125.

RADIOTRONICS

Registered at the General Post Office, Sydney, for transmission by post as a periodical. Single Copy, One Shilling

Volume 19 **November 1954** **Number 11**

F.M. Antenna Choice and Installation

by Kenneth Fowler

General

The proper type and location of the antenna for F.M. reception is very important if the best results from the F.M. receiver is to be obtained.

A great many radio men in the past have given little consideration to the antenna and have put up antennas almost anywhere that they would fit and have made them any convenient length and, in most cases, secured fairly good results — on A.M. receivers. However, in the case of the F.M. receiver, such haphazard antennas will not give good results unless the receiver is fairly close to the transmitter. In cases where the receiver is located some distance from the transmitter, an ordinary antenna will not pick up enough signal to properly operate the limiter in an F.M. receiver and, consequently, the full benefits from an F.M. receiver will not be realized. An F.M. receiver will reduce noise and be free from distortion only if sufficient signal is fed into the receiver to properly operate the limiter as explained in a previous chapter.

Since the F.M. carrier is at a much higher frequency than that for A.M. transmission, it is necessary to use an antenna that will be efficient at these higher frequencies. Experience has shown that an outside antenna of the dipole type, correctly installed, will give the best results.

The half-wave antenna

The simplest antenna for F.M. reception is the half-wave dipole and, as shown by Figure 40, it consists of two quarter-wave rods spaced about 1″ apart at the centre. This antenna provides a radiation resistance of about 72 ohms at resonance. A dipole resonates when its length is approximately equal to one-half wave length of the frequency that it is to be used on. The over-all length of a half-wave dipole for any desired frequency can be computed from the equation L (in feet)

$$= \frac{492 \times 0.94}{\text{Freq. (MC)}}$$

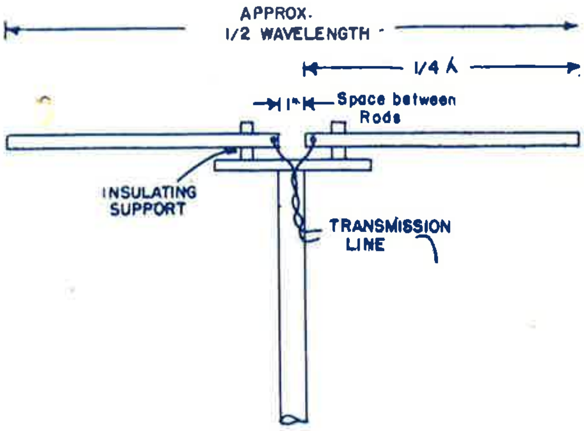


Fig. 40. Half-wave dipole antenna.

Each rod of the dipole will then be one-half the over-all length as computed above. The factor 0.94 compensates for the end effect of a half-wave antenna at high frequencies and consequently the actual length of a half-wave antenna will not be exactly equal to one-half wave length of the frequency it is to be operated on but will be about 5% less. In actual practice the length of the antenna depends upon a number of factors. If the antenna is to pick up signals from only one station, then the over-all length should be calculated from the middle of the frequency band for that particular station. However, in most cases it is desired to be able to pick up signals from a number of different stations in the F.M. band and therefore some compromise must be made in the exact length of the antenna.

Reprinted from "Frequency Modulation Principles and Practice" by courtesy of Australian General Electric Pty. Ltd. and with acknowledgements to General Electric Co., U.S.A.

The usual procedure is to cut the antenna so that it will be $\frac{1}{2}$ wave length long at the centre of the range of F.M. frequencies that it is desired to cover. For a range of frequencies of from, let us say, 42 to 46 mc, the antenna should be cut so that it will be $\frac{1}{2}$ wave length long at a frequency of 44 mc. Substituting this value in the equation L (in feet)

$$= \frac{492 \times 0.94}{\text{Freq. (MC)}}$$

we find that the over-all length of the antenna should be L (in feet)

$$= \frac{492 \times 0.94}{44}$$

= 10 feet 6 inches, and that length of each half of the dipole should be 5 feet 3 inches.

Range of F.M. signals

For all practical purposes the frequencies assigned to F.M. are too high to be refracted back to earth by the ionosphere, as is the case for frequencies somewhat lower. The critical frequency above which refraction in the ionosphere fails to return signals back to earth depends upon the electron density of the ionized region which has daily, seasonal, and yearly variations, dependent upon the sun's radiation. For this reason F.M. must depend upon waves travelling directly from transmitter to receiver through the space above the ground. However, due to the curvature of the earth the range of the signals is limited to moderate distances.

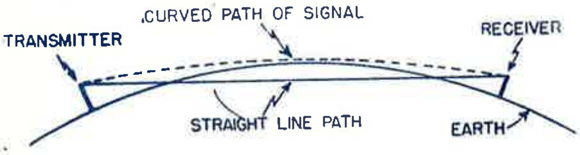


Fig. 41. Refraction of F.M. signal.

Although signals received over a greater distance than the straight-line path would indicate are unreliable, they should be given some consideration in order to understand why they are unreliable. The refraction of ultra-high frequencies by the earth's atmosphere comes about because the variation of atmospheric temperature, pressure, and moisture content with height cause the refractive index of the atmosphere to decrease with elevation and tends to bend the waves back toward the earth. The amount of curvature that results varies with atmospheric conditions but, on the average, it is equivalent to assuming that the earth's diameter is increased by 25 to 35 per cent. In Figure 41 is shown a diagram to illustrate the path of a wave as the result of atmospheric refraction. However, due to the continually varying conditions upon which this refraction depends, it is obvious that a signal travelling along this path will not be reliable and, consequently, we must depend upon the straight-line path or the line-of-sight path for dependable F.M. reception.

