WHAT'S UP?

KNOW HOW TO REPAIR & FABRICATE ANTENNAS

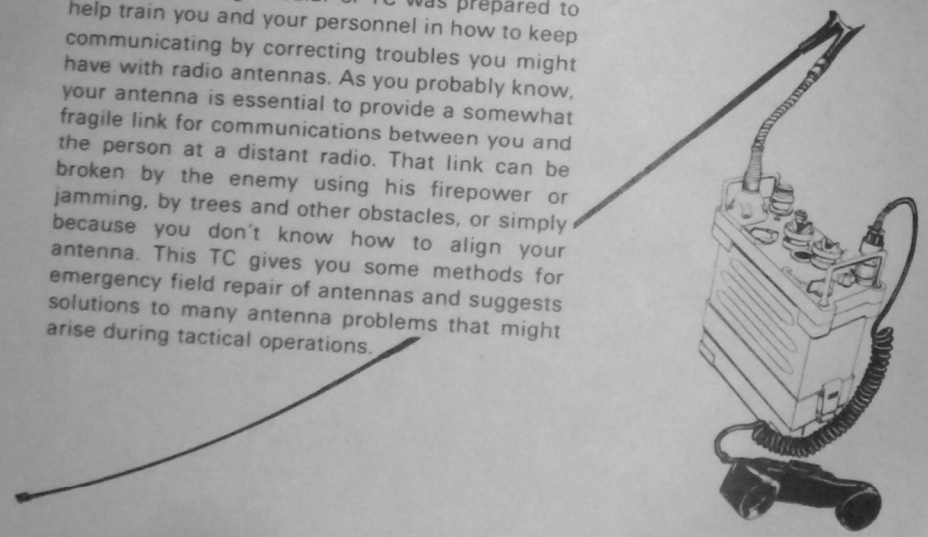


TC 11-5

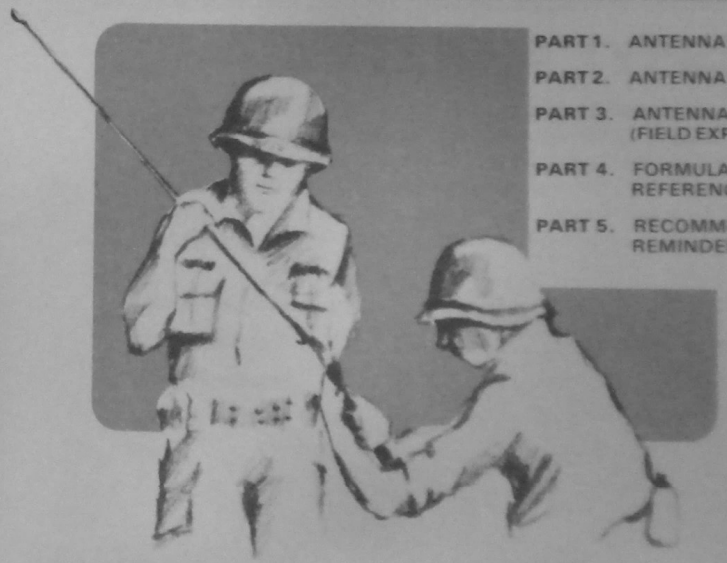
29 APRIL 1977

PREFACE

This training circular or TC was prepared to help train you and your personnel in how to keep communicating by correcting troubles you might have with radio antennas. As you probably know, your antenna is essential to provide a somewhat fragile link for communications between you and the person at a distant radio. That link can be broken by the enemy using his firepower or jamming, by trees and other obstacles, or simply because you don't know how to align your antenna. This TC gives you some methods for emergency field repair of antennas and suggests solutions to many antenna problems that might arise during tactical operations.



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PART 1

ANTENNA TYPES

When you need to communicate with someone, it is important that you know where that someone is located. Why? Because direction and distance are critical factors in determining how well you are able to communicate. You will have an antenna which falls into one of the three basic types and it will be based on its directional features. The three types of antennas are: Omnidirectional, Bidirectional, and Unidirectional.

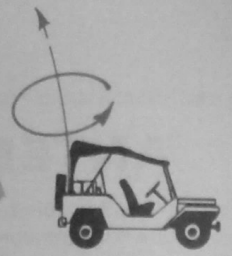
Omnidirectional ..... **All directions**

Bidirectional ..... **Any two opposite directions**

Unidirectional ..... **Any one direction**

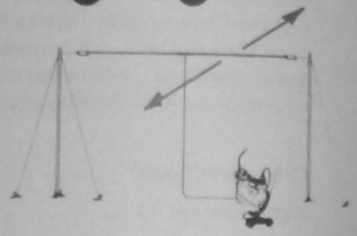
OMNI-
DIRECTIONAL

WHIP



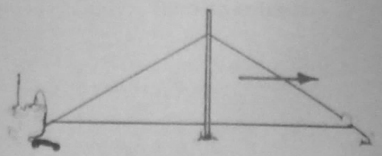
BI-
DIRECTIONAL

DOUBLET



UNI-
DIRECTIONAL

LONG WIRE



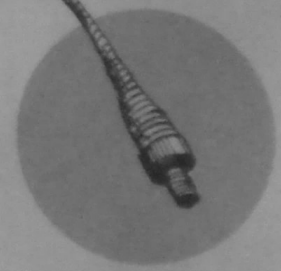
Each one of the three antennas has advantages and disadvantages. The omnidirectional or whip antenna enables you to communicate without worrying about the location of the receiving station, but it also makes you open to enemy radio direction finding. The bidirectional or doublet antenna allows you to communicate with two or more stations in opposite directions, but you must be sure that the antennas at these stations are parallel to yours. The doublet should be positioned at 90 degrees to the enemy lines to reduce the possibility of his intercepting your communications. A terminated long-wire antenna is unidirectional and is the least open to enemy interception if it can be positioned properly. Its disadvantage is that you can transmit and receive best in only one direction.

One other fact that you should remember is that the radio waves it transmits are affected by whether the antenna is vertical or horizontal to the ground. Waves from a vertical antenna are vertically polarized. Waves from a horizontal antenna are horizontally polarized. So make sure that your antenna and the antenna at the distant station are either both horizontal or both vertical: a horizontal antenna receives from a horizontal and a vertical from a vertical.

