Antenna Construction

THE USE of good materials in the antenna system is important since the antenna is exposed to wind and weather. To keep electrical losses low, the wires in the antenna and feeder system must have good conductivity and the insulators must have low dielectric loss and surface leakage, particularly when wet.

For short antennas, No. 14 gauge hard-drawn enameled copper wire is a satisfactory conductor. For long antennas and directive arrays, No. 14 or No. 12 enameled copper-clad steel wire should be used. It is best to make feeders of ordinary soft-drawn No. 14 or No. 12 enameled copper wire, since hard-drawn or copper-clad steel wire is difficult to handle unless it is under considerable tension at all times. The wires should be all in one piece; where a joint cannot be avoided, it should be carefully soldered.

In building a resonant two-wire feeder, the spacer insulation should be of as good quality as in the antenna insulators proper. For this reason, good ceramic spacers are advisable. Wooden dowels boiled in paraffin may be used with untuned lines, but their use is not recommended for tuned lines. The wooden dowels can be attached to the feeder wires by drilling small holes and binding them to the feeders with wire.

The ends of tuned feeders or the ends of the antenna are points of maximum voltage. It is at these points that the insulation is most important, and Pyrex glass, Isolantite or steatite insulators with long leakage paths are recommended. Glazed porcelain also is satisfactory. Insulators should be cleaned once or twice a year, especially if they are subjected to much smoke and soot.

In most cases poles or masts are desirable to lift the antenna clear of surrounding buildings, although in some locations the antenna will be sufficiently in the clear when strung from one chimney to another or from a chimney to a tree. Small trees usually are not satisfactory as points of suspension for the antenna because of their movement in windy weather. If the antenna is strung from a point near the center of the trunk of a large tree, this difficulty is not so serious. Where the antenna wire must be strung from one of the smaller branches, it is best to tie a pulley firmly to the branch and run a rope through the pulley to the antenna, with the other end of the rope attached to a counterweight near the ground. The counterweight will keep the tension on the antenna wire reasonably constant even when the branches sway or the rope tightens and stretches with varying climatic conditions.

"A"-Frame Mast

The simple and inexpensive mast shown in Fig. 1701 is satisfactory for heights up to 35 or 40 feet. The materials required are the 2 × 2-inch lumber, five ¼-inch carriage bolts 5½ inches long (with washers), a few spikes, about 300 feet of No. 12 galvanized iron wire, and several small strain insulators. The latter are used every 10 to 12 feet to break the guy wires into sections. Clear, sound lumber should be selected. The completed mast may be protected by two or three coats of house paint.

If the mast is to be erected on the ground, a couple of stakes should be driven to keep the bottom from slipping and it may then be "walked up" by a pair of helpers. If it is to go on a roof, first stand it up against the side of the building and then hoist it from the roof, keeping it vertical. The whole assembly is light enough for two men to perform the complete operation — lifting the mast, carrying it to its permanent berth and fastening the guys — with the mast vertical all the while. It is entirely practicable, therefore, to erect this type of mast on any small, flat area of roof.

By using 2 × 3s or 2 × 4s, the height may be extended up to about 50 feet. The 2 × 2 is too flexible to be satisfactory at such heights.

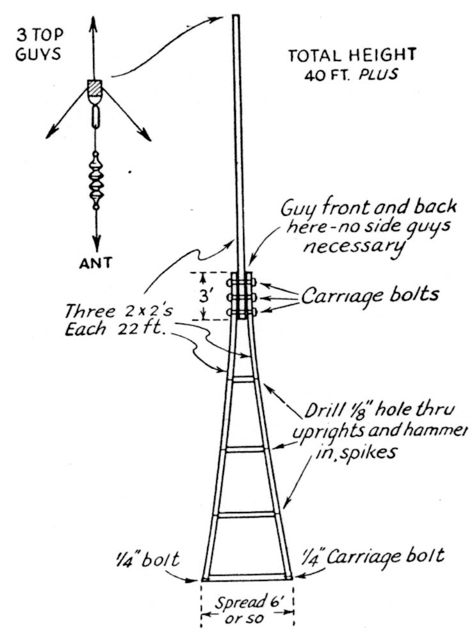

Fig. 1701 — Details of a simple 40-foot "A"-frame mast suitable for erection in locations where space is limited.

