THREE BANDS, ONE BOOM: ANOTHER APPROACH

BY JIM GREEN,* W1GT

A 3-element yagi for 14 mc, and a 2-element quad for 21 and 28 mc in a single compact assembly.

THE success of rotatable beam antennas in improving signal strengths over long distance paths has led to their increasing acceptance since the early 1940's This success, particularly on the 10, 15, and 20 meter bands, has encouraged a number of different attempts to secure the advantages of a rotatable beam antenna in a configuration which would work at maximum efficiency on all three of these principal frequency bands. Certainly the most successful and most widely applied solution to this problem is the so called "tri-bander." In this configuration, series resonant traps are located in the driven element, in the reflector, and in the directors to shorten the effective lengths of these elements so that they will resonate properly at each of the bands. It is unquestionably a good compromise engineering solution to the problem. It does, however, leave something to be desired from the point of view of the perfectionist who demands optimum performance from his antenna.

Element spacing in the "tri-bander" can be optimized for only one of the frequency bands to be operated. Further, the series resonant traps act as inductors when the beam is operated on the lowest frequency band. These inductors shorten the physical length of the antenna at resonance and insert ohmic losses. Both effects tend to decrease the overall efficiency of the antenna. Finally, the impedance presented to the driving transmission line will not be the same on all three bands and therefore the matching network used again represent a compromise.

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Despite these shortcomings, the "tri-bander" is still an excellent compromise solution and only the purist need read further.

Log Periodic Antenna

Perhaps one of the most theoretically satisfying solutions to the problem is the LPA, or Log Periodic Antenna. This antenna has the interesting characteristic of not only performing well on three bands, but on being able to perform well on any frequency over a range of approximately ten to one. Despite this startling advantage, it has found a little favor with amateurs and probably will not fare much better in the future, and for a very basic reason.

In general, the gain of a directive antenna can be expected to go up with the square of the transmitted frequency if its physical size is held constant. If a beam antenna will give a gain of 6 db on 20 meters, or 14 mc, a properly designed beam of the same physical dimensions operated on 28 mc should give a gain of approximately 12 db. The Log Periodic obtains its broadband characteristic by effectively decoupling portions of the beam as the frequency rises. Thus, in effect, the size of the beam diminishes as the frequency goes up and the frequency gain of the beam remains approximately constant over the entire frequency range. The performance on the highest frequency band is, therefore, far below what can be achieved with a properly designed structure of the same size.

Interlaced Elements

A more appealing approach is the one which has been described in great detail by Sam Parker in the November and December

