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The Expanded Quad

This article describes an experimental expanded quad which is practical to construct and which has considerably more gain and directivity than an ordinary quad of equal elements. A three-element version was constructed which works excellently on 10, 15, 20 and 40 meters.

The antenna originated in an attempt to construct the expanded (XQ) two-wavelength quad described by William I. Orr, W6SAI in his book on "Quad Antennas". This book should be read by anyone who plans to construct a quad antenna. Orr developed the "XQ" quad from the "Lazy H". It had a side length of ½ wavelength and the three-element version was estimated to have more than 10 db gain over a dipole.

Originally a 3-element, 3-band quad was constructed in which the 10 and 15 meter elements were the XQ 2-wavelength loops. The 20 meter elements were conventional 1.0-wavelength loops. The 15 meter elements were loaded with coils to reduce the size, but they were still larger than the 20 meter ones.

After considerable experimentation, the 2-wavelength XQ was given up because of structural weakness and because the high impedance (2,000-3,000 ohms) at the feed point made matching too difficult.

During the experimenting it was noticed that the 10 meter XQ had a strong resonance and low impedance at a frequency near the 15 meter band. A check showed that the antenna was 1½ wavelengths at this frequency, and the feed point at the center of the bottom side had an impedance close to 50 ohms.

With the belief that this 1½ wavelength loop would approach the high performance predicted by Orr for the 2-wavelength XQ, the antenna was reconstructed to have 3-element, 1½ wavelength loops for 10 and 15 meters and the 20 meter was left as the standard quad.

All three bands have been satisfactorily matched to a single 52 ohm RGSU coaxial feed line. However, matching would have been simplified and the interaction less if a separate line had been used for the 15 meter antenna.

Numerous contacts and comparative tests have proven the 10 and 15 meter 1½λ XQ's to be very effective. In over 90% of the contacts the S-meter rating received was better than could be given to the contact even though many of them used kilowatt linears in comparison to the 300 watts of the TR3.

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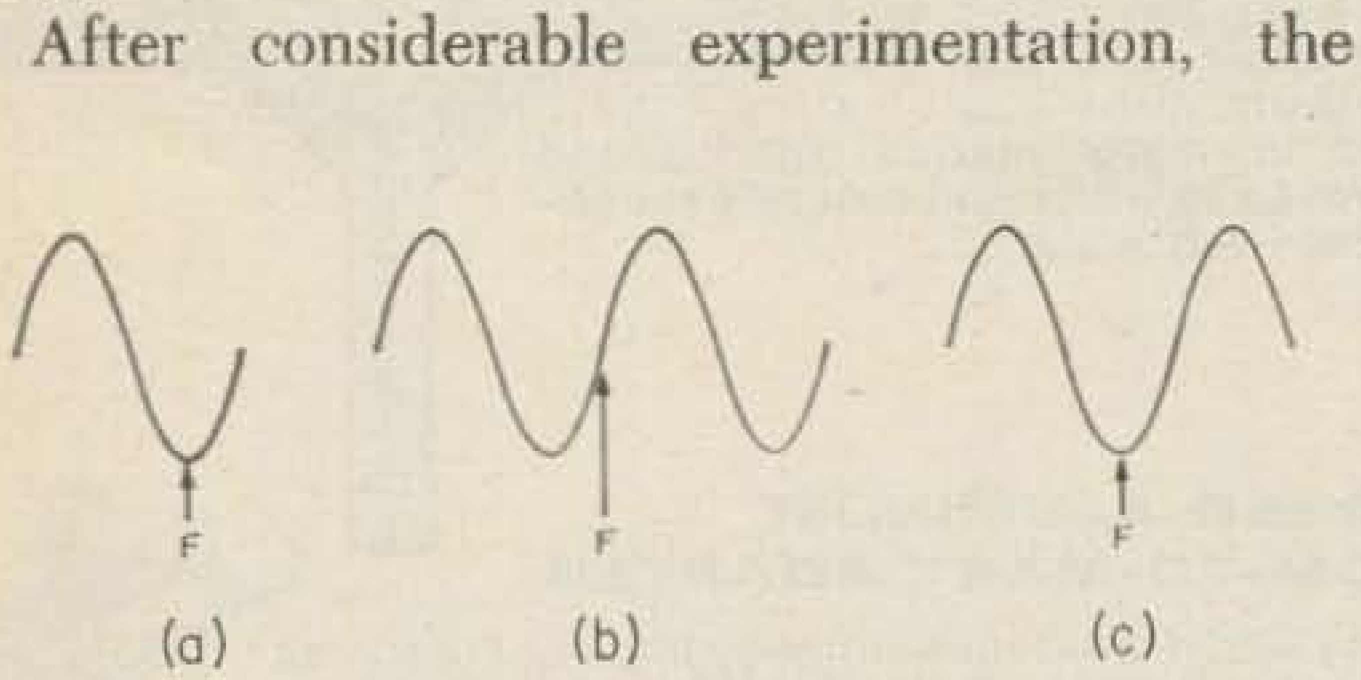

