SHORT WAVE ANTENNAS

THEORY AND HOW TO BUILD

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radio television 10

SHORT WAVE ANTENNAS

THEORY - PRACTICE
HOW TO BUILD

By

J. D. NICHOLSON

Second Edition December 1967

WORLD PUBLICATION, LINDORFS ALLE 1
HELLERUP - DENMARK

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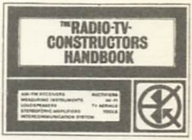
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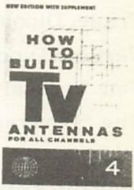
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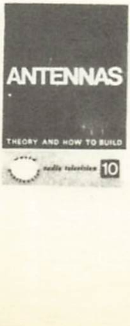
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Chapter 1.

GENERAL

This book contains the design and construction information for those receiving antennas suitable for use by shortwave listeners (SWL's) to the International Shortwave Broadcast Bands. That is, those antennas suitable for the collection of electro-magnetic energy in the form of shortwave radio transmissions in the frequency range 3 to 30 megacycles per second.

A receiving antenna is a device for collecting electro-magnetic energy from space. But since there are a great number of different forms of electro-magnetic energy in space, the antenna must be designed and constructed to collect more of the wanted energy and less of the other unwanted energy. Therefore, the design and construction of an antenna, either receiving or transmitting, will depend on the form of energy that it is required to collect or transmit.

However, it should be mentioned that all of the antennas contained in this book can be used for transmitting as well as receiving. They will also have the same characteristics, that is, gain and radiation patterns on transmit as on receive.

Chapter 2.

PROPAGATION OF RADIOWAVES

In order for the reader to fully appreciate the operation of antennas it is necessary that some explanation of radio wave propagation be given. However, it is not necessary that the reader plod his way laboriously through the following chapter, since an understanding of radio wave propagation is not necessary to build and erect any of the antennas contained in this book.

Generation of Radio Waves

When a transmitter is connected to an antenna it injects an oscillating electric charge into the antenna. This oscillating electric charge sets up a changing electric field in the medium surrounding the antenna. The changing electric field, in turn, sets up a changing displacement current, resulting in a changing magnetic field which in its turn gives a changing electric field. Thus a complete cycle of cause and effect takes place in the medium surrounding the antenna resulting in alternate electric and magnetic fields being set up in the medium progressively further and further from the antenna. Hence the changing electric and magnetic fields or electro-magnetic wave, can be said to be travelling away from the antenna.

The speed with which it travels will vary depending on the medium through which it is travelling, but can never exceed that of light. For all practical purposes it can be assumed to be the same as the speed of light, that is, 300,000 km/sec.

The electric and magnetic strains can be represented vectorially as shown in figure 1, the direction of each being at right angles to the other. The direction of travel of the wave front will be towards the reader.

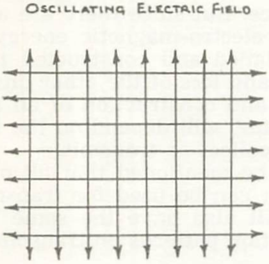


FIG. 1

Types of Waves

Radio waves fall into two main groups, ground waves and sky waves.

Referring to figure 2, those waves leaving an antenna at angles greater than 90° to the vertical would become sky waves. Those leaving at less than 90° to the vertical would become ground waves.

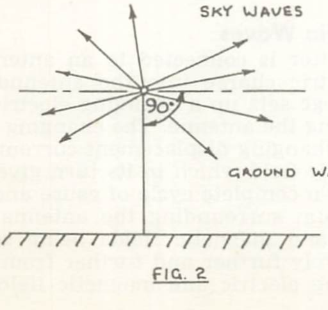


FIG. 2

Ground Waves

By definition these waves travel along the ground; they, therefore, unavoidably must come in contact with the ground. When this happens the waves are attenuated due to "ground absorption." This ground absorption varies depending on the material of the ground, that is, its conductivity, and also the wavelength of the wave. This latter is due to the fact that the resistivity or conductivity of a material is constant only for a given frequency. But it is only when the frequency increases to the kilocycle range and above that the increase in resistivity becomes significant.

This means, therefore, that if the frequency of the ground wave was to be increased, the resistance of the ground along which it was travelling would increase. Therefore, the amount of energy that the ground would absorb from the wave would also increase. Hence, the energy from a wave of high frequency would be absorbed quicker than the energy from a low frequency wave. This means that a low frequency wave would travel further along the ground before being lost due to ground absorption.

Therefore, if a ground wave is to be used it is usually kept in the low or medium frequency bands.

Sky Waves

These waves are beamed up into the atmosphere and are then reflected back down to the ground by one of the layers of ionised gas in the ionosphere. The formation of these layers is explained later.

Each of these layers has certain depth or thickness, and being composed of ionised gas has also an abundance of free electrons. These free electrons, however, are not uniformly

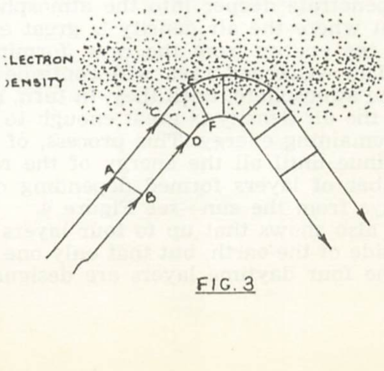


FIG. 3

distributed, but increase in density the higher in the layer. The wave travels into the layer and is bent until it is travelling back towards the ground as shown in figure 3.

Referring to Figure 3, if we consider a ray with wave front AB travelling up through the atmosphere, when the wave front reaches the position CD, point C is just about to enter the layer. Now, since there are free electrons in the layer the wave front finds it easier to travel. Therefore, during the time that the point D takes to travel to F, C will have travelled to E, resulting in the wave front now travelling in a new direction. Thus the ray continues to bend until it is completely reflected back to the ground.

Ionosphere—Formation of Layers

The earth's atmosphere decreases in density with increasing height above ground. This means that the air molecules are at their greatest density at ground level, becoming more rarefied as the height increases, until outer space is reached where there is no air at all. It is this decrease in air molecules and hence air atoms that results in the formation of layers of ionised gas.

The rays arriving from the sun are composed of many wavelengths ranging from the infra-red to ultra-violet. All of them have an effect on the atmosphere, but the one that has the greatest is the ultra-violet.

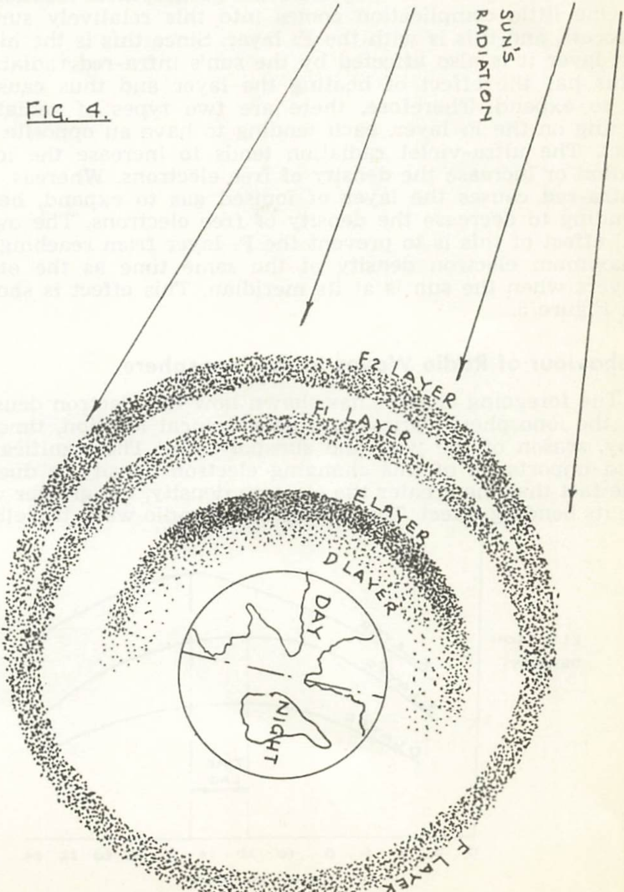
These rays arrive from the sun with varying intensity depending on the amount of sunspot activity there happens to be at that time. When they reach the atmosphere, they cause a certain amount of ionisation to take place. However, in the outer reaches of the atmosphere, since the air is rarified, no significant ionisation can take place. This too will also depend on the intensity or strength of the ultra-violet rays. As the rays penetrate deeper into the atmosphere they will reach a height where the air density is great enough to absorb most of the energy from the rays, forming a layer of ionised gas. The weakened rays will continue to penetrate deeper into the atmosphere, until they, in turn, reach a lower height where the air density is great enough to again absorb most of the remaining energy. This process, of forming layers, will continue until all the energy of the rays is absorbed, the number of layers formed depending on the intensity of the rays from the sun—see Figure 4.

This figure also shows that up to four layers can exist on the daylight side of the earth, but that only one exists on the night side. The four daytime layers are designated D, E, F_1

and F_2 and the night-time layer F being made up of a merging of the F_1 and F_2.

All of these layers are dependent on the intensity of the sun's radiation and therefore as the radiation varies so will the layers. Since the radiation will vary throughout the day

FIG. 4.



(diurnal), and with the season as well as with the eleven year sunspot cycle, the density of the layers will also vary for the same reasons. Therefore, at any geographical location the condition of the layers will be continually changing throughout the day. Also at any time of the day the condition of the layers will vary with the geographical location.

One little complication comes into this relatively simple process, and this is with the F_2 layer. Since this is the highest layer it is also affected by the sun's infra-red radiation. This has the effect of heating the layer and thus causing it to expand. Therefore, there are two types of radiation acting on the F_2 layer, each tending to have an opposite effect. The ultra-violet radiation tends to increase the ionisation or increase the density of free electrons. Whereas, the infra-red causes the layer of ionised gas to expand, hence tending to decrease the density of free electrons. The overall effect of this is to prevent the F_2 layer from reaching its maximum electron density at the same time as the other layers when the sun is at its meridian. This effect is shown in Figure 5.

Behaviour of Radio Waves in the Ionosphere

The foregoing chapter has shown how the electron density in the ionosphere varies with geographical location, time of day, season of the year and sunspot cycle. The significance and importance of this changing electron density is due to the fact that the greater the electron density, the greater will be its bending effect. This means that a radio wave travelling

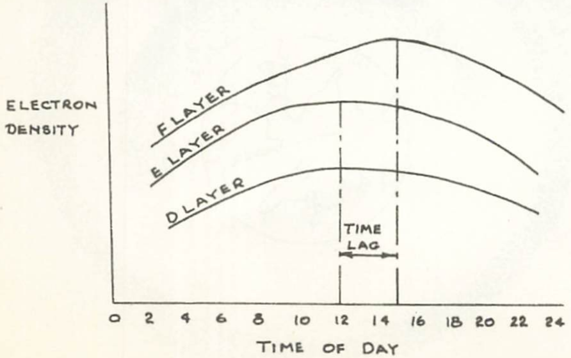


FIG. 5

through a layer will be bent more, or reflected back easier if the layer has a greater density of free electrons. Also the higher the frequency of the radio wave the greater must be the density of electrons in the layer to cause bending and reflection.

