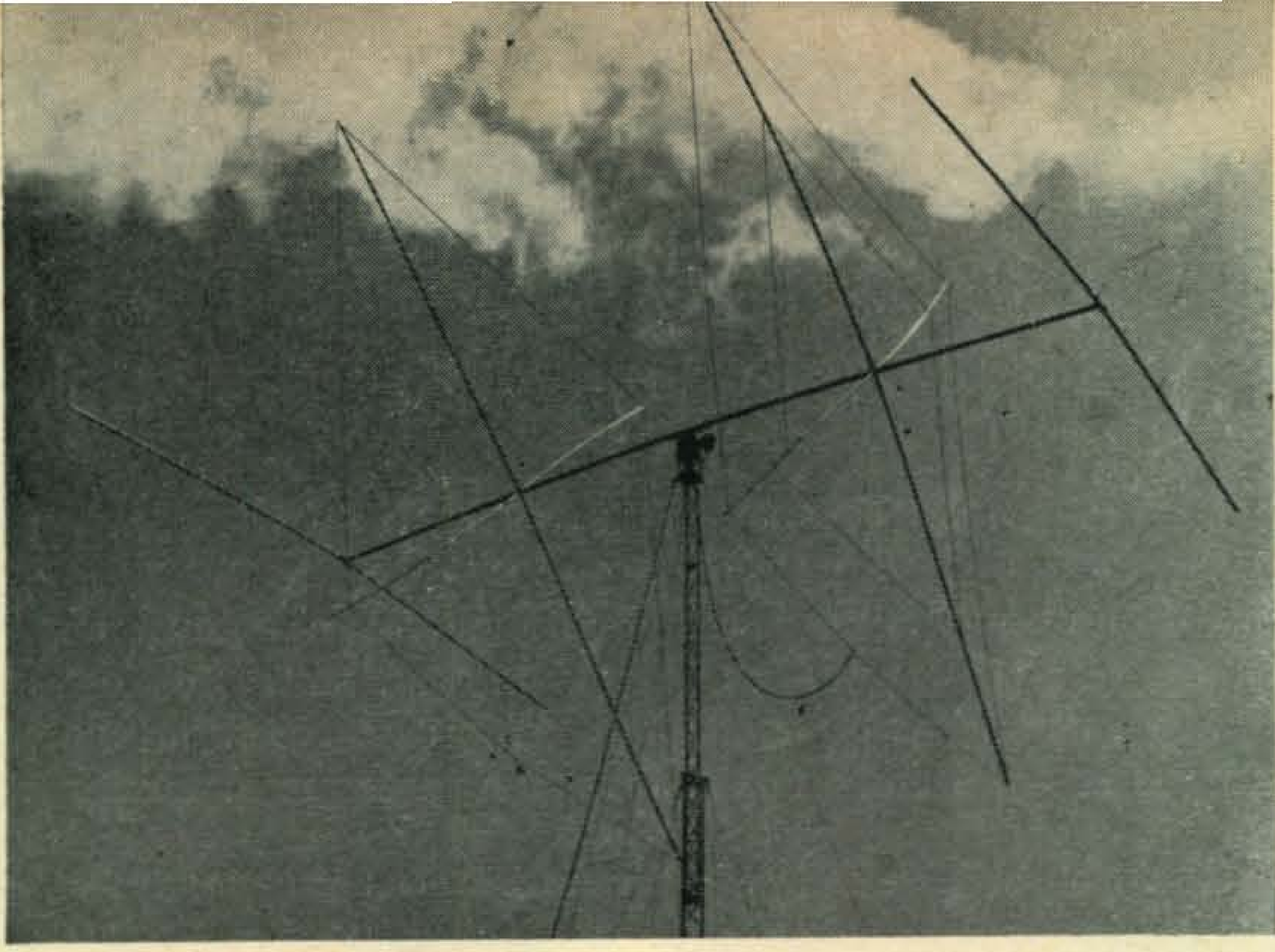


A Cubical Quad Cum Yagi

BY RALPH TURNER*, VK5TR

This 20 meter antenna combines the features of the Quad and Yagi antennas for simple construction and improved performance. The information given is also valid for the conventional two element Quad and can help to improve performance of these antennas.

THE two element cubical quad is in the writers opinion the best all around antenna yet devised. When assessed on a forward gain, angle of radiation, front to back ratio, and low initial cost, as compared to any other type of antenna, for similar performance, it excels.

I have had so much success with the two element quad that, after listening to G3VNA, it was decided to try his approach to quads. G3VNA uses a quad with two conventional elements plus a Yagi type reflector and director. As a result G3VNA puts the best and most consistent signal into VK5 land.

I have talked to many hams all over the world who have built quads and have come to the conclusion that only about 50% of them have been satisfied that their quads are really working at their peak performance. Most think their quad is working but they are not confident enough to say that they *know* that it is working 100%.

The reason for the failure to get a quad working properly is, in my opinion, due to four main points which are as follows:

1. The exceptionally high Q of the reflector.
2. The fact that it appears to be impossible to accurately "grid dip" a quad radiator.
3. The disastrous effects that metal spreaders have on the operation of a quad.
4. The interaction between the radiator and reflector elements.