The range of a station, considering only the straight-line path, depends upon the heights H_t and H_r of the transmitting and receiving antennas respectively. According to the formula:

$$\text{Maximum distance for straight-line path} = 1.23\ (\sqrt{H_t} + \sqrt{H_r})$$

where the antenna heights are in feet and the distance is in miles. If atmospheric refraction is considered, the distance is increased by a factor of 1.25 to 1.35, depending upon the atmosphere's refractive index K. In Figure 42 there are several curves showing the effect of antenna heights and atmospheric refractions upon the direct line-of-sight transmission. With the exception of the first curve which is for the straight-line path, all curves are calculated on the basis of the effective range being increased by a factor 1.3 because of refraction in the earth's atmosphere. Below the figure is a chart giving the range for several transmitting antennas in excess of 1000 feet.

It is of interest to note that when one antenna is high (usually the transmitting antenna) and the other relatively low, a given number of feet increase in either antenna is much more effective in increasing the range if it is applied to the lower antenna. This fact may not at first be apparent until we consider the fact that the line-of-sight range is directly proportional to the square root of the height of either antenna. For example, if one antenna is 10 feet high and the other 1000 feet high, the straight-line path in miles will equal:

$$\begin{aligned} D &= 1.23\ (\sqrt{10} + \sqrt{1000}) \\ &= 1.23\ (3.16 + 31.6) = 42.75 \text{ miles.} \end{aligned}$$

Now suppose we increase the height of the lower antenna by 90 feet, the straight-line path will now be:

$$\begin{aligned} D &= 1.23\ (\sqrt{100} + \sqrt{1000}) \\ &= 1.23\ (10 + 31.6) = 51.8 \text{ miles.} \end{aligned}$$

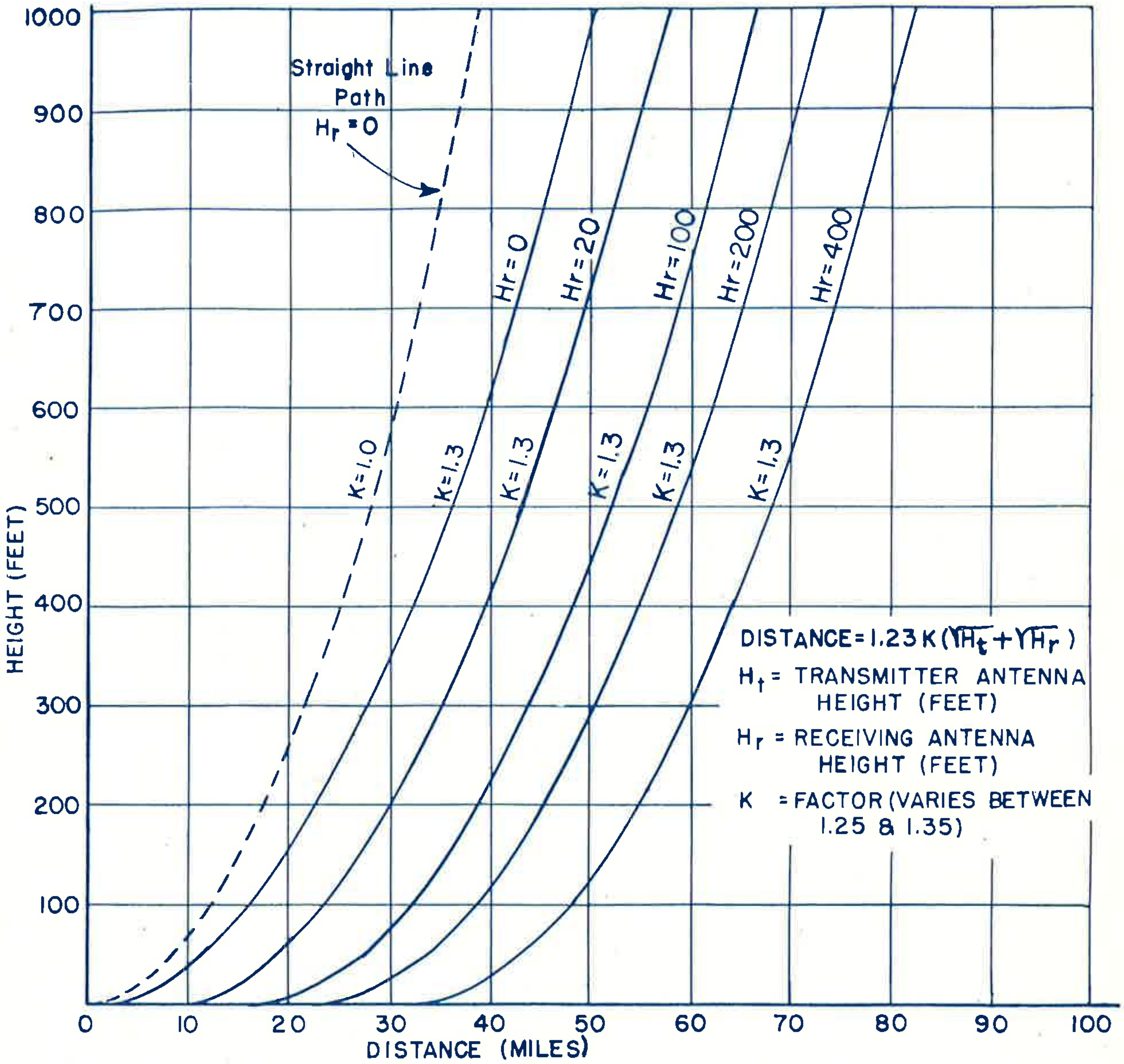
Now suppose that instead of increasing the lower antenna by 90 feet, we had increased the higher antenna by 90 feet, the straight-line path would have then been:

$$\begin{aligned} D &= 1.23\ (\sqrt{10} + \sqrt{1090}) \\ &= 1.23\ (3.16 + 33) = 44.5 \text{ miles.} \end{aligned}$$

From the foregoing example, it is obvious that since receiving antennas are relatively low and transmitting antennas relatively high, that increasing the height of the receiving antenna is much more effective than increasing the height of the transmitting antenna an equal amount. Therefore the importance of placing the receiving antenna as high as possible when the receiver is located a considerable distance from the transmitter.

