positive ghost signal is of the same polarity as the direct signal, and results in a ghost image on the screen, having the same shading or tone value as the directly received image. Figure 17A illustrates such a ghost pattern. On the other hand, a negative ghost signal appears in opposite polarity, so that the ghost image is reversed in tone value, i. e., white areas of the desired signal image are reproduced as black in the ghost, and vice versa.

There may be combinations of direct and unwanted reflected signals which can cause complete reversal of shading on the picture tube. In these cases, all of the image that is normally dark or black, becomes light or white in color, while the normally light areas reproduce dark or black.

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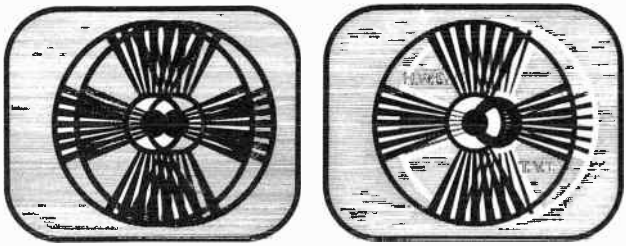

Fig. 17. Types of Ghost Signals.

Another type of ghost signal follows a reflected path that is only slightly longer than that of the direct signal. Consequently, its displacement on the picture tube screen is so small that it cannot be discerned as a separate duplicate image, but rather appears as a blurring trace, causing loss of detail on the viewing screen.

Reflections from intervening objects such as tall buildings, water towers, etc., are not the only causes of ghost signals. If considerable mismatch exists at both the antenna and receiver ends of the transmission line, ghosts can be produced by the reflected energy from the receiver going back to the antenna, and, in turn, being reflected back to the receiver with a phase displacement from that of the main signal. On many occasions, servicemen have spent considerable time attempting to eliminate ghosts by rotation of the antenna, only to find that the trouble was mainly due to mismatch in the antenna and input system.

Passing aircraft can also cause ghost conditions, and are frequently responsible for customer complaints. Such ghost conditions are naturally temporary, and cease to exist as soon as the aircraft is beyond the reflected path range.

The elimination of ghosts and reflected signals will be taken up under "Common Installation Problems", later in this book.

RECEPTION OF RADIATED ENERGY. A receiving antenna can be considered as a conductor that is coupled to the transmitting antenna by the electromagnetic lines of force that exist between them. When a receiving antenna of the same wave length as the transmitting antenna is placed where some of the transmitted energy can reach it, the energy in the transmitted electromagnetic field will set the electrons in the receiving antenna in motion. The electrons in the receiving antenna will flow in a

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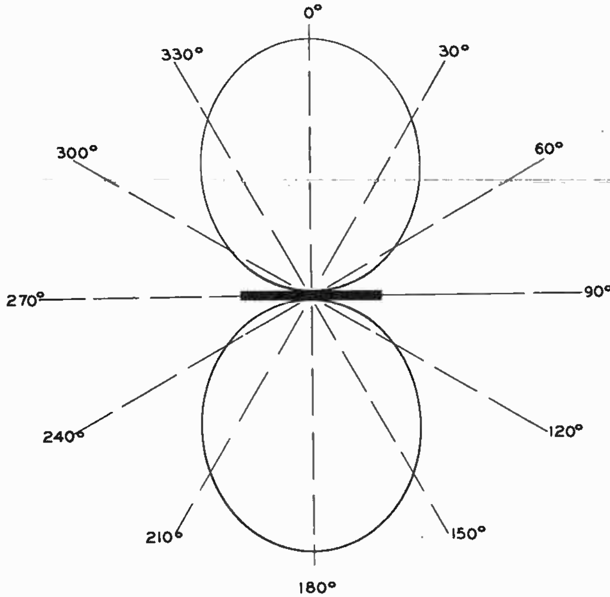

Fig. 18. Field Pattern of a Dipole Antenna.

ratio proportional to the variations in the transmitted field. Therefore, any intelligence and pulse variations in the current at the transmitter will be reproduced as current variations in the receiving antenna. Unless the receiving antenna is cut (with respect to physical length) to some multiple of the transmitted wavelength, the amount of signal picked up by the antenna will be insufficient to operate the receiver properly.

Different types of television antenna receiving systems have definite properties and characteristics that are common only to the particular antenna. In order to select the correct antenna for a given installation, it is necessary to consider the individual requirements with respect to frequency or frequencies which are to be received, the amount of gain desirable in view of probable signal strength available, the directivity necessary to isolate reception from ghosts or possible interfering stations, and impedance characteristics to match the requirements of transmission line and receiver input design. Since most of these factors are interpedendent, the final choice must usually be a compromise between advantages of the various designs. To make the best compromise choice, it is necessary to thoroughly understand the contributing factors enumerated above.

<u>Field Patterns (Directivity).</u> The field pattern, or

directional response pattern, of an antenna can be considered as the response that an antenna has to a given signal, as it is rotated with respect to the signal source. Figure 18 graphically illustrates the response of a dipole antenna. The antenna is considered to be at the point of tangency between the two directive lobes parallel to the 90° and 270° lines. The points on the field pattern where some signal can be received (the area enclosed by the loop) are called lobes, and the area where no signal is received is called a null. The antenna has the greatest signal response along the 0° axis and the 180° axis, as seen on the chart. The response of the antenna to any point, can be found by the line intersecting the lobe at the desired point, and the center of the graph. The antenna will not respond very well to a transmitter located in the 60° to 120° region, or to a transmitter located in the 240° to 300° region because of its directive nature. Thus the best reception will be obtained when the antenna is placed broadside to the transmitter. Because there is equal response in two directions, the dipole antenna is said to be bi-directional. An antenna that will receive well from only one direction is termed unidirectional. One that will receive well in many directions is said to be omni-directional. Most commercial antenna manufacturers publish the response patterns of their antennas. From the practical standpoint, field patterns are used mainly to interpret the gain and directivity of an antenna for a particular frequency.

If the antenna is to be constructed by the serviceman, it is sometimes desirable to check its response pattern. This information is particularly useful when signals are to be received from transmitters located at considerable distances from each other, and it is necessary to receive them on the same antenna. A rough response pattern can be obtained when the transmitter is on the air by rotating the antenna and utilizing a test receiver and output meter. The output meter should be employed in the audio detector circuit of the test receiver. The antenna should be oriented until maximum output is obtained on the output meter. Rotate the antenna, through 10-degree steps, the entire 360 degrees of rotation and note the output reading at each 10-degree point. After the notations have been made, plot the curve on polar co-ordinate graph paper with a scale equal to the equivalent points on the output meter. Be sure that only one station is on the air when making the tests to prevent interference. The A. G. C. (Automatic Gain Control) should be disconnected in the test receiver, to prevent it from operating in the receiver, and giving a number of readings that are almost the same value. This is especially true if the automatic gain circuit controls the RF amplifier stage.

The directivity or response pattern varies with the frequency, thereby causing the antenna to have many directive

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patterns for a range of frequencies as wide as that of the two television bands (54-88 megacycles and 174 to 216 megacycles). This factor is very important in the design of television antennas, because it is very difficult to design and construct an antenna that will have essentially the same response patterns over a wide band of frequencies.

Impedance Considerations. Impedance plays an important role in the method of obtaining power from the antenna, since the impedance at the point from which the power is taken determines the type of transmission line that must be used, and whether or not the antenna will be matched to both the transmission line and receiver. A thorough discussion of impedance matching and standing wave theory is beyond the scope of this book; therefore, only the essential parts that are of practical use to the servicemen are included.

The impedance of any electrical circuit is equal to the voltage divided by the current. In an ac circuit, if the voltage and current reach their positive and negative maximum together, they are in phase; and the only impedance present is that of the resistance. If the current and voltage maximums do not coincide, an out-of-phase relationship exists; and a reactive component is present. This phase difference is expressed in degrees, because the fraction of a cycle separation between the voltage and current is a time factor.

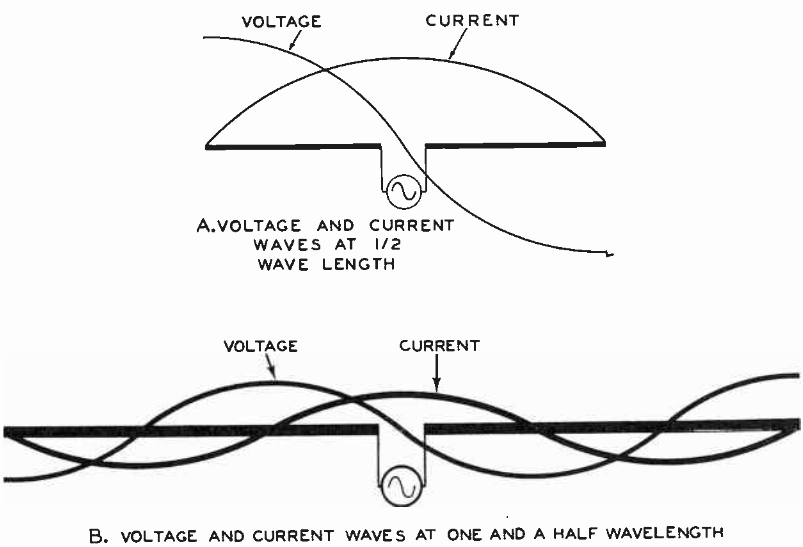

Fig. 19. Impedance Factor with Respect to Voltage and Current Waves.

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In a half wave antenna (part A of Figure 19), the current and voltage are 90° out of phase. This condition exists for any multiple of a half wave antenna. The impedance of a half wave antenna reaches its lowest value at a current maximum and voltage minimum. It reaches its highest value at a voltage maximum and current minimum. This impedance follows regular cycles in the same manner as the standing waves of current and voltage. Standing waves of voltage and current result along the transmission line if the impedances of the antenna, the transmission line, or the receiver are not properly matched. For example, standing waves would result if a 300 ohm folded dipole antenna were connected to a 72 ohm transmission line, which, in turn, was connected to a receiver with a 300 ohm input impedance. The result would be: first, attenuation of the input signal by the mismatch between the antenna and transmission line; second, partial signal reflection from the receiver input back on the transmission line toward the antenna, due to mismatching between the line and the receiver; and third, re-reflection of the reflected signal back down the transmission line by the antenna, due to the secondary mismatch between the antenna and the transmission line. Figure 20 shows a representation of such action. If the impedance mismatch is great enough, a ghost image displaced to the right of the direct picture results. A small impedance mismatch results in a small phase difference between the direct signal and reflected transmission line signal. A loss of picture definition and resolution results.

The condition in the installation that creates ghost signals results from the existence of an impedance mismatch at both the receiver and antenna ends of a transmission line. If there is a mismatch at only one of the two ends, no ghost signal is produced; but, instead, signal attenuation results. No ghost signal is created, because no energy will be reflected at the matched end and a lower standing wave ratio results. Mathematically, the amplitude of the ghost signal is dependent upon the line attenuation and the reflection coefficients. If there is no reflection at one end of the transmission line, then the ghost problem caused by double mismatch is overcome. However, this does not mean that a great mismatch between the transmission line and the receiver or the antenna can be tolerated. Instead, good matching should be attempted wherever it is possible to achieve a minimum of attenuation and a low standing wave ratio.

The impedance at the input of the antenna varies with the frequency. When a station of differing frequency is received, the antenna is no longer sharply resonant to the frequency, due to the change in current and voltage relationships. With a change in current and voltage relationships the impedance relationships are

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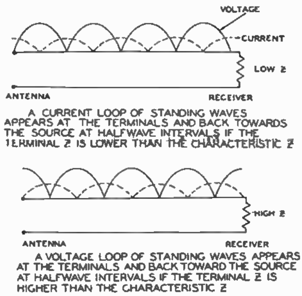

Fig. 20. Reflected Standing Waves.

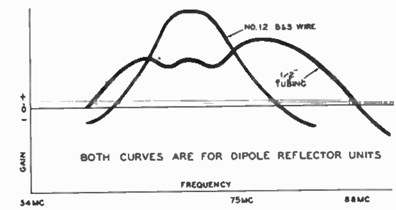

Fig. 21. Effect of Antenna Element Diameter on Frequency Response.

changed, the standing wave ratio is increased, and less signal arrives at the receiver. Therefore, the wider the frequency response, the better the receiving antenna.

Commercially, the design of a television antenna has been approached in two basic ways. First, there is the type of commercial antenna designed to receive only one television station. Second, there is the broad band type of antenna designed to receive the entire television spectrum of frequencies.

In the case of the single channel antenna, the design problem is not too great; because many types of antennas have a 6 megacycle bandpass if they are cut to resonate in the 54 to 216 megacycle region. It is absolutely necessary that an antenna does not discriminate against any frequency in the 6 megacycle bandpass. If this frequency discrimination were present, one portion of the picture signal would have more gain than another and would result in lack of picture intelligence and definition. The impedance of this general type of antenna is made to match the impedance of the transmission line and the receiver for the station received.

However, in the case of the all-channel broad band antennas, the design and impedance matching problem becomes much more involved. Since the reactance of an antenna is a function of the frequency, it is very necessary that the reactance or impedance of an antenna remain fairly constant over all of the television channels that the antenna is designed to receive. If it is not maintained at a constant level, there will be a mismatch to the transmission line, and ghost images or signal attenuation results. Linear impedance over a wide band of frequencies can best be obtained by having an antenna with a low value of "Q". An antenna

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is a resonate circuit; therefore, its response curve will be broad and flat if a low value of "Q" is maintained. Generally speaking, the thinner the antenna element, the higher the "Q"; and conversely, the thicker the receiving elements, the lower the "Q". (Figure 21.) These facts fit in very well with the mechanical structure problems of antenna design. Since the elements must be thick for electrical reasons, it is very simple to make the elements self-supporting with the aid of a center mast to elevate it to the desired height. Thus the installation problem has been somewhat simplified. In summary, it is very important that broad band antennas have a low value of "Q" in order to present a constant impedance to the transmission line over the television frequencies.

Receiver manufacturers have standardized receiver input circuits at 72 or 300 ohms impedance. Some 300 ohm receivers have 72 ohm taps so that either input impedance can be utilized, depending on the type transmission line used. The design requirement involved in the receiver input circuit, as far as impedance considerations are concerned, is more stringent than the impedance requirements of a broad band antenna. The input of the receiver must be as close as possible to a 300 ohm or 72 ohm non-reactive impedance over the 12 television channels to compensate for any mismatch at the antenna. It is easier to achieve a constant impedance in the receiver input circuit than it is to maintain a constant output impedance at the antenna, because circuit elements can be changed in the receiver input circuit with a change of the channel selector control. This, of course, is impossible in the antenna.

Low "Q" considerations are also very important in input circuits so that no frequency discrimination is present to amplify one picture frequency more than another in the same channel. Typical input circuits are illustrated in Figure 22. The basic receiver input circuits used, are the grounded grid and grounded cathode types. Usually, no parallel capacity is used; because, at the frequencies involved, the input capacity of the tube and shunt wiring capacity is sufficient to tune the circuit to resonance.

When a 300 ohm transmission line is employed, it is usually terminated in a balanced input where the surge impedance of the line is equal to the input load impedance. When 72 ohm shielded coaxial cable is used, the input is still properly terminated with 10% accepted tolerances. Terminals a and b are connected together, and the coaxial line is connected across their junction and terminal c (part of Figure 22). A 300 ohm line would be connected across terminals a and b.

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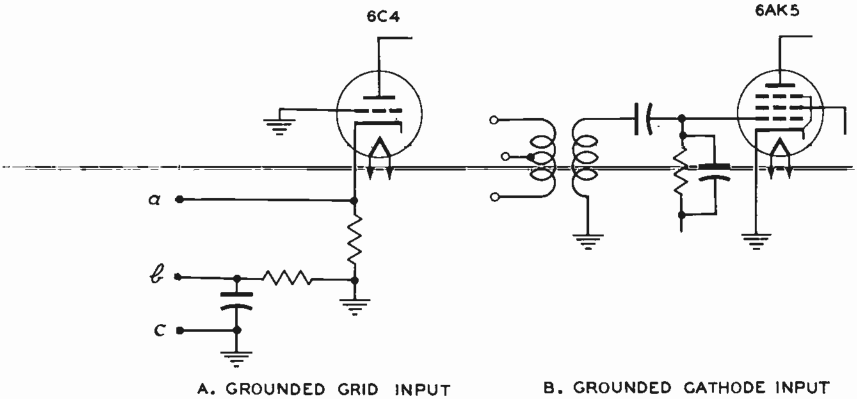

Fig. 22. Typical Receiver Input Circuits.

In many cases, it is desirable to use an antenna of one impedance with a transmission line of a different impedance. For example, the high gain of a 72 ohm stacked dipole reflector array is needed, and it must be matched to a 300 ohm transmission line and receiver. In cases of impedance matching of this type, it is possible to construct impedance matching transformers that efficiently convert impedances from one value to another. These devices are also known as quarter wave matching stubs and are discussed in detail in a later section of this book.

Summarizing "Impedance Considerations", it is essential that the impedances of the antenna, the transmission line, and the receiver be matched in order to attain a maximum ghost-free signal. If the antenna does not match the impedance of the receiver or the transmission lines, standing waves result; and the amount of signal transferred to the receiver is diminished, because the voltage and current reflect from the unmatched element back on the line, causing signal cancellation and ghost signals in a ratio proportional to the impedance mismatch. If the system is located in an area where there is sufficient signal strength, some mismatch between the antenna and the line can be tolerated, because there is enough signal present for the proper operation of the receiver. In other cases, to obtain an impedance match between an antenna of one impedance and a transmission line of another impedance, it is necessary to employ matching stubs which effectively add length to the line so that the current is taken from an impedance point on the antenna where it will match that of the transmission line.

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Dipole Antennas. A dipole antenna consists of two quarter wavelengths of wire, rod, or tubing located in a parallel plane and resonated to a particular frequency. It is also known under the names of the Hertz or the more familiar half wave doublet antenna. The half wave dipole antenna acts as a basis from which approximately 90% of all television antenna arrays are designed. It is the fundamental form of very high frequency antennas. Since it is operated independently from ground, it can be easily installed above the surface of the earth and any other interfering objects. The current is removed from a half wave antenna at its center where the impedance is 72 ohms. (Figure 23.)

The dipole antenna, when used by itself as the recipient of television signals, has some distinct drawbacks which may demand the use of a more complicated system:

First, most present day television receivers require that there be approximately 200 to 300 microvolts of signal present at the point where the dipole is to receive the signal, in order to have enough signal transferred from the antenna to the receiver for good picture detail and contrast with a lack of "snow". "Snow" appearing on the viewing screen is a result of insufficient signal level with respect to the noise level, and the resulting pulses of noise over-ride the signal level to appear on the viewing screen as minute snowflakes throughout the picture.

Second, if a number of stations are on the air in a given area, the dipole antenna is not sufficient, because its response is not uniform over a wide band of frequencies. This is especially true if the stations are located on both the upper and lower bands. The dipole, at its best, will give somewhat uniform response over a 12 megacycle bandwidth considering the frequency to which it must be cut. A graph depicting the frequency response of a dipole

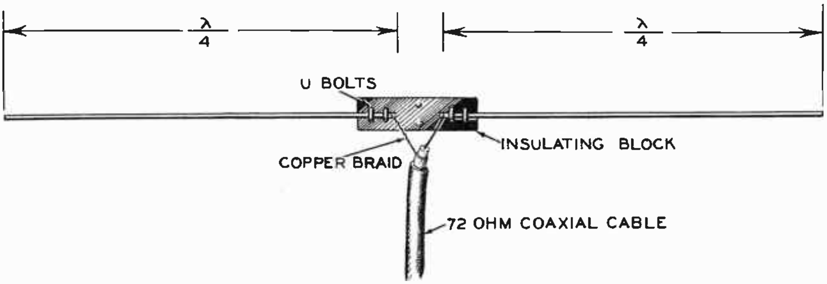

Fig. 23. The Dipole Antenna and how It Is Connected.

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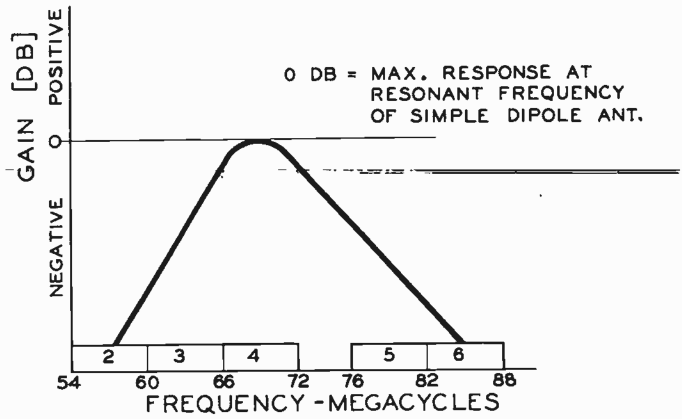

Fig. 24. Frequency Response of a Dipole Antenna.

is shown in Figure 24. This means that if the dipole is cut to channel 4, for example, the gain of the antenna will be reduced considerably on channels 2 and 6. Under such a condition, reception is not feasible unless the stations located on channels 2 and 6 have enough power to overcome the reduced gain of the dipole.

Third, the dipole antenna may not be sufficiently directive to overcome the effects of multiple reflections. In this case, multiple or ghost images would appear on the viewing screen. One method that has been used to remove ghost images is to rotate the antenna so that the direct signal reception will be slightly weakened, whereas reception of the unwanted signal coming in at a much wider angle will be entirely eliminated, as shown in Figure 25A.

In other cases, it may be that the inherent width of the dipole response pattern is too great to allow elimination of the ghost image by rotation of the antenna. This is especially true if the reflected signal approaches the antenna in a path within 30 degrees of the direct signal. For example, in Figure 25B, when the antenna is placed broadside to the main signal (a), the reflected signal (b), is received approximately 30 degrees to the left of the main signal. Any rotation up to 30 degrees will still allow the reflected signal to be received by the antenna, and the ghost image will remain. If the antenna is rotated beyond 30 degrees, the reflection will be eliminated but the strength of the main signal will be so greatly reduced that it will be insufficient to provide good picture reproduction in the receiver. Obviously, a dipole antenna cannot be used in this application.

The response pattern of a more complicated antenna system, shown in Figure 25C, where the lobe width is narrow enough to

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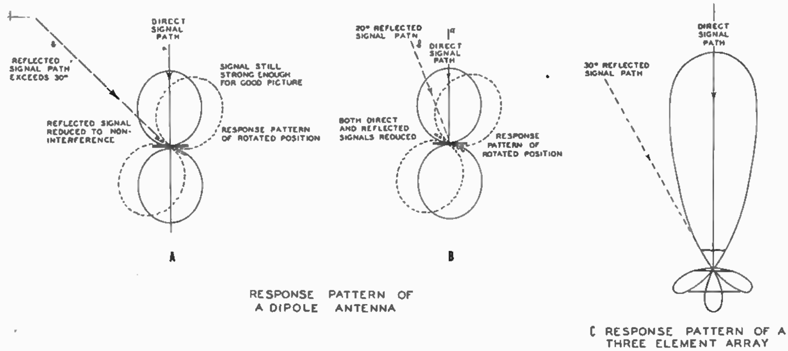

Fig. 25. Field Pattern and Ghost Elimination.

eliminate the reflected signal from the picture without sacrifice of direct signal, would be required for such an application.

Fourth, the dipole antenna has no "front-to-back" ratio. "Front-to-back" ratio can be defined as the ability of an antenna to receive a signal from a given direction, in comparison to its ability to receive a signal from an exactly opposite (180°) direction. The ability of an antenna to receive a signal from a given direction compared to its ability to receive undesired signals from the ends of the antenna is called "front-to-side" ratio. The basic dipole has no "front-to-back" ratio because of its bi-directional characteristic. It has a very small "front-to-side" ratio, because its loops of reception are large. (Figure 25A.) In many installations; amateur, police, or FM radio stations may be located to the rear, or to the side of the receiving antenna, and in relatively close proximity to it. Due to the closeness and the magnitude of the signal, any one of the three may over-ride the picture signal, and cause undesired sound bars to appear in the picture. If an antenna with a good "front-to-back" ratio is used, these signals will not interfere to as great a degree as they will with an antenna that has equal response in two directions.

Although the dipole antenna has many drawbacks when used by itself, there are still many locations where a dipole is not only adequate but advantageous to use. Usually, a dipole is sufficient within 5 to 6 miles of the transmitting antenna if no tall buildings are between the transmitting and receiving antennas to produce dead spots or reflections. If the receiver is located between two local transmitting stations, the dipole is advantageous because of its bi-directional qualities.

Folded Dipoles. A folded dipole is essentially an ordinary, half wave, center fed dipole with an identical half wave element

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connected to it by shorting the ends of the two elements together as illustrated in Figure 26. It has distinct advantages over the ordinary dipole just described, because it combines the similar bi-directional characteristics of a half wave antenna with the impedance transforming properties of a 300 ohm quarter wave stub. It has an inherently wider frequency bandwidth than the dipole, and the relative amount of signal it will pick up is more equal over the bandwidth it covers. A bandwidth versus response curve is shown in Figure 27. When this curve is compared with that of the simple dipole shown in Figure 24, it is obvious that the folded dipole is an improved antenna with respect to frequency response. The wider frequency response stems from the fact that, when two elements are connected as in a folded dipole, the combination acts like a single conductor with a greater diameter. The greater effective diameter of the receiving element results in a lower resonant Q for the circuit, which results in a desirable widening of the frequency response of the antenna.

If the two elements or conductors of a folded dipole are of the same diameter, the resultant impedance at the antenna terminals will be approximately 4 times the terminal impedance of a simple dipole (72 ohms), or nearly 300 ohms. This results from the fact that only half the current is present at the terminals of a folded dipole, as is present at the terminals of an ordinary dipole. It is possible to use a 300 ohm twin-lead transmission line and match it to the folded dipole antenna without utilizing a frequency-sensitive matching transformer. Due to the excellent impedance match between the 300 ohm line and the folded dipole, a low SWR (standing wave ratio) results for all frequencies within the response of the antenna.

In a design of the folded dipole antenna, the spacing between the elements must be considered with respect to the resonant

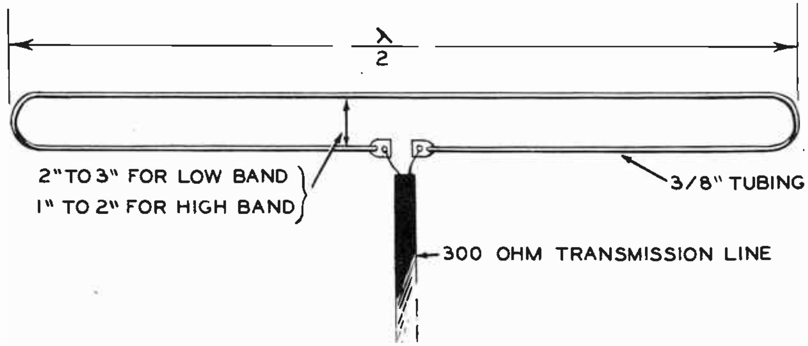

Fig. 26. The Folded Dipole.

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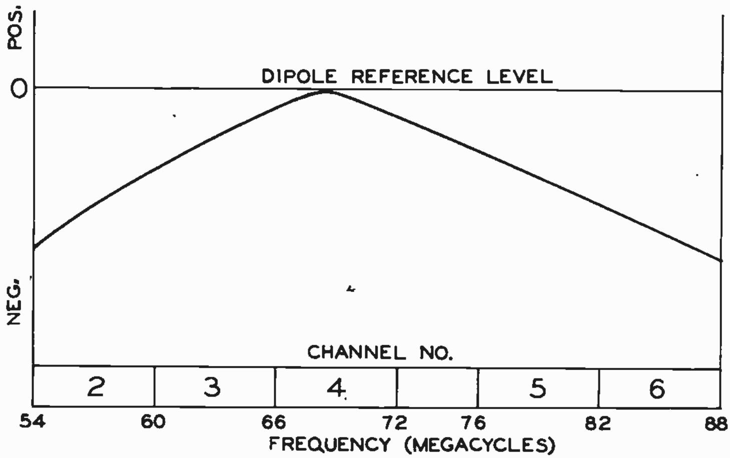

NOTE: THE DIPOLE REFERENCE LEVEL FOLLOWS A STRAIGHT LINE BECAUSE A DIPOLE IS CUT TO RESONATE AT EACH CHECK FREQUENCY FOR COMPARISON WITH THE ANTENNA UNDER TEST.

Fig. 27. Frequency Response of a Folded Dipole.

length of the elements. The spacing between the elements should vary with the frequency; the higher the frequency, the less the spacing. The element spacing for the center frequency of the low band should be 2 to 3 inches, and 1 to 2 inches for the high band. At frequencies above one-half meter, the general term for element spacing is $\frac{\text{wavelength}}{100}$.

The folded dipole can be utilized in the same locations as the dipole where the transmitting antenna is not more than 10 miles away. It can be used to advantage where the receiver is located between two local transmitters on widely separated channels because of its bi-directional characteristics and its wide frequency response.

T-Matched Half Wave Antenna. A T-matched half wave antenna is a combination of an ordinary half wave antenna and a folded dipole antenna. If the two ends of the top element on a folded dipole are cut off and if the remaining stub ends are connected to the bottom element as shown in Figure 28, a T-matched antenna results. The resonant frequency and Q of a T-matched antenna differs from that of a folded dipole.

The Q of the antenna is varied by the distance between the T

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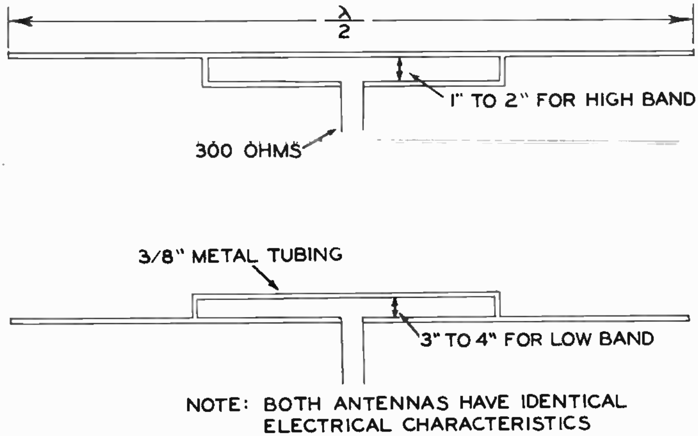

Fig. 28. The T-Matched Dipole Antenna.

element and the dipole antenna. The T element should be placed 3 to 4 inches from the dipole element for the low channel and 1 to 2 inches on the high band for unity coupling. With unity coupling, equal currents flow in the two elements giving 300 ohms impedance at the terminals.

The physical length of both the T section and the dipole affects the resonating point of the system. If the T section is maintained at 2/3 the length of the dipole, the dipole need not be any longer than ordinary. If the T-matching section is made shorter than 2/3 the length of the dipole, then the dipole must be made longer to resonate the antenna to a given frequency.

Basically, the T-matched antenna has an inherently narrower frequency response than the folded dipole. However, it can be designed to have approximately the same bandpass by having the proper diameter ratio and spacing between the elements.

The terminal impedance of this antenna can be varied over a wide range by varying the length of the T section, the space between it and the main element, and the ratio of diameters between the elements. For television installations, the impedance is 300 ohms to match standard transmission line and receiver inputs.

Used by itself without directors or reflectors to make it directional, the T-matched antenna should be used in the same installations as a folded dipole. The T antenna has two advantages over the folded dipole:

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1. It is easier to construct and is more self-supporting.

2. When used with a directional array, the T section can be easily adjusted to give the right terminal impedance when the mutual impedance from the reflector or director varies the terminal impedance from 300 ohms.

Directional Antennas. All television receiving antennas are directional to some extent. For example, even the simplest type, such as the dipole, is bi-directional. However, through common usage, the term directional for television receiving applications has been limited to systems that concentrate their radiation field in one direction. Theoretically, there is a variety of antenna types that will receive television signals and give many times the gain of an ordinary dipole. Some of these systems are: Colinear Arrays, Broadside Arrays, Corner Reflectors, and Rhombic Antennas. Practically, these antennas are not suited for television receiving installations because of the space they require and the length of time that it takes for their construction. In some cases, these antennas will be approximately 75 feet long to resonate in the low band. An antenna system which is to be placed on a user's home must be simple in design and as unobtrusive looking as possible. Television receiver owners do not want a "bunch of chicken wire" cluttering up their roofs and marring the beauty of their homes. For these reasons, most commercial antenna manufacturers have confined their antenna design to either 2 and 3 element directive parasitic arrays or stacked versions of directive parasitic arrays. In the case of apartment houses, it is impossible to install many complicated arrays on one roof. Special apartment house installations where a single antenna and an amplifier system will feed up to 100 television receivers will be discussed later in the book.

Another factor which must be considered when choosing a directive array is the number of stations which must be received. Generally speaking, when parasitic elements are added to make an antenna directional, the spectrum of frequencies which the antenna will receive is limited. This results from elements being added to the driven element at a definite physical distance which resonates the system to one frequency and raises the Q of the antenna. When other frequencies are received, the mutual impedance between the elements is changed, and not as much signal reaches the receiver.

Directional antennas have more power gain than an ordinary dipole or folded dipole antenna. The gain of an antenna system is measured by comparing its signal strength to that of a dipole of

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the same polarity resonated and cut to the measuring frequency. Since the gain of an antenna is always a reference measure, an antenna will have Db gain instead of actual gain.

Parasitic Reflectors and Directors. Directional effects are obtained by placing a parasitic element slightly more than one-half wavelength long in a parallel plane with an ordinary dipole or folded dipole. When the parasitic element is spaced one-quarter wavelength or less behind the driven element, a reflector system results. It absorbs transmitted power and re-radiates it with such a phase relationship to the original radiation that the fields of the two elements add in one direction and subtract in another direction to give a field pattern as shown in Figure 29. When the signal is received by the driven element, it is also received by the parasitic reflector. The received signal creates a field in the reflector that is opposite in polarity to the field surrounding the driven element. If a properly designed and spaced reflector is employed, the reflector field will be approximately 85% of the driven element field; and almost complete cancellation of signal reception behind the reflector will occur. When there is a lack of signal response behind the antenna, it has greater signal reception ahead of the driven element than behind it and a good "front-to-back" ratio results. An antenna having a good "front-to-back" ratio can be used to advantage where a reflection from some object behind the antenna is causing ghost images on the viewing screen. When an antenna with a reflector is used, the ghost signal is usually reduced to a point where it will not interfere with the direct signal because the antenna will not respond to signals behind it.

A parasitic element that is cut to a frequency that is one-half of a wavelength or less and placed parallel and ahead of the driven element at a spacing of one-quarter wavelength or less is

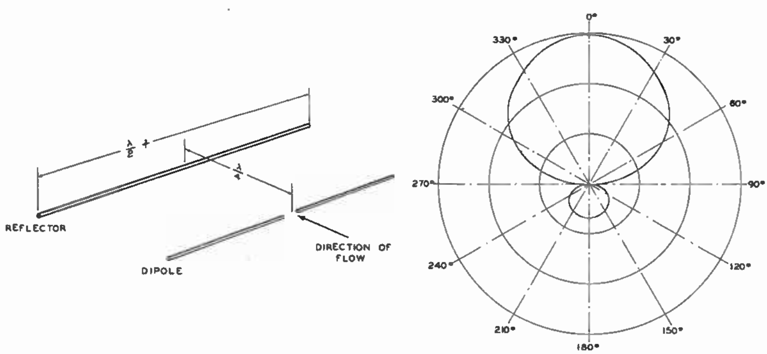

Fig. 29. Response Pattern of a Dipole and Reflector.

known as a director system. The reflector is always behind the driven element with respect to the signal source, and the director is always ahead of the driven element. As in the reflector, the parasitic director picks up the signal and re-radiates a portion of it to the driven element in the proper phase relationship to add to the signal in one direction and cause cancellation in the other.