*25 Austral Avenue, Linden Park, South Australia, Australia.

High Q

The two elements of a Quad could be viewed as the two tuned circuits of a very high Q i.f. transformer, where tuning one coil detunes the other. Those readers who have tried to band pass a series of tight coupled i.f. transformers will appreciate that trying to tune these circuits is like a dog chasing its tail.

The Q of a quad reflector is so high that it is practically impossible to tune it except by remote means, the proximity of a hand being sufficient to move the resonant frequency many kc. If this effect is clearly understood you are on the way to success with your quad.

Obviously the design of the reflector should be such that any alterations that have to be made to the length of this element can be made without too much pain or strain.

We found that using a loading coil in place of a tuning stub broadened out the characteristics of the reflector and was a whole lot easier to adjust than a stub.

Grid Dipping Quad Radiators

For some reason unknown to the writer, a quad radiator *cannot* be grid dipped in the same manner as a Yagi element. This peculiar effect has resulted in all sorts of varying lengths of radiator elements being published. We suggest that the lengths specified, 17′2″ on all sides, be strictly adhered to until final adjustments are made. The only method of determining the resonant frequency of a quad is by means of an s.w.r. meter. The frequency indicating the lowest s.w.r. is the resonant frequency of the quad.

Metal Spreaders

The writer has not been able to make a quad work efficiently when metal spreaders were used. The reason for this effect is not known.

Interaction Between Elements

The quad is basically two high *L*, low *C* tuned circuits with a high degree of coupling between the elements, and, as with any such circuit, the tuning of one circuit detunes the other. Hence, the advice that the lengths of the radiator must be left alone until the correct length of the reflector is determined by means of adjusting the loading coil.

Design

Well now so much for the why; now for the how. For mechanical balance it is necessary to have four elements on a quad. It is impractical to have three elements, as the quad radiator would be hard up against the tower, or alternatively the weight of the elements on the boom would not be evenly distributed. The Yagi elements were thought to be easier to construct than additional quad elements, but no claim is made for performance as compared to a four element quad.

Boom—As we had a light telescopic mast made of three 15′ sections, a portion of this was used as a boom. The 15′ length of 2″ o.d. was used as the main boom, with the 15′ of 1¾″ o.d. section cut in half and used as extensions to mount the Yagi reflector and director. This procedure allows the spacing between the Yagi and quad elements to be adjusted to some extent.

The ends of the main boom are cut every ¼″ for a length of 2″ and a radiator hose clamp is used to tighten the end of the main boom on to the extension boom. When optimum spacing is selected the two booms should be drilled and locked up with self-tapping screws.