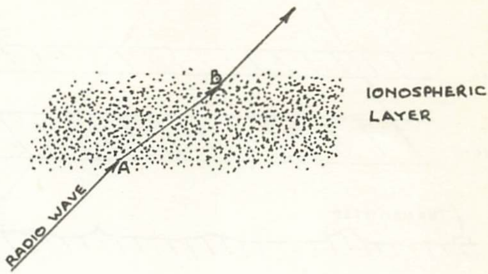


FIG. 6

Figure 6 illustrates a radio wave of a certain frequency travelling upwards until it meets one of the ionosphere layers. As soon as it passes into the layer at A it starts to bend. But if the electron density of the layer is not great enough, the radio wave will not be bent enough to cause reflection, and it will pass through the layer at B and carry on travelling upwards. However, if the frequency of the radio wave was lowered, then the layer electron density would have a greater effect and so cause complete reflection. Therefore, international broadcasting organizations have to choose their transmission frequencies in order that there is no likelihood of them not being reflected. Also they have to change them throughout the day to allow for changing conditions in the ionosphere throughout the day.

A simple answer to this problem of ensuring that the radio wave will always be reflected would appear to be to always use a low frequency. However, it must be kept in mind that there is not just one ionospheric layer, but somctimes up to four. Therefore, a radio wave travelling from the transmitter to a receiver in the target area would be propagated as shown in figure 7.

Notice that each time the radio wave passes through an ionised layer it is bent. This has the effect of increasing the length of the path. Also, as the radio wave passes through each ionised layer it loses some of its energy and the amount of energy lost will increase if the frequency is lowered.

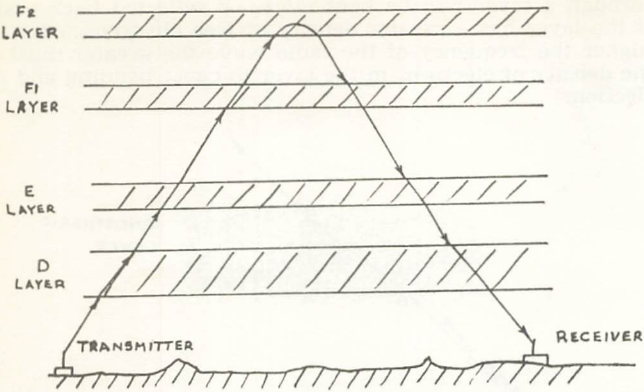


FIG. 7

Therefore, summing this up, we see that as the radio wave passes through each layer it loses energy or, in other words, is attenuated. Also it is bent from the direction it was travelling. This bending increases the length of the path through the layer and therefore also increases the amount of attenuation. But, if the frequency was lowered, the amount of attenuation would increase, and if it was lowered enough the attenuation would become so great, that all of the radio wave energy would be used up before it could reach its target area on the ground.

Therefore, we can see from all the foregoing that, if the frequency of the radio waves is too high, it will not be reflected back to the ground. But if the frequency is made too low, all of the radio wave energy would be attenuated. Therefore, a frequency between these two limits must be used to ensure that the radio wave will be reflected, and will arrive at the target area with sufficient strength to provide a good listening signal.

Behaviour of Radio Waves in the Target Area

In the previous chapter were explained some of the difficulties that a radio wave could encounter on its journey through the ionosphere. These, however, can be overcome by the broadcasting organization choosing the frequency correctly, and transmitting with enough power. But when the radio wave reaches the target area, it has passed beyond the control of the broadcasting organization, and it is then entirely up to the person doing the receiving as to what kind of signal or programme is finally obtained for listening.

Therefore, an SWL should give careful thought to the receiver and the antenna to be used. Particularly the antenna, since good results can be obtained from an inexpensive receiver with a good antenna. But an expensive and elaborate receiver is useless without an antenna.

An explanation, therefore, of how a radio wave enters the target area and what is likely to happen to it while in there will help in deciding on the type of antenna to be used.

The angle at which a radio wave enters the target area depends on the distance from the transmitter site. The greater this distance the smaller will be the angle of entry. A look at Figure 8 will explain this.

Another way of saying this is that the further away the transmitting station, the closer to the horizon will be the signals. Therefore, radio waves coming from a distant transmitter could be effected by any large object that is likely to block it. This could be hills or mountains, large buildings in a built-up area or woods in the country. To combat this the antenna should be erected as high as possible and as far away as possible from any large object.

Once inside the target area the radio wave has to compete with other radio noises already there. These noises can

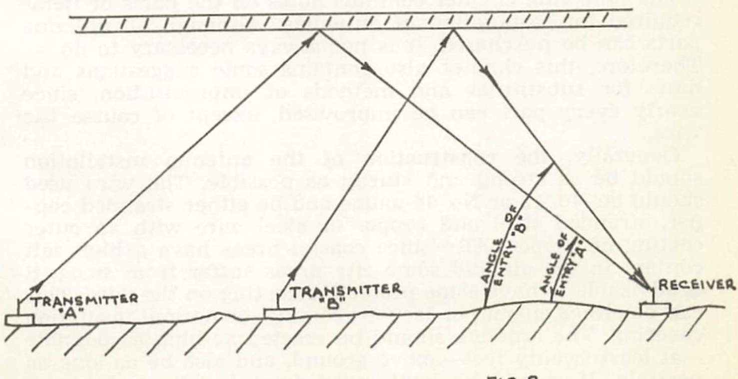


FIG. 8

be divided into two categories, man-made and natural. The man-made noises are generated by electrical equipment and appliances, such as electric saws and drills or car ignition systems, or even other broadcast radio signals. The natural noises, on the other hand, are generated by lightning or electric storms. These do not, however, have to be actually in the target area. Storms many hundreds and even thousands of miles away can effect reception in the target area, as well as local storms Also extra-terrestrial noise from outer space will affect reception.

All of these sources of noise, man-made and natural, maintain a certain noise level in the target area, and it is this overall noise level with which the signal has to compete, since both are picked up by the antenna and fed to the receiver. In order to improve the proportion or ratio of signal to noise, so that more signal than noise is being fed to the receiver, a directional antenna can be used. This type of antenna can be pointed towards the transmitting station, and will pick up signals coming from that direction only. Therefore, it will not receive too much local noise or interfering signals from other transmitters.

Chapter 3.

GENERAL NOTES ON ANTENNA INSTALLATION

The following chapter contains notes on the parts or items required for installation of antennas. Although all antenna parts can be purchased, it is not always necessary to do so. Therefore, this chapter also contains some suggestions and hints for substitutes and methods of improvisation, since nearly every part can be improvised, except of course the wire.

Generally, the construction of the antenna installation should be as strong and sturdy as possible. The wire used should be No. 12 or No. 14 gauge and be either stranded copper, stranded steel and copper or steel wire with an outer coating of copper. Also since coastal areas have a high salt content in the air and some city areas suffer from smog, it is advisable to have some protective coating on the wire. This can be either enamel or lacquer coating, or normal insulation covering. The antenna should be erected as high as possible —at least twenty feet—above ground, and also be as long as possible. It should be kept away from buildings, trees or other obstructions that are likely to impair its reception qualities. Also nearby telephone or power lines should be avoided to prevent noise pick-up from them by the antenna. If, however, space does not permit this, and there is no way of avoiding the lines, the antenna should be erected at right-angles to the telephone or power line. This will reduce the amount of pick-up to a minimum. All connections should be well twisted together to provide a good mechanical connection before being soldered.

Insulators

These can be purchased in practically any size, shape or colour. Two of the more common types are shown in Fig. 9.

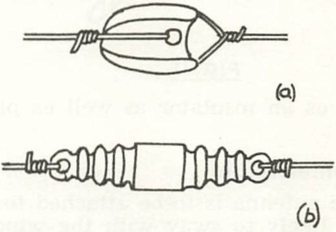


FIG. 9

However, if insulators are not readily available, they can be improvised out of some suitable material. One method is as shown in Figure 10.

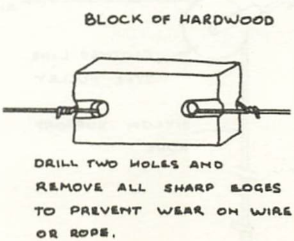


FIG. 10

A simpler method still would be to obtain a hardwood dowel, wrap the wire around it, and then tie the support rope also to the dowel with a clove hitch, as shown in Figure 11.

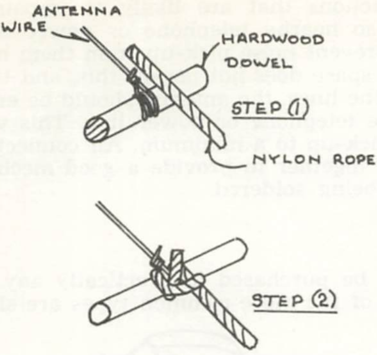


FIG. 11

This will act as an insulator as well as providing a good support.

Pulley and Counterweight

Whenever the antenna is to be attached to a tree or other support that is likely to sway with the wind, a pulley and counterweight should be used, see figure 12. This will prevent the antenna from sagging and also protect it against the possibility of too much strain being placed on it, causing it to snap.

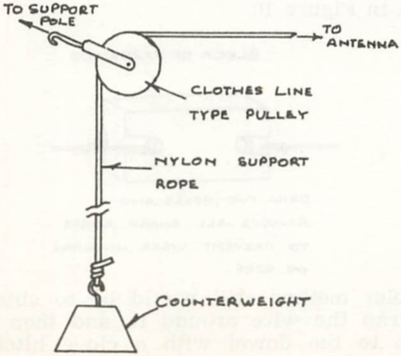


FIG. 12

The counterweight need not be specially made. It can be several housebricks, a metal pipe, a rock or a log of wood. Anything that can be attached to the support rope, and will keep the sag out of the antenna but not put too much strain on it, will be suitable.

Anchor Pegs

These are used to anchor the lower end of a vertical antenna or hold down-leads or feed-lines steady. They can be of either wood or metal. A tent peg would be suitable for this purpose, or they can be cut from a block of wood or a tree, see figure 13. The length of the peg will depend on the ground into which it is to be driven, the softer the ground the longer the peg will have to be.

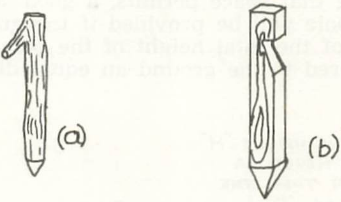


FIG. 13

Guy Lines

Whenever it is necessary to erect a pole, it will also be necessary, in most cases, to have guy lines for its support. There are a few simple rules that apply to the positioning of the guys and will ensure that they are providing the best support for the pole. Usually three guys will be sufficient to support the pole, and these should be anchored to the ground so that there is approximately 120° between each. A look at figure 14 will explain this. Also, one of the guys should should be positioned so that it is in direct line with the antenna wire. This will provide a means of taking the sag out of the antenna during erection.