Polarization of antenna

Since a radio wave consists of magnetic and electrostatic fields at right angles to each other, the polarization of a radio wave simply means the relationship of the electrostatic field with respect to the earth as the radio wave travels into space. If the electrostatic field is vertical with respect to the earth, the radio wave is said to be vertically polarized.



TRANSMITTER HEIGHTS ABOVE 1000 FEET

Ht.	Straight Line Path	With Atmospheric Refraction K = 1.3	Hr. 20'	Hr. 40'	Hr. 100'	Hr. 200'	Hr. 400'
1250	44	57	64	67	73	79	89
1500	48	62	69	72	78	85	94
2000	55	72	79	82	88	94	104
3000	68	88	95	98	104	111	120
4000	78	101	108	111	117	124	133
6000	95	123	130	133	139	146	155
10,000	123	160	167	170	176	183	192

Fig. 42. Distance vs. Antenna Height.

If the electrostatic field is horizontal with respect to the earth, the radio wave is said to be horizontally polarized. If the arms of a dipole transmitting antenna are vertical with respect to earth, then the antenna is said to be polarized vertically and for maximum induced voltage the receiving antenna should also be vertically polarized, i.e., the arms of the receiving dipole should also be vertical with respect to earth.

If the arms of the transmitter dipole are horizontal with respect to the earth, then it will send out a horizontally polarized wave and therefore for maximum signal pick-up the receiving antenna should also be horizontally polarized, that is, the arms of the receiving dipole should be horizontal with respect to the earth.

It has been found that a horizontally polarized receiving antenna is less susceptible to ignition noise and other electrical interference and, consequently, most F.M. transmitting antennas send out a horizontally polarized wave.

Response characteristics of the dipole antenna

The solid curve of Figure 43 illustrates the horizontal directivity of a horizontal dipole antenna.

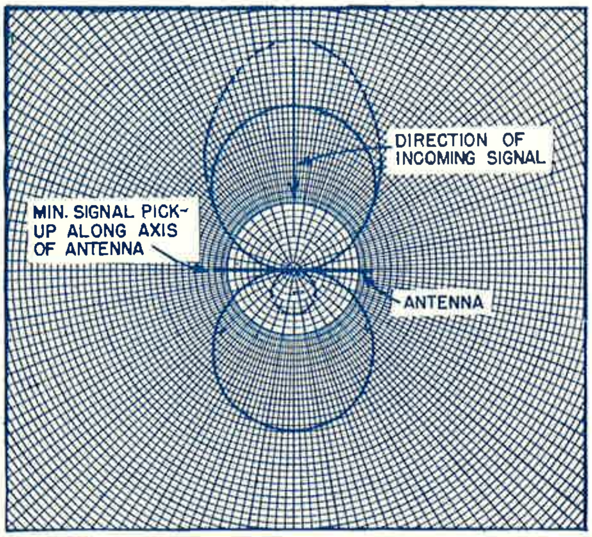


Fig. 43. Horizontal directivity pattern of dipole.

As shown, the signal pick-up is greatest when the signal arrives in a direction that is at right angles to the broad side of the antenna. In other words, for maximum signal pick-up, the broad side of the antenna should be pointed in the direction in which the signals are arriving from, i.e., toward the transmitting antenna. An inspection of Figure 43 shows that in the direction along the axis of the antenna the signal pick-up is practically zero. Use can be made of this fact in locations having a high-noise level by rotating the antenna so that its axis points in the direction from which the noise signal is arriving. Such an orientation may decrease the signal pick-up somewhat since the broadside of the antenna may not be pointing exactly in the direction of the arriving F.M. signal but will be very beneficial because of the very great reduction in noise signal pick-up.

As shown by Figure 43, the horizontal dipole responds equally well to signals arriving in either direction that are at right angles to the broad side of the antenna and under certain conditions this is undesirable.

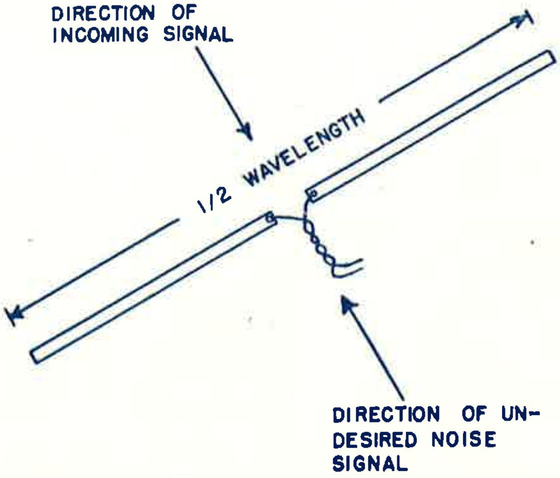


Fig. 44. Signal response of half-wave dipole.

For instance, if there is a noise source near the antenna such that the noise signal from it arrives in a direction that is just the opposite from that of the arriving F.M. signal as shown in Figure 44, it will greatly reduce the signal-to-noise ratio which may result in poor reception. This undesired condition can be greatly reduced by making use of a reflector. A reflector is simply another rod which is placed parallel to and behind the receiving dipole. The reflector element is usually about 5% longer than the receiving dipole and is placed about ¼ wave length behind the receiving dipole with a resulting gain in signal pick-up of about 3 db in the direction in which the broadside of the receiving dipole is pointed. The directional characteristics are illustrated by the dashed curve in Figure 43 and, as shown, results in strengthening the desired signal and also in greatly reducing any interfering signal that comes from a direction which is directly behind the receiving dipole. A half-wave dipole with a reflector is shown in Figure 45.