NOTES:

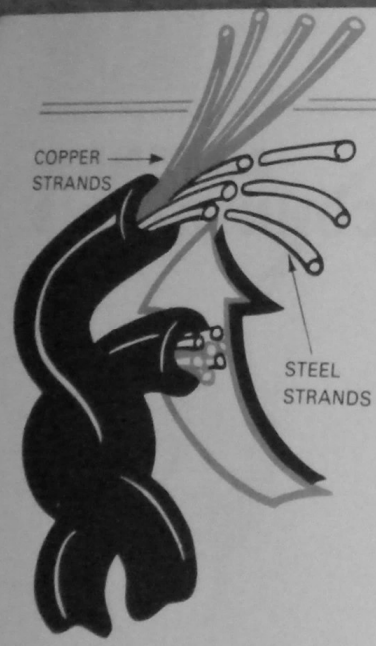
PART 2

ANTENNA CONNECTIONS



Of all the antennas used in the Army, the whip antenna is the most common. It is omnidirectional and can be used to communicate while you are on the move. The RC-292 antenna takes a little time to set up, but it gives out a stronger signal than your vehicular-mounted whip, and it is omnidirectional. Bidirectional and unidirectional antennas are somewhat more difficult to construct and align, but the security factor you gain from being less open to the enemy is well worth the effort. However, none of these antennas are worth much if you don't have a good connection. So make sure the antenna lead connections are clean and free of corrosion.

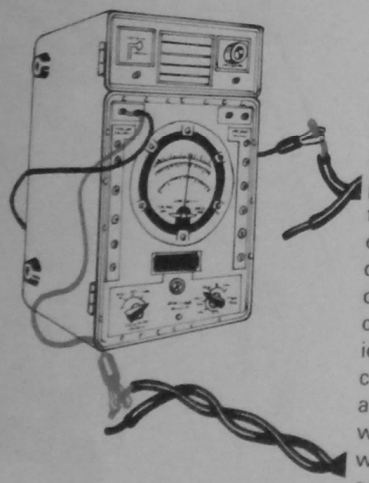
USING WD-1



Here's an important "know-how" item if you're rigging an antenna lead-in using WD-1, which is a pair of twisted wires. Since a good electrical connection is a must, remove an inch or two of insulation from the ends of the wires. Separate the three steel strands from the four copper strands in each wire and cut the steel strands off at the insulation. Twist the four copper strands of each wire together. Connect the ends of the wires to the antenna and to the radio, and you have a usable antenna lead-in. For some antennas such as the ground plane, the wire connected to the vertical element (inner part of a receptacle on the antenna) must connect to the inner part of the antenna receptacle or to an antenna terminal on the radio set. The other wire must connect to the outer shell of the antenna receptacles. Usually you can loosen one of the screws on the receptacle shells and connect the wire at those points. To tell which wire of the twisted pair is which, use one of the methods shown and described on the next two pages.

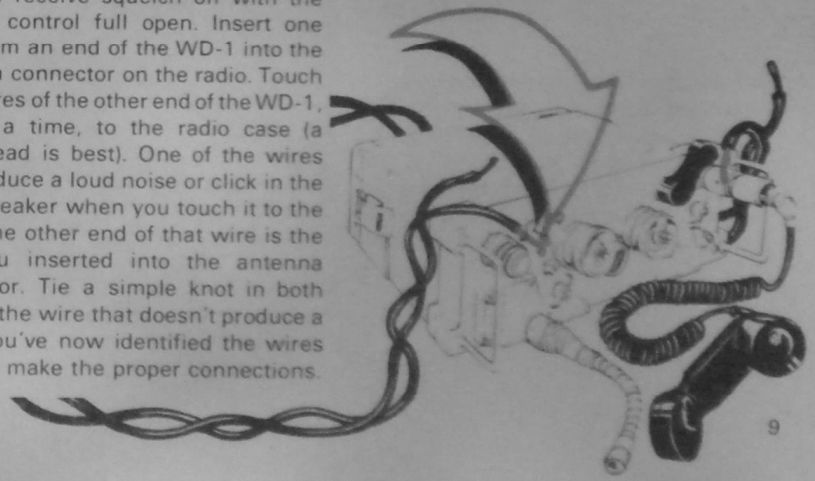


CHECK OF WD-1 CONDUCTIVITY



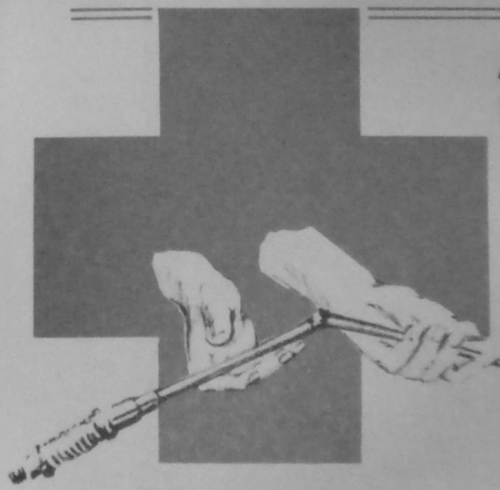
If you have a multimeter, you can identify the wires in WD-1. You can also check to make sure there are no hidden breaks or shorts in the wires. Strip an inch of insulation from all four ends of the WD-1. Make sure your multimeter is set to measure ohms. Touch or clip one end of a wire with a multimeter probe. Then with the second probe, touch the opposite ends of the WD-1, one at a time. You'll get a full-scale deflection ohmmeter reading from one of the wires. Tie a loose knot in each end of the wire to identify it. You have now identified the wires and can make the correct antenna hookup. If you fail to get a full-scale deflection reading on either wire, make sure your ohmmeter is working. Then get another piece of wire and start over.

If you don't have a multimeter, strip an inch of insulation from the two wires at each end of the WD-1. Operate the radio to receive squelch off with the volume control full open. Insert one wire from an end of the WD-1 into the antenna connector on the radio. Touch both wires of the other end of the WD-1, one at a time, to the radio case (a screwhead is best). One of the wires will produce a loud noise or click in the radio speaker when you touch it to the case. The other end of that wire is the one you inserted into the antenna connector. Tie a simple knot in both ends of the wire that doesn't produce a click. You've now identified the wires and can make the proper connections.



NOTES:

PART 3



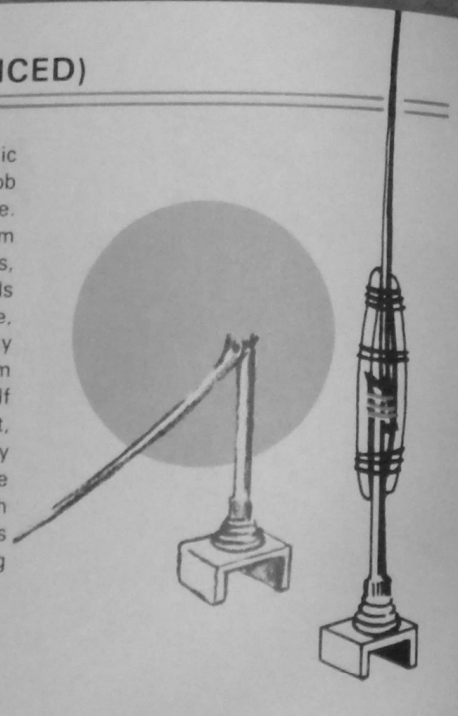
ANTENNA FIRST AID!