As a rough guide, the guys should be attached to the pole at approximately one-third of the total height from the top of the pole. Also the height at which the guys are attached

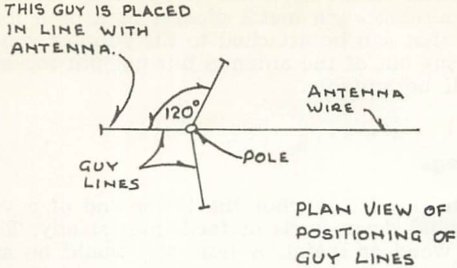


FIG. 14

to the pole should never be greater than the distance from the base of the pole to the point on the ground where the guy will be anchored. Figure 15 illustrates this point. Therefore, providing that space permits, a good support arrangemen for any pole will be provided if the guys are attached at two-thirds of the total height of the pole, from the base, and are anchored to the ground an equal distance from the base.

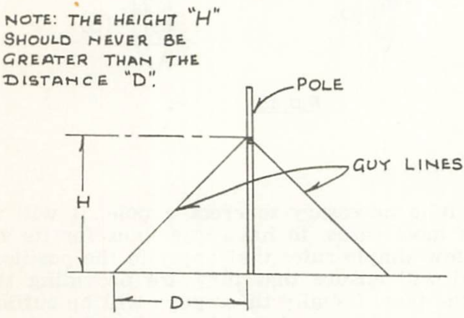


FIG. 15

There are various methods of attaching a guy to the pole, but no matter how this is done one item must always be provided, and this is some means of preventing the guy from slipping down the pole. This will be more of a problem if the pole is the same size all the way down. If the pole is of wood the problem can be simply solved by putting a nail, a spike or even cutting a notch, where the guy wraps around. Figure 16 illustrates these methods.

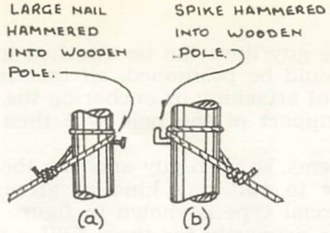


FIG. 16

More elaborate devices can be obtained commercially or even devised by the reader, since the three illustrated are by no means the only method that can be used.

However, when the pole is made of metal the problem becomes a little more difficult to solve, and requires more work on the part of the installer. Several methods are illustrated in figure 17, that require holes to be drilled and threaded in the pole.

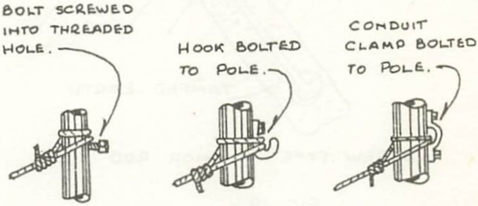


FIG. 17

Alternatively, devices can be obtained commercially or made by the installer using clamps to hold guy supports on to the pole. Some of these are illustrated in figure 18.

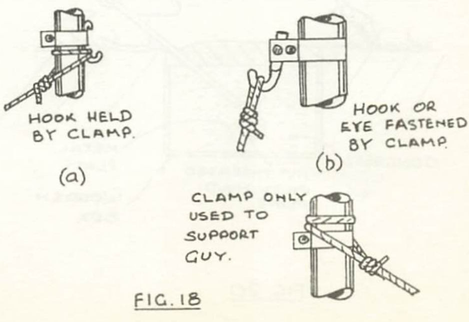


FIG. 18

Guy Anchors

Having seen how the guy lines can be attached to the pole and also how they should be positioned, all that is now required is some means of attaching or anchoring the guy lines to the ground. The support of the pole will then be complete.

As with the other items, so with guy anchors, these can be obtained commercially to suit any kind of ground conditions, and one commercial type is shown in figure 19. However, since this book is primarily for those SWL's who want to make and do for themselves, several samples of improvised guy anchors are also given.

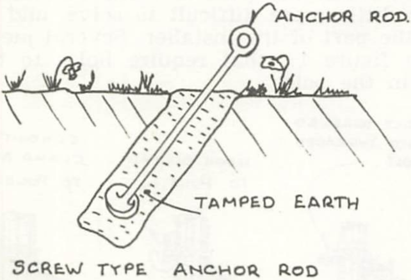


FIG. 19

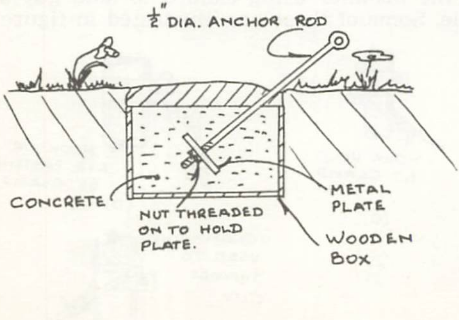


FIG. 20

In figure 20, the wooden box is placed into the hole, and then filled with cement. The anchor rod is placed into the cement at approximately 45° and left until it hardens. The whole assembly is then covered with earth and tamped down.

FIG. 21

The log of wood or piece of piping is buried in the hole with strong wire or rope wrapped around it. This wire or rope is brought out to the surface and the guy line attached to it by means of an insulator.

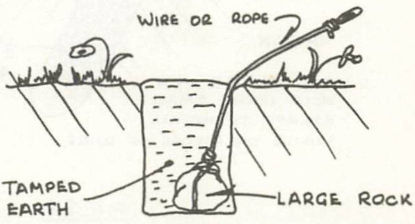


FIG. 22

Strong wire is wrapped securely around the rock and brought out to the surface. The hole is filled with earth and tamped down. The guy line can then be attached to this wire by means of an insulator.

An old bucket can successfully be used as an anchor providing the handle is securely fastened. Fill the bucket with small rocks and bury it after fastening wire to the handle. This wire is then brought out and can be attached to the guy line by an insulator.

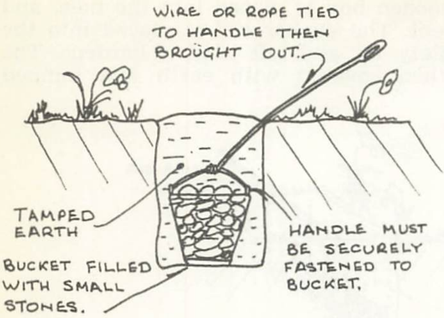


FIG. 23

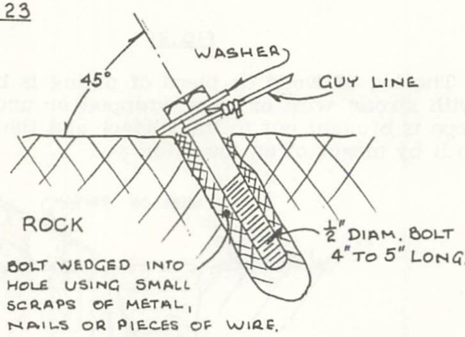


FIG. 24

The anchor shown in figure 24 is for use in rock. A hole will have to be drilled or chiselled out first. Then the bolt can be wedged into the hole using pieces of metal, at approximately 45° as shown. A washer should be placed on the bolt to give additional security against the guy line slipping off.

All of the guy anchors shown so far are for the support of medium to large poles. However, for the SWL who is going to install a small pole only, it is not then necessary to have anchors such as these. Good sturdy pegs driven well into the ground as shown in figure 25 will usually prove quite adequate.

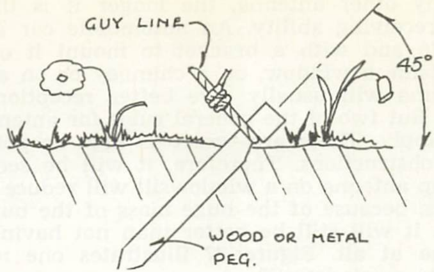


FIG. 25

Lead-ins

This is the connection between the antenna and the receiver. In most cases it will be made with co-axial cable, as shown in figure 26. This type of cable provides a shield around the conductor which, when grounded, prevents the lead-in from picking up extra noise, which would tend to drown out the signal picked up by the antenna. However, since all lead-ins cannot be of the co-axial type, it is a good general rule to make the lead-in as short as possible, and keep it away from areas where noise is likely to be generated.

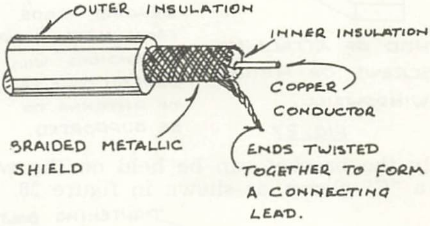


FIG. 26

Chapter 4.

Short Wave Antennas

WHIP ANTENNA

The whip antenna is the answer to the antenna problem for those SWL's living in apartment buildings or other locations where it is not possible to erect something larger.

The whip is an omni-directional antenna, which means that it will receive signals equally well from any direction.

And like any other antenna, the longer it is the greater will be its receiving ability. An automobile car antenna is very suitable and with a bracket to mount it on, can be installed outside a window, on a chimney or on a pole.

This antenna will usually give better reception than an indoor type. But two of the general rules for antenna installation still apply. These are—erect as high as possible and away from obstructions. Therefore, it will be seen that to install a whip antenna on a windowsill will reduce its reception qualities, because of the huge mass of the building besides it. But it will still be better than not having an outdoor antenna at all. Figure 27 illustrates one method of attachment to a windowsill.

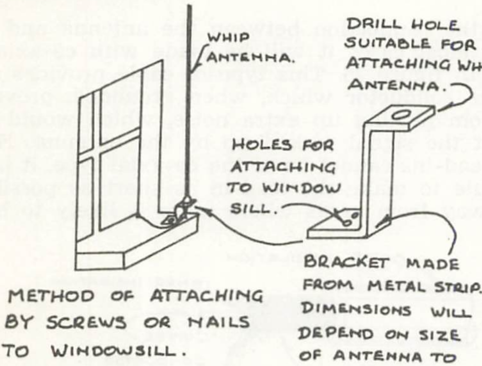


FIG. 27

Alternatively the bracket can be held on the windowsill by means of a "C" clamp, as shown in figure 28.

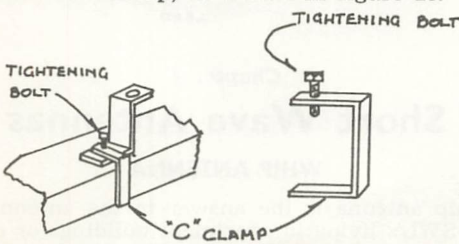


FIG. 28

However, as was mentioned before, it is preferable if the antenna can be mounted above the building, or on a pole.

If either of these locations is used, then the antenna support bracket can be mounted on the chimney or pole by means of straps. Figure 29 shows how a bracket can be attached to a chimney by means of straps. For this type of attachment, one side of the bracket should be quite long, in order to give better support.

