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STUDY AND INVESTIGATION OF A UHF-VHF ANTENNA

by

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ABSTRACT

Construction of final models of the loaded rectangular cavity slot antennas was completed, final tests were conducted, and delivery made.

Experimental results show the lower cutoff frequency of the equiangular cavity-backed spiral may be reduced by a factor of 2 with ferrite loading. Broad-banding possibilities are indicated.

Preliminary results on the cavity-backed log conical spiral indicate the antenna resonant frequency can be reduced by ferrite loading by a factor of 2.

1. REPORTS, TRAVEL, AND VISITORS

On July 9, 10 and 11, 1963, Dr. John A. M. Lyon attended the 1963 International Symposium on Space Telecommunications at Boulder Colorado. During this Symposium he discussed with Mr. Edwin M. Turner, Chief Antenna Section, ARDC, WPAFB, the use of ferrite antennas for space vehicles. Additions to the future efforts on this project were outlined.

During this period no reports were issued, and no one visited the project.

2. FACTUAL DATA

2.1 Rectangular Cavity Slot Antennas

Construction of final models of the solid ferrite and solid dielectric antennas was completed. Final models of the air loaded slot, ferrite powder, loaded slot, and solid ferrite loaded slot were delivered. The dielectric loaded slot is scheduled for delivery by October 1, 1963.

Table 1 shows the relative characteristics of the four antennas. The solid ferrite loaded slot was the smallest and the dielectric loaded slot the most efficient, although it had the narrowest bandwidth. VSWR (voltage standing wave ratio) curves for the slot antennas are shown in Figures 1, 2, 3, and 4.

2.2 Equiangular Spiral Antenna

The VSWR of the cavity backed equiangular spiral shown in Figure 5(a) was measured both with and without ferrite powder loading. The feed, shown in Figure 5(b), is of the "infinite balun" type used by Dyson.* Standard 50 ohm coaxial cable was used for the feed construction.

The VSWR for the simplest loading condition is shown in Figure 6. The cavity was fully loaded with the ferrite powder. A thin layer of powder was also placed on top of the spiral. The fully loaded case produced a reduction of the lower cutoff frequency by a factor of 2.

Figure 7 shows that approximately the same result can be obtained by loading only one arm of the spiral. This method has the advantage of using less ferrite material.

Figure 8 shows the response of the bi-directional spiral without a cavity in both the loaded and unloaded conditions. The curves have the same general shape as the cavity backed spiral. Thus the cavity introduces little basic deterioration of the antenna response.

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* J. D. Dyson, "The Equiangular Spiral Antenna," IRE Transactions on Antennas and Propagation, April 1959, pp. 181-187.

COMPARISON OF RECTANGULAR SLOT ANTENNAS

	Size	Vol.	BW with Flange VSWR=3.0	BW with Flange VSWR=6.0	BW-No Flange VSWR=3.0	BW-No Flange VSWR=6.0	Eff.	Dir.	Wt.
Air loaded	30" x 7-1/2" x 10	2250 cu.in.			64 mc	90 mc	90 percent	5.8	25-3/4 lbs.
Power loaded	12" x 3" x 4"	144 cu.in.	22 mc	50 mc	20 mc	36 mc	65 percent	5.0	16-3/4 lbs.
Solid loaded	5" x 2" 1-1/2"	15 cu.in	19 mc	34 mc	19 mc	32 mc	30 percent	5.0	3.6 lbs.
Dielectric loaded	12" x 3" x 4"	144 cu.in	10 mc	18 mc	8 mc	16 mc	85 percent	5.0	14-1/2 lbs.

