H.F. CONICAL CAGE ANTENNAS

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Conically shaped, cage-type antennas have been used for some years in the v.h.f. range for broad-band antenna systems. The author presents some models which were developed for use in the 80-10 meter range.

THE subject of the ideal multi-band antenna has intrigued amateurs for years. Trap-type dipoles do provide multi-band operation but because the *Q* of the traps must be high to effectively isolate the various sections, their resonance is narrow within each band and often so restricted that coverage of the phone and c.w. portions of a band are not possible. Paralleling dipoles provides another form of achieving a multi-band antenna system. However, construction does become awkward when 3 or more dipoles are used and if one participates in MARS or other activities on frequencies outside the amateur bands, a separate dipole is needed for these frequencies also.

Military communications people have been faced with the same problem but on even a broader scale. They required an antenna that would be broad-banded for all, or at least a major portion, of the spectrum from 3 to 30 mc and be as efficient as a dipole or quarter-wave vertical dimensioned for a specific frequency.

The main approach used to construct such antennas has been to use the form of broadband v.h.f. antennas dimensioned for the h.f. bands. None of these antennas are "small," since at their lowest operating frequencies they are approximately the same size as a one-band antenna. However, they may be just the answer for someone who enjoys multi-band operation and doesn't want to compromise performance nor have an assortment of antennas draped around his QTH.

The Canadian Royal Air Force was interested for its communications needs in a dipole

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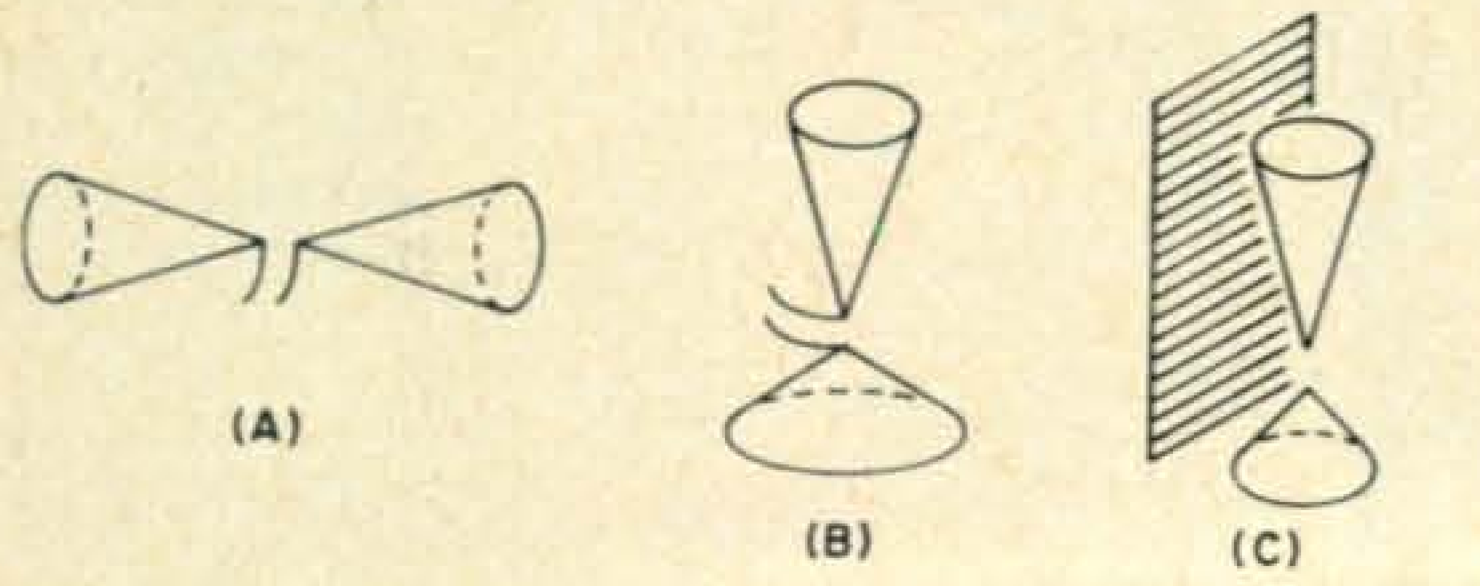

Fig. 1—Types of u.h.f. antennas studied for broadband h.f. usage. Horizontal cone dipole (A), vertical type (B) and vertical with reflector screen (C).