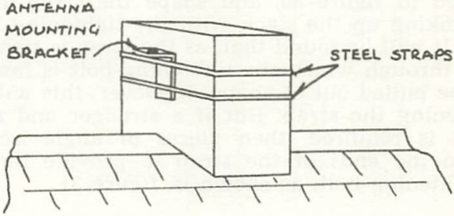


FIG. 29

The straps for installations such as this can be obtained commercially and will be the same as those used for mounting TV antennas. However, like everything else, if the SWL is also a handyman with tools and has materials available, they can also be made. Figure 30 shows what a typical strap would look like before being tightened up. A suitable material for the strap would be 3/4" wide by 1/8" thick steel strip. The outside dimensions of the chimney should be measured to give the total length of strap required. However, the strap should be cut some 4" shorter than the total circumference of the chimney.

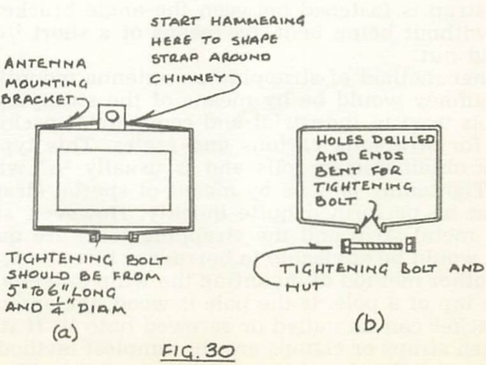


FIG. 30

This will give allowance for 1″ to be bent at either end to form a bracket for the tightening bolt and also will allow approximately 6″ of adjustment for the final tightening. Wrap the strap around or slip it over the top of the chimney. Then with a hammer start at the middle of the strap as indicated in figure 30, and shape the strap around the chimney, taking up the slack with the tightening bolt when necessary. It will be found that, as the strap is tightened, the bent ends through which the tightening bolt is fastened will probably be pulled out of shape. However, this will not prevent tightening the strap. But if a stronger and neater arrangement is required, then pieces of angle iron can be fastened to the ends of the strap to provide the brackets for the tightening bolt, as shown in figure 31.

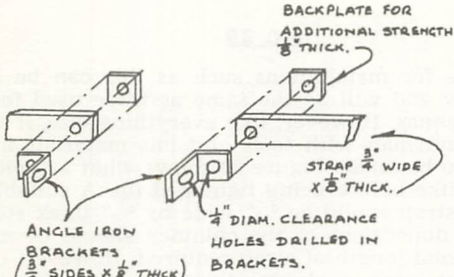


FIG. 31

The strap is fastened between the angle bracket and back plate, without being bent, by means of a short 1/4″ diameter bolt and nut.

Another method of strapping an antenna mounting bracket to a chimney would be by means of the strapping materials and tools used in industrial and commercial packing departments for strapping cartons and crates. This type of metal strip is obtainable in rolls and is usually 1/2″ wide by 1/16″ thick. Tightening is done by means of special strapping tools and can be performed quite quickly. However, since a role of this metal strip and the strapping tools are quite expensive, it would be advisable to borrow or hire them, if possible.

The other method of mounting the whip antenna mentioned was on top of a pole. If the pole is wood, the antenna mounting bracket can be nailed or screwed onto it. If it is a metal pole then straps or clamps are the simplest method of attaching the mounting bracket, as shown in figure 32.

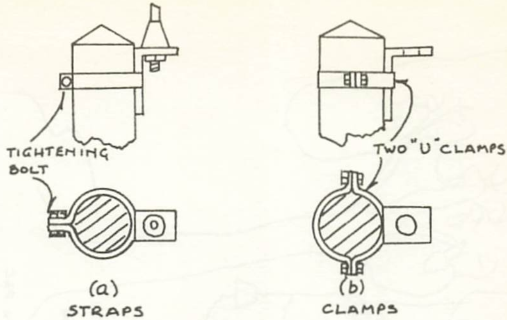


FIG. 32

Once again these clamps and straps or similar devices can be obtained commercially, but the handyman can easily make them for himself out of strips of metal. One simple type of strap is shown in figure 33, which allows easy tightening. Its dimensions do not have to be too accurate since any looseness can be taken up by using a long tightening bolt.

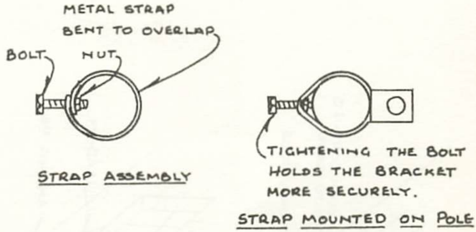
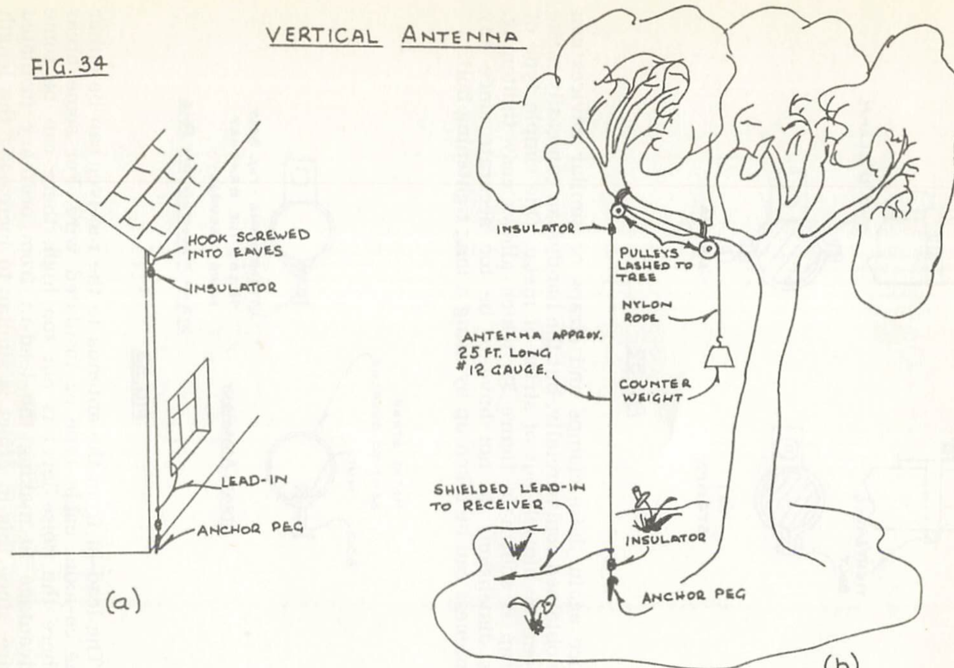


FIG. 33

The lead-in from the antenna to the receiver can be either the co-axial cable type or insulated wire. For some areas where the noise level is not too high, there can be some advantage to making the lead-in from ordinary insulated wire, since this in effect is similar to increasing the length of the antenna.

VERTICAL ANTENNA

FIG. 34



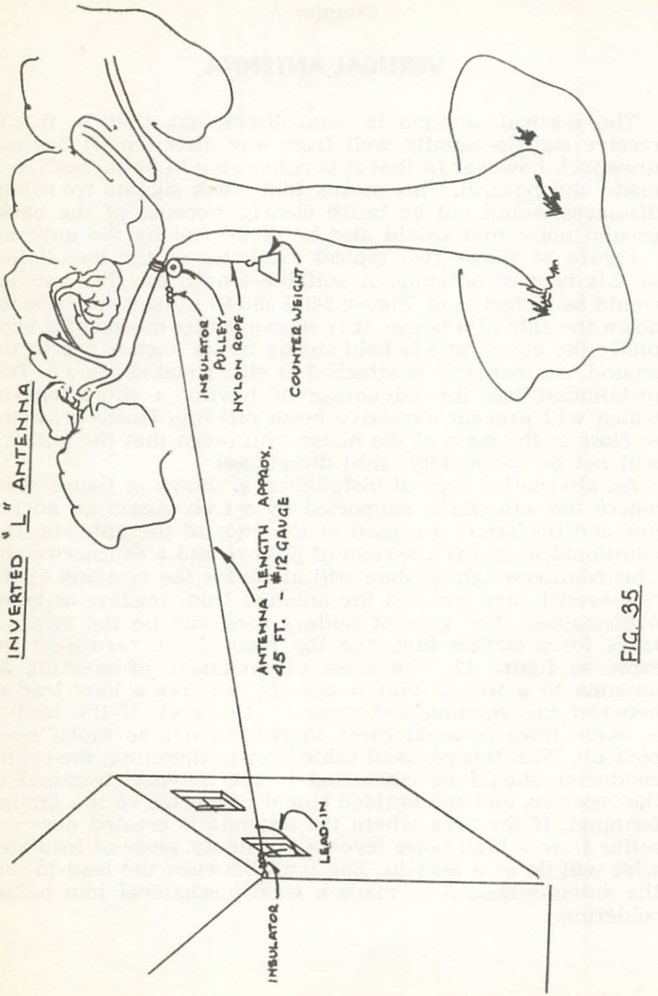
Chapter 5.

VERTICAL ANTENNA

The vertical antenna is omni-directional, that is, it will receive signals equally well from any direction. It has one drawback however in that it is responsive to noise, both man made and natural. This means that weak signals from long distances would not be heard clearly, because of the background noise that would also be picked up by the antenna.

Figure 34 shows two typical examples of the installation of this type of antenna. A suitable length for this antenna would be 25 feet long. Figure 34(a) shows the antenna erected down the side of a house. It is supported by means of a hook under the eaves, and is held steady by an anchor peg in the ground. An insulator is attached at either end as shown. This installation has the advantage of having a short lead-in, which will prevent excessive noise pick-up. However, being so close to the mass of the house, will mean that the antenna will not be completely omni-directional.

An alternative type of installation is shown in figure 34(b), where the antenna is supported by a tree. Again an anchor peg and insulators are used at the ends of the antenna. But additional to this is a system of pulleys and a counterweight. This counterweight system will allow for the swaying of the tree branch, and prevent the antenna from sagging or being overstrained. The type of pulleys used can be the same as those for a clothes line, and the type of counterweight the same as figure 12. The main disadvantage of erecting an antenna to a tree is that it usually requires a long lead-in between the antenna and receiver. However, if the lead-in is made from co-axial cable there will not be much noise pick-up. With this co-axial cable lead-in therefore, the centre conductor should be connected to the antenna terminal of the receiver, and the braided shield connected to the ground terminal. If the area where the antenna is erected does not suffer from a high noise level, an ordinary piece of insulated wire will do as a lead-in. The joint between the lead-in and the antenna should be made a good mechanical join before soldering.


INVERTED "L" ANTENNA
ANTENNA LENGTH APPROX.
45 FT. - #12 GAUGE
INSULATOR
PULLEY
NYLON ROPE
COUNTER WEIGHT
LEAD-IN
INSULATOR
FIG. 35

Chapter 6.