Fig. 1. Feedpoints in the current wave for (a), an ordinary 1 wavelength quad, (b), a 2 wavelength quad, and (c), the 1.5 wavelength expanded quad.

The directivity, front to side and front to back ratios are noticeably better than those of the 20 meter quad which was used for comparison. It is believed that the gain of the 1½λ XQ is close to that estimated by Orr for the 2λ XQ.

An added bonus is that the 15 meter 1½λ antenna works very well as a ½λ folded beam for 40 meters. This was observed after the antenna was erected so no attempt has been made to match it for better SWR or front to back ratio. As it is the SWR is 2.5 at 7.3 mc. and 1.05 at 7.2 mc. The element spacing constructed for 15 meters is much too close for 40 meters and a compromise should be made for more emphasis on the latter band.

Since the 1½λ XQ has performed so well on 10 and 15 meters, a 20 meter version has been planned. In the existing antenna, the spacing between the 15 and 20 meter wires is about 8 inches and there is considerable interaction when using a common feed line. With the 1½λ XQ for both 15 and 20 meters the spacing will be 3½ feet and the interaction should be greatly reduced.

With existing quad antennas, the 10 and 15 meter elements can be readily converted to the 1½λ XQ for improvement in DX operation.

The 20 meter 1½λ XQ requires a side of 25 feet and spreaders 18½ feet long. However, this is conservative when compared with some of the beams having 50 ft. booms and weighing 150 lbs. or more. A full size 40 meter quad at W3APO has 25 ft. fiberglass spreaders.

Theory

The reader is again referred to the book on Quad Antennas or the Antenna Handbook for the theory of the XQ and the detailed discussions of quads. **Fig. 1** shows the feed-points in the current wave for (a) an ordinary 1.0λ quad, (b) a 2.0λ XQ and (c) the 1.5λ XQ, when the feed is at the center of the bottom side. The impedance of the quad and the 1.5λ XQ is usually between 40 and 75 ohms, while the 2.0λ XQ will be in the enighborhood of 2,000-3,000 ohms. A ¼ wave matching section may be used to reduce the high impedance to that of the line.

Tne ends of the quad are in phase and can be electrically joined, but the 1½λ XQ antenna ends are out of phase and must be separated by an insulation.