Table 1

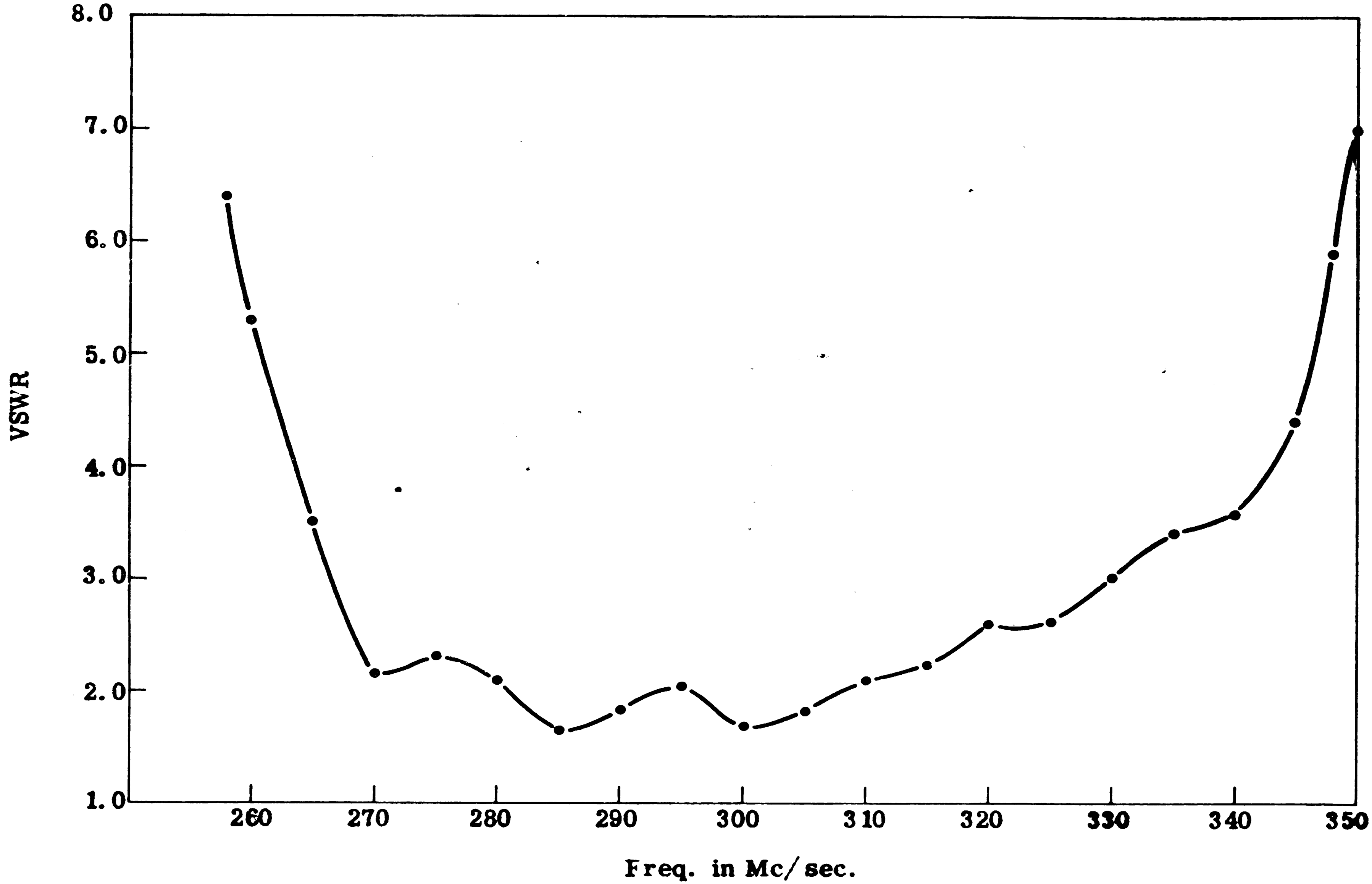

Fig. 1. VSWR for air filled rectangular slot antenna

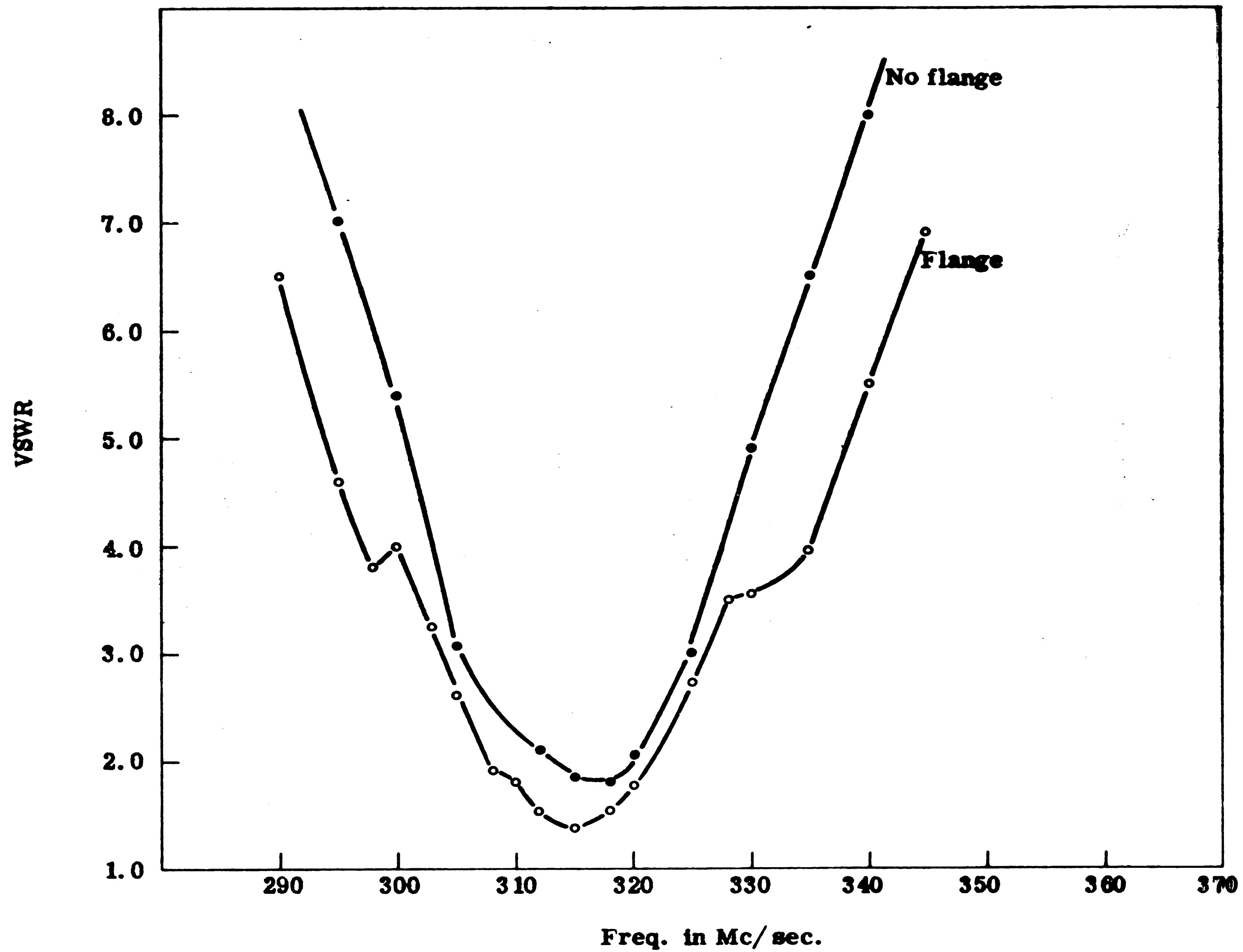

Fig. 2. VSWR for ferrite powder filled rectangular slot antenna

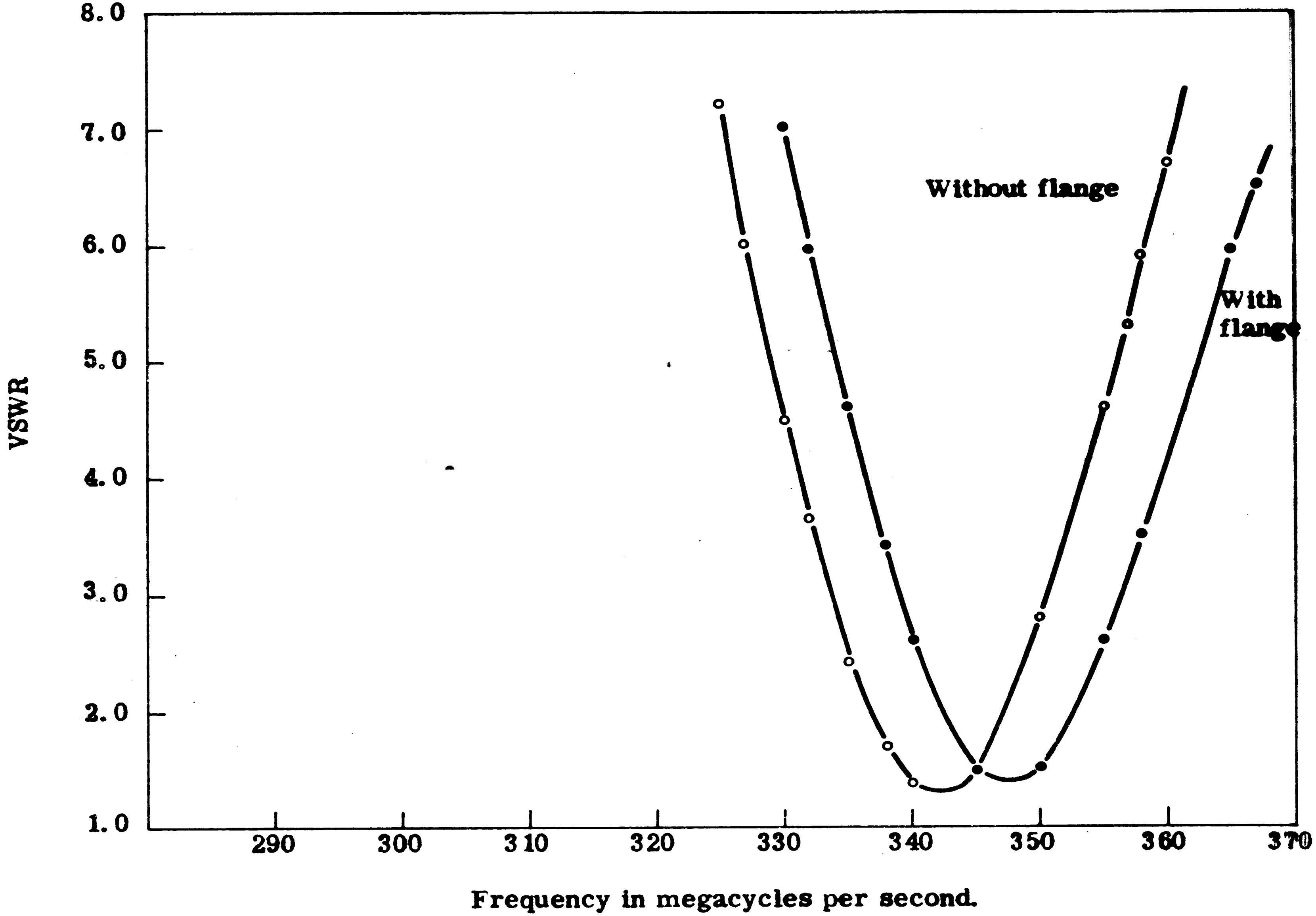

Fig. 3. VSWR for solid ferrite filled rectangular slot antenna

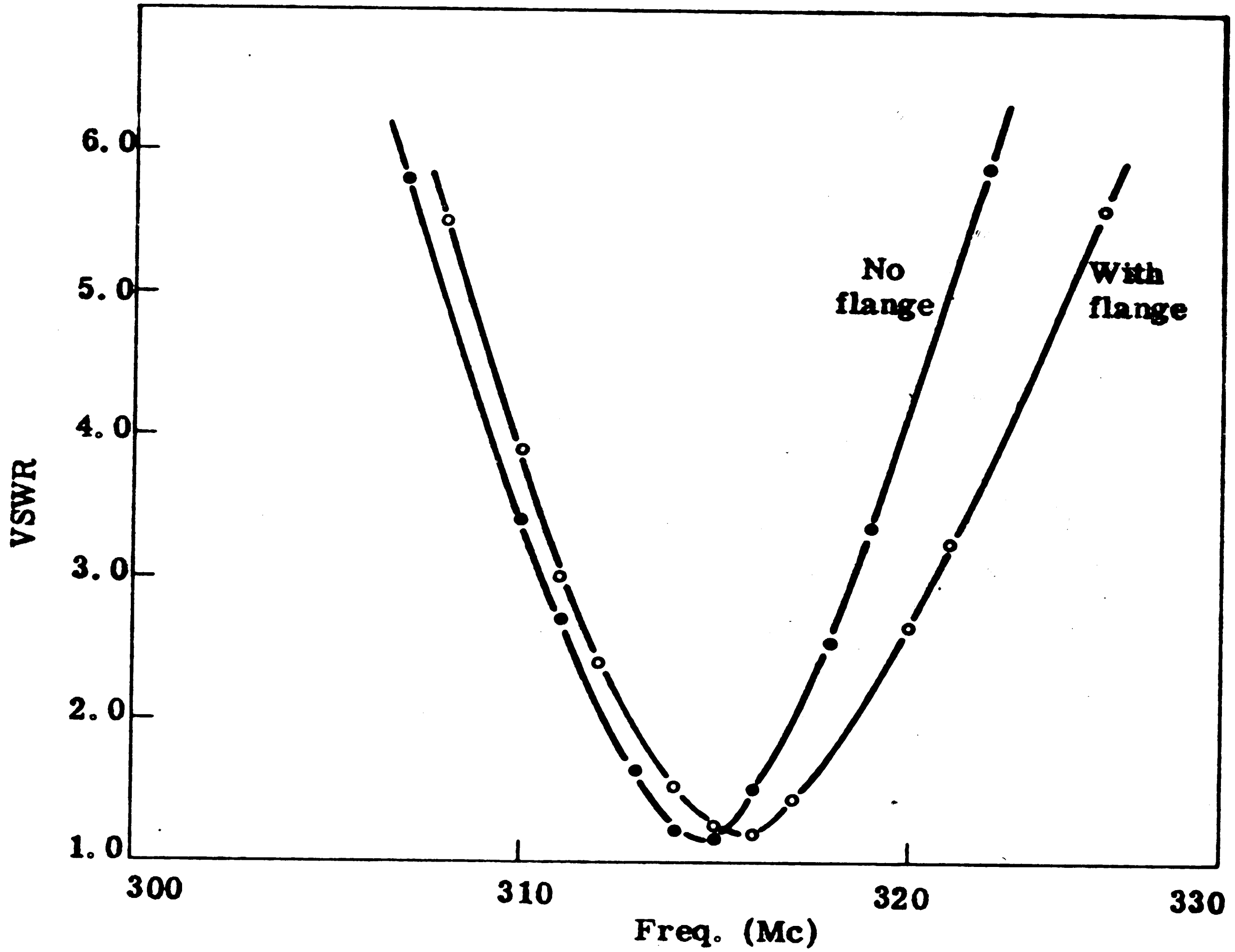

Fig. 4 VSWR for dielectric loaded rectangular slot antenna

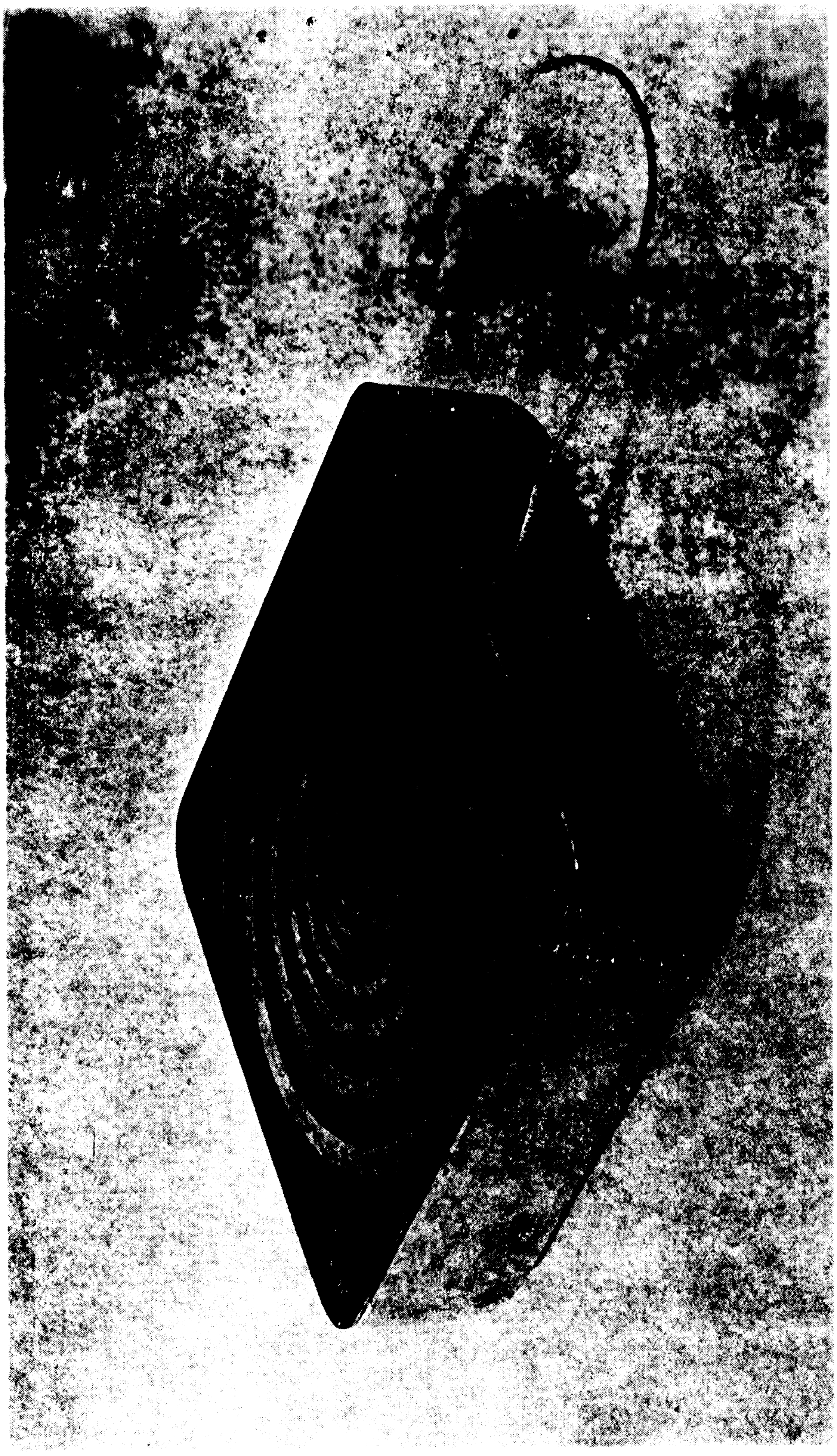

Fig. 5(a) Equiangular spiral

Fig. 5(b) Construction showing feed and loading