INVERTED "L" ANTENNA

The inverted "L" antenna is another omni-directional type. It can be erected between any two supports. Figure 35 shows a typical installation between a house and a tree. However, any of these supports can be substituted by a pole, suitably supported. The length of the antenna should be approximately 45 feet and be erected at least 20 feet above the ground. The antenna wire is terminated at an insulator each end, which are in turn supported by tie-offs of nylon rope or similar material. The tie-offs at the ends of the antenna are attached to the two support points. If one of the support points used is a tree then it is advisable to use a pulley and counterweight arrangement. The lead-in is taken from the nearest end of the antenna in order to keep it as short as possible. It should be securely connected to the antenna to prevent a dry joint, and well soldered. The lead-in can be an ordinary piece of wire, but should be insulated to prevent it becoming accidentally grounded. If grounding of the lead-in occurs the signal from the antenna would go to ground instead of being fed to the receiver.

Chapter 7.

WINDOM OR "OFF-CENTRE FED" ANTENNA

The "off-centre" fed antenna was named the Windom after the experimenter who first started using it. It is a directional antenna, with the maximum receptivity being obtained when it is broadside-on to the incoming radio signals. In order to make it directional and therefore more efficient as a signal collector, the length of the antenna must be cut to a specific length. This length is determined by the lowest frequency band that the listener intends to use, and is found by the formula:

$$L = \frac{468}{f\ (mc/s)}\ \text{(feet)}$$

where
L = required length of antenna in feet
f = frequency in megacycles per second

It is important that the lead-in be connected to the antenna at the correct position. This is determined by dividing the required length of antenna by three, and the length in feet so obtained will be the distance from the end of the antenna at which the lead-in should be connected. Since it is still necessary to keep the lead-in as short as possible, it therefore follows that it should be connected one-third along the antenna from the end nearest to the receiver.

The antenna itself is erected horizontally between two supports. Figure 36 illustrates a typical installation where the antenna is erected between a house and a pole. The height of the antenna above the ground should be as great as can be obtained and, if possible, not less than half the length of the antenna.

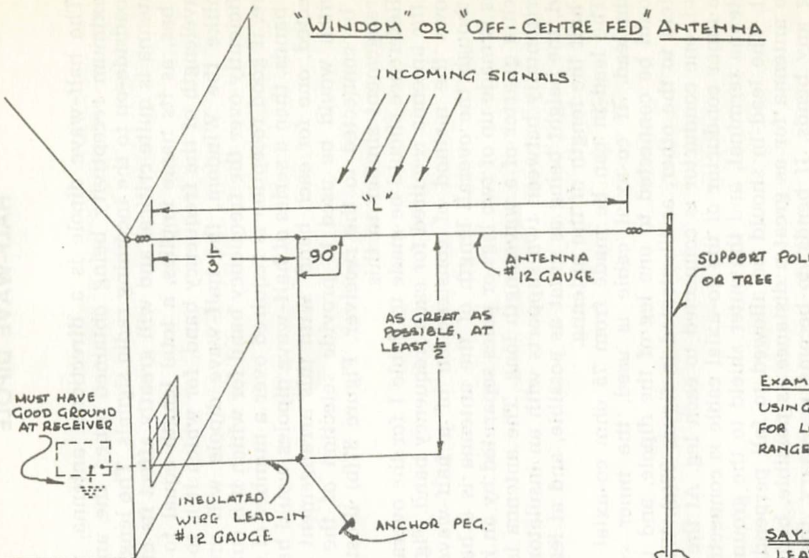
The lead-in should be allowed to drop freely from the antenna, so that it hangs at right angles to it, for as great a distance as possible. If it is necessary to make bends in the lead-in they should be made as gradually as possible. This is necessary in order that the impedance of the lead-in will remain constant. Any common type of insulated wire will be suitable for the lead-in, and can be No. 12 or No. 14 gauge. An anchor peg or some similar means should be used to hold the lead-in steady.

Since this type of antenna is a ground return type, the receiver to which it is connected should be well grounded.

For a Windom antenna suitable for use from 5 mc/s up, the dimensions would be—length approximately 95 feet, lead-in connected 32 feet from one end and height above ground 45 feet, if possible.

"WINDOM" OR "OFF-CENTRE FED" ANTENNA

FIG. 36



EXAMPLE

USING $L = \frac{468}{f(mc/s)}$ FEET FOR LOWEST FREQUENCY RANGE OF 5 MC/S.

$L = \frac{468}{5}$ FT.

$= 93{\cdot}6$ FT.

SAY 94 FT

LEAD-IN CONNECTED AT $\frac{L}{3}$, i.e. 32 FT.

VERTICAL LENGTH OF LEAD-IN, $\frac{L}{2}$ = 47 FT.

Chapter 8.

HALF-WAVE DIPOLE

The half-wave dipole is a directional antenna, with the maximum receptivity being obtained when the antenna is broadside-on to the incoming radio signals. The length of the antenna is quite critical and will greatly affect its efficiency. It has, as its name implies, a total length equal to half the wavelength of the frequency band, for which it is to be used. Unlike the Windom, the half-wave dipole will only work efficiently over the frequency band for which it is cut. Therefore, if good reception is required over a number of frequency bands, then a series of half-wave dipoles would have to be erected, one for each band. With this arrangement a multi-switch would be used to provide selection of the antenna to be connected to the receiver. Figure 37(b) illustrates an arrangement similar to this.

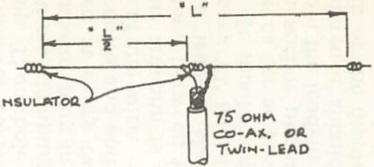
Reference should be made to Table I for the overall length of the antenna required for each frequency band. Figure 37(a) shows the method of construction of a half-wave dipole. Although the overall length of the antenna is a half-wave, this is made up of two legs or poles separated by an insulator, each a quarter of a wavelength long. The antenna is erected horizontally between two supports with an insulator at each end, the height being as great as possible, and at least equal to half the length of the antenna.

The lead-in can be made from 75 ohm co-axial cable or twin-lead. If co-axial cable is used, the inner conductor should be connected to one leg of the dipole, and the outer shield to the other, as illustrated in figure 37(a). With twin-lead, one conductor is connected to each leg. At the receiver the inner conductor of the co-axial cable is connected to the antenna terminal, and the outer shield to the ground terminal. The lead-in should be allowed to fall perpendicular to the antenna for as great a distance as possible, before making any bends. If bends do become necessary, they should be made gradually.

An anchor peg should be placed under the lead-in to provide a means for securing it, as shown in figure 37(b).

HALF-WAVE DIPOLE

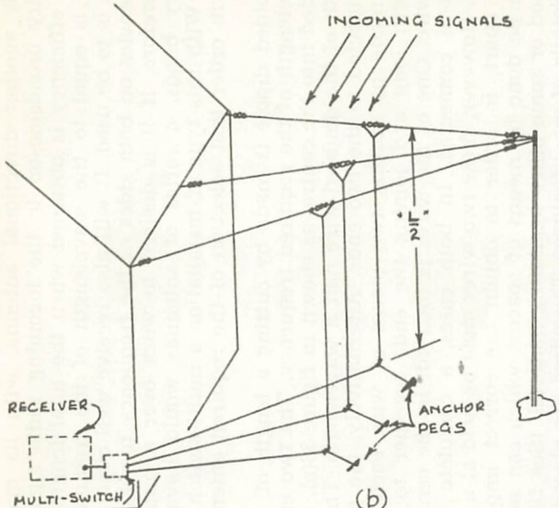
CAN BE USED WITH MULTI-SWITCH



(a)

TABLE I

FREQ. MC/S	METRE BAND	LENGTH "L" FEET	LENGTH "L" METRES
21	13	22	7
17	16	27	9
15	19	31	10
11	25	42	14
9	31	52	17
7	41	67	21
6	49	78	25
5	59	94	30



(b)

FIG. 37

Chapter 9.

FOLDED DIPOLE

This is another directional antenna, with its maximum receptivity broadside-on to the incoming radio signals. Its greatest efficiency is obtained when the total length of the antenna is equal to the wavelength of the frequency for which it is to be used. It will also receive well over a range of frequencies on both sides of the frequency to which it is cut Therefore, if it is desired to work over a number of frequency bands, a series of antennas would have to be erected. With this type of installation a multi-switch should be used in order that selection of the required antenna can be made.

The folded dipole is made by cutting a length of wire to the wavelength of the required frequency. The two ends are then folded into the centre, as shown in figure 38(a), making the length of the doubled wire half a wavelength. The lead-in is connected to the two ends. Alternatively, the antenna can be made by cutting two pieces of wire each half a wavelength long and joining the ends together to give a double wire. One of the wires is then cut in the centre and the lead-in connected. In both cases, a complete loop is obtained. However, these two wires must be held at a certain distance apart, in order to obtain the correct impedance. This can be done by means of spacers which can be made from wood or some other insulating material. (See figure 39 for the details of manufacture.) The wires are placed in the two grooves cut in the spacer and another spacer placed on top. The whole assembly is then tightened by means of the three clamping bolts, thus holding the two wires at a distance of four to six inches apart. The spacers should be placed at every two to three feet along the antenna, with the centre and end ones being placed to give support to the ends of the wire.

This antenna is suspended horizontally, by means of insulators, between two supports.

The lead-in should be made from 300 ohm twin-lead, ordinary TV lead-in cable being very suitable for this purpose. It should also be allowed to fall away from the antenna as far as possible, before being bent.

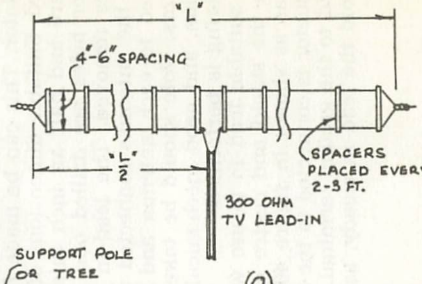
An anchor pèg or some other means will also be needed to hold the lead-in steady, and prevent it from swinging.

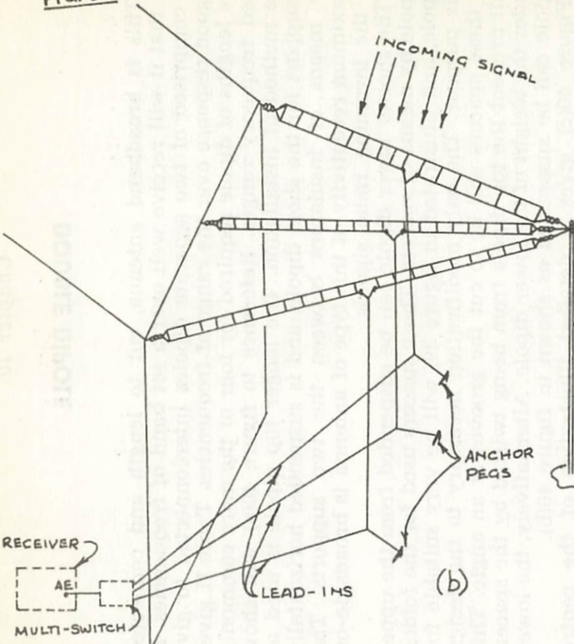
Reference should be made to Table I for the required length of the dipole. However, for the folded dipole it must be remembered that the total length of wire is twice the dipole length.

