FOR OFFICIAL USE ONLY

ANTENNA SYSTEMS

a-2; a-2-a; a-2-B;
a-3; a-3-a; a-4;
a-6; a-9.

(*Confidential*)

Radio Communication Pamphlet
No. 2

Signal Corps, U. S. Army
Third Edition, Revised to
10-31-18

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Prepared in the
Office of the Chief Signal Officer
Training Section
Washington

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Antenna Systems

General Theory of Antennae — Data from Which to Select Best Antenna for a Given Set — General Method of Erecting Antennae

THE UNDERLYING principle of radio communication is the production by a transmitting circuit of an electromagnetic and electrostatic field which will extend far enough to interlink with a receiving circuit, and be strong enough to induce currents in the latter, these being used to produce sound signals. The production of a field of such shape and strength, and the effect of this field upon the receiving circuit, depend to a great extent on the size, shape and position of the transmitting and receiving antenna circuits. Also, the standard radio sets employed by the Signal Corps to transmit and receive signals of definite wave length between certain stations, require that the antennae shall have certain electrical characteristics (inductance, capacitance, resistance, natural wave length) and directional effects. It is the purpose of this pamphlet to outline methods of establishing an antenna of given characteristics, as determined by the type of radio set to be used, taking into account the location of the stations to be communicated with and the limitations of space which may be encountered in the field.

Various Types of Antennae

The antenna of a transmitting or receiving circuit forms part of an oscillatory circuit which comprises inductance, capacitance, and resistance. Although these electrical constants are distributed throughout the oscillatory circuit, this distribution is in most cases unequal, and for small antennae and sets of the longer wave lengths the greatest part of either the capacitance or the inductance is concentrated inside the set box in the form of a condenser or inductance coil of small dimensions, the antenna then performing the function of the inductance coil or condenser of the circuit, respectively, as the case may be. And due to the large dimensions of this inductance coil or condenser, the antenna circuit has an electric field suitable for the establishment of radio communication. For large antennae and sets of short wave length the antenna may form the greater part of the total inductance or capacitance of the open oscillatory circuit.

When the antenna forms the inductance coil of the oscillatory circuit, it is called a "loop" antenna and the resulting radiation of energy is called magnetic radiation. It generally consists of a rectangular or triangular coil of a very few turns (1 to 10 as an average), and of large overall dimensions. The properties of this type of antenna are not taken up here, as its use is restricted to a few sets only for which it takes on definite dimensions and shape. Such antennae are described in separate pamphlets, in conjunction with the radio set of which they form a part.

When the antenna forms the condenser of the oscillatory circuit, the resulting radiation is called electrostatic radiation. The antenna may be given a large number of different shapes, depending on the conditions of each particular problem. Such antennae are used with most Signal Corps ground radio sets, and on almost all airplane sets. Only ground antennae are taken up here.

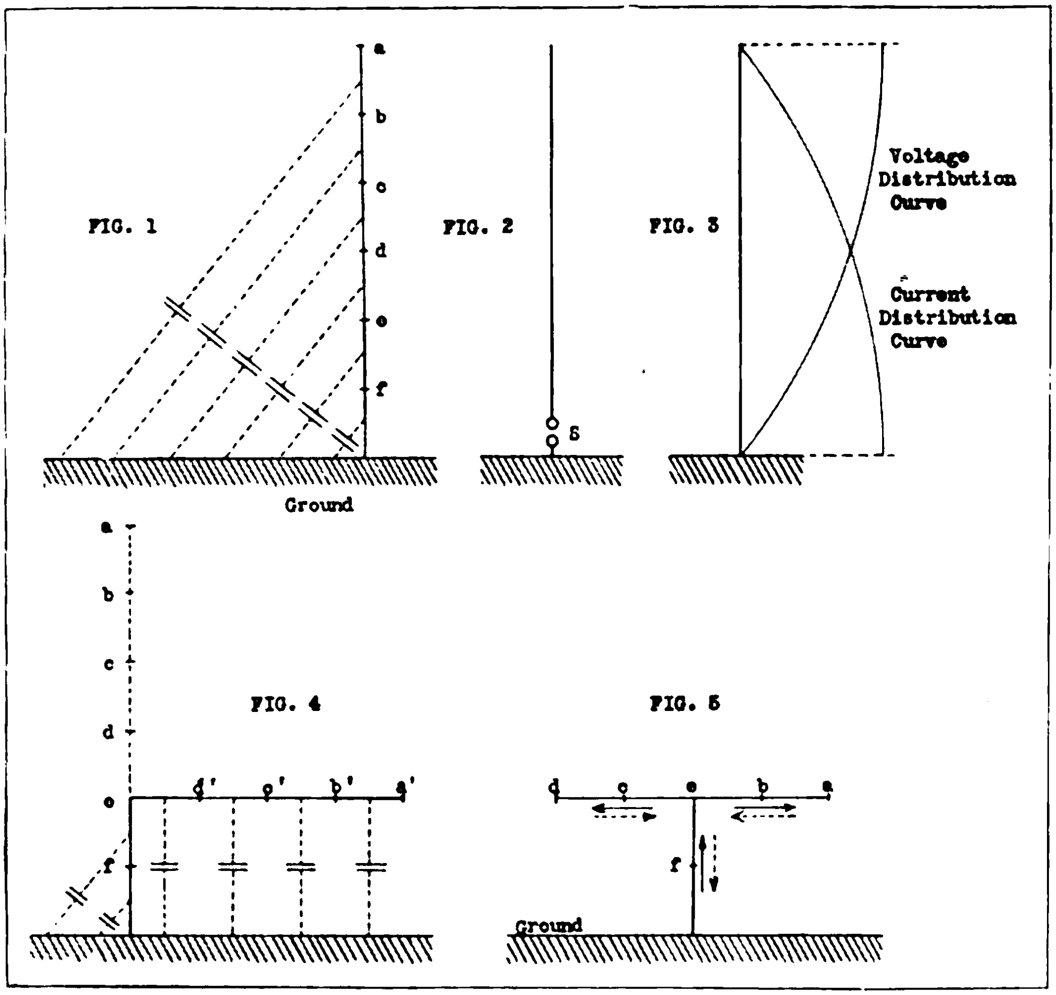
Such an antenna is made up of an aerial system and a ground or counterpoise system, each of which is connected to the radio set terminals by means of leading-in wires. This constitutes a so-called open oscillatory circuit, the aerial and ground systems being the two plates of a large air condenser. The aerial system is made up entirely of metallic wires. The other plate of the condenser antenna may be made up of wires, or of the earth itself if it is damp and conducting.