(FIELD EXPEDIENT)

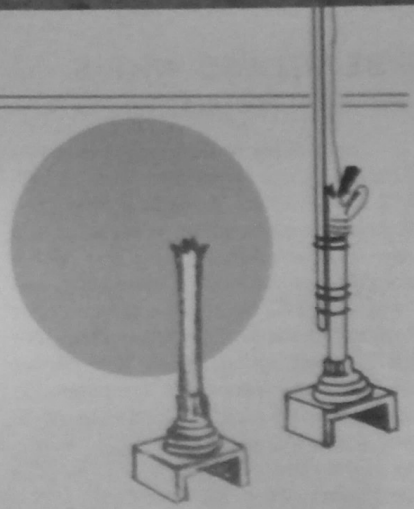
Probably the biggest headache the commander has is his radiotelephone operator (RTO) saying "It broke" or "I lost it" when asked what happened to the antenna. The next few pages of this TC will show and tell how to repair the antenna or to make a field expedient antenna, if necessary.

METALLIC WHIPS (SPLICED)

Take a common case—a metallic whip broken into two pieces. A splint job is the quickest repair you can make. Scrape off the paint 3 to 6 inches from the broken ends. Use sand, rocks, metal, or a knife to scrape the ends clean. Take about 1 foot of copper wire, stripped WD-1 if you have it. Overlay the cleaned ends and wrap them together tightly with the copper wire. If you have the time and equipment, solder the connection. Then place a dry stick, pole, or branch on each side of the break and wrap the splint tightly with WD-1, rope, tape, or whatever is available. If everything else is working right, you're ready to communicate.

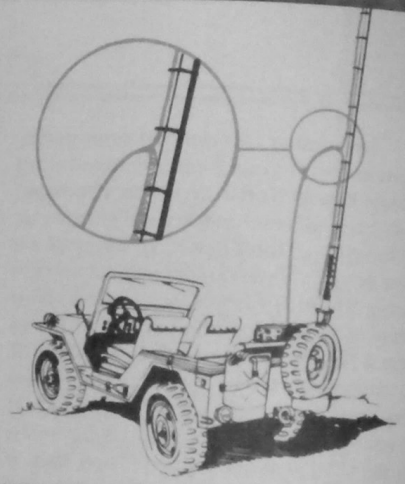


In combat, a common emergency would be for your 9-foot whip antenna to get knocked off in an artillery barrage. Let's say all you have left is a stub about 1 foot long. Don't panic. To get back on the air, you'll need a pole about 10 feet long, about 9 feet of WD-1, and some tape. First, scrape off the paint from the top 2 inches of the whip's stub. Wrap 12 inches of bare wire around the scraped portion of the stub. Wrap it tight, pass it over the top of the stub, and jam it in the hole with a wooden peg. Tape this, if you can, to hold it securely. Now, take the 10-foot pole and tie it tightly to the antenna base and stub. Attach the WD-1 along the length of pole with tape. The total length of the upright WD-1 and antenna stub should not be more than 9 feet. Trim away any extra wire and you're ready to communicate. Move slowly! This makeshift mast will not withstand abuse like the original, but it will serve you well in an emergency.



FIBERGLASS WHIPS

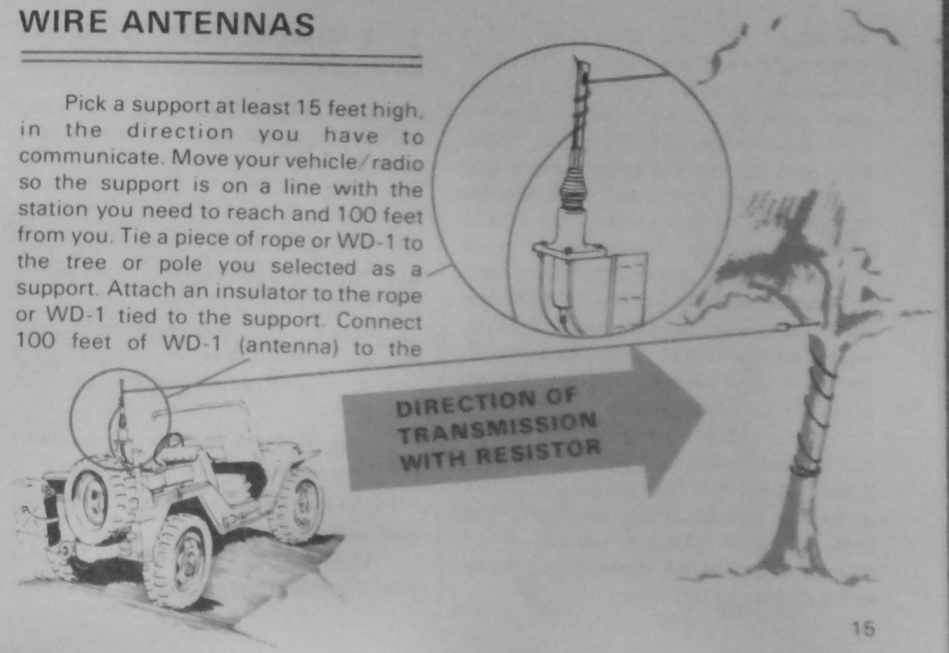
The makeshift whip you see in this illustration is a replacement for an AT-912 or AS-1729 fiberglass whip. You can't splint a fiberglass whip, so here's how you can make a quick fix. Take a length of coaxial cable, 15 feet long, and measure off 5 feet of it. Strip the rubber sleeve from the 5-foot section. Separate the braided shield from the center conductor as described on page 33. Lash a dry, 10-foot pole to the antenna base. Tape the center conductor to the top of the pole and the braided shield to the bottom. Tape the stripped coax at several more places along the pole so it will stay in place. If there's a BNC (twist lock type) connector on the coax, attach it to the radio. If not, wedge the center conductor firmly into the antenna



connector and attach the braided shield to a screwhead on the radio case. It may not be the best system, but it will work. Remember, it's only a temporary solution, so replace it the first chance you get.

WIRE ANTENNAS

Pick a support at least 15 feet high, in the direction you have to communicate. Move your vehicle/radio so the support is on a line with the station you need to reach and 100 feet from you. Tie a piece of rope or WD-1 to the tree or pole you selected as a support. Attach an insulator to the rope or WD-1 tied to the support. Connect 100 feet of WD-1 (antenna) to the



insulator. Pull the slack out of the antenna. Wrap the other end of the WD-1 around the lower part of the broken whip to secure it and connect it to the ANT (connector) on the radio. Make sure you remove the control cable and antenna cable connected between the matching unit and radio. Now you're ready to operate. Remember to point your antenna in the right direction and keep in mind that you should not tie the antenna close to the tree's foliage. Remember also that you have converted the original omnidirectional antenna into a bidirectional antenna.