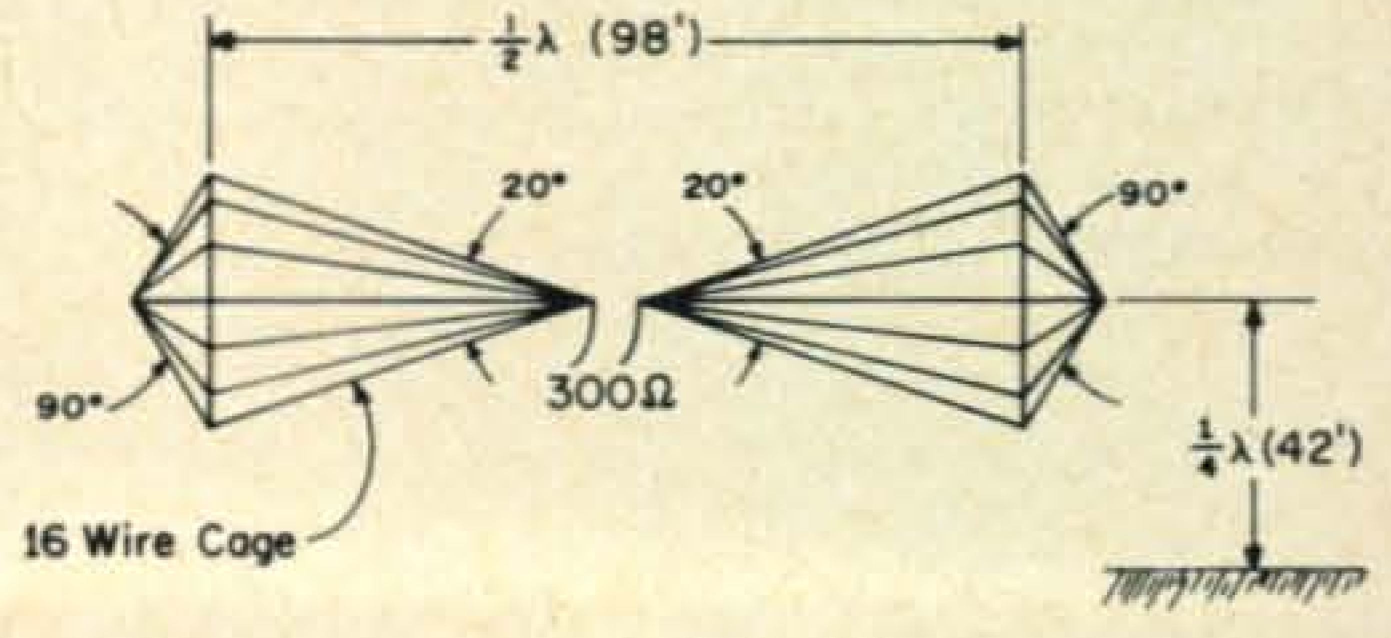

Fig. 2—Dimensions of large horizontal antenna which could be modified to extend down to 80 meters.

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giving continuous coverage of the h.f. range. They performed some very extensive tests on conical dipoles trying to arrive at the simplest design which would satisfy their needs. Courtesy of the RCAF, this article presents some of the results of their tests.

Experiments

The experiments were concerned with studying the three forms shown in fig. 1. Figure 1(A) is a conventional cone element dipole antenna of the type used at u.h.f. frequencies. Figure 1(B) is a vertical version of the conical dipole and Figure 1(C) is the same antenna shown at Figure 1(B) except that a reflector screen is added behind the antenna. The purpose of the screen was to determine if the basic design could also be used as a broad-band directive antenna.

The antenna elements were constructed of wire cages and both the number of wires in the cage and the angle of the cage was varied in order to determine which set of conditions produced maximum bandwidth with minimum design complexity. As might be expected, the greater the number of wires used in the cage, the lower the cone angle could be made and still retain the same bandwidth. Changes in the number of wires, if the cone angle was held constant, increased the bandwidth as the number of wires was increased. The impedance of the antenna also increased slightly as the number of wires was increased.