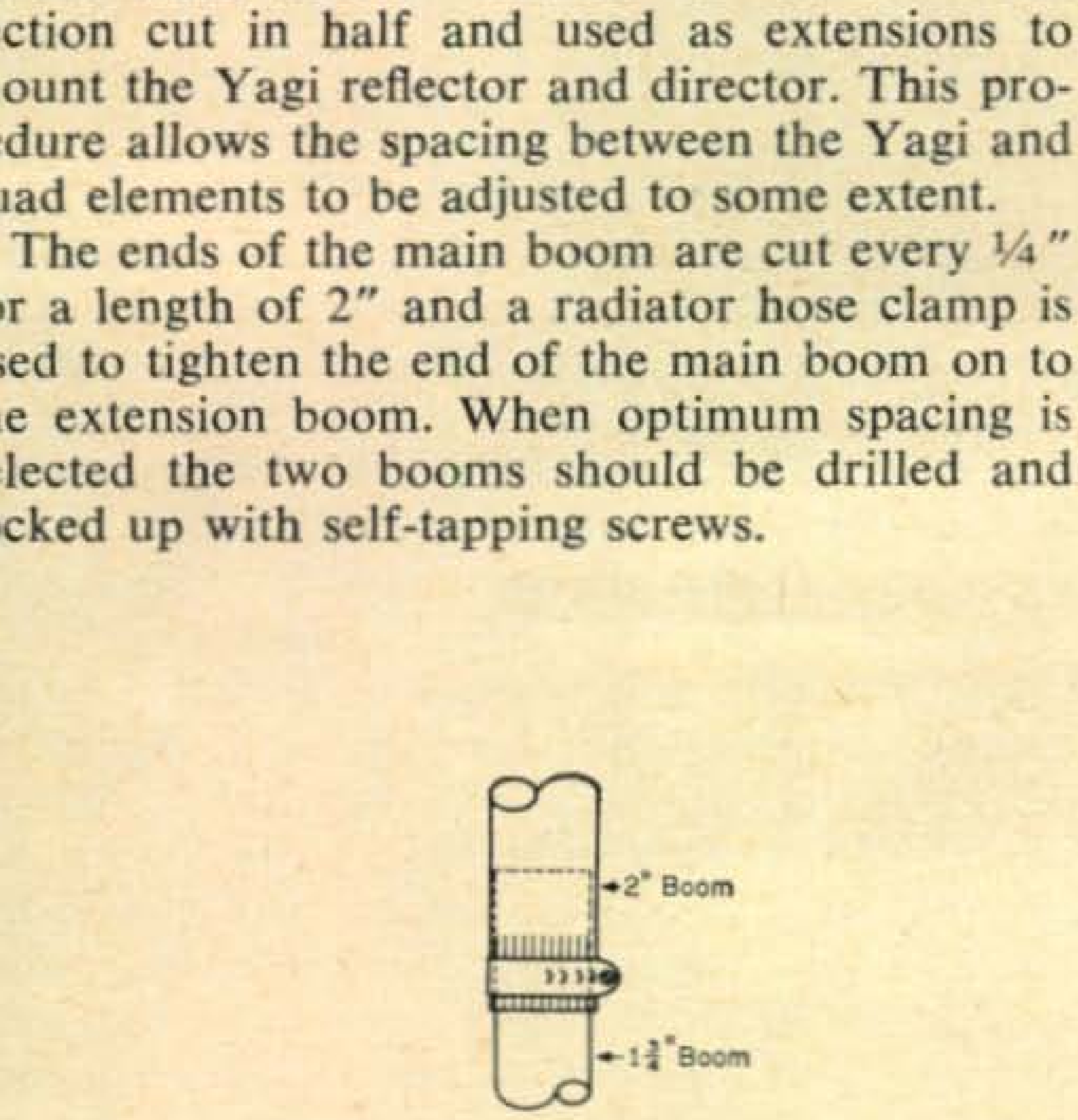


Fig. 1—Method of mounting the Yagi reflector and director to the boom ends is shown above. The details are given in the text.

Yagi Director and Reflector Mountings—In order to mount the directors and reflectors on the extension booms, a 3″ length of 1″ o.d. × 16 gauge steel tube is welded at right angles to the boom. The boom end is filed out to fit and slightly flattened on two sides to meet the diameter of the smaller tube.

A 15″ length of ⅞″ wood dowel, well varnished, is passed through the 3″ length of tube so that six inches projects on each side of the mounting. The Yagi elements slip over the wood dowel to a length of 5″. This is shown in fig. 1.

Yagi Elements—The Yagi elements consist of four 12′ lengths of 1″ o.d. × 16 gauge aluminum tube, two for the reflector and two for the director. This length was chosen at random and has no special significance. The inboard end of each element is cut in four places with a hack saw to a length of 1½″ for clamping purposes. The tube is pushed over the piece of ⅞″ dowel, leaving a space of 1″ between the end of the tube and the steel mount.

The elements are clamped to the wood dowel by means of two 1″ diameter hose clamps. These clamps also serve to mount the loading coils.

Yagi Element Support—In order to prevent the sag in the 1″ aluminum tubing, five 5″ TV type stand-off insulators are mounted along each element as shown in fig. 2. Two ⅛″ diameter holes are drilled approximately ¼″ in from the end of the elements and a #16 wire loop tied through each hole. Two lengths of 100 lb. nylon fishing line are tied to one end, then passed through the stand offs and tied to the other end of the element. If the nylon is tied when the element has an upward curve the entire element should become straight when mounted on the boom.

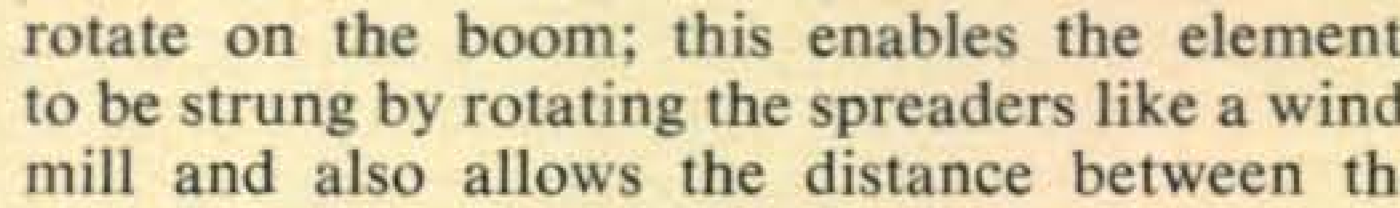


Fig. 2—The director and reflector would sag without the support shown above. Nylon fish line, 100 lb. weight, is stretched through five 5″ TV stand-off insulators.

Quad Spider—The quad spider is designed to rotate on the boom; this enables the elements to be strung by rotating the spreaders like a windmill and also allows the distance between the quad elements to be varied easily.

The spider mount consists of a 12″ length of 2¼″ 18 gauge steel tube. Four pieces of 1″ i.d. 16 gauge steel tube, 15″ long, are welded to the mount in the form of a square as shown in fig. 3. One end of each of the four pieces of tube are filed to fit perfectly before welding. It is highly desirable to use a jig for setting up, as the tube will move during welding and will not finish up square.

When the spider is welded, four 3/16″ holes should be drilled adjacent to each weld to allow for drain out of any water that seeps into the spider.