When a reflector is added to the regular dipole it increases the antenna directivity considerably, so that the orientation of the antenna array with respect to the direction of the incoming signal is a rather critical adjustment for optimum results. When installing antennas of this type it is usually advisable to check the results of rotating the antenna by listening to the receiver. This normally requires two men to make the installation, one on the roof at the antenna and the other at the receiver. An intercommunicating system of some sort is necessary for communication between the two men.

Transmission lines

A transmission line is used to transfer power with a minimum of loss from its source to the device in which the power is to be usefully expended. At r-f, where every wire carrying r-f current tends to radiate energy in the form of electromagnetic waves, special design is necessary to minimize radiation and thus permit as much as possible of the input power to be delivered to the receiving end of the line. There are various types of transmission lines in use, namely, the open wire line which consists of two parallel wires maintained at a fixed spacing of a few inches by insulating spacers; the twisted pair line which consists of two rubber-insulated wires twisted together to form a flexible line; the coaxial or concentric line which uses a wire conductor which is centred inside of a metal tube which is used as the outer conductor; the flexible coaxial line which uses solid insulation between the inner and outer conductors, instead of spacers or beads, with the outer conductor being made of copper braid rather than solid tubing so that the line will be flexible; the shielded pair balanced to ground which consists of two parallel wires maintained at a fixed spacing by solid insulation around which is an outer shield of copper braid.

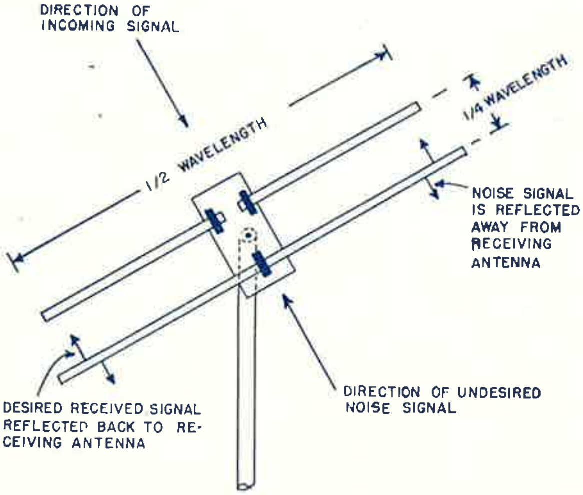


Fig. 45. Dipole with reflector.

The open wire line has a fairly low attenuation loss per wave length but due to its rather high surge impedance it is more difficult to balance out extraneous signal pick-up. The most usual method of transferring the signal from the antenna to the receiver is by means of a low impedance twisted or parallel pair transmission line, which has a surge impedance of about 100 to 300 ohms. An ordinary twisted pair line is not satisfactory for this purpose since it probably will not have the correct surge impedance and will also probably have a high attenuation loss. A special type of twisted or parallel pair line is made for this purpose, having the correct surge impedance and the proper kind of insulating material to keep the attenuation losses as low as possible, even after being exposed to the elements. However, even the best line has a fairly high attenuation loss, about 3 db per 50 feet of length at 100 mc. A twisted or parallel pair transmission line is usually satisfactory for distances up to about 100 feet, but for distances beyond this it is advisable to use one of the low-loss transmission lines, such as the coaxial line or the shielded pair balanced to ground.

Impedance matching

In the preceding paragraph, mention was made of the surge impedance of a transmission line. The characteristic or surge impedance of a line is not determined by the ohmic resistance of the conductors but is determined by the construction of the line and is equal to the square root of the ratio of inductance to capacity per unit length of line, thus

$$Zo = \sqrt{\frac{L}{C}}$$

Therefore, every transmission line has a characteristic or surge impedance which acts as a pure resistance, the value of which depends on the construction of the line.

If a transmission line is terminated in its characteristic or surge impedance, it is equivalent to an infinitely long line and there will be no standing waves or reflections along the line and the line is said to be non-resonant. The input end of a transmission line that is terminated in a resistance equal to its surge impedance will appear as a pure resistance having a value equal to the characteristic or surge impedance of the line.

However, if, on the other hand, the transmission line is not terminated in a load that equals the surge impedance of the line, then there will be standing waves produced along the line which may result in a serious loss of signal between the antenna and the receiver, depending upon the amount of mismatch between the load impedance and the surge impedance of the transmission line.

For maximum transfer of power from the source to the load, it is necessary that the load impedance be equal to the source impedance. When the average resistance at the centre of a half-wave dipole varies from about 72-100 ohms, the antenna input circuit of the receiver is designed for an impedance of about 100 ohms so that there will be a maximum transfer of energy from antenna to receiver.

The transmission line is usually balanced to ground by means of a centre tap on the primary of the antenna transformer so that any noise signal picked up by the line will cancel out.

From the foregoing it is evident that for the maximum transfer of signal from the antenna to the receiver it is necessary that the surge impedance of the transmission line match the input impedance of the receiver at least fairly closely and also that the input impedance of the transmission line match the impedance at the centre of the dipole. Since the input impedance is about 100 ohms for most F.M. receivers and since the average impedance of a half-wave dipole is also 100 ohms, a transmission line having a surge impedance of about 100 ohms will work very satisfactorily.

Installation of F.M. antennas

The first step in installing an F.M. antenna is to make a survey of the location and check on the line-of-sight of direction between the F.M. station and the receiver and also determine the location of possible noise interference sources. Also, determine what the length of the transmission line is to be and if over 100 feet it is advisable to use a low-loss line, such as a coaxial line, unless the antenna is in a location where the signal strength is quite high.