FIG. 38

FOLDED DIPOLE

CAN BE USED WITH A MULTI-SWITCH





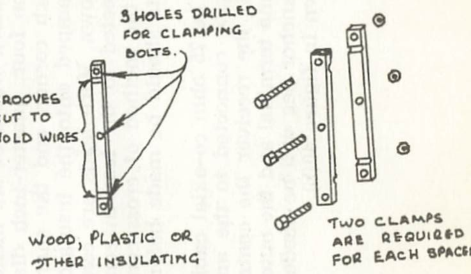


FIG. 39

Chapter 10.

DOUBLE DIPOLE

This is broadband antenna, cut to length and connected so that it will receive well over a set band of frequencies. It is comprised of two separate dipoles interconnected to give a good response over the range of frequencies. Table II gives the lengths of dipole required for four of the more commonly used frequency ranges. Reference to figure 40(a) will show the method of installation. The longer top dipole is used as a support for the short dipole, and is suspended horizontally by means of insulators between the two supports. The maximum receptivity of this type of antenna is broadside-on to the incoming radio signals.

The shorter lower dipole can be suspended from the upper dipole by means of spacers. Those spacers used for the folded dipole, and illustrated in figure 39, will be very suitable for this purpose. The only modification necessary to the design of these spacers will be to cut the grooves at an angle. This will prevent the top dipole from being twisted by the spacer, under the weight of the lower dipole. Alternatively, the lower dipole can be suspended as shown in figure 40(b).

Figure 40(c) gives a detailed illustration of the centre insulator. This can be made from a block of wood or plastic board. Suitable dimensions of the block would be six inches square and half an inch thick. The four, quarter-inch diameter holes are drilled one in each corner, and the sharp edges removed. The lead-in is clamped onto the insulator and the antennas connected as shown. Wire leads are connected to each antenna and connected to the lead-in conductors. Note should be taken of the method of cross-connection, and good mechanical joints should be made before soldering is performed.

A suitable lead-in to use would be 75 ohm co-axial cable with the shield and centre conductor connected to the antennas as shown in figure 40(c). At the receiver the centre conductor is connected to the antenna terminal and the outer shield to the ground terminal. An anchor peg will be needed to hold the lead-in steady, as shown in figure 40(b).

DOUBLE DIPOLE

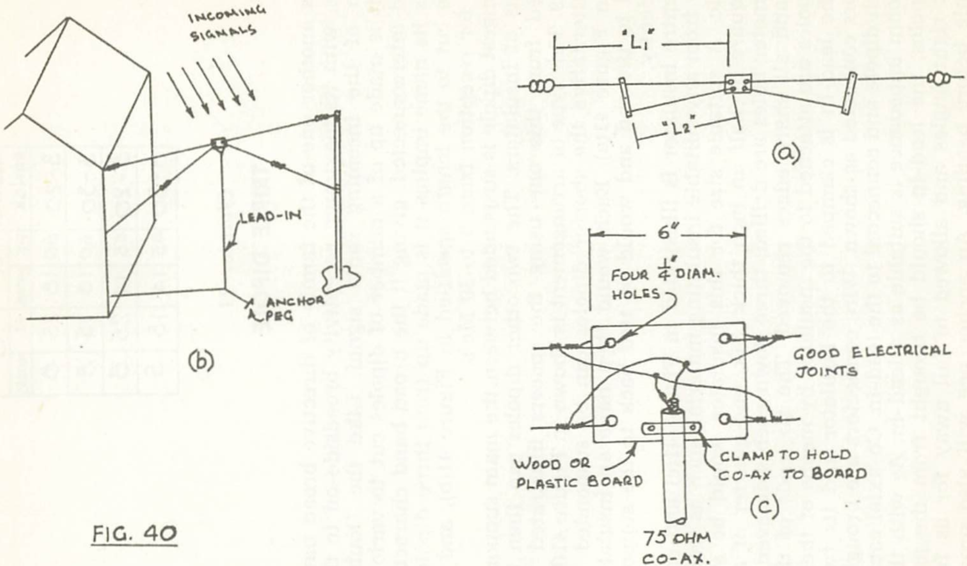


FIG. 40

TABLE II

FREQUENCY RANGE	L1		L2	
	FT.	METRES	FT.	METRES
3-20	60	18	25	8
3-30	60	18	15	5
5-20	45	14	25	8
5-30	45	14	15	5

Chapter 11.

TRIPLE DIPOLE

This is another one of the family of directive broad band antennas, with its maximum receptivity broadside-on to the direction of the incoming radio signal. Like the Double Dipole, it is made up of a number of dipoles cut to various sizes and interconnected, giving it the broad band characteristic. As its name implies it is made up from three dipoles, each one cut to the length specified in Figure 41(b), and is suitable for reception from 5 to 30 Mc/s.

The longest dipole is suspended between the main supports by means of insulators. The two other dipoles can then be suspended from this one using the spacers illustrated in Figure 39. This type of arrangement is shown in Figure 41(b). As an alternative the shorter dipoles can be suspended as shown in Figure 41(a). Each would then have an insulator attached to the end and would be tied back to the support independently.

The centre insulator is illustrated in Figure 41(c) and can be made from any suitable insulating material, such as wood or plastic. A suitable size for this insulator would be six inches square by half an inch thick. Six, one-quarter of an inch diameter holes are drilled, three down each side evenly spaced, and all sharp edges removed. The six ends of the three dipoles are attached to the insulator by means of these holes. The lead-in is clamped to the insulator and its two conductors connected as shown. Wire connectors are brought from each dipole and connected to the lead-in. Co-axial cable with 75 ohm impedance is suitable as a lead-in. As with the other dipoles, the lead-in should be brought from the antenna at right angles and allowed to fall away for as far as possible before bending. An anchor peg will also prove useful in order to tie down the lead-in and hold it steady.

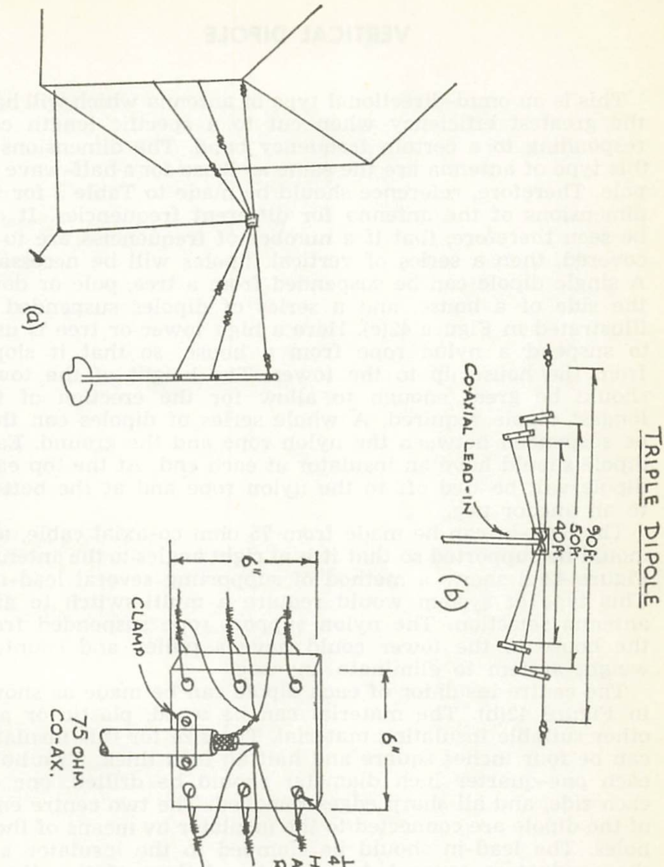

TRIPLE DIPOLE
90Ft.
50Ft.
40Ft.
CO-AXIAL LEAD-IN
(a)
(b)
(c)
CLAMP
6"
6"
75 OHM
CO-AX.
$\frac{1}{4}$" DIAM. SIX
HOLES DRILLED
AND EDGES
REMOVED.

FIG. 4.1

Chapter 12.

VERTICAL DIPOLE

This is an omni-directional type of antenna which will have the greatest efficiency when cut to a specific length corresponding to a certain frequency band. The dimensions of this type of antenna are the same as those for a half-wave dipole. Therefore, reference should be made to Table I for the dimensions of the antenna for different frequencies. It can be seen therefore, that if a number of frequencies are to be covered, then a series of vertical dipoles will be necessary. A single dipole can be suspended from a tree, pole or down the side of a house, and a series of dipoles suspended as illustrated in Figure 42(c). Here a high tower or tree is used to suspend a nylon rope from a house, so that it slopes from the house up to the tower. The height of the tower should be great enough to allow for the erection of the longest dipole required. A whole series of dipoles can then be suspended between the nylon rope and the ground. Each dipole should have an insulator at each end. At the top each dipole will be tied off to the nylon rope and at the bottom to an anchor peg.

The lead-in can be made from 75 ohm co-axial cable, and should be supported so that it is at right angles to the antenna. Figure 42(c) shows a method of supporting several lead-ins. This type of system would require a multi-switch to give antenna selection. The nylon support rope suspended from the house to the tower could have a pulley and counterweight system to eliminate any sag.

The centre insulator of each dipole can be made as shown in Figure 42(b). The material can be wood, plastic or any other suitable insulating material. The size for this insulator can be four inches square and half an inch thick. Two holes each one-quarter inch diameter should be drilled, one on each side, and all sharp edges removed. The two centre ends of the dipole are connected to the insulator by means of these holes. The lead-in should be clamped to the insulator and the conductors connected to the two halves of the dipole, as shown.

At the receiver, the centre conductor should be connected to the antenna terminal and the outer shield to the ground terminal.