Two ⅜″ steel nuts are welded to the spider mount to provide fixing to the boom. These nuts are easily held in position for welding if the tube is drilled and tapped first and a stud screwed through the nut and the tapped hole.

Spreaders

In the interests of economy and for reasons previously stated the spreaders are half of aluminum tubing and half of wood dowel. Bamboo canes, where available, are ideal but are not readily available in this neck of the woods.

The aluminum spreaders are six feet of 1" o.d. 16 gauge tube. The wood spreaders are six feet of ⅞" wood dowel which should be varnished with three coats before assembly. The aluminum spreader is pushed into the spider for a distance of 4" and held in position by means of two ⅛" × ½" self-tapping screws.

The wooden spreader is pushed into the end of the aluminum spreader for a distance of four inches and is held by means of two ⅛" × ½" self-tapping screws. Drain holes should be drilled in the aluminum spreader adjacent to the end of the wooden dowel on the two bottom spreaders.

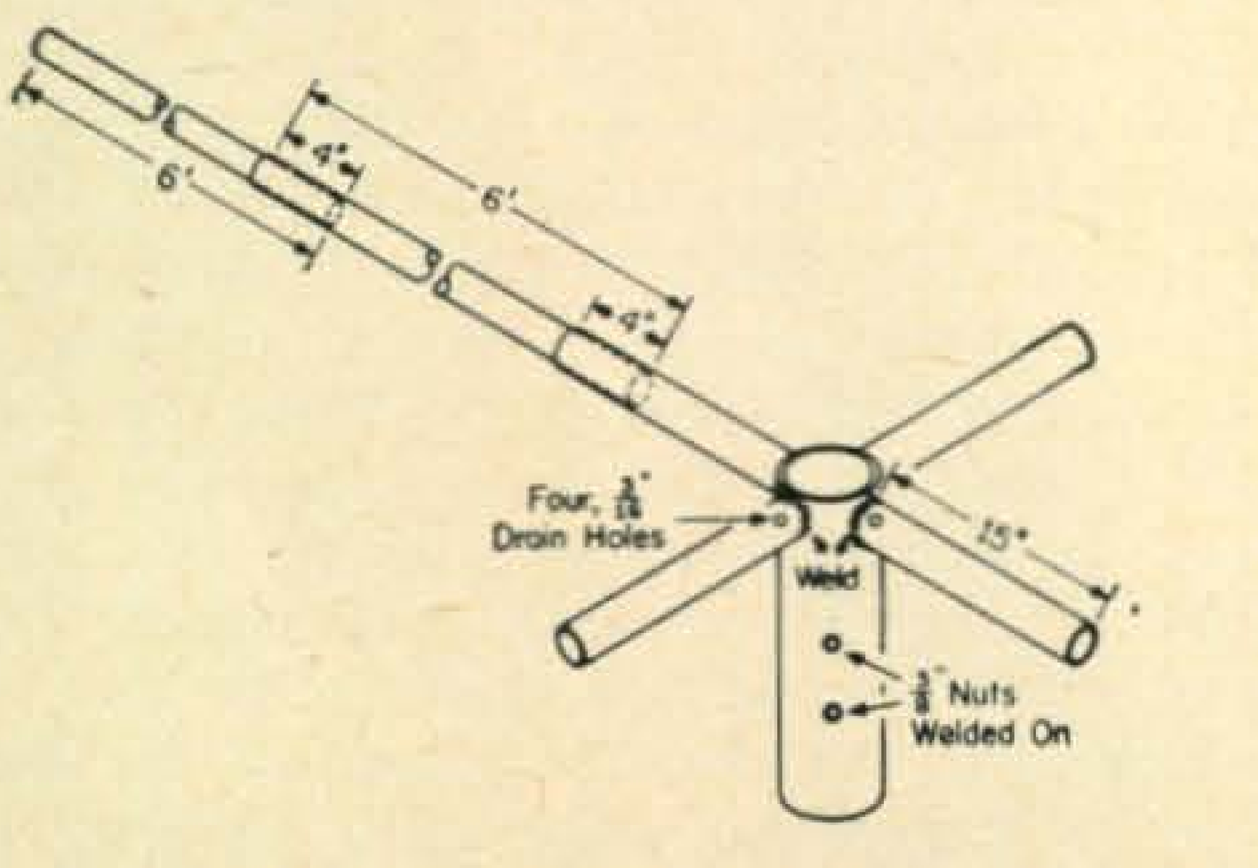


Fig. 3—Details of the spider and spreaders. If bamboo spreaders are used, commercial spiders would be suitable.

Stringing Quad Elements

The quad elements consists of 68'8" of #14 bare copper wire. Other wire of similar size will do but stranded wire is preferred because of its greater flexibility. Two lengths of wire should be run out and pre-stretched and marked at 17'2" with plastic insulation tape. Marking should start from the middle of the 69' to allow for the half lengths of wire from the bottom spreaders to the feed and coil points. When the wire is marked at the center point two points 8'7" each side of the center should be marked. Now remove the center marking and measure the other points.

In selecting the spreaders which are to be at the top of the quad remember that you have to tighten up the ⅜" set screws on the spider after the wire is fastened. These screws are more easily tightened when they are projecting downwards.