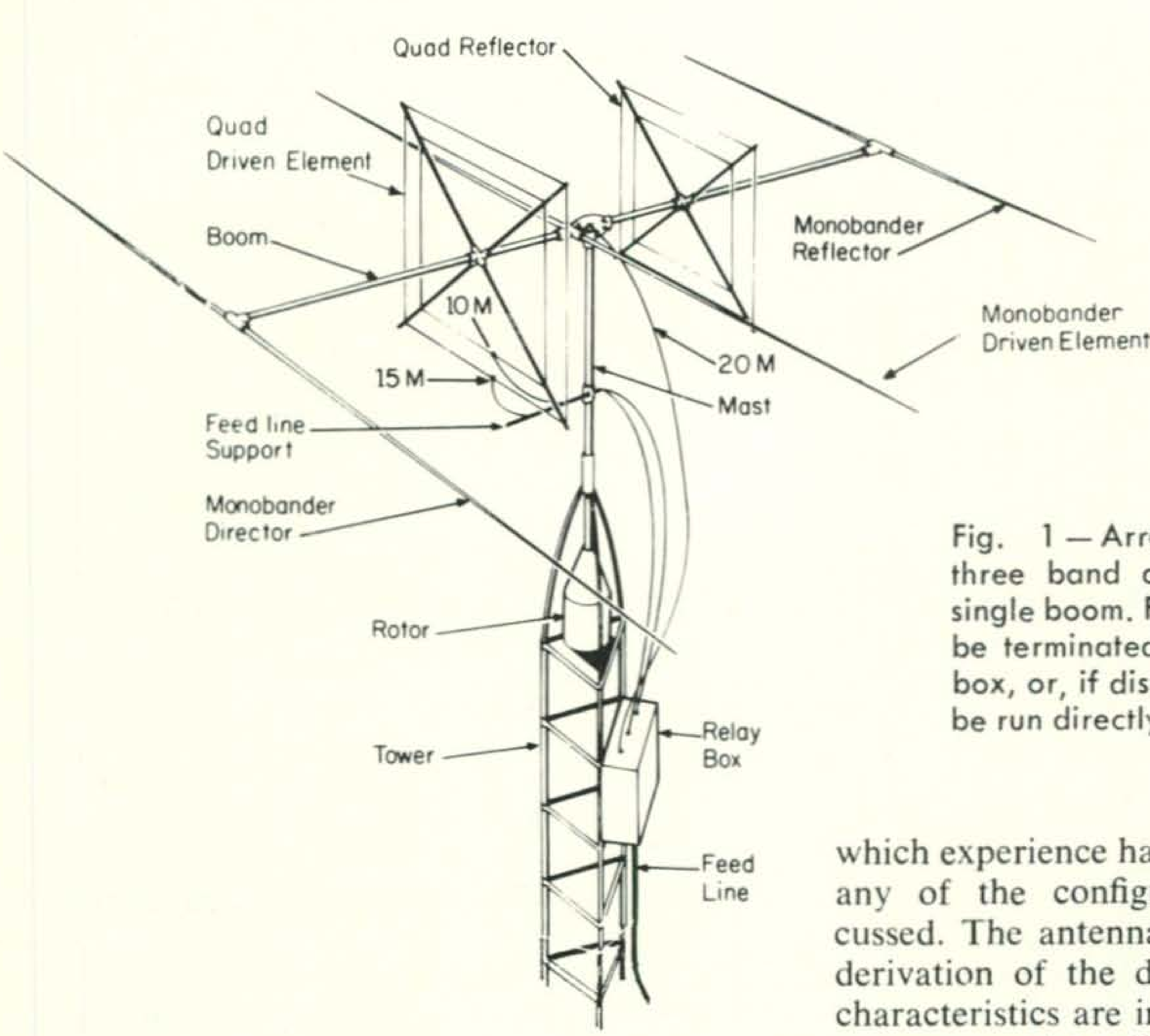

Fig. 1—Arrangement of three band antenna on a single boom. Feed lines may be terminated at the relay box, or, if distances permit, be run directly to the shack.

issues of *CQ* magazine.[1] In his approach, Parker interlaces the elements of three separate Yagi Antennas on the same boom. This permits each of the three separate antennas to be designed with optimum element lengths and optimum element spacing. It represents a refinement of the more standard approach of mounting three separate antennas, one above the other, on the same mast. Surprisingly the amount of interaction is tolerably small and each of the beams can be tuned separately with only a modest amount of interaction. It does, however, tend to be a bit "fussy" for many applications. I also feel, personally, that feed system proposed by Parker leaves something to be desired. He uses decoupling filters to permit the use of a single feed line to drive more than one of the beams. While such filters can be designed and built, the calculation is somewhat tricky and the resulting filter has many of the objectionable characteristics of the traps which are present in the "tri-bander" configuration. Losses occur and it is difficult to obtain a good match on all three bands.

Yagi-Quad

The author has constructed and had in service for the past six months an antenna which experience has shown to be superior to any of the configurations previously discussed. The antenna is shown in fig. 1. The derivation of the design and the operating characteristics are immediately obvious. The antenna consists of a standard three element monobander for the 20 meter band with two element quads for 10 and 15 strung on standard spiders attached to the same boom as the Yagi. Adequate room is available for the installation of a third spider, thus permitting the quads to operate as three element arrays. The next model of this antenna will be so configured.

It is immediately apparent that this configuration permits us to avoid most of the pitfalls pointed out for the three configurations previously discussed. The three element monobander for 20 meters can easily be adjusted for optimum element length and optimum element spacing. The elements of the 10 meter and the 15 meter quads are likewise independent and their lengths can be suitably adjusted for optimum performance on each of these two bands. It is also possible to obtain optimum spacing between the quad elements by running light dowels between the spiders, but here our desire for perfection gave way to a more practical desire to use standard and readily available components to assemble this first model. We expect to try this refinement in the next version. Finally, the interaction between the three beams is completely negligible. Essentially no effect on the tuning of one beam is noticed when the element length of either of the other two beams is varied. All of these advantages would of course be shared by a

[1]Parker, S., "Experiments With Three Arrays On One Boom," *CQ*, Part I Nov. '69, p. 78, Part II Dec. '68, p. 43.

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full "tri-band" quad. It was our personal preference, however, to adopt the configuration shown in order to decrease the overall size of the array.

Feed Lines

The approach to the feed problem used is as direct as is the approach to the problem of reducing interaction between the three beams. Separate feed lines are brought to the mast where a remotely controlled coax switch is used to connect the proper beam to the transmission line. The switching arrangement is shown schematically in fig. 2. This switching system is assembled from available s.p.d.t. relays. A single pole, three position relay, which is perhaps more suitable, is also available from the Dow Key Company. It would also be possible to bring the three feed lines into the shack and use a manual coaxial switch to select the proper antenna if the distances involved make this a practical solution.