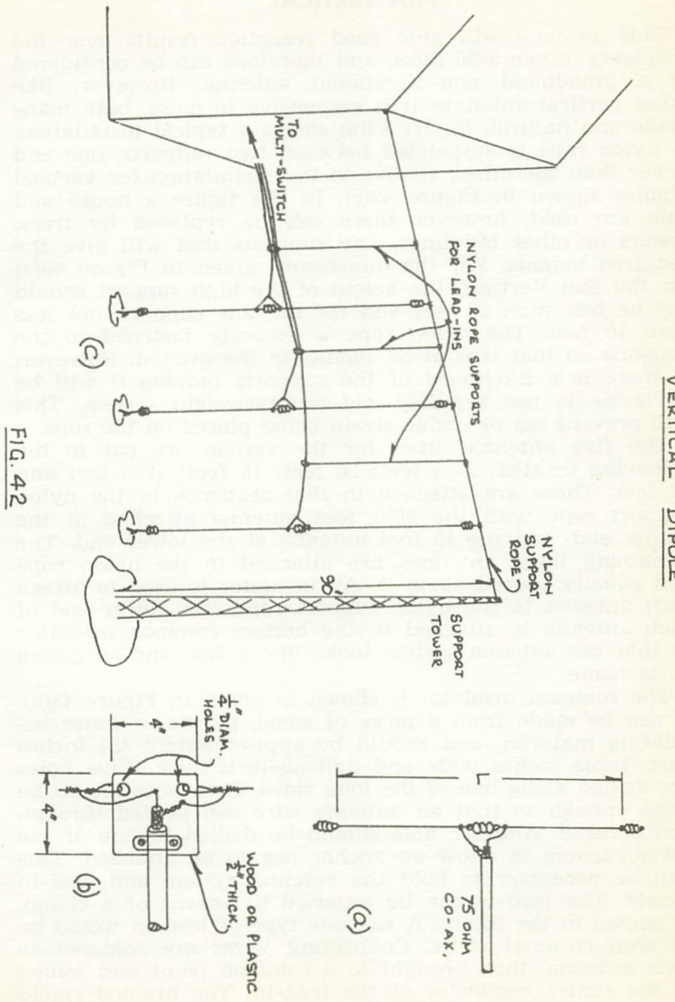

VERTICAL DIPOLE
NYLON ROPE SUPPORTS FOR LEAD-INS
TO MULTI-SWITCH
NYLON SUPPORT ROPE
90'
SUPPORT TOWER
(c)
L
75 OHM CO-AX.
(a)
1/4" DIAM. HOLES
4"
4"
WOOD OR PLASTIC 1/2" THICK.
(b)

FIG. 42

Chapter 13.

FAN VERTICAL

This antenna will give good reception results over the frequency range 5-30 Mc/s, and therefore can be considered as a broadband non-directional antenna. However, like other vertical antennas it is responsive to noise, both man-made and natural. Figure 43(a) shows a typical installation. A nylon rope is suspended between two supports, one end lower than the other, similar to the installation for vertical dipoles shown in Figure 42(c). In the figure a house and pole are used, however these can be replaced by trees, towers or other buildings, any supports that will give the required heights. For the dimensions given in Figure 43(a) for the Fan Vertical, the height of the high support should not be less than 25 feet and for the low support, not less than 10 feet. The nylon rope is securely fastened to the supports so that it is at an incline to the ground. However, if there is a likelihood of the supports moving it will be advisable to use a pulley and counterweight system. This will prevent sag or undue strain being placed on the rope.

The five antennas used for the system are cut to the following lengths: 25½ feet; 20 feet; 15 feet; 12½ feet and 10 feet. These are attached in that sequence to the nylon support rope with the 25½ foot antenna attached at the higher end, and the 10 foot antenna at the lower end. The remaining three antennas are attached to the nylon rope and equally spaced along it. An insulator is used to attach each antenna to the nylon support rope. The lower end of each antenna is attached to the bottom common insulator so that the antenna system looks like a fan, and so giving it its name.

The common insulator is shown in detail in Figure 43(b) It can be made from a piece of wood, plastic or other insulating material, and should be approximately six inches long, three inches wide and half-an-inch thick. Five holes are drilled along one of the long sides. Each hole should be large enough so that an antenna wire can be fed through and secured. Another hole should be drilled in one of the lower corners to allow an anchor peg to be attached. This will be necessary to hold the antenna system and lead-in steady. The lead-in can be attached by means of a clamp, as shown in the figure. A suitable type of lead-in would be 50 ohm co-axial cable. Connecting wires are soldered to each antenna, then brought to a common point and joined to the centre conductor of the lead-in. The braided shield can be connected to a ground rod placed in the ground beside the common insulator. At the receiver the centre conductor of the lead-in will be connected to the antenna terminal and the braided shield to the ground terminal.

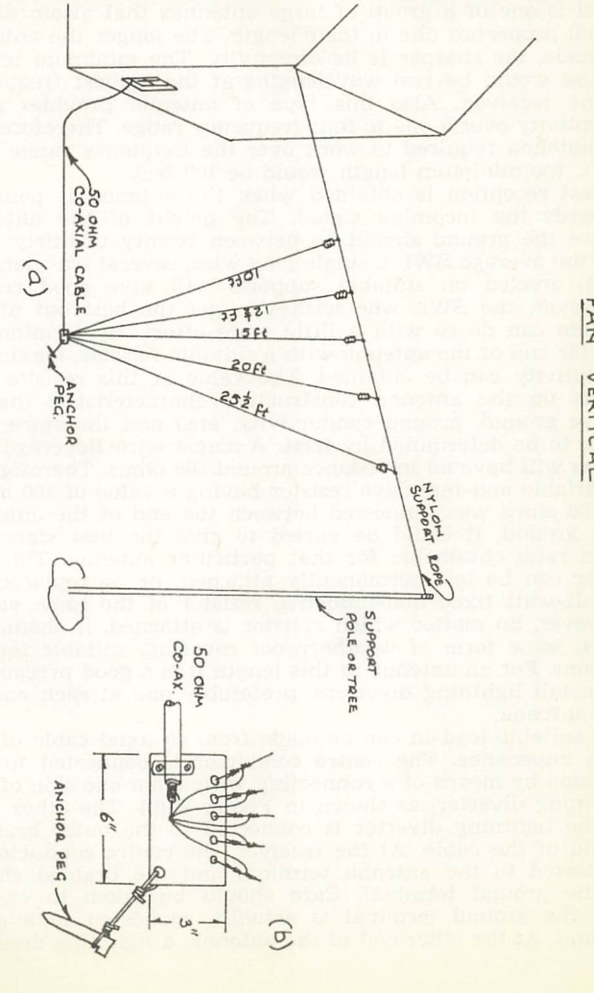


FIG. 4.3

Chapter 14.

THE "BEVERAGE" OR SIMPLE LONG WIRE ANTENNA

Tsi is one of a group of large antennas that attain directional properties due to their length. The longer the antenna is made, the sharper is its directivity. The minimum length to use would be two wavelengths at the highest frequency to be received. Also this type of antenna provides good receptivity over a one to four frequency range. Therefore, for an antenna required to work over the frequency range 5-20 Mc/s, the minimum length would be 100 feet.

Best reception is obtained when the antenna is pointing towards the incoming signal. The height of the antenna above the ground should be between twenty to thirty feet. For the average SWL a single long wire, several wavelengths long, erected on suitable supports will give good result. However, the SWL who wishes to get the best out of his system can do so with a little more effort. By terminating the far end of the antenna with a suitable resistor, maximum receptivity can be obtained. The value of this resistor depends on the antenna construction characteristics (height above ground, ground conductivity, etc.) and therefore will have to be determined by trial. A single wire Beverage antenna will have an impedance around 600 ohms. Therefore, if a variable non-inductive resistor having a value of 250 ohms to 900 ohms was connected between the end of the antenna and ground, it could be varied to give the best signal to noise ratio obtainable for that particular antenna. This resistor can be left permanently attached, or be replaced by a half-watt fixed non-inductive resistor of the same value. However, no matter which resistor is attached, it should be given some form of weatherproof covering, suitable for all seasons. For an antenna of this length it is a good precaution to install lightning diverters, preferably one at each end of the antenna.

A suitable lead-in can be made from co-axial cable of 600 ohm impedance. The centre conductor is connected to the antenna by means of a connecting wire, from one side of the lightning diverter, as shown in Figure 44(b). The other side of the lightning diverter is connected to the outer braided shield of the cable. At the receiver, the centre conductor is connected to the antenna terminal and the braided shield to the ground terminal. Care should be taken to ensure that the ground terminal is actually connected to a good ground. At the other end of the antenna, a lightning diverter

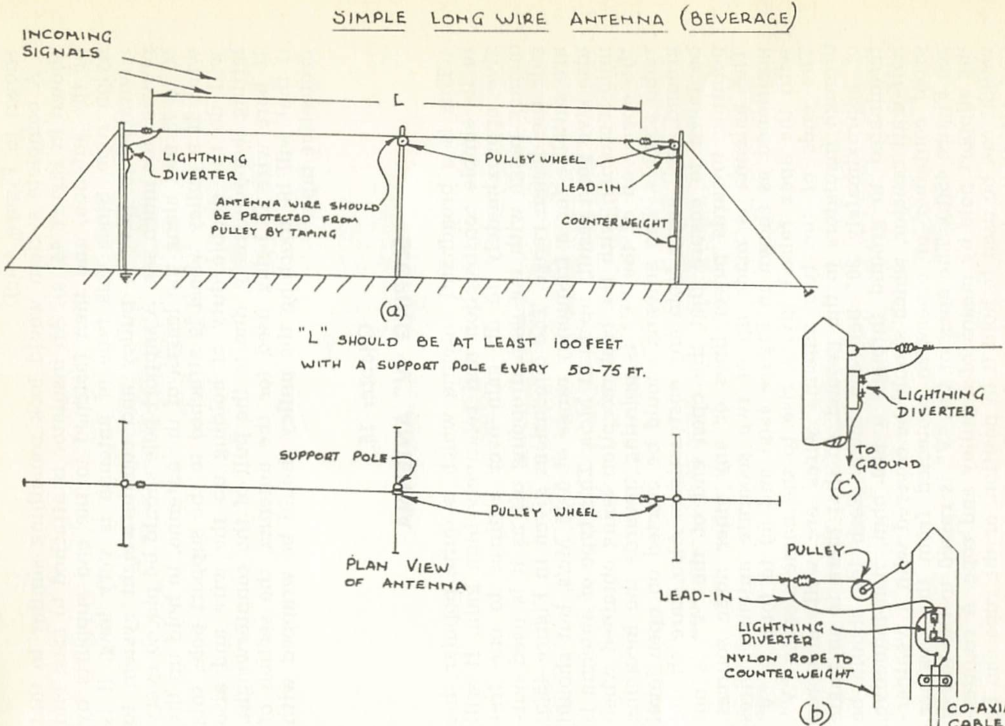

SIMPLE LONG WIRE ANTENNA (BEVERAGE)
INCOMING SIGNALS
L
LIGHTNING DIVERTER
ANTENNA WIRE SHOULD BE PROTECTED FROM PULLEY BY TAPING
PULLEY WHEEL
LEAD-IN
COUNTERWEIGHT
(a)
"L" SHOULD BE AT LEAST 100 FEET WITH A SUPPORT POLE EVERY 50-75 FT.
SUPPORT POLE
PULLEY WHEEL
PLAN VIEW OF ANTENNA
LIGHTNING DIVERTER
TO GROUND
(c)
PULLEY
LEAD-IN
LIGHTNING DIVERTER
NYLON ROPE TO COUNTERWEIGHT
CO-AXIAL CABLE
(b)

FIG. 44

should also be installed and connected to a good ground, as shown in Figure 44(c).

A complete system would look something similar to that shown in Figure 44 (a). An insulator is attached to each end of the antenna, and then fastened to the end supports by nylon rope. Since this type of antenna is very long, it is advisable to have a pulley and counterweight system to prevent too much sag. A support pole should be placed every 50 to 75 feet along the length of the antenna, to hold up the wire. If a pulley wheel is attached to the support pole, this will do the double duty of holding up the wire and also letting it move freely, due to the pull of the counterweight. If bare wire is being used for the antenna, the section of it that will be touching the pulley should be wrapped with protective tape.