Distributed Constants of an Antenna

The simplest form of antenna is the single wire vertical antenna, illustrated in Fig. 1. Such an antenna may be made up by suspending a metal wire from an insulator, and grounding the lower end. This wire has a certain amount of inductance which is equally distributed throughout its length. That is, any segment of the wire will have the same inductance as any other segment, provided they have the same length.

Consider now a segment ab of the antenna Fig. 1, to the exclusion of the rest of the antenna. This segment is at a certain height above the conducting ground, and is separated from it by a layer of air which is an insulator. The ground and this section of the antenna wire thus form the two sides of a condenser, the dielectric being the air between them. This is shown schematically by the circuit in dotted lines. Similarly, the segment bc of the wire, equal in length and immediately below the segment ab, will form a condenser with the ground; and so on for the entire wire. However, although the various segments, ab, bc, etc., are of equal length, their electrostatic capacity to ground, that is, the capacitance of the individual condensers considered above, is not equal. This is due to the fact that the distance of the segments to the ground, and therefore the thickness of the dielectric (air) of each condenser, is not the same for the different segments. And since for various condensers otherwise similar, but differing in the thickness of their dielectric, the capacitance is greater for the condenser having the thinnest dielectric, it follows that the lower sections of the antenna wire have a capacitance to ground greater than the upper sections.

Since such an antenna contains capacitance and inductance, it is possible to produce oscillating currents in it by suitable excitation. This may be done in a number of ways, one method being to insert a spark gap S in the circuit, Fig. 2, and establishing a difference of potential between the aerial (upper part of the antenna) and the ground, great enough to produce a spark across the gap. High frequency oscillations will then take place in the antenna, the process being similar to the oscillatory discharge of a closed (non-radiating) circuit, as explained in Radio Pamphlet No. 1; that is to say, an electric current will flow in the antenna wire, alternately upward and downward. Such a high frequency current will flow through a condenser, and, as is known, the greater the



capacitance of the condenser, the greater the current. It follows that the capacitance of the antenna being greatest at its base, the current in the antenna wire is a maximum near the grounded end, and a minimum near the top. This produces an unequal distribution of the current along the antenna wire, which may be represented for a particular instant as in Fig. 3. This current distribution curve is obtained by plotting off horizontally at each point of the antenna wire a length proportional to the instantaneous current flowing in the antenna at this point.

It may be similarly shown that the voltage distribution along the antenna wire is unequal, the greatest voltage point being at the ungrounded end of the aerial, while the voltage of the grounded end is zero.

The practical conclusions to be drawn from the above remarks are that the wire and connections must be made of metal of large capacity or cross section, so that the parts which have to carry the greatest currents, will not have too high resistance. Also, if the wire is supported at various points, the insulation must be made increasingly heavier as the top of the antenna is approached.

Natural Wave Length of an Antenna

In the previous paragraphs it was shown that an antenna made up of a single vertical wire grounded at its lower end, has capacitance and inductance, the values of which, respectively, are the sum of the capacitances to ground and inductances of the various sections ab, bc, . . ., of the antenna wire. When an oscillating current takes place in the antenna, electric waves are radiated by it (see Radio Pamphlet No. 1), the length of which is numerically expressed by the equation.

$$\text{Wave length} = \text{velocity of light} \times \sqrt{\text{inductance} \times \text{capacitance}}.$$

This wave length is called the "natural wave length" of the antenna.

It has been found that the inductance and capacitance of an antenna of the type described above are of such value that its natural wave length is equal to four times the length of the antenna wire. This is frequently expressed by saying that the antenna oscillates at quarter wave length.

If now instead of using the antenna above described, the same length of wire is given the shape shown in Fig. 4, by suspending a length ae of the wire horizontally, a so-called "inverted L" antenna is obtained. As a result of this bending of the antenna wire, the sections of the wire above point e have been brought closer to the ground, so that the capacitance of the corresponding individual condensers, or, which is the same thing, the capacitance to ground of sections ab, bc, cd, de, has increased correspondingly. The total capacitance of the antenna has therefore increased. Its inductance has similarly increased, but to a lesser degree. These changes result in a longer natural wave length for the inverted "L" antenna, as may be seen from the above equation, so that the quarter wave length rule no longer holds.

Another arrangement is that of Fig. 5, known as the "T" antenna, where the vertical wire fe is connected to the center of the horizontal wire, instead of the end. If the vertical and horizontal wires are respectively equal to those of the "L" antenna considered above, the total electrostatic capacity will be the same, since the distances to ground of the various segments of the wire have not been changed. The total inductance of the antenna is however considerably less than before, as the oscillating current always flows in opposite directions in the two horizontal branches of the "T", so that their magnetic fluxes neutralize. The natural wave length of the "T" antenna is thus smaller than that of the "L" antenna considered above.

It may thus be seen, that with a given amount of wire to be used, the shape of the antenna should be so chosen that the natural wave length will be of the order required by the radio set to be used. Also, since various shapes may give the same wave length, or may have the same capacitance or inductance, the choice of antenna which takes up the least space, or which is easiest to erect, etc., should be made, according to circumstances. Other considerations which are of great importance must be taken into account, however; namely, the distance over which radio communication is to be established, and the directive effect of the antenna. These are taken up below. In general, where a low antenna is necessary, one having fairly high capacitance is usually used in order to get sufficient input of power to give appreciable radiation.