Fasten the wire to the top spreader by means of an insulated staple. The staple is not hammered home but allows the wire to pass freely through it. This allows the spreaders to be adjusted so that they are all in line and straight. The spreaders are now rotated like a windmill and the wire is fastened to each spreader.

It is wise to connect the plastic terminal block to the two ends of the wire in order that the bottom side of the wire may be set square. Once the wire has been fixed at all four points the array can be checked for "squareness" and the staples driven home.

Both the quad elements are identical in length of wire and method of fixing. The two quad elements should now be spaced 6' each side of the center of the boom and the set screws locked up. A boom mount is shown in fig. 4. The final position of the elements is shown in fig. 5.

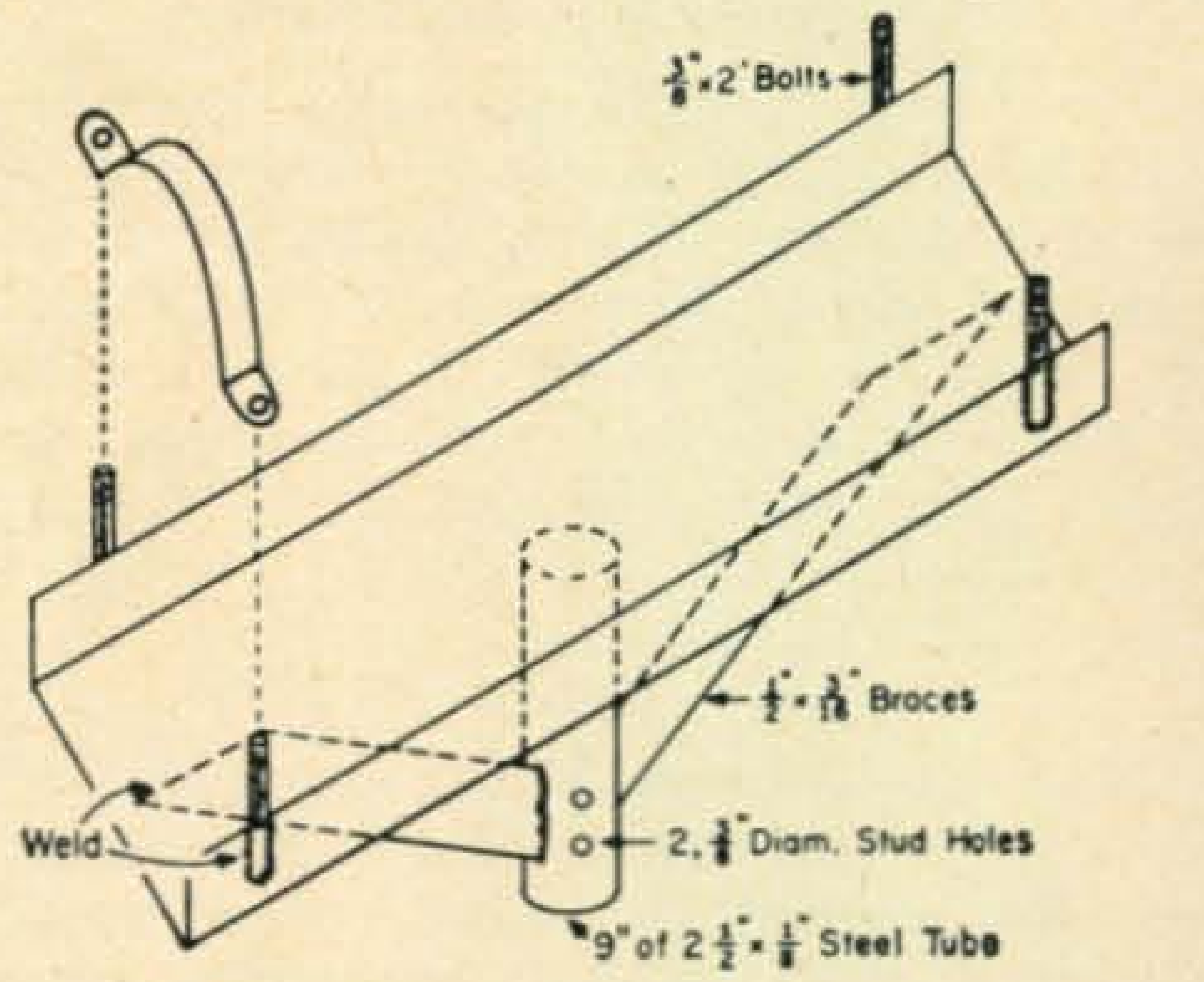


Fig. 4—The boom mount is made of a 2 foot length of 2" × 3/16" channel with four ⅜" × 2" bolts weld as shown. The clamps are 2" × 3/16". The support pipe is braced diagonally by ½" × 3/16" stock.

Square or Diamond

The square type set up is used in preference to to diamond owing to the difficulty experienced with entanglement with guy wires when a diamond shape was used. It has been stated that the diamond set up gives 1 db more gain but our tower and guys did not allow a true comparative test.