The directivity of a receiving antenna refers to the narrowness of the reception loop in the response pattern. A variety of field patterns can be obtained even with a two element array. This is possible because of the two variables in the reflector or director; namely, the length of the tuned parasitic element and the distance it is placed from the driven element. For the utmost cancellation and reinforcement of the driven element, the parasitic reflector should be placed one-quarter wavelength behind the driven element. If the physical spacing is made less than one-quarter wavelength, the required half wave time delay must be made up by electrical means. This can be accomplished by utilizing the fact that current leads in a circuit that is predominantly capacitive and lags in a circuit that is predominantly inductive. If the parasitic element is placed less than one-quarter wavelength behind the driven element, it must be made physically longer than the driven element. If it is placed further away from the driven element than the prescribed quarter wavelength, it must be made shorter than the driven element. For example, place the parasitic reflector one-eighth wavelength (45°) behind the driven element. In this case, the parasitic reflector's resonant frequency must be made lower than that of the driven element to produce the additional 45° current lag at the operating frequency. Hence, the parasitic element must be made physically longer to increase its inductive reaction and make up the 45° phase loss created by moving the two elements closer together.

A similar condition exists when the director is spaced less than a quarter wavelength in front of the driven element. In this case, the parasitic director must be made slightly shorter than the driven element to cause the current to have a capacitive lead in the director. It must be cut or tuned to provide a lead in current that will cause the waves to add in the driven element.

The reflector's signal voltage aids the voltage in the driven element; because, by the time the energy from the reflector has reached the driven element, the signal voltage has traveled one-half wavelength and is additive. It has traveled one-quarter wavelength past the driven element on its way to the reflector, and now

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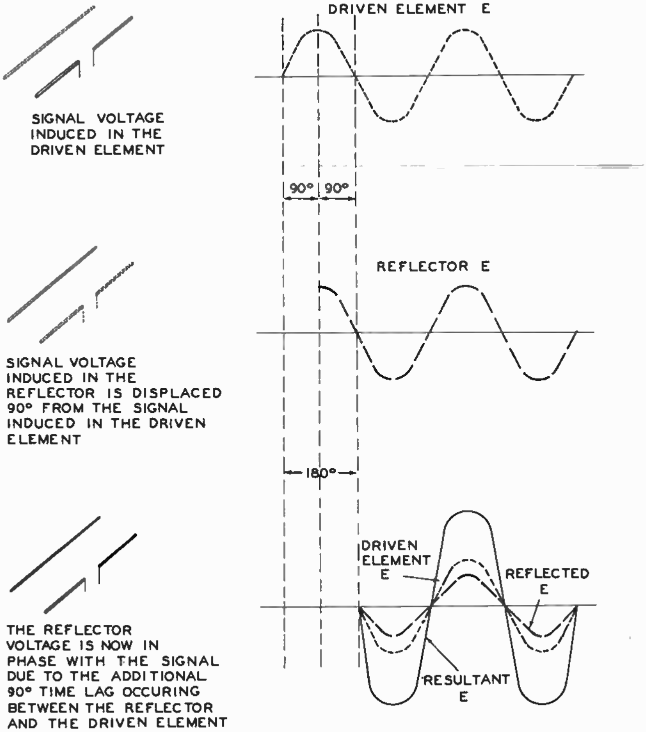

Fig. 30. Phase Relationships in a 2 Element (Reflector) Antenna.

it has traveled another quarter wavelength from the reflector back to the driven element. By the time the reflected energy reaches the driven element, a time factor of one-half wavelength (180^{o}) has elapsed since the initial signal reached the driven element. This 180^{o} phase shift or motion gives an in-phase relationship between the reflected energy and the voltage induced in the driven element. The two voltages are additive and present a stronger signal to the receiver. This action is shown in Figure 30.

Curve A of Figure 31 illustrates the power gain of a 2 element reflector array for various spacing between the elements. The driven element is a simple dipole. It is of interest to note that the most gain can be obtained at .2 of a wavelength, and that gain falls off very sharply below .15 wavelength. At spacings slightly below .1 of a wavelength, an actual loss is incurred.

In order to have a maximum gain at .2 of a wavelength spacing between elements, it is necessary to lengthen the reflector

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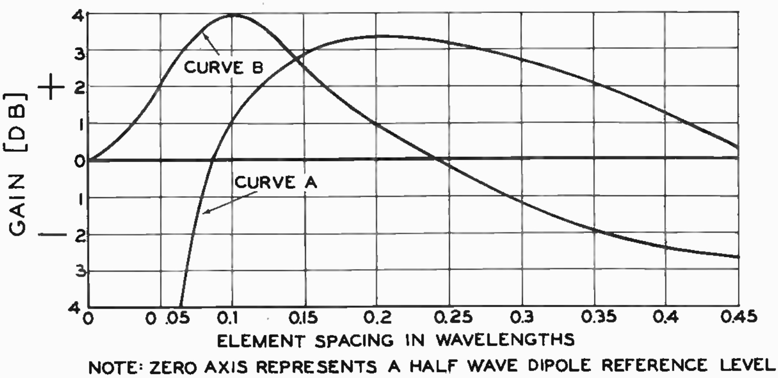

Fig. 31. Relative Power Gains with the Use of a Reflector or a Director.

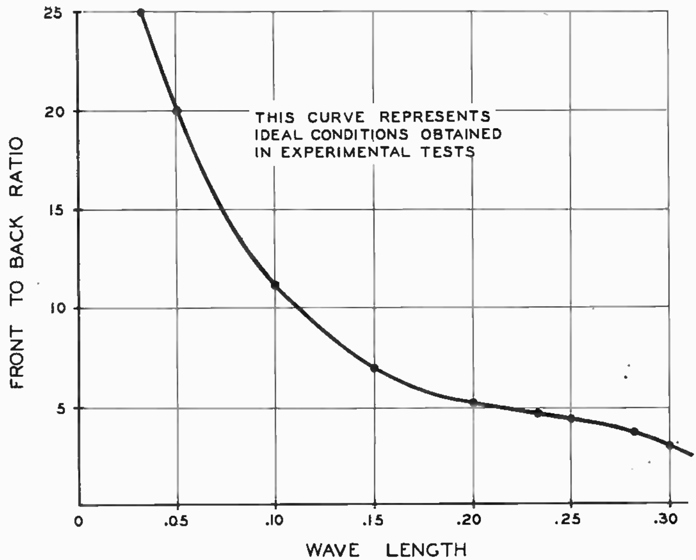

Fig. 32. Element Spacing with Respect to Front-to-Back Ratio.

physically to compensate for the reduction in element spacing from a quarter wavelength.

The gain curve of a director is shown in curve B of Figure 31. Note that the director has maximum gain at element spacings of .1 to .15.

If maximum "front-to-back" ratio is desired, the element spacing must be made less. (Figure 32.) By proper director

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spacing (.07 wavelength), "front-to-back" ratio can be made as high as 15 to 1. If this spacing is used, the gain, as shown by curve B of Figure 31, drops only 1 Db from the maximum of 4.5 Db.

When the element spacing is made small, the Q of the antenna is increased and the frequency spectrum that the antenna will receive is narrower. In television applications, where it is necessary to receive a very wide band of frequencies, the element spacing is made wider than is the usual case. Obviously, gain and "front-to-back" ratio is sacrificed at the resonant frequency. If more than one channel reception is required, it is far more important that the antenna have limited gain and "front-to-back" ratio over a wide band of frequencies than to have high gain and "front-to-back" ratio at one particular frequency.

Combinations of a dipole, folded dipole, or T-matched dipole and a director are not used to a very great extent in television applications because of an inherently narrow frequency response. It is of no advantage to employ a dipole-director combination when a dipole-reflector will give practically identical gain and a wider frequency response.

The different modifications of the dipole-reflector system are used extensively in locations where medium amounts of gain, or good "front-to-back" ratio are required. A dipole-reflector system can be used successfully at distances ranging up to 25 miles from the transmitter.

<u>Three Element Arrays.</u> Gains of 7 to 10 Db can be obtained if both a reflector and director are used with a driven element.

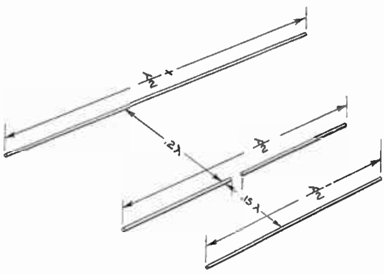

Fig. 33. 3-Element Spacing Representative Array.

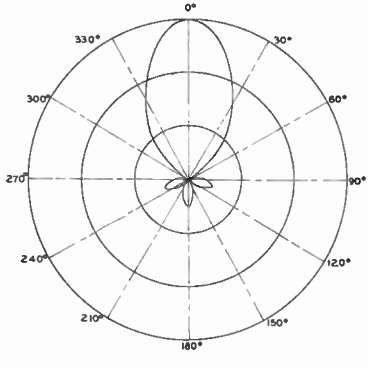

Fig. 34. Response Pattern of a 3-Element Array.

(Figure 33.) Any of the three basic types of dipoles (dipole, folded dipole, or T-matched dipole) can be used. The response pattern of a three element array is shown in Figure 34. The directivity and narrowness of the reception loop makes this an excellent antenna for ghost-free signals. Any reflected signal more than a few degrees from the direct signal will not be received with sufficient strength to interfere with the picture quality. This antenna is designed to be used in fringe areas where only one station is normally receivable.

High gain in an antenna is usually indicative of a high Q system with a sharply resonant curve. The three element array, if designed for maximum gain, has a flat bandpass of only 2-1/2 to 3% of the designed resonant frequency. In other words, at a mid-frequency of 80 megacycles, the usable bandpass is only 2.4 megacycles. Obviously, gain must be sacrificed to give a bandpass at least 6 megacycles wide. This can be accomplished by moving the elements further apart from the point where maximum gain is present. A better method, if elements with adjustable lengths are used, is to space the antenna for optimum gain and then lengthen the reflector and shorten the director by 10%. This will help give the desired frequency bandwidth.

The use of a folded or T-matched dipole for the driven element will not increase the overall frequency response, because the high Q of the array comes mainly from the sharpness in the response curves of the director and reflector. Instead, a matching transformer is used to bring up the terminal impedance of the system to match a 300 ohm transmission line.

If a high "front-to-back" ratio is desired, the elements should be spaced as close together as is possible, remembering that a sufficiently wide bandwidth must be maintained. The "front-to-back", ratio can be made as high as 15 to 1 under these conditions. Almost any desired combination of gain, bandwidth, and "front-to-back" ratio can be obtained by experimentally adjusting the spacing and lengths of the parasitic elements with reference to the driven element.

Stacked Arrays. Another method of obtaining increased gain, over that of a single dipole element, is to stack one driven element on top of another at a spacing that will cause the signals to be in phase at the terminals where the transmission line is connected. It is necessary to feed the two elements in the proper phase relationship so that the amplitudes of the element currents are not influenced by the mutual impedance between the elements. Some forms of stacked arrays do not need reflectors, but most commercial television receiving antennas utilize reflectors to

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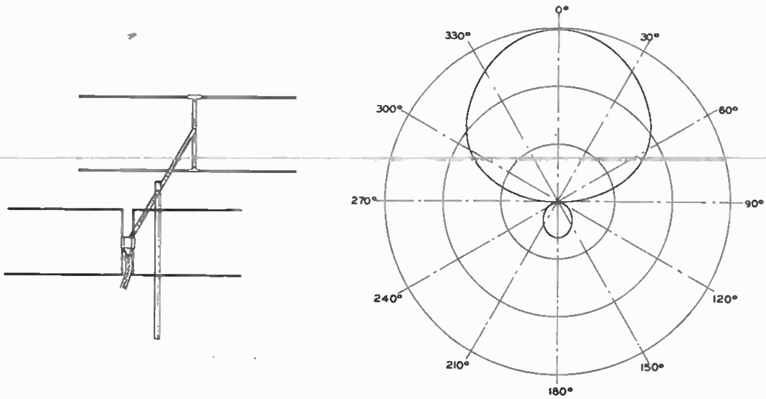

Fig. 35. "Lazy H" Antenna and its Response Pattern.

further increase the overall gain of the system.

One form of simple broadside curtain consisting of two colinear elements is shown in Figure 35. It has become known as the "Lazy H" antenna because of its resemblance to a reclining "H". For amateur use, this antenna is not always outfitted with reflectors, but in television receiving applications reflectors are employed. The reason they are not always in use in amateur antennas is due to the fact that at amateur frequencies a structure problem exists. The antenna must be so big that it is impractical to place a reflector behind the driven element. At television frequencies, physical size is no problem for this type of array. The Lazy H antenna can be used in locations where transmitters are separated by some distance. An advantage of the Lazy H antenna is its ability to reject signals coming from underneath it. This is advantageous if the antenna is located in a position where cash register noise or ignition interference can be received. The gain of this antenna, if reflectors are employed, is in the order of 4 to 5 Db. The frequency response is average, and the antenna can be used to receive both bands. This practice is not recommended unless relatively strong signals exist.

One or two additional elements can be added under a Lazy H antenna for increased gain. (Figure 36.) When 3 or 4 driven elements are employed and connected together in the correct phase relationship, the resultant system is known as a multi-element broadside array. The driven elements are placed in a horizontal plane with a spacing ranging from a quarter wavelength to a half wavelength between elements, to give an in-phase relationship to the signal at the terminal from the various elements. As in the smaller Lazy H, reflectors are usually employed for television

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application. A matching transformer is interconnected between the elements for compensation of phase differences and the matching of the entire array to a 300 ohm line. This type of array can be employed for only one station, as it is very frequency-sensitive due to the number of driven elements employed and the phase relations that exist between them. Any signal other than the small spectrum frequencies for which the antenna is designed will cause mismatching and large mutual impedances to be present in the system. Mismatching at the feed terminals, and inter-element signal cancellation will result. A 3 or 4 element broadside array with reflectors is designed to give single channel reception in outermost fringe areas, with a minimum of ghost interference.

Another type of broadside antenna uses two folded or T-matched dipoles stacked at one-half of a wavelength to give an in-phase relationship between elements. The two driven elements are connected together with a matching transformer. (Figure 37A.) The terminal impedance will be approximately 150 to 300 ohms for matching twin lead transmission line. Reflectors are employed for each element to obtain increased gain and to give the system a unidirectional pattern as shown in Figure 37B. The relative power gain of the system is 7 to 10 Db over that of a single dipole and the frequency response is such that the antenna can be used

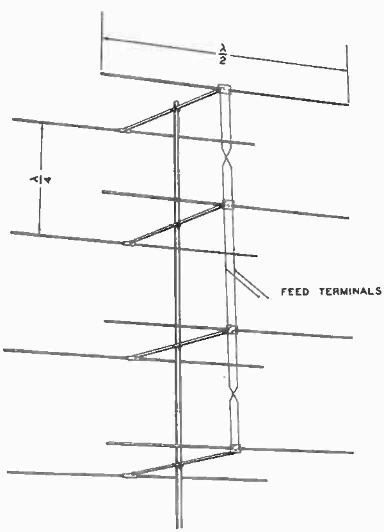

Fig. 36. A 4-Element Broadside Array.

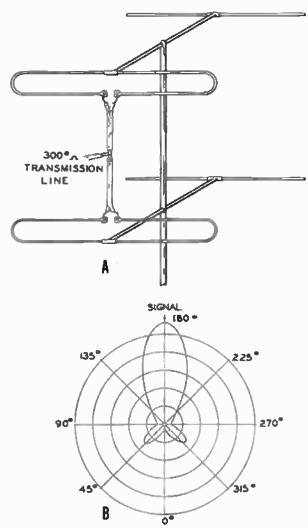

Fig. 37. Stacked Folded Dipoles and Reflectors.

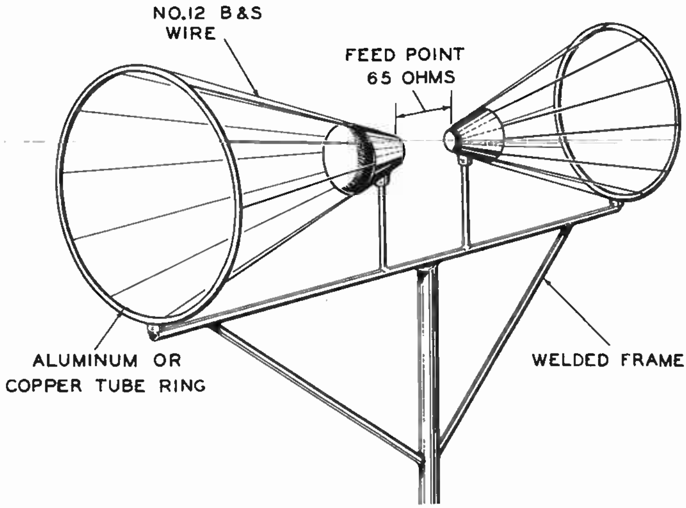

Fig. 38. Conical Antenna.

for either one of the two bands. In order to receive both television bands, it is possible to design one array for the center frequency of each band and connect them together by means of a matching transformer. This method gives a relatively constant terminal impedance. Either 150 or 300 ohm transmission line can be used for both channels. It is very important that the two stacks are separated by at least a half of a wavelength (at the low frequency) in order to keep the mutual impedance to a minimum.

Conical Antennas. A large crosswise dimension, as compared to element length, is a requirement for all antennas capable of operating over a wide frequency range. The large diameter does not appreciably affect the characteristic impedance of the elements, but it does lower the inductance and raise the capacity to give a lower Q and, hence, a broader response. The folded dipole can be considered as one method of presenting a system with a large cross section to the transmitted signal. Theoretically, one of the best types of television receiving antennas is the conical antenna illustrated in Figure 38. Because of its cone-like design (large cross section area), it will receive a very wide band of frequencies and maintain an almost constant terminal impedance over the entire frequency range it is designed to cover. Practically, however, problems arise in its construction, as it is rather large and unwieldy to place on a roof top.

Actually, the best arrangement for a flat impedance versus

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frequency characteristic would be the use of solid closed cones made of copper. This arrangement is not practical from the standpoints of cost, weight, and wind resistance. A satisfactory compromise uses 10 or 12 number 12 B & S wire rods to take the place of the solid cones. A metallic supporting loop of heavy rod or tubing is connected to the outer ends of the wires to prevent their bending in high winds or extreme icing conditions.

If at least 10 rods or wires are used, the angle of revolution is optimized, producing an output impedance of approximately 65 ohms for all frequencies that the antenna is designed to receive, including those where the rods of each cone act as more than quarter wavelength elements. For all practical purposes, the angle of revolution can be considered as the angle between a side of the cone and an imaginary line drawn through the center of the cone toward its end. (Figure 39.) The angle of revolution, therefore, is dependent on the size of the hoop (diameter D) on the outside of the cone.

If fewer rods are used, the characteristic impedance varies and creates a problem of matching the antenna to a standard impedance transmission line. With an antenna terminal impedance of 65 ohms, it is possible to use a 72 ohm line and maintain a very low SWR (standing wave ratio) over the frequency spectrum.

TRANSMISSION LINES

Four general types of transmission lines are used as the connecting link between transmitters and antennas or receivers

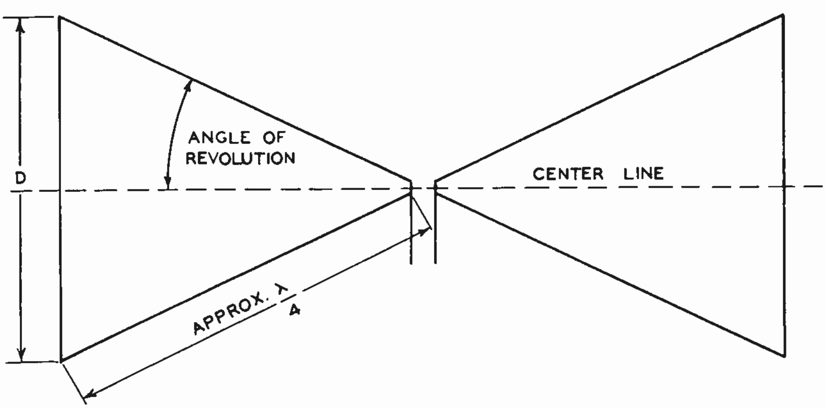

Fig. 39. Angle of Revolution in a Conical Antenna.

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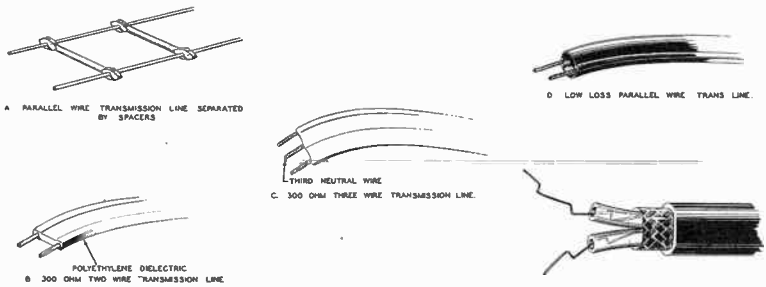

Fig. 40. Parallel Wire Transmission Lines.

and antennas in the V. H. F. range. They are:

1. The two-wire parallel-conductor line.

2. The concentric (coaxial) cable.

3. The twisted pair.

4. The shielded pair.

For practical television receiver installations, the two-wire parallel-conductors and coaxial cable are most commonly employed.

Parallel Wire Lines. Originally, a parallel line was thought of as two parallel conductors maintained a fixed distance apart by means of insulating spacers or spreaders at suitable intervals. (Figure 40A). The dielectric between the conductors consisted of air. This type of line is still employed with excellent results by commercial and amateur users. It is impractical for television receiving installations because of the high cost and the difficulties involved in its installation.

Two-wire transmission lines are available using a polyethylene dielectric. The parallel wires are actually molded and embedded in the polyethylene as illustrated in Figure 40B. It makes a very good transmission line for television installations, because it is inexpensive and can be strung from the antenna to the receiver with a minimum of offset insulators to hold it in place. This line is manufactured in impedances of 75, 150, and 300 ohms for use with almost any type of antenna or receiver input.

Another type of 300 ohm molded ribbon line, with a third

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neutral wire separating the parallel pair, is also available for use in high ambient electrical noise areas. (Figure 40C.) To obtain noise reduction and neutralization, the third wire should be grounded to the receiver chassis. This in no way upsets the balance of the conducting lines, because the third wire is placed exactly midway between the conductors and is in a neutral plane with respect to their fields. 72 and 150 ohm impedance lines are also available in both 2 and 3 wire parallel transmission lines for use with antennas and receivers with input impedances other than 300 ohms.

A fourth type of parallel wire transmission line uses a polyethylene tubing with an air core. (Figure 40D.) The conductors are imbedded in the tubing wall, and the air between them acts as the dielectric. The leakage path or attenuation factor is considerably less than that of the flat type line. One disadvantage is that its tube-like, hollow construction, does not permit it to be routed under windows, etc.

A fifth type of shielded parallel twin lead has recently been introduced. It is known as a shielded-balanced 300 ohm transmission line (Federal Telephone and Radio Corporation type K111) and Figure 40E illustrates its construction. This line employs two polyethylene jacketed conductors, which are, in turn, enclosed within a copper braid shield and a moisture-proof thermoplastic cover. The line is ovally shaped due to the build-up from its essentially flat parallel core. It promises to be of help in high noise level areas and in installations where moisture effects are of major importance.

Coaxial Cable. Coaxial cable is designed in such a manner that extraneous noise is almost completely shielded from the

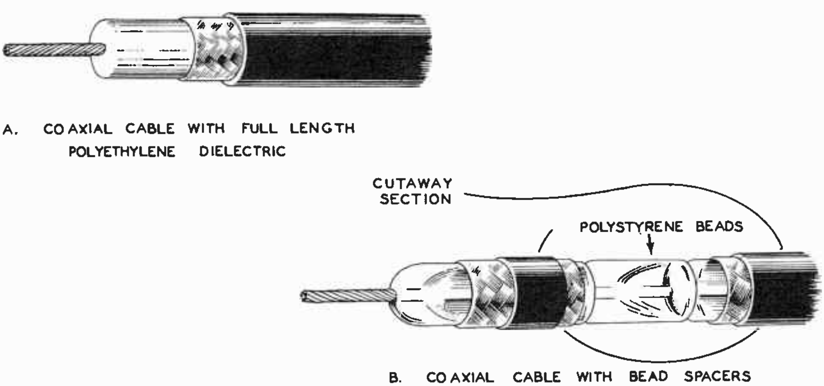

Fig. 41. Coaxial Cable Transmission Lines.

current carrying conductor. The fields set up by the voltage and current are confined inside the line; because the outer conductor, in the form of copper braid, entirely surrounds the inner conductor. (Figure 41A.) This shielding effect also prevents extraneous noise from entering the inner conductor's field and superimposing itself upon the desired signal. The inner conductor is separated from the outer conductor by a dielectric composed of either full length polyethylene or equally spaced beads (spacers) made of polystyrene or pyrex. (Figure 41B.) The full length polyethylene coaxial type is used almost universally for television receiver installations where cable must be employed. Coaxial cable can be purchased with characteristic impedance values of 52, 72, or 150 ohms. Impedances greater than 150 ohms seem impractical, because the ratio of the inner and outer conductor's size increases with an increase of impedance. Thus a 300 ohm coaxial cable would tend to be very large and expensive. However, it is possible to match a 72 ohm coaxial line to a 300 ohm antenna by use of matching transformers.

Many manufacturers have made provisions on the 300 ohm input of their receivers to allow for the direct connection of 72 ohm cable. This is accomplished by the use of a tap connection to unbalance the input circuit when the 72 ohm cable is attached.

Some of the factors which must be considered in the choice of a transmission line are:

1. Amount of extraneous noise present.

2. Cost.

3. Weather effects.

4. Loss characteristics.

It is very important that noise pickup by the transmission line be kept to a minimum. Noise can be almost completely eliminated by the use of shielded cable. However, such cable is more costly than parallel wire transmission line. In many cases the use of three-wire transmission line (utilizing a neutral third wire) will reduce the noise sufficiently to allow noise-free reception. Noise can be reduced to a limited extent in a 300 ohm parallel wire line by twisting it one revolution per foot. Sometimes noise is present even where shielded cable is used. It should be noted that the antenna itself can pick up noise and in such event no amount of transmission line shielding can help. All that the use of shielded cable can do is to reduce the noise from a given level to a lower

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level. If there is too much noise being injected into the antenna, the use of shielded cable cannot lower the noise level to a point where a good "signal-to-noise" ratio exists. The only present solution to this problem is costly. It involves the elevation of the antenna to a point where the noise level is lowered sufficiently with respect to the signal level.

Weather effects are negligible in a shielded, moisture-proofed cable. However, weather does affect the parallel wire line to a limited degree, since it is somewhat sensitive to the effects of surface moisture. Dew or rain will not penetrate polyethylene and join with it to change its dielectric constant. Instead, the surface moisture joins with the polyethylene web and the air surrounding it to change the outside dielectric. This results from the fact that the two conductors run very close to the surface, and part of their fields utilize the air surrounding them for their dielectric. This moisture effect produces a change in the characteristic impedance of the transmission line, causing standing waves and signal attenuation.

Line attenuation can be considered as the resistance that the line itself offers to the received signal. Because line attenuation is a function of frequency and the television spectrum is so wide, it is impossible to assign one figure for the percent of line attenuation. Line attenuation increases with an increase of operating frequency, and this factor should be taken into consideration in planning for the requirements of individual installations. Generally speaking, parallel wire lines have less attenuation loss than shielded or coaxial cable. Some coaxial types, such as RG-11/U, have less attenuation than other types of coaxial cable, and their use may be advisable in special applications.

IMPEDANCE MATCHING TRANSFORMERS: The signal energy received by the antenna must be transferred to the input circuit of the receiver with a minimum of attenuation, in order to have a satisfactory picture on the viewing screen. The transmission line must be terminated at both ends with its characteristic impedance, if standing waves and attenuation are to be avoided. If a line is terminated in a reactance equal to the characteristic impedance, the line is non-resonant. All television installations use non-resonant lines, because it is practically impossible to have a pure resistive component of line termination over a wide band of frequencies.

When a reactive component is present in the load, the impedances at the ends of the transmission line will vary with the frequency. In broad band applications, this ratio of impedance change or mismatch can vary greatly from one end of the frequency

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spectrum to the other end. With these facts in mind, it can be seen that a limited amount of mismatch must be tolerated. Most mismatching occurs at the antenna end, because it is relatively easy to change input circuits in the receiver by changing the channel selector switch to match the receiver to the transmission line. For city installations within 6 miles of the transmitter, where the signal strength is sufficient, a mismatch should not under any circumstances exceed 4 to 1. This means that a 72 ohm line could be used with a 300 ohm antenna satisfactorily. However, better results can be obtained by using a 300 ohm line or a matching transformer. In other installations beyond the 6-mile limit, the degree of mismatch should never exceed 2 or 3.

Unwanted reactive components in an antenna system can be effectively cancelled by the use of quarter wave matching transformers. When standing waves exist on a transmission line, there are points along the line where the resistance is equal to the characteristic impedance of the line. (Figure 20.) If a reactance of the opposite polarity in the form of a matching transformer is attached to the line at that point, there would be no standing waves from that point to the receiver, assuming that a uniform transmission line is used. It is necessary to place the matching section as close as possible to the source of mismatch in order to keep line attenuation to a minimum. In this case, the quarter wave section would be connected close to the antenna terminals.

Physically, the matching transformer consists of a quarter wave section of parallel wire transmission line connected as shown in Figure 42. Actually, any type of two-wire line can be

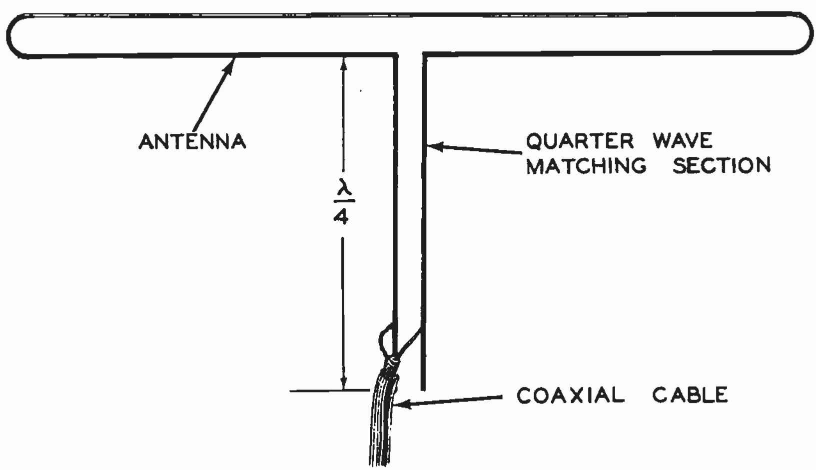

Fig. 42. Quarter Wave Matching Transformer.

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used as a matching device. Copper or aluminum tubing is recommended because of its rigid construction and ease of installation. If rods are used, they should be spaced 2 to 3 inches apart for best results. The matching section should be made a length that is equal to one quarter the wavelength of the center frequency in the frequency spectrum for which the antenna is designed. The formula for computation of quarter wave line sections is -

$$\frac{1952V}{f(mc)} = \text{length in inches}$$

where V, the velocity factor, has the approximate values shown in the accompanying table 1.

Table 1

Velocity Factor of Transmission Lines

Two conductor parallel tubing, air insulated	0.950
Two wire parallel, air insulated	0.975
Two wire polyethylene line	
300 ohm	0.820
150 ohm	0.770
72 ohm	0.710
Coaxial cable, polyethylene insulated	0.660

The impedance of the matching transformer varies from 60 ohms at one end to several thousand ohms at the other end. The transmission line should be experimentally moved along the rods of the stub until the best picture is obtained on the viewing screen. This indicates that the line and antenna are matched. The transmission line should then be soldered to the stub rods at the point of maximum signal reception.

Another solution to the problem of matching the transmission line and the antenna is the use of a "Q" matching section. A Q section can be considered as a modified form of a quarter wave matching transformer. The difference between it and the quarter wave section lies in the fact that a Q section must have a definite impedance value transmission line. It requires that the load impedance be practically non-reactive for proper operation. Physically, it consists of a quarter wavelength transmission line of a

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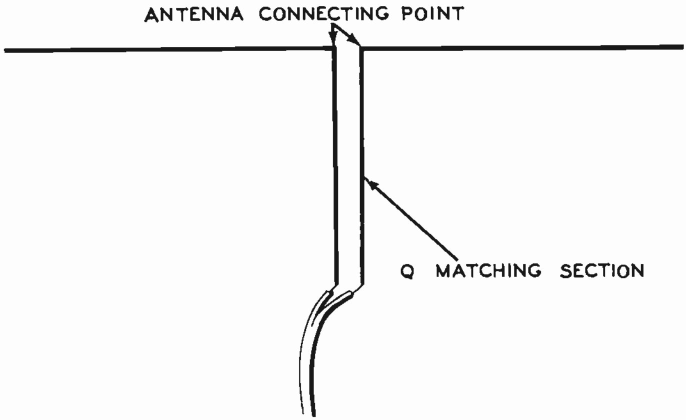

Fig. 43. "Q" Matching Transformer.

definite impedance value placed between the antenna and the lead-in conductors. (Figure 43.) The length of the matching section can be determined by the formula for quarter wavelength sections given above. The characteristic impedance which it must possess can be calculated by:

$$Zm = Zt \times Za$$

In the above formula, Zm equals the impedance of the Q matching section, Zt equals the characteristic impedance of the transmission line, and Za equals the impedance of the antenna. For example, assume that a 300 ohm antenna must be matched to a 72 ohm line. Zt equals 72 ohms, and Za equals 300 ohms. Therefore:

$$Zm = 300 \times 72, \text{ or}$$
$$Zm = 21{,}600$$
$$Zm = 147 \text{ ohms}$$

Since 147 ohms is very close to 150 ohms, the Q matching section should consist of a quarter wavelength 150 ohm parallel wire transmission line.

In many cases, the characteristic impedance that the matching section must possess will not approximate the impedance of a standard transmission line. When this condition arises, the Q section must be made from parallel wires or tubing and experimentally varied in spacing (the distance between the wires) until maximum picture clarity is obtained.

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If the impedance conversion transformation or ratio becomes too high, the frequency sensitivity is increased to the point where linear response is unattainable. For broad band use, it is sometimes necessary to use two Q sections so that each section handles a conversion ratio equal to only the square root of the total impedance conversion ratio.

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CHAPTER 2

ANTENNA CONSTRUCTION

It is of advantage in some cases to construct the television antenna for an installation. Usually the primary reason is one of antenna availability or suitability rather than cost, since if labor time is charged at full value, no real saving is likely. However, regardless of cause or choice, many television antennas have been, and will continue to be locally constructed. The section which follows on antenna construction has been included for guidance on all considerations of this activity.

TOOLS AND SUPPLIES: If other than the simplest form of room or attic antennas are to be constructed, it is necessary to have machinist and plumbing tools. A complete antenna construction workshop should contain the following equipment:

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Table II
Antenna Construction Tools

Bench Vise

Open End Wrench Set (small opening size)

Allen Wrench Set

Machinist Tap and Die Set

Drill Set (1/16 to 1/2 inch)

Portable Power Drill or Drill Press

Hack Saw

Tube Cutter (1/4 to 5/8 inch)

Tube Bender (1/4 to 5/8 inch)

Pipe Vise (this item is not necessary if the bench vise has pipe jaws available)

Pipe Cutter (for pipes to 1-1/2 inches)

Pipe Dies and Stock (for pipes to 1-1/2 inches)

Pipe Wrenches

Note: The above tools are in addition to the miscellaneous tools found in any radio shop.

While all of the above tools are not necessary for the occasional installation, it is advisable to take stock of what tools are needed for a particular job before starting it. If antennas are to be constructed on a relatively large scale, a sufficient supply of 3/8 inch aluminum tubing, 3/4 to 1-1/2 inch pipe and fittings, bakelite or large ceramic insulators, and miscellaneous hardware should be stocked.