Directional Effect of an Antenna

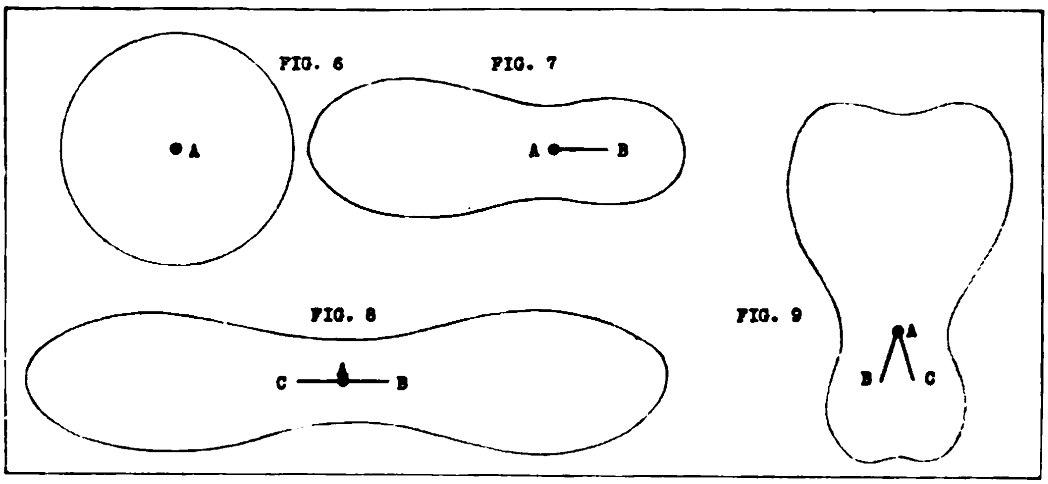
The directional effect of an antenna is a property of the latter whereby the strength of the signals radiated is greater in certain directions than it is in others. This may be illustrated as follows:

A vertical wire antenna, shown in plan view by the point A, Fig. 6, is used as a transmitting antenna; that is, oscillating currents are set up in it, as a consequence of which an oscillating electromagnetic and electrostatic field are built up in the space surrounding the wire. As is known, these varying fields will induce electric currents in a suitable receiving circuit, and these in turn produce sounds in a telephone receiver, corresponding to the signals transmitted. The loudness of the sound may be measured (by means of an audibility meter), and is an indication of the strength of the electric field at the point at which the receiving station is installed. It need not be demonstrated that the strength of the signals emitted by a certain station decreases as the distance to the receiving station is increased.

Using the vertical wire antenna A, Fig. 6, as a transmitting antenna, if a number of observers are scattered around that transmitting station, and equipped with identical receiving circuits, and these observers move toward or away from the station A until the loudness of the signals in the various receiving circuits is the same, all the observers will find themselves on a circle, the center of which is point A. In other words, the strength of the signals emitted by a vertical wire antenna is the same in all directions.

Repeating the experiment, using an inverted "L" antenna AB, with the lead-in end (grounded end) at point A, the observers will find themselves no longer on a circle, but on a curve having the general shape shown in Fig. 7. From this curve, it will be seen that the strength of the waves sent out by an "L" antenna is greatly dependent on the location of the receiving station with respect to the position of the transmitting antenna, and is a maximum in the vertical plane of the "L" antenna, in the direction of the grounded end of the horizontal branch of the "L." The practical conclusion is that when it is desired to transmit to one particular station in a known direction, an "L" antenna should be used, setting it up so that it will point toward the station it is desired to reach, with the free end of the aerial in the direction away from the distant station.

Figs. 8 and 9 similarly illustrate the directive effect of a "T" and a "V" antenna. The latter, which may be considered as two "L" antennae



having a common vertical wire, is used instead of the "L" when communication is to be established with a station in motion, such as an airplane, but which remains in the same general direction.

The "V" antenna, while uni-directional in the same general direction as the "L" antenna, has an electric field of fan-like shape which will cover a greater width of the front, permitting a greater lateral movement of the forward station while remaining in the field of the antenna. This will be seen by comparing the fields of Fig. 7 and Fig. 9.

The directive effect of an antenna used for receiving messages is the same as when the antenna is used for transmitting, so that the diagrams of Figs. 6, 7, 8 and 9 may be used. From these, the relative positions of the antennae of various stations which are to communicate with each other are easily established. As an illustration, Fig. 10 shows the correct method of setting up two stations using "L" antennae.

As a general rule, it may be said that any antenna is directive in the direction of its plane of symmetry, and, in that plane, in the direction of the end of the aerial at which the lead-in wire is connected.

Ground and Counterpoise Systems

In the theory of the antenna explained in the opening paragraphs, it was assumed that the ground surface was a perfectly good conductor of electricity. Actually, the ground is only a partial conductor, especially when dry or rocky. And when wet, its effectiveness depends to a great extent on the manner in which the antenna wire is connected to the ground. Another consideration is, that like any other oscillatory circuit, the resistance should be as low as possible, so that the oscillations will take place satisfactorily.

It is therefore important that the ground connection and ground side of the large condenser making up the antenna, be of low electrical resistance. This condition may be accomplished by either making a good ground connection, or using an insulated counterpoise system.

Ground Connection.—A ground connection should be used preferably when the ground is wet or fairly conducting. The best method is to bury one or more copper mats, about 1 ft. deep. When several mats are used, they should be spaced equal to their widths, and placed in the area covered by the aerial wires. When it is not possible to bury the mats, they may simply be laid on the ground. All the mats should be carefully interconnected, and this system used as the ground.

