WAR DEPARTMENT TECHNICAL MANUAL

TM 11-2616

ANTENNA EQUIPMENT
RC-63

WAR DEPARTMENT 17 OCTOBER 1944

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WAR DEPARTMENT,
WASHINGTON 25, D. C., 17 OCTOBER 1944.

TM-11-2616, Antenna Equipment RC-63, is published for the information and guidance of all concerned.

[A. G. 300.7 (13 Apr 44).]

BY ORDER OF THE SECRETARY OF WAR:

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The Adjutant General.

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IBn (2); IC6, 11(5).
(For explanation of symbols see FM 21-6.)

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DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW—1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut—Use axes, handaxes, machetes.

3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

4. Explosives—Use firearms, grenades, TNT.

5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT—1. Smash—Mast, terminal blocks.

2. Cut—All wires, ropes, guys.

3. Burn—All equipment, associated training and technical manuals.

4. Bend—All reels, stakes, hooks.

5. Bury or scatter—All parts after destroying their usefulness.

DESTROY EVERYTHING

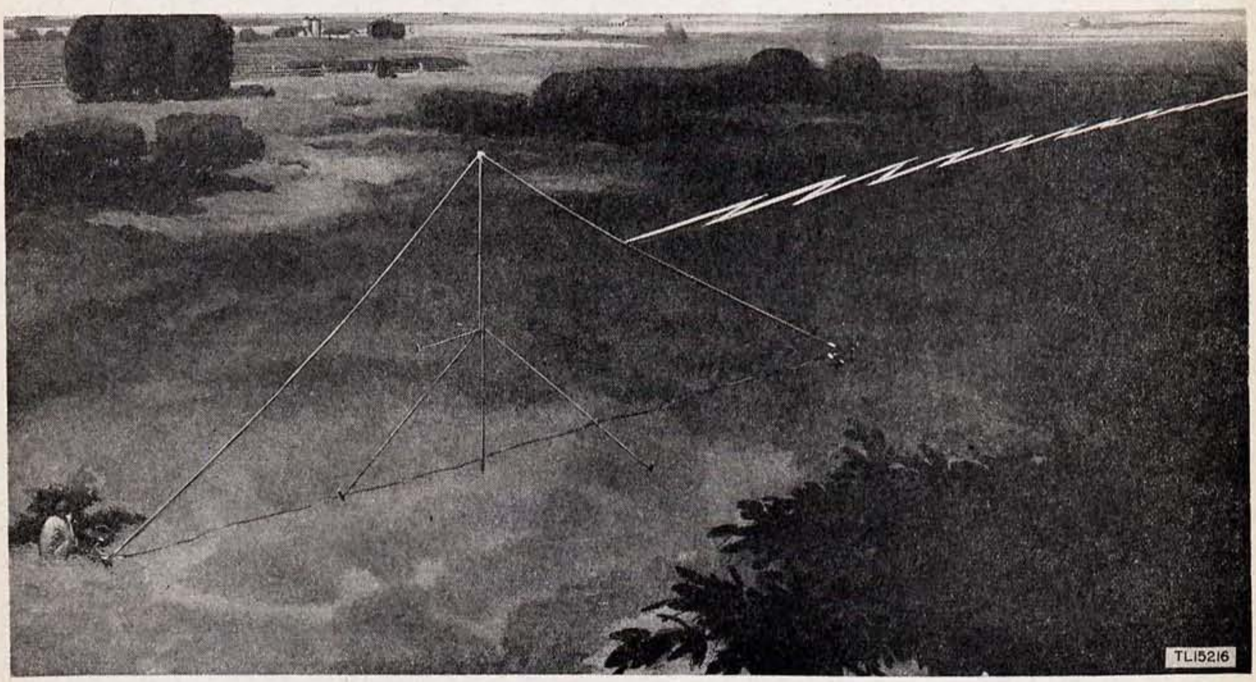


Figure 1. Typical installation of Antenna Equipment RC-63, showing radio beam leaving antenna.

SECTION I

DESCRIPTION

1. PURPOSE.

Antenna Equipment RC-63 is designed to be used as a vertically polarized directional antenna. This equipment is used with, but is not part of, various radio sets.

2. GENERAL DESCRIPTION.

Antenna Equipment RC-63, when dismantled and packed in Bag BG-93 for shipment, measures 8 feet by 1 foot by 8 inches and weighs 51 pounds. It provides a means for increasing the range of radio sets 100 percent, in one direction, over other antennas in use with various radio sets. The antenna (fig. 1) consists of a 100-foot antenna wire erected over a single 30-foot mast, and an 85-foot counterpoise wire laid along the ground. The antenna and counterpoise are terminated in a 500-ohm resistor unit, Terminal Block TM-194. The mast consists of four 8-foot sections of 1-19/32-inch wooden rods with metal ferrules, and is so designed that it may be easily erected. The upper half of the mast is hoisted into position by a rope and pulley, and the complete assembly is held in place by three guy ropes.

3. SOME EQUIPMENTS WITH WHICH ANTENNA EQUIPMENT RC-63 MAY BE USED.

a. Antenna Equipment RC-63 is a broadly tuned half-rhombic antenna. It may be used in conjunction with any radio receiver or low-power radio transmitter operating at frequencies of from 30 to 70 megacycles and equipped with either an r-f impedance output of 500 ohms, or suitable antenna-tuning components.

b. Several typical radio sets which will have greater range when using Antenna Equipment RC-63 are as follows:

Equipment	*Frequency range*
Radio Set SCR-194-( ).	27.7 to 52.2 mc.
Radio Set SCR-195-( ).	52.8 to 65.8 mc.
Radio Set SCR-300-( ).	40 to 48 mc.
*Radio Set SCR-508-( ).	20 to 27.9 mc.
*Radio Set SCR-528-( ).	20 to 27.9 mc.
*Radio Set SCR-538-( ).	20 to 27.9 mc.
*Radio Set SCR-608-( ).	27 to 38.9 mc.
*Radio Set SCR-609-( ).	27 to 38.9 mc.
*Radio Set SCR-610-( ).	27 to 38.9 mc.
*Radio Set SCR-628-( ).	27 to 38.9 mc.
*Radio Set SCR-808-( ).	27 to 38.9 mc.
*Radio Set SCR-828-( ).	27 to 38.9 mc.

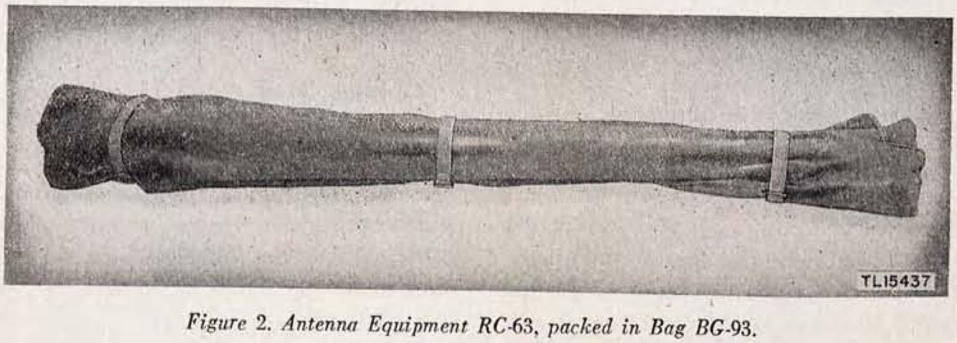


Figure 2. Antenna Equipment RC-63, packed in Bag BG-93.

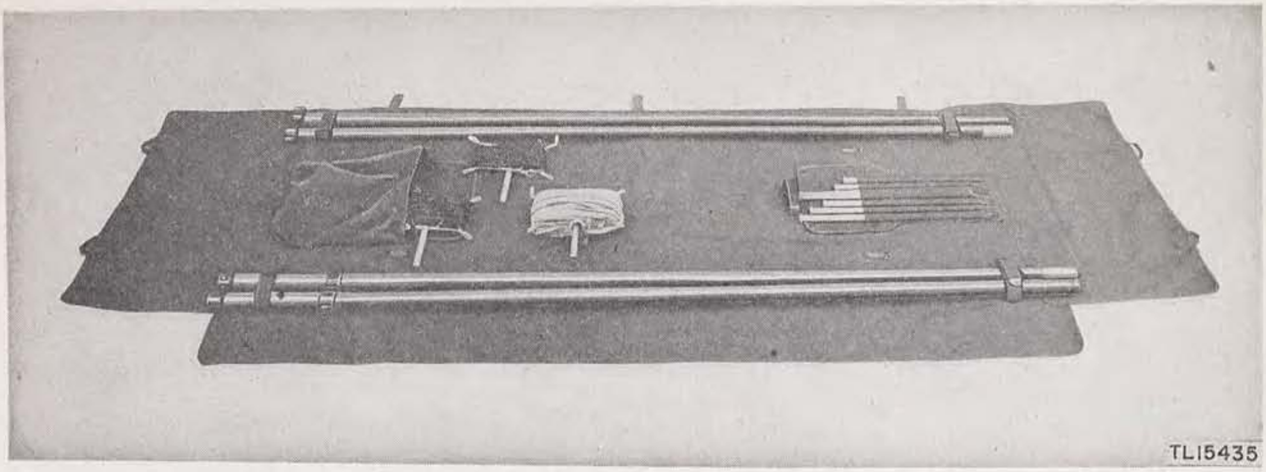


Figure 3. Antenna Equipment RC-63, Bag BG-93 open.

*At frequencies below 35 megacycles Antenna Equipment RC-63 has a wide beam width and complex lobe details. Refer to section V. In general, beam angles greater than 90° should not be used (fig. 19).

NOTE: Lowest frequency at which Antenna Equipment RC-63 will work efficiently as a beam antenna is 35 megacycles. However, it is more efficient than a vertical antenna as low as 20 megacycles.

4. COMPONENT PARTS.

The component parts of Antenna Equipment RC-63 are listed below.

Quantity	*Article*	*Weight (lbs)*
1	Antenna AN-36	1.87
1	Antenna AN-37	1.69
3	Guy GY-34	0.69
1	Guy GY-35	0.87
1	Mast Section MS-91	4.75
1	Mast Section MS-92	6.12
1	Mast Section MS-93	5.88
1	Mast Section MS-94	5.37
3	Reel RL-3	1.00
5	Stake GP-2	1.93
1	Bag BG-93	6.80
1	Hammer HM-1	1.94

Total weight of equipment 51 pounds.

