THE UNIVERSITY OF MICHIGAN

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STUDY AND INVESTIGATION OF A UHF-VHF ANTENNA

Bimonthly Report No. 9

May through 30 June 1964

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TABLE OF CONTENTS

1. REPORTS, TRAVELS AND VISITORS

During this period there were no official visits of project personnel. The project was visited on 22 April 1964 by Messrs. E F. Erickson and J K. Kelly of HRB-Singer, Inc., of State College, Pennsylvania. On 30 June 1964, Mr. Larry Perenic of General Precision, Inc., Little Falls, New Jersey visited this activity. All of these individuals had an interest in ferrite antennas and the trips were made at the suggestion of Mr. E. M. Turner of Wright-Patterson Air Force Base.

2. PERIOD ACTIVITIES

2.1 Equiangular Spiral

Additional experiments were performed on the equiangular spiral which was mounted on the apex of a Styrofoam cone. This mounting allowed the equiangular spiral antenna to be centered in a cylindrical cavity flush with the flanges of the cavity. The space between the Styrofoam cone and the wall of the metal cavity was, in the ferrite loading situation, filled with powdered ferrite as shown in the insert of Fig. 1. Figure 1 depicts the VSWR situation for this antenna with and without ferrite loading. Figure 2 shows in several parts the various radiation patterns taken for the equiangular spiral with and without ferrite loading. The range of frequency used for these pattern studies was 300 - 900 Mc. In taking the patterns an APR-4 receiver was used. The tuning unit for frequencies below 300 Mc was not available at the time these observations were made. However, this tuning unit will be used in the near future for additional pattern measurements.

2.2 Ferrite Loaded Rectangular Slot

Detailed studies on the utilization of magnetic fields for shifting the operating frequency band were undertaken. The inset in Fig. 3 shows the physical arrangement of the magnet and the ferrite-filled slot cavity. The

curves in Fig. 3 illustrate the amount of shift possible for two values of field intensity. It appears that the primary consideration in the shift of center frequency has been the change in the incremental permeability corresponding to the use of the permanent magnet. It was also observed that other orientations of the magnet could be used with a shift in frequency in the same direction as shown in the curves of Fig. 3. The reduced value of incremental permeability, resulting in each case, accounts for the observed direction of shift; in every case, the shift in frequency was upward as a result of the application of the magnet. Corresponding to the three cases shown in Fig. 3, several radiation patterns were taken. These are shown in Fig. 4 and it is interesting to see that there is very little change from the radiation pattern of the basic ferrite loaded slot. Some minor variations in the side lobes are observed.

Efficiency measurements were made using the ferrite-filled slot with solid rods of ferrite as the filling. The application of magnetic bias in the manner shown in Fig. 4 has resulted in the efficiency dropping from 30 percent to approximately 25 percent. This small drop in efficiency using this type of magnetic control was considered very encouraging.

2.3 Log Conical Spiral Antenna

The studies commenced upon this type of antenna as recorded in the bimonthly report dated May 1964 have been continued. In this latter report VSWR curves were shown. In Fig. 5 of the present report, a number of patterns taken on the log conical spiral antenna with and without loading are shown. The inset in Fig. 5a shows the arrangement of this antenna in a cavity with provision for use with and without ferrite loading. The result of pattern studies has been very encouraging. One of the remarkable aspects of these studies has been that the use of ferrite has lowered the low frequency limit on this antenna; furthermore, this lowering has been accomplished while keeping the antenna operating in the desired axial beam mode. It is recognized

that antennas of this type degenerate at the low frequency end by operating in a split beam mode at a still lower frequency. Although efficiency measurements have not been made on this antenna. The pattern measurement indicates that a reasonable efficiency may be anticipated.

The possibility of controlling the mode of operation of the log conical spiral is very intriguing especially from the standpoint of retro-directive antenna arrays. For instance, it is possible to use a log conical antenna for the reception of a low frequency signal in the split beam mode. The received signal might then pass through a frequency mixing system and the new higher frequency could be fed back to the same antenna now operating in the axial mode. This means that a log conical spiral antenna can be made to be a useful antenna element operating on a semi-active or semi-passive basis. Flexibility could be added to such an operation through ferrite loading and possibly by the use of magnetic bias.

3 FUTURE RESEARCH EFFORT

3.1 Equiangular Spiral Antenna

It now appears that the remaining important work on this type of antenna is to make efficiency measurements. Since the antenna utilizes circular polarization, the initial attempt to make good efficiency measurements will be one which makes use of the field intensity meter. Then the pattern will be assumed to have axial symmetry and an integration performed.

3.2 Ferrite Loaded Rectangular Slot

The next report will concentrate upon additional tests utilizing magnetic bias control. The influence of the magnitude and direction of the magnetic field upon the radiation pattern will be an object of these studies.

3.3 Log Conical Spiral Antenna

There remains the need for making adequate efficiency measurements for this circularly polarized antenna also. It is hoped that these measurements can be made in the next report period.