As a general rule, the antenna should be as high as possible and as far from any noise source as feasible, always bearing in mind that the longer the transmission line the greater will be the line loss. In residential sections, a height of from 30 to 40 feet above the ground or 10 to 20 feet above the roof is, in most cases, satisfactory.

One of the greatest sources of interference to F.M. signals originates in automobile ignition systems. It is accordingly desirable to locate the antenna as far from the traffic stream as is practicable.

Where it is desired to receive more than one F.M. station, which is the usual case, the dipole antenna should be orientated for a satisfactory signal from all F.M. stations. The position where the best signal strength can be obtained will be found by slowly turning the antenna in one direction and then in the other direction while checking the results on the receiver.

Most F.M. transmitting stations now use horizontally-polarized antennas for the reason mentioned previously. This means that the elements of these antennas are horizontal or parallel to the ground. The receiving dipole should also be installed in a horizontal position. Some F.M. stations may, however, employ vertically polarized antennas, and in areas where signals from both types of transmitting antennas are present it may be necessary to make a compromise where installing the receiving dipole antenna. This can be effected by tipping the dipole to a diagonal position, half horizontal and half vertical.

The transmission line between the dipole and the receiver should be as short as possible to keep losses at a minimum. It should also be weatherproofed and should also have the correct surge impedance for reasons mentioned previously. When bringing the transmission line into the house it should not be cut, as is sometimes done, and connected to window strips since this will change the surge impedance of the line and will probably cause enough of an impedance mismatch to introduce a loss in signal. The transmission line should always be continuous from antenna to receiver.

A typical F.M. antenna installation on a private home is shown in Figure 46, which illustrates the method used in securing the antenna to the house. Note that the transmission line is fastened so that it will not sway in the breeze. The antenna might also be secured to the chimney in the event that it is not feasible to fasten it as shown.

Figure 47 illustrates a method of securing the antenna on apartment house roofs, and, as shown, it is fastened to the wall running along the edge of

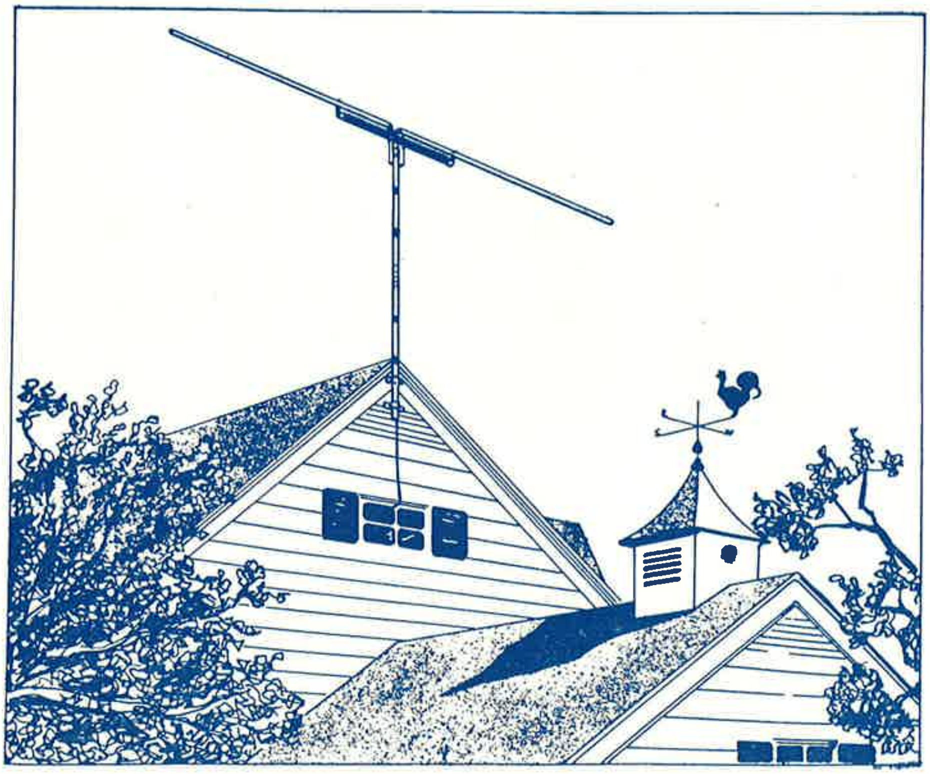


Fig. 46. A typical F.M. antenna installation.

the roof. These illustrations are merely to give some idea of the possible methods of securing the antenna and, in most cases, it will be necessary to use a little ingenuity for the particular case involved.

It should be evident from the foregoing discussion that a proper antenna installation for F.M. usually involves much more care and consideration than is necessary for an ordinary broadcast antenna. However, if the great advantage and the full enjoyment of F.M. is to be realized, too much consideration cannot be given to the antenna installation.

This article completes the series on frequency modulation.

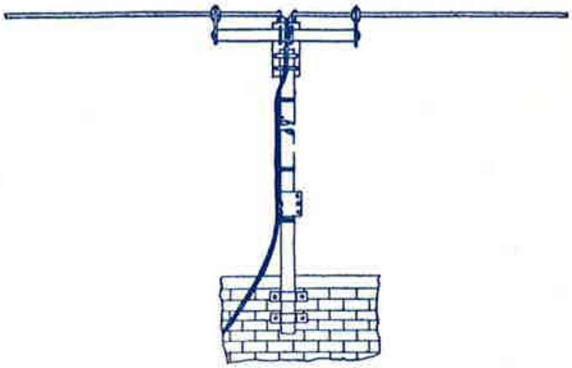


Fig. 47. Mounting of antenna to side wall.

Sensitivity of Microphones to Stray Magnetic Fields

L. J. ANDERSON,

RCA Victor Division of RCA, Camden, New Jersey.