Another method is to drive 10 to 15 stakes into the ground, as deep as possible, and 3 ft. to 6 ft. apart, in the area covered by the aerial system. These should then be carefully interconnected and used as the ground.

FIG. 10

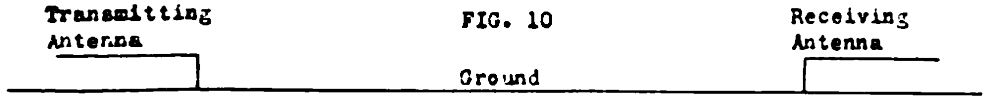


FIG. 11

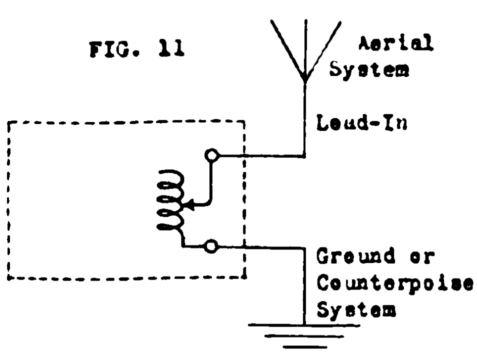
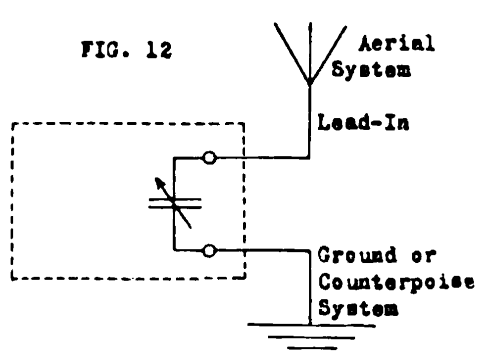


FIG. 12



Counterpoise Systems.—This is by far the best method of establishing the ground side of the antenna. Instead of using a ground connection, a system of wires insulated from the ground, preferably by supporting them about 1 ft. above the ground, and run parallel and underneath the aerial wires, is employed.

It is not advisable to make simultaneous use of a counterpoise and ground mats or stakes.

Methods of Changing the Wave Length

When an antenna is set up, it is generally used at a number of different wave lengths, the adjustment being made by means of a loading coil or an antenna condenser connected in series with the antenna, Figs. 11 and 12. This coil or condenser is generally inclosed in the set box and is arranged so that the amount of inductance or of capacitance in the antenna circuit may be readily varied. Adding inductance in series with the lead-in wire lengthens the wave, while similarly adding capacitance shortens it. Hence, to increase the wave length, increase the inductance or decrease the capacitance. To decrease the wave length, decrease the inductance or increase the capacitance.

TABLE OF ANTENNA REQUIREMENTS OF VARIOUS RADIO SETS

Radio Set Type No.	ANTENNA CONSTANTS FOR BEST OPERATION OF SET.		Suggested Antenna Construction (Item No)	Antenna Equipment Furnished with Set. (Type No.)
	Electrostatic Capacity (Micro-mfd)	Resistance (Ohms)		
SCR-54	320	-	7	A-2
SCR-54-A	320	-	7	A-2-A & A-2-B
SCR-67	At Least 500	Less than 40	Umbrella, 40 ft. high; 6 aerials & 6 ctps.wires 50 ft. each	A-4 (Obsolete)
			or, Item No. 26 or 29	A-9
SCR-69	At Least 500	As Low As Possible	26 or 29	A-6 * (Obsolete)
SCR-70	At Least 500	"	26 or 29	"
SCR-74	About 350 to 500	As Low As Possible	4, 5, or 6; See Radio Pamphlet No 11	A-3
SCR-74-A	"	"	"	A-3-A
SCR-78	-	-	Special Tank Antenna	A-7 A-8
SCR-79	300-600; Best Value 450	Less than 60	7, 21, or 22	A-9
SCR-99	"	Less than 30	11 or 22	A-9

* Type A-9 Antenna Equipment may be used instead.