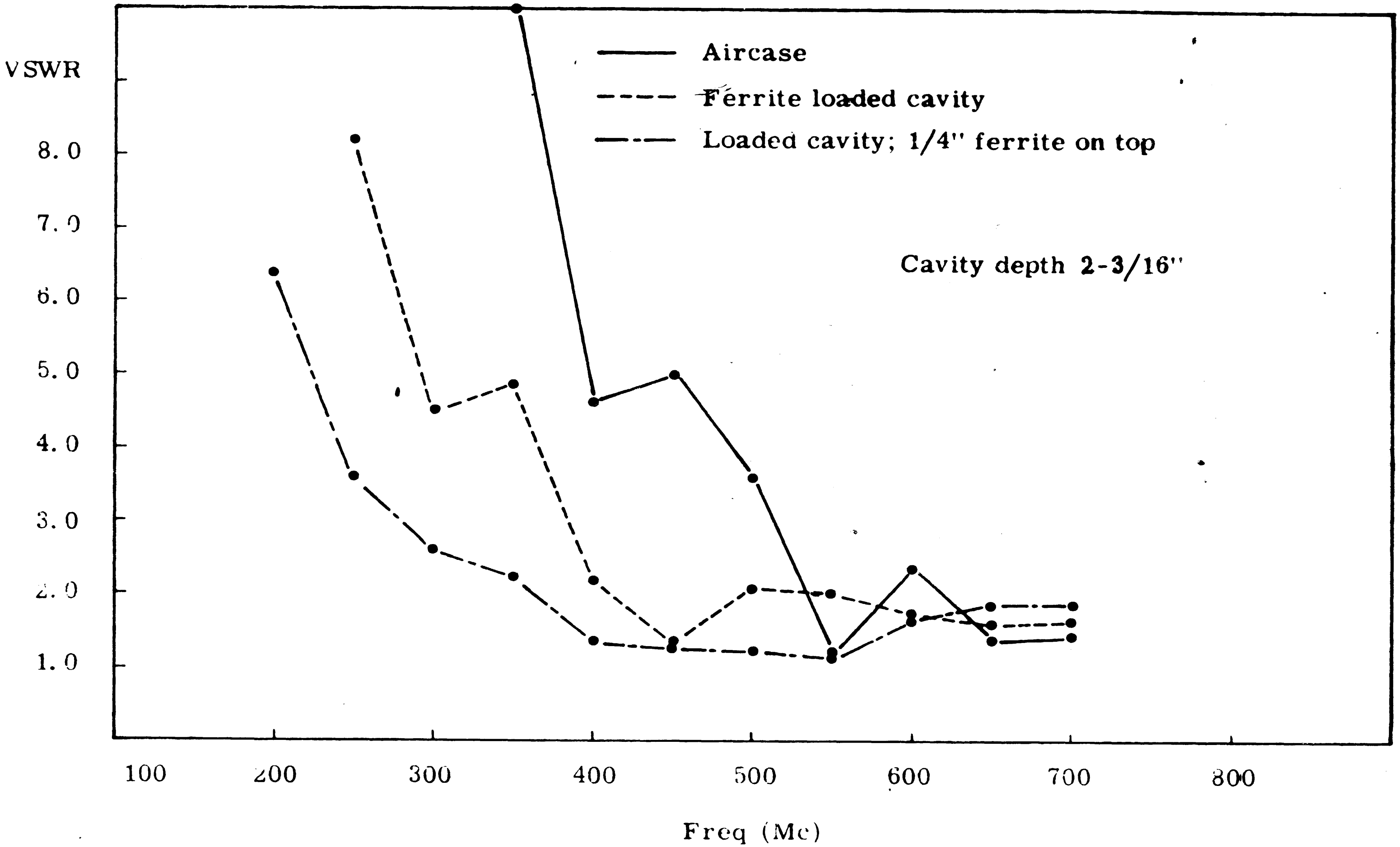

Fig. 6. VSWR for fully-loaded spiral

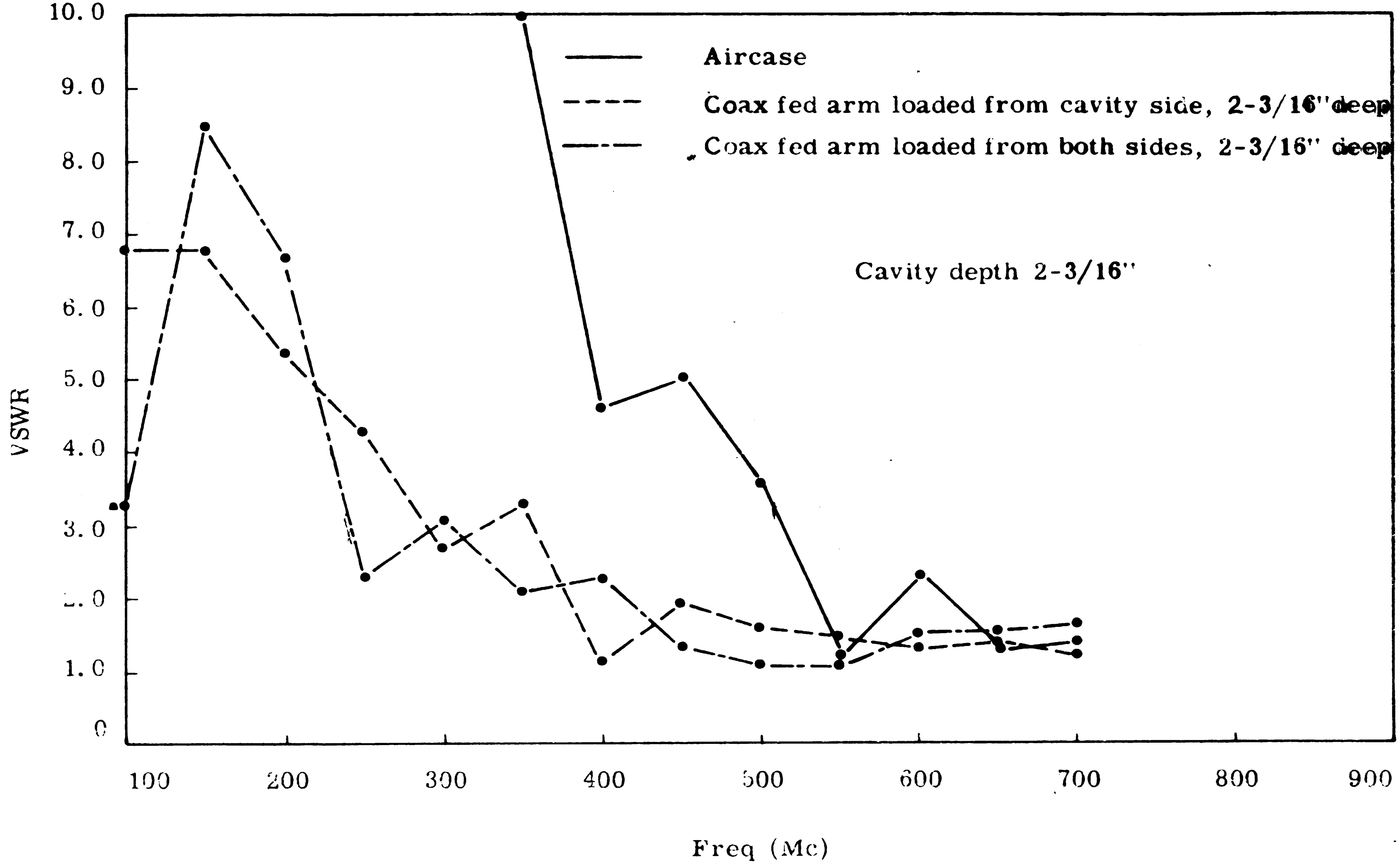

Fig. 7. VSWR for single-filar loading

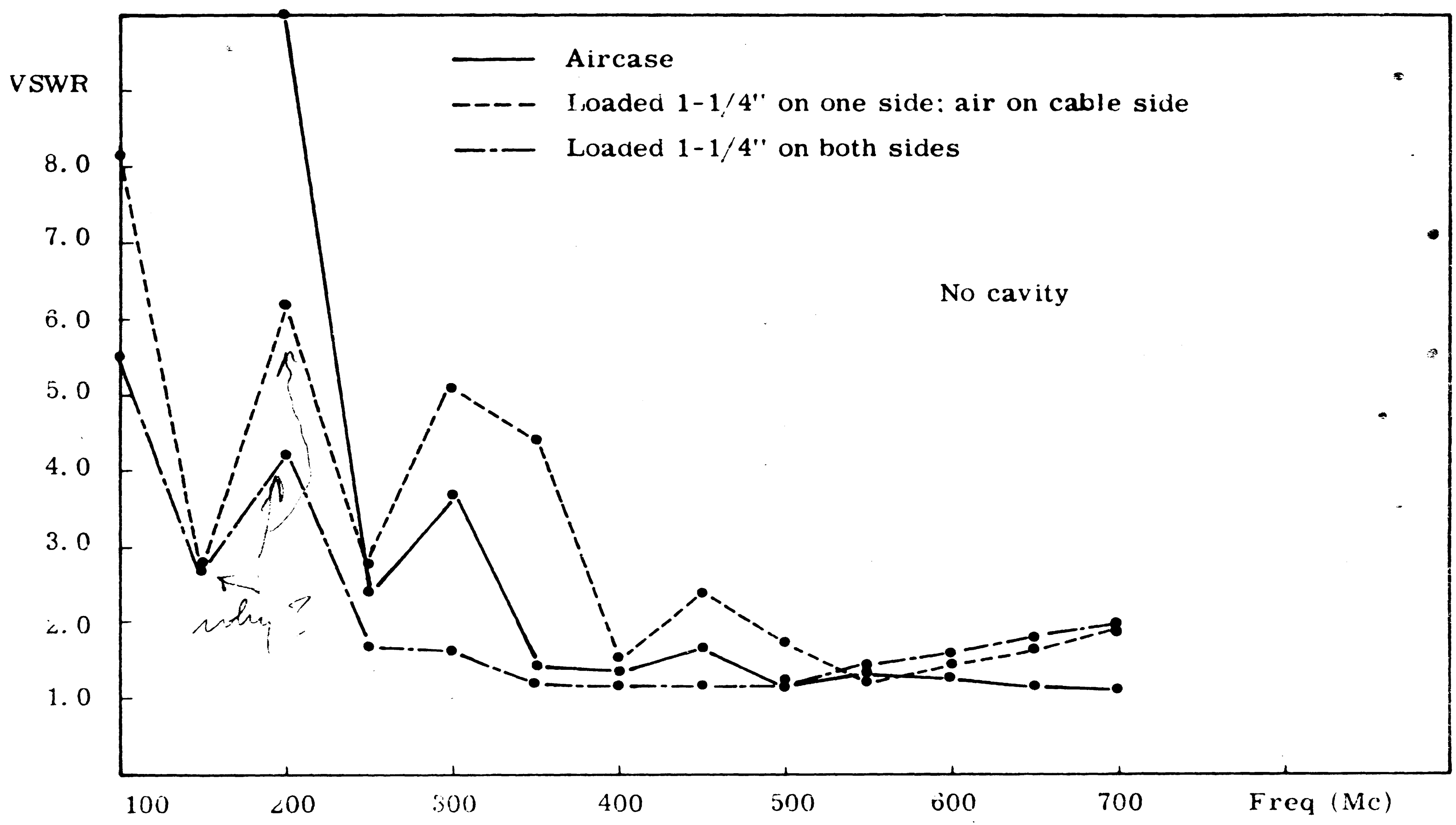

Fig. 8. VSWR for loaded spiral with no cavity

Preliminary efficiency measurements for the loaded spiral indicate an efficiency of about 80 percent. Efficiencies of unloaded spirals are typically greater than 90 percent.

Although miniaturization of the spiral has been achieved, the introduction of the ferrite powder introduces a narrow-banding effect. This is due to the fact