In addition to the usual attributes of a microphone which are commonly measured, such as sensitivity, response - frequency characteristics and directional properties, there are secondary attributes which may be of equal importance in specific applications. Most significant are the following:—Sensitivity of the microphone to stray magnetic fields of low frequency, sensitivity to wind, and sensitivity to mechanical shock.

The purpose of the following discussion is to describe a possible standard method for evaluating one of these factors, namely: the sensitivity of microphones to stray magnetic fields of low frequency, such as are commonly referred to as hum fields.

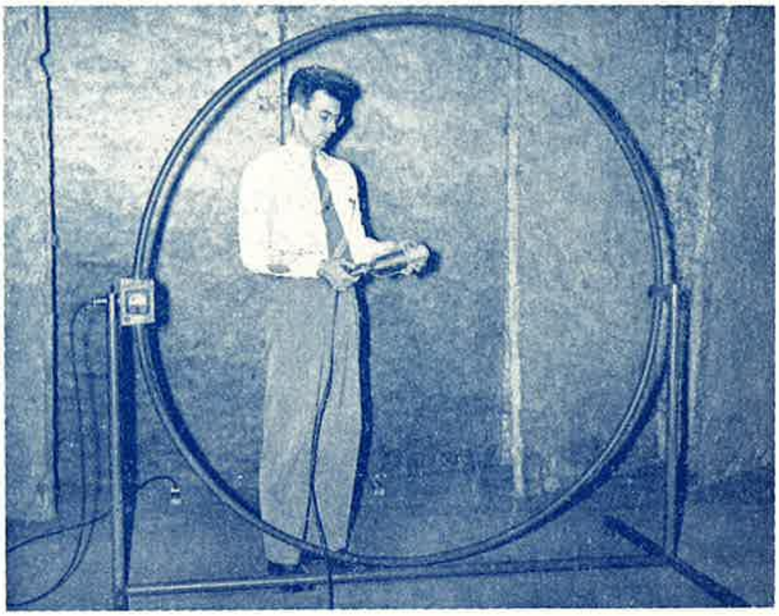


Fig. 1. Sensitivity tests are performed on RCA Type 77-D Polydirectional Microphone by employing field intensity measurements.

Electrodynamic transducers, and all types of microphones in which a coupling transformer is included as a part of the microphone, are sensitive in some degree to hum fields. The evaluation of this sensitivity has always been of some importance for microphones used in Broadcast applications, and of late it has become increasingly important where microphones are used in Television programming, because of the number, strength, and closeness of the hum sources.

Hum fields may originate from any device operating an alternating current or from the incident wiring, and, of course, the strength of the source and the relative proximity to the microphone are factors which are of equal importance. The most likely sources of stray fields are motors, power transformers, voltage regulating transformers, fluorescent light-fixtures, electric clocks, wiring incident to high power lighting, power supplies, and amplifiers

Reprinted from Broadcast News with acknowledgements to RCA.

with self-contained power supplies. Some sources are a serious handicap because of their strength, and others because of their closeness to the microphone.

Within the microphone and associated circuit, excluding the microphone preamplifier, there are several hum sensitive elements as follows:—The microphone cable, the microphone transformer, the internal wiring, the moving conductor and compensating reactor if any.

The problem is two-fold. First, it is necessary to have a standard hum source which will allow various microphones to be compared with regard to their sensitivity to hum fields, and second, equipment is required to properly evaluate hum fields in microphone locations in order that the performance of a microphone may be predicted with reasonable accuracy.

Hum excitation equipment

A large diameter coil of small cross section is best for this purpose, because of the uniformity of the field close to the centre and the resulting non-critical positioning of the microphone during testing.

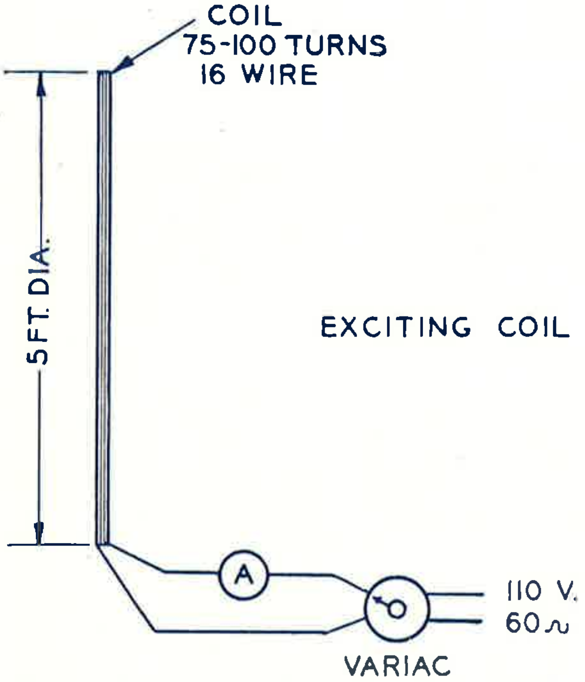


Fig. 2. Sketch of exciting coil set-up pictured in Fig. 1.

The field intensity at the centre of the coil may be calculated from the following:—

$$(1)\quad H = \frac{0.2\pi NI}{r}$$

H = magnetizing force (Oersteds)
N = number of turns
I = current (Amperes)
r = radius (Centimetres)

For practical reasons, values of H between 0.1 and 0.5 Oersted are most suitable. Values lower than 0.1 are likely to approximate ambient fields in magnitude and values above 0.5 pose difficulties from heating of the coil and acoustic noise. The normal power mains are most convenient for the coil excitation because of availability and the similarity of the resulting field to those usually encountered in practice.