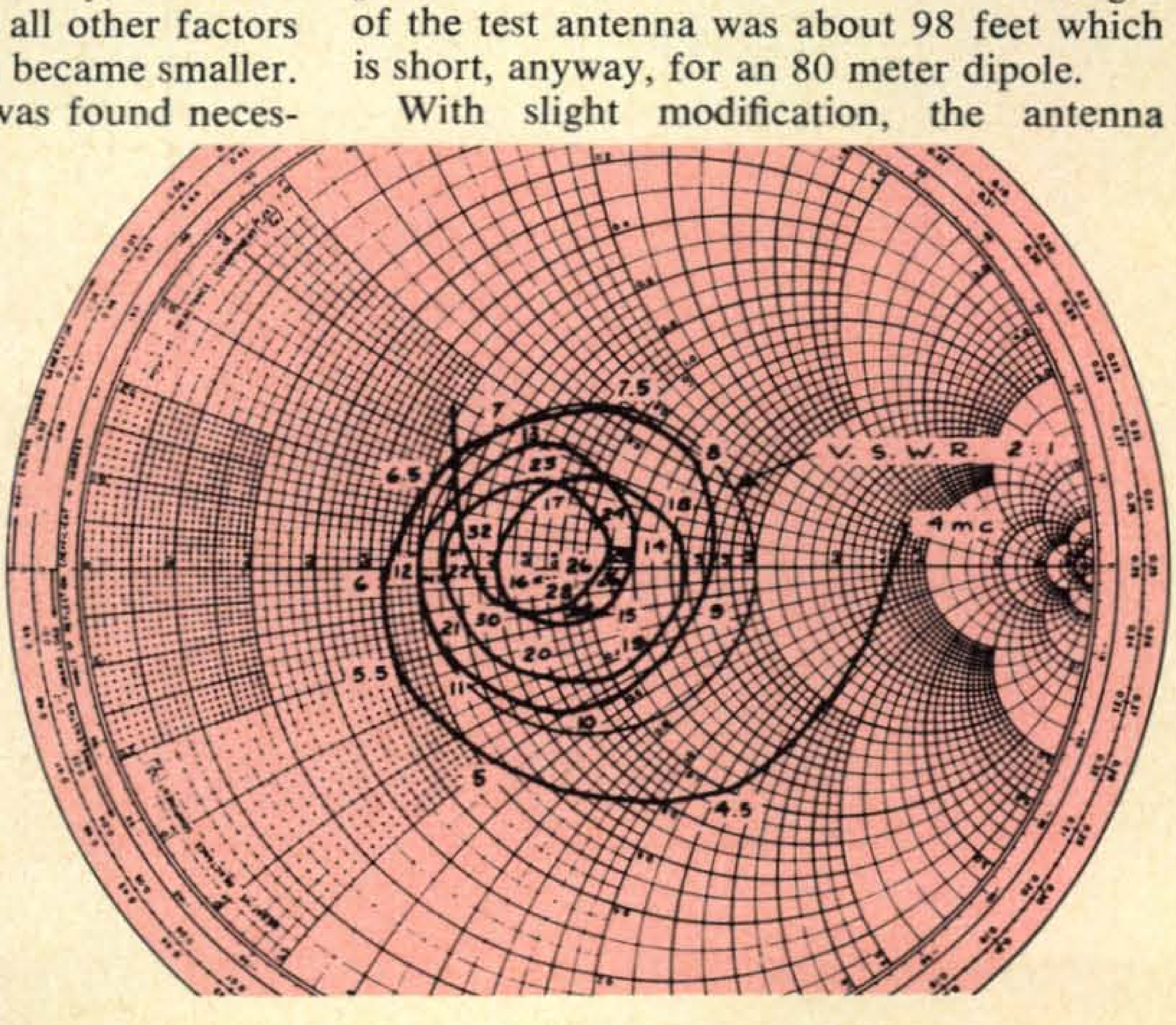
The height of the horizontal antenna above ground was also varied. Generally, the lower the antenna was made, with all other factors held constant, the bandwidth became smaller. A minimum height of ¼λ was found necessary to achieve a reasonably broad bandwidth.