5. DESCRIPTION OF PARTS.

a. Antenna AN-36. Antenna AN-36 is comprised of 100 feet of 42-strand bronze, number 32 B&S-gauge wire (Wire W-29), and is black weatherproofed. One S-hook is mounted in the center of the antenna wire and is used to attach the center of the antenna to the mast. On each end is an S-hook attached through an isolantite strain insulator to the antenna. Both ends terminate in a bare wire.

b. Antenna AN-37. Antenna AN-37 (counterpoise) is comprised of 85 feet of 42-strand bronze, number 32 B&S-guage wire (Wire W-29), and is black weatherproofed. An S-hook is attached to each end. One end terminates in a clip and the other end terminates in a bare wire. Terminal Block TB-194 (terminating resistor) is mounted on and is part of Antenna AN-37. Terminal Block TM-194 comprises a phenolic plate 1¼ by ¼ by 7 inches on each of which is mounted two Binding Posts TM-146-A. It includes Resistor RS-164 (500-ohms, 1-watt, 10-percent, insulated) connected between the binding posts and inclosed by a phenolic box-like cover screwed to the phenolic plate.

c. Guy GY-34. Guy GY-34 is made up of 30 feet of Rope RP-5 fitted with Hook FT-131 at one end and Fastener FT-9 at the other end.

d. Guy GY-35. Guy GY-35 is made up of 30 feet of Rope RP-5, fitted with Hook FT-131 at one end, Fastener FT-9 at the other end, and Block FT-127 and Hook FT-131 free on the rope.

e. Mast Section MS-91. Mast Section MS-91 is the top section of the antenna mast for Antenna Equipment RC-63. It is made of straight grain ash, fir, or spruce wood. It includes a metal plug and screw eye on the top end, and a metal-tubing socket fitted to Mast Section MS-92 on the lower end. Its dimensions are 1-19/32 inches in diameter and 96-19/32 inches long.

f. Mast Section MS-92. This is an intermediate section of the antenna mast which connects to Mast Section MS-91. It is similar to Mast Section MS-91 except that it includes metal-tubing sleeve on the top end for fitting Mast Section MS-91 and two steel guide brackets for raising the mast. Its dimensions are 1-⅞ inches in diameter by 5-⅜ inches at brackets by 95-¾ inches long.

g. Mast Section MS-93. This is another intermediate section of the antenna mast which connects to Mast Section MS-91 except that it includes a metal-end plug for fitting to Mast Section MS-94 and a combination steel guide bracket and guy clamp on the upper end. Its dimensions are: diameter of mast, 1-19/32 inches; diameter at guy clamps, 2-¾ inches; diameter at guide bracket, 6 inches; length of mast, 95-¾ inches.

h. Mast Section MS-94. This is the bottom section of the mast which connects to Mast Section MS-93. It is similar to Mast Section MS-91 except that it includes metal tubing on the top end for fitting Mast Section MS-93 and a metal end piece at the bottom end for resting on the ground. Its dimensions are 1-19/32 by 95-¾ inches.

i. Reel RL-3. Reel RL-3 is a hand reel. One is used for winding and carrying each of the following: Antenna AN-36, Antenna AN-37 (counterpoise), and Guys GP-34 and GP-35. Reel RL-34 consists of a flat rectangular frame, 11¾ by 10 inches. It is made of 3/16-inch iron wire and equipped with a handle made of a 4-9/16-inch length of ½-inch standard iron pipe.

j. Stake GP-2. Stake GP-2 is a solid galvanized-iron rod 16 inches long, ¾-inches in diameter, and with a 1⅛-inch diameter head.

k. Hammer HM-1. Hammer HM-1 is a double-faced engineer's hammer. It has a 16-inch handle and weighs 2 pounds.

l. Bag BG-93. Bag BG-93 is a hard texture, number 8, olive drab duck case, 8 feet long by 3 feet wide with an 18-inch flap at each end. It closes to approximately 8 feet by 1 foot by 8 inches. It is used to pack and carry Antenna Equipment RC-63 complete.

SECTION II

INSTALLATION AND OPERATION

6. CHOOSING AN ANTENNA SITE.

a. Initial Procedure. Before unloading or unpacking Antenna Equipment RC-63, choose an antenna site which will provide a location favorable for strong, forward, radio-beam propagation in the direction required.

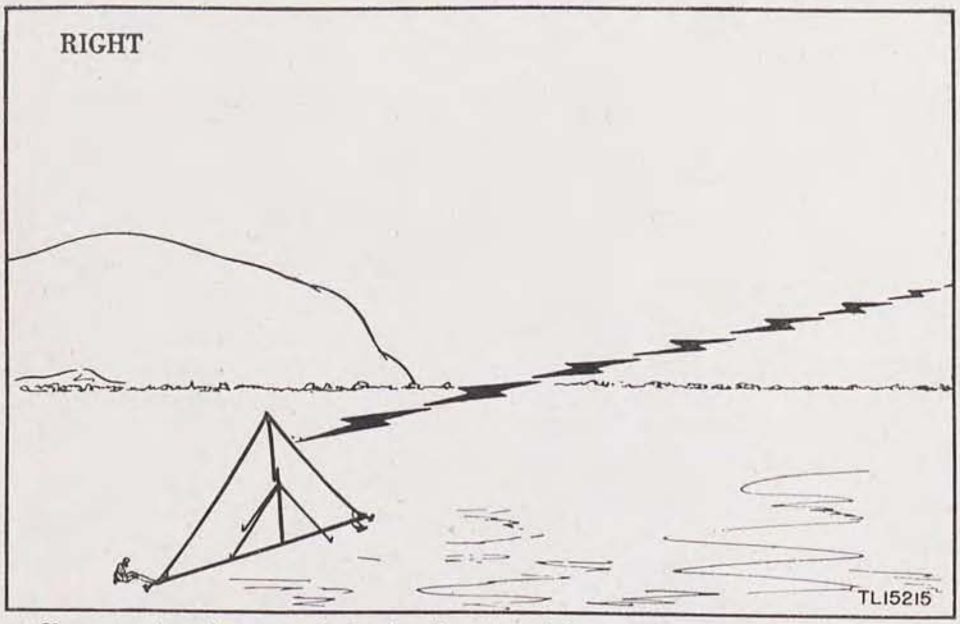
b. Requirement of the Site. For maximum propagation using half-rhombic antennas of this type, sites where these antennas are to be erected must be carefully studied.

(1) First, tentatively select a site; then survey the terrain which will be directly in the path of the proposed beam. To fix this direction, stand at the rear or radio set end of the antenna site and look toward the station or center point between stations with which communications is desired. The beam will leave the antenna in this direction.

(2) The terrain in the direction of the beam should be flat, gently rolling, or sloping downward in the beam direction, to provide a clear and unimpeded path to the outgoing and incoming radio signals. Good locations are shown in figures 1 and 4.

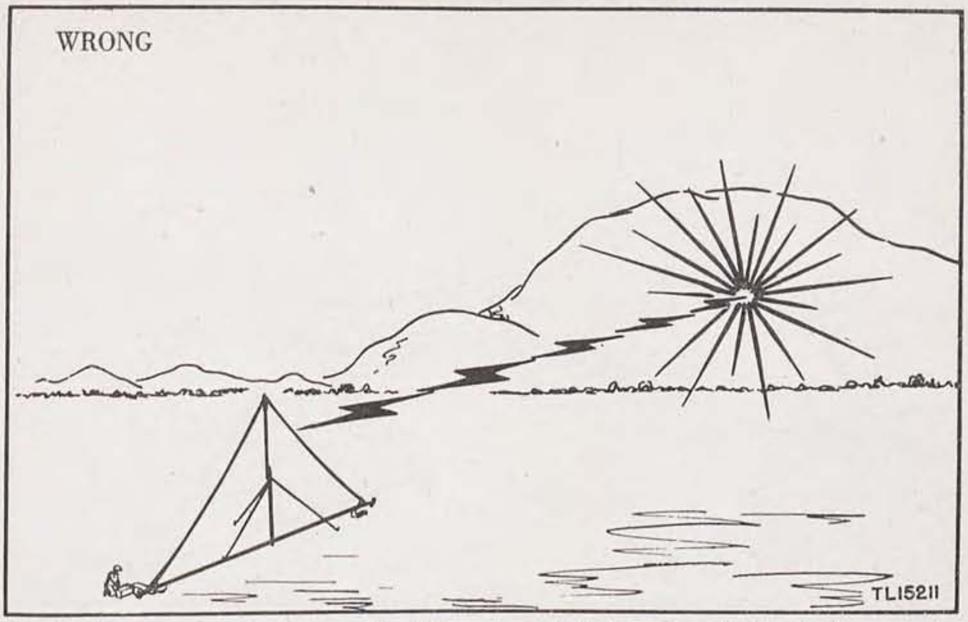
(3) Terrain in the direction of the beam should never include obstructions. Some of the major obstructions are outlined below:

(a) Mountains and hills will obstruct outgoing and incoming signals, causing poor radio performance or complete loss of communication. Figure 5 gives a graphic picture of a signal being deflected in its path by a mountain.



Choose a site where terrain in the direction of beam is flat or slopes downward.

Figure 4. Right choice of antenna site.

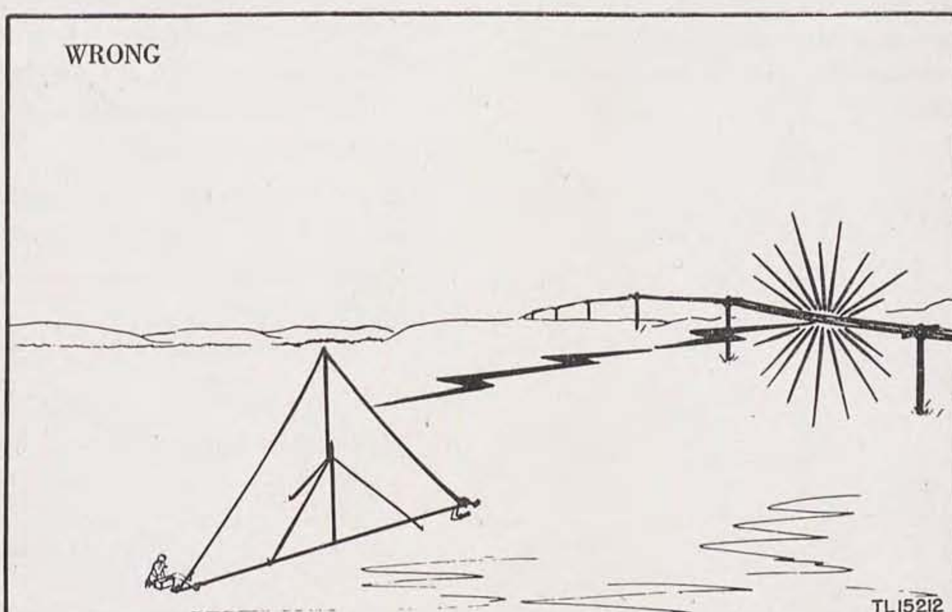


Don't choose a site where a nearby hill or mountain lies directly in the beam path.

Figure 5. Wrong choice of site.

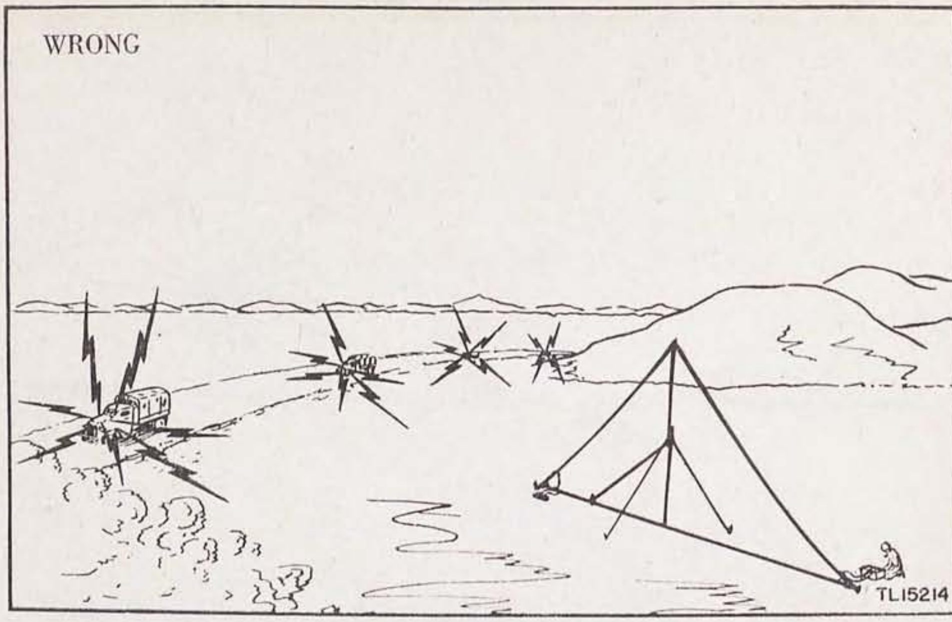
(b) Avoid sites (fig. 6) where overhead high-tension or telegraph lines, bridges, buildings, etc., lie directly in beam path. They will absorb and reduce the power of the transmitted beam, and may warp or refract its direction from the indicated by the compass. They may also cause bad interference to radio reception.