Yagi Loading Coils

As the Yagi elements are shorter than the required electrical length, loading coils are necessary. The director coil is 11 turns of #14 copper, wound 1" in diameter over a 2" length. The Yagi reflector coil is 22 turns of #14 wire, wound 1" in diameter over 4". The ends of the coils project for approx 2" and are hammered flat and slipped under the 1" diameter hose clamp.

The Yagi elements should be pretuned to the approx frequency by means of a grid dip meter before fixing to the boom. Remember that in mounting the Yagi elements on the boom the coupling to the other elements will lower the inductance of the loading coil and consequently more turns on the loading coil will be required. We tuned our elements to the desired frequency before mounting on the boom, with the coil wide spaced and then squeezed the coil together to hit the correct frequency when the elements were mounted on the boom.

If a portable grid dip meter is not available a two turn link each end of a two conductor flexible cable can be used to couple the Yagi loading coils to a grid dipper for accurate tuning.

The Yagi reflector and director must be tuned to between 5% and 6% lower and higher respectively in frequency than the desired resonant

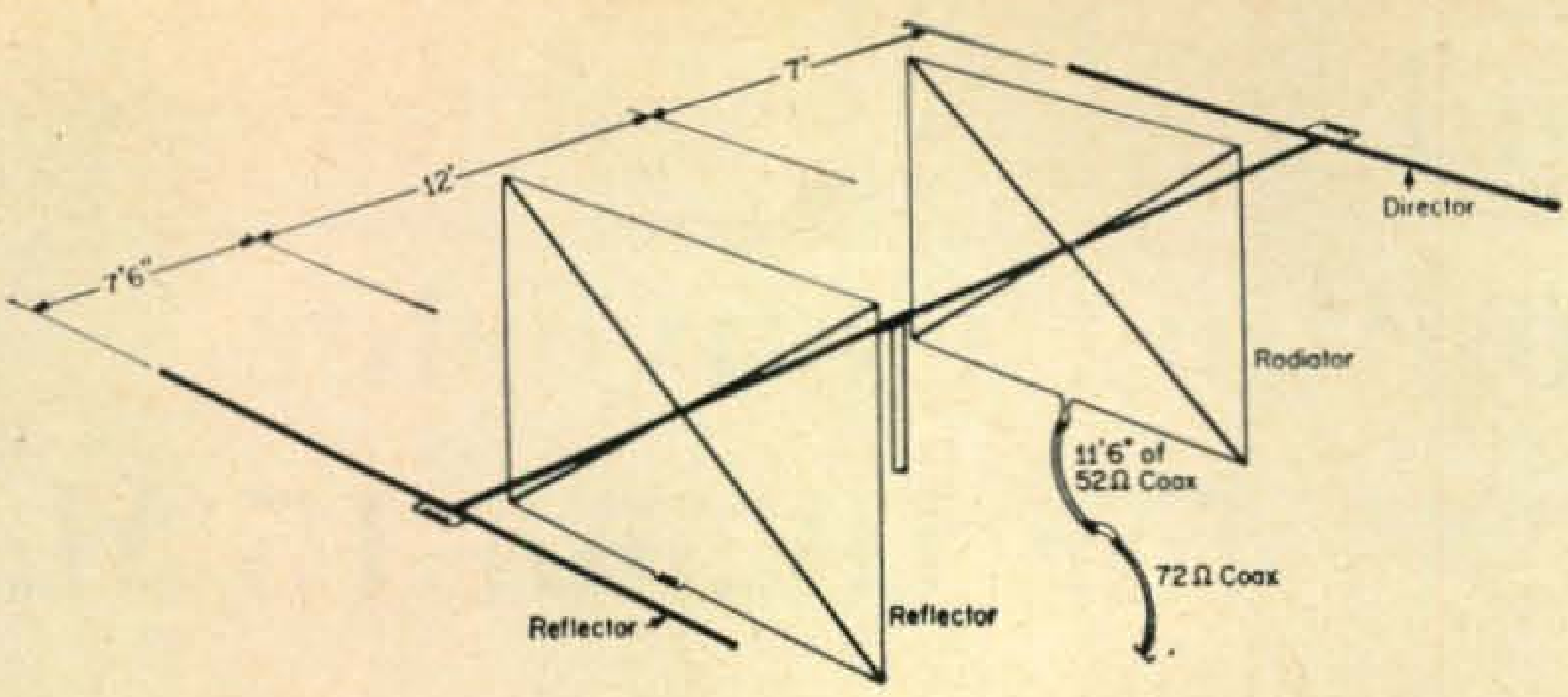


Fig. 5—Overall view and dimensions of the Yagi-quad. The ¼ wave matching stub is described in the text. The quad elements measure 17' 2" on all sides. The coax feed-line is supported by a nylon line, to the boom, to prevent sag.

frequency of the quad radiator. For example, if the desired resonant frequency of the antenna is 14,250 kc the director will be tuned to 13.537 kc and the reflector to 14.962 kc. The antenna will not work 100% unless these elements are correctly tuned *on the boom*.