Simple Mast

The mast shown in Fig. 1702 is relatively strong, easy to construct, readily dismantled, and costs very little. Like the "A" frame, it is suitable for heights of the order of 40 feet.

The top section is a single 2 × 3, bolted at the bottom between a pair of 2 × 3s with an overlap of about two feet. The lower section thus has two legs spaced the width of the narrow side of a 2 × 3. At the bottom the two legs are bolted to a length of 2 × 4 which is set in the ground. A short length of 2 × 3 is placed between the two legs about half way up the bottom section, to maintain the spacing. All pieces are set so the long axis faces the antenna direction.

The two back guys at the top pull against the antenna, while the three lower guys prevent buckling at the center of the pole. The two sets of back guys may be anchored at the same point. The guy anchors should be 15 feet or more from the bottom of the pole.

The 2 × 4 section should be set in the ground so that it faces the proper direction, and then made vertical by lining it up with a plumb bob. The holes for the bolts should be drilled beforehand. With the lower section laid on the ground, bolt *A* should be slipped in place through the three pieces of wood and tightened just enough so that the section can turn freely on the bolt. Then the top section may be bolted in place and the mast pushed up, using a ladder or another 20-foot 2 × 3 for the job. As the mast goes up, the slack in the guys can be taken up so that the whole structure is in some measure continually supported. When the mast is vertical, bolt *B* should be slipped in place and both *A* and *B* tightened. The lower guys can then be given a final tightening, leaving those at the top a little slack until the antenna is pulled up, when they should be adjusted to pull the top section into line.

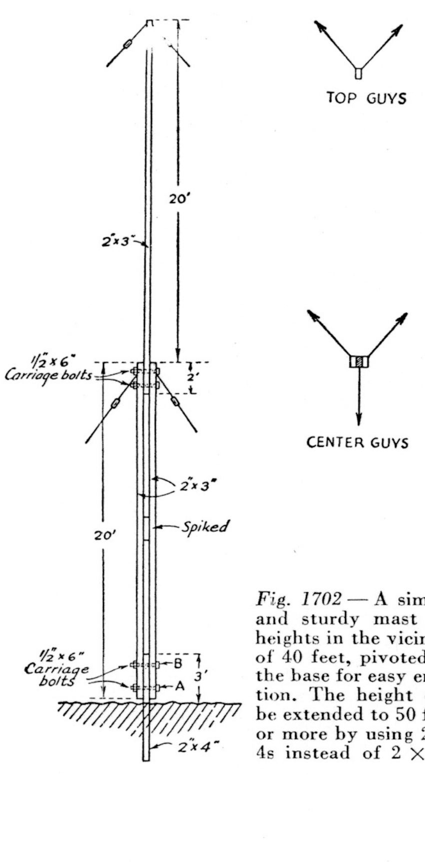

Fig. 1702 — A simple and sturdy mast for heights in the vicinity of 40 feet, pivoted at the base for easy erection. The height can be extended to 50 feet or more by using 2 × 4s instead of 2 × 3s.

The 2 × 4 should extend at least 3 feet into the ground. It will help to pack rocks in the hole to provide bracing. The mast will stand alone without guying when the two bottom bolts are in place, avoiding the necessity for having a helper on each guy while the mast is being raised.

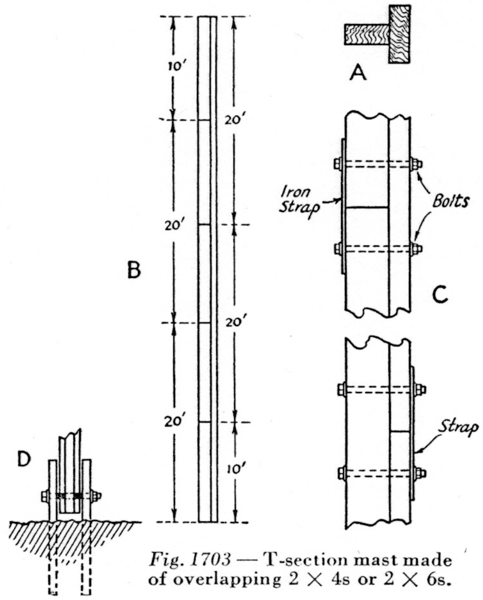

Fig. 1703 — T-section mast made of overlapping 2 × 4s or 2 × 6s.