3.4 Helical Antenna

Studies on the use of a helical antenna having solid ferrite rods as a core have only just started. It is anticipated that this work will be reported in detail in the next report.

3.5 Electric Bias Study

Some time was spent investigating electric bias which would provide electric polarization and hopefully would provide some control of the center frequency of the operating band of an antenna because of the nonlinear permittivity of the material. However, preliminary studies and readings have shown that the amount of nonlinearity of permittivity which can be readily obtained is extremely small. There is, therefore, very real doubt as to the practicality of electric bias as a means of control. Further studies in this area are, therefore, not contemplated.

4 SUMMARY AND CONCLUSIONS

During this report period, the most encouraging result was that found for the log conical antenna wherein the use of ferrite loading inhibited the biaxial mode operation of the antenna at the low frequency end. Because of this, it is possible to say that ferrite has truly extended the useful range of operation of this type of antenna utilizing the desired axial mode.

Further encouraging results were witnessed with respect to the rectangular slot filled with ferrite and utilizing magnetic bias. Certainly all aspects of magnetic

bias control have not been studied in detail as yet. However, the preliminary results show that it is possible to shift upward the center frequency of the operating band through the use of magnetic bias. The deterioration of efficiency is considered a tolerable one in view of the possibilities of operating over a wider frequency band.