(c) Avoid sites where the beam path must cross a heavily traveled highway. Ignition noise from passing vehicles, suppressed or not, may blanket reception. Figure 7 shows a bad installation. Vehicle ignition systems radiate a strong damp wave at these high frequencies, causing large amounts of interference at close range. Sites where the beam must cross a nearby electrified town or village, a motor pool, or a col-



Don't choose a site where nearby overhead wires lie in the beam path. They may absorb power and distort the beam direction; also cause noisy reception.

Figure 6. Wrong choice of site.

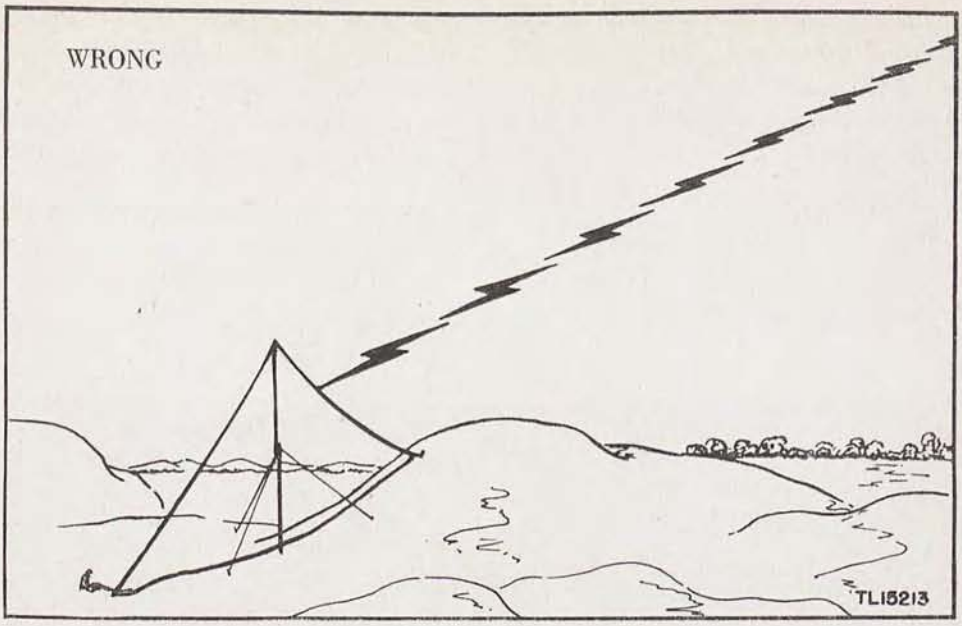


Don't choose a site where beam crosses a nearby heavily traveled highway.
Ignition noise from vehicles may blanket reception.

Figure 7. Wrong choice of site.

lection of operating battery chargers, dynamotors, and electrical equipment must also be avoided. These equipments may prove noisy and cause blanketing of reception. Half-rhombic antennas providing signal voltage gains of 10 to 50 times over and above half-wave vertical antennas are proportionately sensitive to electrical noise as well as radio signals, and will amplify noise considerably more if the antenna site is carelessly chosen.

(d) Avoid installations on the side of a hill away from the direction of the desired beam path (fig. 8). signals from half-rhombic antennas installed in such a location will travel skyward at a high vertical angle, radiating little power at low angles (desired direction) or those angles effective for ground-wave coverage of terrain up to 75 miles. However, sites on the side of a hill toward the beam path and radio target will, for short distances of communication, aid the low-angle transmission and may be used.



Don't choose a site on the side of a hill away from the radio target.
Signals will travel skyward, producing little ground wave.

Figure 8. Wrong choice of site.

(e) When concealment or speed of installation is more important for tactical reasons than sites favorable for efficient installations, less attention may be given to installation. Some of the gain of Antenna Equipment RC-63 will be lost if care is not taken when choosing a site; however, the gain will, in most cases, still be sufficient to warrant this type antenna installation.

(f) In choosing a site for Antenna Equipment RC-63, remember that any type of workable antenna may be used for temporary communication between two or more stations, while a site is being located and Antenna Equipment RC-63 is being installed.

> NOTE. *For purposes of clarity, illustrations in this manual do not show necessary camouflage and concealment precautions. These precautions must be closely followed at installations of Antenna Equipment RC-63.*

7. INSTALLATION PROCEDURE

After having chosen a suitable site, erect the mast approximately 40 feet from the input end of the antenna (end connected to radio set). If the spot where the mast is to stand is soft loose soil, lay a large flat stone, wide plank, or large heavy metal plate on the ground as a base for the antenna mast.

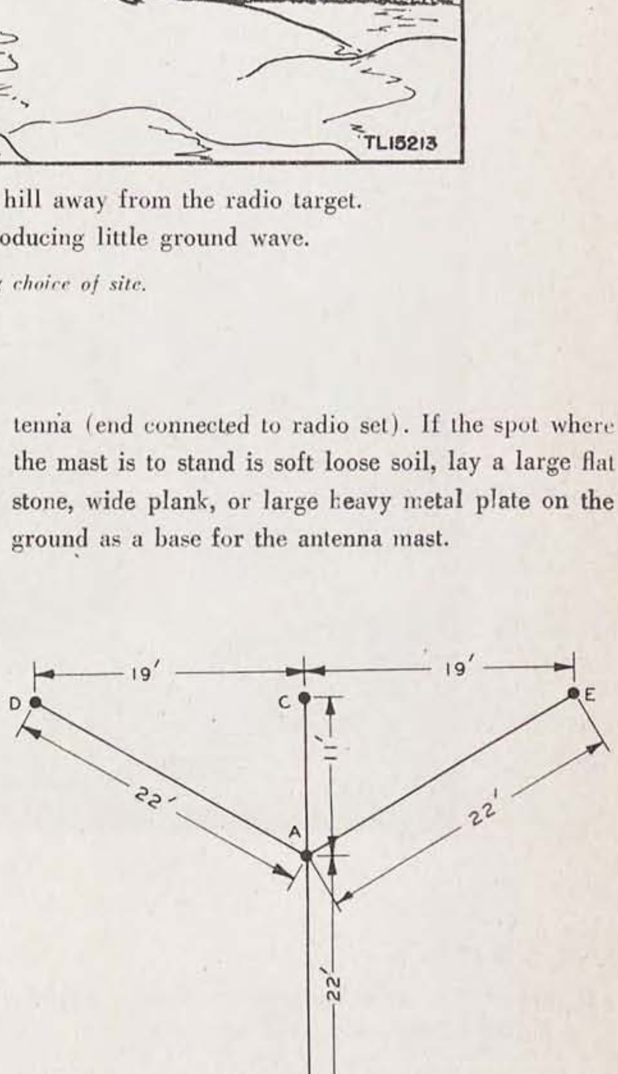


Figure 9. Dimensional drawing of mast and stake layout, showing a simple method for erecting an antenna mast at point A.

a. Stake Layout. With the spot where the mast is to stand as a center, three stakes, each 22 feet from the center, are driven into the ground to form a triangle. Follow the procedure outlined below. Dimensions are given in figure 9.

(1) Drive a stake *temporarily* into the ground at the spot where the mast is to stand (fig. 9, point A.)

(2) Measure 22 feet from point A to point B, and drive a stake into the ground at point B, slanting away from point A.

(3) Measure 11 feet in the opposite direction to point C, and drive a *temporary* stake into the ground.

(4) Measure 19 feet at right angles outward from C and drive a stake at D. Repeat and drive a stake at point E, both stakes slanting away from point A.

(5) Check to see that stakes at B, D, and E are each 22 feet from point A, forming an equilateral triangle with A as the center.

b. Mast Assembly. The mast consists of four sections which are designated as Mast Sections MS-91, MS-92, MS-93, and MS-94, beginning with the top section. Assemble the four sections on the ground as outlined below and indicated in figure 10.

(1) Attach Mast Sections MS-91 and MS-92 by inserting the metal tube socket on end of Mast Section MS-91 into the metal tube sleeve at the top of Mast Section MS-92.

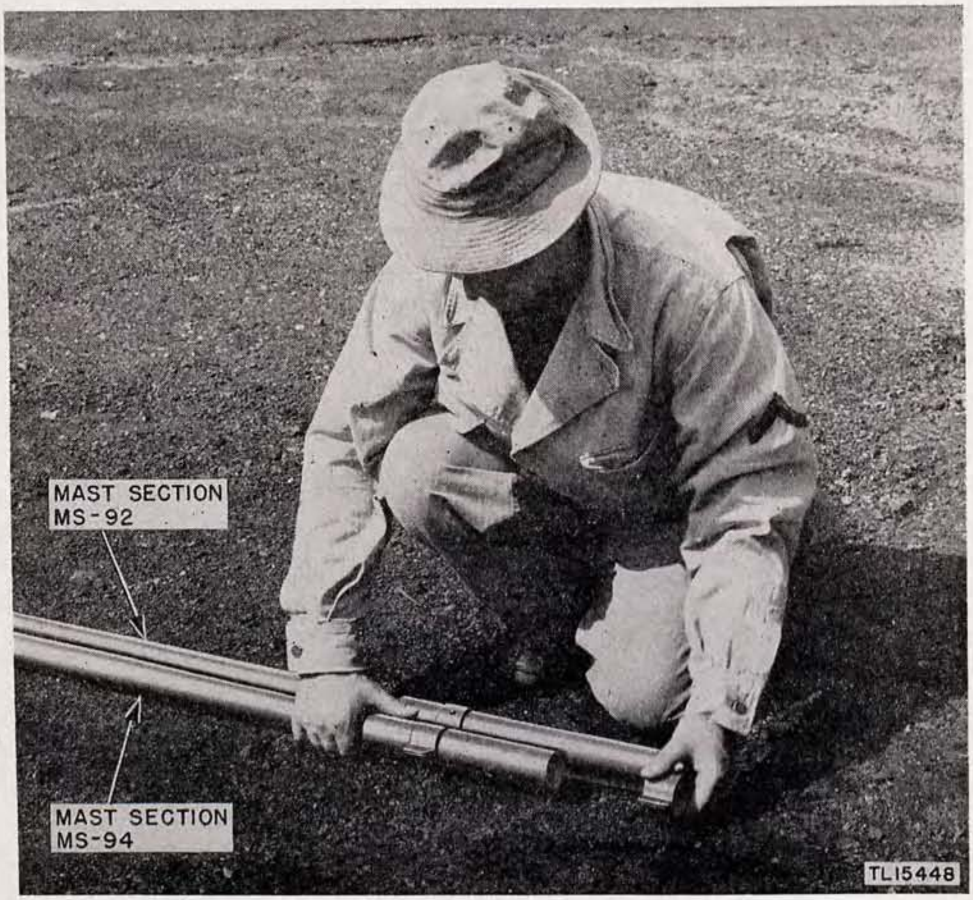


Figure 10. Mast Section MS-94 being inserted into the two steel guide brackets attached to Mast Section MS-92.