T-Section Mast

A type of mast suitable for heights up to about 80 feet is shown in Fig. 1703. The mast is built up by butting 2 × 4 or 2 × 6 timbers edgewise against a second 2 × 4, as shown at A, with alternating joints in the edgewise and flatwise sections. The construction can be carried out to greater lengths simply by continuing the 20-foot sections. Longer or shorter sections may be used, if more convenient.

The method of making the joints is shown at C. Quarter-inch or $\frac{3}{16}$-inch iron, 1½ to 2 inches wide, is recommended for the straps, with ½-inch bolts to hold the pieces together. One bolt should be run through the pieces midway between joints, to provide additional rigidity.

Although there are many ways in which such a mast can be secured at the base, the "cradle" illustrated at D has many advantages. Heavy timbers set firmly in the ground, spaced far enough apart so the base of the mast will pass between them, hold a large carriage bolt or steel bar which serves as a bearing. This bolt goes through a hole in the mast so that it is pivoted at the bottom. As the mast is swung upward

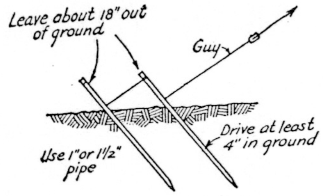

Fig. 1704 — Pipe-guy anchors. One pipe is sufficient for small masts, but two installed as shown will provide the additional strength required for larger poles.

in an arc while being raised, the bottom will be free to pivot on the bearing.

The job of raising the mast can be simplified, when a bottom bearing of this nature is used, because half of the guys can be put in place and tightened up before the mast leaves the ground. Four sets of guys should be used, one in front, one directly in the rear, and two on each side at right angles to the direction in which the mast will face. Since the base position is fixed by the bearing, all the side guys can be put in place, anchored and tightened while the mast is lying on the ground. A set of guys should be used at each of the joints in the edgewise sections, the guy wires being wrapped around the pole rather than fastened to bolts or passed through holes in the pole; either of the latter methods tends to weaken the joints.

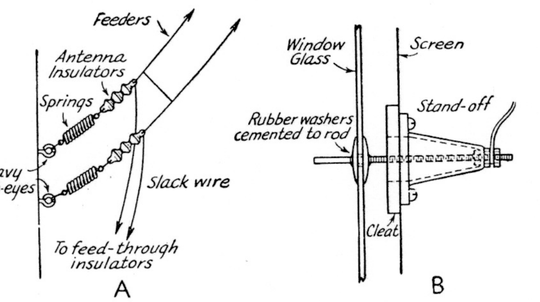

Fig. 1705 — (A) Anchoring feeders takes the strain from feed-through insulators or window glass. (B) Going through a full-length screen, a cleat is fastened to frame of the screen on the inside. Clearance holes are cut in the cleat and also in the screen.

For heights up to 50 feet, 2 × 4-inch members may be used throughout. For greater heights, it is advisable to use 2 × 6s for the edgewise sections, although 2 × 4-inch pieces will do for the flat sections.

ℂ Guys and Guy Anchors

For masts or poles up to about 50 feet, No. 12 iron wire is a satisfactory guy-wire material (No. 12 iron wire is considerably heavier than copper). Heavier wire or stranded cable may be used for taller poles or poles installed in locations where the wind velocity is high.

Guy wires should be broken up by strain insulators, to avoid the possibility of resonance at the transmitting frequency. Common practice is to insert an insulator near the top of each guy, within a few feet of the pole, and then cut each section of wire between the insulators to a length which will not be resonant either on the fundamental or harmonics. An insulator every 25 feet will be satisfactory for frequencies up to 30 Mc. The insulators should be of the "egg" type with the insulating material under compression, so that the guy will not come down if the insulator breaks.

Guy wires may be anchored to a tree or building when they happen to be in convenient spots. For small poles, a 6-foot length of 1-inch pipe driven into the ground at an angle will suffice. Additional bracing will be provided by using two pipes, as shown in Fig. 1704.

ℂ Halyards and Pulleys

A free-running pulley and a long-lived halyard are definite assets to an antenna system. Common clothesline is strong enough for small antennas, but does not stand the weather well and should be renewed frequently. Sash cord is better, but still not weather resistant. A satisfactory halyard is ⅜- or ½-inch waterproofed manila rope, the larger size being needed only to hold long stretches of wire. Ordinary rope or cord can be waterproofed by soaking it a day or two in automobile top dressing.