TABLE OF ANTENNA CONSTANTS

ANTENNA TYPE	Item No.	AERIAL SYSTEM Length Ft.	Height Lead-In End, Ft.	Height Free End, Ft.	COUNTERPOISE SYSTEM	PLAN VIEW	NATURAL WAVE LENGTH (Meters)	ELECTRO-STATIC CAPACITY Micro-mfd.	MINIMUM EFFECTIVE RESIST. (Ohms)
Inverted "L"	1	100	20	20	1 Wire, Insulated 100 ft. long		200	200	42
Inverted "L"	2	100	20	20	4 Ground Stakes (salted)		220	270	56
Inverted "L"	3	150	27	1[illegible]	1 Ground Mat 3 ft. x 6 ft. buried		270	400	57
Inverted "L"	4	150	3	3	1 Wire, Insulated 150 ft. long		330	420	46
Inverted "L"	5	150	3	3	1 Ground Mat 3 ft. x 12 ft.		270	450	92
Inverted "L"	6	150	3	3	4 Ground Stakes		300	550	88
Inverted "L"	7	150	20	20	1 Wire, Insulated 150 ft. long		325	320	33
Inverted "L"	8	150	20	20	2 Wires, Insulated close together 150 ft. long		315	345	32
Inverted "L"	9	150	20	20	2 Wires, Insulated 4 ft. apart, 150 ft. long		300	335	23
Inverted "L"	10	150	20	20	2 Wires, Insulated 12 ft. apart, 150 ft. long		260	325	22
Inverted "L"	11	150	20	20	3 Wires, Insulated 12 ft. to center 150 ft. long		225	350	17
Inverted "L"	12	150	20	20	3 Mats, 3' x 6', spaced 10 ft. between centers		250	350	49
Inverted "L"	13	150	20	20	3 Mats, 3' x 6', spaced 3 ft. between centers		230	320	64
Inverted "L"	14	150	20	20	6 Ground Stakes		255	360	74
Inverted "L"	15	150	20	20	4 Ground Stakes		245	350	60
Inverted "L"	16	150	20	20	2 Ground Stakes		240	370	85
Inverted "L"	17	200	20	20	1 Wire, Insulated, 200 ft. long		340	400	38
Inverted "L"	18	200	20	20	1 Wire, Insulated, 120 ft. long		340	380	37
Inverted "L"	19	200	20	20	3 Mats, 3' x 6', spaced 15 ft. between centers		300	460	60
Inverted "L"	20	200	20	20	4 Ground Stakes		340	490	54
60-Deg. "V"	21	100 ft. each side	24	24	2 Wires, Insulated 100 ft. each		255	400	32
60-Deg. "V"	22	100	24	24	3 Wires, Insulated 100 ft. each		245	410	23
60-Deg. "V"	23	100	24	24	3 Ground Mats, 2'10" x 5'6"		265	410	46
60-Deg. "V"	24	100	24	24	1 Mat, buried, 3 ft. x 6 ft.		235	465	59
60-Deg. "V"	25	100	20	20	2 Mats, buried, 3 ft. x 12 ft.		240	420	34
60-Deg. "V"	26	150	24	24	2 Wires, Insulated 150 ft. each		340	568	24
60-Deg. "V"	27	150	24	24	2 Wires, Insulated 100 ft. each		330	550	31
60-Deg. "V"	28	150	24	24	3 Wires, Insulated 150 ft. each		300	600	21
60-Deg. "V"	29	150	24	24	3 Wires, Insulated 100 ft. each		360	600	18
60-Deg. "V"	30	150	24	24	2 Ground Mats, 3 ft. x 12 ft.		310	620	45
60-Deg. "V"	31	150	24	24	2 Mats, 3' x 12' and 3 Mats, 3' x 6'		335	680	38

KEY .... Aerial Wire —— Counterpoise Wire ● Stake ▭ Mat

Antennae Used with Signal Corps Apparatus

As explained above, the constants of an antenna depend essentially on its shape. In the Table of Antenna Constants given herewith are the constants of a number of antennae of various designs which may be used with Signal Corps apparatus. They may be altered to suit special conditions. Also, each radio set will give best results when used with an antenna of certain definite constants. This is summarized in the Table of Antenna Requirements, which may be found of use when setting up in the field under various conditions.

The size of the antenna may of course be changed, as desired. If the lead-in wires are short as compared with the length of the aerial and counterpoise wire, it may be said that the lower the aerial, the greater the capacitance. As a general rule, the higher the antenna, the greater the distance over which signals may be transmitted.

How to Use the Antenna Tables

As an illustration of how to use these tables, assume it is desired to set up an antenna for use with the type SCR-79 set. The requirements of this set are to be found in the Table of Antenna Requirements. Thus, the antenna must have a capacitance of from 300 to 600 micro-mfd., preferably 450 micro-mfd., and a resistance of less than 60 ohms. Referring to the Table of Antenna Constants, it may be seen that several types of antennae fulfil those requirements. Three types are especially recommended in the first table, as found in items 7, 21 and 22. It is seen that item 7 is an inverted "L" antenna, 150 ft. long, and 20 ft. high, using an insulated counterpoise wire of the same length. Items 21 and 22 are "V" antennae. The choice between these three different designs will depend upon the material available (poles, wire, etc.) and upon the degree of directional effect required on the particular occasion. It will be remembered that the "L" antenna is more directional than the "V." If a "V" antenna is suitable for the purpose, and sufficient material is at hand, the item 22 would probably be better than the item 21, since, with almost the same natural wave length and capacitance, the resistance of the former is less than that of the latter, resulting in smaller resistance (heat) losses in the antenna and consequently greater radiation.

Setting Up Antennae

After having determined the type of antenna to be used, as explained above, it is now necessary to erect it properly. The first thing to do is to choose a location suitably protected from enemy shell fire and observation, and among surroundings which will not cause absorption of the waves in the direction of transmission or reception.

In many instances it may be possible to use trees, houses, etc., to support the aerial. In most cases however, it is necessary to use the