that the magnetic Q of the powder becomes small above 700 mc. This causes the efficiency of the spiral to fall above 700 mc. This is a superficial effect, however, since it is a function of the type of material used. It is expected that with the development of wideband, high Q ferrites moderate widebanding of the spiral antenna can be achieved; some reduction in efficiency may have to be accepted.

2.3 Log Conical Spiral Antenna

Preliminary tests have been made on the log conical spiral antennas shown in Figures 9(a) and 9(b), both in air and embedded in ferrite powder. For testing purposes two models were constructed according to designs based upon Dyson's work.* The physical dimensions of the antenna were 4 - 7/8 inches in base diameter and 11 - 1/4 inches in height. A 93 ohm cable (RG62/U) and a 50 ohm cable (RG 141/U) were separately used as radiators. An apex angle of 10 degrees with a pitch angle of 73 degrees was chosen in order to compare with the known results with the same parameters. The cone was made with balsa wood which has a dielectric constant close to that of air. The choice of a solid base for the antenna was made due to the limited amount of ferrite powder available for the experiment. The cavity backing was an aluminum casting of cylindrical form with 5 - 1/2 inches in the base diameter and 15 inches in height.

VSWR was measured as a function of frequency for the antenna backed with an air-filled cavity and a ferrite-filled cavity. The results obtained

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* John D. Dyson, "The Unidirectional Equiangular Spiral Antenna," IRE Transactions on Antenna and Propagation, p. 329, October 1959.