Note that what you have constructed has a long piece of wire as a replacement for the whip. Long-wire antennas are discussed on page 23 of this circular. Don't expect good transmission in all directions off the sides of this antenna.

1/4-WAVE VERTICAL

Now let's put up a quarter-wave vertical antenna. Quarter-waves may also be used to replace regular whip antennas.

Step 1. Using the quick reference chart on page 40 or the formula for a quarter-wave, determine the length of the wire (WD-1) you need.

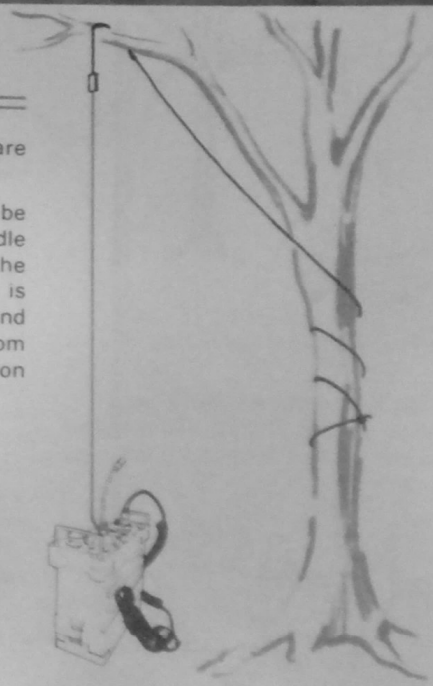
Step 2. Attach an insulator to one end and insert the other end (stripped) into the antenna connector on your radio.

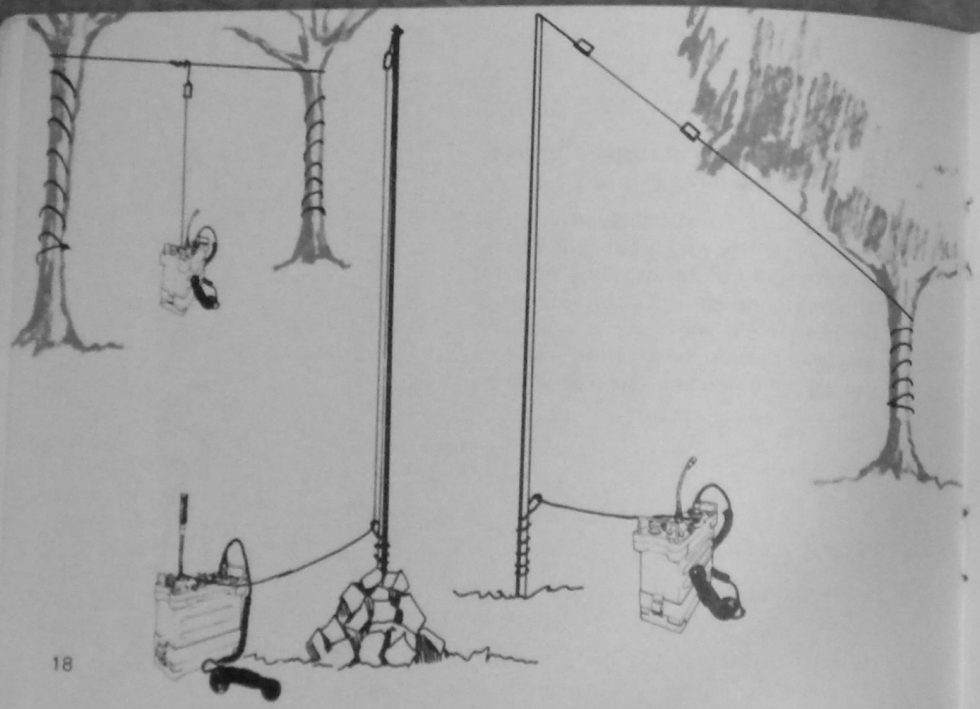
Step 3. Tie a rope to the insulator end and throw the rope over a limb.

Step 4. Pull it up until it's vertical and you're ready to go.

The verticals on page 18 are constructed the same way, but each has a different means of support. They are all simple and quick to erect.

If you're using insulated wire, be sure to loop the wire around the handle of the radio before attaching it to the antenna connector. If your antenna is made of bare wire, use a stake and insulator to keep the antenna wire from pulling out of the antenna connector on the radio.





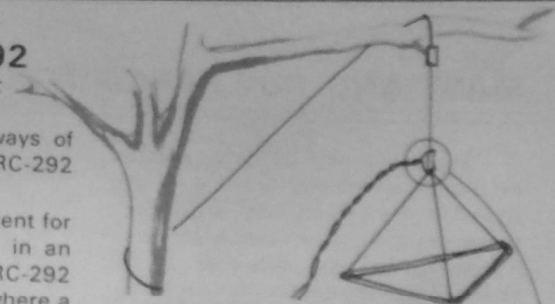
IMPROVISED RC-292

Now let's look at some ways of replacing and repairing your RC-292 antenna.

We'll start with a replacement for the RC-292 that you can use in an emergency. This improvised RC-292 can be used in wooded areas where a tree limb can be used to raise the antenna.

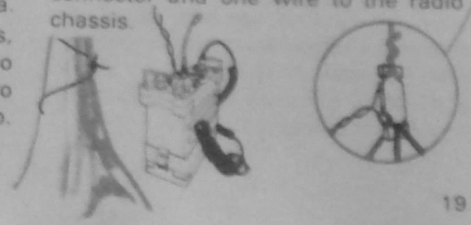
Step 1. Using the quick reference chart on page 40 (or the formula, if you know it) to determine the length, cut all four wires for a quarter-wave antenna.

Step 2. You'll need two insulators, one to separate the vertical element, so you can attach a rope with a rock tied to it, to aid in throwing it over a tree limb.



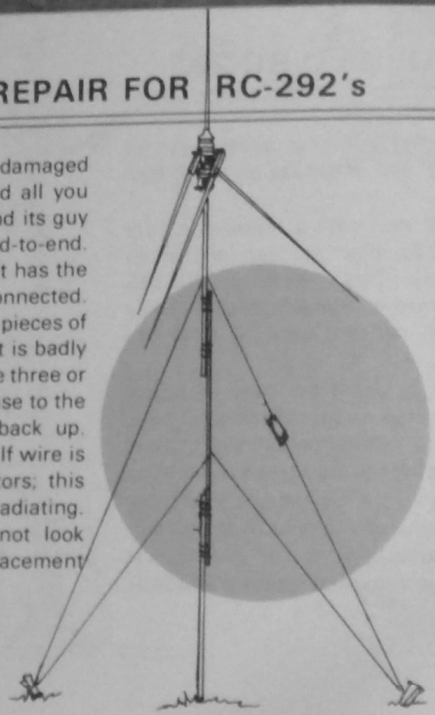
Step 3. Connect the WD-1 as shown, before you pull the antenna up in the air.