Quad Radiator Matching

With the dimensions given it was found that the feed impedence of the quad radiator was approx 38 ohms. Our method of feed was to use a 70 ohm coax cable with a quarter wave matching section of 50 ohm coax at the antenna end. The impedance transformation is thus:

$$Z_m = \sqrt{Z_L Z_A}$$

where Z_m = Impedance of required $\lambda/4$ section.
Z_L = Impedance of feed line.
Z_A = Impedance of antenna feed point.

$$Z_m = \sqrt{72.38} \approx 52.5 \text{ ohms}$$

The quarter wave section of 11'6" long and should be well spliced and soldered to the 70 ohm coax and waterproofed with plastic tape.

Terminal Block

A plastic cable connector is used to connect both the feed points on the quad radiator and the coil on the quad reflector. This connector is a handy device and it simplified the replacement of the coax feed as the cable usually breaks, due to flexing by the wind, at the feed point.

Quad Reflector Loading Coil

In order to obtain the correct electrical length of the quad reflector it is considered that a coil is easier to handle and adjust than a stub as it does not flap around in the wind.

The coil is 7½ turns of #14 copper wire 1¼" in diameter, air wound, and is adjusted by means of squeezing the turns together.

Remember the previous warning; the Q of the quad reflector is so high that the proximity of a hand is sufficient to detune it many kc. This element should be roughly tuned for the maximum front to back ratio by turning the antenna back on to a fixed signal. Adjust the coil for minimum received signal. Raise the quad to its full height and check the F/B ratio, it should be in the order of 40 db. It will probably be found that it is necessary to increase the inductance of the coil slightly as the extra height above ground will lower the effective inductance.

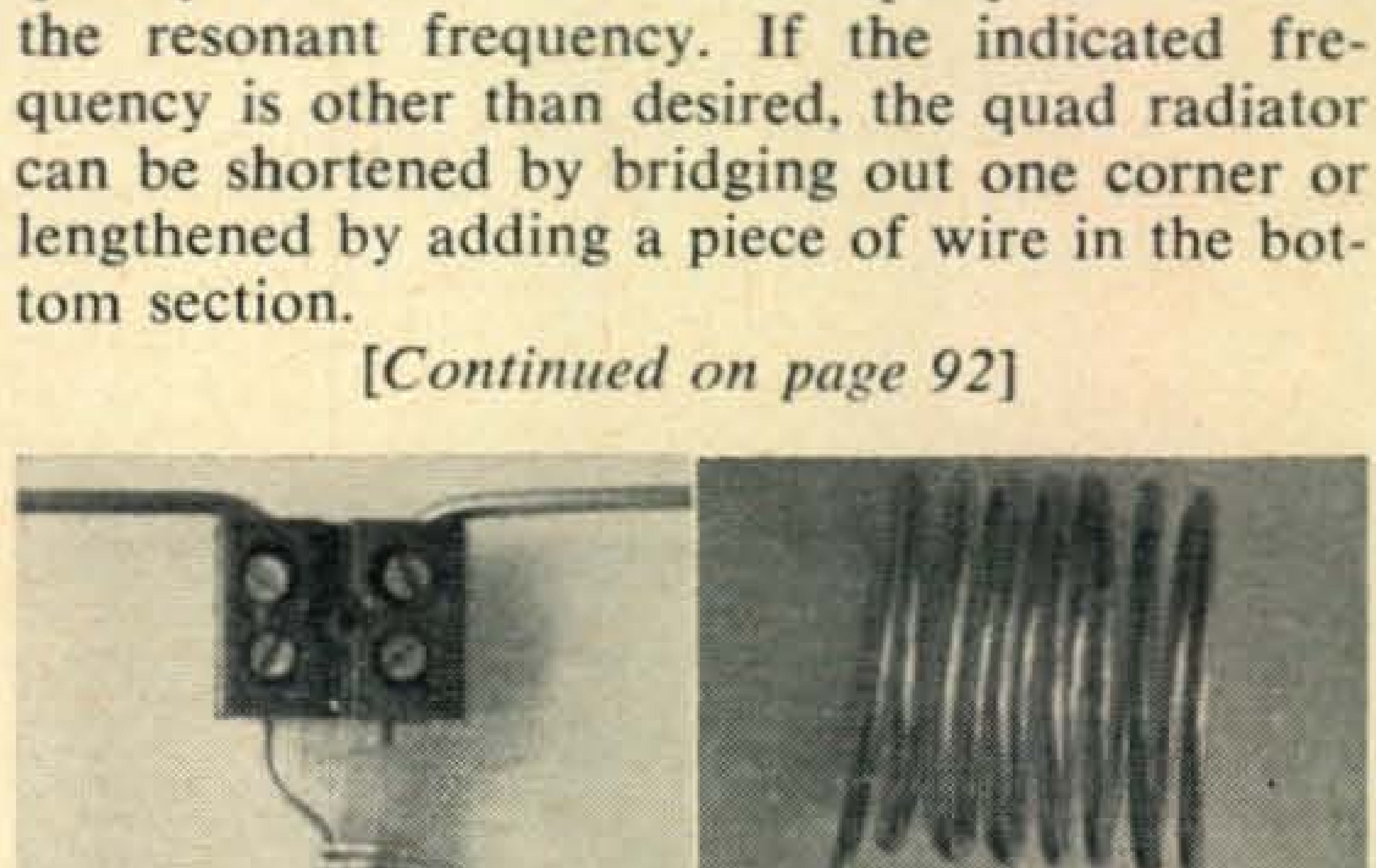
A simple method of checking the accuracy of the setting of all coils is to tape a 6" length of ferrite rod and brass rod about 3" apart on the end of a long pole. This enables the coils to be checked at a much greater height than can be done otherwise. Inserting the ferrite rod will increase the inductance and the brass rod will decrease the inductance and thereby indicate which way the coils should be moved. Both the ferrite and the brass rods should be covered with insulating material to prevent shorting the turns of the coils.