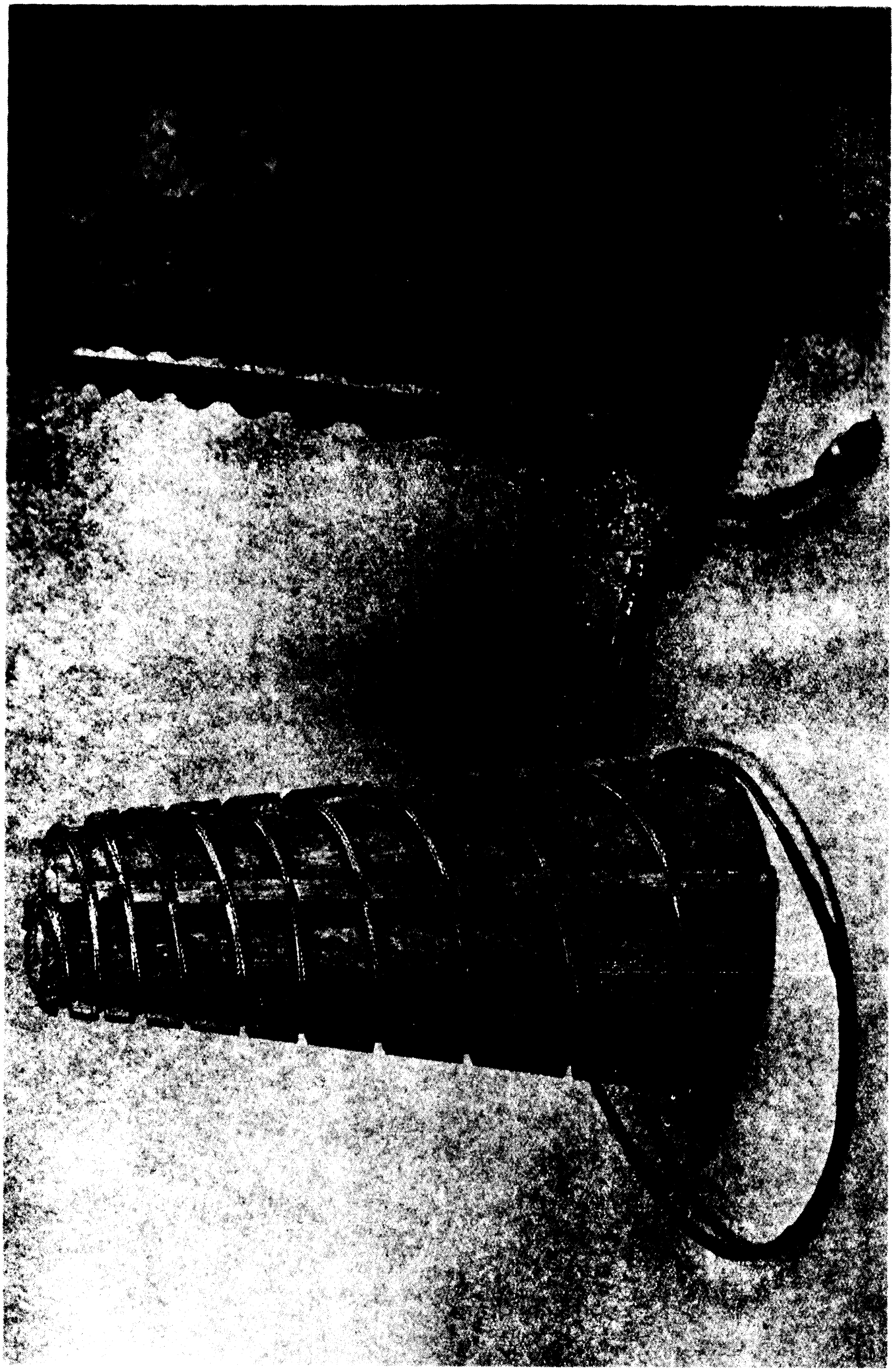

Fig. 9(a) Models of log conical antennas

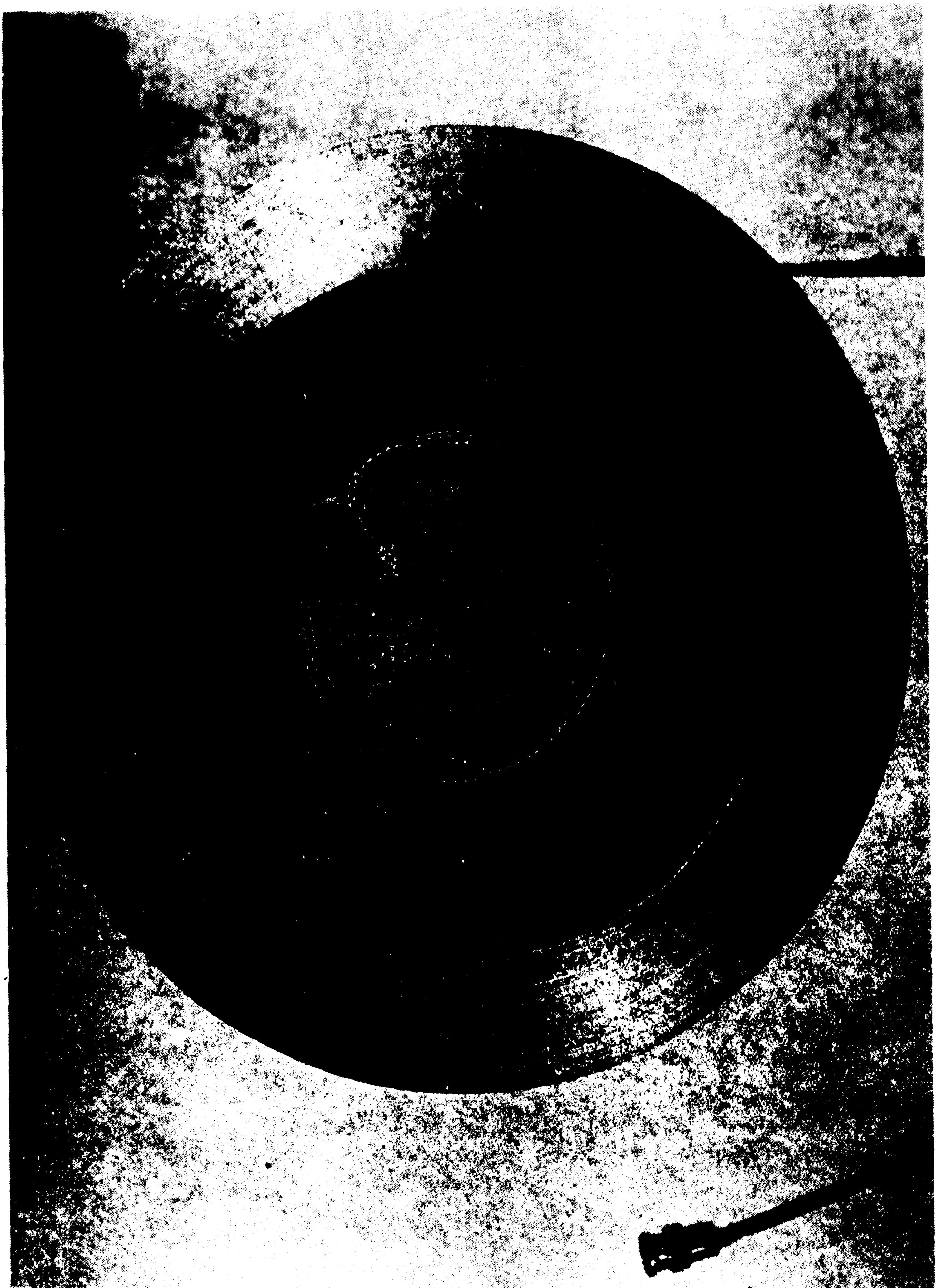

Fig. 9(b) Cavity-back log conical antenna from the measurements are given in Figure 10. Due to the limited amount of available information on construction details, the design of the antenna was not sufficiently close to produce results comparable to published data. However, the effect of ferrite powder on the low frequency cutoff was encouraging.

3. FUTURE EFFORT

It appears that considerable time should be devoted in the future to:

1. Power limitations of ferrite filled antennas
2. Magnetic bias of ferrite antennas for improvement of frequency bandwidth
3. Extent of validity of reciprocity relations
4. Assessment of possibilities of ferrite changing mode of operation