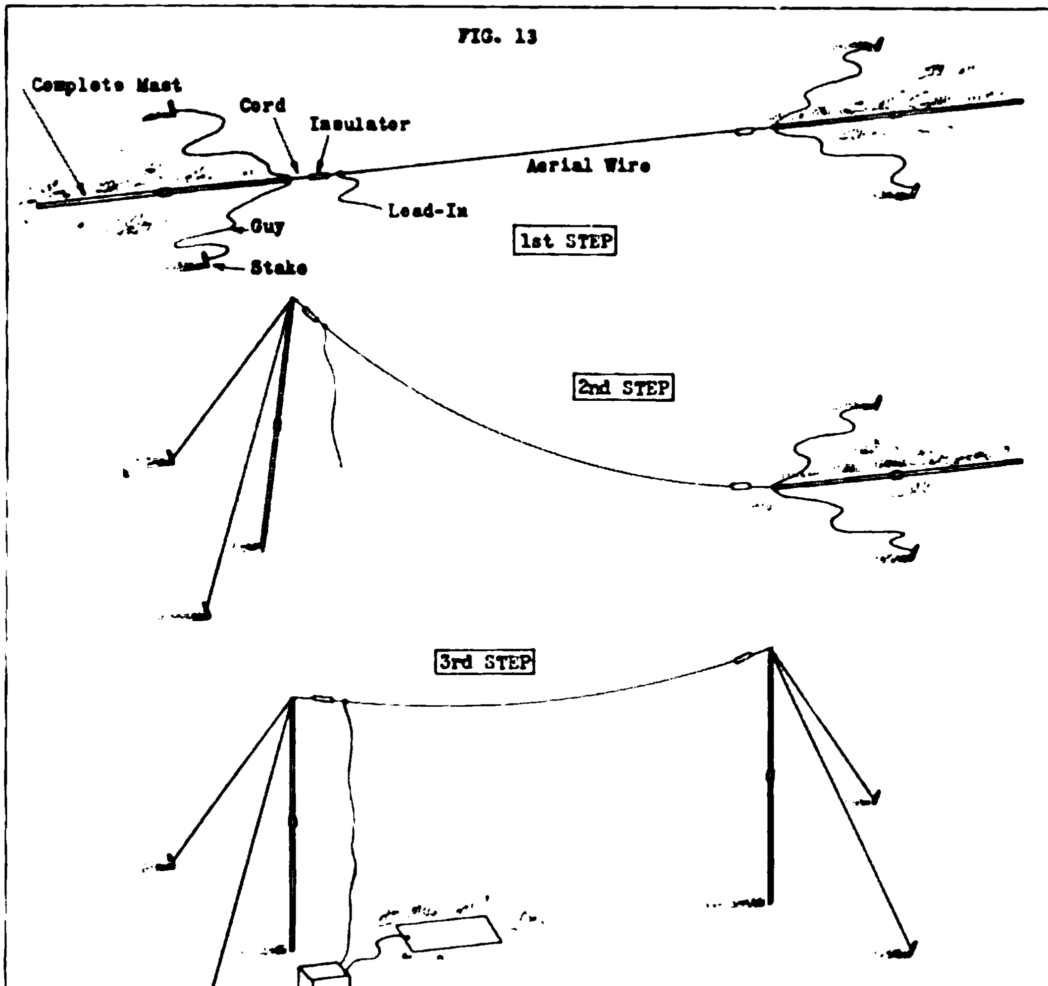


FIG. 13
SETTING UP AN "L" ANTENNA

antenna poles or supports furnished with the set. In such an instance, the proper procedure is explained below, this being such as to enable one man to erect the antenna without any assistance.

Inverted "L" Antenna

1. Stretch out the aerial wire on the ground in line with the direction of the distant station and with the lead-in end nearest that station.

2. Couple the mast sections and lay the assembled masts at each end of the antenna in the same straight line as the wire, Fig. 13.

3. Attach the antenna wire to the insulators and attach the latter to the mast tops by means of cords or snap hooks, etc. Attach two guys to each mast top.

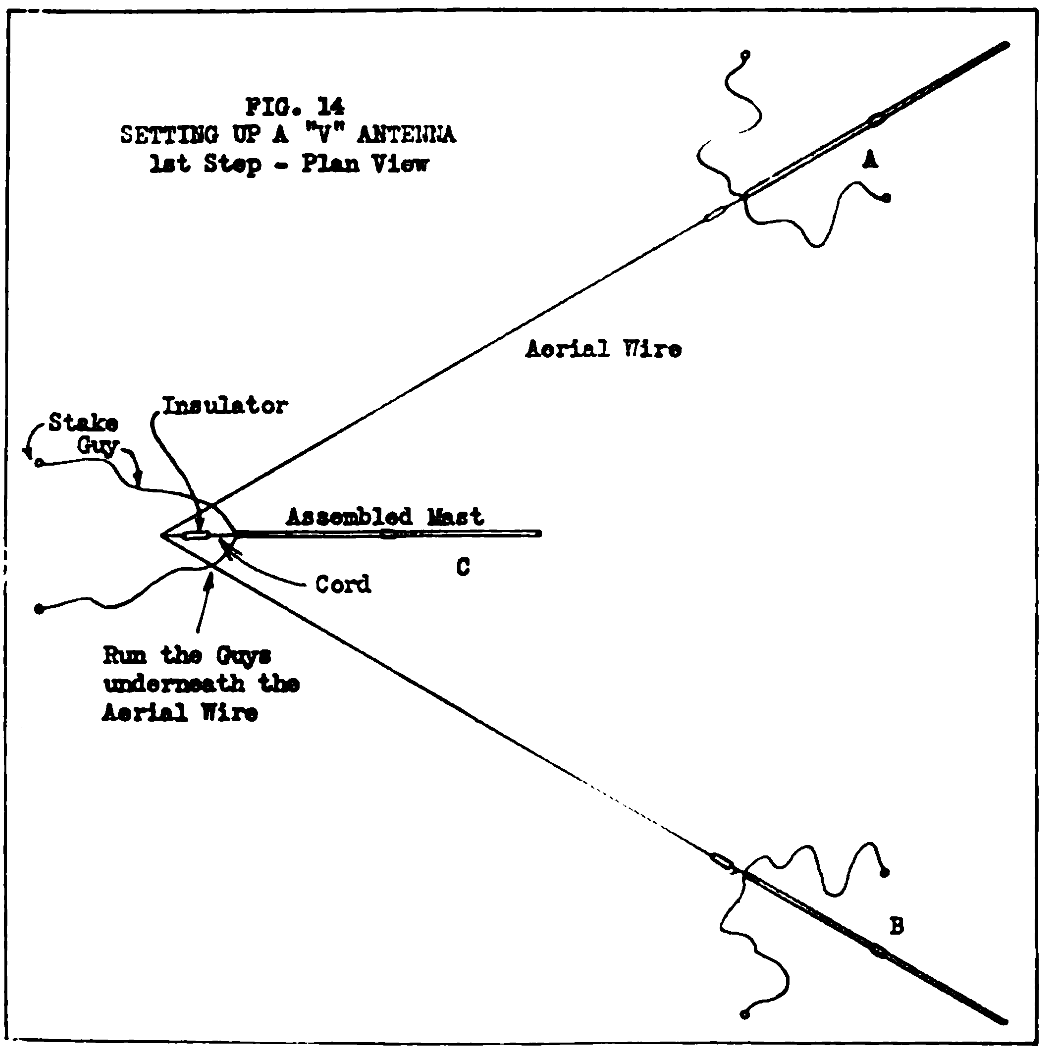
4. Drive two stakes near each mast and at an angle of about 45 deg. to the line of the antenna wire. The distance from the top of the mast must be estimated from the length of the guys and the height of the mast, Fig. 13, 1st Step.