The measurement is quite simple. The microphone is placed at the centre of the coil and oriented until a maximum output is indicated on a voltmeter whose input impedance is high enough to assure that the open circuit voltage is being measured. If no such meter is available voltage substitution method may be used. The sensitivity of the microphone to hum is then expressed as follows:—

$$(1)\quad G_H = (20 \log_{10} \frac{E_H}{H} - 10 \log_{10} R_{MR}) - 50 \text{ db}$$

where the reference values are 0.001 watt and a field of 0.0002 oersteds.

The value of G_H is without practical significance because the criterion of the performance of the microphone is the signal-to-noise ratio. This is obtained as follows:—

$$(2)\quad G_{MH} = (G_M - G_H) \text{ db}$$

where G_H is as expressed above and

$$^*G_M = (20 \log_{10} \frac{E_p}{p} - 10 \log_{10} R_{MR}) - 50 \text{ db}$$

(G_M = Microphone Sensitivity)

G_{MH} then reduces to:

$$(3)\quad G_{MH} = (20 \log_{10} \frac{E_p}{p} - 20 \log_{10} \frac{E_H}{H}) \text{ db}$$

(*See RTMA Standard SE-105 Microphones for Sound Equipment.)

In the preceding equations,

E_H = the open circuit hum voltage
H = field strength
E_p = the open circuit signal voltage
p = sound pressure dynes $\frac{2}{\sqrt{cm}}$
R_{MR} = microphone rating impedance

A suitable exciting coil is sketched in Fig. 2.

Evaluation of hum fields

Hum fields may be very easily evaluated for a given location by means of an exploring coil and a voltage indicating device.

The coil should be air core so that the magnetic field is not disturbed. For such a coil:

$$(1)\quad E_s \frac{N d\varphi}{dt} 10^{-8}$$

where

N = number of turns
φ = flux through the coil
E_s = open circuit voltage due to the stray field.

$$(2)\quad \varphi = A_c B \sin \omega t$$

where

B = flux density = H for air
A_c = area of coil
(assuming a sinusoidal variation for B)

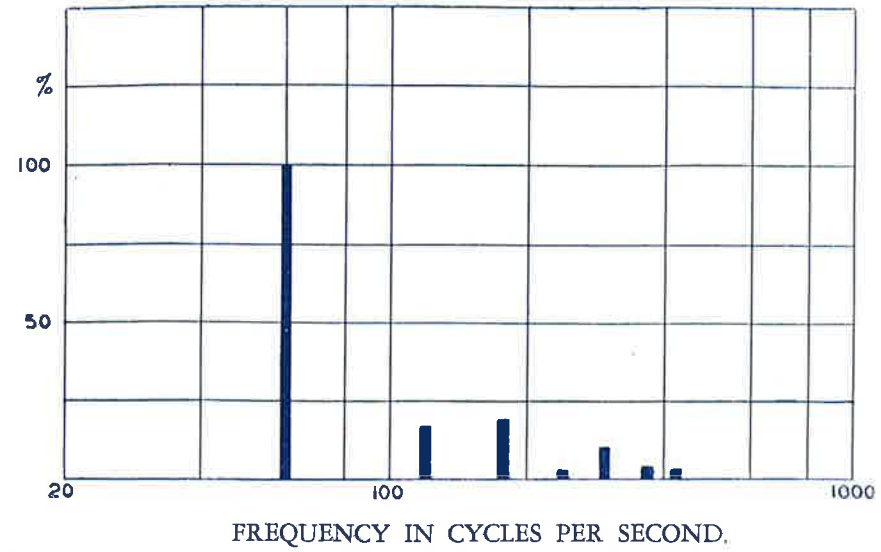


Fig. 4. Field analysis in a typical Broadcast studio.

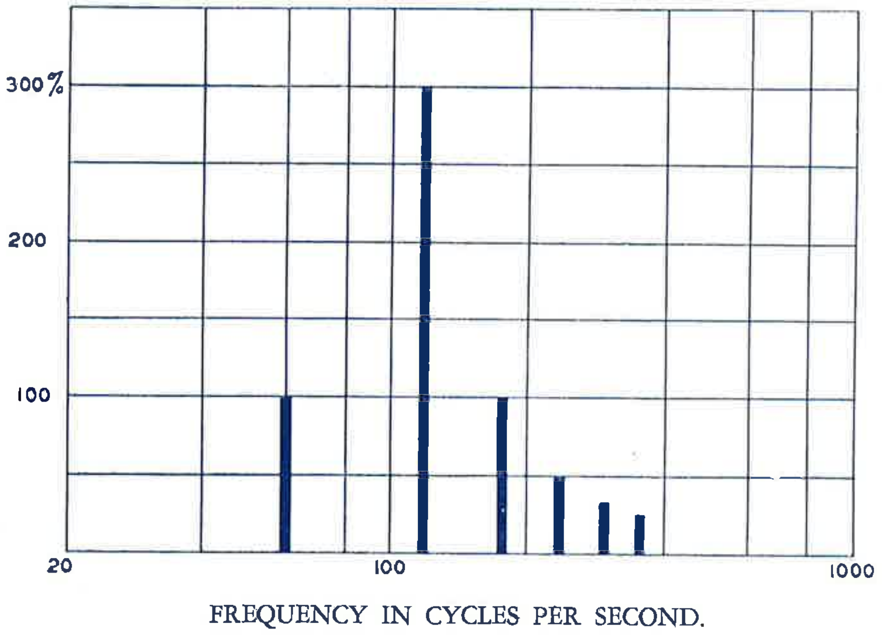


Fig. 5. Field analysis near power amplifier.