CONSTRUCTION MATERIAL: Corrosion and collections of moisture at element joints and bolt connections, plays an important role in the durability and operation of an antenna over a long period of time. These conditions are more prevalent in coastal areas where salt moisture is present, than inland, where the moisture is relatively free from oxidizing agents. Some commercial antenna manufacturers have used monel metal in the construction of special antennas for use along the sea coast. To keep corrosion effects to a minimum, all joints should be liberally painted with a protective coating. If an outdoor shellac is not available, ordinary red lead, white lead, or aluminum paint will suffice.

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The use of aluminum rods or tubing is stressed. Such use is advantageous from the standpoint of weight; because, with a lighter antenna, a lighter supporting structure can be used. This not only reduces the cost of the system, but also makes the overall installation easier. With a heavy antenna, the mast must be more sturdily constructed than if a light, aluminum antenna is used. It would take 3 or 4 men to erect a fringe area steel antenna instead of the customary 2 that are necessary for a system made entirely of aluminum.

Aluminum elements are also advantageous to use from the standpoint of corrosion due to weather effects. While aluminum does corrode to a limited extent, it soon forms its own protective oxide coating. If aluminum is not available and it is necessary to construct the antenna of steel, the tubing should be painted with one coat of red lead paint and a second coat of aluminum paint. The red lead paint is used on both the inside and outside of the tubing. The aluminum paint is used only on the outside to give the antenna a neat and finished appearance. To coat the inside of the tubing, one end of it should be stopped up and a large amount of red lead paint poured in the other end. Tilt the tubing to an almost horizontal position, and rotate it until the entire inside is coated. Any excess paint can then be returned to its can. Galvanized or stainless steel tubing need not be painted, because it is already corrosion and rust resistant.

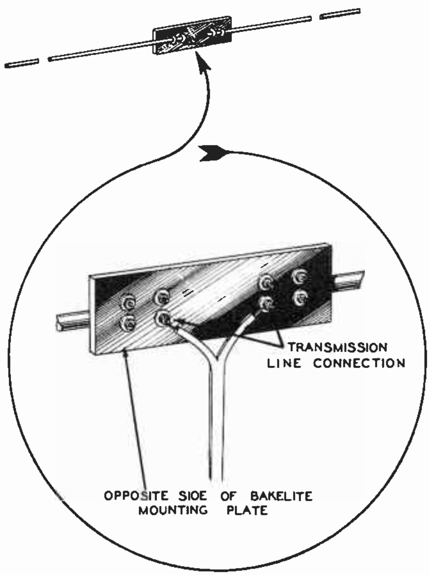

Fig. 44. Dipole Antenna Construction - Outdoor Type.

DIPOLE ANTENNAS: A dipole antenna that is to be used in an outside roof installation consists of two quarter wavelength sections of 3/8 inch aluminum alloy tubing or rods, as shown in Figure 44. Lighter weight 1/4 inch tubing or rod may be used if the frequency range that the antenna is designed to cover is in the high band where physical dimensions are small, or the installation is made where there will be no icing of the antenna causing element breakage. A 2-1/2 x 6 inch piece of 1/2 inch bakelite or similar insulating material can be used as the center supporting section. It is essential that the insulated center support be made of a durable product that will not be affected by weather conditions and extreme changes in temperature. The quarter wavelength elements are normally held to the bakelite by means of small U bolts or clamp straps.

An alternate method of element support consists of drilling 1/8 inch holes through the tubing and the bakelite center support. The elements and bakelite mounting bracket are held together by bolts of adequate length. Large diameter washers should be placed between the nut and the bakelite to prevent the bakelite from cracking, as might happen if the small surface area of the nut were placed directly against the bakelite under great pressure. The transmission line or matching transformer should be connected to the inner ends of the dipole elements. If the supporting bolt is placed far enough toward the inner end of the dipole elements, it can serve the dual purpose of acting as a terminal for connecting the transmission line, as well as acting as an element support. This can be accomplished by having the bolt sufficiently long to connect the transmission line to it by the use of an additional nut and lockwasher.

The computation of the length of each quarter wave element, in inches, is accomplished by use of the following formula:

$$L \text{ (inches)} = \frac{2952V}{f(mc)}$$

where L equals the length of each quarter wave section in inches, V equals the velocity of the signal in the elements, and f equals the frequency. The above formula is obtained directly from the basic wavelength formula:

$$\text{Wavelength (feet)} = \frac{984{,}000{,}000V}{f \text{ (cycles)}}$$

Since television allocations are all in the megacycle range of frequencies, the equation can be changed to read:

$$\text{Wavelength (feet)} = \frac{984V}{f(mc)}$$

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To obtain the length for a half wave antenna, it is necessary to divide 984 by 2; for a quarter wavelength, 984 should be divided by 4. The formula now reads:

$$L \text{ (feet)} = \frac{246V}{f(mc)} \text{ (quarter wavelength)}$$

For practical measurements, the formula should calculate the length in inches:

$$L \text{ (inches)} = \frac{246V \times 12}{f(mc)} = \frac{2952V}{f(mc)}$$

The above formula can be shortened, because the velocity of the signal in aluminum alloy (V) is equal to approximately 0.95. Because this factor is constant, we can multiply 2952 by 0.95 and eliminate the V factor in the formula. The formula then becomes:

$$L \text{ (inches)} = \frac{2952 \times 0.95}{f(mc)} = \frac{2804}{f(mc)}$$

The following table gives the length, in inches, of each element (quarter wavelength) of the simple half wave dipole antenna.

Table III

Dipole Antennas

Channel No.	Frequency (mc)	Length (inches)
Sputnik 20mc	20mc	140.2
Sputnik 40mc	40mc	70.1
2	54-60	49-1/4
3	-66	44-1/2
4	66-72	40
5	76-82	35-1/4
6	82-86	33
FM→	88-108	28.60
7	174-180	16
8	180-186	15-1/4
9	186-192	14-3/4
10	192-198	14-1/4
11	198-204	13-7/8

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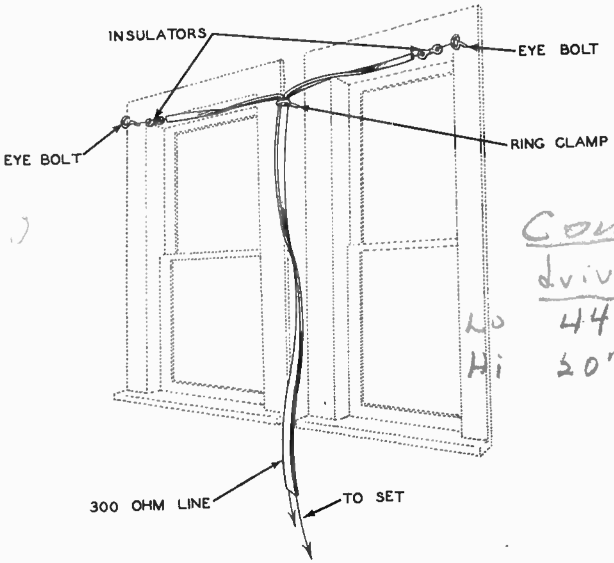
12	204-210	13-1/2
13	210-216	13-1/4

Characteristic Impedance - 72 ohms

An inside or room dipole antenna made from transmission line has found wide usage in apartment houses where building codes or owners forbid the installation of a roof antenna. An RF booster is usually employed with an indoor antenna to increase the signal strength sufficiently for a good picture. Commercially built signal boosters are available with gains ranging from 2 to 10 Db over all channels.

To construct this type of antenna, merely slit a piece of 300 ohm parallel wire transmission line down the center a distance that is equal to a quarter wavelength of the channel or channels that are to be received. Table III should be used to determine this length. If several channels are used, it is sometimes necessary to make the antenna a compromise length between the channels that must be received. A ring clamp should be attached to the transmission line at the point of separation to prevent the polyethylene dielectric from tearing further and increasing the length of the quarter wave elements. It is then an easy task to suspend the antenna with insulators behind drapes or other objects that will



Conic
driven Reflector
Lo 44" 48"
Hi 20"

Fig. 45. An Indoor Dipole Installation Made of 300 Ohm Parallel Wire Transmission Line.

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hide it from observation. The antenna must be erected in a horizontal plane for best signal reception. This type of installation is illustrated in Figure 45.

FOLDED DIPOLE ANTENNA: The folded dipole antenna should be used where more than one station is to be received, and all stations are within a 5 to 6 mile radius of the transmitter. There are two ways in which a folded dipole can be easily constructed:

1. It can be bent to form the folded dipole illustrated in Figure 46 from one length of 3/8 or 1/2 inch aluminum alloy tubing. 1/4 inch tubing may be used if the antenna is designed for high band use where physical dimensions are small. The tubing should be made one wavelength long. The straight tubing can be bent into the shape of a folded dipole by placing it in a vise and bending it at the desired points with a tubing bender. The folded dipole can be attached to the supporting structure at the center of the half wavelength section, because a voltage null exists at this point. (Figure 46.) The 300 ohm transmission line should be connected to the inside end of the quarter wave section by tapping a thread into the tubing and using a cap screw to establish a firm connection between the antenna and transmission line.
2. The folded dipole can consist of one half wavelength sec-

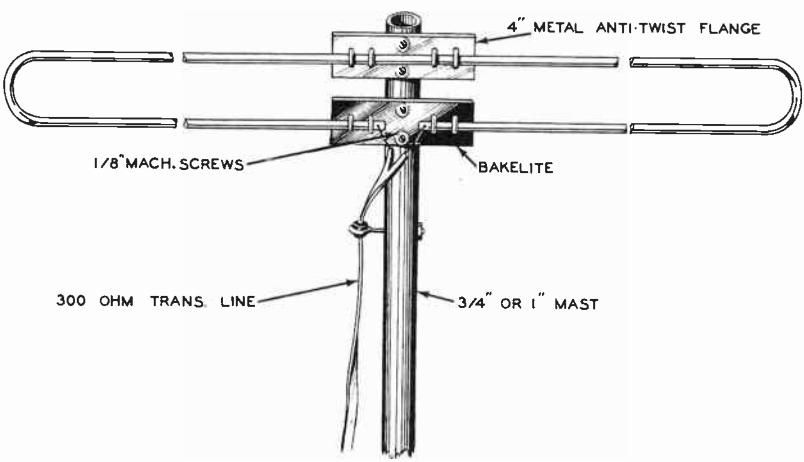

Fig. 46. One-Piece Folded Dipole Antenna.

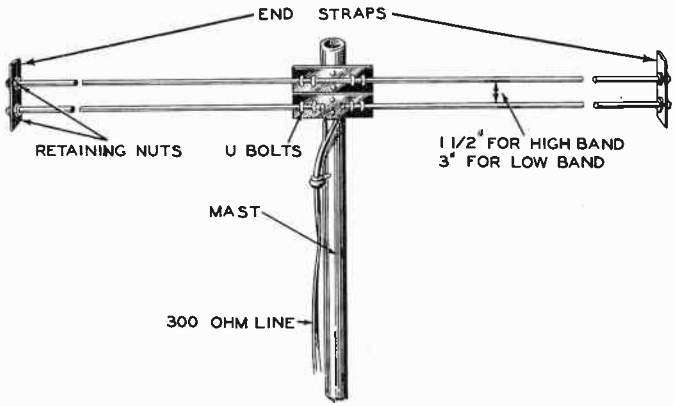

Fig. 47. Three-Piece Folded Dipole Antenna.

tion and two quarter wavelength sections of aluminum alloy tubing held together at the ends by means of a strap as shown in Figure 47. Each quarter wave section should be cut 1/2 inch short of a full quarter wavelength to allow for the 1 inch spacing between the terminals. A 1/8 or 3/16 inch hole should be bored into one end of each quarter wave section so that the transmission line can be firmly bolted to the antenna. After cutting all of the elements to the proper size, the half wavelength section should be threaded at both ends a distance of 1 inch. The quarter wave sections should be threaded at one end a distance of 1 inch. Nuts should be threaded all the way on the elements of the antenna. The end strap should then be placed over the ends of the tubing and the outside nuts attached. The completed dipole can be supported in the air by connecting it to a supporting structure in the same manner as the one-piece folded dipole.

The formula used to find the total length of a folded dipole is:

$$\text{Length (feet)} = \frac{935}{f(mc)}$$

V, the velocity factor, is already taken into account in this formula. Table IV gives the total length and the half wavelength for each channel used.

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Table IV

Folded Dipole Antennas

Channel No.	Wavelength (feet)	1/2 Wavelength (feet)	1/4 Wavelength (inches)
2	16 ft. 5 in.	8 ft. 2-1/2 in.	49-1/4 in.
3	14 ft. 10 in.	7 ft. 5 in.	44-1/2 in.
4	13 ft. 6 in.	6 ft. 8 in.	40 in.
5	11 ft. 9 in.	5 ft. 10-1/2 in.	35-1/4 in.
6	11 ft. 0 in.	5 ft. 6 in.	33 in.
7	5 ft. 4 in.	2 ft. 8 in.	16 in.
8	5 ft. 1 in.	2 ft. 6-1/2 in.	15-1/4 in.
9	4 ft. 11 in.	2 ft. 5-1/2 in.	14-3/4 in.
10	4 ft. 9 in.	2 ft. 4-1/2 in.	14-1/4 in.
11	4 ft. 7-1/2 in.	2 ft. 3-3/4 in.	13-7/8 in.
12	4 ft. 6 in.	2 ft. 3 in.	13-1/2 in.
13	4 ft. 5 in.	2 ft. 2-1/2 in.	13-1/4 in.

Characteristic Impedance - 300 ohms

In most cases, the folded dipole is cut to the center frequency (the mid-channel in each band) to give complete coverage. In specific installations, however, where one channel comes in weaker than the other received channels, it is necessary to cut the folded dipole to the weakest channel frequency. The remaining stations will be picked up with sufficient signal strength because of the broad band characteristics of the folded dipole antenna. If stations on both high and low bands are to be received, it is sometimes necessary to use one folded dipole tuned to the high band and a second folded dipole tuned to the low band. The two folded dipoles should be separated by at least 1/2 wavelength in terms of the low band folded dipole. A 300 ohm transmission line should then be connected between the two dipoles to act as a matching section. The lead-in transmission line should then be experiment-

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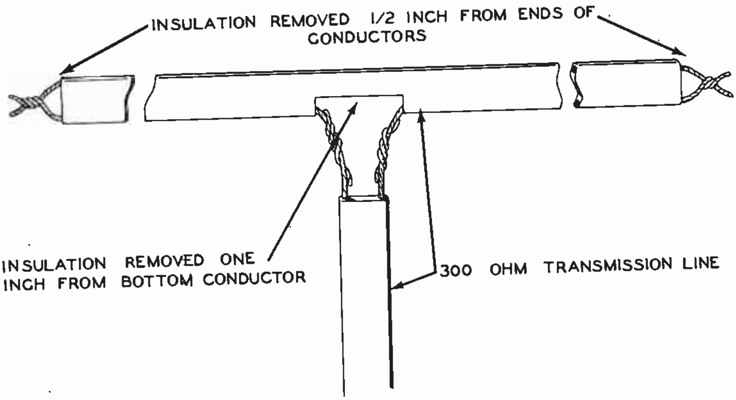

Fig. 48. The Indoor Type Folded Dipole.

ally connected to the center of the matching section. If a good picture results on all channels, the transmission line should be soldered to the matching transformer at this point. If good pictures do not result with this setting, the transmission line connecting position should be varied on the matching transformer until good pictures result on all channels in both bands. If many stations are to be received on both bands, it is sometimes necessary to slightly compromise the picture on one channel to create an impedance match and better picture on another channel.

An indoor room installation can be made in the form of a folded dipole by using a section of 300 ohm transmission line. The transmission line should be cut to 1/2 wavelength of the center frequency of the band which must be received. The polyethylene dielectric should be removed from the ends of the transmission line (approximately 1/2 inch) and the two conductors connected together as shown in Figure 48. One conductor should be cut in the exact center and the polyethylene insulation removed from each side a distance of 1/2 inch. The lead-in transmission line should be connected at this point. This antenna can be suspended between curtain rods by means of insulators and guy wires. If the signal is sufficiently strong, this type of antenna has a broad enough characteristic to receive stations on all channels, provided it is cut to channel 7 or channel 6. It may be necessary to use an RF booster with this type of installation unless it is in the immediate vicinity of the transmitter. An indoor installation should only be resorted to if building codes or rules forbid the construction of an antenna on the roof.

THE T-MATCHED HALF WAVE ANTENNA: The long elements

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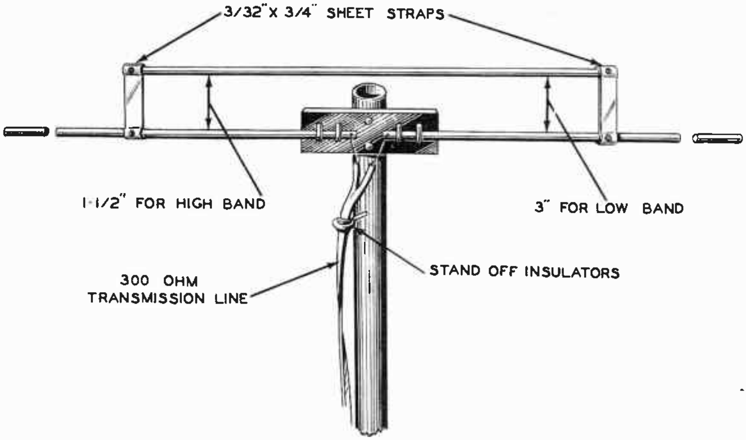

Fig. 49. Construction of T-Matched Dipole Antenna.

of a T-matched antenna (see Figure 49) should be made the same size and in the same way as a dipole antenna. The T unit, to broaden the bandwidth and increase the characteristic impedance, should be made 1/6 of a wavelength long at the center frequency of the band that it is to cover. One T-matched antenna will suffice for each of the two television bands because of its broad frequency response.

The formula for 1/6 of a wavelength is:

$$\frac{\text{Wavelength (inches)}}{6} = \frac{156}{f(mc)}$$

The T section should be constructed of 1/4 or 3/8 inch tubing and is connected to the dipole elements by supporting straps as shown in Figure 49. It is necessary to drill holes and use bolts, or tap both the long element and the T section with 3/16 inch threads and use cap screws, to secure the supporting strap. If welding equipment is available, it can be welded to the dipole element. When the T antenna is designed for the low band, the length of the T section should be approximately 26 inches. For the high band, the T section should be approximately 9-1/2 inches. The lengths of the T-matched sections are not too critical as long as they are not made much shorter than 1/6 wavelength of the center frequency for the particular frequency spectrum they are designed to cover.

TWO-ELEMENT PARASITIC ARRAY (REFLECTOR TYPE): The

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two-element parasitic array can be composed of a dipole reflector, folded dipole reflector, or a T-matched dipole and reflector. Any one of the three driven elements may be constructed in the aforementioned manner. A dipole-reflector combination is usually employed to receive only one channel, while the folded dipole-reflector combination can be used to receive a number of channels in a single band, if properly designed and constructed.

The bandwidth that the two-element reflector type antenna will receive is dependent upon reflector spacing and physical length, as well as the type of driven element used.

Maximum gain is attained if the reflector is spaced approximately .2 to a quarter wavelength from the driven element. (Figure 31.) Table V gives element spacing and reflector lengths of a two-element parasitic array (reflector type) designed for maximum gain. A simple dipole is used as the driven element.

Table V

Dipole and Reflector Designed for Maximum Gain

Channel No.	Spacing Between Elements	Reflector Length
2	40 in.	108 in.
3	36 in.	98 in.
4	33 in.	88 in.
5	29 in.	78 in.
6	26 in.	72 in.
7	13 in.	36 in.
8	12-1/4 in.	34 in.
9	11-3/4 in.	32-1/2 in.
10	11-1/2 in.	31 in.
11	11-1/4 in.	30-1/2 in.
12	11 in.	29-1/2 in.
13	10-3/4 in.	29 in.

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Gain must be sacrificed to a limited extent if the array is to be constructed for broad band applications. When the antenna is designed for maximum gain, the element spacing and length is very critical. The frequency response is narrow for a condition of maximum gain. Broad band applications apply to antennas that receive well on practically any channel in a given band. To increase the broad band effects, the antenna should be made with slightly more than quarter wavelength spacing between the parasitic element and the driven element. The reflector must be slightly longer in physical length than the driven element in order to achieve the proper phase relationship for maximum signal reflection from the parasitic element to the driven element, over a wide band of frequencies. If a two-element array is to be broad band, the reflector should be made approximately 15% longer than the driven element; and the element spacing should be .27 wavelength. Table VI gives element spacing and reflector length for a two-element antenna (folded dipole-reflector) designed to cover a bandwidth of 3 to 4 channels. If the signals are all the same strength, the antenna should be designed for the channel nearest the center frequency of the spectrum that is to be received. If the signals are of unequal strength in one band, the antenna should be constructed to the weak channel signal to increase the amount of signal presented to the receiver for that channel.

Table VI

Folded Dipole-Reflector Antenna
Designed for 3 to 4 Channel Bandwidth

Channel No.	Element Spacing	Reflector Length
2	52 in.	114 in.
3	48 in.	102 in.
4	44 in.	92 in.
5	38 in.	82 in.
6	35 in.	74 in.
7	17 in.	37 in.
8	16-1/4 in.	35 in.
9	15-3/4 in.	34 in.
10	15-1/2 in.	33 in.
11	15 in.	32 in.

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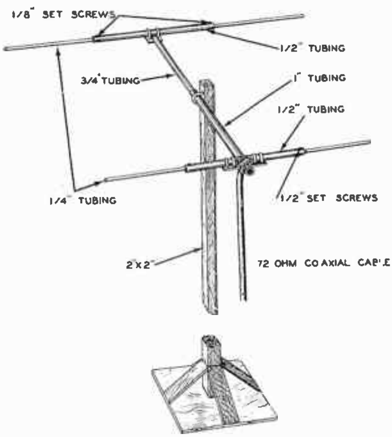

Fig. 50. An Experimental Dipole-Reflector Antenna with a Telescoping Reflector Dipole and Supporting Arm.

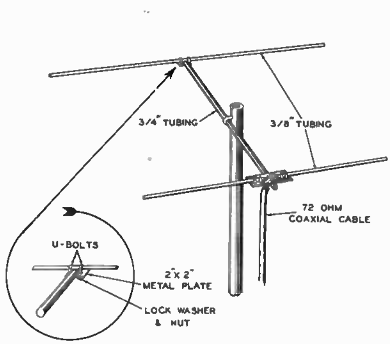

Fig. 51. Dipole-Reflector Antenna Construction.

Reflector spacing and length may vary in other applications due to the different channel combinations that are possible in a given area. For example one metropolitan area may have channels 7, 9, 11, and 13 in use. In this case, the antenna should have very broad frequency characteristics to receive all channels in the band. Another area may only have channels 7 and 9 in use. An antenna with higher gain and a narrower frequency response should be used. One way to overcome this difficulty is to build an experimental antenna with a telescopic reflector element and supporting arm, as shown in Figure 50. Field tests can then be made and the reflector adjusted to the proper spacing and length to give the best reception on all channels. The tests can be run with the antenna relatively close to the ground (for ease of adjustment), because the ground has very little effect on horizontally polarized signals. After the proper spacings for the particular area in question have been found with the experimental model, ordinary antennas can be built to the experimental specifications.

Typical construction of a two-element array is shown in Figure 51. The 3/8 inch reflector is separated from the driven element by a supporting spacer made of 3/4 inch aluminum tubing. If 3/4 inch aluminum tubing is not available, a 2 x 2 inch piece of wood or a 3/4 inch iron pipe may be substituted in its place. The reflector can be attached directly to the supporting arm without the use of an insulator, because a voltage null exists at the center of the reflector. One method of attaching the reflector to the sup-

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porting arm is accomplished by drilling two 3/16 inch holes in the 3/8 inch tubing and using a U bolt that fits the 3/4 inch supporting arm. A better method involves the use of a small 2 x 2 inch metal plate through which 4 holes are drilled to accommodate two U bolts. One U bolt is placed on each side of the 3/4 inch supporting arm. The 3/8 inch reflector element is placed on top of the 3/4 inch supporting arm and the plate on the bottom of it. The folded-dipole driven element can be connected to the supporting arm in a similar manner. Caution should be observed when using a dipole or T-matched dipole as the driven element so that the bakelite center insulator is not cracked or broken when it is attached to the supporting arm by U bolts or bolts and nuts. The dipole-reflector is usually supported by attaching the center of the supporting arm to the vertical mast.

Two separate arrays for both high and low band reception can be made by stacking one array on top of another as long as they are separated by at least one half wavelength at the low band frequency. A 300 ohm parallel wire transmission line should be connected between the two arrays to act as a matching transformer. The lead-in transmission line should be connected to the matching transformer at the mid-point. If a satisfactory picture is not obtained on both bands, the lead-in line should be moved along the matching transformer until good results are obtained.

THREE-ELEMENT PARASITIC ARRAY: The three-element array is essentially a single channel beam antenna consisting of a dipole driven element, a reflector, and a director. The use of a folded dipole in this combination will not give an appreciable broad banding effect, because the narrow frequency sensitivity is due to the high Q injected into the system by the parasitic elements. In practical use, with proper element spacing and length, the frequency response can be made relatively linear for 6% to 8% of the design frequency. An antenna of this type has a linear band pass of only 3.6 to 4.8 megacycles at a center design frequency of 60 megacycles.

Table VII gives reflector and director lengths, and spacings for three-element parasitic arrays. The designs listed in the table are for one channel reception and with optimum gain and front-to-back ratio for a band pass of at least 3 megacycles at the low frequency. The reflector is spaced .2 of a wavelength behind the half wave dipole driven element, and the director is spaced .15 wavelengths ahead of the driven element to optimize the gain of the array. (Figure 31.) The reflector should be made 6% longer and the director 10% shorter than the driven element to give additive or in-phase relationships at the terminals of the dipole antenna.

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Table VII

Three-Element Single Channel
Parasitic Array Designed for Optimum Gain

Channel No.	Reflector Spacing	Reflector Length	Director Spacing	Director Length
2	40 in.	104 in.	25 in.	88 in.
3	36 in.	94 in.	22 in.	80 in.
4	33 in.	84 in.	20 in.	72 in.
5	29 in.	74 in.	18 in.	64 in.
6	26 in.	70 in.	16-1/2 in.	60 in.
7	13 in.	34 in.	8 in.	29 in.
8	12-1/4 in.	32-1/2 in.	7-3/4 in.	27-1/2 in.
9	13-3/4 in.	31-1/2 in.	7-1/2 in.	26-1/2 in.
10	11-1/2 in.	30-1/2 in.	7-1/4 in.	25-1/2 in.
11	11-1/4 in.	29-1/2 in.	7 in.	25 in.
12	11 in.	28-1/2 in.	6-3/4 in.	24-1/2 in.
13	10-3/4 in.	28 in.	6-1/2 in.	24 in.

The construction details of this antenna are given in Figure 52. The director and reflector can be attached directly to the 3/4 inch aluminum alloy supporting arm without the use of insulating strips. The parasitic elements can be connected to the supporting arm in the same manner as described in the two-element arrays. The three-element antenna is usually attached to the vertical mast by connecting the vertical mast to the supporting arm between the driven element and reflector.

H TYPE ANTENNA WITH REFLECTORS: The H type antenna is actually two half wave dipole-reflector arrays stacked a given distance apart and connected together by the use of a matching transformer. In theory, the spacing between the arrays should be one quarter wavelength for maximum gain at one particular frequency. For broad band applications where it is desirable to

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receive more than one channel in a given band, the spacing may vary between .15 wavelengths and .25 wavelengths.

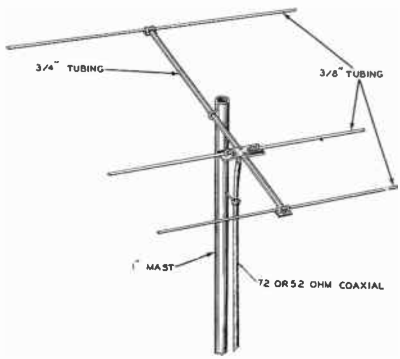

Fig. 52. Three-Element Parasitic Array. Construction Details

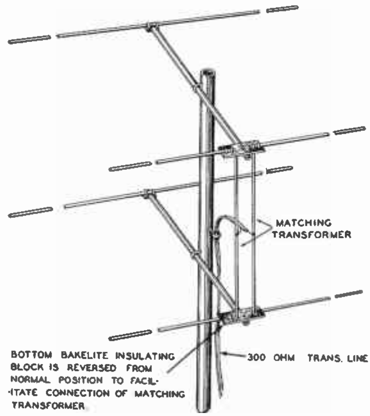

Fig. 53. "H" Antenna Construction Using Two Supporting Arms.

Table VIII gives the length of each quarter wave section of the dipole, the distance between the dipole and reflector, the length of the reflector, and the vertical stack spacing. Both mid-band and individual channel spacings and lengths are given. If only one station is allocated to an area, the antenna should be designed for one-station operation. The same conditions hold true if one station is considerably weaker than the other stations in multi-channel operation; the antenna should be designed to the specifications of the weak channel. When many stations are in operation with equal signal strengths, the antenna should be designed to the mid-frequency of the channels that are to be received.

Table VIII

H Type Antenna

Channel No.	Reflector Length	Reflector Spacing	Stack Spacing and Quarter Wave Dipole Element Length
Mid-Point Low Band	75 in.	30 in.	36 in.

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Table VIII (continued)

Mid-Point High Band	29 in.	11-1/2 in.	14-1/4 in.
2	98 in.	40 in.	49 in.
3	88 in.	36 in.	44 in.
4	80 in.	33 in.	40 in.
5	70 in.	29 in.	35 in.
6	66 in.	26 in.	33 in.
7	32 in.	13 in.	16 in.
8	30 in.	12-1/4 in.	15-1/4 in.
9	29 in.	11-3/4 in.	14-3/4 in.
10	28-1/2 in.	11-1/2 in.	14-1/4 in.
11	28 in.	11-1/4 in.	13-7/8 in.
12	27 in.	11 in.	13-1/2 in.
13	26-1/2 in.	10-3/4 in.	13-1/4 in.

Characteristic Impedance - 72 or 300 ohms depending on matching transformer.

NOTE: The two quarter wave dipole element lengths can be obtained from the Stack Spacing column, as the elements are stacked exactly a quarter wavelength apart.

The simplest way to assemble an H antenna consists of building two dipole reflector units as described before. A 3/4 inch supporting arm should be used. The top supporting arm can be attached to the antenna by drilling two 3/8 inch holes 1-1/8 inches apart at the top of the antenna. The arm can now be attached to the center mast with a U bolt, lockwashers, and nuts. The supporting arm for the lower dipole reflector should be connected in the same manner the required distance down the mast from the top elements. Two 1/4 inch rods should be connected between the terminals of the top and bottom driven elements to form a matching transformer. If the dipole sections have been properly con-

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structed, the transformer rods will be 1 inch apart. The output impedance at the center of the matching transformer should be approximately 300 ohms. If a 72 ohm impedance is required for matching a 72 ohm transmission line, it can be obtained by experimentally moving the lead-in terminals up or down the matching transformer for the best picture on all channels being received.

Another method of H antenna construction, using only one supporting cross arm, is illustrated in Figure 54. The dipole sections are made in the same manner as previously described. They are connected to the center supporting arm by the use of an L flange. L flanges are also used to attach the reflectors to the supporting arm. They should be made of 3/16 inch steel sheeting which can be easily bent and formed into the desired shape in a vise. The center insulating strip of each dipole should be attached to the flanges by 2 bolts. 3/16 inch bolts are sufficient to hold each reflector to its flange. Two 1/4 inch bolts should be used to attach each flange to the supporting arm. The supporting arm can be attached to the center mast by means of a U bolt. The matching transformer should be connected in the same manner as described under the preceding "H" antenna.

FOUR-ELEMENT COLINEAR ARRAY (WITH REFLECTORS): The four-element colinear array is an elaboration of the H antenna and can be used in the outermost fringe areas for single channel reception. It is constructed with four half wave dipoles, spaced a quarter wavelength apart and connected together by a matching transformer. The individual channel portion of Table VIII can be used to obtain element lengths, reflector spacing, and the distance (stack spacing) between the dipole-reflector units.

To construct this antenna, build 4 dipole reflector units, and attach them to the mast 1/4 wavelength apart (per Table VIII). The Q matching transformer should be constructed as illustrated in Figure 55. The point where the transmission line should be connected must be found experimentally, because the spacing between the rods of the matching transformer plays a very important part in the characteristic impedance. The proper impedance point can be obtained by experimentally moving the transmission line up and down the Q matching transformer. Almost any impedance between 52 and 600 ohms can be obtained in this manner. When the right impedance point is found, the transmission line should be soldered to the matching transformer. A rigid, heavy-duty mast or tower must be used with this array because of its weight and wind resistance. Supporting structures and their construction will be discussed in the "Installation" section of this book.

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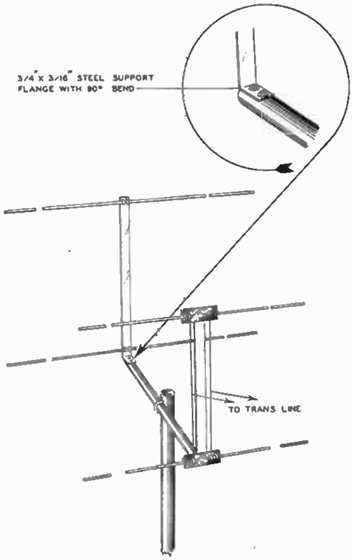


Fig. 54. An "H" Antenna Utilizing a Single Supporting Arm.

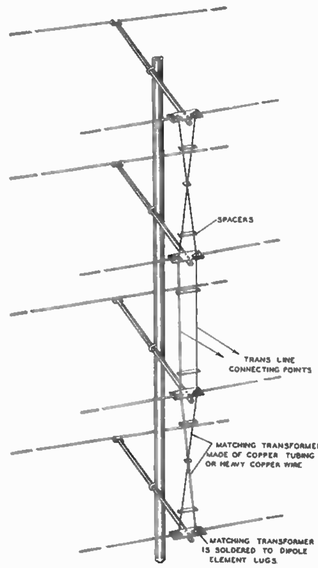


Fig. 55. Construction of a 4-Dipole Array with Reflectors.

STACKED FOLDED DIPOLES (WITH REFLECTORS): A folded dipole-reflector combination stacked from a quarter to a half wavelength above another folded dipole-reflector combination and connected together by a matching transformer creates a good, broad band antenna with high gain. Table IX gives the mid-frequency lengths of the folded dipole elements, the reflectors, the reflector spacing, and the element spacing (stack spacing) for the high and low bands.

Table IX

Stacked Folded Dipoles

Channel No.	Total Folded Dipole Length	Reflector Length	Reflector Spacing	Stacking Distance
Low Band Mid-Freq.	13 in.	88 in.	41 in.	39 in.
High Band Mid-Freq.	4 ft. 9 in.	33 in.	16 in.	14-1/2 in.

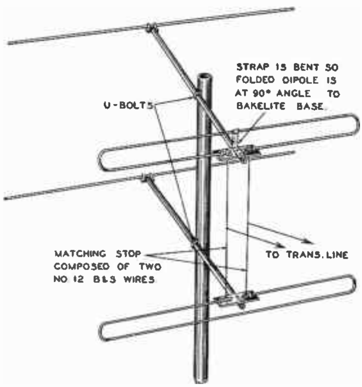


Fig. 56. Two Stack Folded Dipole with Reflectors.

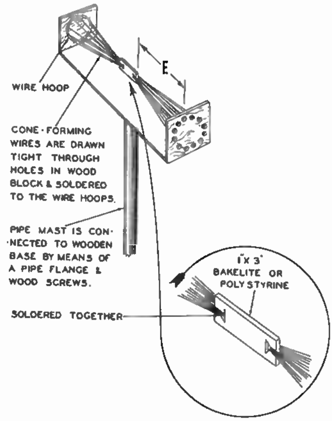


Fig. 57. The Conical Antenna.