(2) Attach Mast Sections MS-93 and MS-94 by inserting the metal tube socket on end of Mast Section MS-93 into the metal tube sleeve at the top end of Mast Section MS-94.

(3) With Mast Sections MS-91 and MS-92 attached and lying parallel to Mast Sections MS-93 and MS-94 also attached, insert Mast Section MS-94 into the two steel guide brackets on Mast Section MS-92; at the same time insert Mast Section MS-91 into the steel guide bracket on Mast Section MS-93 (fig. 10).

Figure 11. Antenna AN-36 being attached to Mast Section MS-91.

(4) Secure Guy GY-35 (hoisting rope) to the mast by attaching Hook FT-131, part of Block FT-127, to the eye provided on top of Mast Section MS-93, and attach Hook FT-131 (at one end of Guy GY-35) to bottom of Mast Section MS-92.

(5) Secure three guys GY-34 to the three ears in the metal collar on top of Mast Section MS-93 with Hooks FT-131 and adjust the guys to approximately their correct length (27 feet).

(6) Attach the center of Antenna AN-36 to the eye of top of Mast Section MS-91, using the S-hook secured to the center of Antenna AN-36 (fig. 11).

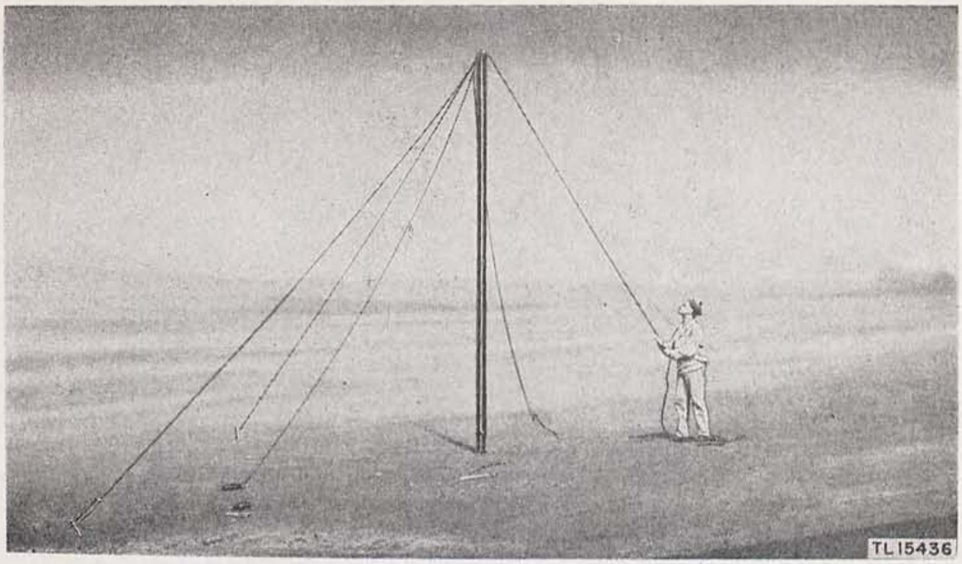


Figure 12. Erecting mast in a vertical position.

c. Erecting Mast Antenna and Counterpoise. After two guys are previously looped over two of the three guy stakes, the mast is erected in a vertical position (fig. 12). A third guy is then attached to the third guy stake. After the mast is erected in a vertical position and all three guy ropes are *adjusted under strain*, the mast is hoisted to its *full* height and held secure in this position by looping Guy GY-35 (hoist rope) over one of the guy stakes. Antenna and counterpoise are then stretched out in the direction of the beam and staked down.

(1) Attach two Guys GY-34 to two guy stakes by making at least one complete loop over each stake.

(2) Lay base of mast against temporary stake C. (fig. 9) and raise mast to a vertical position.

(3) Hold antenna mast in place with the third guy GY-34 (fig. 12). While holding Guy GY-34, walk over to third stake, make one complete loop around Stake GP-2, and take up on the guy.

(4) Tighten up on all three guys. *Put a heavy strain on each and be sure the mast is in a vertical position.*

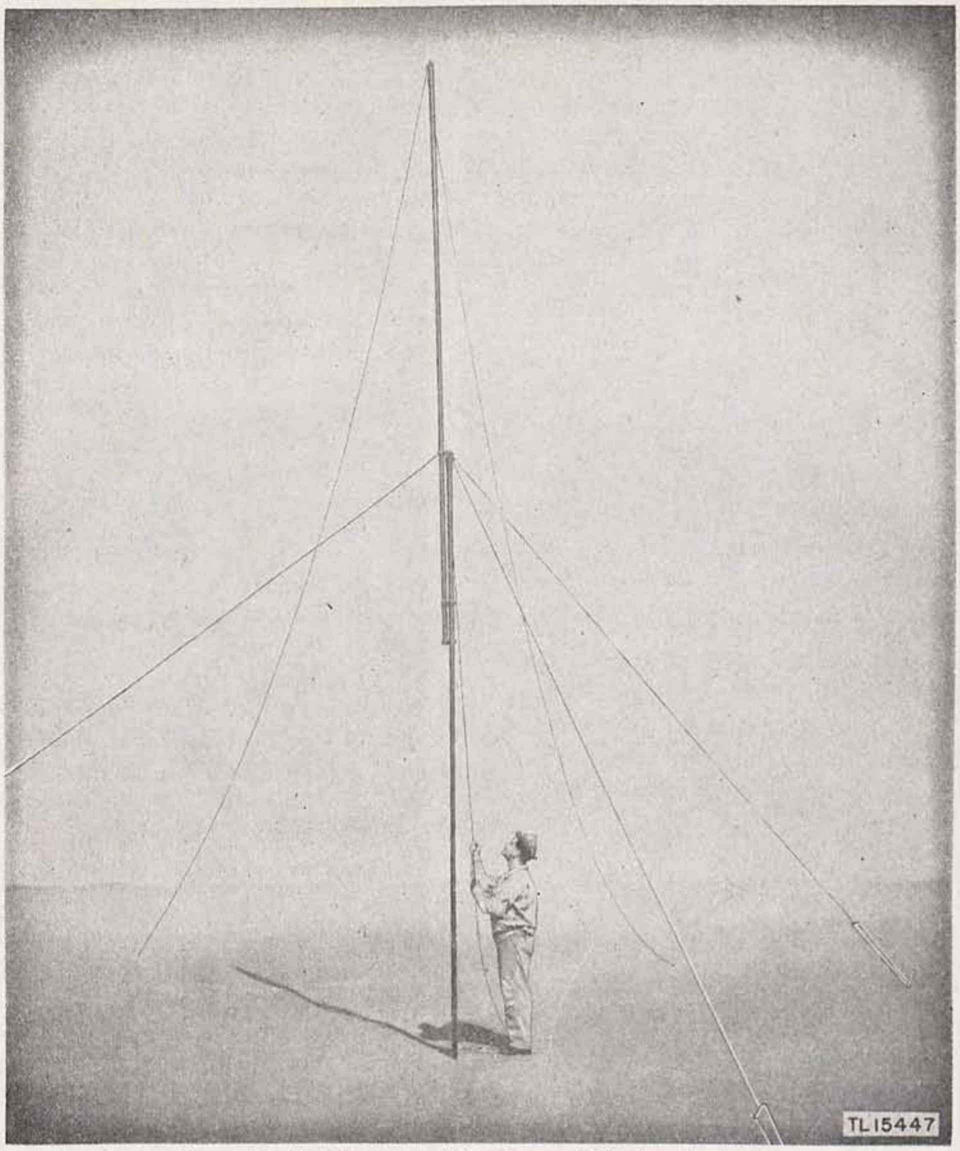


Figure 13. Hoisting mast with Antenna AN-36 hanging loose.

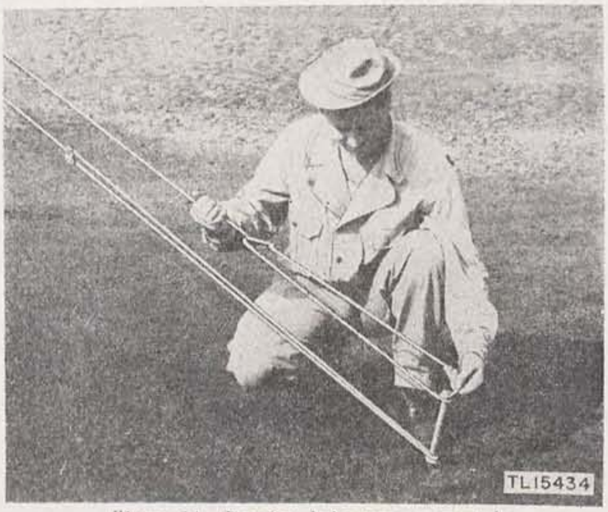


Figure 14. Looping hoist rope over stake.

(5) Using Guy Rope GY-35, hoist mast to its full height (fig. 13) and attach Guy GY-35 to one of the guy stakes. Make one complete loop around guy stake (fig. 14) and adjust guy for a *slight strain.*

(6) Remove stake C from base of mast (fig. 9).

(7) Stretch the input end of Antenna AN-36 (end which connects to radio set) out its full length and slip a Stake GP-2 through the S-hook. Slip the same stake through the S-hook attached to the clip end of Antenna AN-37 (counterpoise) and, while stretching Antenna AN-36 out with a little sag to it, drive Stake GP-2 into the ground.

> CAUTION: Never pull Antenna AN-36 tight or put undue strain on it. The antenna mast is pliable and pulling the antenna will cause the mast to bend or arch over with a possible break resulting.

(8) Unreel Antenna AN-37 (counterpoise) its full length, straight out past the mast, and slip a Stake GP-2 through the S-hook. Stretch the far end of Antenna AN-36 (end in direction of the beam) out its full length and slip the same stake through the S-hook. Drive the stake into the ground, leaving a little sag in the antenna.

(9) Adjust the stakes at both ends of Antenna AN-36 and Antenna AN-37 (counterpoise) so that no bend is apparent in the mast and Antenna AN-36 *sags* just a little, as illustrated in figure 1.

(10) Slide Terminal Block TM-194 along Antenna AN-37 (counterpoise) toward the far (beam) end of the antenna, and connect Antenna AN-36 and Antenna AN-37 to the appropriate binding post of Terminal Block TM-194. Terminal Block TM-194 is the antenna-terminating resistance.

d. Dismantling Antenna Equipment RC-63.

(1) Pull the stakes out of the gound at both ends of Antenna AN-36 and Antenna AN-37, releasing the strain on the antenna mast.

(2) Lower the antenna mast with Guy GY-35 (hoisting rope).

(3) Release *one* Guy GY-34 from Stake GP-2 and carefully lower mast to the ground.

(4) Reel Antenna AN-36 and Antenna AN-37 with Terminal Block TM-194 attached on separate Reels RL-3.

(5) Reel three Guys GY-34 and one Guy GY-35 together on one Reel RL-3 and pack all parts of Antenna Equipment RC-63 in Bag BG-93.