A good grade of galvanized iron pulley will be satisfactory in locations where the atmosphere is free from salt, but at seashore locations a pulley intended for marine use should be used. One of the best types is a hardwood block with a bronze roller-bearing shaft, which will resist corrosion even under adverse conditions.

ℂ Bringing the Antenna or Transmission Line into the Station

The antenna or transmission line should be anchored to the outside wall of the building, as shown in Fig. 1705, to remove strain from the lead-in insulators. Holes cut through the walls of the building and fitted with feed-through insulators are undoubtedly the best means of bringing the line into the station. The holes should have plenty of air clearance about the conducting rod, especially when using tuned lines which develop high voltages. Probably the best place to go through the walls is the trimming board at the top or bottom of a window frame which provides flat surfaces for lead-in insulators. Cement or rubber gaskets may be used to waterproof the exposed joints.

Where such a procedure is not permissible, the window itself usually offers the best opportunity. One satisfactory method is to drill holes in the glass near the top of the upper sash. If the glass is

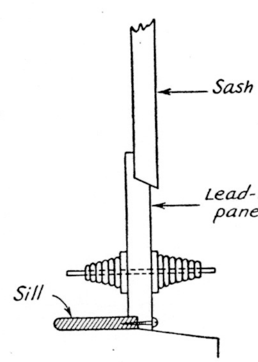

Fig. 1706 — An antenna lead-in panel may be placed over the top sash or under the lower sash of a window. Sealing the overlapping joint will make it weatherproof.

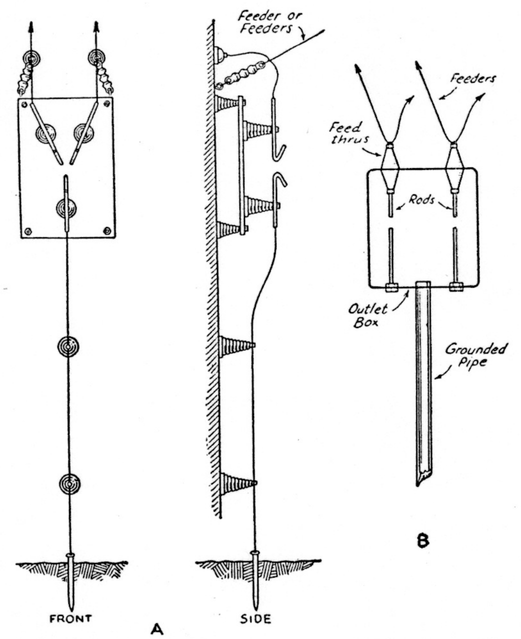

Fig. 1707 — **Low-loss lightning arresters for transmitters.**

ℂ Lightning Protection

An ungrounded radio antenna, particularly if large and well elevated, is a lightning hazard. When grounded, it provides a measure of protection. Therefore, grounding switches or lightning arresters should be provided. Examples of construction of low-loss arresters are shown in Fig. 1707. At A, the arrester electrodes are mounted by means of stand-off insulators on a fireproof asbestos board. At B, the electrodes are enclosed in a standard steel outlet box. The gaps should be made as small as possible without danger of breakdown during operation. Lightning-arrester systems require the best ground connection obtainable.

The most positive protection is to ground the antenna system when it is not in use; grounded flexible wires provided with clips for connection to the feeder wires may be used. The ground lead should be short and run, if possible, directly to a driven pipe or water pipe where it enters the ground outside the building.

ℂ Antenna Switching

It is often desirable, particularly in DX work, to use the same antenna for transmitting and receiving. This requires switching of

replaced by plate glass, a stronger job will result. Plate glass may be obtained from automobile junk yards and drilled before placing in the frame. The glass itself provides insulation and the transmission line may be fastened to bolts fitting the holes. Rubber gaskets cut from inner tube will render the holes waterproof. The lower sash should be provided with stops at a suitable height to prevent damage when it is raised. If the window has a full-length screen, the scheme shown in Fig. 1705-B may be used.

As a less permanent method, the window may be raised from the bottom or lowered from the top to permit insertion of a board which carries the feed-through insulators. This lead-in arrangement can be made weatherproof by making an overlapping joint between the board and window sash, as shown in Fig. 1706, and covering the opening between sashes with a sheet of soft rubber from a discarded inner tube.