Chapter 15.

SLOPING "V" ANTENNA

This is a broadband antenna which is quite popular due to its simple construction and relatively high gain. It will give approximately 10 db gain over a three to one frequency range with the gain dropping off as it is used outside the design range. The dimensions given in Figure 45(a) are suitable for a frequency range of 5-15 Mc/s, but should also give good results up to 21 Mc/s. This type of antenna is unidirectional, with the best reception being obtained when the open end of the "V" is pointing towards the incoming radio signals. The antenna should be erected on open level ground, well away from any obstructions. Also, care should be taken to ensure that the open end of the "V" is not pointing towards power lines or any other noise sources. The antenna is made up of two separate antenna wires positioned as shown in Figure 45(a) and (c) to form a "V" with the apex raised, giving rise to the name sloping "V". The ends of the two antenna wires are well anchored through insulators to the ground, so that there is an angle of approximately 30° between them. Each leg should be terminated to ground through a 350 ohm, non-inductive, half-watt resistor, which should be covered with a weatherproof container or otherwise protected from the weather, see Figure 45(b). The apex of the "V" is raised to the top of the support pole by means of a pulley and rope. A counterweight can be used to hold it in position, or the rope can be tied off at the base of the pole. The most suitable type of

SLOPING "V" ANTENNA

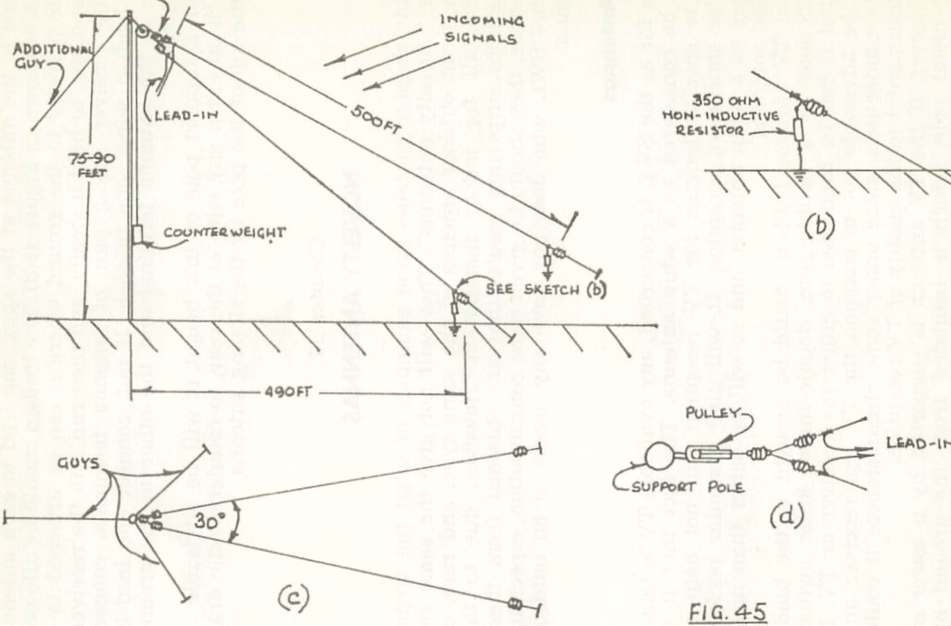


FIG. 45

lead-in to use would be 600 ohm open-wire. This is connected to the antenna at the apex, one lead to each antenna wire, as shown in Figure 45(d). The lead-in should be allowed to drop freely to the ground where it can be attached to a ground peg, to hold it steady, and then run into the receiver. If the receiver has a pair of antenna terminals, connect the lead-in wires, one to each. If not, connect one lead-in wire to the antenna terminal and the other to the ground terminal.

For a support pole of this height it will be advisable to attach an extra guy wire at the rear, to counteract the drag on the top of the pole by the sloping antenna.

Chapter 16.

NOVELTY ANTENNAS

This chapter contains some examples of what the writer calls " novelty antennas". They will not give the same results as an outdoor antenna of the same type, and rare, of course, all for indoor installation. However, due to the sometimes surprising results that are obtained from these antennas, they should be given some consideration, especially by the SWL who does not have any access to an outdoor antenna.

TV Antennas

As far as the SWL is concerned, any available TV antenna can be considered as a whip antenna. The fact that it is cut to specific lengths for TV reception will not help or hinder shortwave reception. It will give a similar performance as a whip antenna, and so will be better than most indoor antennas.

The TV antenna lead-in should be brought to the blade connections of a double-pole, double-throw knife switch, so that it can be connected to either the receiver or TV. It will be advisable not to common the TV and receiver antenna connections, since under some circumstances it could be detrimental to the quality of TV reception.

However, if the TV antenna is supported by a tower or long metal pole, which is insulated from the ground by either a wooden board, rust or dirt, this will do very well as a vertical antenna. A separate single lead-in can be run from this tower to the receiver antenna terminal.

TV Cable Folded Dipole

This antenna is made from 300 ohm TV lead-in cable. The length of cable used is the same as for a half-wave dipole and is given in Table I. This antenna would give a comparable performance to a normal half-wave or folded dipole, if erected in the same location. It can be erected outdoors or indoors, with an expected drop in receptivity for the indoor installations. The outdoor type of installation would be similar to that used for a folded or half-wave dipole. Indoors, however, the antenna can be suspended from the ceiling, attached around the walls or laid along the floor and covered with a mat or carpet.

In order to make the antenna, the required length of TV cable should be obtained, as called for in Table I. The two conductors at each end should be bared, then connected together and soldered. In the centre of the antenna one of the conductors should be cut and the two ends stripped back. The antenna is now ready for connection to the lead-in, which should be another length of 300 ohm TV twin-lead cable. The lead-in should be connected to the two bared ends in the centre of the dipole. A system of these folded dipoles can be set up and used with a multi-switch.

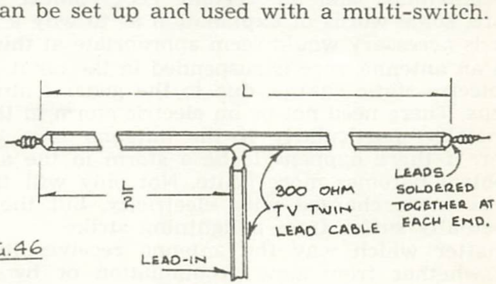


FIG. 46

Aluminum Foil Dipole

This type of antenna is made from ordinary household aluminum foil, obtainable in rolls from any grocery store, and is usually approximately 12 inches wide. If two strips are cut off, each about two to three feet long, then attached to two opposite walls of a room and a lead clipped to each, then a dipole of sorts will be obtained. It will not have any directional properties, nor be any more responsive at any particular frequency.

Long Wire Antenna

Good results can be obtained by taking a long piece of wire and attaching it around the room to form a large coil of several turns.

Chapter 17.

Antenna Accessories

LIGHTNING DIVERTERS

Reference has been made quite often in previous chapters on the advisability of installing lightning diverters with certain antennas, and in certain geographical locations. Therefore, some words of explanation as to why a lightning diverter is necessary would seem appropriate at this point.

When an antenna wire is suspended in the air it can store up an electro-static charge, due to the general atmospheric conditions. There need not be an electric storm in the immediate vicinity, particularly if the antenna is a long one. However, if there happens to be a storm in the area, then the problem becomes more acute. Not only will the atmosphere be more charged with electricity, but the antenna could actually suffer from a lightning strike.

No matter which way the antenna receives its electric charge, whether from slow accumulation or by lightning strike, it will have to be removed or else it will do damage to the attached equipment. The voltage that can accumulate can amount to several hundred by electro-static charge and several thousand when struck by lightning. Therefore, by installing a lightning diverter this dangerous voltage can be diverted to ground, where it can dissipate harmlessly.

Lightning diverters are used on a great number of different types of electric equipment, that are required to be installed out-of-doors. They therefore take various forms, and the most commonly used is the simple spark gap. This is the one most suitable for the SWL. Figure 47 shows a lightning diverter suitable for installation to the rear of a receiver. As with all the other antenna parts, these can be obtained commercially; but they are also very simple to make.

All that is required are two small brackets suitably drilled, two bolts and four nuts. The nuts and bolts are assembled to the brackets, after they have been attached to the rear of the receiver cabinet. The bolts are set to give the required gap between the ends. This gap should be between one-eighth to one-quarter inch to prevent the charge on the antenna becoming too great. These dimensions can be decreased if desired, but it is advisable not to increase them since a gap of one inch between the bolt ends is sufficient for a charge of 1,000 volts across normal air.

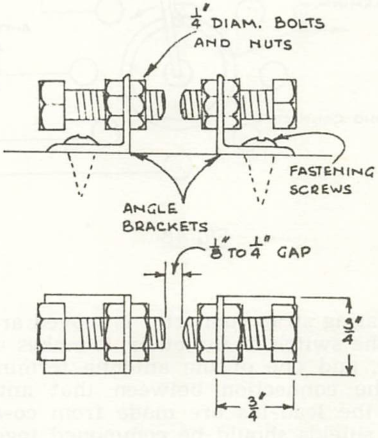


FIG. 47

Chapter 18.

MULTI-SWITCHES

When a system or complex of antennas is to be used, such as a series of dipoles, then for convenience the lead-ins can be brought to a multi-switch where easy selection of the required antenna can be made. The size of the multi-switch will depend on how many antennas have to be connected. Therefore a simple, single-pole, double-throw switch will do for two antennas, but a rotary selector switch would be required for more. Rotary selector switches can be obtained commercially, and Figure 48 shows diagramatically what a typical switch will look like, and the method of connecting the lead-ins.

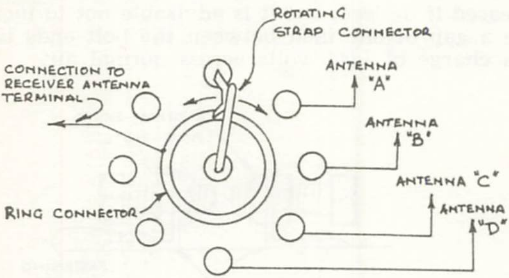


FIG. 48

As the rotating strap connector is moved around from one position of the switch to the other, it makes a connection to the receiver, and one of the antenna terminals. This then completes the connection between that antenna and the receiver. If the lead-ins are made from co-axial cable all the braided shields should be commoned together and connected to the ground terminal of the receiver.

If each terminal on the switch is suitably identified, then quick selection of the required antenna can be made, for the frequency band to be used.

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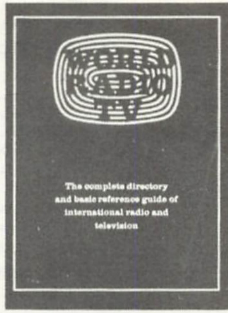

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