8. OPERATION.

a. Transmit-receive Operation. A half-rhombic antenna works equally well on receiving or transmitting. If it will transmit a strong signal to a given point, it will receive equally well from that point, the

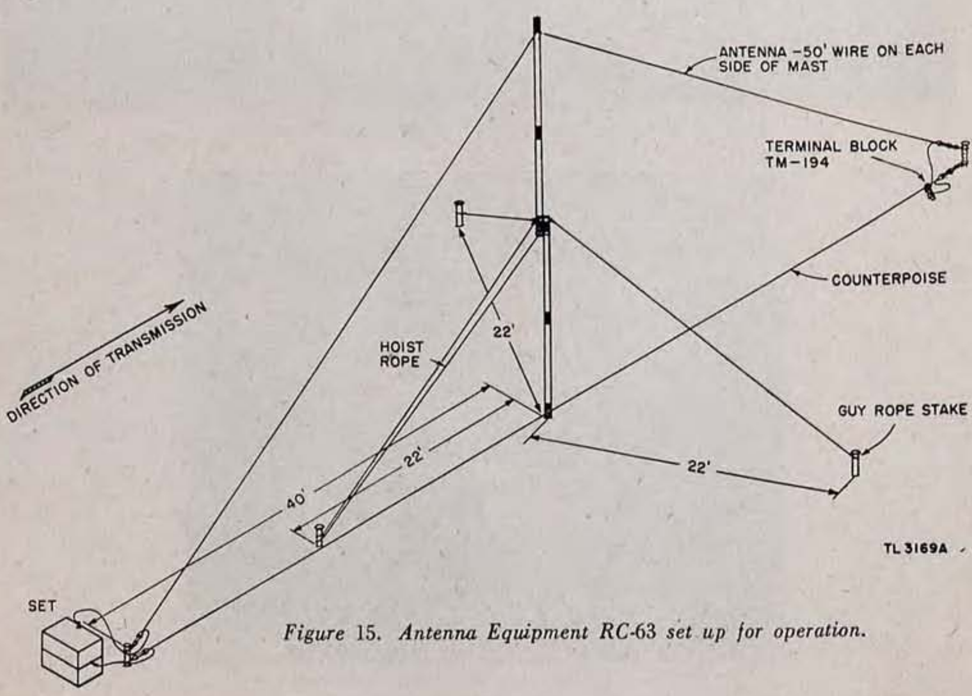


Figure 15. Antenna Equipment RC-63 set up for operation.

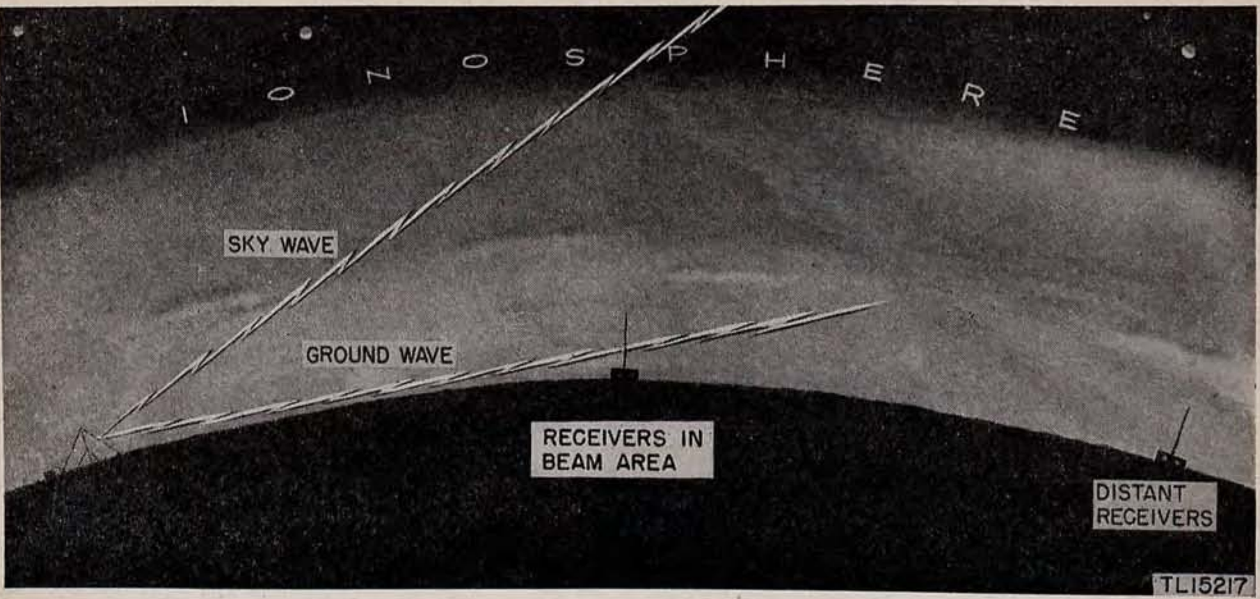


Figure 16. Ground and sky wave produced by Antenna Equipment RC-63.

power gain of the antenna being applied to both incoming and outgoing signals. For example, if radio transmitter A delivers 5 watts at 30 megacycles to Antenna Equipment RC-63, which has a gain of five times at this frequency, the effective power of the transmitter will be increased, in the direct line of the beam, to 25 watts. Similarly, signals received from a 5-watt station directly in the beam will be increased in the direct line of the beam to a level equal to a signal coming from a 25-watt station. This equal performance of an antenna on transmitting and receiving is known as antenna reciprocity and is more fully covered in TM 11-314, Antennas and Antenna Systems.

b. Ground Wave and Sky Wave. As is the case with most very-high-and-ultra-high-frequency antenna systems, transmissions from this antenna depend for effect on the ground wave. As shown in figure 16, the ground wave is sent out at a low vertical angle from the antenna and, skirting the ground, is effective in reaching receivers within approximately 5 to 25 miles and under exceptional conditions more than 25 miles. The sky-wave, power-radiated at a high vertical angle, strikes the ionosphere and either is absorbed in traveling through the ionosphere, or is reflected off the ionosphere at a low vertical angle continuing past the earth into space.

9. ORIENTATION OF ANTENNA FOR MAXIMUM SIGNAL STRENGTH.

If it is desired to receive or transmit signals to one locality, the antenna is normally aimed at that locality with the aid of a compass, or other method which may be available. For the greatest possible signal strength, follow the procedure outlined below, after the initial installation has been made.

a. Tune in the desired signal. Once tuned in, leave the receiver controls fixed so that any changes in the antenna will cause an increase or decrease in receiver volume.

b. Using the mast as a center, rotate the entire antenna, counterpoise, and radio set from left to right until a maximum received signal is produced on the receiver. When a position is found, at which a maximum signal is received from the desired station, stake down and secure both ends of the antenna and counterpoise in the same manner as outlined in paragraph 7.

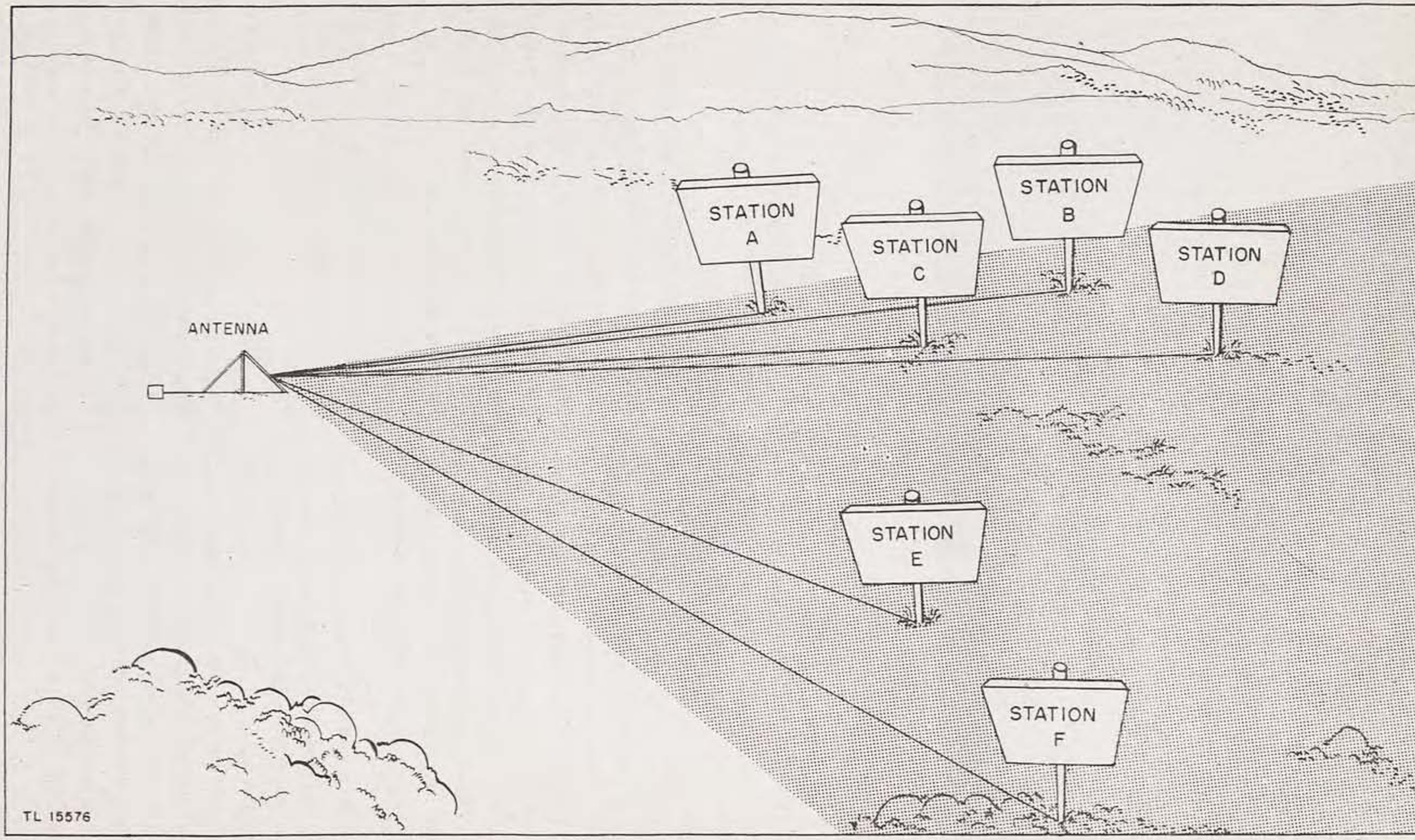


Figure 17. Half-rhombic antenna correctly oriented.

10. ORIENTATION FOR COMMUNICATION WITH A GROUP OF STATIONS.

a. It may be desirable to transmit and receive the strongest possible signals with a number of stations spread over a wide sector. It will therefore be necessary to analyze the beaming action and beam coverage of the antenna.

b. Antenna Equipment RC-63 concentrates radio energy fed to it into a beam precisely as a searchlight concentrates the light it casts in the direction it is pointed (fig. 18). Unlike a searchlight, however, the width of the radio beam sent out by the antenna varies with the frequency at which the antenna is used; the higher the frequency used, the sharper and more powerful the beam.

(3) Turn on the receiver and tune in a station to the extreme left of the antenna. Station located at position A or B (fig. 17) should be tuned in.