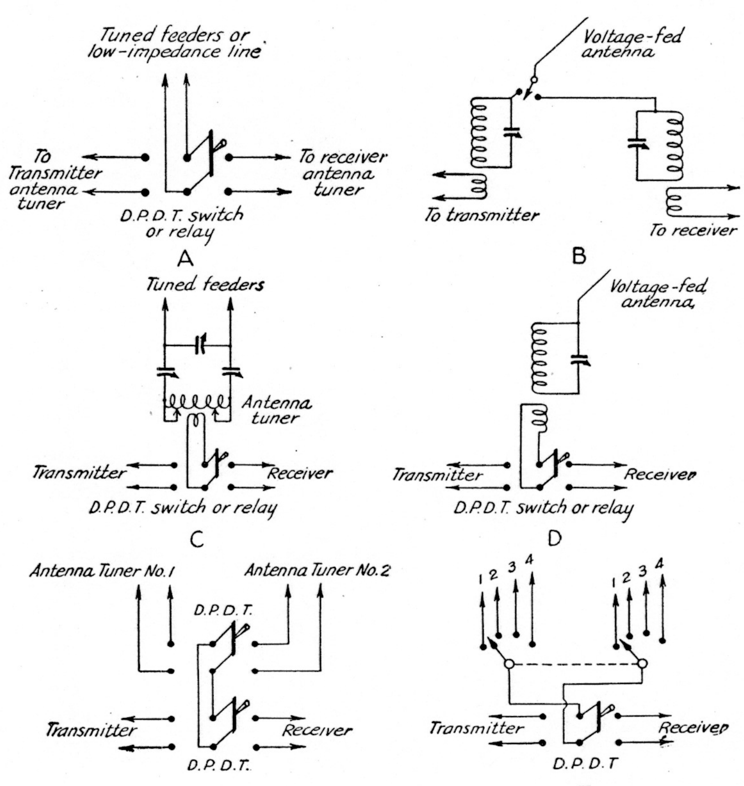

Fig. 1708 — **Antenna-switching arrangements for various types of antennas. A — For tuned lines with separate antenna tuners or low-impedance lines. B — For a voltage-fed antenna. C — For a tuned line with a single tuner. D — For a voltage-fed antenna with a single tuner. E — For two tuned-line antennas with a tuner for each antenna or for two low-impedance lines. F — For several two-wire lines.**

antenna from transmitter to receiver. One of two general systems may be employed. In the first, the transmitter and receiver each are provided with an antenna tuner, and the antenna transmission line is switched from one to the other. In the second system, one antenna tuner is provided for each antenna and the switch is in the low-impedance coupling line. Several typical arrangements are shown in Fig. 1708.

The high voltages which develop on tuned lines require switches and wiring having good insulation. Frequently relays with low-capacity contacts are substituted for manually operated switches. Either way is satisfactory.

ℂ Rotary Beam Construction

Many amateurs mount the simpler types of directive antennas in such a way that the antenna can be rotated to shift the direction of the beam at will. Obviously the use of such rotary antennas is limited to the higher frequencies, if the structure is to be of practicable size. For this reason the majority of rotary-beam antennas are constructed for use on 14 Mc. and higher frequencies. The problems in rotary-beam construction are those of providing a suitable mechanical support for the antenna elements, furnishing a means of rotation, and attaching the transmission line so that it does not interfere with the rotation of the system. The antenna elements usually are made of metal tubing so that they will be at least partially self-supporting, thus simplifying the rotating structure. The large diameter of the conductor is beneficial also in reducing resistance, which becomes an important consideration when close-spaced elements are used.

When the elements are horizontal a supporting structure is necessary, made usually of light but strong wood. Dural tubes often are used for the elements, and thin-walled corrugated steel tubes with copper coating also are available for this purpose. The elements frequently are constructed of sections of telescoping tubing, making length adjustments quite easy. Electricians' thin-walled conduit also is suitable for rotary-beam elements.