5. One mast is then erected by gradually raising the mast top, keeping the bottom end on the ground at all times and moving it toward the opposite end of the antenna wire, until the mast is in a nearly vertical position, Fig. 13, 2nd Step, where it will stand without having to be held.

6. Proceed similarly with the other mast. Then shift the first mast slightly to bring it in a vertical position, Fig. 13, 3rd Step. It will be noted that the aerial wire is stretched out in the process of erecting the masts.

"V" Antenna

The method of erecting a "V" antenna is similar to that explained above for the "L" antenna. The antenna is first laid out on the ground as shown in plan view in Fig. 14. The masts A and B are first raised like the first mast of the "L" antenna, after which mast "C" is erected by raising the mast top and moving the bottom of the mast (held on the ground) in the direction of the point of the "V."



Parts Lists

EQUIPMENT, TYPE A-2

2 Mast Sections, Type MS-1; top; same as type MS-2, but without steel coupling tube.

8 Mast Sections, Type MS-2; intermediate.

6 Guys, Type GY-1; 43-ft., complete.

3 Guys, Type GY-2; 22-ft., complete.

4 Reels, Type RL-3; hand; one for antenna and lead-in wire, and one for each set of 3 guys.

6 Stakes, Type GP-1; guy; 3 in use for each mast.

2 Plates, Type MP-2; upper guy; complete with mast tube; one for each mast.

1 Plate, Type MP-3; lower guy; for 29-ft. mast.

2 Plates, Type MP-1; antenna, complete with Electrose No. 4500 insulators connected to plate with closed wire link; other end provided with open wire hook to receive antenna wire thimble.

1 Antenna, Type AN-1; 150 ft. antenna wire with thimble at each end; the thimble for the 29-ft. mast end has connected to it a 50-ft. lead-in of No. 16 B&S gauge, single conductor, new code lamp cord, weather-proofed.

2 Connections, Type GD-1; ground; ground mat with 20-ft. No. 16 B&S gauge single conductor new code lamp cord, weather-proofed; 1 in use, 1 spare.

2 pr. Bags, Type BG-1; carrying; for masts.

1 Bag, Type BG-2; carrying, for antenna and accessories.

1 Hammer, Type HM-1; 2 lb.; two-face engineer's; 16-in. handle.

1 Twine, Measuring, Type TW-1; 35-ft.; for measuring distance of guy stakes from masts.

1 Marker, Type MR-1; guy stake; for locating direction of ground stakes from masts.

EQUIPMENT, TYPE A-2-A

6 Masts, Type MS-5; bamboo; 13 ft. long; iron tipped at both ends; total weight, 16 lbs.

6 Insulators, Type IN-6; mast top; 3-5/8 in. x 1 1/2 in.

6 Pins, Type FT-3; insulators; 4-9/16 in. x 3/8 in. square.

750 ft. Wire, Type W-1; antenna; 7-strand, No. 22 B&S gauge, soft tinned copper, bare; net weight, 8 lb. 12 oz.; to be in one piece and wound on spool of 6 in. outside diameter.

75 ft. Wire, Type W-4; lead-in; modified No. 16 B&S gauge, N.E.C. lamp cord, spec. W-4, wound on 8-in. coil; total weight, 1 lb. 8 oz.

2 lb. Wire, Type W-2; No. 14 B&S gauge, soft drawn copper, bare; in one piece wound in 7-in. coil.

1 Mat, Type MT-2; ground; 9 ft. x 20 in.; total weight, 3 lb. 4 oz.

14 Stakes, Type GP-3; ground; 1 in. x 1 in. x 1/8 in. angles; total weight, 35 lb.

8 Insulators, Type IN-5; hard rubber; 5½ in. x 5/8 in.; total weight, 10 oz.

6 Couplers, Type FT-2; pole; 4 in. x 5 in. x 1 in.; total weight 4 lb.

150 ft. Rope, Type RP-1; manila; 1-in. circumference; 5/16 in. diameter; tensile strength, 1,000 lbs.; in one piece wound on 8-in. coil; total weight, 3 lb. 12 oz.

4 Reels, Type RL-3; hand; 11¾ in. x 10 in.

1 Pliers, Type TL-20; universal; 8-in.; similar to Fairbanks' combination pliers No. 70; drop forged steel with blue handle and polished head.

1 Tape, Friction, Roll, spec. 569-B; ¾-in.

1 Hammer, Type HM-1; 2 lb. 16-in. handle.

2 Marlin, Type RP-2, Coils; 42-ft. lengths.

EQUIPMENT, TYPE A-3

2 Supports, Type MS-4; antenna; complete with guys.

1 Antenna, Type AN-2; antenna cord, 150 ft. complete with 20-ft. lead-in wire and 4 Electrose No. 4500 insulators, of which 2 are linked in series at each end of antenna wire; free end of insulator provided with open wire hook.

1 Counterpoise, Type CP-1; two 150-ft. lengths counterpoise wire, spec. 416-1, with terminal plug on one end.

1 Block, Type BL-3; connecting; at one end of 20-ft. lead-in wire.

4 Stakes, Type GP-2; ground, standard.

3 Reels, Type RL-3; hand; for antenna and counterpoise wires.

1 Bag, Type BG-8; carrying; for ground stakes, antenna and accessories.

2 Hammers, Type HM-1; 2 lb.

EQUIPMENT, TYPE A-3-A

1 Bag, Type BG-15; carrying.

2 Antenna Supports, Type MS-4-A; each complete with insulator type IN-5, guy rope type RP-5, ground stake type GP-5, and guy rope fastener type FT-9.