Results

Various combinations of antenna cone configurations were found which would provide reasonably broad-band performance. A cone angle of 20 degrees for the horizontal antenna and for the upper cone of the vertical antenna was found to be the smallest usable which still permitted the rest of the antenna to be reasonably dimensioned. The number of wires in the cage was determined to be 16 since it permitted the 20 degree cone angle, was not too complicated to construct and also produced a convenient input impedance for the antennas. The input impedance of the horizontal antenna was 300 ohms and that of the vertical antenna was 150 to 160 ohms. While these values are not as convenient as a 50 ohm termination, they do permit the use of common baluns, transformers or transmission line devices as matching elements.

Figure 2 shows the dimensions and fig. 3 shows the Smith graph impedance plot for the largest horizontal antenna that was tested. As shown in fig. 3, the s.w.r. remains below 2:1 for all frequencies between 7 and about 33 mc. The s.w.r. rises below 7 mc, although not too rapidly, and reaches 4:1 at 4 mc. Undoubtedly if the antenna dimensions were increased slightly or if it were elevated somewhat higher, the s.w.r. at 4 mc would improve. It should be noted that the total length of the test antenna was about 98 feet which is short, anyway, for an 80 meter dipole.

With slight modification, the antenna



g. 3—Smith Chart impedance plot for antenna with mensions shown in fig. 2.

should work as a design which would cover 80 to 10 meters continuously. Generalized dimensions are given for the antenna in fig. 2 so the design size can be determined for other bands as well. A 40 meter model should do well beyond 10 meters. A 20 meter model will provide 20, 15 and 10 meter service as well as possible 6 meter coverage.

The horizontal radiation pattern of such an antenna is basically the same as that of a dipole broadside to the direction of the wire cage on the lower frequency bands and splitting into lobes on those bands where the antenna is longer than about 1.3λ. The nulls in the radiation pattern aren't as pronounced as those of a single wire dipole, however, and orientation may not be as great a problem as with a normal dipole. Their vertical radiation angle follows that of a normal dipole elevate a similar distance above ground. If the an tenna is elevated ¼λ on the lowest band thi means, generally, higher angle radiation wi prevail on the lower bands and low angl radiation towards the upper frequency limi of the antenna.

Tests were also run on a small size horizon tal dipole as shown in fig. 4 with the Smit chart impedance plot shown in fig. 5. Th dimensions of the antenna were somewha short for 15 meters but if the elements wer extended from 9 to about 11 feet each, th antenna should easily provide continuou coverage from 15 through 6 meters.

The vertical designs showed, generally the same broad-band characteristic as th

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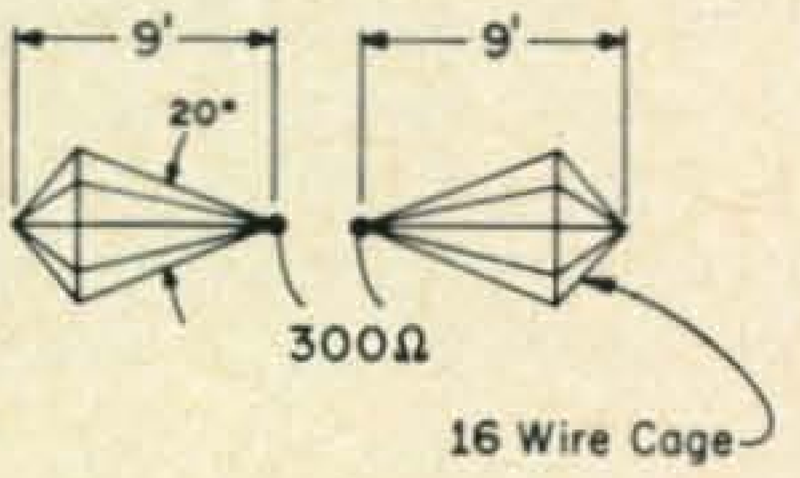

Fig. 4—Dimensions of small conical dipole antenna that can be modified for use from 15 to 6 meters.