An easily constructed supporting frame for a horizontal rotary beam is shown in Fig. 1709. It may be made of 1 × 2 lumber, preferably oak for the center sections and white pine or cypress for the outer arms. The self-supporting tubing antenna elements are intended to be mounted on stand-off insulators on the arms marked *E*. The square block at the center (*A*) may be fastened to the pole by any convenient means. The dimensions of such a structure will, of course, depend upon the type of antenna system used. It is particularly well suited for a half-wave antenna with a single director or reflector on 14 Mc., or a three-element beam on 28 Mc. For 56 Mc., the dimensions may be reduced proportionally. (*Bib. 1.*)

Various means of rotation and of making contact to the transmission line have been devised. One method is shown in Fig. 1710. In this case the pole is rotated by a chain-and-sprocket arrangement, with the base resting on a bearing. Feeders are brought down the pole from the antenna to a pair of wire rings, against which sliding contacts press. (*Bib. 2.*)

Parts from junked automobiles often provide gear trains and bearings for rotating the antenna. Rear axles, in particular, can readily be adapted to the purpose. Some amateurs use motor-driven rotating mechanisms which, although complicating the construction, simplify remote control of the antenna. More or less elaborate indicating devices, which show the direction in which the antenna is pointed, often are used with motor-driven beams.

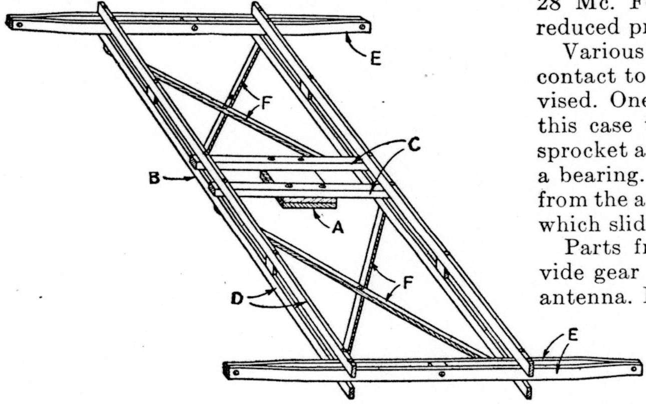

Fig. 1709 — An easily built supporting structure for horizontal rotary beams. Made chiefly of 1 × 2s, the structure is strong yet light in weight. Antenna elements are supported on stand-off insulators on the *E* arms. Length of the *D* sections depends on element spacing.

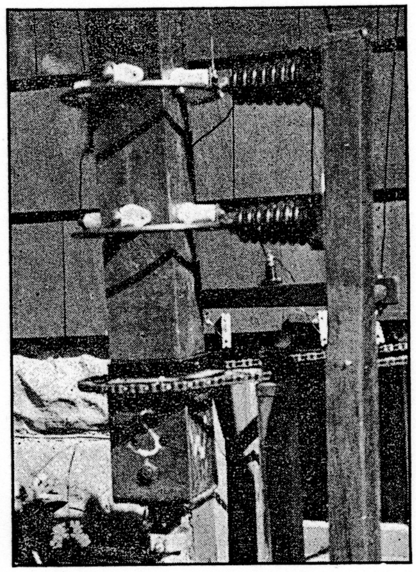

Fig. 1710 — One form of rotating mechanism. A bicycle sprocket and chain turn the pole which supports the beam antenna. Feeder connections from the antenna are brought to the metal rings, which slide against spring contacts mounted on the large stand-off insulators.

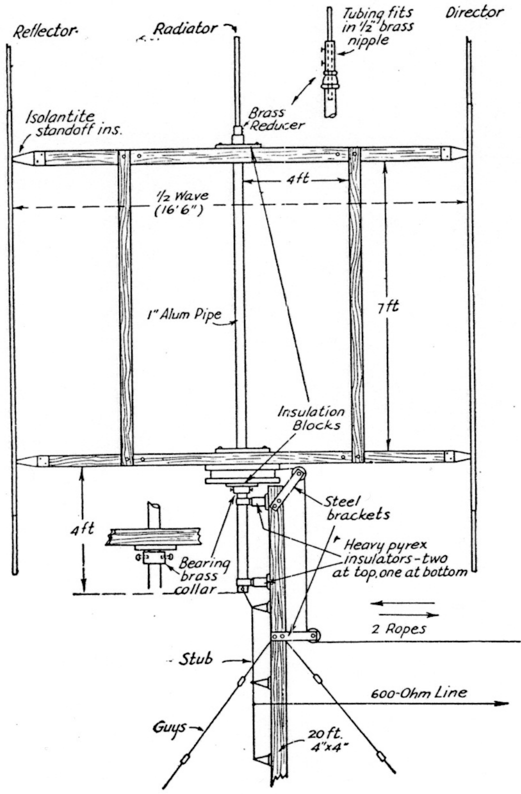

Fig. 1711 — **A practical vertical-element rotatable array for 28 Mc. No special feeder-contact mechanism is needed, since the driven antenna is fixed. The reflector and director elements, parasitically excited, rotate around it. Close-spaced elements may be used if desired.**