The assembly of the folded dipole-reflector units has already been given. They can be connected to the center supporting mast, as shown in Figure 56. Two aluminum rods or parallel wires should be connected between the terminals of the top and bottom folded dipoles to act as a matching transformer. The transmission line should normally be connected to the center of the matching section.

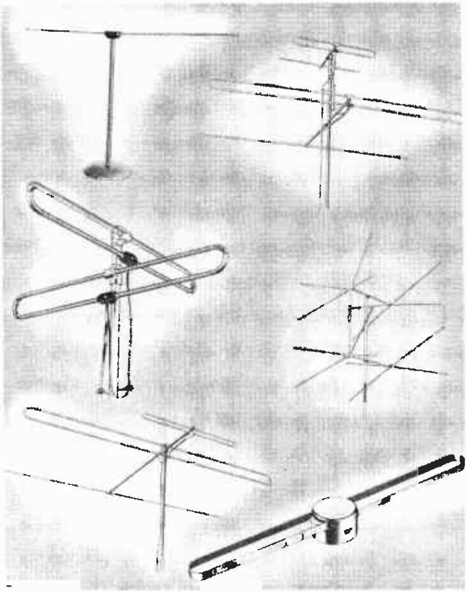
CONICAL ANTENNAS: The construction of a conical antenna is more difficult than any type of antenna yet described. It has the advantage of a very broad frequency response, and possesses a bi-directional characteristic similar to a dipole. Length E (rod length) should approximate .2 of a wavelength at the low frequency end in the band of frequencies that are to be received. The overall length of the antenna at the mid-frequency is found by

$$L\ (ft) = \frac{936 \times .73}{f\ (mc)}$$

The diameter of the open cone end can be found by the formula

$$D\ (ft) = \frac{114}{f(mc)}$$

Figure 57 gives details of the simplest type of conical antenna construction.



CHAPTER 3

COMMERCIAL ANTENNAS

Television receiving antennas, representing practically all types and designs discussed thus far, are now being manufactured by a large number of companies and are available through normal distribution outlets of these manufacturers. The antennas are usually packaged in kit form and include such items as connecting hardware, short lengths of mast, mounting flanges, and transmission line. In some cases, it is possible to purchase the antennas alone without the associate installation materials. This is a more economical method of buying antennas if a large number of installations are to be made.

Table X alphabetically lists the antenna manufacturers, the type of antennas they produce, and their model numbers, for easy reference when choosing a commercial television antenna. The information appearing in Table X has been compiled from catalog literature available at press time. Every effort has been made to make it completely current and impartial. However, in view of rapid development in the TV antenna field, new models are constantly appearing and some omissions on this basis are unavoidable.

World Radio History

Table X

TV Antenna Manufacturers

Aeronics, Inc., 132 Nassau St., New York 7, N. Y.

Model	Type
ATR-1	Simple dipole and reflector
ATR-2	Folded dipole and reflector

American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill. (AMPHENOL)

Model	Type
114-005	Double folded-dipole array
114-301	2 Stack conversion kit
114-302	2 Stack double folded dipole array

Amy, Aceves & King, Inc., 11 W. 42nd St., New York 18, N. Y.

Type
Multiple apartment antenna systems

Anchor Radio Corp., 2215 S. St. Louis, Chicago, Ill.

Model	Type
A	Adjustable indoor folded dipole

Andrew Corp., 363 E. 75th St., Chicago 19, Ill.

Model	Type
710	Di-Fan TV-FM

Ber-Mac Television Mfg. Corp., 1381 Lexington Ave., New York 28, N. Y.

Type
Indoor deluxe
Indoor-Master deluxe (by channels)

Birnbach Radio Co., 145 Hudson St., New York, N. Y.

Model	Type
7027	Flexible indoor dipole

L. S. Brach Mfg. Corp., 200 Central Ave., Newark 4, N. J.

Model	Type
337	Straight dipole and reflector
338	Double broad-band dipole
344	FM and TV double dipole multi-band

Camburn, Inc., 32-40 57th St., Woodside, Long Island, N. Y. (CAMCO)

Model		Type
FEATHERLITE	SWIFT RIG	
T31, T31X	SRT31, SRT31X	Simple dipole

World Radio History

Camburn, Inc. (continued)

T32, T32X	SRT32, SRT32X	Folded dipole
T33, T33X	SRT33, SRT33X	Simple dipole and reflector
	SRT34, SRT34X	Folded dipole and reflector
T35, T35X	SRT35, SRT35X	"H" Antenna (stacked simple dipoles and reflectors)
	SRT36, SRT36X -2, -3, -4, -5, -6	Stacked folded dipoles with reflectors (suffix -2 etc., indicates channel for operation)
T41, T41X		Stacked simple dipoles, for high and low bands
T42, T42X		Stacked folded dipoles, for high and low bands
T43, T43X	SRT43, SRT43X	Stacked simple dipoles and reflectors for high and low bands
T44, T44X	SRT44, SRT44X	Stacked folded dipoles and reflectors for high and low band
T45, T45X	SRT45, SRT45X	"H" Antenna (stacked simple dipoles and reflectors) plus high band simple dipole and reflector
	SRT46, SRT46X	Stacked, high band (folded dipole and reflector), and low band (simple dipole and reflector)

DHG (Directional High Gain) ARRAYS

	Channel			
DLF23-2		2*	3)	Director, folded dipole, and reflector
DLF23-3	2	3*	4)	
DLF23-4	3	4*	5)	
DLF23-5	4	5*	6)	
DLF23-6	5	6*	)	
DHF24-8	7	8*	9)	2 Directors, folded dipole, and reflector
DHF24-10	9	10*	11)	
DHF24-12	11	12*	13)	
DHF24-13	12	13*	)	

*Optimum performance

Two or three unit stacked arrays are available from combinations of DLF, and DHF assemblies. The letter "X" on catalog types denotes inclusion of transmission line with the antenna.

World Radio History

Camburn, Inc. (continued)

Indoor Types

Model	Types
TA60	Simple dipole
TA61	High and low band simple dipoles (window type)
WA59	Folded dipole

Cole & Worner, Inc., 11 W. Monument Ave., Dayton, Ohio

Model	Type
101	Single array, simple dipole and reflector
202	2 Stack array, simple dipoles and reflectors
404	4 Stack array, simple dipoles and reflectors

Collins Machine Co., 56-21 Northern Blvd., Woodside, N. Y.

Model	Type
TFM-300R	Dipole with reflectors
TFM-200	Dipole
TFM-301R	Dual dipole and reflector
TFM-201	Dual dipole

Cornell-Dubilier Electric Corp., 333 Hamilton Blvd., South Plainfield, N. J.

(SKY HAWK)

Model	Type
CD-81LTV	Low band folded dipole
CD-81HTV	High band folded dipole
CD-81ATV	Low band and high band folded dipoles
CD-82LTV	Low band folded dipole and reflector
CD-82HTV	High band folded dipole and reflector
CD-84LTV	2 Stack folded dipoles and reflectors - low band
CD-85ATV	All band unit consisting of high band folded dipole with reflector and low band folded dipole with reflector
CD-85X	High and low band folded dipoles and reflector
CD-AT2	Indoor adjustable telescoping dipole - 2 sections per rod
CD-AT3	Indoor adjustable telescoping dipole 3 sections per rod

World Radio History

Delson Mfg. Co., 126 11th Ave., New York 11, N. Y.

Model	Type
Jiffy-Tenna (window)	Simple dipole high band, and folded dipole low band

Dielectric Pro. Co., Inc., 125 Virginia Ave., Jersey City 5, N. J.

Model	Type
72M	Folded dipole and reflector
72MW	Folded dipole

Eastern Transformer Co., 147 W. 22nd St., New York 22, N. Y.

	Type
	7 Element array

Electro Technical Industries, 1437 N. Broad St., Philadelphia, Pa

	Type
	Low and high band folded dipole

Electronic Indicator Corp., 35-44 61st St., Woodside, L. I., N. Y. (ELINCOR)

Model	Type
300-D	Straight dipole
300-DR	Dipole with reflector
300-FD	Folded dipole
300-FDR	Folded dipole with reflector
310-FDR	Folded dipole with reflector
310-SA	H type stacked array
350-SA	H type stacked array
250	TV and FM
250-R	TV and FM with reflector

Hy-Lite Antenna, Inc., 523 Tiffany St., Bronx, N. Y.

Model	Type
LC-30-S	Low and high band folded dipole with reflectors

Insuline Corp. of Am., 36-02 35th Ave., Long Island City 1, N. Y.

Model	Type
6055	Dipole
6056	Folded dipole
6057	Dipole with adjustable reflector
6058	Folded dipole with adjustable reflector
6009	Flexing dipole (indoor)
Wasp	Indoor adjustable dipole

World Radio History

Intra-Video Corp. of Am., 851 Madison Ave., New York 21, N. Y.

	Type
	Multiple installation (apartment) system

Jerrold Electronics Corp., 121 N. Broad St., Philadelphia 7, Pa.

Model	Type
In-tenna	Adjustable indoor dipole with booster amplifier

JFD Mfg. Co., Inc., 4109 Ft. Hamilton Pkwy, Brooklyn 19, N. Y.

Model	Type
TA-100	Dipole
Ta-101	Dipole and reflector
TA-102	FM-TV double dipole with reflector
TA-103	Folded dipole
TA-104	Folded dipole with reflector
TA-105	FM-TV double folded dipole with reflector
TA-106	FM-TV multi-element with reflectors
TA-107	FM-TV multi-element stacked array
TA-108	FM-TV dual band with folded lobe
TA-115	Low and high band folded dipole with reflector
TA-116	Double stacked high band folded dipole and reflectors, and double stacked low band folded dipole and reflectors
TA-124	Double stacked low band folded dipoles and reflectors
Quick-Rig Window Ant.	High and low band dipole

Kings Electronics Co., Inc., 372 Classon Ave., Brooklyn 5, N. Y.

Model	Type
A-1000	"Roto Beam" rotating double dipole
A-1022	Director, dipole, and reflector array
A-1100	Tunable dipole for TV and FM
A-1200	Dipole, TV and FM
A-1300	Tunable dipoles with tunable parasitic element
A-1400	Double dipole

World Radio History

LaPointe-Plascomold Corp., Unionville, Conn.
(VEE-D-X)

Model	Type
JR-13	2 Dipole array with reflectors
RD-6	4 Dipole array with reflectors (channels 1-6)
RD-13	4 Dipole array with reflectors (channels 1-13)
DGA-12	Large diameter bat-wing dipole

Lyte Parts Co., 15 Washington Ave., Plainfield, N. J.

Model	Type
LTA	All band folded dipole
LTC-R	Folded dipole and triple reflector
LTD	2 Stack folded dipole and reflectors

Marine Radio Corp., New York, N. Y.

	Type
	Indoor dipole

Oak Ridge Antenna Co., 28 Clinton St., Yonkers, N. Y.
(RIG-FAST)

Model	Type
D-4	Single dipole
DR-4	Dipole reflector
DDR-4	Double dipole, double reflector
FD-4	Folded dipole
FDR-4	Folded dipole with reflector
CVS-4	Conversion kit, from D-4 to DR-4 or FD-4 to FDR-4

Philco Corp., Tioga and C Sts., Philadelphia 34, Pa.

Model	Type
45-1584	Low band dipole
45-1590	High band dipole
45-1585	Low band reflector kit
45-1591	High band reflector kit
45-1586	H type array with reflectors

Philson Mfg. Co., Inc., 156 Chambers St., New York 7, N. Y.

Model	Type
FD-160	Rotatable folded dipole with tunable center "Signalator"
HF-40	High band folded dipole
HF-230	High band dipole with reflector
HF-240	High band folded dipole with reflector

World Radio History

Philson Mfg. Co., Inc., (continued)

FD-150	Adjustable folded dipole
SSD-180	2 Stack dipole with reflector

Premax Products, Div. of Chisholm-Ryder Co., Inc., 4909 Highland Ave., Niagara Falls, N. Y.

Model	Type
FMTL-254	Extended "V" dipole
FMTL-330	Adjustable "V" dipole
T-448	Low and high band adjustable "V" dipoles with reflectors
TA-4481	Low band adjustable "V" dipole with reflector
TB-4482	High band adjustable "V" dipole with reflector

Public Operating Corp., 100 W. 42nd St., New York 18, N. Y.

Model	Type
Gyro-Tenna	Folded dipole - window mounting

Rad-El-Co Mfg. Co., 6300 Euclid Ave., Cleveland 3, Ohio

Model	Type
HD-12	Low band dipole
HD-22	Low band folded dipole
HD-22R	Low band folded dipole with reflector
HD-23R	High and low band folded dipoles with reflector
HR-2	Reflector kit for use with HD-12 and HD-22

The Radiart Corp., 3571 West 62nd St., Cleveland 2, Ohio

Model	Type
T81-LTV	Low band folded dipole
T81-HTV	High band folded dipole
T81-ATV	Low band and high band folded dipoles
T82-LTV	Low band folded dipole and reflector
T82-HTV	High band folded dipole and reflector
T84-LTV	2 Stack folded dipoles and reflectors - low band
T84-HTV	2 Stack folded dipoles and reflectors - high band
T85-ATV	All band unit consisting of high band folded dipole with reflector and low band folded dipole with reflector
T85-X	High and low band folded dipoles and reflectors

World Radio History

The Radiart Corp. (continued)

AT-2	Indoor adjustable telescoping dipole - 2 sections per rod
AT-3	Indoor adjustable telescoping dipole - 3 sections per rod
81-RL	Reflector kit for use with T81-LTV
81-RH	Reflector kit for use with T81-HTV
K82-HTV	High band folded dipole and reflector kit for addition to low band unit
K82-LTV	Low band folded dipole and reflector kit for addition to high band unit

Radio Corp. of America, RCA-Victor Division, Harrison, N. Y.

Model	Type
203	Folded dipole driven element and folded dipole reflector
225	Uni-directional TV-FM
226	Bi-directional TV-FM
228	Folded dipole-reflector
696	Adjustable end loaded indoor dipole
	Multiple Installation (apartment or store system)

Radio Craftsmen, Inc., 1341 S. Michigan Ave., Chicago 5, Ill

Model	Type
Slide-Rule Ant.	Indoor adjustable folded dipole

Radio Merchandise Sales, Inc., 550 Westchester Ave., New York 55, New York

LOW-BAND SERIES

Model	Type
SD-10	Low band straight dipole
FD-25	Low band folded dipole
SDR-50	Low band dipole and reflector
CIJ	Low band dipole and reflector
LBS-30U	Same as SDR-50 except mast not supplied
FDR-100	Low band folded dipole and reflector
LBF-40U	Same as FDR-100 except mast not supplied
2LBS-350U	2 Stack dipole and reflector - low band
2LBF-400U	2 Stack folded dipole and reflector - low band

World Radio History

ALL-CHANNEL SERIES

Model	Type
FFD-120	Dual folded dipoles
FRD-130	Dual folded dipole and reflector
ALH-700	High and low band folded dipoles and reflectors
ALHS-675	High and low band straight dipoles and reflectors
ASD-150, ASD-150U	High and low band straight dipoles and reflectors
AFD-200, AFD-200U	High and low band folded dipoles and reflectors
CAS-725	Modified pyramid (V) dipoles and reflectors
CAD-750	2 Stack modified pyramid (V) dipoles and reflectors
VAC-800	Modified "Lazy-H"

HIGH-BAND ATTACHMENTS

Model	Type
HFS-250	High band straight dipole and reflector
SAH-1	High band straight dipole and reflector
HFF-300	High band folded dipole and reflector
DAH-5	High band folded dipole and reflector
2HBS-450U	2 Stack dipoles and reflectors - high band
2HBF-500U	2 Stack folded dipoles and reflectors - high band

TUNED DIPOLE SERIES

Model	Type
D-2 thru D-13	Single channel units cut for specified frequency

WINDOW ANTENNAS

Model	Type
WSS-160	Straight dipole - low band
WSFL-180	All channel dual folded dipole

Radion Mfg. Co., 1137 Milwaukee Ave., Chicago 22, Ill

Model	Type
A	Indoor adjustable V dipole

World Radio History

The Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.

Model	Type
155	Low and high band T-matched dipoles
	Store and apartment multiple installation systems

Rogers Television, Inc., 336 Madison Ave., New York, N. Y.

Model	Type
RQ2-13	5 Element parasitic array

S/C Laboratories, Inc., 20 Van Wagenen St., Newark 4, N. J.

Model	Type
704-2A	Stacked array
704-A	Single array with reflector
705-A	Single array with reflector
706-A	Single array with reflector

Shur-Antenna Mount, Inc., 266 Sea Cliff Ave., Sea Cliff, N. Y.

Model	Type
D-62	Simple dipole
I-62	Interceptor* dipole and director or reflector
FI-62	Folded interceptor (folded dipole)
ID-62	Dual interceptor (folded dipole and director or reflector)
"Jiffy"	
JD-62	Simple dipole
JI-62	Dipole and director
JFI-62	Folded dipole
JID-62	Folded dipole and director
"DeLux"	
DD-62	Simple dipole
DI-62	Interceptor (dipole with director or reflector)
DFI-62	Folded interceptor (folded dipole)
DID-62	Dual interceptor (folded dipole and director or reflector)
SH-62	H type interceptor
3E-62	"High Gain" Interceptor

*TM

World Radio History

Technical Appliance Corp., Sherbourne, N. Y.
(TACO)

Model	Type
435	Double-doublet antenna-reflector
436	H type dipole array
440	Adjustable folded dipole antenna-reflector combination
441	Folded dipole
455	Dipole antenna-reflector
453	Single dipole
457	Double-V dipole
465	Low and high band folded dipole with reflectors
490	2 Stack folded dipoles with reflectors
621	Folded dipole (specify station frequency, i. e., 621-66 for 66mc.)
975	Adjustable indoor dipole

Telrex, Inc., 26 Neptune Highway, Asbury Park, N. J.

Model	Type
IX-TV-FM	Single conical V
IX-TV-FM-S	2 Stack conical V
2X-TV	Double V conical with V reflectors
4X-TV	2 Stack double V conical with V reflectors
8X-TV	4 Stack double V conical with V reflectors

Tricraft Products Co., 1535 N. Ashland Ave., Chicago 22, Ill.

Model	Type
300	All wave double dipole
400	2 Stack double dipoles
500	Double dipole, window mount
200	Under carpet dipole

Tuck Electronic Corp., 76 Montgomery St., Jersey City 2, N. J.

Model	Type
"Pray"	Folded dipole TV-FM

U. H. F. Resonator Co., Guion Road, Rye, N. Y.

Type
8 Element array
16 Element array
32 Element array

World Radio History

Veri-Best Tel. Products, Inc., 8-10 Forrest St., Brooklyn, N. Y.

	Type
	Folded dipole (window mount)

Vertrod Corp., 17 Williams Ave., Brooklyn 7, N. Y.

Model	Type
332	TV-FM single dipole
444	TV-FM dipole and reflector

Ward Products Corp., 1523 E. 45th St., Cleveland 3, Ohio

Model	Type
TV-88	Straight dipole
TV-94	Folded dipole
TVR-92	Reflector kit
TVH-9	Low and high band folded dipoles with reflectors
TV-28	High band folded dipole and reflector kit
TVS-6	2 Stack folded dipoles with reflectors
TVI-43	Adjustable indoor dipole

Workshop Associates, 66 Needham St., Newton Highlands 61, Mass.

Model	Type
TV-57	3 Element parasitic array (channel 2)
TV-63	3 Element parasitic array (channel 3)
TV-69	3 Element parasitic array (channel 4)
TV-79	3 Element parasitic array (channel 5)
TV-85	3 Element parasitic array (channel 6)
TV-183	3 Element parasitic array (channels 7, 8*, 9)
TV-195	3 Element parasitic array (channels 8, 9*, 10)
TV-207	3 Element parasitic array (channels 11, 12*, 13)

*Optimum performance on this channel

World Radio History

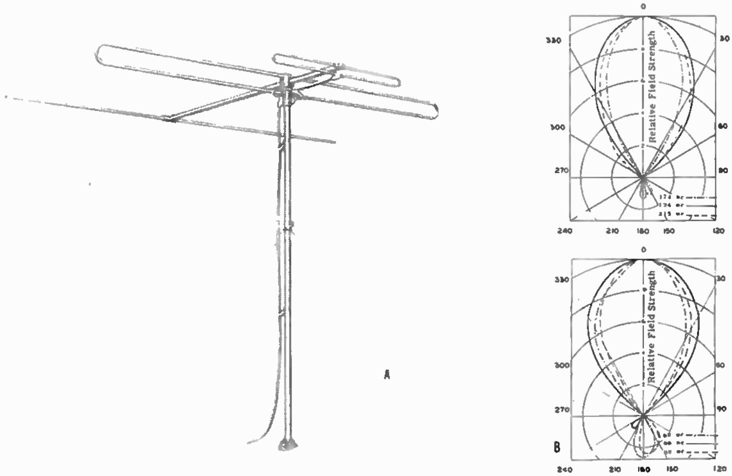


Fig. 58. Double-Folded Dipole and Reflector. (Courtesy American Phenolic Corp. - ''Amphenol'')

Table X indicates that there are many varieties of commercial antennas available. Actually, most commercial antennas are based on the dipole principle or some commercial variation of it. They can be broken down into approximately 12 general types other than types described in the section on Antenna Construction, and all these general versions are discussed under the 12 tabulated headings immediately following:

1. <u>Double Folded Dipole with Reflector.</u> This antenna is designed for installation in low signal areas. It has a highly directional characteristic as shown in Figure 58B and, therefore, has good front-to-back, and front-to-side ratios. A 2 Db gain is realized over most of the 12 channels it is designed to receive. The large folded dipole acts as a reflector for the high band folded dipole, and as the driven element on the low band. A matching section connects the two folded dipoles together. A half wavelength reflector is used for the low band. The elements are constructed of aluminum alloy and a rust-resistant 5-foot steel supporting mast containing guy wire clamps is included in the complete kit. The output impedance is practically constant at 300 ohms for both TV bands. This indicates that the antenna has a low overall standing wave ratio. The double dipole antenna is also available in stacked form when more gain and directivity are required.

2. <u>All-Channel Dual Element Antenna.</u> The antenna illustrated in Figure 59 acts as a half wave dipole for the low band, and a one and one-half wavelength dipole for the high band. 3/8-inch aluminum tubing is used in the construction of the elements.

World Radio History

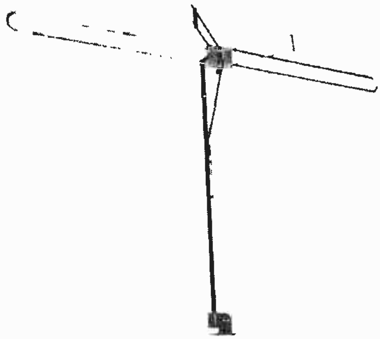


Fig. 59. Dual-Element Antenna. (Courtesy L. S. Brach Mfg. Corp.)

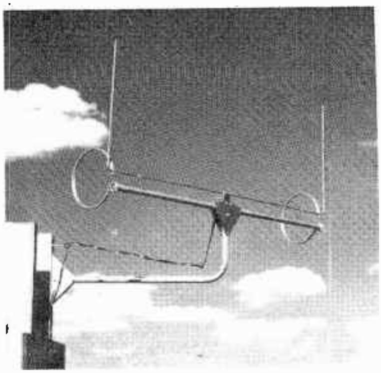


Fig. 60. Double-Dipole Window Mounting. (Courtesy Tricraft Products Corp.)

The antenna has a "figure 8" response pattern for the center of the low frequency band, and a "three halves" field pattern for the high frequency band. A reflector may be employed with the antenna to give it a uni-directional response characteristic. The standing wave ratio of this type of antenna does not exceed 6 to 1, if it is matched to a 300 ohm transmission line. It is designed to give FM rejection so that there will be no FM interference in the television band. A universal mounting bracket is furnished with the complete kit so it can be mounted on the side of a building, on the roof, or under the eaves.

3. Double-Dipole. The double dipole broad band antenna will function well on all 12 channels. The model illustrated in Figure 60 is designed for window casement mountings in apartment houses where a roof installation is not possible. Other models are available on mast mountings for roof installations. A matching stub is utilized in this antenna to give it a characteristic impedance of 300 ohms over all television channels. The response pattern is a "figure 8" for the low band, and a "three halves" pattern for the high band. The antenna must be oriented so that it is at a 90° angle to the large lobe for best reception on the high band. It can be assembled and installed with a minimum of tools.

4. T-Matched Dipole. The T-matched dipole antenna in Figure 61 covers the FM band as well as the two television bands. Maximum efficiency and minimum standing wave ratio is attained through the use of a coil type matching transformer mounted under the metallic hood of the antenna. On the low television and FM

World Radio History

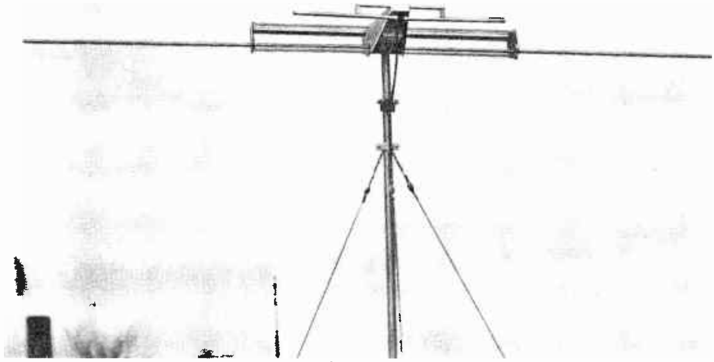


Fig. 61. T-Matched Dipole. (Courtesy The Rauland Corp.)

bands, the antenna has a "figure 8" directional pattern. In other words, the large element acts as a single T-matched dipole. On the high television band, the response is uni-directional, because the large T-matched dipole is acting as a reflector for the small, high frequency T-matched dipole. It is constructed of heavy aluminum tubing to withstand conditions of high wind, or heavy icing. The characteristic impedance approximates 300 ohms over the entire frequency spectrum it is designed to cover.

5. High and Low Band Folded Dipole with Reflectors. This unit consists of two separate arrays: one folded dipole and reflector unit designed for high band operation and another folded dipole and reflector unit designed for low band operation. (Figure 62.) The two arrays are separated by approximately one-half of a wavelength at the center low band frequency. The two arrays are connected together with a matching transformer designed for 300 ohms output impedance. The antenna has uni-directional characteristics for all channels.

6. Five-Element Beam (Figure 63). The five-element beam is commonly known as a Yagi array. It consists of three directors, a dipole driven element, and a reflector. It is frequency-sensitive (3 to 4 megacycles) and should be used for single channel reception in the outermost fringe areas. A very narrow omnidirectional response pattern is obtainable because of the large number of parasitic elements used. The output impedance of this array is 72 ohms; therefore, a matching transformer must be employed if the array is to be used with a 300 ohm parallel wire lead-in.

World Radio History

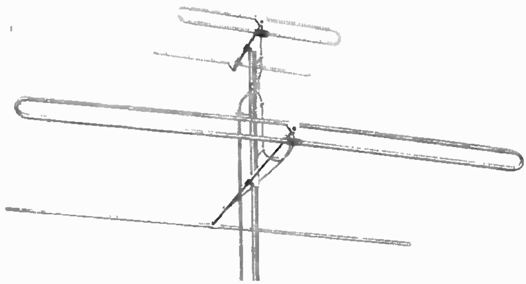


Fig. 62. High and Low Band Folded Dipole with Reflectors. (Courtesy The Radiart Corp.)

7. Four Dipole Element Array with Reflectors. (Figure 64.) This antenna is essentially a single-channel uni-directional antenna. It has a high forward gain with a minimum of pick-up to the rear and sides. The output impedance can be varied from 50 ohms to 600 ohms by changing the position of the transmission line takeoff on the special "Q" matching transformer, connected between the dipole elements of the antenna. The four-element array with reflectors, can be used in the outermost fringe areas where a very high gain is required. A heavy-weight, guyed mast or tower is required to support the assembly in the air.

8. Double Conic Section. The antenna illustrated in Figure 65 is designed to assume response characteristics similar to a double conical antenna. It gives broad band and high gain response over the entire television spectrum. The driven elements angle forward to present a V to the incoming wave, this tending to prevent the uni-directional receiving lobe from changing with an increase of frequency. The driven element is approximately one-half of a wavelength on channel 2, increasing to 5/8 wavelength on channel 3, and becomes a V beam on channel 5. Each element is a full wavelength on channel 13. The antenna has a front-to-back ratio of approximately 4 to 1 on all channels. The standing wave ratio does not exceed 1.6 to 1. The output impedance is 150 ohms over almost all channels in both bands.

9. Adjustable Angle Low and High Band Dipole with Reflectors. This antenna features adjustable angle driven dipole elements to compensate for any polarization changes that the transmitted signal may encounter between the transmitting and receiving antennas. One V dipole and reflector unit is cut to

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resonate at the center frequency of the high band, while the other V dipole and reflector unit is designed to resonate at the center of the low television band. Both high and low band reflectors can be adjusted for stacking distance, to obtain maximum gain. (Figure 66.) The two stacks are connected by a common transmission line. The output impedance of the antenna is 300 ohms.

10. Rotatable Dipole Antenna. The Roto Beam antenna has two dipoles in the same plane at right angles to each other. One dipole is tuned to a mean frequency of 67 megacycles, covering the low band; and the other dipole is tuned to a mean frequency of 192 megacycles, covering the high band. The antenna can be rotated by a remotely controlled switchbox located at the receiver for the elimination of ghost signals and for maximum signal reception. The dipoles of the antenna rotate in a complete 360° circle with an automatic change-over of dipoles with every 180° of rotation. A 24 volt ac motor is located in the antenna head. The 24 volts are obtained through the use of a step-down transformer from the 110 volt line. It is designed with either a 72 or 300 ohm output impedance.

11. Di-Fan Antenna. The di-fan antenna has the broad band characteristics of a conic antenna. It consists of four dipole antennas spread in a fan arrangement in a single plane to achieve a

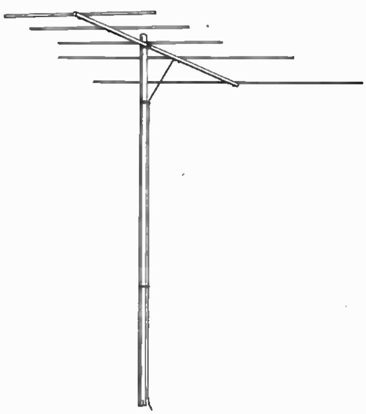

Fig. 63. A Typical Five-Element Parasitic Array.

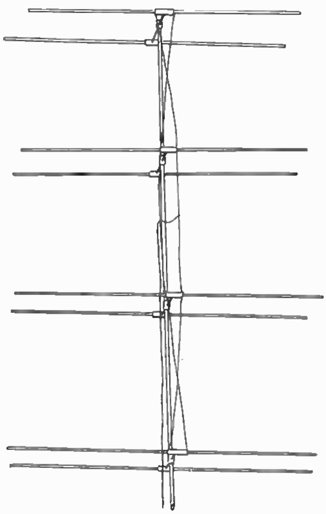

Fig. 64. Four-Stack Dipole Array with Reflectors. (Courtesy Cole & Worner, Inc.)

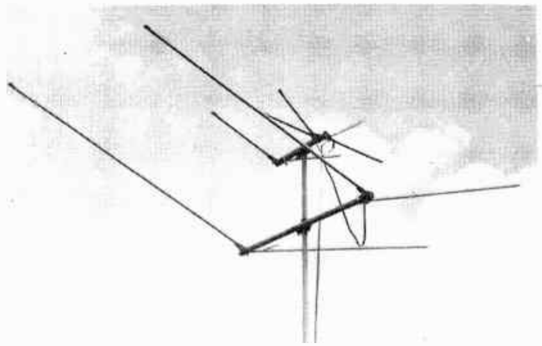

Fig. 66. Adjustable Angle Dipole Array with Reflectors. (Courtesy Premax Products, Division of Chisholm-Ryder Co., Inc.)

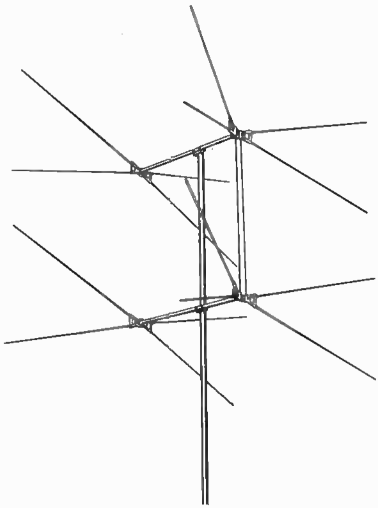

Fig. 65. Double-Conic Section Antenna. (Courtesy Telrex, Inc.)

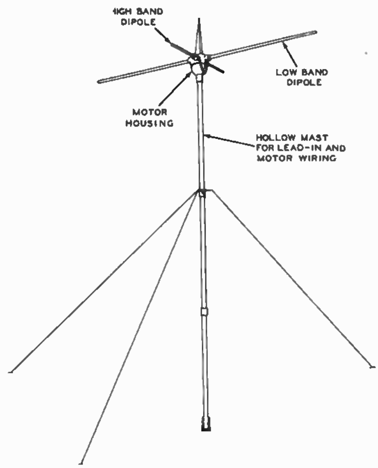

Fig. 67. Rotatable Dipole Antenna. (Courtesy Kings Electronics, Inc.)

conic section. It has a "figure 8" response curve for both the high and low band. (Figure 68B.) In the high band, however, the ends of the figures have been flattened tending toward a cloverleaf pattern. It can be seen that reflected signals coming in at wide angles from the broadside direction will be sharply attenuated. The antenna can also be rotated from the broadside position and a reflected signal will then be received so far down on the response curve that it will be effectively eliminated as a ghost signal. This unit is designed to match 300 ohms.

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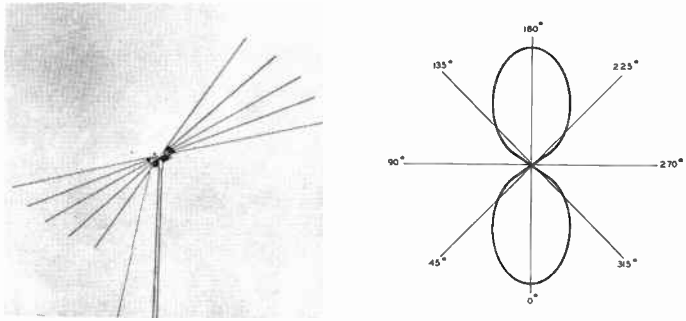

Fig. 68. Dipole Fan Antenna. (Courtesy Andrew Corp.)

12. Adjustable "V" Indoor Dipole Antenna. This antenna consists basically of two adjustable fish-pole type antennas connected in the form of a V dipole for indoor mounting on top of a television receiver. (Figure 69A.) It is usually advisable to employ an indoor antenna only in the immediate vicinity of the transmitter unless an RF booster is employed. This unit can be easily rotated by hand for maximum reception from various stations. Each dipole element can be physically adjusted in length for best reception. It has chromium plated elements and a ball type base to make an unobtrusive design for an indoor installation. The output impedance is designed to match a 300 ohm transmission line.

Fig. 69B. Adjustable Indoor Folded Dipole - Slide Rule Type. (Courtesy Radio Craftsman, Inc.)

Fig. 69A. Adjustable "V" Indoor Dipole Antenna. (Courtesy Radion Mfg. Co.)

Fig. 69C. Adjustable Indoor Dipole with Built-in Booster Unit. (Courtesy Jerrold Electronics Corp.)

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EDITOR'S NOTE

As this book goes to press, a number of announcements, pertaining to new indoor television antenna designs, are occurring.

We have accordingly taken the liberty of adding to the original manuscript a brief descriptive section and representative illustrations of some of the newer designs:

A. Slide Rule Folded Dipole Type. Figure 69B illustrates a unique new design for indoor antenna application. The unit is extremely compact and its retracting feature provides easy portability. Operation requires only the adjustment of one metal loop to the desired channel; the other loop adjusts automatically. Settings for each of the twelve television channels, as well as for FM reception, are marked on the metal loop. The unit is designed to match the standard 300 ohm transmission line.