5. Assessment of possibilities of ferrite being used to achieve new and different radiation patterns
6. Extension of work to frequencies of 100 Mc and below; reduced efficiency may be tolerable.

4. SUMMARY AND CONCLUSIONS

Three final models of the rectangular cavity slot antenna have been delivered and the fourth has been constructed and is being readied for delivery.

Experiments on the equiangular cavity-backed spiral show a decrease in lower cutoff frequency by a factor of 2. Efficiency seems to be about 80 percent as compared to over 90 percent for the unloaded case. Broadbanding possibilities are indicated.

Preliminary results from the study of the cavity backed log conical spiral indicates miniaturization possibilities. Further modifications in design will be made.

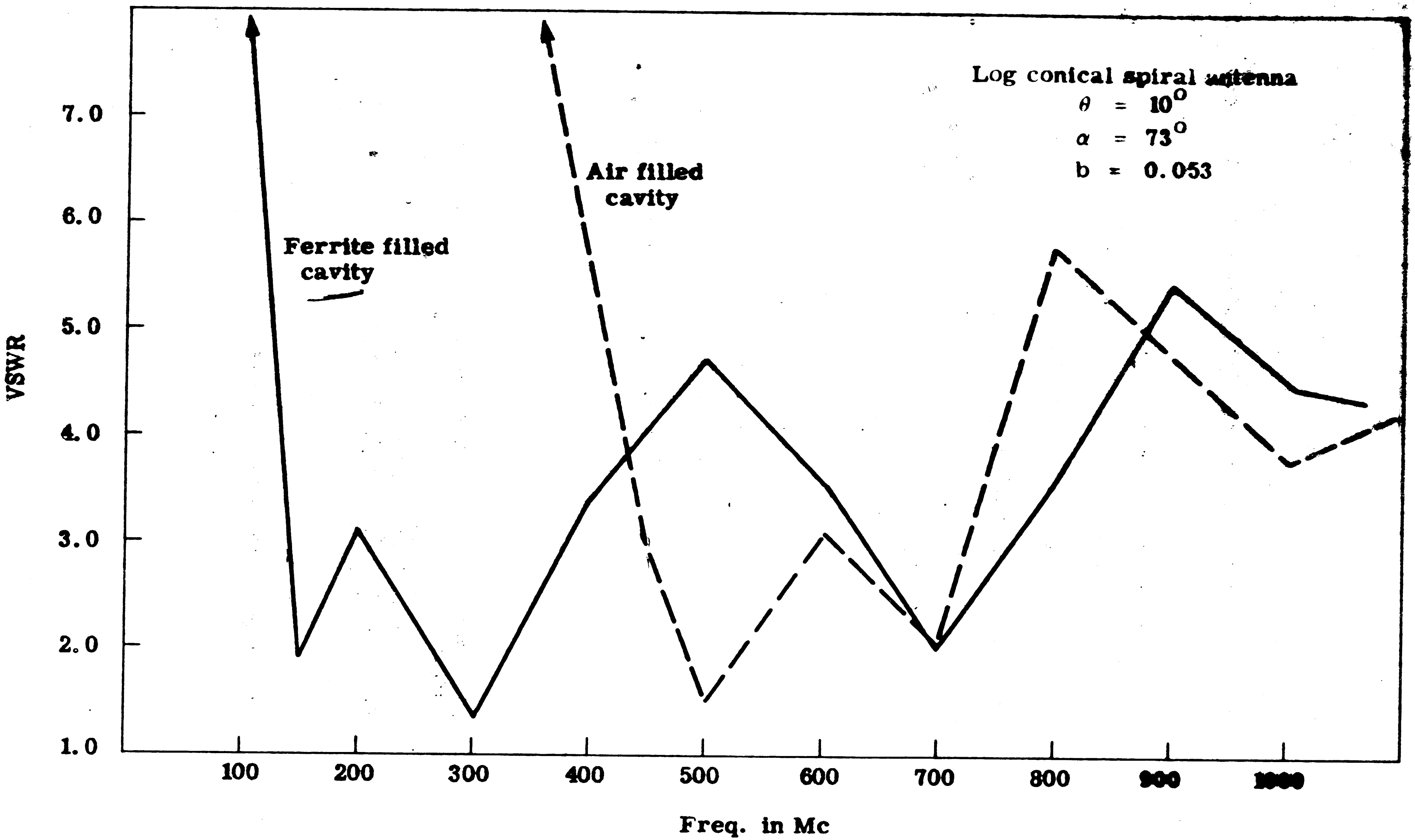

Fig. 10. VSWR for log conical spiral antenna