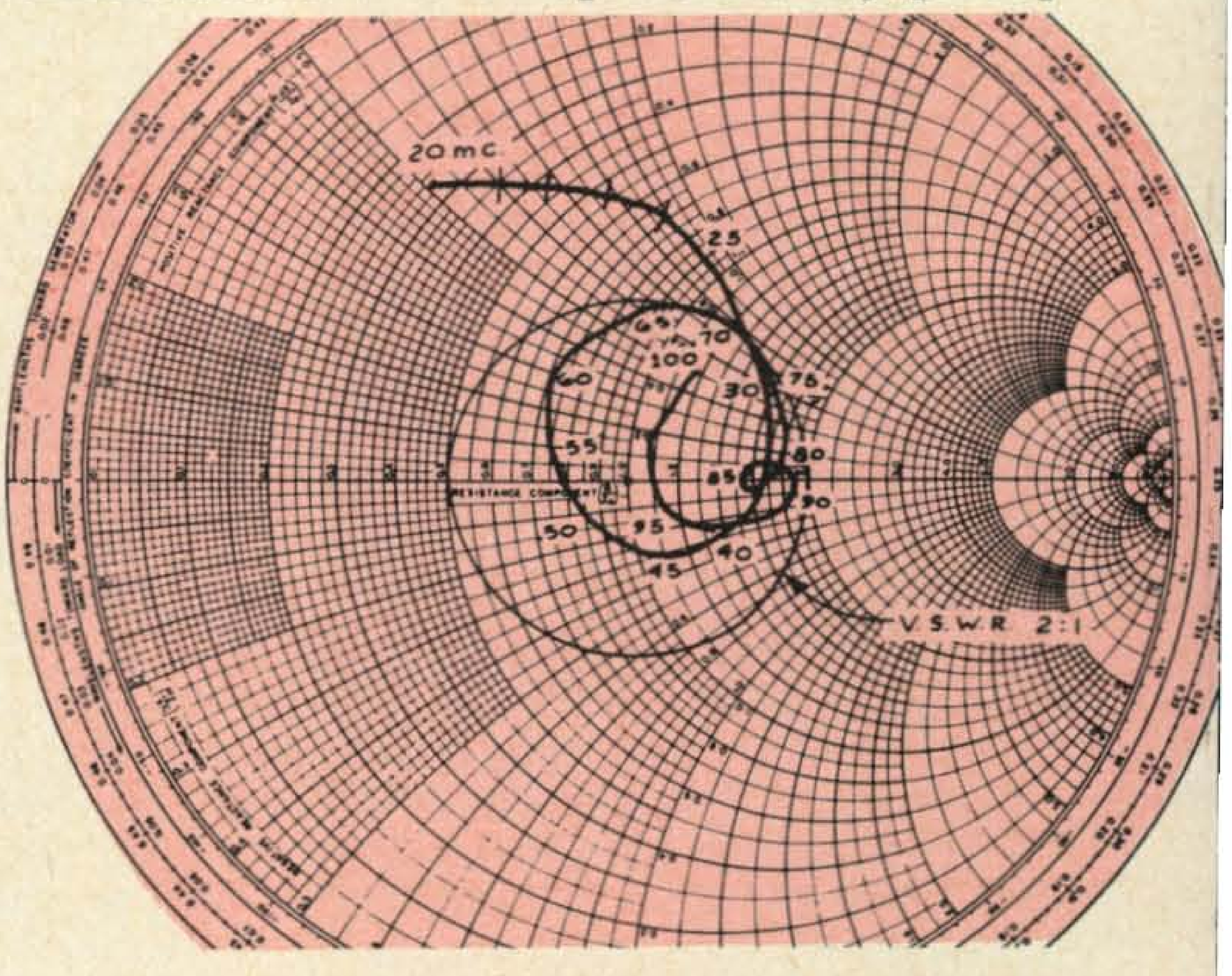

Fig. 5—Impedance plot of antenna of fig. 4. If made slightly longer, coverage of 15 through 6 meters is possible.