One other aspect of the feed system may also be of general interest. The monoband beam is supplied with its own balun. Each of the quads was fitted with its own balun. These baluns were fabricated by slipping standard shielded braid over the outside of the coaxial feel line and connecting as shown in fig. 3. This type of construction has proven, on this and other beams constructed by the author, to be both simple and effective.

Summary

This approach to the construction of a three band directive antenna system is so uncomplicated and straightforward that I hesitated for some time before preparing this note describing it. It seemed almost inevitable that others had or soon would independently arrive at the same result. I am still convinced that such must be the case. Nevertheless, from a rather cursory review of the literature, and from talking to many of my friends, I can only conclude that everyone else must be holding back as I was since nothing has, to my knowledge, appeared in print.

The antenna described has by a substantial margin been the most satisfactory of many designed, constructed, and operated at my present or previous locations. The satisfaction stems from the ease of construction, the ease of operation, and the close match which can be achieved between predicted and observed performance characteristics. It is equally obvious that many attractive variations can be conceived and easily implemented. The three element monobander could be replaced by a four or five element array. The quads can likewise have additional elements added. It is hoped that this discussion of the basic principles involved will encourage others to develop even more effective combinations. ■

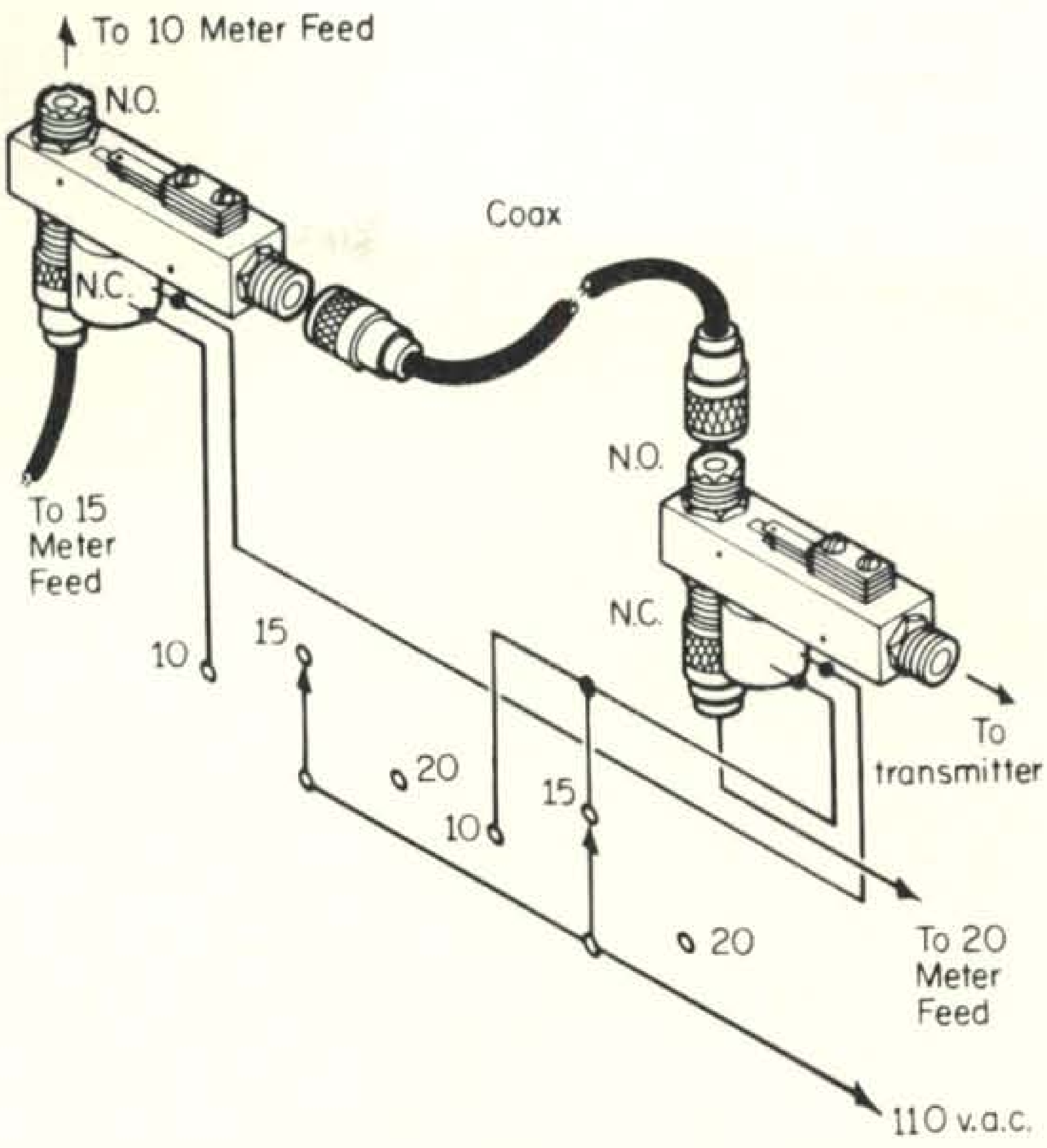

Fig. 2—Switching system makes use of two s.p.d.t. coaxial relays as shown above. If local electrical codes prohibit 110 v.a.c. wiring in other than conduit, low voltage relays may be used.