The full benefit of a rotating directive antenna is realized only when the system is unidirectional, since such an antenna affords maximum reduction of interference and noise in reception. A unidirectional antenna also reduces interference to other stations not along the line of transmission. Bi-directional systems, while somewhat less advantageous from this standpoint, are mechanically somewhat easier to build, because it is necessary to rotate the antenna only through 180 degrees rather than 360. Thus feeder contact is not so difficult a problem. When the antenna is designed for 360-degree rotation it is preferable to have the feeders arranged so that continuous rotation is possible, rather than to have a stop at some point on the circle. This avoids the necessity for retracing almost the whole circle when moving the antenna from one side of the stop to the other.

Fig. 1711 shows a mechanical arrangement suitable for use with vertical elements. The antenna, which is a vertical section of metal tubing, is mounted in a fixed position and is provided with a director and reflector which rotate about it. The advantage of this arrangement is that no provision need be made for special contacts between the antenna and the feeder system, since the position of the antenna is fixed. A rope-and-pulley arrangement provides rotation from the operating room, so that, when a signal is picked up, the antenna can be rotated rapidly to the position which gives maximum response. It is then also pointing in the proper direction for transmission. The system can be varied in details; for instance, close element spacing might be used to give greater gain. (*Bib. 3*).

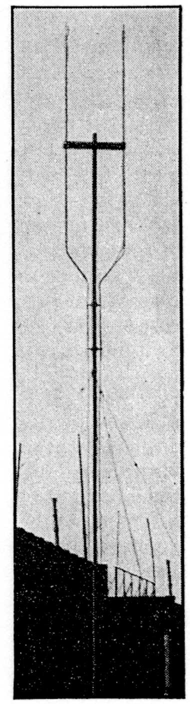

Fig. 1713 — A simple form of end-fire array as used at W2JCR. The two copper-tubing elements are curved in and run down the pole to form part of the feed line.

V.H.F. Antennas

Although antennas for the very-high frequencies are constructed on the same principles as those for lower frequencies, the smaller dimensions permit structural arrangements which would be unwieldy, if not impossible, on lower frequencies. The extended double Zepp, used vertically, is particularly easy to mount, the elements being made of ¼-inch copper or dural rod or tubing and fastened to the side of a pole by stand-off insulators. Two arrangements are shown schematically in Fig. 1712. The open-wire feeder is better if the line is long, the losses being lower than with twisted pair. (*Bib.* 4.)

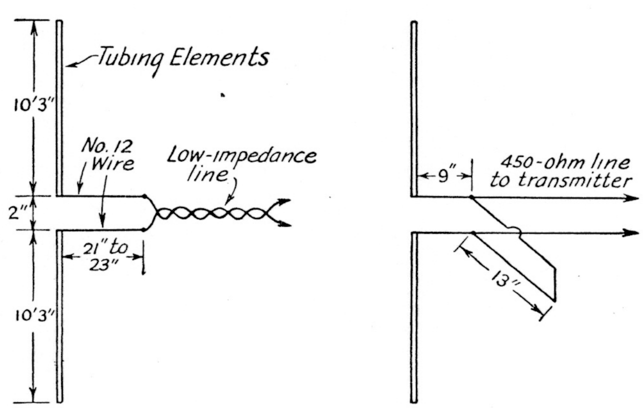

Fig. 1712 — Two methods of feeding an extended double Zepp type of collinear array. The dimensions given are for the 56-Mc. band, and should be halved for 112 Mc. The 450-ohm line may be made of No. 12 wire with 2-inch spacing. The stub should be adjusted for minimum change in the final tank tuning when the line is coupled to the transmitter.

A simple application of the end-fire principle is shown in Fig. 1713. Two lengths of copper tubing are bent to form a "pitchfork" a half-wavelength long (down to the bend) and with a quarter- to an eighth-wavelength separation. If the pole can be made to rotate 180°, full advantage can be taken of the directivity of the system. Tuned feeders may be used if the length is not more than one or two wavelengths; for greater lengths an untuned line and a matching stub are desirable. (*Bib. 5.*)

Combination arrays as described in Chapter Ten give good gain and are not difficult to construct. One practical application is shown in Fig. 1713. The elements can be of wire or tubing. The assembly can be simply wires hung from a rope stretched between two supports, or it can take the form of a more permanent structure, as shown in the photographs.