B. Adjustable Dipole Antenna and Built-in Booster. As indicated, this unit, illustrated in Figure 69C, combines the adjustable telescopic dipole antenna with a booster unit covering the television frequencies. The combination of antenna and booster is particularly applicable to apartment and other installations where it is difficult, if not impossible, to erect an outdoor type. In addition, many potential TV receiver owners do not like the appearance of outside installations, and if they are located at a reasonable distance, with respect to the transmitter, the indoor installations can be completely satisfactory.

C. Figures 69D and E illustrate typical telescoping type adjustable dipoles for indoor service. The unit appearing in Figure 69D employs a slotted insulator for angular adjustment where space is limited.

The unit appearing in Figure 69E employs either two or three-section telescopic construction. Selection of the three-section unit is indicated for optimum performance on the lower frequency channels.

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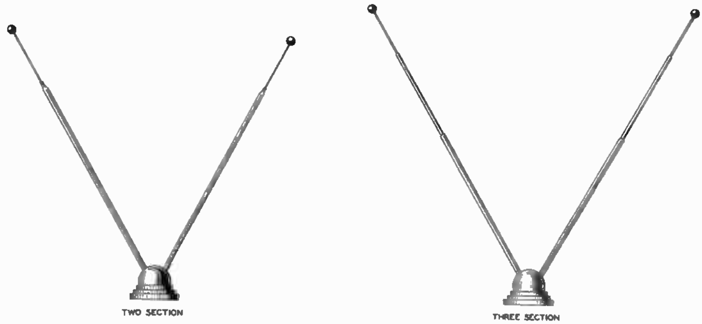

Fig. 69E. Adjustable Indoor Dipole - 2 and 3 Section Units. (Courtesy Radiart Corp.)

Fig. 69D. Adjustable Indoor Dipole with Angular Adjustment. (Courtesy Ward Products Corp. - Division of the Gabriel Co.)

Fig. 69F. Indoor Dipole with End-Loading Discs. (Courtesy Radio Corp. of America - RCA)

The unit illustrated in Figure 69F is an indoor dipole type with concave metallic disks located at the end of the dipole sections. The disks are employed to provide additional effective electrical element length in a physically smaller space for improved operation on the lower channel frequencies.

The choice of the antenna is dependent upon the location of the installation with reference to the television transmitter. A simple, inexpensive array will prove satisfactory for locations close to the transmitter, while a large, high gain, and consequently more expensive system, is necessary for remote fringe area installation. The serviceman will find that there are commercial systems available for any type of installation he may encounter.

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CHAPTER 4

ANTENNA INSTALLATION

Most television receiver manufacturers require that the dealer or distributor who handles his products have a competent service staff capable of servicing and installing television receivers and antenna systems. If the service organization does not meet the manufacturers' standards, they will not issue a television franchise to the dealer. This does not mean that the dealer with a small service department, or no service department at all, cannot obtain a franchise for selling television receivers. There are companies organized in every television area that do nothing but install and service television receivers and antenna systems. They take the service and installation problem completely away from the smaller dealers who wish to utilize their service.

Television receivers are, for the most part, sold with a one-year warranty policy. This policy costs the set buyer an additional $60.00 to $75.00 over and above the cost of the receiver itself. It includes such items as the original antenna installation and complete service of it for one year as well as the installation and complete repair of the receiver for a one-year period. The above cost figures are based on a metropolitan installation within 15 miles of the transmitters where a simple antenna and an ordinary installation will give good results. For fringe area or spec-

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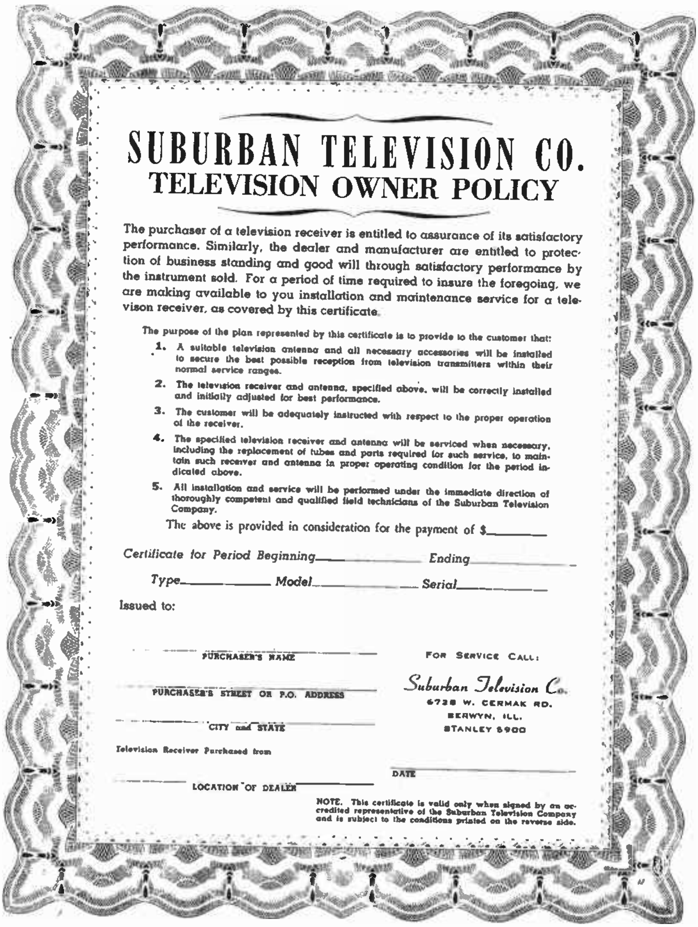
ial metropolitan installations, the cost of the service policy can be increased in a ratio proportional to the added cost of the antenna system that must be employed for satisfactory reception.

In apartment house installations where a separate service organization installs the master system, the warranty fee should be reduced; because there is no antenna installation or maintenance charge. All that the television dealer must guarantee is the service of the receiver.

A typical warranty policy issued to the set owner by the installation company is shown in Figure 70. An authorized mem-



SUBURBAN TELEVISION CO.
TELEVISION OWNER POLICY

The purchaser of a television receiver is entitled to assurance of its satisfactory performance. Similarly, the dealer and manufacturer are entitled to protection of business standing and good will through satisfactory performance by the instrument sold. For a period of time required to insure the foregoing, we are making available to you installation and maintenance service for a televison receiver, as covered by this certificate.

The purpose of the plan represented by this certificate is to provide to the customer that:

1. A suitable television antenna and all necessary accessories will be installed to secure the best possible reception from television transmitters within their normal service ranges.
2. The television receiver and antenna, specified above, will be correctly installed and initially adjusted for best performance.
3. The customer will be adequately instructed with respect to the proper operation of the receiver.
4. The specified television receiver and antenna will be serviced when necessary, including the replacement of tubes and parts required for such service, to maintain such receiver and antenna in proper operating condition for the period indicated above.
5. All installation and service will be performed under the immediate direction of thoroughly competent and qualified field technicians of the Suburban Television Company.

The above is provided in consideration for the payment of $________

*Certificate for Period Beginning*________ *Ending*________

*Type*________ *Model*________ *Serial*________

Issued to:

PURCHASER'S NAME

PURCHASER'S STREET OR P.O. ADDRESS

CITY and STATE

Television Receiver Purchased from

LOCATION OF DEALER

FOR SERVICE CALL:
Suburban Television Co.
6728 W. CERMAK RD.
BERWYN, ILL.
STANLEY 5900

DATE

NOTE. This certificate is valid only when signed by an accredited representative of the Suburban Television Company and is subject to the conditions printed on the reverse side.

Fig. 70. Typical Warranty Policy. (Courtesy Suburban Television Co.)

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ber of the installation company should see that the warranty policy is filled out properly and signed by the customer and himself.

A very complete record is kept by the receiver manufacturer, the distributor, and the installer or dealer, on the initial receiver operation and the installation performance. Figure 71 shows a typical record blank that the dealer must fill out and return to the distributor, and receiver manufacturer, after the set has been installed. This form is made in triplicate by the use of attached carbons. It is of the utmost importance that these forms be filled out and returned to the proper authorities for filing. Every blank should be completely filled out so that there will be

FEATURES AND CONDITIONS OF THE TELEVISION OWNER POLICY

1. IDENTIFICATION OF OUR EMPLOYEES: For your protection, each of our employees carries appropriate identification. Do not entrust your instrument for service under this POLICY to anyone who cannot identify himself as an authorized employee of the Suburban Television Company.

2. The Suburban Television Company will furnish and determine type of standard television atenna, or other suitable antenna, including essential transmission line, accessories and mast or supports. The antenna will be erected on the specified premises in accordance with standardized methods, National Board of Fire Underwriters' Codes, and applicable local ordinances. Where necessary, the customer shall obtain permission from the owner of the specified premises for erection of the antenna.

3. The Suburban Television Company will assemble, test, adjust, install, and place the specified television receiver in proper operating condition.

4. The Suburban Television Company will instruct the customer with respect to the proper operation and care of the instrument.

5. The Suburban Television Company will service and maintain the specified television receiver and antenna in normal working order for a period of one (1) year from the date of installation, provided that such service and maintenance are necessitated by normal usage as determined by the Suburban Television Company. Genunine factory replacement materials, parts, and tubes (including the kinescope) will, if required, be furnished during this period.

   One (1) Scheduled post-installation performance check-up of the receiver will be provided.

6. All installation and service work in connection with this plan will be performed under the immediate direction of thoroughly competent and qualified field technicians of the Suburban Television Company.

7. CHANGES IN ANTENNA SYSTEM: Whenever a new television station comes on the air or an existing station makes a change in transmitting conditions which affects reception, it may be desirable to redirect or reorient your existing antenna. We agree to do this, if it is necessary, in the case of any station within effective range.
   If for any such reason, however it becomes necessary to move, add to or replace any part of the antenna system, we will perform such work for you, upon request, at a reasonable charge for the additional materials and labor.

8. OPERATION FROM CENTRALIZED ANTENNA SYSTEM: In the event your instrument is operated from a centralized antenna system, we shall not be held responsible under this POLICY for either the performance or maintenance of such system or its associated distribution elements.

9. The services provided by this plan shall normally be available and rendered during the regular working hours of the customary work-week. Every effort will be made to give prompt attention to service requests of an urgent nature.

10. This ceritficate applies only to installations within the continental limits of the United States, and within the defined service areas of transmitters, operating in the commercial channel frequencies covered by the specified television receiver.

11. Changes Made Necessary by FCC Regulations: If curcuit or component adjustments or alterations become necessary as a result of changes in transmission standards or band assignments by the U. S. Government, such work, if technically feasible, will be performed for you, upon request, as promptly as possible at a reasoncble charge for labor and materials.

12. DESIGN CHANGES: This policy provides only for the service and maintenance of the specified receiver as originally designed and manufactured. No responsibility is assumed for modifying, making additions to, or modernizing its basic design or arrangement as the technical art progresses.

13. PROPERTY OWNER'S ASSENT: You agree to secure for us all required authorizations if any contemplated physical changes, such as the relocation of the antenna, etc., require the consent of any other person (as, for example, the owner of the premises).

14. This certificate does not cover replacement or repair due to loss or damage incurred in transportation of the instrument, or due to fire, lightning, theft and other causes normally beyond the control of Suburban Television Company.

15. The television receiver specified herein, and its antenna, are designed and arranged to minimize all controllable forms of interference; however, it is regretted that liability for elimination of external interference in the picture or sound, created by passing automobiles, electrical phenomena, appliances, diathermy, aircraft, short-wave and "FM" receivers, etc.– cannot be assumed by Suburban Television Company.

16. The Suburban Television Company assumes no liability with respect to the installation, service and maintenance of motor-generators or other devices required or used for furnishing power to the receiver, nor to effects on reception produced by or emanating from such power supplied.

17. This certificate covers only the initial installation of the receiver, and does not cover subsequent installation resulting from the instrument having been moved to a different location, or from structural alterations, redecorating, etc. However, in such event, the Suburban Television Company will furnish the materials and services required at its then prevailing rates: and subject to the foregoing conditions, will then continue the maintenance of the receiver through the unexpired portion of the prescribed one-year period.

18. Maintenance service shall not continue if the specified receiver or antenna has been altered or repaired by other than Suburban Television Company representatives, in a way that, in the opinion of the Suburban Television Company, affects reliability or detracts from the performance of the receiver; or if the receiver or antenna has been subjected to misuse through negligence or otherwise; or if the receiver has its serial number altered, effaced, or removed.

19. SPECIAL CONDITIONS: ______________________________

____

____

____

FOR SERVICE UNDER THIS PLAN - - Phone Suburban Television Company at address shown on reverse side of this certificate, or notify your dealer.

Fig. 70. Typical Warranty Policy. (Courtesy Suburban Television Co.)

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DATE OF INSTALLATION________ SUBURBAN TELEVISION CO.
Owner's name________________ RECEIVER INSTALLATION REPORT
Receiver type______ finish__________
Chassis No.________Serial No.______ C. R. T. No.________________
Factory Inspection No. __________ Packing No.______________

Check the following after unpacking the receiver.

Check the following after receiver is installed.

	O.K.	Adjust.			O.K.	Adjust.
Ion Trap				Sound Quality		
Height				Picture Quality		
Width				Hum		
Vert. Center				Sound Bars		
Hor. Center				Diathermy		
V. Linearity				Ghosts		
H. Linearity						
V. Sync.				Ignition noise		
H. Sync.				Other noise		
Fine Tuning						
Focus						
Brightness						
Contrast						

Check contrast setting on all channels in use.

Channel									

Type of Antenna__________ Height above ground______________
Building type__________Roof type______ Accessibility to roof______________
Chimney or roof mount______Lightning Arrestor type____Grounded to______
Trans. Line type______Length______Distance from antenna to
Distance to transmitters__________ street traffic______________
Materials used over and above standard installations______________
____
____
Installation time__________Traveling time_______ Distance______________

Installer's Signature______________________

Fig. 71. Typical Installation Report. (Courtesy Suburban Television Co.)

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no question if it is necessary to obtain reimbursement, from the manufacturer, for parts put into the receiver when service is required on the receiver during the warranty period. It also gives the serviceman a complete record of the installation so that he will be better able to service the receiver when it fails to operate properly. For example, a customer calls in and states that there is interference on the viewing screen, and he wishes the receiver serviced. The serviceman can go to his files and note that diathermy interference was evident when the set was installed. He can then call the customer back and have the customer check the receiver over a period of a day to see if the interference is spurious. In this way, it is possible that a service call could be eliminated. It can also act as a guide in determining the possible location of trouble in the receiver when it is brought in for service.

The filing of the record aids the manufacturer by keeping an accurate check on the condition of the receivers when they reach the dealer for installation. If a number of reports show, for instance, that the linearity control could not be adjusted properly, the set manufacturer could take steps to correct the circuit so that receivers manufactured from that point on could be properly adjusted. All manufacturers strive to properly align and adjust their receivers before they leave the factory so the installer has very few adjustments to make to put the set in operation.

It is especially important that each television installation be made as near perfect as possible, because the set owner usually has a one-year policy with the dealer installing the set; and any complaints that may arise during the year, due to a faulty installation, mean added cost and less profit to the dealer. Experience has proved that there is relatively little service required on television receivers. They are designed and built to the most rigid specifications for continuous use over a long period of time. It follows then, that the proper antenna must be chosen to give an adequate, ghost-free signal; and that it must be installed with the utmost care. Never, under any circumstances, be satisfied with less than the best installation. In the sale of an ordinary radio, the customer buys the set, and generally, he is not heard from again until he wishes to purchase something else. When a television receiver is sold with an installation, and both are guaranteed, the owner can call, complain, and demand prompt service of his service and installation. If he does not receive it, it is highly unlikely that he will purchase anything else from the dealer or renew his service policy at the end of the year. A very good business of extending service policies from year to year can be built up by having satisfied customers. Over a period of years, fair

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dealing and satisfactory service is the best advertisement a dealer can have.

INSURANCE AND SAFETY PRECAUTIONS: Many states have compulsory Workman's Compensation Laws. This means that employers are compelled by law to carry insurance on their employees if the employee is doing a type of work that is hazardous or possibly injurious to his health. Since the installation of television antennas involves climbing and a form of steeple jack work, it falls into the hazardous category. A substantial accident insurance policy should be carried on employees engaged in antenna installation work, whether or not state laws make it compulsory.

The owner of the building on which the installation is placed is also liable in case an employee is injured or meets his death during the time he is working on the building. Many times the building owner will demand a written release in case of injury, from the installer, unless the installer has adequate accident coverage. This release should be given without hesitation. While installation work may be classified as hazardous, if a few simple safety rules are observed, the chance of an accident is reduced to a point where little or no danger is incurred. The simplest installation can become dangerous if common sense is not employed.

1. Always wear rubber-soled shoes when any climbing is involved. On some gabled roofs, even rubber soles do not offer enough traction.

2. Place rubber pads on the bottom ends of the ladder to prevent it from slipping when weight is placed on it.

3. Always keep one hand free when carrying the antenna or tools up the ladder to the roof.

4. Do not stand on the edge of the roof when elevating or installing the antenna. If it is necessary to lean over the edge of a roof or upper story windows, tie a safety rope around your waist or have someone hold onto your feet. If a safety rope is used, tie it securely around the chest under the arms, and fasten the other end to a firmly moored object such as the bottom of a chimney.

5. Always use a safety rope when working on steeply-pitched, gabled roofs.

TOOLS AND SUPPLIES: Basically, television dealers and installers fall into two categories as far as company size is concerned. First, there is the serviceman who has an occasional

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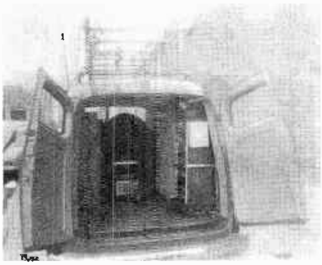

Fig. 72. Typical Installation Truck. (Courtesy Suburban Television Co.

Fig. 73. Portable Receiver Used to Determine Orientation of the Antenna.

Fig. 74. Operator Type Headphone. (Courtesy Suburban Television Co.)

television installation to perform and uses his delivery truck or passenger car to carry the receiver, the antenna, and the installation tools. Second, there is the service company that installs many sets every day and has a special truck especially outfitted for television installation. If the installer uses a car or delivery truck, it is necessary to have roof or fender carriers installed to carry the pipe and antenna to the installation. A completely outfitted installation truck is shown in Figure 72. Usually a 1/2 or 3/4 ton panel truck is used for this purpose. The interior of the truck can be outfitted with special cabinets to allow for the storage of tools, parts, and test instruments. These cabinets should be installed along the sides of the interior and their width should be held to values permitting the placing of the widest console model in the truck. Roof or fender carriers must be installed to carry the mast and antennas. A panel truck is used because it offers a closed body style to prevent rain or snow from reaching the tools and set during transit. Some dealers have even gone to the extent of building repair shops in a panel truck for "on the spot" repair. This truck contains test equipment and a stock of parts adequate

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for all but the most difficult type of repair job.

Table XI gives all of the tools and supplies which the serviceman must have to make an average antenna installation on any type of building, whether it be wood, stone, cement, or brick. It does not include the tools necessary for an apartment house, multiple-receiver installation, where the cabling or transmission line is placed between the outer and inner walls of the building for concealment.

Table XI

Installation Tools

1. Adjustable 50-foot ladders (steel, aluminum, or wood).
2. Pipe wrenches.
3. Open end wrenches (all sizes).
4. Screw drivers (large, medium, and small).
5. Pliers (regular, long-nose, and diagonal-cutting).
6. Saws (wood and hacksaw).
7. Rope (75-foot).
8. Portable electric drill.
9. 100-foot extension cord with multiple outlets.
10. Brace.
11. Drills (wood and metal).
12. Masonry Drills.
13. Punches.
14. Chisels.
15. Hammer.
16. Soldering iron (heavy-duty type).
17. Portable intercommunication system or portable all-channel receiver.

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Most television installation crews consist of 2 or 3 men. When this is the case, the portable intercommunication system should be used to determine the proper orientation of the antenna with respect to the transmitted signal. If only a one-man crew does the installation, it is necessary to use the portable remote receiver so the installer can check for the best signal on the viewing screen, while he orients the antenna on the roof. (Figure 73.)

If a two-man crew is used, it is mandatory that the man on the roof orienting the antenna be able to talk with the man at the receiver who is watching for the best signal reception. If the distance separating the antenna and the receiver is not more than 180 to 200 feet, a portable telephone system may be used. Two types are available. One consists of a reel with 180 feet of two-wire cord, a 4-1/2 volt battery and two plug-in, French type phones. One jack is attached to a slip-ring attachment on the reel and another jack is attached to the end of the two-wire cord. The phones can be carried separately and can be plugged into the two jacks when it is necessary to put the system in use. The reel can be carried in the house to the receiver and the cord unwound from it and placed by the antenna for an intercommunication system. The second type uses operator-type phones that can be mounted over the ears and on the chest, thus leaving both hands free. This type of unit is illustrated in Figure 74. The telephones are sound-powered, and no battery need be used as a power source. The voice causes fluctuation in the magnetic circuit of the mouthpiece, with energy sufficiently strong to be transmitted to the other receivers.

If it is necessary to have the antenna separated by more than 200 feet from the receiver, an electronic intercommunication system should be used. Commercial systems can be purchased for this purpose. However, if the serviceman wishes to build his own, a system can be designed from an ordinary small audio amplifier circuit. Jacks can be used in the system to make possible the use of an operator type headphone and mouthpiece. If a speaker is used, a press-to-talk switch can be placed in the circuit in a manner so that the speaker acts in the conventional way when the press-to-talk switch is released, and as a microphone when it is pressed.

If the antenna is installed by one man, the portable, all-channel television receiver should be carried to the roof and connected to the transmission line which has been cut to the proper length for the installation of the purchaser's receiver, after it has been determined where the set will be situated in the room. The

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receiver end of the transmission line should be brought back up to the roof and connected to the portable test receiver. It is necessary to use the long line to attempt to duplicate the situation that exists in the normal installation, if the customer's receiver were used as the test indicator. The antenna should be oriented until the best picture is obtained on the viewing screen of the portable test receiver, for all channels in use. The transmission line can then be lowered and connected to its offset insulators for the permanent installation. A one-man installation is recommended only in case of emergency, because:

1. It is very difficult for one man to install and erect the antenna.

2. Using a test receiver on the roof cannot exactly duplicate the conditions that exist when the transmission line is connected to the installed receiver. The transmission line lying on the roof, may not have the same characteristic impedance as exists when it is run down the side of the building on offset insulators. For example, when the transmission line is run down the building, it may be near a gutter or water pipe. This may not occur when it is lying on the roof.

3. The impedance of the installed receiver may vary slightly from that of the portable test receiver, causing a different matching condition to exist which reflects different amplitudes of standing waves back on the transmission line. This can affect the orienting of the antenna.

ANTENNA LOCATION: The location of the antenna on the roof is of prime importance in obtaining a good picture in the receiver. Listed below are the general factors which must be taken into consideration when choosing the point where the antenna is to be located:

1. The supporting structure should be as small and as light in weight as is possible and still be able to support the antenna in high winds and ice conditions. Naturally, the size and weight of the supporting structure is dependent upon the size of the antenna array and the point to which it must be elevated for good reception. If it can be kept small enough, the need for a heavy mounting flange and guy wires is eliminated, thus reducing the number of points for anchorage in the roof. It also materially reduces the time necessary for erection. To keep the supporting structure small, the antenna should be located on the highest portion of the building.

2. It is often necessary to have access to the receiving

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antenna, after it has been installed, for service and repair. The most frequent trouble is transmission line breakage at the antenna terminals, or between the standoff insulators, due to heavy icing or high winds.

3. If the installation is to be made in the outer fringe area, the weight of the antenna and the height of the mast which must be used sometimes makes a roof installation impossible. In this case, it is necessary to buy a separate commercial antenna tower for yard erection. If this is not feasible, it is possible to build a heavy-duty flag-pole type mast, or buy a telegraph pole to act as the supporting structure.

4. The antenna should be placed at a point on the roof where the shortest length of transmission line can be used between it and the receiver. A longer transmission line creates more signal attenuation and is more susceptible to noise pick-up.

5. Electrical machinery and neon signs can emit RF energy of sufficient strength to over-ride the television signal, and produce noise pulses and picture tearing in the receiver. Automobile ignition systems have the same effect. Post-war automobile ignition systems have been redesigned to eliminate RF radiation as much as possible. It would be a serious mistake to erect an antenna directly over or near neon signs or electric motors (such as those used in elevators). The antenna should be moved as far as possible from any disturbing electrical elements.

6. It is imperative that the antenna be located where it gives the best ghost-free reception. Ghost signals can sometimes be eliminated by moving the antenna from one location to another or by elevating it. Moving the antenna 5 to 10 feet or elevating it the same distance can appreciably reduce or entirely eliminate ghost signals. Actually, the only way to find the exact location is by a trial and error method. Ghost signals can be removed if it is possible to elevate the antenna above any surrounding buildings or other objects present. This, of course, is not always possible from the standpoint of both cost, and practical mast height.

7. Large, metallic objects and surfaces on the roof can reflect unwanted ghost signals to the antenna and can cause a change in the characteristic impedance of the transmission

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line if it is placed too close to a metallic object or surface. If it is at all practical, place the antenna as far as possible from any metallic reflecting surfaces. When it is necessary to run the transmission line near or over a metallic surface (such as a rain gutter), there should be at least one inch, and preferably two inches, separating them at all points. This can be accomplished by the use of offset insulators. (Figure 75.)

In many cases, it is necessary to compromise one of the above conditions for another. For example: a small, supporting tower would not be used if it did not elevate the antenna to a sufficient height for good signal reception; nor would the antenna be placed in a position where large ghost signals could cause interference on the receiver when the transmission line could be lengthened and the antenna moved to give ghost-free reception.

Whenever possible, the antenna should not be mounted directly to the roof itself where the retaining lag screws or anchors puncture the roof surface and allow rain to seep in and damage the ceilings of the rooms, or rot the roof base. Many roofs are bonded and guaranteed for a long period of time by the roofing material manufacturers. Any deliberate damaging of the roofing material

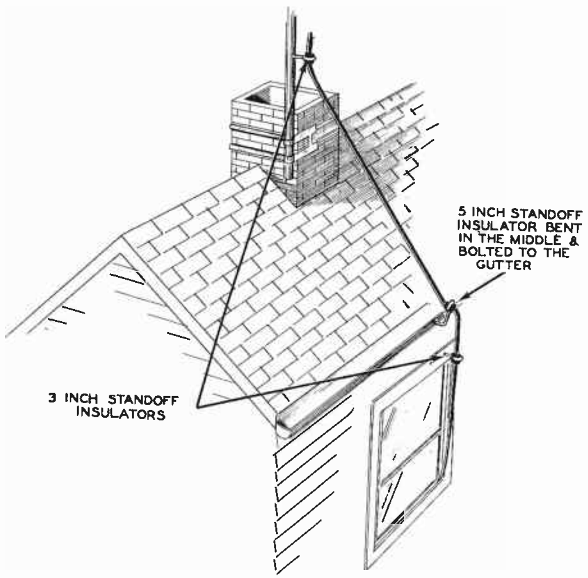

Fig. 75. Use of Offset Insulators to Prevent Changes in Transmission Lines.

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automatically nullifies the roof warranty. Care should be observed when working on a roof to prevent its being punctured or having shingles torn loose by the installer. It is very easy to penetrate it with the mast pipe or loosen a shingle by scuffing against the bottom of it. Destruction of the weather-proofing qualities of a roof can be used as a basis for legal action against the installer to compel him to restore the roof to its original condition and to repair the damage done inside the building by the leak in the roof. If it is absolutely necessary to install the antenna so that its anchor punctures the roof, the owner should always be consulted first for approval to see if it is all right. He can then tell you whether or not the roof is bonded and if it is, obtain written permission from the bonding company for the installation. The bonding company should be consulted as to the best method for securing the antenna mast to the roof without breaking the roofing seal. If it is not necessary to break the roofing seal, no legal action could be taken against the installing company. In most cases, landlords or home-owners do not approve of an actual roof installation and demand that the antenna be anchored on the side of the building, the chimney, or the parapet wall enclosing the roof. Of the three, the side of the building is the best mounting point.

ROOF STRUCTURES: It is essential that the different types of roof structures be thoroughly understood in the event that the antenna mast and guy wires must be secured directly to the roof. Practically all roof structures can be divided into three sections: the supporting structure, which is actually a part of the building itself; the insulation, which tends to minimize any atmospheric changes affecting the inside temperature of the building; and the outer waterproof roofing material, which prevents water from entering the building. The supporting structure is composed of wood, steel, or concrete. The insulating section usually employed is composed of porous wood fibre or cotton, although it can be made from almost any combination of materials such as felt, cork, hair, jute, cornstocks, or other porous substances. The materials used can be pressed into rigid or flexible boards, depending upon the type of roof in which they are used.

WOOD ROOF STRUCTURE. Most small apartment houses and small commercial buildings use wood structures to support the roof. Wood is used almost universally as the supporting structure for gabled roofs on individual homes. An isometric view showing typical construction of a flat type apartment house, or commercial building roof using a wooden supporting structure, is shown in Figure 76A. A cross-section view showing gabled roof construction is shown in Figure 76B. Note that the insulation is placed between the roof boards and the outer roof in the flat

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style roof; and, if any is used in the gabled style roof, it is placed between the ceiling joists. Longer lag screws must be used in the flat style roof to make sure that they adequately penetrate the roof boards to secure the mounting flange or guy wires. If they penetrate only to the insulation section of the roof, it will not offer a sufficient base to hold the antenna and mast in place. Always check to see how many layers of roofing and insulating material are present before deciding what length lag screws to use. The old roofing material is not always removed before a new layer is applied. Some roofs may be encountered that have as many as 4 or 5 thicknesses of outside roofing material.

CONCRETE ROOF STRUCTURE. Concrete roof structures will be found on large commercial buildings and large apartment houses. Figure 77A is an isometric view of a concrete roof structure. The whole roof is of a concrete slab type with steel reinforced concrete joists. A layer of felt or corkboard is placed between the concrete and the roofing material. The felt or insulating material is usually applied to the concrete by using a layer of hot tar as an adhering agent. The roofing material may be composed of built-up roofing or a layer of asphalt. Since the asphalt is hot, and in a semi-liquid state when applied to the roof, it is an easy matter to embed a layer of pebbles over the asphalt to give it longer wearing qualities and added protection from people walking on the roof. Always ascertain what type of roof the antenna is to be mounted on, so that the proper kind of anchor bolts can be employed.

STEEL ROOF STRUCTURE. Like concrete roof structures, steel roof structures are found on large apartment houses and commercial buildings. A base of steel plates covers the steel I beams that are used as roof joists. (Figure 77B.) When heavy antenna arrays or masts are used, it may be necessary to drill holes through the plates. A felt or corkboard insulation section is tarred

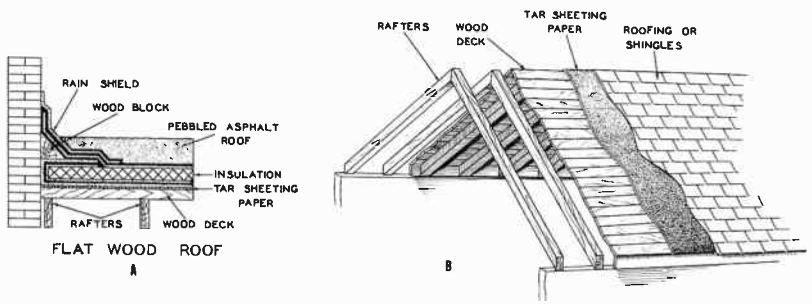

Fig. 76. Typical Wooden Roof Structure.

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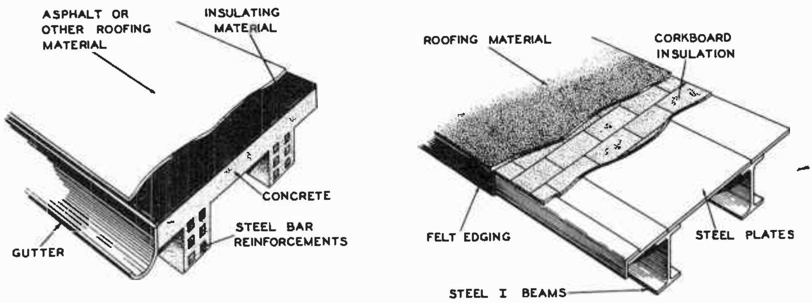

Fig. 77. Concrete and Steel Roofs.

on the steel plates. A pebbled asphalt roofing is placed over the insulating section for weather-proofing.

MISCELLANEOUS ROOF COATINGS: The most common roof coatings are given above. All outer roofs are placed on wood, concrete, or steel supporting structures. Other types of outer roofs which might be encountered are:

1. Copper-coated roofs.

2. Tile or slate roofs.

3. Galvanized steel or aluminum plate roofs.

WALL STRUCTURES: The wall is the best position to locate an antenna in order to prevent possible damage to the roof of the building. The antenna, in many cases, is much easier to install on the wall than on the roof, thus reducing both the installing time and the cost.

The various types of building walls that an antenna installer might have to work upon are wood, brick, brick veneer, stone, stone veneer, tile, cement block, and stucco. An isometric view of each is shown in Figure 78 so the serviceman can better understand their construction.

From the standpoint of installation, building walls can be grouped into four general categories. They are wood, veneer, hollow material, and solid material walls.

WOOD WALLS. Wooden walls are the easiest type of wall on which an antenna can be installed. They consist of an outer wall of lap siding or plain vertical siding, a layer of tar paper, an inner sheathing of 1x6 inch tongue and groove siding, and vertical

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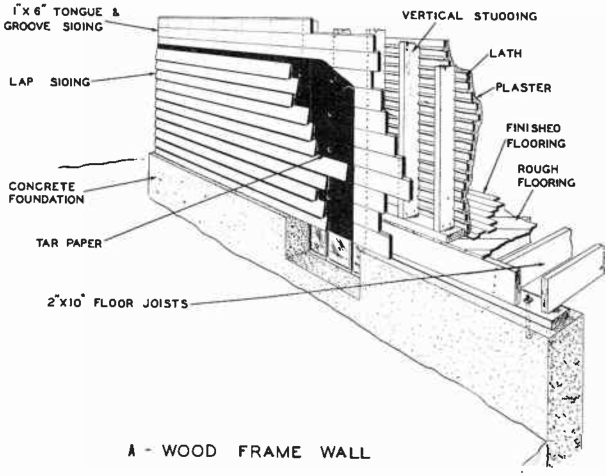

Fig. 78. Wall Structures.

2x4 inch or 3x4 inch studdings. A layer of rock wool insulation may be placed between the studding in the area between the plaster inner wall and the wood outer wall if the climate requires it. The amount of insulation and the size of the vertical studdings depends on the regional location and the size of the building. The antenna can be mounted on a wooden wall with wood or lag screws or by drilling holes through the wall and using bolts and nuts. If wood or lag screws are used, it is not necessary to go in the buyer's attic.

VENEER WALLS. A veneer wall must have a framework composed of vertical studdings to support it. The supporting structure is constructed in the same manner as the supporting structure for wooden walls. A sheathing paper is placed between the studding and the veneer material. Metal ties or brads are embedded in the mortar between the veneer bricks or blocks. The metal ties are nailed to the wooden studding to hold the veneer wall in place. The brick and stone used in veneer walls vary in thickness between 1-1/2 and 4 inches, depending on the particular height and size of the wall in which it is used. If the installer finds the veneer wall is less than 2 inches thick, holes should be drilled completely through it and bolts and nuts used to hold the mounting base to the wall. One must be able to gain access to the attic to accomplish this. When the walls are over 2 inches thick or no attic is present, special masonry anchors can be employed.