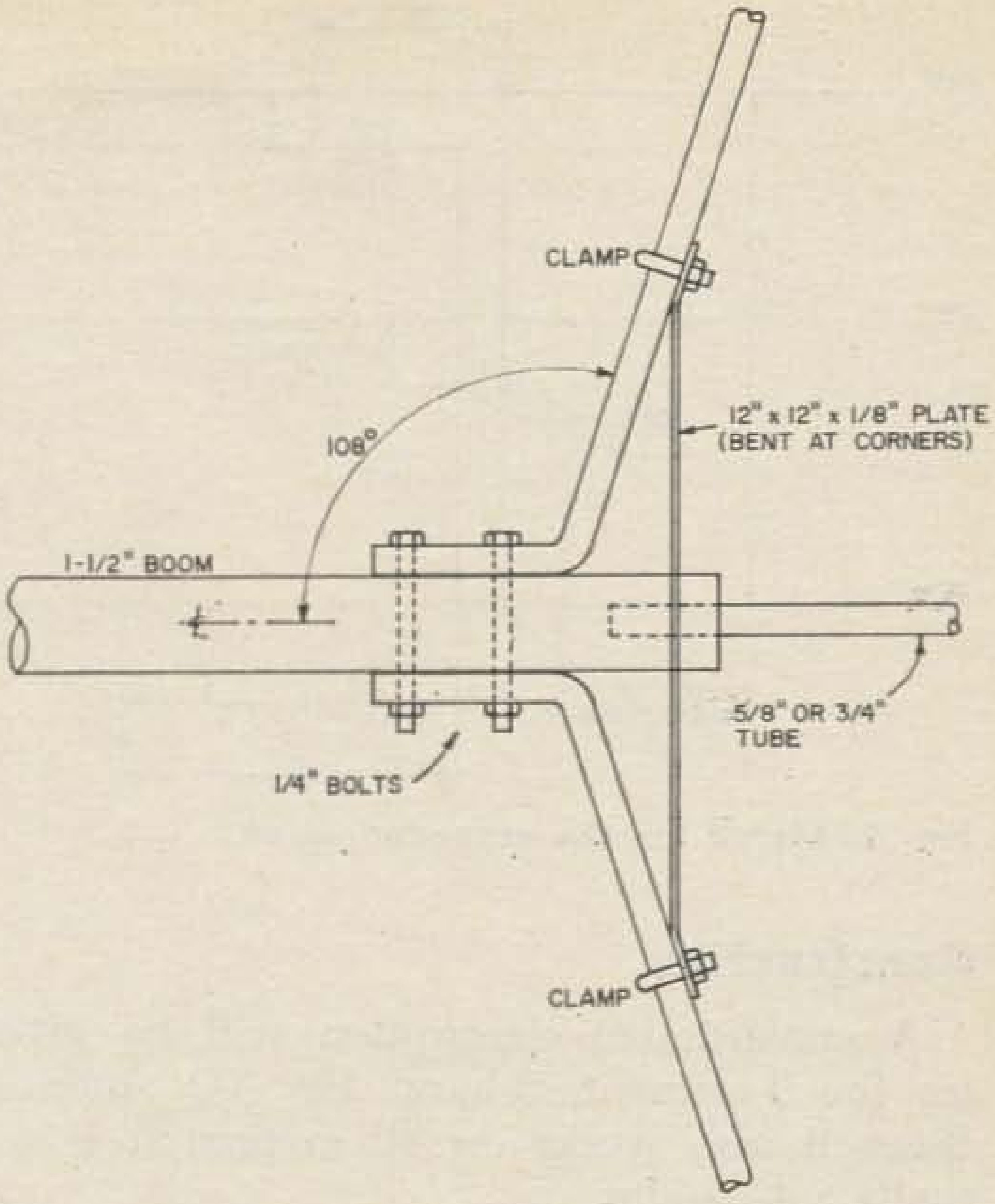

Fig. 2. Attaching the spreaders to the boom.

The 15 meter antenna works on 40 meters since 21 MHz is a third harmonic of 7.0 MHz. Actually if the antenna resonates at 21.4 MHz at 1½ wavelengths it will resonate at 7.14 MHz as a ½ wavelength antenna. Experience has shown that the tuning is broad enough to cover the whole 40 meter band.