Resonant Frequency and S.W.R.

As no way has been found by the writer to grid dip a quad the method of checking the resonant frequency is by means of an S.W.R. meter. With homebrew meters make sure the meter will zero on a 70 ohm dummy load before starting to test the antenna. Our S.W.R. meter zeroed perfectly on low power, 20 watts, but would not zero on full power.

Starting at 14,000 kc take readings of the S.W.R. at 50 kc points up to 14,350 kc and plot the S.W.R. against the frequency. It should be found that the S.W.R. is lowest on 14,250 kc and should be not more than 1 to 1.07 at this frequency. The S.W.R. will rise rapidly each side of the resonant frequency. If the indicated frequency is other than desired, the quad radiator can be shortened by bridging out one corner or lengthened by adding a piece of wire in the bottom section.

[*Continued on page 92*]



Photographs illustrating the use of plastic terminal blocks for connecting to the quad reflector and driven element.

Cubical Quad [*from page 43*]

Differing ground, mast, guys and proximity to other buildings can all cause changes in the resonant frequency of the system.

Checking the front to back ratio on transmission should be carried out with a station at least 1,000 miles away as local checks are very apt to be erroneous due to radiation from other antennas and buildings. One local ham 7 miles away measured our F/B ratio 12 db; two others, one in Hawaii and the other in California both said the F/B ratio was in excess of 40 db.

Painting

The spider and booms should be galvanized, but if such treatment is not possible all steel should be treated with a rust inhibitor and painted with two coats of zinc base primer and two coats of silver finish. Careful preparation of all steel work prior to painting will be well repaid by the long rust free life of the work.

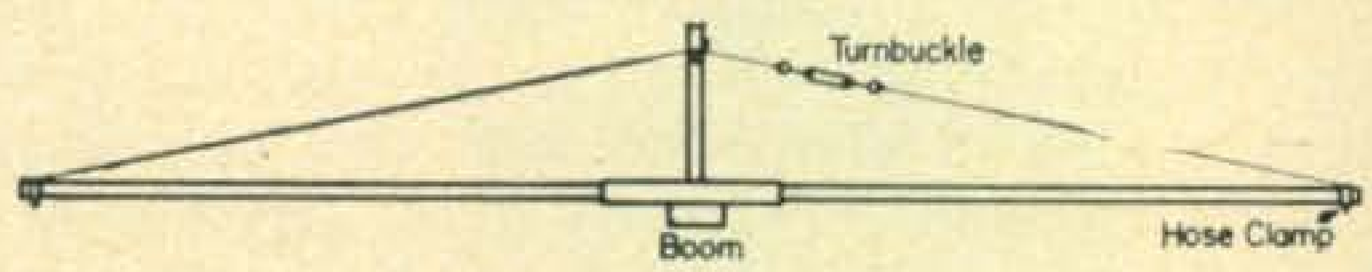


Fig. 6—To prevent boom sag a 2′ length of ½″ steel tubing was weld to the side of the boom mount. A 3″ ¼″ diameter is welded to the top of the rod as a hook to support the ⅛″ stranded steel cable. The tension is adjusted with the turnbuckle.

Bracing

Due to the light material used in the "boom" a 3/16″ stranded steel cable brace was fitted as shown in fig. The cable can be fastened at each end of the boom with hose clamps. A 2′ long vertical post was fastened to the center of the boom or mast. A light turnbuckle provides for adjusting the tension of the cable. Nylon fishing line of 100 lb. weight is used to brace the quad spreaders. The line is fastened to the ends of the boom and tied to each spreader at about 9′ above the spider. This bracing really stiffens the spreaders. ■

RTTY A-Z [*from page 29*]

Up to this point in referring to the speed of teletype machines, the author has talked in terms of words per minute such as you would speak of automobile travel in miles per hour. Like the car, a teletype machine has a motor and gears which have a bearing on the speed. In the case of the teletype machine it is powered by a synchronous electric motor of fixed r.p.m. and the speed of the teletype machines main shaft (called the receiving shaft) controlling the printing mechanism is determined by the fixed gears connecting the motor to this shaft. Naturally, the C.C.I.T. speed of 66.67 w.p.m. requires a considerably higher receiving shaft speed than does the American Bell system speed of 61.33 w.p.m.