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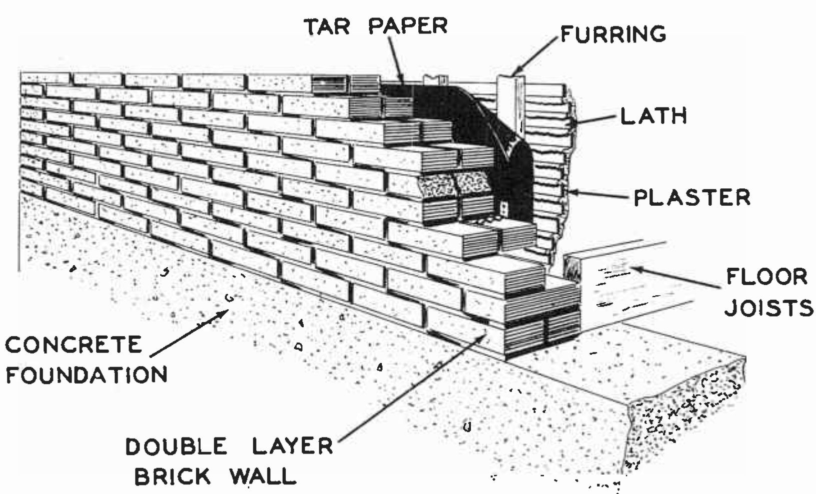
Stucco walls consist of an outside layer of stucco cement plastered on metal or wood lath. The lathing material may be nailed directly to the studding, or it may be nailed to 1x6 inch siding covering the studdings. In some cases, stucco has been placed directly over the lap siding of a wooden house. Lag screws should be used to fasten the antenna mounting base to a stucco wall. When the stucco lath is connected directly to the studding, the mounting base should be located at a position where the lag screws can be secured in a studding. If there is an inner wood wall under the stucco, the mounting base can be located anywhere on the wall.

HOLLOW MATERIAL WALLS. Building tile and cement blocks are made a sufficient width to make a wall self-supporting, if it is not over two stories high. If the inside wall is plastered, 2x2 inch, or 2x4 inch studding may be used between the plaster lath and the block to give a dead air space for reducing dampness in the dwelling. Cement blocks usually contain three hollow sections, as shown in Figure 78. The holes for the mounting bracket anchors should be drilled at the junction of two blocks to use expansion masonry anchors. If a hole is drilled through the outer wall of a block into a hollow section, a wing toggle bolt or toggle screw anchor can be used.



B. BRICK WALL

Fig. 78. Wall Structures.

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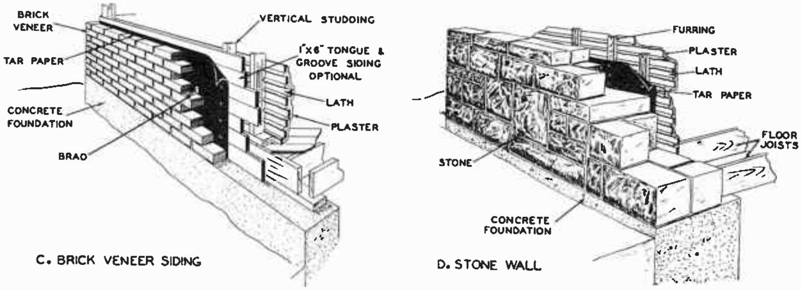

Fig. 78. Wall Structures.

SOLID MATERIAL WALLS. Brick, stone, and cement walls are entirely self-supporting in smaller apartment houses and single-family dwellings. In large apartment houses and commercial buildings, a steel framework may be employed to reinforce the walls and roof. Brick and stone walls vary from 8 to 20 inches in width, depending upon the height and length of the building. Wall thicknesses for certain heights and lengths of the building are usually governed by city building codes. In any event, the walls are too thick to drill holes through to mount the antenna with bolts and nuts. Expansion masonry anchors, therefore, must be employed.

PRELIMINARY INSPECTION: There is a great deal of information which the serviceman must obtain before he attempts to install an antenna for a television receiver. These details can sometimes be obtained from the purchaser when he is in the store to buy his new receiver. In most cases, (when the location is not familiar to the installer) it is necessary to make a preliminary inspection of the premises where the installation is to be made. The serviceman must first ascertain whether or not he is permitted to install the antenna on the roof. If the purchaser rents the house or apartment, it is imperative that the installer obtain permission from the owner of the building to place the antenna on the roof. Sometimes city building codes forbid their erection. The installation authorization can best be obtained by having the set buyer contact his landlord to obtain this permission. In some cases, when permission cannot be obtained, it is necessary to return to the building to take down the antenna and install it elsewhere. At a recent hearing in Cleveland, Ohio, a court ruled that a tenant could be evicted for having an antenna placed on the roof without the building owner's consent. In this particular case, the owner had forbidden the erection; but the tenant had the antenna installed anyway.

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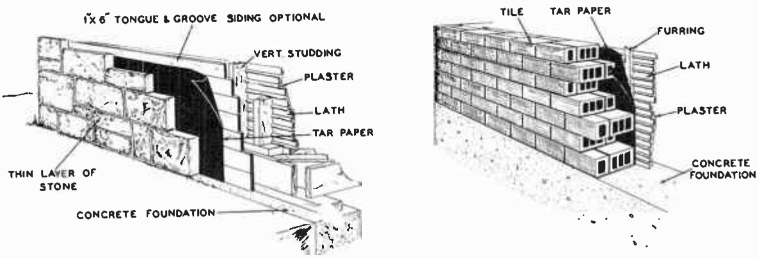

E. STONE VENEER WALL

F. TILE WALL

Fig. 78. Wall Structures.

The serviceman should ascertain where the receiver is to be installed in the house, making sure that it is in a shaded portion of the room where direct rays of sunlight do not reach the viewing screen and dim the picture. Usually, the owner and his wife will have a position in the room picked out where they wish to place the receiver. It is sometimes necessary to tactfully change their minds, as far as the location of the receiver is concerned, so that the set will give them a picture that appears brighter and easier on the eyes. Each suggestion for a change in location should be accompanied by a reason so that the owner is always fully informed as to why the change was made.

The serviceman should also note the path that the lead-in is to follow between the antenna and the receiver. From the location, it is possible to judge, within reason, just what type of antenna array is necessary and the length of transmission line that is needed between the antenna and the receiver. If the serviceman does not have a fully equipped installation truck, he should "size up the job" to see what tools he will need to perform it. Tall buildings that could cause reflected signals should also be observed in the vicinity of the installation. It may be necessary to gain access to the roof to accomplish this. If tall buildings are present, extra lengths of mast should be brought when the installation is made in order to find a point where minimum ghost signals are obtained.

All of the preliminary information and data should be noted on a separate card which bears the owner's name, address, and the type of set he is to receive. The card can be filed, serving as a reference for future installations in the same area as well as containing the information for the immediate installation.

MAST CONSTRUCTION AND EXTENSION: The size (diameter) and weight of an antenna supporting structure is dependent upon the weight of the antenna array and the height to which it must be

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elevated in order to receive sufficient signal for good reception. Most masts are constructed from aluminum tubing, steel tubing, or galvanized pipe. Wooden masts can be used, although they are somewhat more awkward in appearance than the metal mast. The antenna mast is usually placed on the roof or wall of the building in which the set is located. Wooden and steel towers are available commercially, however, if a very high antenna structure is needed for the outermost fringe area installation. They are generally mounted on the ground instead of on a building.

Most commercial antennas come in kit form with a 5 to 8 foot mast and a mounting base included. The length of the mast and the type of mounting base included in the kit is dependent upon the individual antenna manufacturer. This length of mast is usually sufficient for the average metropolitan installation. If a longer mast is needed to elevate the antenna in order to eliminate reflected signals from adjacent buildings, extension sections and guy wires can be added. The extension sections can be made from aluminum and steel tubing, which is available at most antenna distributors, or of adequate size galvanized pipe. Whatever type of structure is used as an antenna support should meet the following requirements:

1. It must be as inexpensive as possible.

2. It must be rigid enough to support the antenna under conditions of heavy icing and high winds.

3. It must not detract from the appearance of the building upon which it is placed.

4. It must be easily installed.

5. It must be designed in such a way that it is easily oriented for best reception.

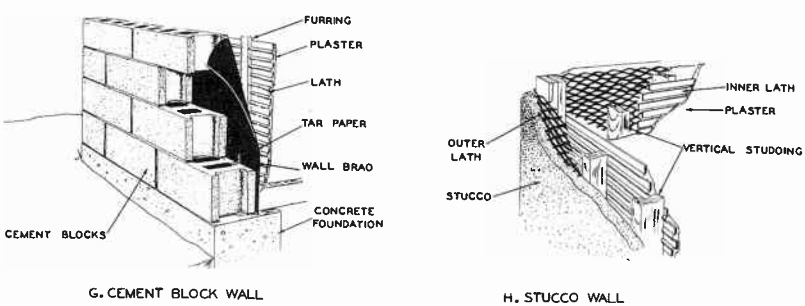

Fig. 78. Wall Structures.

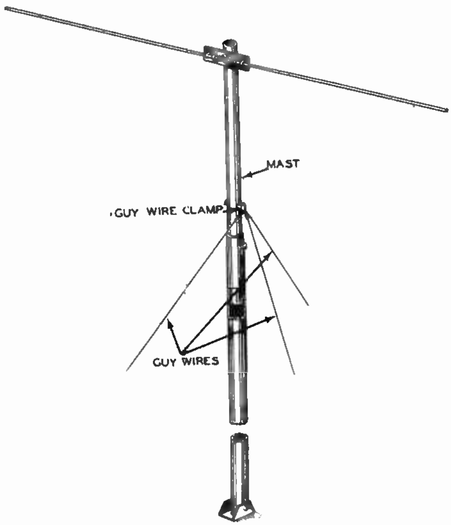

Fig. 79. An Antenna Mast Composed of Aluminum or Steel Tubing.

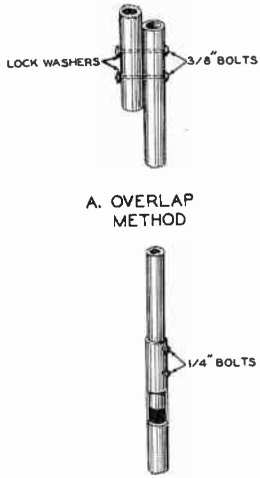

Fig. 80. Methods of Connecting Tubing.

6. It should be designed so that it does not reflect any signal to the antenna and cause ghost images.

7. It must have a mounting base that does not affect the weather-proofing of the roof.

Mast sizes for various elevations and weights of antennas are given in each sub-section on mast construction that follows. It is understood that each mast has an adequate sized mounting base and is properly guyed according to the information which is given in the guy wire and mounting base sections.

TUBING-TYPE MASTS. (Figure 79.) Masts constructed of either steel or aluminum tubing are the lightest, and the easiest to install, of all the types of antenna structures. If the antenna array does not weigh over 10 pounds (most commercial single stack arrays do not), and the antenna is not elevated over 8 feet, tubing with a one inch diameter is sufficiently rigid. If the antenna is heavier than 10 pounds, and is to be elevated between 8 and 16 feet, tubing with a 1-1/4 inch diameter should be used. Tubing can be purchased in wall thicknesses that vary from 1/16 to 3/16 inch. Some have the same thickness as pipe, and can be threaded with

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pipe dies for use with pipe couplers to join two sections of tubing together. Do not attempt to cut threads on tubing unless the tubing manufacturer recommends it. Never use tubing or pipe that is too small. If the tubing has a very thin wall (1/16 inch or less), it is advisable to increase the diameter size of the tubing used by 1/4 inch to make sure the antenna will withstand high winds or the increased weight of element icing.

Most tubing comes in 5, 8 or 12 foot lengths. When it is necessary to add an extension onto a mast, the recommended way of doing it is to drill two holes about 8 inches apart at the top end of the bottom section and the bottom end of the top section, as shown in Figure 80A. An alternate method is to use a top section of mast that is slightly smaller in diameter than the bottom section. The slightly smaller top section can then be telescoped into the larger bottom section for a distance of 10 to 12 inches. Two holes, at right angles to each other and separated by a distance of 8 inches, can be drilled through the two telescoped sections so that they can be held together with bolts and nuts. (Figure 80B.) The first method, where the two pieces of tubing are placed side by side, is recommended; because it makes a very tightly bonded joint with no chance of a rocking motion. If the second method is employed, where one piece of tubing is telescoped into a larger piece of tubing, there is bound to be some rocking evident; because the tubes cannot be an absolutely tight fit. If this were the case, one could not be placed inside of the other without using a great deal of force. Another disadvantage lies in the fact that any irregularities around the outside of the small tubing and the inside of the large tubing can cause them to "hang up" when they are placed together. The second method, if it is used at all, should only be used on seamless tubing. If this process were attempted on seamed tubing, the rocking action of the smaller top unit might cause the seam to break open and spread apart.

PIPE MASTS. (Figure 81.) Pipe, while heavier in weight than aluminum or steel tubing, makes a more secure mast, especially if it is to be more than 20 feet in height. Galvanized pipe should be used for this purpose so that it does not rust when exposed to the air. If it is necessary to use black pipe (unprotected), the pipe should be painted both inside and out with a base coat of redlead paint and a finishing coat of aluminum paint. As in tubing, the height of the antenna and the weight of the array are the factors which determine the size of pipe to use. If the antenna is to be from 5 to 8 feet long, a 3/4 inch pipe will suffice. For distances between 8 feet and 16 feet, a 1-1/4 inch pipe will suffice. It is not necessary to use 1-1/4 inch pipe for the complete length of the mast, but only for the base section. If 8 foot lengths of pipe are used, the bottom section can be 1-1/4 inch pipe, and the top

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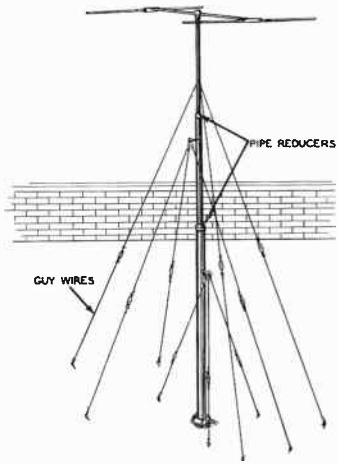

Fig. 81. A 30 Foot Mast Constructed of Pipe.

section can be 3/4 or 1 inch pipe. They can be coupled together with a comparable reducing coupling. For lengths between 16 feet and 25 feet, the bottom section of the pipe should be at least 1-1/2 inches in size. Three sizes of 8 foot pipe can be used, reducing from 1-1/2 to 1-1/4 to 1 inch. For masts from 25 feet to 40 feet, a pipe of at least 2 inch diameter must be employed. Four sections of reductions can be employed with this type of antenna (2, 1-1/2, 1-1/4, and 1 inch). Heights greater than 40 feet demand the use of a tower, because it is impractical and unsafe to attempt to make a single mast construction to be placed on the building. The problem of raising an antenna over 40 feet in height from a horizontal position to a vertical position is unsurmountable unless a special A-frame or a crew of 4 or 5 men is used.

When constructing an antenna from pipe, always thread the pipe with the maximum number of threads. If only a few threads are cut on the pipe, there is not enough bearing surface between the pipe and the coupling. This can cause the pipe to break at its junction with the coupling whenever stress is imposed on the mast. The approximate length that the pipe should be threaded can be found by measuring half the length of the coupling.

WOODEN MASTS. A 2x2 or 2x3 inch wooden mast will support a 10 pound antenna array to an elevation of 10 feet, if it is properly guyed. The antenna array can be connected to the wooden mast by means of a U clamp and wood screws, as shown in

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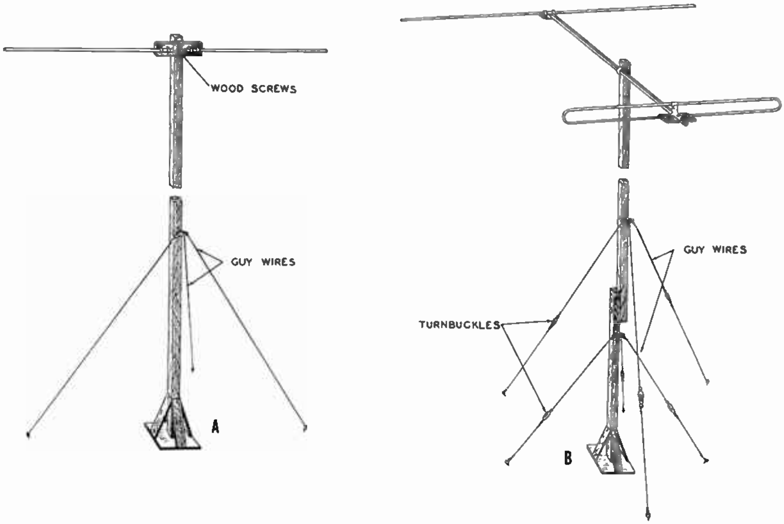

Fig. 82. Masts Constructed of Wood.

Figure 82. An antenna can be elevated to a height of approximately 19 feet by the use of two lengths of 2x4's. The sections can be bolted together by two 1/2x6 inch carriage bolts. The two 2x4's should overlap each other by at least 10 inches, and the bolt holes should be separated by 8 inches. The best types of wood to use for this purpose are white pine or cypress. If these are not available, yellow pine or redwood will suffice.

TOWERS. Steel and light-weight wood antenna towers are available from commercial sources. Practically any length and size tower can be purchased. The serviceman should not attempt to build his own tower unless he is thoroughly familiar with structural design. Commercial television receiving towers are designed for simplicity of construction and installation. The manufacturers send complete instructions for the construction of their towers. In many cases, they will send an erection crew to the installation location to install the antenna for the serviceman. Figure 83 illustrates two types of commercial television receiving towers for outermost fringe areas.

GUY WIRES. The use of sufficient guy wires on antenna installation is, perhaps, the most important part of keeping the antenna erect in heavy winds and gales. Any antenna over 10 feet in height must be guyed. Usually, when an antenna is mounted on a wall, it does not require guy wires. Of course, this does not hold true if the antenna is over 10 feet in height. It will then be

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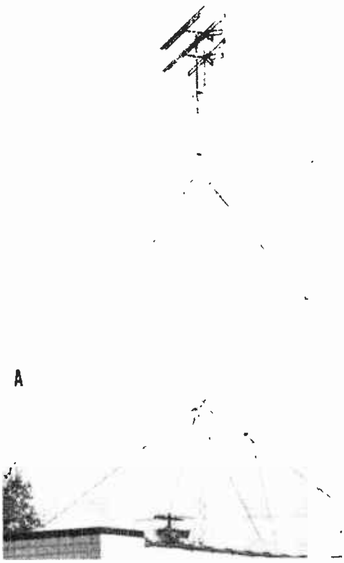

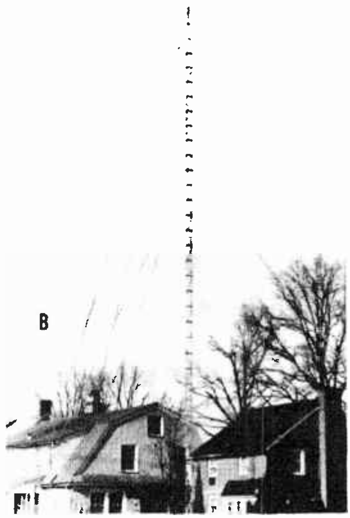

Fig. 83. Commercial Antenna Towers. (A) Courtesy A-1 Radio Tower Co. (B) Courtesy Wind Turbine Co.

necessary to guy the antenna to some point off the roof or else move the antenna to the roof. There are many factors which decide the number of guy wires that should be used:

1. The strength and rigidity of the mounting base anchor.

2. The length of the mast.

3. The size (diameter) of the mast.

4. The weight of the antenna.

5. The wind resistance of the antenna and mast.

6. The ice load which the array has to carry.

Generally speaking, one group or layer of guy wires is sufficient for antennas between 10 and 20 feet. For antennas that are between 20 and 30 feet high, two groups of guy wires should be used. If the antenna is between 30 and 40 feet high, three groups are necessary.

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There are two methods of attaching the guy wires to the mast. One method is to purchase special guy wire clamps of the appropriate size. (Figure 84A.) This type of clamp slides over the mast and is held in place with bolts. An alternate method is to drill a 3/8 inch hole through the mast and use an eye-bolt and nut. (Figure 84B.) The guy wires can then be attached to the eye-bolt for antenna support.

The size of the wire used for guying purposes is dependent upon the weight of the antenna and the length which the guy wire must be run. No. 10 solid aluminum wire is recommended for use as guy wires, if the antenna array is over 20 feet in height. It can be purchased in any hardware store, because it is commonly used for clothes-lines. It is recommended because it does not kink readily and is easily bent. Many installing companies located in metropolitan areas, where antennas do not exceed 10 or 15 feet, use No. 18 or 20, 7-strand, steel wire. Solid copper or steel wire is not recommended; because solid copper wire is easily broken, and solid steel wire is hard to bend and, if bent, easily broken.

If it is necessary to run the top guy wire closer than 9 feet from the antenna itself, the guy wire should be broken at a point approximately 3 or 4 feet from the mast and an insulator inserted. This prevents the guy wire from reflecting any signal to the antenna which might cause ghosts. However, this is only required if the top guy wires are less than 9 feet from the mast. The 9 foot value is used because it is greater than one half wavelength at the lowest television frequency. As long as the guy wires are kept a greater distance than one half wavelength from the antenna, they

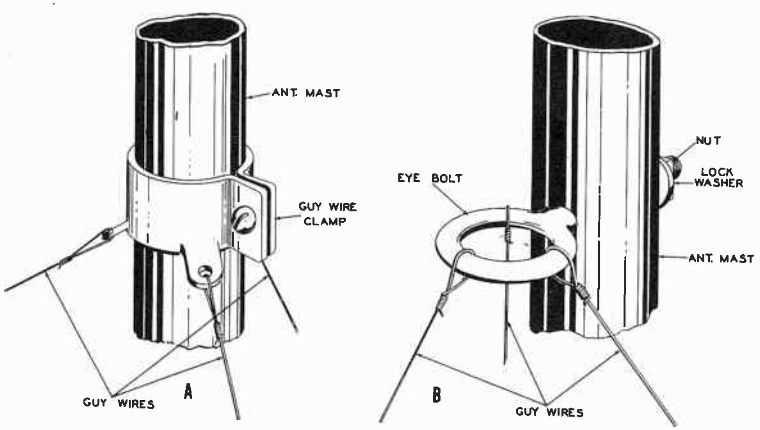

Fig. 84. Methods of Attaching Guy Wires to a Mast.

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will have negligible effect as far as ghost reflections to the antenna are concerned.

Turnbuckles must be used with the guy wires so they can be tightened to keep the antenna from swaying. (Figure 85.) For antennas less than 15 feet in height, 3 inch turnbuckles (extended length) can be used. If the antenna is higher, making the guy wires longer, a turnbuckle which will take up more slack in the guy wire is needed to make the antenna rigid from all angles. A 6 inch turnbuckle (extended length) should be used in these instances.

Three guy wires per group are sufficient for the average antenna and mast. For the most secure mooring, they should be mounted to the building at a distance from the base of the antenna that is equal to the height of the guy wire connecting point on the mast. This means that the guy wire forms a 45° angle with the mast. (Angle A, Figure 85.) The three building mooring points should be an equal distance apart (120°) for mast load equalization on the guy wires. If two of the three mooring points are placed too close together, the load is unbalanced; and the antenna might fall in the direction opposite the point where the guy wire should be secured. The size of the angle A is not too critical as long as it is not reduced to an angle of less than 20°. When it is smaller than 20°, the wind creates too much of an upward thrust on the building mooring point, and it pulls loose. When more than one group of guy wires is needed for a higher antenna, they should be staggered with respect to each other as is shown in Figure 86.

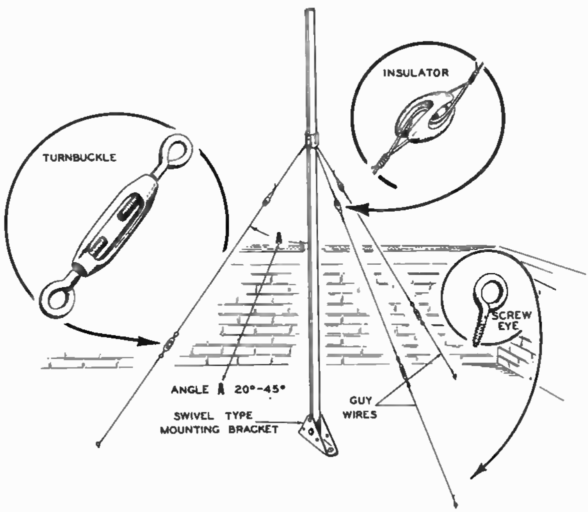

Fig. 85. Guy Wire Installation.

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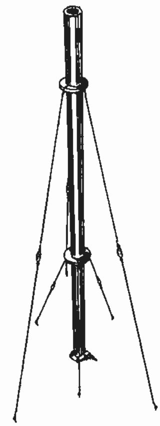

Fig. 86. Staggering the Guy Wires for a Better Installation.

A heavy mast and stacked antenna array demands the use of 4 guy wires to a group. The mooring points should be located at approximately 90° angles from each other to assure a secure installation.

MOUNTING BASES: The type and style of the mounting base used is dependent upon the weight of the mast and the antenna, and their position on the building. A mounting base adequate to hold a short mast and small antenna is usually included in each commercial antenna kit. Some mounting bases are designed for universal mounting (that is, they can be adjusted to any angle), while others are for roof or wall mounting only. In some installations, it is necessary to mount the antenna on the chimney or some other location where the mounting bracket cannot be used. The bases sent with the kits are generally designed to hold only a short length of antenna mast. When it becomes necessary to increase the height of the antenna, the mast base is not sufficiently strong to hold the elevated antenna. In many cases, the serviceman must design his own mounting base to fit a particular installation, or purchase a special commercially-built one that meets the requirements.

One general rule to follow in the installation of mounting bases, as well as all antenna construction, is to paint all bolts, screws, and nuts after they have been tightened, to prevent them from working loose as a result of vibration and antenna rocking after a period of time.

CHIMNEY MOUNTS. There are several manufacturers of chimney mounting brackets. Basically, most of their products

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are similar and vary only in clamp and adjustment design. A typical chimney mounting bracket is shown in Figure 87. Due to the band-like construction of the mount, it is mounted without drilling holes into the chimney proper. The bracket can be adjusted for size, placed around the chimney, and tightened ready for the mast to be inserted in less than 15 minutes. The flexible retaining straps can be adjusted to the size of the chimney by changing the position of bolt A. Nut B is then tightened to draw the strap to the chimney. The two supporting sections can be separated as desired to hold the antenna more securely. This mount will support up to 10 feet of mast without guying, if the two supporting bands of the mount are separated by two feet, and the antenna does not weigh over 5 pounds. The bands are constructed of stainless steel, and the mast plate is constructed of aluminum alloy. A U bolt holds the antenna mast to the plate. Extended mounting plates allow the use of this bracket with overhanging chimney tops.

An alternate method of mounting an antenna to a chimney is shown in Figure 88. Two 1/2 inch holes are drilled in the bottom and top of the chimney to allow for the securing of mounting brackets. These brackets are fastened to the chimney by means of masonry anchors. The space between the brackets is governed by the height of the antenna. There should be one foot between the brackets for every 3 feet of antenna mast above the upper bracket. This bracket is stronger than the type which does not mount into the chimney, because there is less chance of its giving slightly and permitting the antenna to sway or rock. This style bracket is available commercially. The bottom bracket is fitted with extendable sides so it can be adjusted to fit an overhanging chimney. It is constructed of 1/4x1 inch cold-rolled galvanized steel.

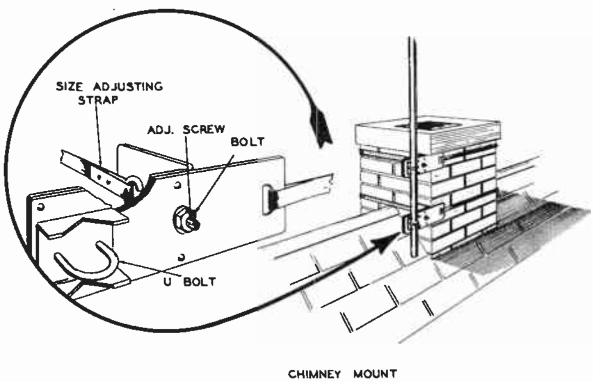

Fig. 87. Strap Chimney Mount. (Courtesy Telrex, Inc.)

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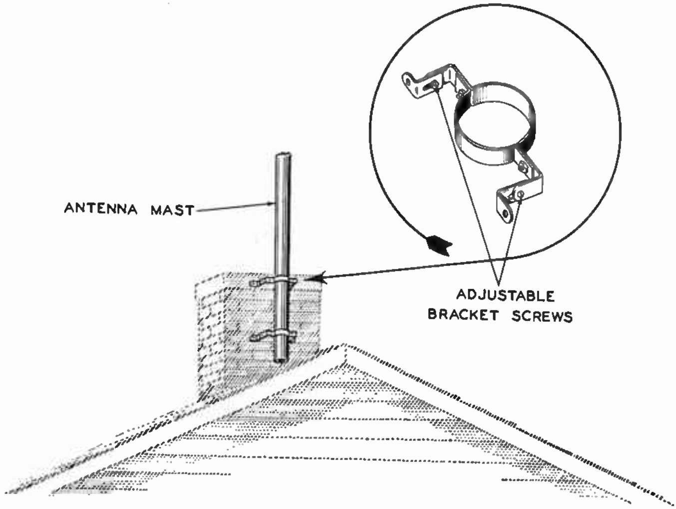

Fig. 88. Bracket Chimney Mount.

The antenna should always be elevated at least 3 feet above the top of the chimney to prevent the combination of heat and gases from corroding the antenna elements.

WALL MOUNTINGS. Figure 89 shows a wall-type of mounting bracket. This type of bracket is very useful for mounting in the peaks of a gabled roof. A U bolt clamp holds the antenna mast to the mounting bracket. The bottom bracket, which has the two braces, carries the weight of the antenna. The other bracket acts as a support to prevent antenna sway. The bracket is designed to be of 3/8x1-1/4 inch galvanized steel with reinforced angles. The physical dimensions of the bracket are given in Figure 89.

When a wooden mast is used, it can be connected directly to the side of the building by bolts, if the building is wood, or by metal braces and masonry anchors, if the building is brick or stone. Figure 90 illustrates a wood mast mounted on a brick wall by means of metal braces. The dimensions of the bracket used are entirely dependent on the size of the antenna and the particular installation. Recesses in walls, projected eaves, or wall parapets govern the choice of the bracket as far as size is concerned.

If the serviceman wishes to make his own mounting brackets, he should be sure they are made of sturdy material. On the other hand, they must not be made too large and awkward looking so as to mar the appearance of the set owner's residence. Small

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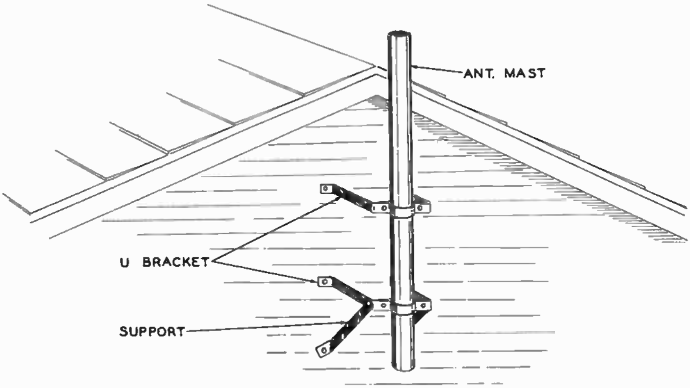

Fig. 89. Wall Type Mounting Bracket.

angle iron, or 3/16x1-1/4 inch cold-rolled galvanized straps are ideal to work with. It is desirable to use U bolt type clamps in the construction of any bracket. It allows for antenna orientation, because the clamp can be tightened just enough to hold the mast in place and yet permit freedom of rotation so the antenna can be turned to give the best signal reception. When best reception is obtained, the U bolt can be tightened, thus securing the antenna in its permanent position.

UNIVERSAL MOUNTING BASES. A universal mounting bracket is shown in Figure 91. It is constructed of 1/8 inch cold-rolled steel and is capable of supporting a 10 foot mast if the antenna array does not exceed 5 pounds. To do this, the bracket must be mounted in the most secure manner to the wall, eave, or

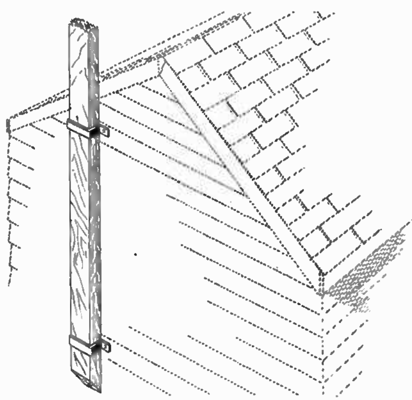

Fig. 90. Wooden Mast Mounted on a Wall with Metal Brackets.

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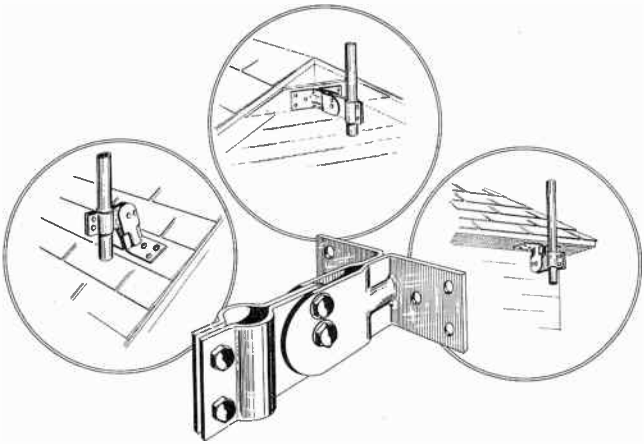

Fig. 91. Universal Mounting Bracket.

roof. The adjustable outer plate containing the mast bracket can be moved through 180° of rotation with respect to the mounted base plate section. When the antenna has to be mounted on a stone or brick wall, the base can be secured to a 2x4 inch block of wood, which in turn is attached to the brick or stone with masonry anchors. No guy wires are needed with this mount if the antenna height and weight are kept within the specified limits.

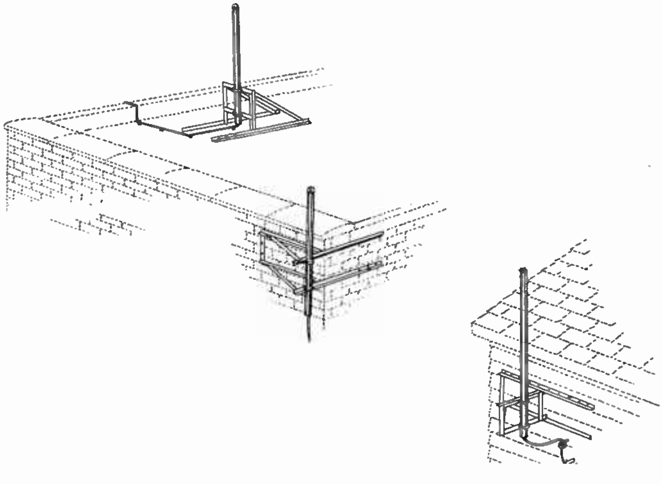

Fig. 92. Angle Iron Universal Mounting Bracket.

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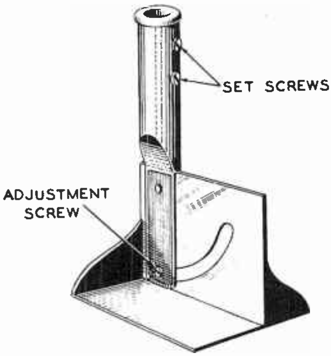

Fig. 93. Socket Type Universal Mounting Bracket.