Step 4. At the radio, connect one wire of the WD-1 to the antenna connector and one wire to the radio chassis.



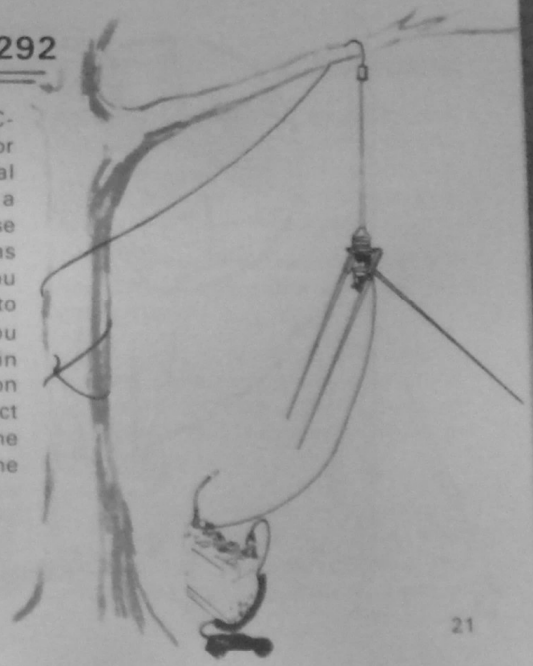
MAST AND GUY REPAIR FOR RC-292's

Suppose your RC-292 is damaged by mortar or artillery fire and all you have left is a broken mast and its guy ropes. Lay the broken mast end-to-end. If possible, save the piece that has the stub to which the antenna is connected. Using a sturdy pole, splint the pieces of the mast together. If the mast is badly damaged, you may have to use three or four poles. Tie the antenna base to the top of the pole and put it back up. Replace the guy rope or wire. If wire is used, be sure to use insulators; this prevents the guy wires from radiating. The repaired antenna may not look good, but it will work until replacement equipment can be obtained.

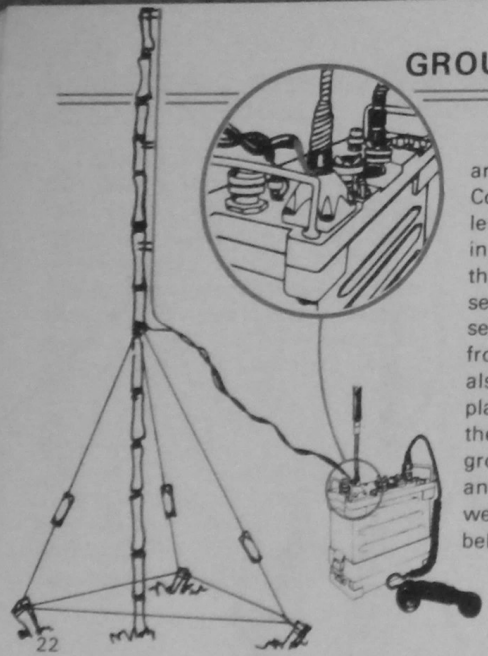


TREE SUPPORTED RC-292

This ground plane is a regular RC-292 antenna radio without a mast or guys. Attach an insulator to the vertical element, add a piece of rope, tie on a weight, and throw the rope over a close tree limb. Pull the antenna up as high as possible. With this arrangement, you can raise and lower the antenna to change element lengths each time you change frequency. The coaxial lead-in attaches to the antenna connector on your radio as before. If you expect strong winds, add a rope from the bottom of the head to a stake in the ground below.



GROUND-PLANE ANTENNA



Here is a ground-plane antenna for areas with no trees or mast substitutes. Compute and cut the four quarter-wave length wires. You can use a single pole in the middle to support the whole thing. The ground-plane elements serve as the guy wires. Use insulators to separate the ground-plane elements from ground. The vertical element must also be insulated from the ground planes. Connect the vertical element to the output terminal of the radio and the ground planes to the radio ground. This antenna will work, but not nearly as well as one up in the air where it belongs.

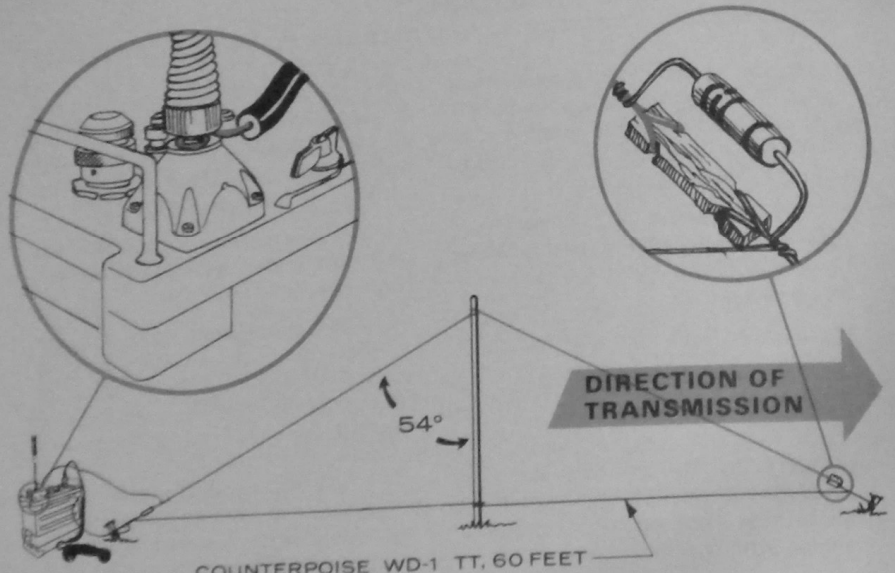
VERTICAL HALF RHOMBIC

If you need more distance and directivity than your whip antenna will give you, try making a vertical half-rhombic (VHR) antenna. It's simpler than it sounds. Here's how!

Step 1. Determine the direction of the station you need to reach and line up your antenna. Plan all your work in that direction.

Step 2. Build your antenna.

- Cut 100 feet of wire for the antenna itself.
- Cut 91 feet of wire for a counterpoise. This is a wire stretched across the bottom of the antenna. It is an artificial ground which helps to produce the required radiation pattern.
- Connect an insulator to each end of the antenna wire and one at the middle as shown in the blowups. Add a tiedown wire outside the insulators on each end of the antenna wire.
- Connect the counterpoise to the insulators at the same point as the tiedown wire.
- Select or erect a middle support (a tree, pole, or a wire or rope suspended between two trees or structures). The midpoint must be at least 30 feet high.
- Stretch the counterpoise out in the direction of the target station with the middle of the counterpoise at the center support. Drive stakes in by each



tiedown wire, stretch the counterpoise tight and tie it to the stake. Elevate the center of the antenna until it's tight.

▫ Run a wire from the antenna terminal and connect it to the antenna above the insulator. Run a second wire from a screwhead on your radio case to the bottom of the insulator.