1 Reel, Type RL-3; hand.

1 Antenna, Type AN-5; with snap hooks on both ends.

1 Mat, Type MT-3; ground.

1 Hammer, Type HM-1.

1 Pliers, Type TL-19; pair; combination.

¼ lb. Tape, Friction; ¾ in.

1 Stake, Type GP-6; ground.

EQUIPMENT, TYPE A-2-B

6 Mast Sections, Type MS-5; bamboo; 13 ft. long; iron tipped at both ends; total weight, 16 lb.

6 Insulators, Type IN-7; mast top; 3 in use, 3 spare.

750 ft. Wire, Type W-1; antenna; 7-strand, No. 22 B&S gauge, soft tinned copper, bare; net weight, 8 lb. 12 oz.; to be in one piece and wound on spool of 6 in. outside diameter.

75 ft. Wire, Type W-4; lead-in; No. 16 B&S gauge, modified, N. E. C. lamp cord, wound on 8-in. coil; total weight, 1 lb. 8 oz.

2 lb. Wire, Type W-2; No. 14 B&S gauge, soft drawn copper, bare; in one piece wound in 7-in. coil.

1 Mat, Type MT-2; ground; 9 ft. x 20 in.; weight 3 lb. 4 oz.

14 Stakes, Type GP-3; ground; 1 in. x 1 in. x ⅛ in. angles; total weight, 35 lb.

8 Insulators, Type IN-5; hard rubber; 5½ in. x ⅝ in.; total weight, 10 oz.

6 Couplers, Type FT-2; pole; 4 in. x 5 in. x 1 in.; total weight, 4 lb.

200 ft. Cord, Type RP-3; sash; No. 5; olive drab.

4 Reels, Type RL-3; hand; 11-¾ in. x 10 in.

1 Pliers, Type TL-20; universal; 8-in.; similar to Fairbanks combination pliers No. 70; drop forged steel with blue handle and polished head.

¼ lb. Tape, Friction; ¾ in.

1 Hammer, Type HM-1; 2 lb.; 16-in. handle.

¼ lb. Marlin, Type RP-2; wound in two coils.

EQUIPMENT, TYPE A-4

1 Mast Section, Type MS-1; top; same as type MS-2, but without steel coupling tube.

8 Mast Sections, Type MS-2; intermediate.

1 Mast Section, Type MS-3; bottom.

1 Insulator, Electrose, No. 3001.

1 Cap, Mast, Type MP-4; complete with 50-ft. antenna lead.

4 Wires, Type GY-3; antenna; complete with guys.

4 Wires, Counterpoise, SPEC. 416-I.

9 Reels, Type RL-3; hand; one for each antenna and counterpoise wire, and one for lead-in wire.

4 Stakes, Type GP-1; guy.

2 pr. Bags, Type BG-1; carrying; one pair for 5 mast sections.

1 Bag, Type BG-6; carrying; for antenna and counterpoise.

1 Bag, Type BG-7; carrying; for accessories.

2 Hammers, Type HM-1; 2-lb.

1 Box and Cord, Type BL-2; junction; for counterpoise wires.

1 Cord, Type CD-26; from set box BC-13 to antenna.

EQUIPMENT, TYPE A-6

3 Mast Sections, Type MS-1; without tubes.

12 Mast Sections, Type MS-2; with tube.

3 Caps, Mast, Type MP-5.

3 Insulators, Type IN-1; hard rubber, with hooks.

9 Reels, Type RL-3; hand.

1 Antenna, Type AN-5; two lengths of braided antenna cord 150 ft. long, and one length of lead-in wire 40 ft. long, all carried on three hand reels.

9 Guys, Type GY-3; No. 5 sash cord, each 36 ft. long, with metal tent slide and hook; a set of three guys to be carried on each of three hand reels.

1 Counterpoise, Type CP-4; two lengths of wire 150 ft. long, and one lead-in wire 40 ft. long, all joined together at their intersection; to be carried on three hand reels.

3 Hammers, Type HM-1.

9 Stakes, Type GP-2; guy.

3 Cords, No. 5 Sash, Pieces, 3 Ft. Long.

1 Chest, Type BC-35; carrying; used for packing antenna equipment for transportation.

EQUIPMENT, TYPE A-9

6 **Masts, Type MS-5;** bamboo, 13-ft. long; iron tipped at both ends.

2 **Bags, Type BG-14;** carrying; 6¾ in. x 2 ft. 7½ in.

12 **Stakes; Type GP-3;** ground.

1 **Bag, Type BG-8;** carrying; 1 ft. 8 in. x 1 ft. 2 in. x 3 in.

50 **ft. Wire, Type W-4;** lead-in; wound in 8-in. coil.

1 **Hammer, Type HM-1;** weight 2 lb.; 16 in. handle.

1 **Marlin, Type RP-2;** coil; 1/16-in. diameter; weight about 8 oz.

300 **ft. Cord, Type RP-3;** sash; No. 5; olive drab.

6 **Insulators, Type IN-6;** mast top; 3-⅝ in. x 1½ in.; 3 in use, 3 spare.

6 **Insulators, Type IN-5;** hard rubber; 5½ in. x ⅝ in.

3 **Pins, Type FT-3;** insulator; 4-9/16 in. x ⅜ in. square.

6 **Couplers, Type FT-2;** pole; 4 in. x 5 in. x 1 in.

3 **Mats, Type MT-3;** ground; 40 in. x 13 ft.

750 **ft. Wire, Type W-1;** antenna; 7 strands, No. 22 B&S gauge, bare, soft tinned copper; net weight, 8 lb. 12 oz.; to be in one piece wound on spool 6-in. x 5½ in.

2 **Reels, Type RL-3;** hand; 11-¾ in. x 10 in.

300 **ft. Wire, Type W-6;** counterpoise; on two reels type RL-3.

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