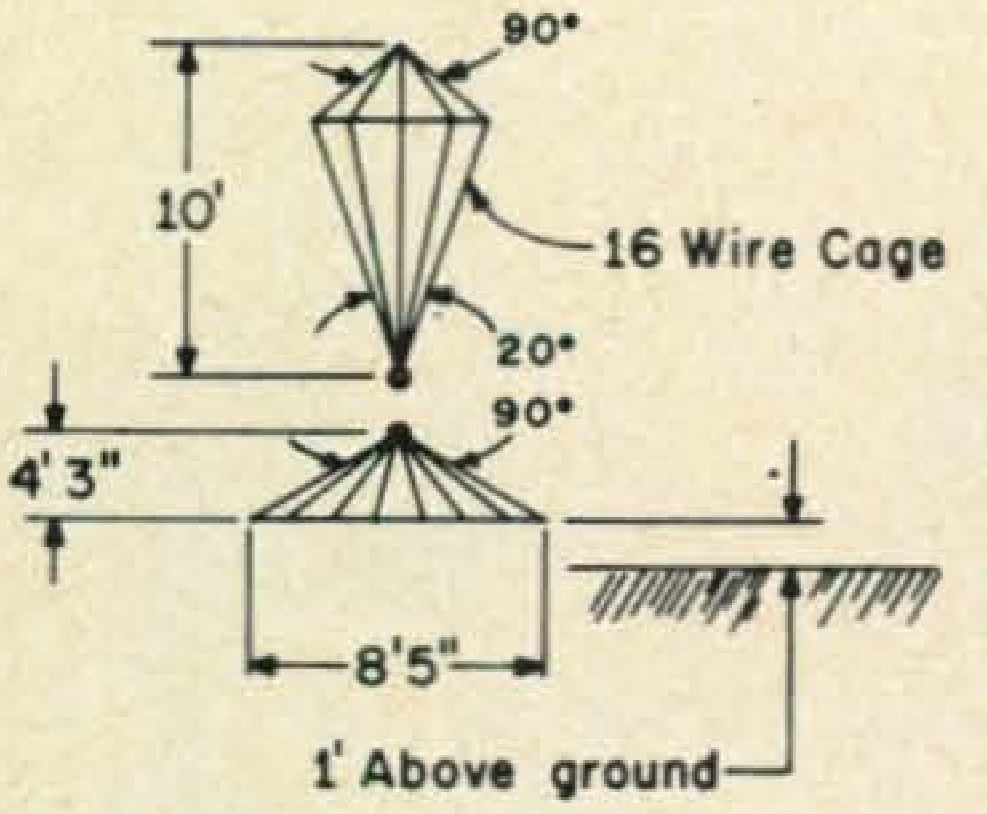

Fig. 6—Dimensions of vertical antenna.