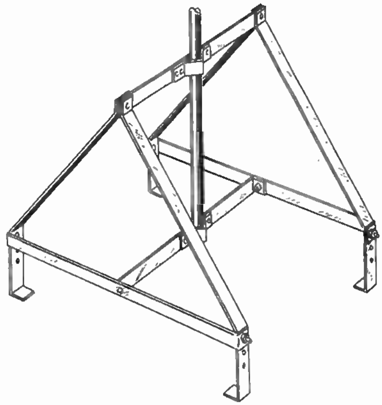

Fig. 94. Bracket for Mounting an Antenna on a Parapet or Fire Wall.

Another type of universal mounting bracket is made up of galvanized cold-rolled angle irons welded together in the form shown in Figure 92. This type of base has the advantage of presenting a large surface to the point where it is mounted, thus keeping sway and rocking action to a minimum. Two U bolts are included. The angle irons to which the antenna must be mounted for various types of wall, corner, or roof installations are already drilled, so the U clamp need only be placed in the proper holes and tightened to hold the antenna. This type of bracket is designed to hold 1 inch pipe or 1-1/4 inch tubing. If a light antenna is to be installed, this mount can be used to secure a 15 foot mast without guy wires.

Figure 93 illustrates a universal mounting bracket that is designed for installations on a gabled roof with any degree of pitch, walls, or chimney. The socket takes any size mast up to 1-1/4 inches and will securely hold an average antenna 10 feet in the air without guy wires.

PARAPET MOUNTING BRACKETS. It is sometimes more advantageous to mount the antenna on the fire wall or parapet rather than the side of the building or roof. Figure 94 shows a commercially available parapet mounting bracket. It is composed of 1-1/2x3/16 inch galvanized cold-rolled steel. The dimensions of this bracket are given in Figure 94. It is impossible to use guy wires when the antenna is mounted on the parapet or fire wall, because the antenna can be guyed from only one side.

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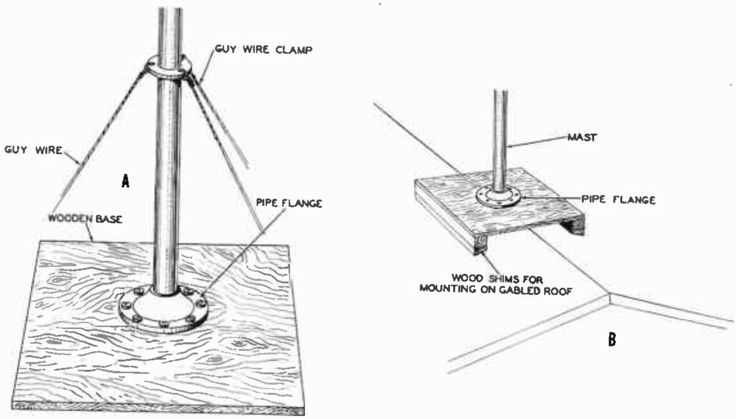

Fig. 95. Wooden Block and Pipe Flange Roof Mounting Antenna Base.

ROOF MOUNTING BASES. When an antenna is to be located on a flat roof, a pipe flange and a block of wood can be used without puncturing the surface of the roof. (Figure 95.) No retaining screws are needed, because the large area of the wood block offers enough friction against the roof to hold the bottom of the mast in place. When a pipe mast is used, it should be threaded into the pipe flange. When tubing is used, the pipe flange size should be chosen so that it must be forced on the tubing. The downward thrust of the guy wires and the weight of the mast and antenna maintain the block firmly against the roof. The block size should be at least 8x8x2 inches. A similar system can be used on the peak of a gabled roof by adding sections to the bottom of the block so that it will fit over the downward sloping sides of the roof. (Figure 95B.)

Figure 96 illustrates an inexpensive mounting that can be used with masts of short lengths for mounting on gabled roofs. The angle the base makes with the roof can be set to almost any point, permitting it to be used on any pitch of roof. The mast can be moored to the chimney, as illustrated, or guy wires can be used to keep the mast erect. Wood screws secure the base to the roof. Always place a coating of tar around the base and over the screw caps to keep rain from entering.

WINDOW MOUNTING. For metropolitan installations on tall buildings, where no master apartment house antenna system has been installed, it is advantageous to use a window mount because of the large signal attenuation which occurs in a long transmission

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line. With the antenna mounted on the window sill just outside the room where the set is located the transmission line is very short, giving minimum attenuation. A supporting section consisting of an elbow and pipe nipple is used on the end of a short length of 3/4 inch pipe to allow for orientation of the antenna. (Figure 97.) This combination is secured to the window with a pipe flange and anchor screws to prevent leaks. If sufficient signal strength cannot be obtained with the antenna mounted on the window, an RF signal booster (pre-amplifier) can be used to give added gain.

ATTIC MOUNTING. With new, high gain receivers, the antenna can be mounted in the attics of buildings with gabled roofs if the set owner wishes, providing the building is not located too far from the transmitter. Practically any type of mounting bracket and small antenna can be used for this purpose; because the antenna is located inside, removed from the wind and the effects of icing. Bed-springs and other metallic furniture are often stored in the attic. They can act as a shield to attenuate the signal, or as a reflector to inject ghosts in the antenna if they are close enough to it. Be sure no large metallic objects are closer than 10 feet to the antenna.

Caution must be observed when walking about attics, because they often have no floor over the ceiling joists. The only way to move about is to step from ceiling joist to ceiling joist. It is a good idea to have a few 60-inch lengths of planks to place over the joists to keep from stepping through the lath and plaster ceiling under the joists. These planks can also be useful when it is necessary to go into the attic for tightening bolts on wall-mounted antennas. Figure 98 shows typical attic installation.

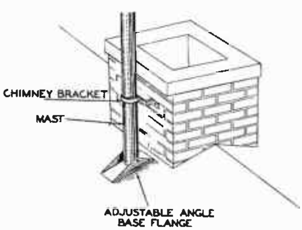

Fig. 96. A Base for Mounting Light Antennas on Gabled Roofs.

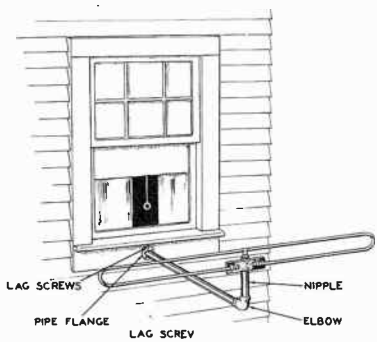

Fig. 97. Window Mounted Antenna.

METHODS OF SECURING MOUNTING BRACKETS AND GUY WIRES: A description of roof and wall structures has already been given so the serviceman can better understand their construction when they are encountered on an antenna installation. It is essential that the mast mounting bracket and guy wires be securely mounted to the building to prevent the antenna from rocking or falling and damaging a portion of the building. Never underestimate the sizes of materials needed for securing an antenna. If there is any doubt in the serviceman's mind, he should use bigger size screws, anchors, or whatever he is unsure about.

WOODEN WALLS. Wood screws can be used to mount light antenna brackets on wooden walls. If a heavier antenna is used, lag screws must be employed. 5/16 or 3/8 inch screws, 2-1/2 inches long, are large enough for the average antenna installation, if the mast is not over 15 feet high. If the antenna is mounted on the peak of a gabled roof, or at any point where there is access to both sides of the wall through the attic, bolts and nuts should be employed. 3/8 or 1/2 inch machine bolts should be used for this purpose. They are necessary when a very heavy antenna or high mast is used. They make a more secure mounting, because they offer more bearing surface.

BRICK, CONCRETE, OR STONE WALLS. Lag screws cannot be used for brick, stone, or concrete walls. Bolts often cannot be used, because the inside wall is frequently plastered at the point where it is necessary to drill a hole. Therefore, some other means must be employed to secure the antenna bracket or guy

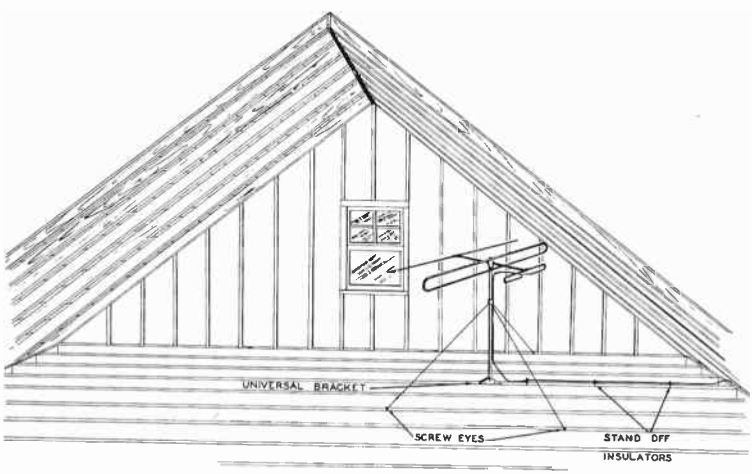

Fig. 98. A Typical Attic Installation.

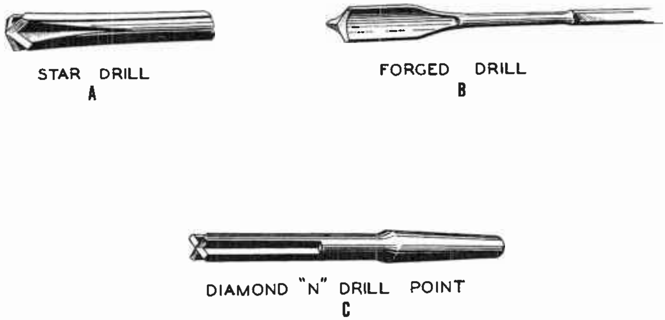

Fig. 99. Masonry Drills.

wires to a wall composed of these materials. A variety of anchor bolts is available for this purpose.

Special drills must be used to cut holes in masonry materials. A masonry drill, unlike an ordinary wood or steel drill, has 3 or 4 sharpened flutes on the point end instead of being twisted. Masonry drills have become known as star drills, because one of the most popular masonry drill manufacturers calls its drill the Star drill. Three kinds of masonry drills are shown in Figure 99. The hole in the masonry is not drilled in; but, instead, it is hammered away by the drill point. When the spot for the hole is chosen, the drill point is placed against it, and the other end of the drill is hammered with an ordinary hammer. In other words, the action is similar to a pneumatic type drill that is used to penetrate cement streets when they are broken up. During the cutting operation, the drill should be turned in the hole so that the cutting edges of the drill hit the entire surface in the end of the hole.

Special spring-type drill hammers are available to use with masonry drills. (Figure 100.) Their action simulates the pneumatic drill principle with a spring. They are relatively simple to operate and are inexpensively priced. Special drills with tapered shanks can be purchased for use with the spring hammer drill. (Figure 99C.) Drill handles are also obtainable for holding the drills in place when they are being hit with a hand hammer. They are shaped to fit the palm of the hand and keep the end of the drill from being pounded out of shape from continuous hammering.

When the outer wall is made of veneer or extremely soft, common brick, it is advisable to use toggle screw anchors, if bolts and nuts would damage the interior of the building. A 4 wing toggle anchor for walls of 5/8 to 1-1/4 inch thickness is shown in

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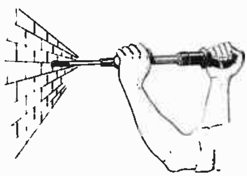

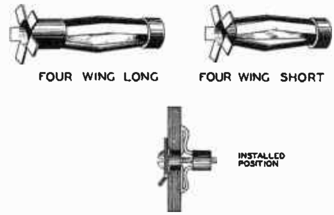

Fig. 100. Spring Hammer Drill.

Fig. 101. Toggle Screw Anchor.

Figure 101A. A 7/16 inch hole must be drilled in the wall and the toggle anchor put in place. A 10x24 machine screw is fastened in the hole to the inside threaded end of the anchor. Any bracket can be firmly attached to the building by placing it between the machine screw and the building. As the screw is tightened, the wings spread outward against the inside of the wall, as illustrated in Figure 101B.

A different kind of winged toggle bolt is illustrated in Figure 102. These toggle bolts can be purchased under the trade names of Paine, Wrigley, or Sprinin. 3 to 6 inch bolts are available for various thicknesses of walls. An appropriate sized hole (usually 1/2 inch) is drilled in the wall. The bolt and winged nut are attached to the bracket, and the bolt with closed wings is inserted far enough into the hole to allow the wings to spring open. The bolt can then be tightened, mooring the bracket firmly to the wall.

Expansion screw anchors must be used when it is impossible to drill completely through the building material (thick, hard brick, concrete, or stone). An expansion screw anchor is made from a special conical, tapered, copper nut encased in a soft lead sheathing. A hole is drilled in the wall to a depth that will accommodate the anchor. For an average-to-heavy weight antenna, drill a 1/2 inch hole, 7/8 to 1 inch deep. The anchor is then lightly driven into the hole with the setting punch illustrated in Figure 103B. A 1/4 inch bolt with 20 threads per inch can be threaded into the copper nut. As the bolt is tightened, it draws the tapered, copper nut forward into the lead sheathing. This causes the lead to expand and make a firm mechanical connection with the side of the hole.

Figure 104 illustrates another type of expansion anchor that is used with lag screws. The anchor consists essentially of a soft lead plug that is threaded on the inside to fit the tapered thread of

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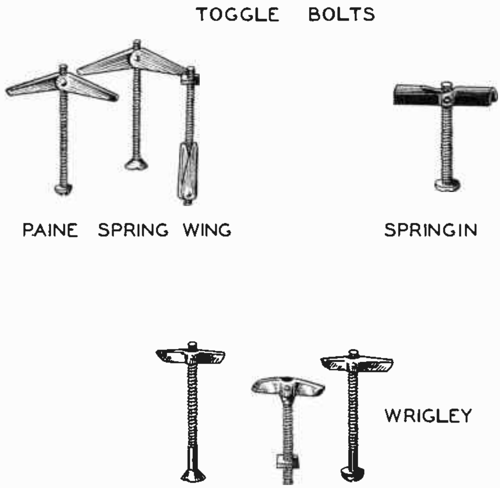

Fig. 102. Winged Toggle Bolt.

a lag screw. A 1/2 inch hole should be drilled 1-3/4 inches deep in the masonry, and the anchor should be placed in the hole. The lip of the anchor is slightly oversize to keep the anchor from going all the way in the hole. A 5/16x1 inch lag screw should be threaded into the anchor and tightened. The anchor will expand and hold to the walls of the hole.

It is not advisable to use masonry nails for anchoring antennas; because there is always some rocking action present, which will, in time, pull the nail loose. They are basically designed for use with constant loads.

LIGHTNING PROTECTION: Any ungrounded, elevated antenna is a lightning hazard. If grounded (by means of a lightning arrestor), the chance of fire and damage caused by lightning is kept to a minimum. It is the duty of the serviceman to use lightning arrestors for the protection of the set owner's building. Many service guarantees stipulate to the set owner that adequate lightning protection has been furnished in the antenna installation on the building. Insurance companies can refuse to pay damage on the building if it is struck by lightning when no approved arrestor system is employed.

LIGHTNING ARRESTORS. There is a variety of lightning arrestors made for amateur and long wire antenna use. Some are designed specifically for use with television and FM systems employing parallel wire transmission line. A lightning arrestor de-

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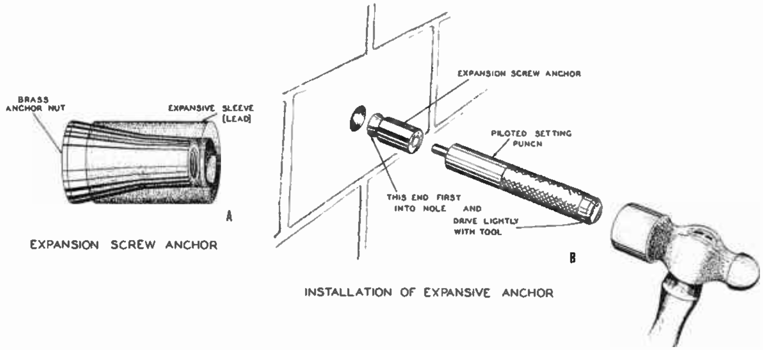

Fig. 103. Expansion Screw Anchor and Setting Punch. (Courtesy Ackerman-Johnson Co.)

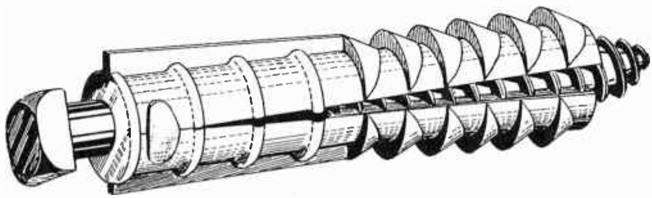

Fig. 104. Lag Screw Expansion Anchor.

signed for minimum high frequency attenuation is shown in Figure 105A. It protects both sides of the transmission line as well as the antenna mast. To connect the 300 ohm transmission line, merely remove the cap, place the transmission line in the slot provided for it, and replace the cap. It is not necessary to cut the line or remove the insulation from the conductors, because special prongs inside the cap bite through the polyethylene dielectric coating of the transmission line, making a firm mechanical connection to the wires. An adjustable ground clamp fastens the arrestor to the mast pipe. The impedance of the transmission line is not changed by this arrestor, because the conductors need not be split for attachment to the arrestor terminals.

The lightning arrestor shown in Figure 105B is also specially designed for use with 300 ohm transmission line. The polyethylene dielectric must be removed from the conductors at the point where the arrestor is to be installed. The bared wires are placed in the slot and the top bracket tightened to keep them in contact with the arrestor lugs. The arc points are hermetically sealed to prevent point carbonization. The case is made of plastic, treated to prevent dielectric losses at high frequencies.

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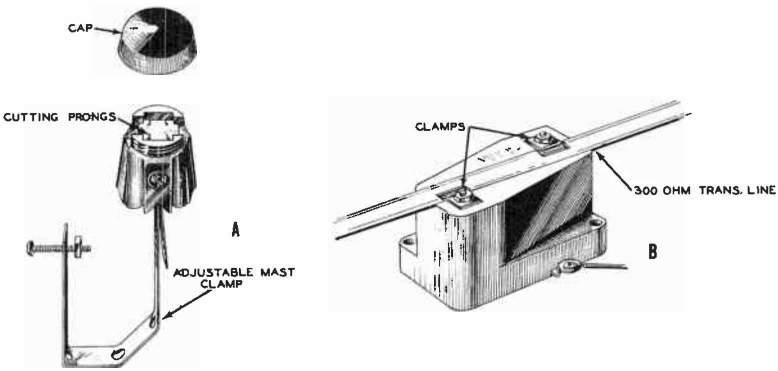

Fig. 105. High Frequency Lightning Arrestors.

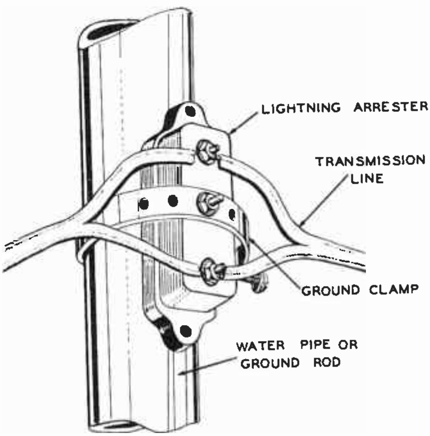

Fig. 106. Three-Terminal, Neon Lightning Arrestor Connected for Use.

If high frequency arrestors are not available or if coaxial cable is employed, ordinary 3-post, neon or argon lightning arrestors can be used. However, each should be inspected before using it for small cracks and leaks which might cause high frequency attenuation. To use this type of arrestor, the transmission line must be cut at the point where the lightning arrestor is placed on the mast. Each section should then be split for a distance of about 7 inches, and 3/4 of an inch of insulation should be removed from the ends. Connect two conductors to each outside terminal post of the arrestor. The center terminal post should be connected to the grounding clamp which surrounds the pipe mast as shown in Figure 106. If the transmission lines are spread grad-

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ually apart as illustrated, they will keep impedance change to a minimum.

The use of two-terminal lightning arrestors is not recommended, because only one side of the transmission is grounded.

GROUNDING THE ANTENNA. Care must be observed when selecting a ground for lightning protection. The ground lead from the antenna should follow the shortest path possible. Often sewer vents are present on the roof to which the ground lead can be connected. Be sure to ascertain that it is metal and not tile before using it as a ground terminal. Another good grounding point is cold water pipes such as garden hose faucets on the side of buildings. Hot water pipes, more often than not, lead to gas flame, hot water heaters and, therefore, should not be used. Unless the serviceman is sure that the pipe he wishes to use as a grounding point has an unhindered path to ground, it should not be used. Never connect to gas pipes, oil pipes, rain gutters, ungrounded vent pipes, or hot air ducts. A spark in gas or oil pipes can cause an explosion. Hot air ducts and rain gutters are usually not grounded. If no convenient ground can be found, a special spade-end stake must be purchased and driven at least 4 feet in the earth at the base of the building. A lead can then be run between the antenna mast and the stake. This lead should be kept as short as possible.

An error in installation often committed by servicemen is the placing of the lightning arrestor on the wall of the building and running the transmission line to it. A lead is placed between the center terminal and the stake to act as a ground. This method leaves the mast and antenna reflector ungrounded; because the transmission line is connected only to the driven element, and it is insulated from the mast and the remainder of the array. To overcome this condition, the arrestor should be placed on the metal mast; and a lead should be run from the bottom of the mast to ground.

INSTALLING THE TRANSMISSION LINE: There are two methods of running the transmission line down the mast to the point where it enters the building for the receiver. It can be placed on the inside of the mast, or it can be connected to offset insulators on the outside of the mast. The second way is, by far, the best if 300 ohm parallel wire line is used.

When the line is placed inside the mast, the metal of the pipe or tubing is so close to the conductor that it cuts the lines of force surrounding them and changes the characteristic impedance

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of the line. While this change may not be evidenced by reduced signals on some channels, it may materially reduce the signal on other channels. Most commercial antenna kits have holes drilled in the mast for mounting standoff insulators. They should be placed at least every 5 feet along the mast to prevent the wind or ice load from breaking the transmission line. Transmission lines often break near the antenna terminals. To prevent this from occurring, a standoff insulator should be placed one foot from the terminals. Figure 107 shows a transmission line properly moored to an antenna mast and building. The line is twisted one turn every foot to minimize stray noise pickup. When a coaxial cable is used for a transmission line, it can be placed inside the mast pipe, because the outer conductor is at ground potential.

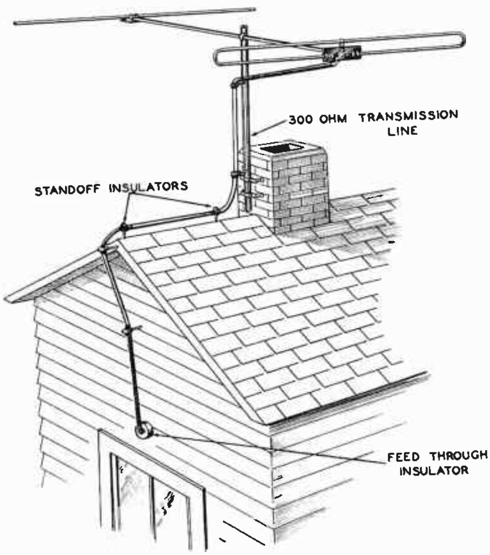

Fig. 107. Transmission Line Lead-in Installation.

Figure 108 shows the various types of standoff insulators that can be used with parallel line or coaxial cable. Both threaded and wood screw ends are available so they can be mounted on the mast or in wooden walls. If it is necessary to use a standoff insulator on a brick, stone, or concrete wall, a small block of wood can be attached to the wall and a screw type insulator used.

One of the best ways to bring the transmission line inside of the house is to bring it down the outside wall to a basement window. A hole can be drilled in the window and the line brought in. An alternate method involves the notching of a space in the top of the window just deep enough to allow the line to pass through. The line is placed along the basement ceiling to a point

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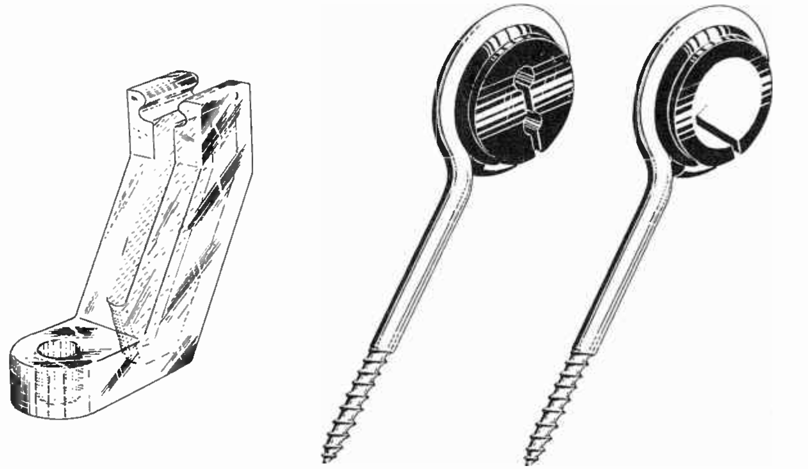

Fig. 108. Stand-off Insulators.

near where the set is to be located. A small hole can be drilled in the floor and the line attached to the receiver or a transmission line socket. While this method uses a somewhat longer transmission line, it is gratifying to the set owner to know that no holes have been drilled in the walls or main windows of his home. Another advantage to this method is the fact that basement windows rarely have storm sashes, a point which must be taken into consideration when bringing the transmission line through a main window.

As stated above, the transmission line can be run through the window nearest the receiver. The window can be notched at the bottom, or a hole can be drilled into it. The hole can then be filled with putty to seal it. Do not bring the antenna line in under the window if metal weather strips are present. When the window shuts down on the line, it is forced against the metal weather strip which changes the characteristic impedance of the line and causes signal attenuation.

If the house has a gabled roof, the line can be brought in under the eaves and through the attic and dropped down the wall between the studdings at a point nearest the receiver. A small hole can then be drilled in the plastered wall, and the transmission line hooked and brought out for connection to the receiver. To bring the line in under the eaves, a hole should be drilled completely through the wall and a porcelain lead-in tube inserted. The transmission line should not be placed between the outer and inner

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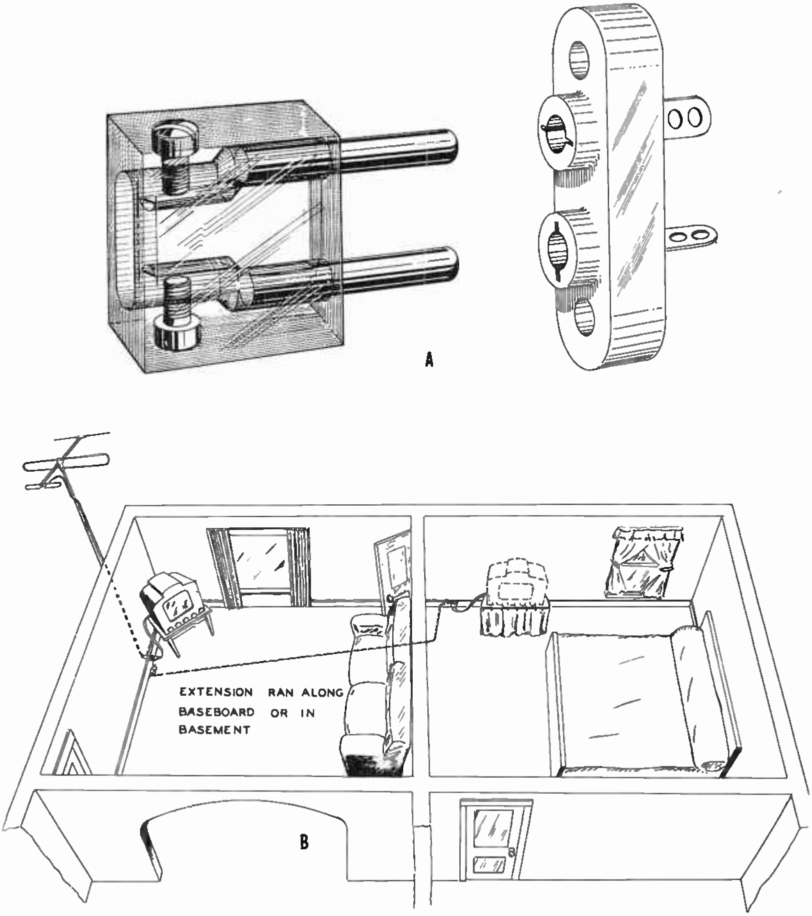

Fig. 109. 300-Ohm Plug and Socket Used for Alternate Room Extensions.

walls along the studding, if metal plaster lath is present. The metal acts as a capacity loss to the line and interferes with signal reception.

If the set owner buys a portable or table receiver, he often wishes to move the receiver from one room to another or to a different point within the same room. To accomplish this, 300 ohm transmission line plugs and sockets are used with appropriate lengths of 300 ohm line. When the transmission line is brought into the room where the set will be most used, it is soldered to a socket, as is illustrated in Figure 109A. The socket is made of

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low-loss porcelain and can be easily mounted in the floor or wall with wood screws. About 6 to 8 feet of transmission line is connected to the receiver. A plug (Figure 109A) is attached to the other end of the transmission line and plugged into the socket. An appropriate length of transmission line is then run along the base board or the ceiling of the basement to the room where the set may be used at other times. Sometimes permission can be obtained to drill a hole and run the transmission line through an inside wall. A plug should be placed on the end of the transmission line in the room where the set will receive the most use, and a socket in the alternate room. (Figure 109B.) When the set owner wishes to move the receiver, he merely unplugs the receiver and plugs in the extension. When the set is placed in the other room, it can be plugged in there. In this way, one set can be utilized in any room that has an extension in it. The same system can be employed for coaxial cable, if coaxial connectors are used.

Installations may be encountered where two sets are to be operated from one antenna. This can be accomplished by a matching impedance network. Figure 110 illustrates the connection of various sizes of resistors to make a minimum loss pad. Since the matching network reduces the signal voltages at the receivers, two sets should be operated from one antenna, only in areas of sufficient signal strength to allow for a 6 Db loss.

APARTMENT HOUSE AND STORE MULTIPLE OUTLET DISTRIBUTION SYSTEMS: Television is, for the most part, restricted to metropolitan centers and their suburbs, where many families live in apartment buildings that may contain from 3 or 4 to 100 apartments. Many building owners forbid the erection of separate antennas on the roof for each individual apartment, leaving the set owner with no alternative but to use an indoor antenna or a window mounted antenna. Even if every apartment house tenant were permitted to place individual antennas on the roof, reception

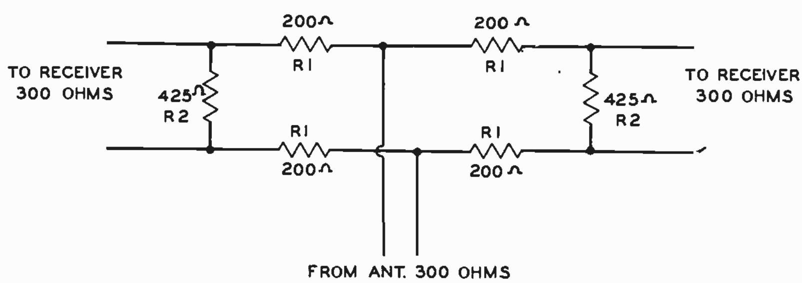

Fig. 110. Resistance Network Needed for Operating Two Receivers from One Antenna.

would be poor and ghost-ridden because of the interaction and reflections from the mutual impedance between them.

Indoor and window installations do not always give satisfactory reception to two or more stations, even if re-oriented and adjusted to each channel, for the following reasons: First, apartment house buildings are usually steel-reinforced, which cuts down the field strength inside the room considerably. It has the same effect on window antennas if they are on any side of the building except the one facing the transmitter. Second, the amount of signal picked up by an indoor antenna tends to vary with the movement of people around the room or the movement of elevators from one floor to another.

GENERAL REQUIREMENTS AND CABLE LAYOUT. Signal distribution systems have been designed for apartment houses where as many as 100 receivers can be attached to the same antenna or antennas. Resistance networks and filters are included in all types to eliminate the need for special switches and to prevent one receiver from affecting the others when it is turned on or off. The resistance networks maintain a relatively constant impedance at the terminals of all receivers, regardless of how many are in or out of the circuit. The signal is distributed on the original carrier frequency to the receivers on coaxial cable or other special cable made expressly for this purpose. No modification of the individual receiver input circuits is required with these systems.

The system should provide every receiver placed in the circuit with sufficient signal for good reception on all channels. To do this, there must be a minimum of attenuation along the line. To eliminate the need of special switching of the receiver and to keep the overall cost down, the distributing network should be laid out to use the fewest cables and those that are used should be kept as short as is possible in length. Usually, all receiver outlets are tapped from just two or three branches of a single distributing cable.

DISTRIBUTION SYSTEM UTILIZING SIGNAL AMPLIFIERS. One method of supplying a large number of receivers with sufficient signal strength is by the use of amplifiers and resistance networks to maintain equal impedance at all outlets. The general layout of this type of system is shown in Figure 111. Note that separate amplifiers and antennas are used for each individual channel.

One of the chief advantages of this system is the fact that separate antennas can be used for each channel. When one antenna

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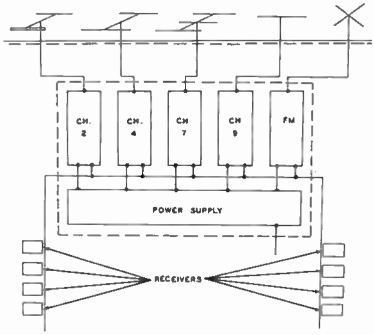

Fig. 111. Distribution System Using Separate Amplifiers and Antennas for Each Channel.

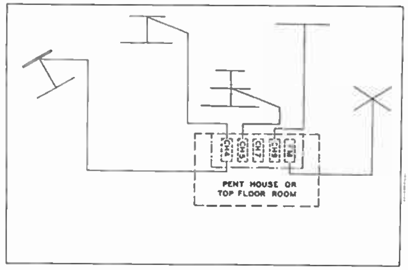

Fig. 112. A Signal Distribution System Using Single Channel Amplifiers.

is used for more than one or two stations, it is often impossible to orient it to a position where there is good reception on both stations. Either the transmitter towers are too widely separated, or ghosts appear on one or more stations when the antenna is oriented for the others. These troubles can be overcome, partially or completely, with the use of individual antennas for each channel. Each antenna can be positioned broadside to the transmitter from which it is designed to receive, or oriented for best, ghost-free reception. The type of antenna chosen for each channel may be a simple, folded dipole or a multi-element, stacked array, depending on the distance between the transmitter and the receiver or the degree of directivity that is required.

The antennas on the roof are separated by a distance of at least 10 feet to prevent any mutual coupling between them which produces a form of ghost image. A typical staggered layout of five antennas is shown in Figure 112. This method can be used as long as one antenna is not in the direct signal path of another. Coaxial cable is used to connect the antenna to the amplifiers to keep the noise pickup by the transmission line to a minimum, and to match the input impedance of the amplifiers.

The amplifiers are designed to work with inputs as low as 30 microvolts and yet supply approximately 30 millivolts to the output network. This large output allows for the attenuation factor present in the distribution lines. A typical amplifier strip is shown in Figure 113. It contains 3 to 7 tubes, depending on the number of receivers which must be supplied and the total length of the distributing cable. Each channel amplifier is designed so that it can be plugged into a master mounting rack, which has the

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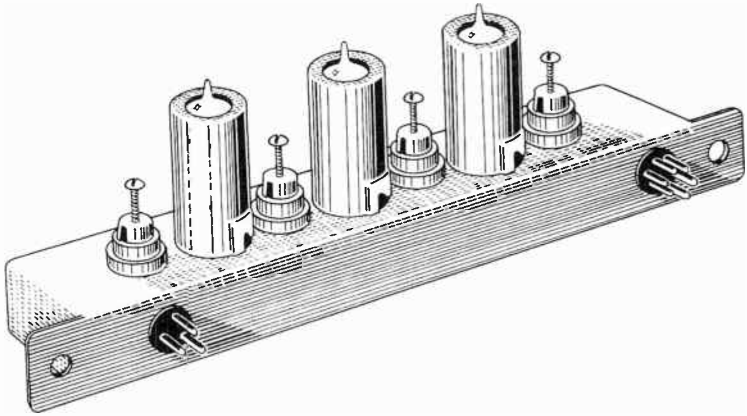

Fig. 113. A Typical Amplifier Strip.

power supply mounted on it. Four or five amplifiers fit into each rack, making two racks necessary if all 7 available channels and FM are employed. The two-prong plug at the left side of the picture is the input terminal, and the six-prong plug supplies filament, plate, and bias voltage from the rack. The output of the amplifier is also taken from two of these contacts. All amplifiers are pre-tuned at the factory for single channel operation, making further tuning in the field unnecessary.