▫ A 600-ohm, 2-watt carbon resistor placed at the end toward the desired station will make this antenna transmit toward the desired station only. Make sure the resistor is carbon and not wire wound. A 2-watt resistor will work for the AN/PRC-77, but a resistor with a wattage rating of half the power output is needed for the higher power radios.

▫ This antenna can be used without the counterpoise, but it won't work as well as it does with the counterpoise.

▫ In a nutshell: When you really have a distance problem, build a VHR. It looks complicated, but it's fairly easy to build. With practice, you can erect one in a few minutes.

BIDIRECTIONAL HF DOUBLET

This antenna will replace your doublet when necessary. You'll need these items:

- ☐ Two supports, 19 to 30 feet high.
- ☐ Wire, any type that's long enough.
- ☐ Rope or wire for halyards.
- ☐ Three insulators.
- ☐ A water can or similar heavy object.

Now build it!

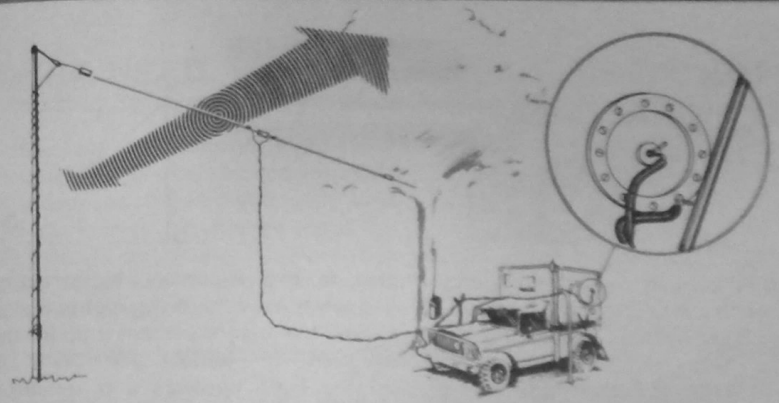
Step 1. Cut the wire to your operating frequency. Use the chart or formula to compute the length needed for a half-wave antenna.

Step 2. Determine the direction of transmission, because the doublet antenna is bidirectional and shoots straight out from both sides of the wire. Note that this is exactly opposite from the long-wire or half-rhombic which are directional off the ends of the wire.

Step 3. Cut the wire in half and put an insulator on each of the ends and one in the center between the two middle ends.

Step 4. Position and erect the two supports. Be certain they are 3 or 4 feet farther apart than the antenna's actual length, and broadside to the direction of communication.

Step 5. Attach your WD-1 lead-in to both sides of the center insulator. Be sure it is long enough to drop nearly to



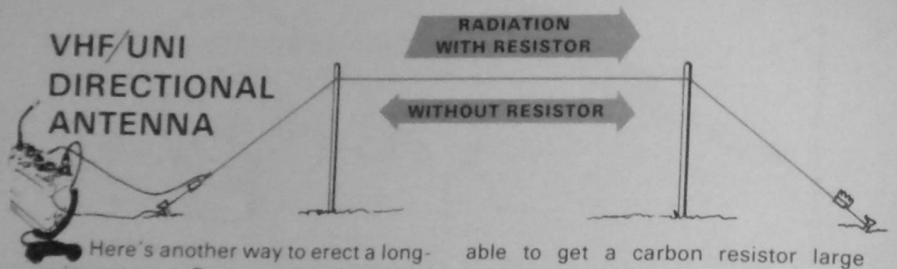
the ground and then to your radio's position.

Step 6. Tie ropes or wires to the two end insulators. Then, using whatever method is easiest, hang the antenna up between the supports and keep it as taut as possible.

Step 7. Connect the lead-in end to your radio and you are in business.

In this example, we've used a tree to support one end of the antenna and used a counterweight. The counterweight is tied to the tree-end halyard and prevents the antenna from breaking in case of high winds blowing the support tree.

VHF/UNI DIRECTIONAL ANTENNA



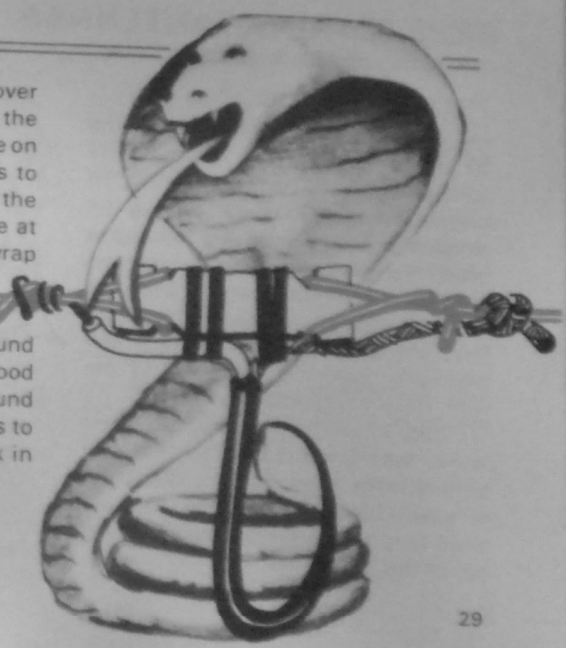
Here's another way to erect a long-wire antenna. Be sure not to forget the basics. The overall length of the antenna wire must be 3 to 7 wavelengths of the operating frequency. Use the quick reference chart or formula to get the correct wire length for the frequency on which you are operating. This antenna is unidirectional for low power VHF, if you use the 500- to 600-ohm, 2-watt carbon resistor. However, it is bidirectional for high power VHF and HF, because in the field you won't be able to get a carbon resistor large enough to terminate the higher power radios. Make sure you set it up for the direction in which you want to communicate because it is definitely not omnidirectional.

Erect the antenna as shown in the illustration. You'll have to use some side guys on the 9- to 10-foot poles to hold them up firmly.

Try it! You'll find that you can communicate over longer distances in either one or two directions.

COBRA HEAD

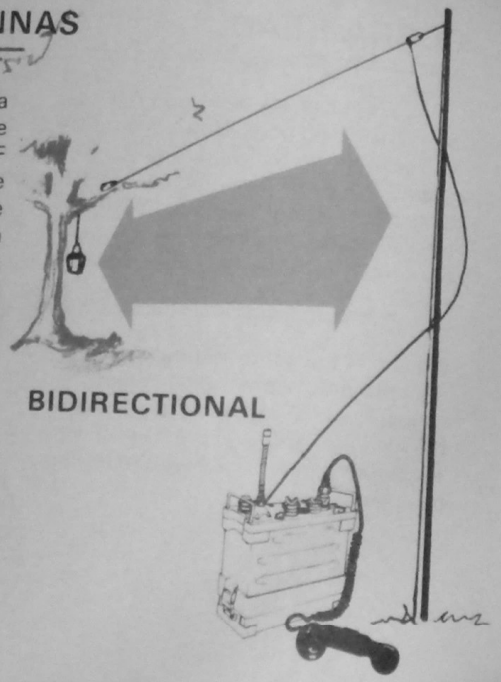
So, your cobra head was run over by a tank! Don't panic. You can strip the end of your coax the way we describe on page 33. Fasten the antenna wires to both sides of any insulator. Wrap the braided shield end around one wire at the center insulator tie point Now wrap the end of the center conductor around the wire on the other side. Make good connections. Wrap some tape around the insulator and over the coax ends to hold it all together, and you're back in business.