Mobile Antennas

For mobile work on the very-high frequencies a rod or "whip" antenna frequently is used, generally mounted vertically from one or a pair of stand-off or feed-through insulators fastened to the car body. If possible, the antenna should be a half-wavelength long, since this length will give best two-angle radiation. A quarter-wave antenna, working against the metal car body as a counterpoise or "ground," can be used but is not as efficient a radiator as the half-wave antenna. The antenna should be placed as high on the car as circumstances permit.

It is advantageous to mount the antenna near the transmitter so that the feeder will be short. This will obviate the necessity for special feeder systems, such as concentric lines, which are highly desirable if the antenna is at one end of the car and the transmitter at the other. A quarter-wave tuned line is a suitable feeder, using appropriate tuning methods. When used with an end-fed half-wave antenna, the feeder end not connected to the antenna may either be left open or grounded to the car body. For details, see Chapter Sixteen.

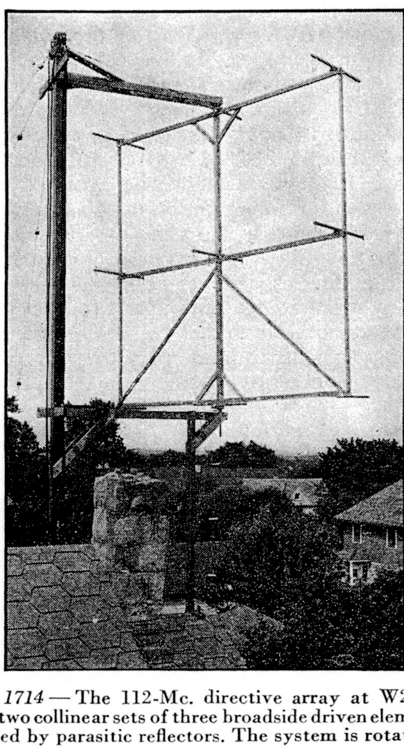

Fig. 1714 — The 112-Mc. directive array at W2CUZ uses two collinear sets of three broadside driven elements, backed by parasitic reflectors. The system is rotatable.

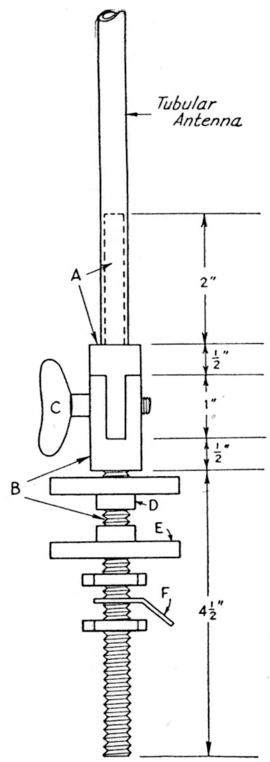

Fig. 1715 — Fitting for a hinged vertical car-roof mobile antenna. By loosening the thumb screw *C*, the antenna may be folded down parallel to the roof of the car.

Fig. 1715 shows a fitting for a vertical car-roof antenna which folds parallel to the car roof. Pieces *A* and *B* are made of ¾-inch brass rod, ¾ inch in diameter. One end of piece A is turned down to fit inside the tubular antenna, which is soldered fast. A tongue 1 inch long and ¼-inch wide is cut on the other end.

One end of piece *B* is turned down and threaded with a ⅜-inch die, while a slot, 1 inch deep and ¼ inch wide is cut in the opposite end to fit the tongue of *A*. The slotted end is drilled and tapped for the ¼-inch thrumbscrew, *C*. A vertical elongated hole is filed out in the tongue so that, with the thumbscrew loosened, *A* can be lifted to clear the shoulders of *B* while the antenna is being folded down.

Two polystyrene washers, *D* and *E*, provide insulation. Each has a hub ¼-inch thick turned on one side to fit through a hole in the car roof. The assembly is clamped to the roof by the locking nuts. *F* is a soldering lug for making the connection to the antenna.

If the assembly is placed near the forward part of the roof, the antenna will fold back without overhanging the rear of the car.

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