A simplified amplifier circuit is shown in Figure 114. Miniature pentode tubes, such as the 6AK5, are used because of their high gain and stability. The input of amplifiers through capacitor C-1 is designed to terminate in a 52 ohm input impedance. Antennas with 72 ohm terminal impedance can be connected to these amplifiers without much mismatch occurring. When a 300 ohm antenna is employed, a Q matching section should be placed at the antenna terminals. The frequency discrimination problem which ordinarily arises when using a matching section is eliminated in this case, because only one channel bandwidth is desired.

Tuning of the amplifier is accomplished by changing the values of inductance in the iron core tuning transformers L-1 through L-5. Each stage is stagger-tuned at approximately 3-1/2 megacycles to give the required overall 6-megacycle bandwidth. The particular circuit shown has a gain control for each amplifier located in the power supply rack. It adjusts the amount of bias voltages on the first three grids. This bias voltage is also pre-set at the factory. It is advisable not to change the coil tuning indiscriminately, because this changes the bandwidth and response of

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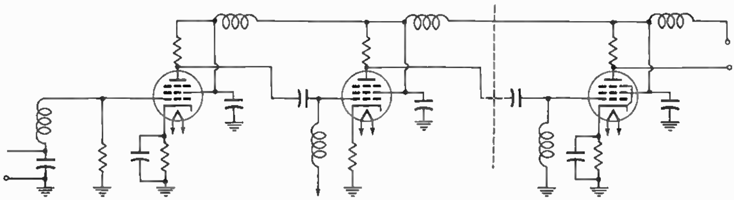

Fig. 114. Simplified Schematic of an Amplifier Strip.

the amplifier. Caution must be observed when adjusting the bias values to prevent the amplifier from breaking into oscillation when the tubes draw more or less current. The bias voltage is very critical as far as oscillations are concerned. The output stage uses a 6AN5 with approximately 25 milliamperes of plate current.

It is very important that the bandwidth of these amplifiers be a full 6 megacycles, and that negligible phase shift occurs through the stages of amplification. The sides of the response curve must drop off very sharply in order to quickly attenuate any signal other than the desired one. The typical response curve of an amplifier is shown in Figure 115. Usually, an undesired signal manifests itself in the form of a smear ghost which can either lead or lag the picture signal. In some cases, a form of cross-modulation is effected from the reception of two television signals (different channels). Cross-modulation on the viewing screen appears as a spurious line or vertical bar weaving across the image somewhat like a windshield wiper.

One power supply is used to supply voltage to four amplifiers. Regulation of the plate supply maintains the voltage within close limits for a plus or minus 10% change in line voltage with load currents between 40 and 300 milliamperes. This is done to prevent one amplifier from changing gain if another one is adjusted to a different value of gain. It may be either a conventional tube or selenium rectifier.

The amplifier output combining network is also housed in the power supply rack. It must match the output impedance of the final stage to that of the cable; namely, 52 ohms. Further, it must combine into a single line, the outputs of as many as eight separate amplifiers, without mismatch at any point for the signals of any one of them. The attenuation loss in the network must be small, and equal for the output of all the amplifiers, regardless of the frequency that they are designed to cover. Basically, the combining network is composed of a low pass filter of series induc-

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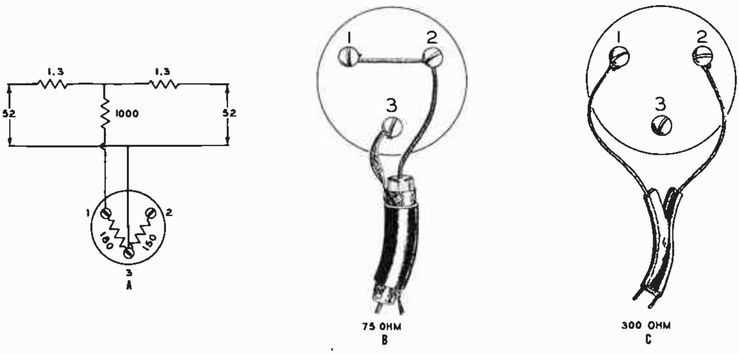

Fig. 115. Distribution Network Outlet.

tance and shunt capacitance. The capacity of the output tube makes up the greater part of the shunt capacitance. The network ordinarily feeds two branches of distribution cables. When one distributing cable is used, the other side is replaced by a terminating resistor.

The amplifiers should be mounted as near the antennas as is convenient and still remain inside of the building. Placing them near the roof keeps noise injection and line attenuation, before signal amplification, to a minimum. The rack is designed for mounting on a wall or on a shelf. (Figure 112.) A very good mounting point is the penthouse for the elevator which is present on most store and apartment house roofs. Two racks are needed when all 7 TV channels and the FM band are to be received.

The distribution network of coaxial cables is the most expensive item of the entire system, even compared with the very elaborate antennas and amplifiers used. Actually, the main cost does not stem from the coaxial cable itself, but rather its installation. It is a major endeavor to attempt the installation of this coaxial network in either a finished building or in one that is in the process of being built. Most manufacturers will send supervising representatives to the installation for the serviceman or contractor. The distributing network is composed of vertical risers of coaxial cable, each feeding an outlet on each floor. For all but the longest connections, a thin coaxial cable with low loss dielectric has been found adequate. RG-58-U with a characteristic impedance of 52 ohms can be used in 90% of the installations. Experimentation in the 500 to 1000 megacycle region is being performed every day in television laboratories. Some day in the near future, these frequencies may be used for television trans-

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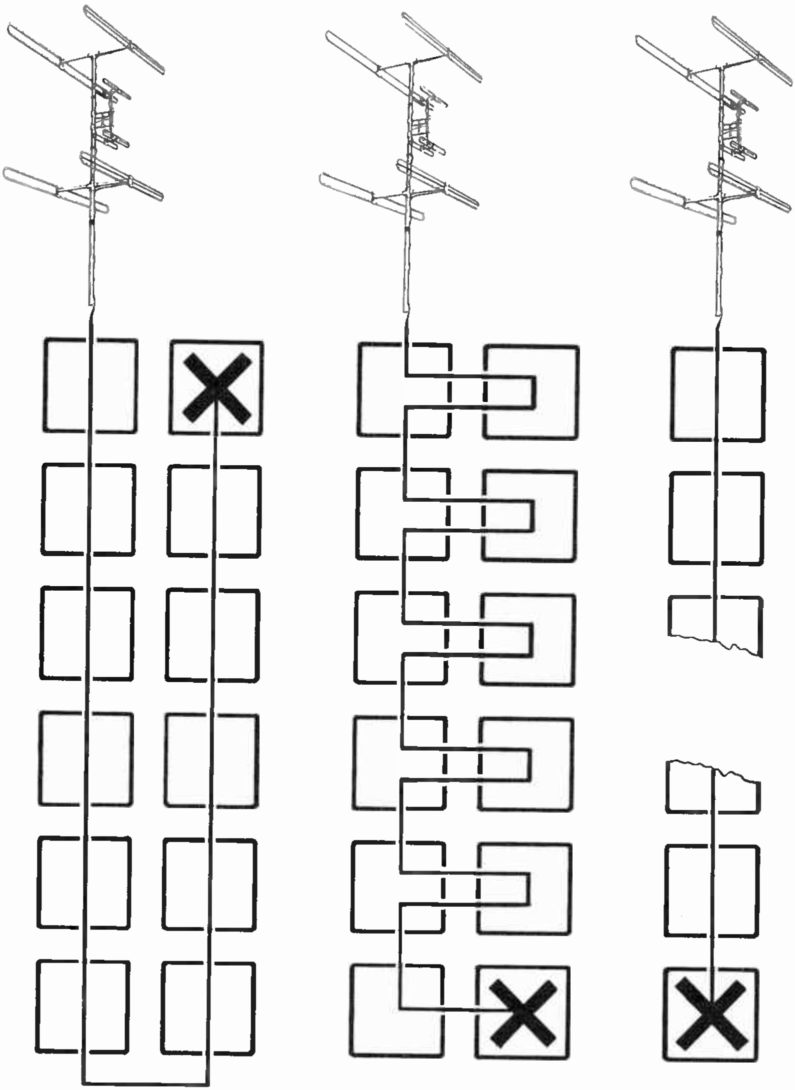

Fig. 116. Antenna and Riser Diagram of a Distributing System.

mission and reception. This system has been designed to allow for this conversion, as it becomes a permanent part of the building in which it is installed and can be used for as long as the building is in existence.

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Each outlet where a receiver is to be connected is composed of a resistive T attenuator pad, as is shown in Figure 115. The cable itself is shunted by a resistance (1000 ohms) through which a small fraction of the signal power is fed to the receiver socket. Three connections are available on the socket for connecting either a 72 ohm or a balanced 300 ohm line from the receiver. Each outlet has terminals 1, 2, and 3 to receive a three-pronged plug. A 1000 ohm resistor is connected to point 1, while terminal 3 is grounded to the braid of the distribution cable. A 180 ohm resistor is connected between points 1 and 3, and a 150 ohm resistor is connected between points 2 and 3. The receivers are matched to the cable by merely plugging into the proper terminal of the socket. For a receiver of 72 ohms, the center conductor of the connecting coaxial cable is connected to both terminals 1 and 2. (Figure 115B.) The braid is connected to terminal 3. For receivers of 300 ohms, the transmission line is connected to terminals 1 and 2. (Figure 115C.)

Further information concerning the purchase and installation of a distribution system using signal amplifiers can be obtained from the manufacturers. They are:

Intra-Video Corp.,
851 Madison Ave.,
New York 21, N. Y.

The Rauland Corp.,
4245 N. Knox Ave.,
Chicago 40, Ill

Radio Corp. of America,
Camden, N. J.

DISTRIBUTION SYSTEMS USING A HIGH GAIN ANTENNA WITH NO AMPLIFIER. This system operates on the principle that enough signal is picked up by a super high gain antenna to distribute it between 3 to 30 receivers, if a coupling network of balanced impedance is used at each outlet. One of its chief advantages lies in the fact that it is less expensive than the system described above. There is no upkeep of amplifiers and no power is required. Since no amplifiers are used, no addition to the system need be made when a new station comes on the air. Figure 116 shows how this system is connected for a master distributing system of 12 outlets.

A high-low band, folded dipole and reflector antenna is used when the building is located relatively close to the transmitter. For remote locations, a two-stack folded dipole reflector combin-

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ation is used for the high band, and another two-stack folded dipole reflector combination is used for the low band. In new building installations, two RG-59-U coaxial cables or one A. A. & K. type DX-150 cable is placed inside a half-inch conduit and run from the antenna to each receptacle outlet box. These boxes are the standard 4 inch galvanized metal type, having a 3/4 inch single gang cover. Figure 117 shows the terminal box and television receptacle used in this system. It is necessary to connect a non-inductive resistor across the screw terminals of the last receptacle at the end of each riser.

Figure 118 shows an exposed outside distributing network for buildings already built. Down-leads are mounted on standoff insulators, which are placed on the wall near the living room windows of the apartments. The down-lead used is parallel wire transmission line with a characteristic impedance of 150 ohms. A resistance pad is connected to the down-lead outside of each living room. Each coupler is provided with a lead-in cable. It should be brought into the room through a hole drilled in the window sill.

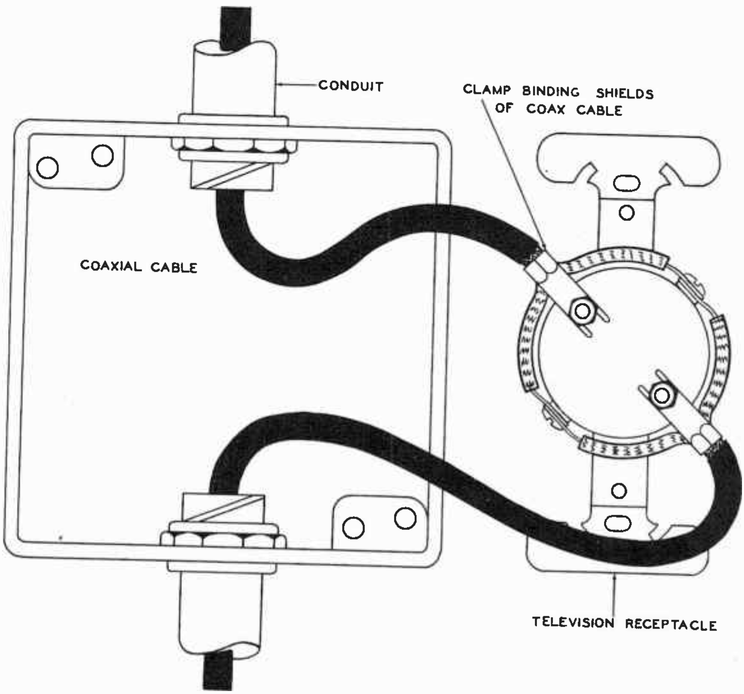

Fig. 117. Terminal Box and Receptacle for Concealed Wiring Installation.

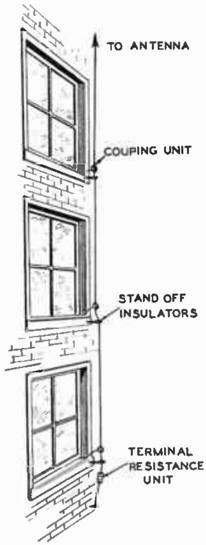

Fig. 118. Exposed Outside Distribution System Installation.

A terminal box is secured to the inside of the window sill, and the lead-in cable should be connected to it. The set is connected to the window terminal with 150 ohm parallel wire line. This impedance line is necessary to match the distribution system. The down-lead is grounded through a terminating resistance after the last resistance pad.

This type of system is sold to the installer, and it is installed by him under the supervision of the manufacturer. It is manufactured by:

Amy, Aceves & King, Inc.,
11 W. 42nd St.,
New York 18, N. Y.

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CHAPTER 5

COMMON INSTALLATION PROBLEMS

(TROUBLE SHOOTING)

In any trouble shooting procedure, the trouble must be localized to a certain section of the installation. Unless the serviceman can be relatively sure of the defect location, valuable time and the cost of parts that are not needed may be wastefully expended. Trouble can be localized to the functioning of the receiver or to the operation of the antenna system. Each one can be further broken down into smaller sections. In the case of the antenna system, these sections are the antenna itself and the transmission line connecting it to the receiver. Before determining definitely that the trouble is located in the antenna or transmission line, it should be ascertained that the trouble is not brought about by maladjustment or improper functioning of the receiver. In most instances, when an antenna has been properly installed, it will cause no further difficulty for a long period of time.

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The television receiver, because it offers visual as well as audible signals, is an excellent indicator of abnormal conditions which exist due to trouble in the overall system. By simply looking and listening, the serviceman can often localize the trouble immediately, without needless testing or experimentation. The receiver accepts the video and audio signals and amplifies them through a series of video and audio amplifiers. In the case of the audio amplifier, the signal is detected, further amplified, and fed to the speaker. The video signal is detected, amplified, and injected on the grid of the cathode-ray tube where it intensity-modulates an electron beam. The beam strikes a phosphorescent coating and effectively changes the signal into a varying light potential. This video signal is also used to trigger sawtooth oscillators which scan the picture tube in both horizontal and vertical directions. From the description given above, it is obvious that if the antenna and transmission line were faulty and did not bring in the proper signal, the receiver would indicate it. If the antenna and transmission line were situated so they could inject a spurious, reflected, or unwanted signal, this, too, would be indicated on the viewing screen.

A customer's complaint does not necessarily mean that any trouble is actually present in the antenna system. For instance, the customer may have been expecting excellent performance under extremely unfavorable conditions for reception. Many times a new customer is not familiar enough with the tuning controls of a television receiver to adjust it properly. No matter what has caused the trouble, the serviceman should treat each complaint as a trouble shooting problem and attempt to clear either it, or the misunderstanding that exists in the user's mind. Before attempting any change of antennas or transmission lines, be sure to check the system under operating conditions. If the trouble is not evident, the owner's explanation of the symptoms may help to determine if it is of an intermittent nature, if it is a misunderstanding on the part of the owner, or if it is caused by local interference. If it is ascertained that the trouble is not a misunderstanding on the part of the owner, the installation should be given a preliminary check as far as connections, transmission line breakage, and transmission line locations are concerned. If the fault cannot be remedied by these means, further inspection is necessary.

Setting up a trouble shooting section for a receiver that contains tubes, capacitors, resistors, and coils, is relatively easy; because it can be placed in the form of a chart or table, using schematic reference numbers. This cannot be done in antenna trouble shooting, because there is a multitude of factors which

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might enter into the same problem. This situation necessitates speaking in generalities on each problem which might confront the serviceman. However, while several solutions may be given for each problem, they are discussed in the order in which they are most likely to occur.

THE GHOST PROBLEM: Ghost signals have been defined previously in this text as unwanted images displaced to the left or right of the main picture signal on the viewing screen of the receiver. They can be caused by a multitude of conditions and, when encountered by the serviceman, are often very difficult to interpret and remedy.

Ghost signals are very obnoxious to the set owner who views his screen for a long period of time; because either they make him feel like he is "seeing double" or, in other cases, make the image appear blurred or out of focus. One ghost condition that the customer often complains about is the image which is slightly displaced to the right of the main image. It is usually unnoticeable or overlooked by the serviceman when the set is installed. The owner, awed with the new set and not being accustomed to watching a picture, will not notice anything wrong with the picture. However, after he has watched the set for a period of one or two weeks, he will begin to observe the small flaws in the picture and call the serviceman for receiver adjustment. Everything possible should be done, at the time of the original installation, to give ghost-free reception. The picture should be closely scrutinized to make sure that not even weak ghosts are present; and, if they are, steps should be taken to eliminate them. If they cannot be eliminated, the customer should be fully informed of the conditions that exist, so he will not call and make a second service trip necessary.

REFLECTED GHOST SIGNALS. Reflected ghost signals are caused by the signal from the transmitter reaching the receiver antenna by more than one route. Usually, the desired signal arrives at the receiving antenna via a direct path, while the unwanted or ghost signal arrives after being reflected from an adjacent building, water tower, or any other elevated structure that is at least the same height as the receiving antenna. Reflected ghosts appear most frequently in cities, where a tall building can reflect a signal to the receiving antenna or in a suburb, where the signal is reflected from a hill. There are three types of ghost signals that appear on the viewing screen due to reflections. The serviceman should examine the viewing screen to determine whether one or more than one type of ghost signal is present. Sometimes, only the strongest ghost will be noticeable on the

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screen to the casual observer. However, as soon as the strong ghost is eliminated, smaller ghost signals become evident and prove just as annoying to the customer. The three types of ghost signals are the negative ghost, the fixed ghost, and the smear ghost.

1. A negative ghost appears to the right of the main image but is opposite in polarity to it. (Figure 119.) If the main image is black, the ghost image appears to be white, and vice versa. There are four methods of eliminating or reducing ghost images.

The first involves the orientation of the antenna until only one signal is received. It may be oriented to a point where it is broadside to the reflected signal or to a point where it is broadside to the direct signal. In either case, the unwanted signal may fall far enough down on the response pattern of the antenna to make it inconsequential.

The second solution involves the elevating of the antenna above any surrounding objects. This is often possible when the surrounding buildings are not too tall.

A third remedy is changing the antenna to one with a more directive response. With the addition of reflectors or directors,

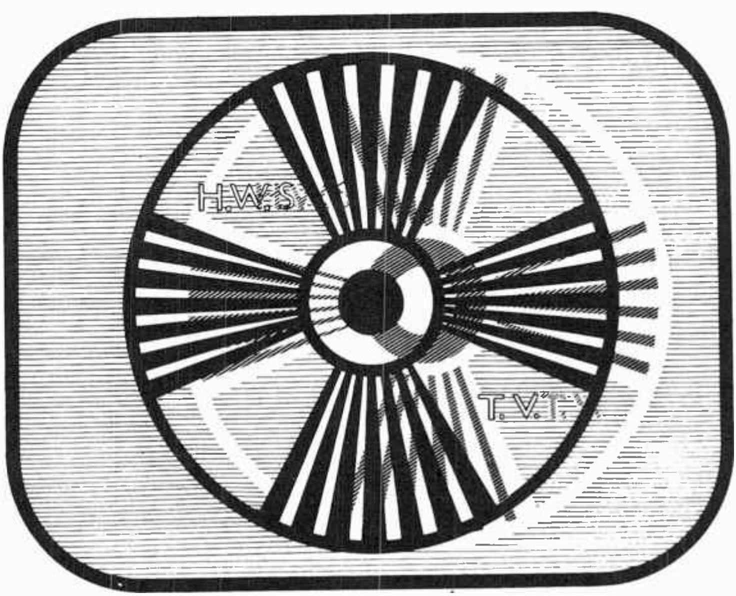

Fig. 119. Negative Ghosts.

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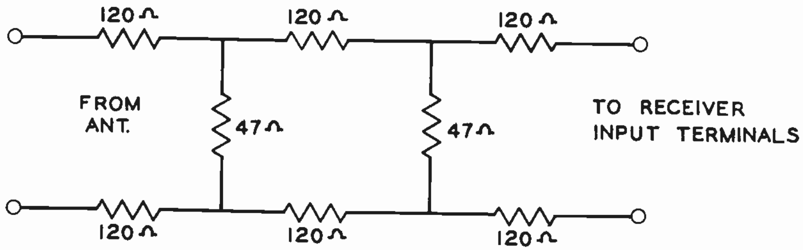

Fig. 120. Resistance Attenuation Pad Used in Ghost Reduction.

the antenna becomes effectively more beamed, thus increasing its front-to-side ratio and front-to-back ratio. Sometimes a reflected signal is received from the rear of a bi-directional antenna. When an antenna with a good front-to-back ratio is employed, the rear signal reception is eliminated or attenuated to a point where it is far less annoying to the customer.

Finally, an attenuation pad can be inserted at the input of the receiver to attenuate the entire signal. Thus, if one signal is, by far, stronger than the other signals and all are reduced in strength, only the direct signal will remain. The undesirable signals will be invisible on the screen, because they are effectively eliminated before they enter the receiver. This method can only be used, however, when the desired carrier is very strong. The signal should be sufficiently strong to "black out" and tear the picture with the contrast control set in the middle of its range. The attenuation pad is composed of a balanced network of resistors, as shown in Figure 120. The same reducing effect on the ghost signal can sometimes be accomplished by orienting the antenna so that it is not broadside to the transmitter. The desired signal strength is reduced, because it is not received on the longest portion of the reception lobe. The reflected signal is then received further down on the response lobe and may not be seen at all on the viewing screen.

2. The second type of unwanted image is the fixed ghost. It is usually displaced to the right of the main image and is weaker than the main image. Figure 121 shows a fixed ghost image appearing on the viewing screen. One solution of the ghost image is the moving of the antenna to a different location on the roof and re-orienting it. If this does not eliminate the unwanted signal, a more directive array must be used.

3. The smear ghost illustrated in Figure 122 shows several ghost images of a lesser degree, closely following the main signal. They are so close, as a matter of fact, that it is impossible to tell

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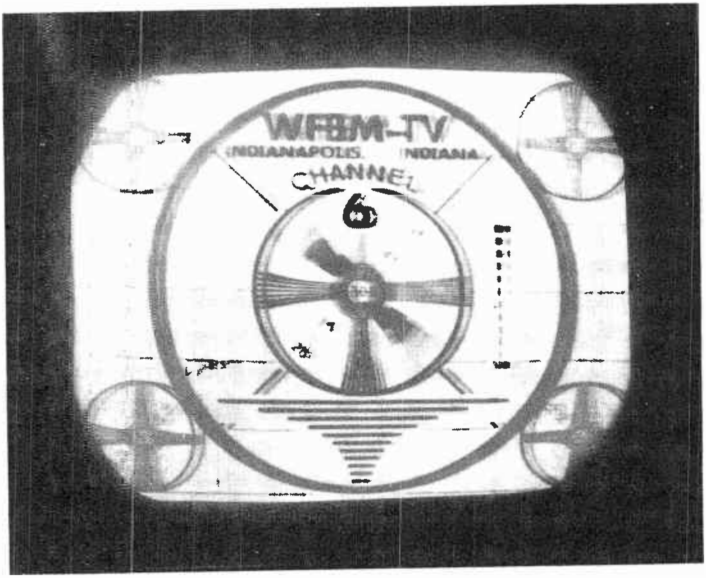

Fig. 121. Fixed Ghost Image. (Photo Courtesy WFBM, Inc.)

where one ends and the other begins. They disrupt all picture definition; hence, the name "smear ghost". This type of trouble is caused by many reflections from closely adjacent buildings, and therefore will appear mostly in the downtown areas very close to the transmitter. The only plausible solution is the elevation of the antenna above all of the surrounding structures which might cause the multiple reflections. It is impossible to use an attenuation pad in this case; because the reflected signals are usually almost as strong as the direct signal, causing the direct signal to be attenuated right along with the unwanted signal to a point where it will not give a sufficiently clear picture.

GHOST SIGNALS CAUSED BY LINE MISMATCH. One or more ghosts may be produced when considerable mismatch exists at both the receiver and the antenna ends of the transmission line. This energy, causing standing waves, reflects from the receiver back to the antenna, to the receiver, and so on. Each time that it is reflected back down the line toward the receiver, a portion of it reaches the grid of the RF amplifier and goes on through the following stages. These damped signals naturally are displaced to the right of the main signal on the picture tube by the time lag that takes place as they reflect back and forth on the transmission line. Usually, only one secondary image is formed; and, unless

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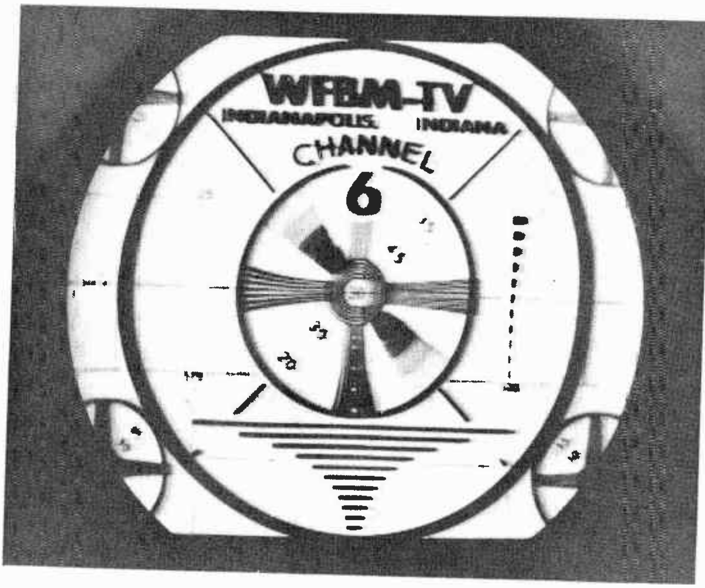

Fig. 122. The Smear Ghost. (Photo Courtesy WFBM, Inc.)

the mismatch is very bad at both ends of the line, the secondary image will be considerably weaker than the main signal.

The ghost caused by line mismatch is usually very close in displacement to the main signal; because, even with a long transmission line, the time delay represented by the back and forth reflection of the signal is, as a rule, very short. Ghosts caused by reflected signals (from buildings, water towers, etc.) are generally displaced further to the right than are ghost signals due to mismatching. This is one way the two can be distinguished when determining the cause of the ghost signal.

With short transmission lines, the time delay is so slight that the ghost signal may show up in the form of poor picture resolution and definition instead of a secondary image. This lack of definition can be likened to a smear ghost. When it is impossible to determine, even with the closest scrutiny of the viewing screen, whether or not the ghost is due to a reflected signal or line mismatch, the question can be resolved by rotating the antenna. If line mismatch causes the ghost signal, the ratio of intensities or strengths will remain constant. If a reflected signal is responsible for the ghost, the ratio of intensities can be raised and/or lowered by rotation of the antenna.

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In order for line mismatch to cause ghosts, the transmission line must be mismatched to both the receiver and the antenna. If there is a mismatch at just one end, the only noticeable effect will be a reduction in the amount of signal that can reach the receiver due to attenuation that occurs between the mismatched elements. Actually, it is practically impossible to perfectly match the transmission line to either the antenna or the receiver over the wide range of television frequencies (54 to 216 megacycles).

The best way to avoid mismatch ghosts is to use a transmission line and antenna that match the input impedance of the receiver. When this is done, no trouble will be experienced from this source. However, it is often desirable to match an antenna with one impedance to a receiver of a different input impedance. Always use a transmission line that has the same characteristic impedance as that of the receiver. If any mismatching is to occur, it is far better to have it at the antenna end of the system. A "Q" or stub type matching transformer can be placed at the antenna terminals to achieve a better match, if this is desirable.

GHOSTS CAUSED BY CROSS-MODULATION. Due to the wide band principles necessary for receiving antennas and receiver input systems, it is not uncommon for signals to be received from other stations, when the installation is located close to the transmitters. Amplification of these unwanted signals causes a different time delay through the amplifying stages, which causes a stationary ghost signal to appear to the right of the desired signal on the viewing screen. They can also cause a form of cross-modulation in the amplifier stages. This cross-modulation is evident even when the unwanted signal is very weak. It shows up on the viewing screen in the form of a granulated appearance of a normally smooth background and the appearance of a vertical bar weaving across the picture like a slow-moving windshield wiper.

The RF alignment of the receiver should be checked to see that the oscillator is tuning to the correct frequency. Re-orientation of the antenna may eliminate the unwanted signal. A more directive antenna, placed broadside to the station which has other channel interference, may reduce the interference to a point where it is not evident on the viewing screen. If that does not help, an attenuation pad should be placed before the input terminals of the receiver. There is generally sufficient signal for the receiver to operate in a central location when an attenuation pad is present in the input of the receiver.

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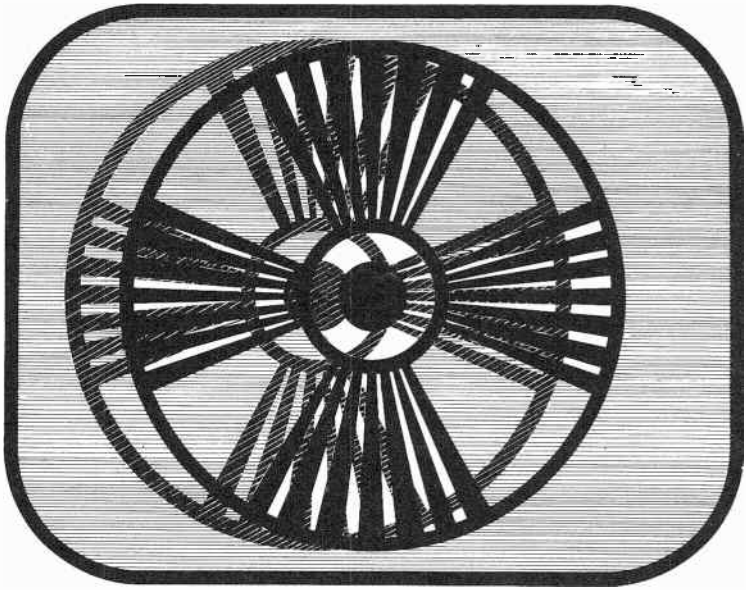

Fig. 123. Ghost Signal Displaced to the Left of the Main Image.

GHOSTS CAUSED BY TRANSMISSION LINE PICKUP. Often when a short transmission line is used, such as in an indoor installation or a window mounted installation, the transmission line itself may be of a length that resonates to a certain channel frequency. It receives an unwanted signal and injects it into the receiver ahead of the desired signal that comes in from the antenna. With this type of ghost signal, it is always displaced to the left of the main signal; and, as a rule, it is somewhat weaker than the main signal. (Figure 123.) The best remedy for this situation is to lengthen or shorten the transmission line until the unwanted signal disappears on ALL channels.

MISCELLANEOUS TROUBLES: Following is a list of miscellaneous troubles which might occur in an antenna installation after it has been in operation for a period of time. Next to ghosts appearing on the viewing screen, more customer complaints arise from these troubles than from any other source.

ELECTRICAL MACHINERY INTERFERENCE. There are occasions when electric motors, cash registers, or other electrical machinery are placed in or near a building where an antenna has already been installed. Arcing of their contacts or brushes produces RF energy, which is picked up by the antenna and transmission line and injected into the receiver. It can cause all or

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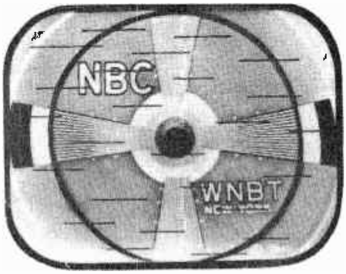

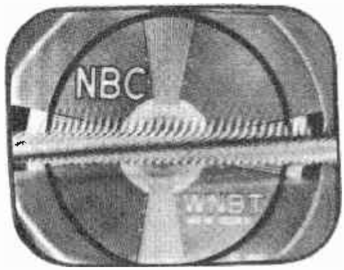

Fig. 124. Effect of Automobile Ignition and Diathermy on the Picture. (Photos Courtesy NBC and the R. C. A. Service Co., Inc.)

part of the picture to go out of synchronization.

The best way to eliminate this interference completely is for the serviceman to have the set owner go to the machinery owner and have him take adequate steps to see that the machinery is repaired to prevent the arcing, and have proper filters installed if necessary. An alternate method is to use shielded transmission line so, at least, there is no noise pickup by the lead-in. However, the antenna will still pick up a portion of the energy and inject it into the receiver. Therefore, this solution is applied only when the first is not feasible.

AUTOMOBILE IGNITION INTERFERENCE. If the building on which the antenna is located is near a main thoroughfare, the antenna and transmission line will both pick up the RF energy produced by automobile ignitions and cause it to interfere with the proper operation of the set. Typical automobile ignition interference is shown in Figure 124A. Essentially, it consists of many small, white or black lines that appear to travel across the picture.

When it is evident that this is the source of interference, the antenna should be moved as far back on the building from the street as it can be; and shielded transmission line should be used.

DIATHERMY INTERFERENCE. Diathermy interference is caused by medical diathermy machines and X-ray equipment. It appears on the viewing screen as a band of dark herringbone configurations. (Figure 124B.) There is very little that can be done to eliminate this type of interference. However, doctors, hospitals, and the medical apparatus manufacturers have been advised by the Federal Communications Commission to lead-sheath the apparatus to prevent its interference. In time, very little diather-

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my interference will be experienced by the owners of television receivers.

IDENTIFYING ELECTRICAL INTERFERENCE SOURCES. In the past, most technicians called upon to locate interference sources have employed battery operated portable loop receivers, possibly with short wave bands, as the indicating instrument. By establishing directivity from three or more positions, it has been possible to arrive at a fairly accurate initial estimate of the interference origin.

The interference sought has usually been that affecting conventional AM broadcast or medium short wave reception. In considering the location of television interference, the equipment used to check for broadcast band disturbances is generally inadequate, because of the much higher frequency ranges involved in TV. Since many forms of TV interference are frequency-sensitive, it is essential that the receiving equipment used for indication, be capable of covering each of the twelve assigned channels (frequencies from 54 to 88 and 174 to 216 megacycles). If the technician has access to field strength measuring equipment, such equipment can be very satisfactorily employed in interference location activity. In the absence of such apparatus, a mobile installation, carefully filtered and known to be free of interference capabilities, should be employed for this work.

A complete study of interference phenomena is of course beyond the scope of this text, and the foregoing material has purposely been limited to the more commonly encountered types of disturbances.

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