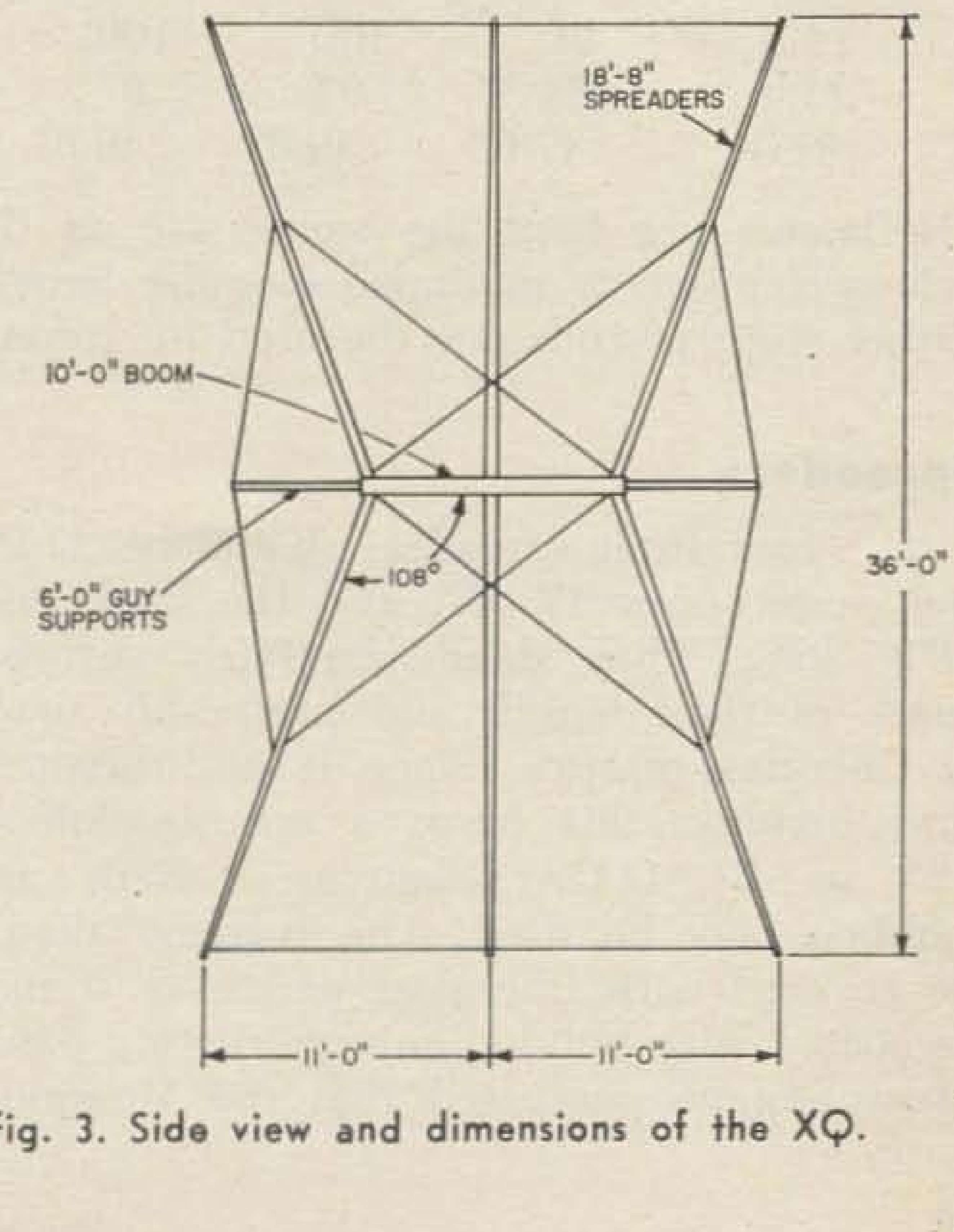

Fig. 3. Side view and dimensions of the XQ.