BIDIRECTIONAL ANTENNAS

This 100-foot, long-wire antenna will work when you are operating in the 30 to 80 MHz frequency range. For HF operation, the antenna wire must be longer. This antenna will improve the range of your radio in the directions in which the wire is stretched. Remember, unterminated long-wires are not unidirectional; they are bidirectional. They are most effective along a line extending from the two ends of the wire. Here's how it works.

Step 1. Erect a pole or select a tree in line with the direction you want to communicate. The antenna should be at least 20 feet high. If you use a tree, make sure the antenna does not touch any of the branches.



BIDIRECTIONAL

Step 2. Tie the rope to the pole or tree. While holding the other end of the antenna wire, pace off 100 feet away from the direction in which you want to communicate. Tie an insulator to the end of the wire.

Step 3. Prepare a mast or pole for the second support. To make a substitute pulley, tie a length of WD-1 or nylon rope to the top of the mast. Leave a good firm loop hanging there.

Step 4. Put a rope or wire halyard through the loop and attach it to the other side of the insulator. Leave enough rope to pull up the antenna once the mast is erected.

Step 5. Attach 25 feet of WD-1 to the antenna side of the insulator. Make a good electrical connection because this is the antenna lead-in.

Step 6. Put up the second support about 6 feet beyond the end of the 100-foot antenna. This allows for the insulators at each end.

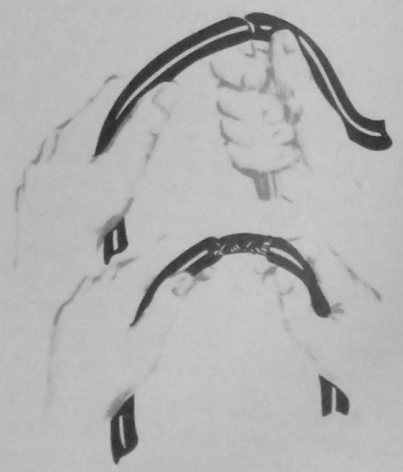
Step 7. Guy both sides of the antenna. Naturally you won't have to guy the tree, but the pole you put up will require a back guy, because stretching the antenna puts considerable strain on it.

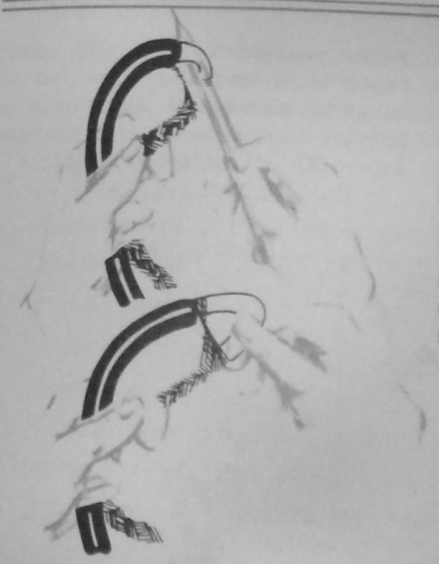
Step 8. Pull on the halyard until the antenna is level, then tie the halyard to the supporting pole.

Step 9. Connect the WD-1 lead-in to your radio and you're ready to communicate.

COAX CABLE ANTENNAS

If you've got to replace your doublet but don't have any wire, try a long piece of coaxial cable. Here's how to do it. Determine the length of the antenna you need by using the formula or the quick reference chart on pages 40 and 41. For example, if you need a 30-foot antenna, measure 15 feet of coax and mark the spot. Using a knife or sharp object, carefully cut through the outer insulation; DON'T cut into the braided shield. After you cut it evenly all the way around, pull off the insulation leaving the braided shield exposed.

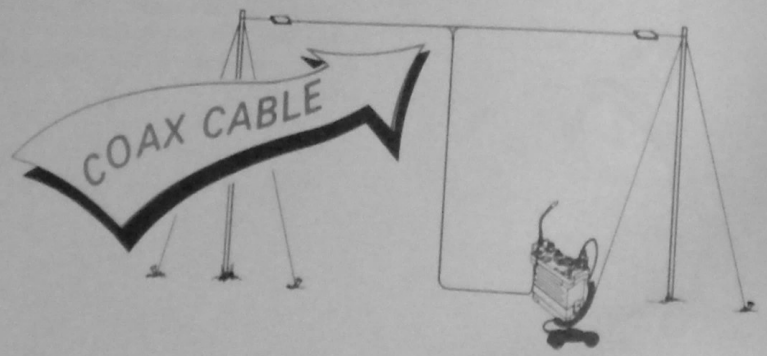




Bend the coax in a loop and hold it in one hand. Using a nail or pencil, carefully separate the braided shield from the insulated center conductor. Now, gradually work the pencil in between the coax and the center conductor as shown. Keep the loop formed and stick a finger in the hole you made with the pencil. Slowly pull the center conductor out of the braided shield.

COAX CABLE DOUBLET

In this illustration, you see an antenna consisting of 15 feet of braided shield and 15 feet of insulated center conductor. Both are firmly attached to the remainder of the coax which is your lead-in cable. All you need to do now is tie an insulator on each end, attach ropes, find something to use as supports, and put it up as taut as possible accross the top. Now you have a good 30-foot doublet antenna.

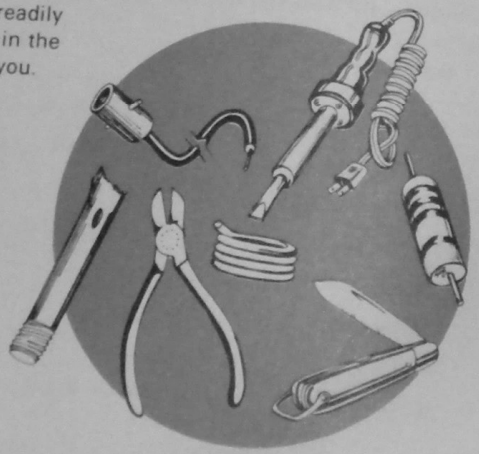


FIELD EXPEDIENT ITEMS

On the previous pages you've read about antenna types, antenna connections, and making antennas. Here are some field expedient items that might help you get the job done in an emergency.