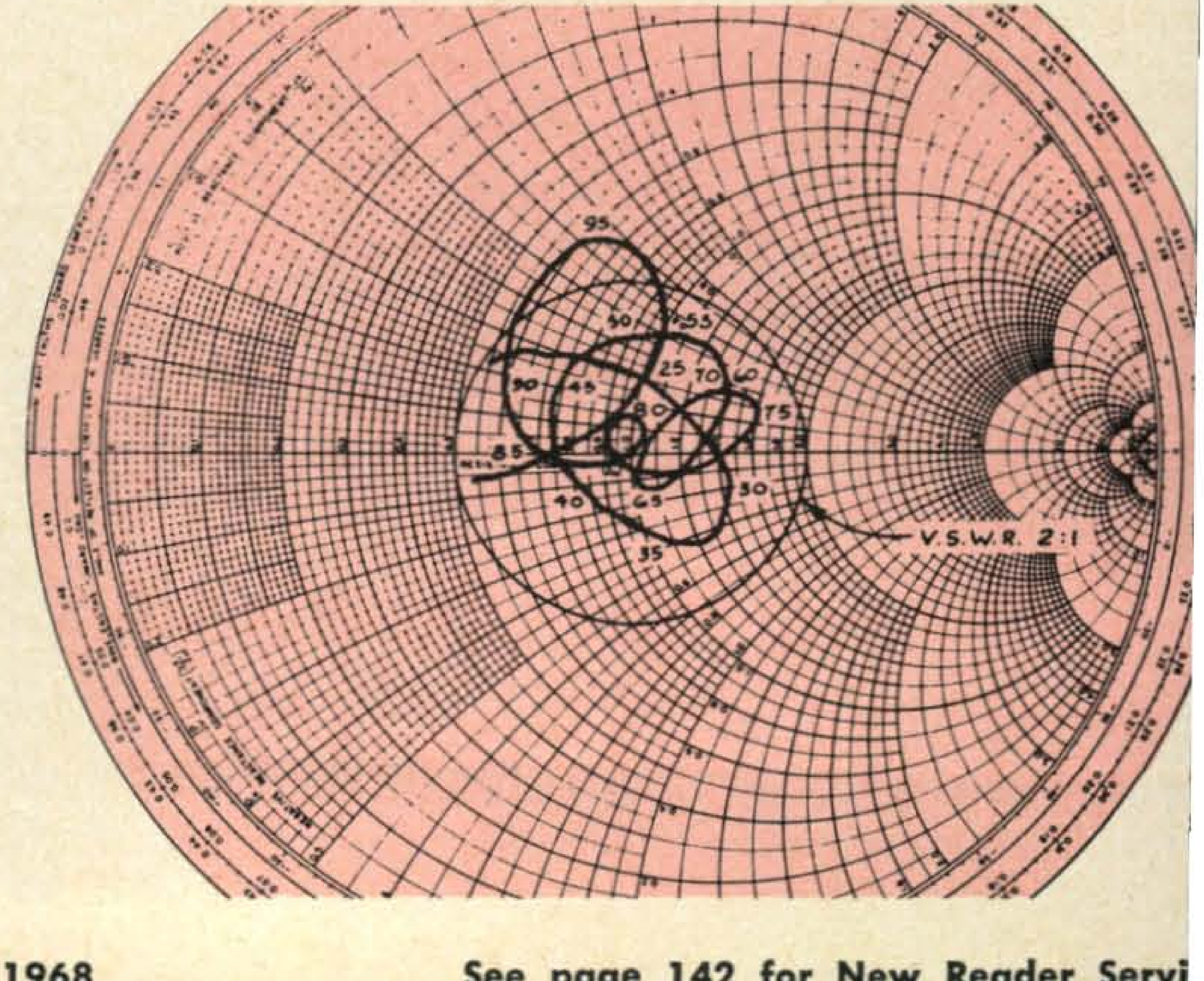

Fig. 7—Impedance plot for antenna of fig. 6.

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horizontal types. Figure 6 gives the dimensions of one model that should be effective from 15 through 2 meters as shown by the Smith graph plot of fig. 7. Similar antennas can be dimensioned to cover other bands. The only problem with the vertical one is something common to all similar types and that is that the radiation angle increases with frequency. So while the antenna gives fine low radiation angle omnidirectional coverage on the lower frequency bands, it does not do this on the higher bands where it is equally desired.

Placing a reflector behind the vertical antenna with about 0.12λ separation produced about 6 db gain. However, because the reflector separation remained fixed as the antenna was operated on different frequencies, the bandwidth of the antenna became greatly restricted. The input impedance went through large variations with frequency as did the radiation pattern with the front-to-back ratio becoming very poor at the upper frequency limit of the vertical antenna. Because of these complications, no practical model for a broad-band directive vertical antenna could be developed.

Conclusions

The experiments conducted by the RCAF were probably the most extensive yet done on the high-frequency application of conical antennas. While not all the data developed has been presented here, the author believes that enough has been given to enable anyone interested in this type of antenna to plan a design to suit his needs. In spite of its somewhat greater constructional complexity, the broad band conical antenna offers many advantages of narrow-band antennas with separate transmission lines, switching arrangements, *etc*,, for general purpose amateur usage. ■

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equipment. Aside from different basic means of circuit interruption, there are also protection devices available which operate on the same principles as discussed in this article but which have added features such a flags or blinking lights to indicate an open circuit. However, the basic fuse or breaker action must be chosen using the same considerations outlined in this article. ■

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