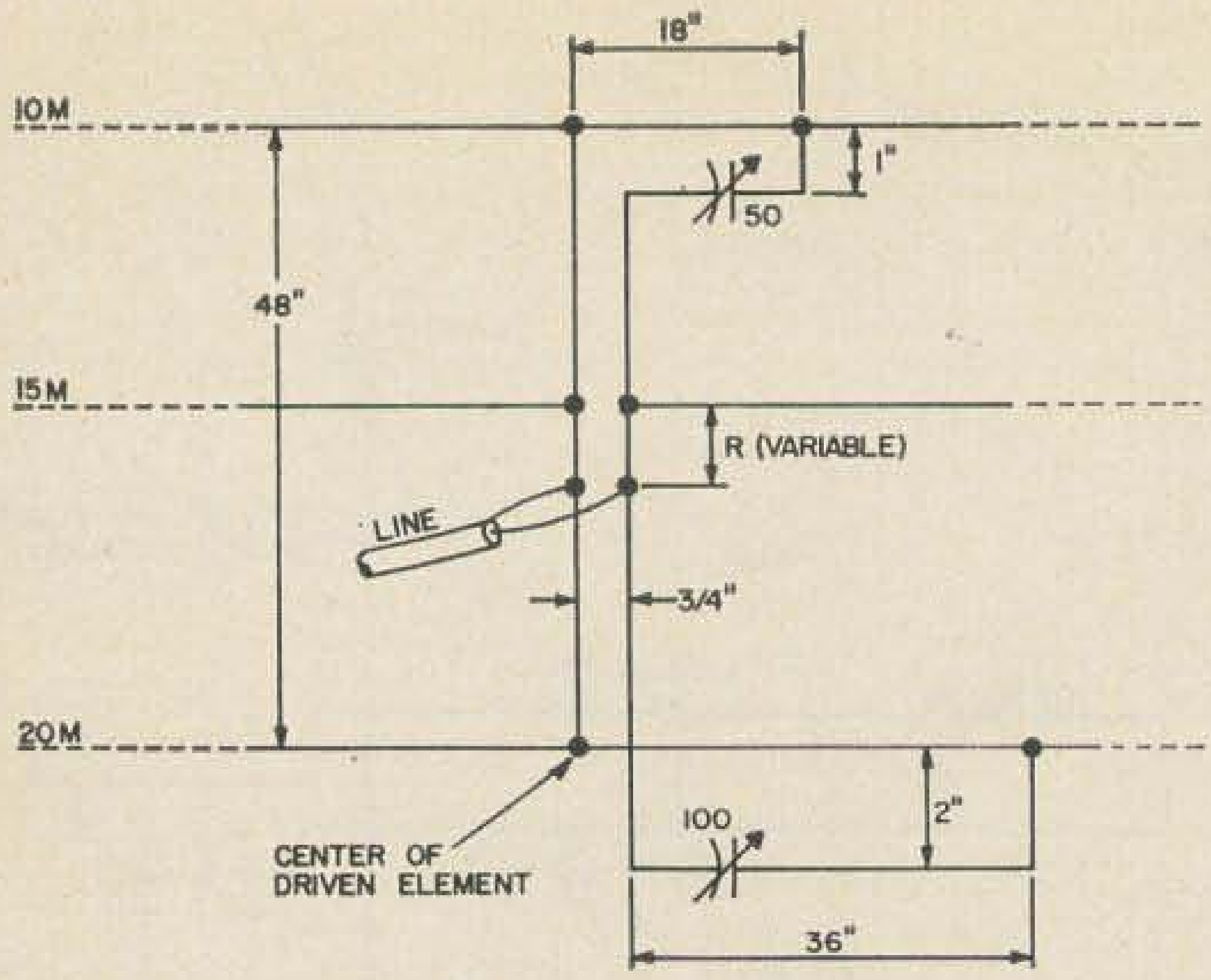

Fig. 4. Match for the expanded quad.

Construction

A construction description will be given for the 3-element, 3-band 1⅛λ XQ antenna. Since it also works on 40 meters, it is actually a 4-bander.

Although a 4-element antenna of this type would give a slightly better performance, it is doubtful if the additional cost, labor, and wind risk is justified. On the other hand a 2-element version would be easier to construct and should have a gain better than 7 dB on all bands except the 40 meter band which would have a gain of 4 or 5 dB over a dipole.

No. 14 solid enameled copper wire is used for the antenna and a little over 8 lbs. is required. The loop sizes are as follows:

Frequency	Director	Driver	Reflector*
14.3	96′	100′	100′
21.4	64′3″	67′	67′
29.0	47′6″	49′6″	49′6″

*Reflectors are kept the same size as the driven elements to minimize spreader length. Either stubs or coils may be used for tuning.