Original issue	Field expedient
Antenna wire	WD-1, barbed wire, electrical wire, coaxial cable
Antenna mast	Trees, sticks, lance pole, telephone pole
Coaxial cable	WD-1, electrical wire
Antenna guy rope	Wire, cloth belts
Guy stakes	Rocks, vehicles, trees, tent pins
Whip antenna	Wire, WD-1, coaxial cable
Pulleys	Wire, nylon rope
Insulators	Plastic rings, spoons, and bags, wood, rope, rags and bottles.

Also, there are a few items that you may want to have available to help you out of a tight situation. In garrison or base camp, these items are readily available. You won't have them in the field unless you take them with you.

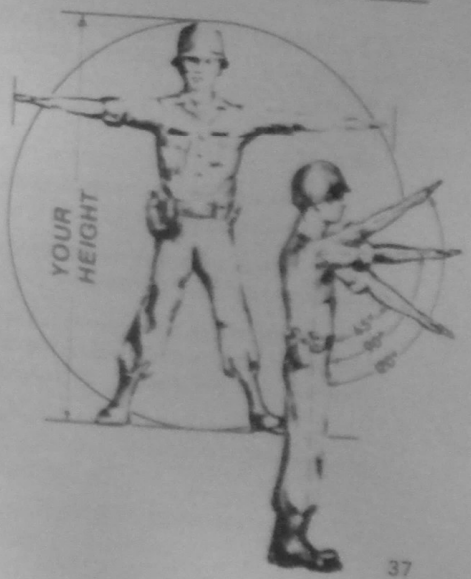


MEASURING LENGTHS AND ANGLES

Everyone who puts up an antenna soon learns that angles and measurements are important.

Lengths: How do you measure something without a tape measure? Use things right around you. Your own height, for example, is a constantly available tape measure of sorts. Did you know that your arm spread equals your height or very close to it? How about your boot size or waist size?

Angles: What about angles? If you have to, try this method. At least you'll be close and that's what counts if it puts you back on the air.



ANTENNA FIRST AID RULES

Medical first aid is intended to do the job until you can see a doctor. The same principle applies to first aid on antennas. Quick work on your antenna helps get your radio back on the air so you can communicate until you can replace the patched up antenna.

RULES:

□ When splicing or splinting a wire or whip antenna, the conductors must be free of paint and dirt.

□ When replacing wire or whips with field wire, the physical length must be the same as the wire or whip you are replacing.

□ When replacing guy ropes with wire, you must separate (insulate) the wire from the mast using any of the expedient insulators. This keeps the guy wire from acting as an antenna.

□ Use dry sticks or poles for splicing. Wet ones can really weaken your signal.

PART 4

FORMULAS AND QUICK REFERENCE CHARTS

You can determine the length of the antenna you need by using the proper formula below or the proper quick reference chart on the next two pages.

□ To figure a quarter-wavelength antenna in feet:
Divide 234 (constant) by your operating frequency in MHz
example: 234 ÷ 44.8 = 5.22 or 5'2"

□ To figure a half-wavelength antenna in feet:
Divide 468 (constant) by your operating frequency in MHz.
example: 468 ÷ 56 = 8.36 or 8'5"

□ To figure a full-wavelength antenna in feet:
Divide 936 (constant) by your operating frequency in MHz.
example: 936 ÷ 45 = 20.8 or 20'10"

□ To convert feet to meters, multiply by .3048 (constant).
example: 110 feet X .3048 = 33.5 meters

□ To convert meters to feet multiply by 3.28 (constant)
example: 100 meters X 3.28 = 328 feet

QUICK REFERENCE CHART

High Frequency (HF) Antenna Length in Feet & Inches

OP Freq in MHz	1/4 Wave	1/2 Wave	1 Wave
2	117′	234′	468′
3	78′	156′	312′
4	58′6″	117′	234′
5	46′9″	93′7″	187′4″
6	39′	78′	156′
7	33′5″	66′10″	136′8″
8	29′3″	58′6″	117′
9	26′	52′	104′
10	23′5″	46′10″	93′8″
11	21′3″	42′6″	85′
12	19′6″	39′	78′
13	18′	36′	72′
14	16′9″	33′5″	66′10″
15	15′7″	31′2″	62′4″
16	14′7″	29′2″	58′4″
17	13′9″	27′6″	55′
18	13′	26′	52′

QUICK REFERENCE CHART

Very High Frequency (VHF) Antenna Length in Feet & Inches

OP Freq in MHz	1/4 Wave	1/2 Wave	1 Wave
30	7′10″	15′7″	31′2″
33	7′1″	14′2″	28′4″
35	6′9″	13′5″	26′10″
37	6′4″	12′7″	25′2″
40	5′10″	11′8″	23′4″
43	5′5″	10′10″	21′8″
45	5′3″	10′5″	20′10″
48	4′10″	9′8″	19′4″
50	4′9″	9′5″	18′10″
55	4′3″	8′6″	17′
57	4′1″	8′2″	16′4″
60	3′11″	7′10″	15′8″
65	3′7″	7′2″	14′4″
68	3′5″	6′10″	13′8″
70	3′4″	6′7″	13′2″
75	3′1″	6′2″	12′4″
80	3′	5′11″	11′10″

NOTES:

PART 5

RECOMMENDATIONS AND REMINDERS

Don't forget our purpose in preparing this curcular-providing facts, know-how, and what-alls to help you out of a tough spot. There are lots of fancy antennas that can be constructed. If you'd care to become an expert, we recommend the following reading material.

TM 11-666 Antennas and Radio Propagation

FM 24-18 Field Radio Techniques

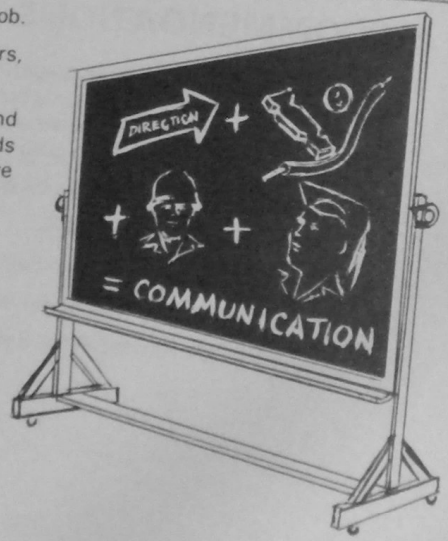
FM 24-21 Tactical Multichannel Radio Communications Techniques

FM 31-20 Special Forces Operational Techniques

FM 31-73 Advisor Handbook For Stability Operations

REMEMBER!

- ☐ Use the right antenna for the job.
- ☐ Use directional rules, insulators, wires, guys, and grounds properly.
- ☐ Use good GI common sense and practical application of the methods given in this circular and you'll improve your communications.



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THANKS.

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General, United States Army
Chief of Staff

Official:

PAUL T. SMITH
Major General, United States Army
The Adjutant General

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