(4) Leave the receiver gain or volume control intact, and tune in a station to the extreme right of the antenna by using only the receiver tuning control. Station located at position E or F (fig. 17) should be tuned in.

(5) If the signal strength from the station to the left (station A) is equal to the signal strength from the station to the right (station F), no realignment of the antenna is required. However, if the signal strength from one side is weaker than from the other side, the antenna will have to be rotated toward the weak station balancing the signal strength from each station. Follow the procedure given in paragraph 9.

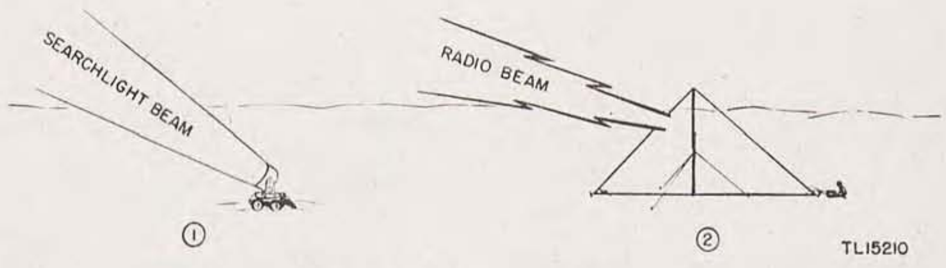


Figure 18. Radio and searchlight beam.

c. When communication is desired between two or more stations and the antenna has been installed in the general direction of the stations, proceed as follows:

(1) Survey the area with a compass, or by observation and available information, and draw a line on the ground from the mast a short distance out toward each station with which communication is desired. This area outlined on the ground from the mast outward is the area to be covered by the antenna.

(2) Pull up from the ground the two Stakes GP-2 which are holding the antenna and counterpoise in place, and rotate the antenna and counterpoise to a point half-way between the two extreme stations (fig. 17).

11. TRANSFER OF BEAM COVERAGE TO A MAP.

Orientation of the antenna may be accomplished with the aid of a map if desired. To help in quickly laying out the beam produced by Antenna Equipment RC-63 on any map regardless of scale, figures 19 and 20 give a number of beam widths for various frequencies at which the antenna is used. These beam widths are drawn to scale and may be traced or transferred to any map. By this method it is possible to ascertain quickly whether the antenna at a given frequency will cover the required area with sufficient signal strength.

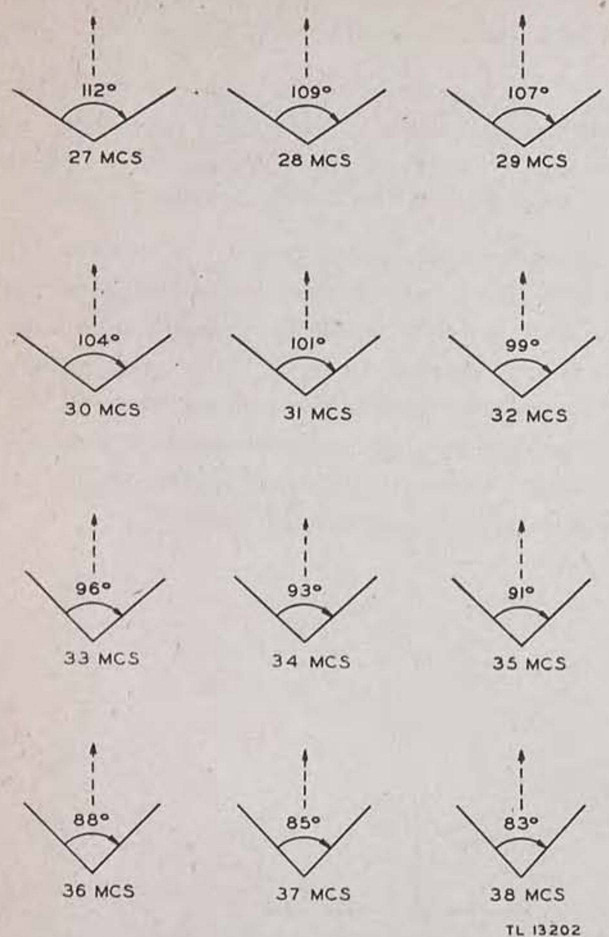


Figure 19. Beam angles at frequencies of 27 to 38 megacycles.

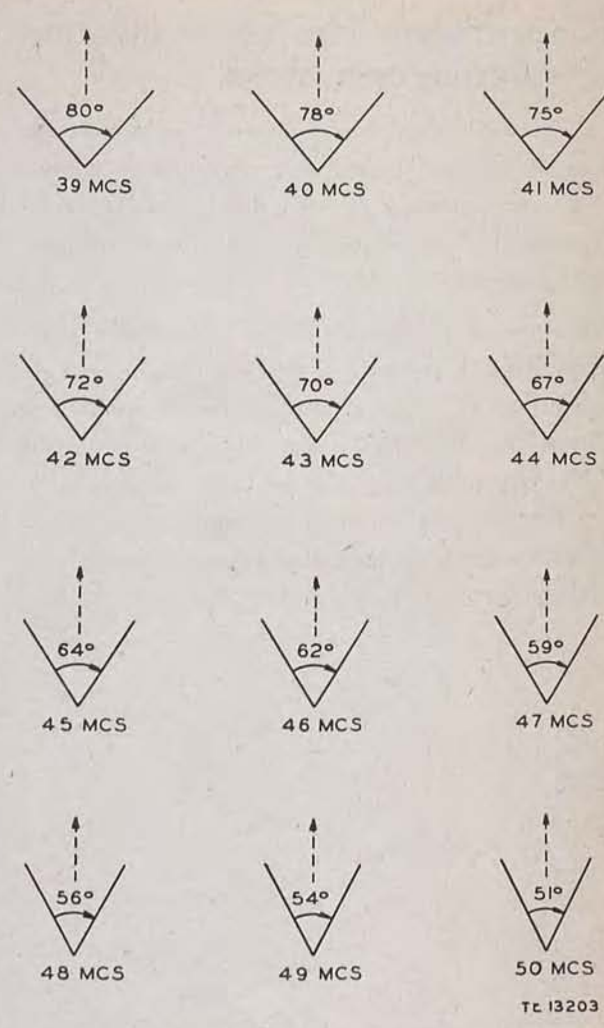


Figure 20. Beam angles at frequencies of 39 to 50 megacycles.

12. MATCHING ANTENNA TO TRANSMITTER OR RECEIVER.

After Antenna Equipment RC-63 has been installed and connected to a radio set, it will be necessary to align the antenna tank circuits of the transmitter, and the antenna circuits of the receiver.

a. Adjust the transmitter antenna tank circuits as directed for the particular equipment in use. Align for maximum antenna current.

b. Adjust the receiver antenna circuits as directed for the particular equipment in use. Align the receiver for greatest sensitivity.

13. TRANSMISSION LINE REQUIREMENTS.

a. In most equipment used with Antenna Equipment RC-63, Antennas AN-26 and AN-27 terminate at the radio set, allowing connection directly to antenna terminals or tank coil.

b. If it is necessary to use a transmission line between the antenna and the radio set, use a parallel pair transmission line as follows.

(1) Obtain the necessary length of No. 14, No. 16, or No. 18 S-gauge copper wire.

(2) Run two parallel wires *evenly spaced at 2 to 2½ inches apart* connecting Antennas AN-36 and AN-37 to the radio set.

(3) Keep the transmission line as short as possible.

(4) Adjust transmission line length for maximum antenna current with transmitter on transmit.

(5) Check transmission line length for maximum sensitivity on receiver. *The length and spacing of transmission line is important in matching antenna and radio antenna circuits.*

14. SIMULTANEOUS OPERATION OF TWO OR MORE HALF-RHOMBIC ANTENNAS FOR THE COVERAGE OF SEVERAL SECTIONS.

a. It may be desirable to cover two or more sections simultaneously using half-rhombic antennas. This may be accomplished by using two or more radio sets connected to separate rhombic antennas, using one radio set connected first to one antenna and then to another antenna or using a combination of both systems. When such operations are planned, half-rhombic antennas must be placed sufficient distances apart so that the antennas or signals from the antennas will not interact on each other.

b. As a relatively small amount of power is radiated at right angles from these antennas, two or more half-rhombic antennas may be placed side by side. When installing half-rhombic antennas side by side, space them approximately 200 feet apart, and in no case less than 100 feet apart. The beams from the antennas should fan outward. *Never cross beams.* Use a common center area for the radio sets.

c. If half-rhombic antennas are installed, one in front of the other or with beams crossing, the antennas must be placed at least 2,000 feet apart.

> NOTE: *If half-rhombic antennas are installed, one in front of the other, or in such a way that the beams cross at close range, the radio beams will interact at a large number of frequencies, causing a bending of each beam. This method should not be used.*

SECTION III

FUNCTIONING OF PARTS

15. BEAM ACTION OF ANTENNA.

a. When properly erected and adjusted, half-rhombic antennas radiate a major portion of the radio-frequency power fed to them in the direction of the triangle baseline as sighted from the input end (end connected to radio set) to the output end (end in direction or radiated beam). Antenna Equipment RC-63 acts to concentrate this radio power as a searchlight concentrates a light beam (fig. 18).

b. Conversely, on reception, Antenna Equipment RC-63 receives and amplifies signals within its beam area, rejecting or discriminating against signals arriving from localities outside the beam. The action on receiving is similar to looking at a target through a telescope; the target itself is magnified, the surrounding area not seen.

16. BEAM-FORMING FUNCTION OF WIRES.

a. Radio frequency power from the transmitter is fed directly to leg No. 1 of the antenna and to the counterpoise (fig. 21). As this power flows through leg No. 1 and leg No. 2, each leg acts as if its were an individual long-wire antenna, producing four major lobes of power radiation at a very definite angular relation to the wire itself. This angular relation depends on the length in wavelengths of each leg (see the angles shown by arrows in figure 21 and marked △). As the length of legs No. 1 and No. 2 are increased at a given frequency, the lobes will lie closer to legs No. 1 and 2, and the angles △ will get smaller in proportion.