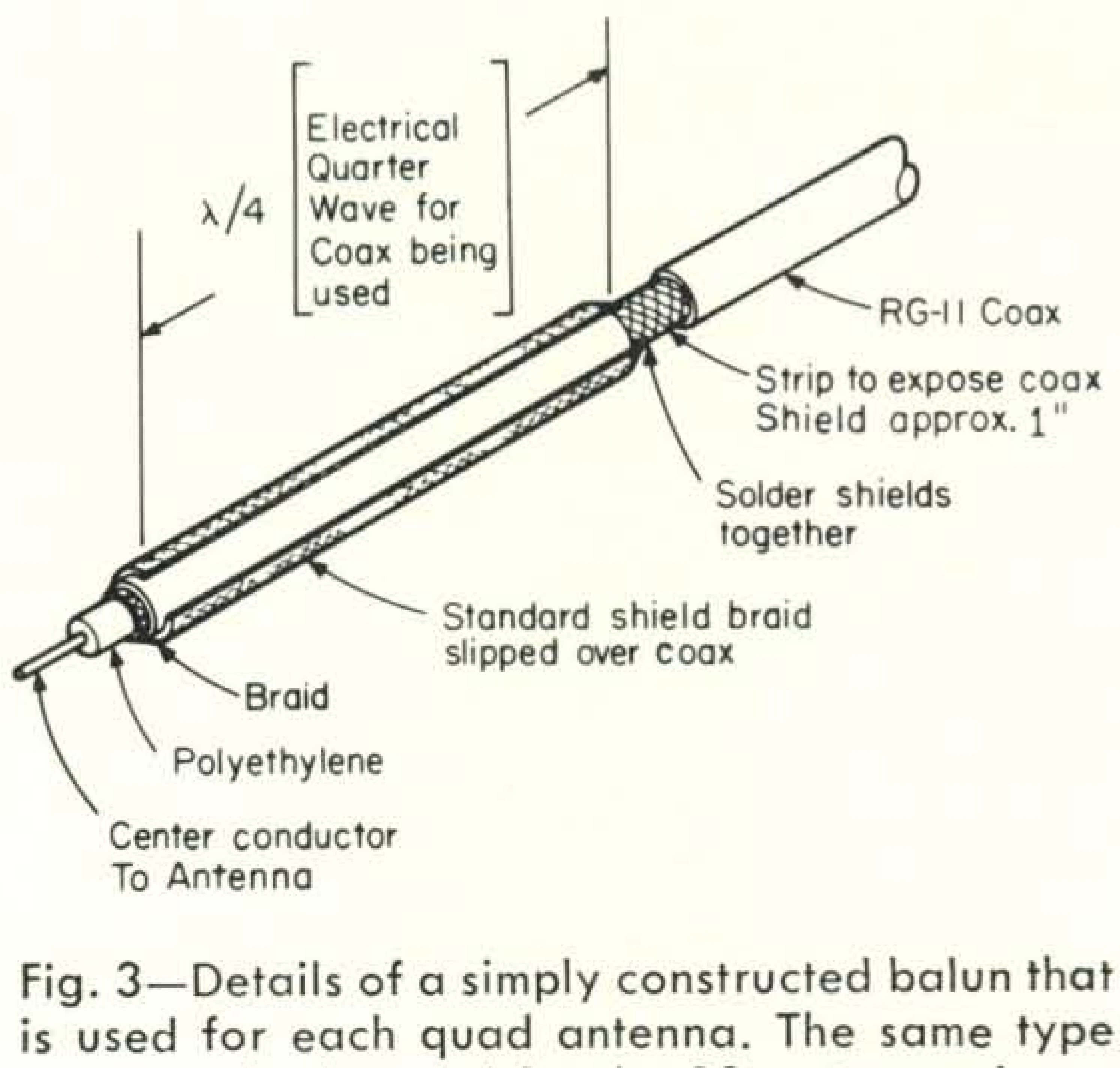

Fig. 3—Details of a simply constructed balun that is used for each quad antenna. The same type can also be used for the 20 meter yagi.

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