Spreaders

The four front spreaders should be 17′9″, the center ones 17′ 9″, and the back ones 18′8″ long. They should be fairly stiff because of their length and preferably made of fiberglass-plastics. Since it is difficult to find bamboo this long, a combination of 1½″ or 2″ O.D. aluminum tubing and bamboo may be used. The bamboo should be covered with fiberglass plastic or it may be coated with butyl-aluminum roofing paint. Measurements indicated that the aluminum paint had no electrical significance.

Boom

A ten foot length of galvanized steel or aluminum electrical conduit is suggested. This should be 1¼″ or 1½″ nominal pipe size or a 2″ O.D. stiff aluminum tube could be used. The boom is extended at each end with 6 foot lengths of ⅝″ or ¾″ O.D. light-weight tubing to serve as terminals for attaching the cross-bracing cards.

Assembly

Assembly of this antenna is quite an engineering feat. It was found convenient to attach the boom to a tilting mast in such a way as to permit rotation for access to the spreaders. The spreaders may be attached to the boom with purchased spiders. However, the author used sections of aluminum tubing as part of the spreaders and these were flattened and bolted to the boom as shown in **Fig. 2.** One foot square stiff aluminum plates were used for bracing.

Fig. 3 shows a section through the boom and center element. This is a diagonal section extending to opposite corners of the quad. Cross bracing with 150 lb. test nylon cord is used to increase strength and the ends of the spreaders are connected with it to hold the proper spacing. For clarity wiring is not shown on the figure.

Adjusting for frequency

Before attaching the connecting network each element was adjusted for proper frequency with a grid dip meter. The exact frequency was obtained by picking up the signal on a receiver. The driver elements were adjusted to 14.3 MHz, 21.4 MHz, and 29.0 MHz. The directors were adjusted to 14.9 MHz, 22.4 MHz and 30.3 MHz. Small tuning coils 2½″ diameter, and having a length of wire of about 4% of the element, were used to adjust the reflector frequencies to 13.6 MHz, 20.4 MHz, and 28.0 MHz. Tuning stubs could be used if preferred.

Connecting to the feed line

A single RG8U, 52 ohm, feed line was used and this was connected to the three antennas as shown in **Fig. 4.** The 48″ long header was constructed of No. 12 stiff copper wire and spaced ¾″ with micarta insulators. Gamma match connections were made to the 10 and 20 meter antennas and a direct connection was made to the 15 meter antenna. The line was connected to the header about 8" below the 15 meter antenna and the distance was varied to serve as a means for tuning.

The gamma match lengths and capacitances are approximate and are varied to obtain the best match. The values are affected by element spacing, proximity of the band loops, and height above ground.

Temporary variable condensers were used in the gamma matches. When tuning was complete they were replaced by short lengths of RG58U coax experimentally cut to give the same match. These were then sealed to keep out moisture.

Although the SWR is the final test, it is desirable to use an antennascope or impedance meter to make the matching adjustments. The antennascope construction is described in the "Radio Handbook" published by Editors and Engineers.

The method used for matching the 15 meter antenna to the line was made necessary by the interaction between it and the 20 meter quad antenna. With 1½λ XQ should be easier.

Since the gamma match lengths, capacitances, and the feed point are all interacting variables, considerable adjusting is needed to obtain a low SWR for all bands. However, the gamma lengths are not very critical and the 10 meter adjustments are almost independent of the 15 and 20 meter settings. So, after a preliminary adjustment of the capacitor on the 10 meter gamma, an optimization of the 20 meter capacitance and the feed-point setting (R) will bring the system to a fairly close balance.

The final SWR readings after the antenna was raised to 40 feet are shown below. These could have been improved by tuning with the antenna further from the ground.

Freq.	7.3	7.2	14.4	14.2	21.45	21.3	28.5	29.0
SWR	2.5	1.05	1.3	1.75	1.1	1.8	1.6	1.2

The results obtained from this antenna have repaid the trials and tribulations of building it. This includes repair after a windstorm blew it into the trees and a broken arm caused by a rotten ladder breaking under me.

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