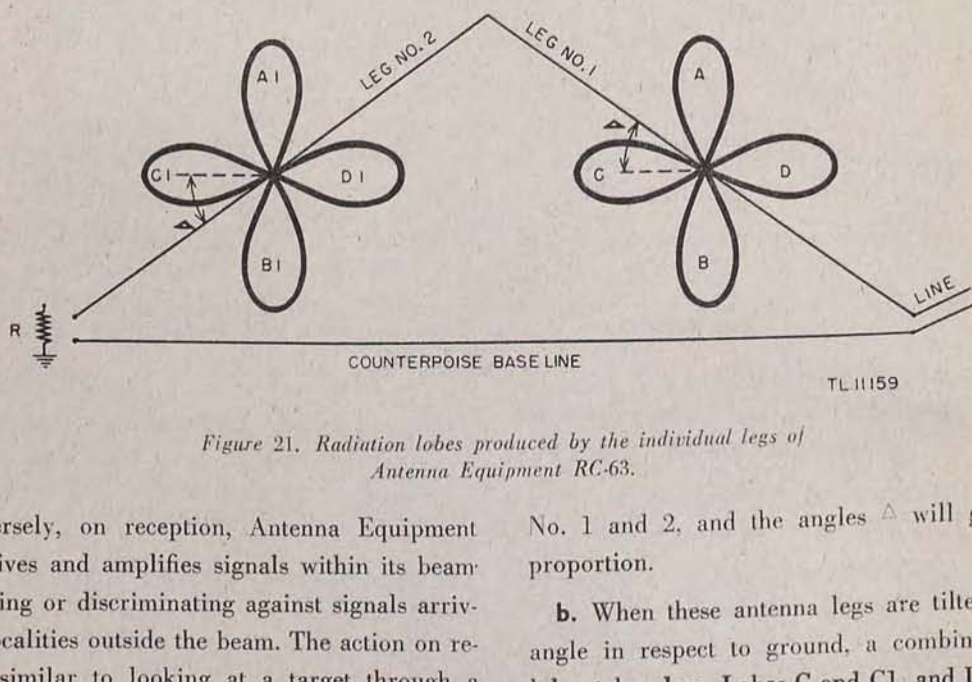


Figure 21. Radiation lobes produced by the individual legs of Antenna Equipment RC-63.

b. When these antenna legs are tilted at a correct angle in respect to ground, a combination of these lobes take place. Lobes C and C1, and D and D1 combine to add their power, while lobes A and B and A1 and B1 act to cancel. Thus radiation from combined legs 1 and 2 is then concentrated in two directions, directly forward and directly to the rear. The terminating resistance in Terminal Block TM-194 acts to eliminate the rear transmission.

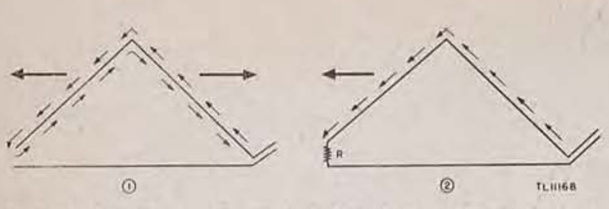


Figure 22. Current flow with and without the terminating resistance. Note that the antenna without a terminating resistance is bidirectional, the antenna with a terminating resistance is unidirectional. Direction of transmission is indicated by large arrows.

c. The action of terminating resistance in eliminating rear transmission can easily be understood by examining current flow. Figure 22 gives an analogy of current flow in the antenna. Small arrows lying close to the antenna wires indicate current flowing from the transmission line to the far end of the antenna wire, and power is radiated in the forward direction of the antenna. The current arriving at the far end of the antenna would normally be reflected back and travel in the opposite direction as indicated by the small arrows pointing from left to right (fig. 22 ①). While traveling in this opposite direction, the current would radiate power in both directions (forward and backward). The terminating resistance, however, prevents this round trip by the current. Figure 22 ② shows the terminating resistor connected and current flowing from the near to the far end of the antenna and radiating energy in the forward direction only. The current not radiated arrives at the terminating resistance and is dissipated in the form of heat. The result is only forward transmission by the antenna. The terminating resistance in no way decreases the power radiated forward, but merely absorbs the power which, without it, would circulate throughout the antenna circuit upsetting the phase relation and causing radiation in more than one direction.

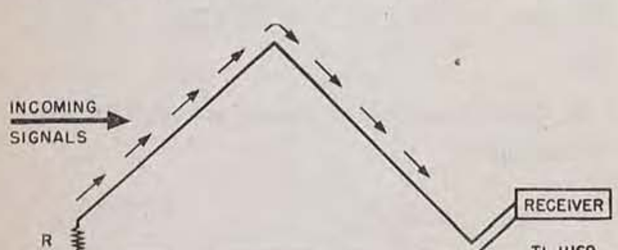


Figure 23. Currents set up in the antenna wire by incoming signals within the beam of the antenna.

d. The function of the antenna on receiving is similar to its function on transmitting. Incoming signals, within the antenna's forward beam, strike the antenna and set up currents moving from left to right (far end to receiver) as shown in figure 23. These currents proceed through to the receiver. Signals arriving from the rear of the antenna, however, set up currents moving in the opposite direction, and arriving at the terminating resistance, are dissipated. Hence, reception from the rear is eliminated. Signals which arrive at angles other than those at the front or rear of the antenna (from the sides, etc.) set up opposing currents in the antenna wires cancelling each other to an extent depending on the angle from the forward center. The sensitivity of the antenna is at a maximum straight forward, and decreases to an increasingly greater extent at angles away from the forward direction.

17. SPREAD ANGLE OF THE ANTENNA TRIANGLE.

As can readily be seen from figure 21, it is essential for the production of greatest beam power that antenna triangle legs No. 1 and 2 be set at an angle which will produce maximum addition of lobes C and C1 and maximum cancellation of lobes A and B and A1 and B1. This upper spread angle for Antenna Equipment FC-63 is approximately 100°, the optimum angle for average lobe at frequencies of 30 to 70 megacycles, and therefore for maximum output. A further interesting and important characteristic of this antenna is that the optimum spread angle varies in opposite direction to the optimum length of the triangle legs for a change in frequency. Beam production by the antenna is therefore self-stabilized as frequency is shifted.

18. COUNTERPOISE FUNCTION.

The counterpoise wire forming the base of the antenna triangle serves as a low-resistance return for the terminating resistance and completes the electrical circuit of the antenna. It also serves, in part, as an artificial ground underneath the antenna which, because of its low resistance as compared to earth, acts to materially increase transmitted and received signal strength, likewise stabilizing the operation of the antenna over differing soil conditions.

19. VERTICAL POLARIZATION.

Signals transmitted by Antenna Equipment RC-63 are *vertically polarized,* and therefore produce maximum signal in all vertical whip antennas used by field radio stations or vehicular installations within the beam of the antenna. This identical polarization is of enormous advantage in missions assigned to Antenna Equipment RC-63. This antenna is also vertically polarized on reception, providing increased signal strength from whip antennas used by installations within the beam area.

SECTION IV

MAINTENANCE

NOTE: Failure or unsatisfactory performance of equipment will be reported on W.D., A.G.O. Form No. 468. If this form is not available, see TM 38-250.

20. ANTENNA ASSEMBLY.

a. Check Antennas AN-36 and AN-37 (counterpoise). See that no kinks, Q-loops, or sharp right-angle bends have been accidently made in the wire.

b. Clean antenna insulators with carbon tetrachloride and see that they are not cracked or broken. Dirty insulators will cause noisy and intermittant reception. When transmitting, dirty insulators will cause loss of radiated power with possible arcing across the insulator. This may also upset the radiated beam angle of the antenna.

c. Clean Terminal Block TM-194 with carbon tetrachloride. Test for defective wiring or open circuit in the terminal block. If resistance is open, the antenna will not function properly, will become bidirectional and more noisy on reception, and will reflect strong reactance back to the transmitter during transmitting on some frequencies. Proceed as follows:

(1) Disconnect Antennas AN-36 and AN-37 from Terminal Block TM-194. Using a low-range ohmmeter, check resistance across the terminals. The resistance should be between 450 and 550 ohms. A continuity resistance between these values *must* be present. High-resistance readings may mean poor prod connections, unsoldered internal leads, or burned-out resistor. If necessary, replace resistor.

(2) As a maintenance expedient to permit operation of radio equipment with Antenna Equipment RC-63 when a replacement resistor is unavailable, use two ground stakes in place of Terminal Block TM-194 and proceed as follows:

(a) Drive one stake into the ground at the far end of the antenna and connect Antenna AN-36 to it, making a good electrical connection.

(b) Drive a second stake into the ground about 5 feet from the first stake. With test prod leads of ohmmeter, measure the stake to stake resistance. Relocate the stake until resistance reads between 450 and 550 ohms.

(c) Connect the leg of Antenna AN-37 (counterpoise) to the second stake, thus providing the antenna with a suitable stopgap terminating resistance. If the volume of water in the ground varies appreciably from day to day, the resistance between stakes will likewise vary.

d. Check connection of antenna at radio equipment for continuity.

SECTION V

SUPPLEMENTARY DATA

21. FIELD EXPEDIENTS, HALF-RHOMBIC ANTENNAS.

For communication or other radio measures, it is possible to use a half-rhombic antenna, correctly designed, at virtually any frequency at which the proper physical support is available, thus putting to use the large power gain and other advantages of this type of radio-beam antenna. This use of half-rhombic antennas other than Antenna Equipment RC-63 is treated in this manual to provide information for field expedients. These antennas should be designed and used only with permission, and under the guidance of the officer in charge.

22. PHYSICAL LIMITATIONS OF HALF-RHOMBIC ANTENNAS.

Since the triangular dimensions of the antennas are related mathematically to the operating frequency used, physical support at the correct height and sufficient wire for the triangle legs must be available to permit the installation of a given half-rhombic antenna. The height of this required support varies inversely with frequency: the lower the frequency used, the higher the support required for maximum gain, while at higher frequencies this support becomes of such practical size that lance poles, small masts, or trees may be used.

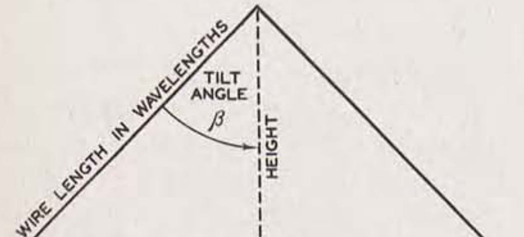


Figure 24. Half-rhombic antenna triangle showing height of the upper apex, wire length on a leg, and tilt angle.

23. WIRE LENGTH AND APEX ANGLES.

As previously stated, the required length of each side of the antenna triangle, the height of the upper apex angle above ground, and the counterpoise length are interrelated. To visualize this, see figure 24.

a. In figure 24 the *height* of the triangle is shown by the dotted line so marked.

b. The Wire length in wavelengths indicated on the left leg is a measure which will be used for the design of any half-rhombic antenna. How to convert it to feet will be shown shortly.

c. The *tilt angle* β is of great importance to the design and must be correct for maximum antenna gain.

d. The *counterpoise* length is determined by the leg length and the angle β

24. SIZE OF HALF-RHOMBIC ANTENNA POWER GAIN AND WIDTH OF BEAM.

At any given frequency there are a number of half-rhombic sizes which may be used, varying from a minimum size at which the beam will work at a given frequency, to a large size limited only by the height of the support (balloon, kite, or pole), the weight of wire the support will carry, and the length of wire available. The larger the size at a given frequency, the sharper the beam produced and the more gain realized within that beam.

a. Various half-rhombic sizes are identified in engineering practice by referring to the number of electrical full wavelengths which lie on one of the vertically-supported triangle legs. For instance, the half-rhombic antenna shown in figure 24 would be identified by the number of full wavelengths which lie on the leg marked *wire length in wavelengths* at a given frequency. If there were two full wavelengths lying on this leg at 40 megacycles it would be referred to as a half-rhombic antenna with two full wavelengths on a leg at 40 megacycles. This, in fact, is Antenna Equipment RC-63.

b. Converting full wavelengths to feet is quickly done by the formula:

$$\text{Length of a full wavelength measured in feet} = \frac{984}{\text{Frequency in megacycles}}$$

c. The minimum size at which a half-rhombic antenna will perform satisfactorily is one having a single full wavelength on a leg, or side, at the average frequency at which it is to be operated.

25. HALF-RHOMBIC ANTENNA DESIGN (fig. 25).

From the chart (fig. 25) the triangular dimensions of any half-rhombic antenna may be quickly derived.