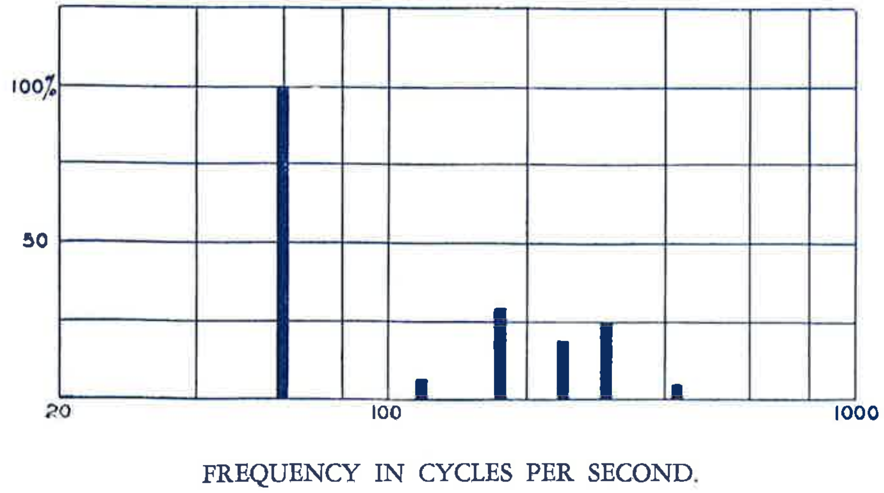


Fig. 6. Field analysis near 80-watt fluorescent fixture.

$$(3)\quad \frac{d\varphi}{dt} = A_c\,\omega G \cos \omega t$$

dropping time function and substituting (3) in equation (1).

$$(4)\quad E_s = NA_c\omega B \times 10^{-8}$$

$$(5)\quad B = H = \frac{E_s \times 10^8}{NA_c\,\omega}$$

If E_s is measured in RMS volts B and H will also represent RMS values.

In order to obtain the maximum value of the field, readings are taken for three mutually perpendicular axes. Then,

$$(7)\quad H_t = \sqrt{H_x^2 + H_y^2 + H_z^2}$$

Where H_x, H_y and H_z represent the field strength along the three axes.

H_t is then referred to a zero level of 0.0002 Oersteds.

$$(8)\quad \text{Field level} = 20 \log_{10} \frac{H_t}{0.0002}$$

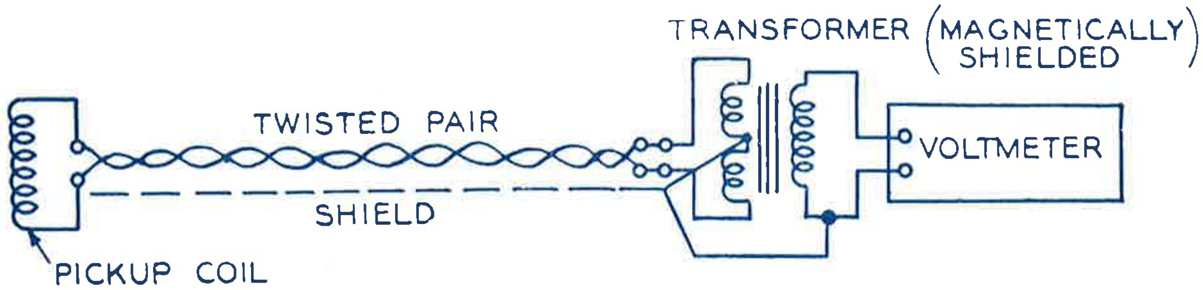


Fig. 3. Schematic diagram of field measuring equipment.

Fig. 3 shows the schematic arrangement of a field measuring set. The number of turns on the pickup coil will depend upon the sensitivity of the voltmeter and the strength of the fields to be measured. If an electronic voltmeter is used, the pickup coil must be kept far away enough from it to assure that the field due to the voltmeter is not contributing to the results.

Typical results

Hum fields encountered are not entirely 60 cycles as can be seen from the analysis shown in Fig. 4, 5 and 6. Since the effectiveness of a given value of H is proportional to frequency for both the hum measuring coil and for most microphones tested, the effect of assuming the entire hum voltage measured to be 60 cycles results in a correct signal-to-noise voltage ratio. On the basis of correlation with actual listening to such signal there may be some merit in considering rating the microphones on a 120- or 180-cycle field.

Hum levels in typical locations

Voltage Regulating Transformer (10ft.)	+ 26.7db
Recording Studio	+ 16.2db
Broadcast Studio	+ 15 db
Broadcast Control Room	+ 14 db
Fluorescent Fixture (80 watt) (36 inch distance)	+ 18 db

G_M AND G_H FOR MICROPHONES

	G_H	G_M
RCA—Type 77-D Polydirectional Microphone	— 139db	— 151db
RCA—Type 44-BX Velocity Microphone	— 129db	— 149db
RCA—Type BK-1A Pressure Microphone	— 116db	— 145db
RCA—Type BK-4A Starmaker	— 139db	— 153db

From the above data the signal to noise ratio may be predicted for any given location if the sound pressure level and hum field levels are known. The following is an example of such a calculation.

G_M for Type 77-D Microphone	— 151db
Sound Pressure Level (assumed)	+ 94db
Output Level for Microphone	— 57db
G_H for Type 77-D Microphone	— 139db
Hum Level in Typical Location	+ 16db
Hum Level from Microphone	— 123db
Signal-to-hum Ratio $G_{MH} = (G_M - G_H)$ or	+ 66db

Editor . . . . Ian C. Hansen
Radiotronics is published twelve times a year by The Wireless Press for Amalgamated Wireless Valve Company Pty. Ltd. The Annual subscription rate in Australasia is 10/-; in U.S.A. and dollar countries $1.50, and in all other countries 12/6. Price of a single copy is 1/-.
Subscribers should promptly notify Radiotronics and also the Post Office of any change of address, allowing one month for the change to become effective. Should any particular issue not be received, please advise us not later than the month following, otherwise replacement copies cannot be guaranteed. No responsibility can be accepted for missing copies if the Post Office is not advised of address changes.
Original articles in Radiotronics may be published without restrictions provided that due acknowledgement is given.