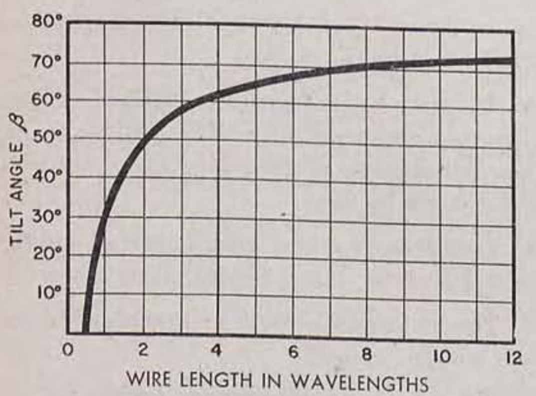


Figure 25. Half-rhombic antenna design chart showing tilt angle plotted against wire length of each triangle leg.

The tilt angle β (fig. 25) is plotted against the wire length measured in full wavelengths lying on an antenna triangle leg. For example, strong point-to-point ground wave communication is desired on 30 megacycles. As an expedient it has been decided to erect a half-rhombic antenna with two wavelengths on a leg at that frequency. Then:

$$\text{Length of a full wavelength measured in feet} = \frac{984}{30} = 32.8 \text{ feet}$$

Each vertically-supported leg of the antenna would then measure 32.8 x 2 (for two wavelengths) or 65.6 feet. From figure 25, the tilt angle β for an antenna with two wavelengths on a leg is shown as approximately 50°. As the tilt angle is exactly half the apex angle, the entire apex angle will be 100°. The correct counterpoise length will be that required to complete the triangle, simply determined by a method shown in the next paragraph.

26. TRIANGLE DIMENSIONS WITHOUT TRIGONOMETRY.

In the above paragraph, the two leg lengths and the apex angle were quickly derived. However, the height of the required supporting pole or mast and the exact counterpoise length were not obtained. To avoid trigonometric functions, the following table keys all dimensions of the antenna triangle to the length of a side. Note that each dimension is expressed in wavelengths at the desired frequency. This is readily converted to linear feet by the formula in paragraph 24. Using this method, any size half-rhombic antenna may be designed for any frequency by no more than multiplication.

Number of wavelengths on a triangle leg.	Tilt angle β	Height of the upper triangle apex from the counterpoise (pole height), measured in wavelengths at the operating frequency.	Entire counterpoise length measured in wavelengths at the operating frequency.
1	30°	0.87	1
2	50°	1.3	3
3	57°	1.6	5
4	62°	1.9	7
5	65°	2.1	9
6	67°	2.3	11
7	68°	2.6	13
8	70°	2.7	15
9	70.5°	3.0	17
10	71°	3.3	19
11	72°	3.4	21
12	73°	3.5	23

a. For example, the half-rhombic antenna using two wavelengths on a side at 30 megacycles was quickly found in paragraph 25 to have 65.6 feet on a leg. Glancing at the table, it can be seen that an antenna with two wavelengths on a leg has a tilt angle or 50°, the pole height required 1.3 wavelengths, and the over-all counterpoise length 3 wavelengths. Since the length of a wavelength at 30 megacycles was found to be 32.8 feet (by dividing the frequency in megacycles into 984), the height of the pole required will be 42.6 feet and the counterpoise length 98.4 feet.

b. Take another example. As a field expedient, a very powerful beam is required to operate at 20 megacycles. The sector to be covered will be narrow; therefore the beam may be sharp and provide high gain. Because balloon or kite support is available, the height of the antenna supporting structure presents little or no problem. It has therefore been decided to erect an antenna with 12 wavelengths on a leg. The table shows that an antenna with 12 wavelengths on each leg must have its apex 3.5 wavelengths above ground, and a counterpoise 23 wavelengths long. Dividing 984 by the frequency in megacycles, or 20, we quickly find that the length of a full wavelength at 20 megacycles is 49.2 feet. Each leg of the triangle will then be 590 feet, the apex supported at 172.2 feet from the ground, and the over-all counterpoise length 1,131.6 feet. The gain of this antenna will approximate 18 decibels or a signal voltage gain of 64 times that of a vertical whip.

c. Where the size of the antenna will be wholly governed by the height of the supporting pole, tree, or mast, calculations can be made using the tabular column showing required pole heights, so that the maximum size antenna (hence the greatest gain) may be designed for the available mast height. For example, a 60-foot palm tree may be available which appears to offer excellent half-rhombic antenna support. If the mean operating frequency to be used is 40 megacycles, dividing 984 by 40 shows a full wavelength to be 24.6 feet at that frequency. The table indicates that an antenna having two wavelengths on a leg requires a mast height of 1.3 wavelengths, or 31.9 feet. As the tree is far taller than 31.9, a larger antenna is possible, therefore the table is reexamined for an antenna having six wavelengths on a leg which, the table indicated, requires a pole height of 2.3 wavelengths or 56.5 easily possible with a 60 foot tree. Simple multiplication then shows the antenna will have 147.6 feet on each leg and 270.6 feet for its counterpoise. The beam produced by this antenna may be pointed in any direction simply by rotating the antenna around the tree.

d. Steel masts, or wooden masts using metal guy wires must never be used. The presence of metal support at the center of the antenna will disrupt its functioning.

27. TRANSMISSION LINE AND TERMINATING RESISTANCE.

a. Teminal Block TM-194 supplied with Antenna Equipment RC-63 may be used with any half-rhombic antenna employed with radio equipment having a low-power radio transmitter. With medium or high-power transmitters a 500-ohm resistor having higher wattage is required.

b. A two-wire parallel-line transmission line as outlined in section II paragraph 13 may be used. This transmission line must have a spacing of 2 to 2½ inches and the wires must be equally spaced. Any good insulator may be used or any good insulating material may be substituted when 2-inch insulators are not available.

28. SITES FOR HIGH-FREQUENCY OPERATION.

Where half-rhombic antennas are to be used for quasi-optical (line of sight), point-to-point work using frequencies above 20 megacycles, the antenna should be located on the highest possible ground for maximum effective range and signal strength. When so installed, the half-rhombic antenna is one of the most effective types of beam antennas for the propagation and reception of high-frequency, vertically-polarized signals. The use of this antenna will increase the distance obtained many times above that provided by a simple vertical dipole (half-wave antenna) at the same average height above ground.

29. BEAM WIDTH.

The width of the beam produced by half-rhombic antennas of various sizes are shown in figure 26. The widths are indicated within each angle and represent an average over varying terrain and soil conditions. They are drawn to half power; in other words, signals sent at any angle within the spread indicated will be more than half the maximum power of the beam.

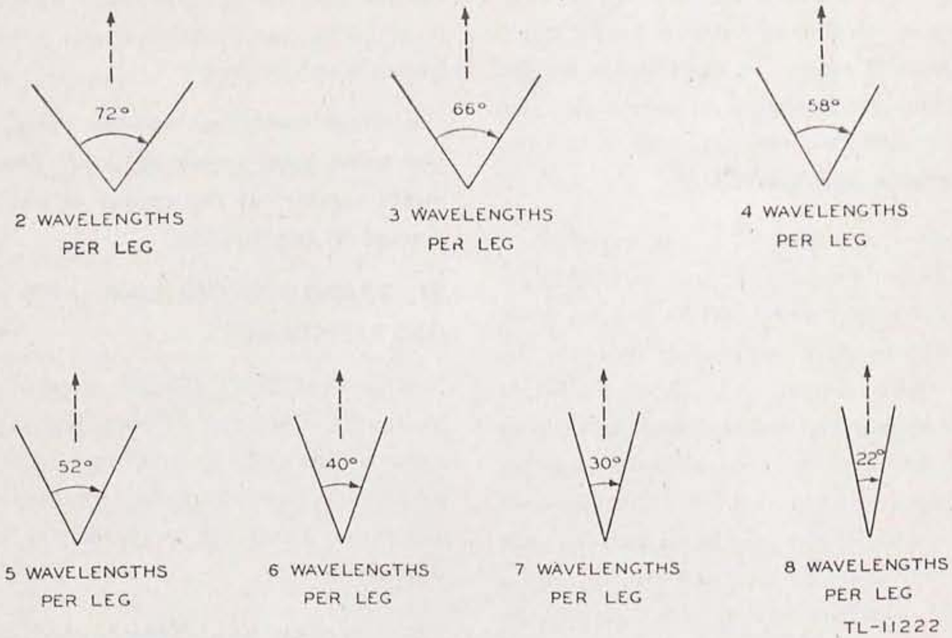


Figure 26. Approximate beam widths of various half-rhombic antenna sizes.

30. MAINTENANCE PARTS LIST FOR ANTENNA EQUIPMENT RC-63.

Ref. symbol	Signal Corps stock No.	Name of part and description	Quan. per unit	Mfrs. part and code No.	†Station stock	†Region stock
	2A276-63	ANTENNA EQUIPMENT RC-63: directional; in accordance with Spec. 71-1035; consists of: 1 Antenna AN-36, 1 Antenna AN-37; (includes Terminal Block TW-194), 1 Bag BG-93, 3 Guys GY-34, 1 Guy GY-35, 1 Hammer HM-1 (6Q49001), 1 Mast Section MS-91, 1 Mast Section MS-92, 1 Mast Section MS-93, 1 Mast Section MS-94, 3 Reels RL-3, 5 Stakes GP-2.	1			
	2A278-63.1	ANTENNA EQUIPMENT RC-63: (includes 2 Binding Posts TM-176 and 1 less Guy Reel RL-3 and 2 less Guy Reels GY-34); directional; in accordance with Spec. 71-1035; consisting of: 1 Antenna AN-36, 1 Antenna AN-37, (includes Terminal Block TM-194), 1 Bag BG-93, 1 Guy GY-34, 1 Guy GY-35, 1 Hammer HM-1, 1 Mast Section MS-91, 1 Mast Section MS-92, 1 Mast Section MS-93, 1 Mast Section MS-94, 2 Reels RL-3, 5 Stakes GP-2, 2 Binding Posts TM-176 (1 in use, 1 spare).	1			
	2A278-63.2	ANTENNA EQUIPMENT RC-63: includes 2 Binding Posts TM-176, less 1 Mast Section MS-91, less 1 Mast Section MS-92, less 1 Mast Section MS-93, less 1 Mast Section MS-94, and less 1 Reel RL-3; directional; in accordance with Spec. 71-1035; consisting of the following: 1 Antenna AN-36, 1 Antenna AN-37, (includes Terminal Block TM-194), 1 Bag BG-93, 3 Guys GY-34, 1 Guy GY-35, 1 Hammer HM-1 (6Q49001), 2 Reels RL-3 (2A3103), 5 Stakes GP-2 (2A3302), 2 Binding Posts TM-176, (1 in use; 1 spare).	1			
	2A278-63.3	ANTENNA EQUIPMENT RC-63: directional in accordance with Spec. 71-1035; consisting of: 1 Astenna AN-36, 1 Antenna AN-37, 1 Bag BG-93, 2 Binding Posts TM-176 (1 in use; 1 spare) (3Z276), 3 Guys GY-34, 1 Guy GY-35, 1 Hammer HM-1, 1 Mast Section MS-91, 1 Mast Section MS-92, 1 Mast Section MS-93, 1 Mast Section MS-94, 2 Reels RL-3, 5 Stakes GP-2, 1 Terminal Block TM-194.	1			

† Parts not stocked in station or region stock are carried in depot stock.
* Indicates stock available.