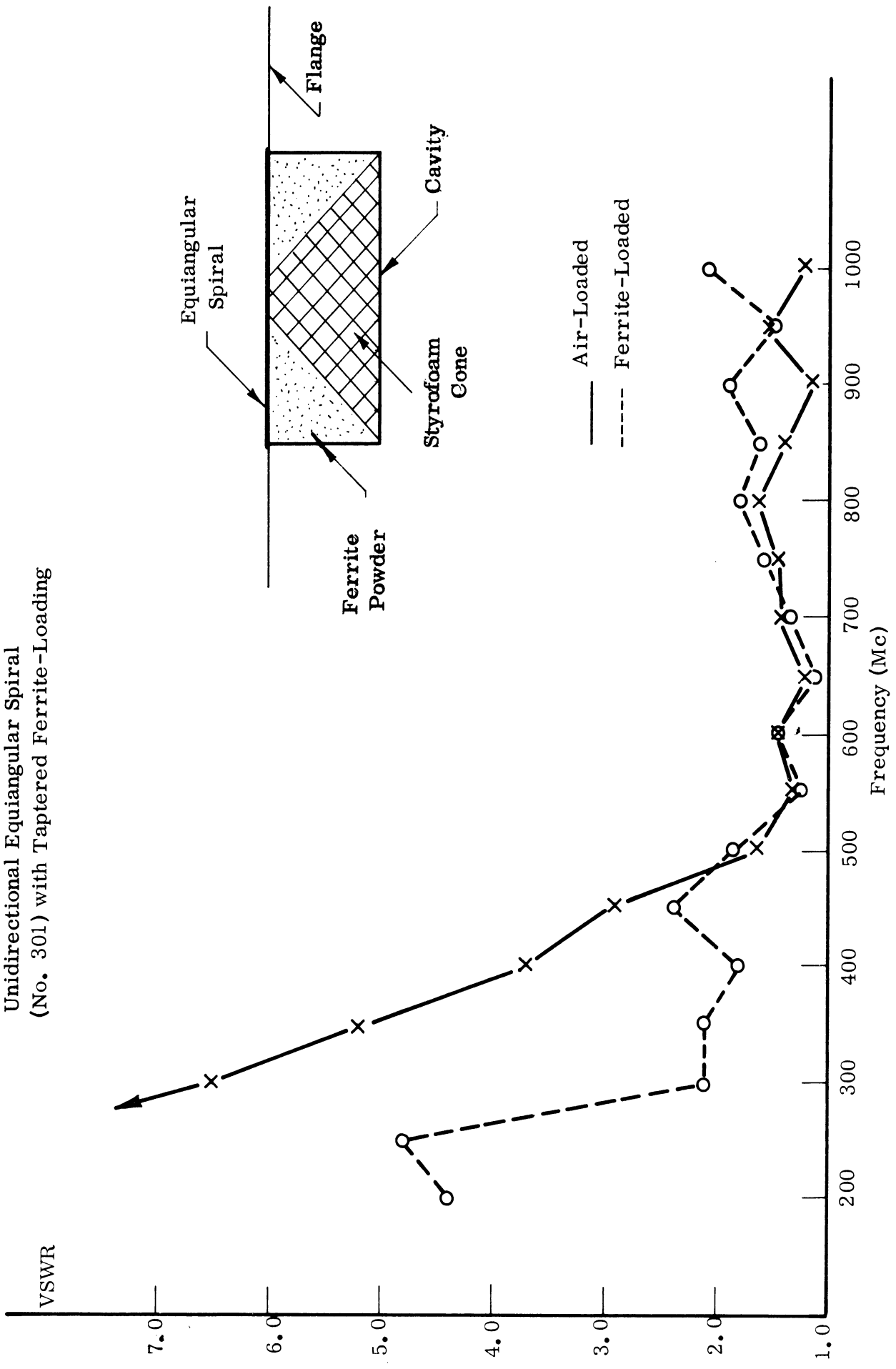

Unidirectional Equiangular Spiral
(No. 301) with Taptered Ferrite-Loading
VSWR
7.0
6.0
5.0
4.0
3.0
2.0
1.0
200
300
400
500
600
700
800
900
1000
Frequency (Mc)
Air-Loaded
Ferrite-Loaded
Flange
Cavity
Equiangular Spiral
Styrofoam Cone
Ferrite Powder

FIG. 1

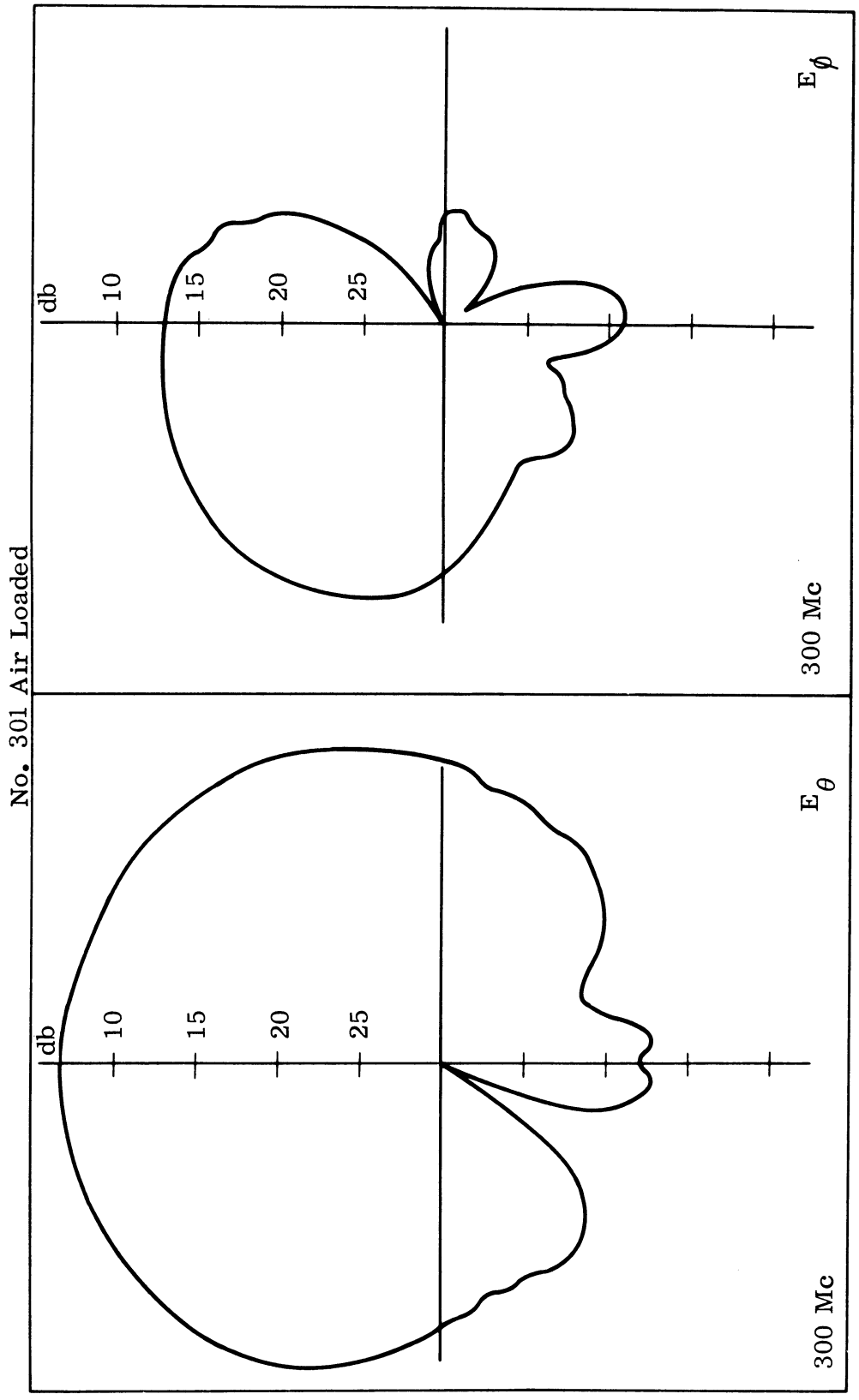

No. 301 Air Loaded
db
10
15
20
25
E_ϕ
300 Mc
db
10
15
20
25
E_θ
300 Mc

FIG. 2a

No. 301 Air Loaded

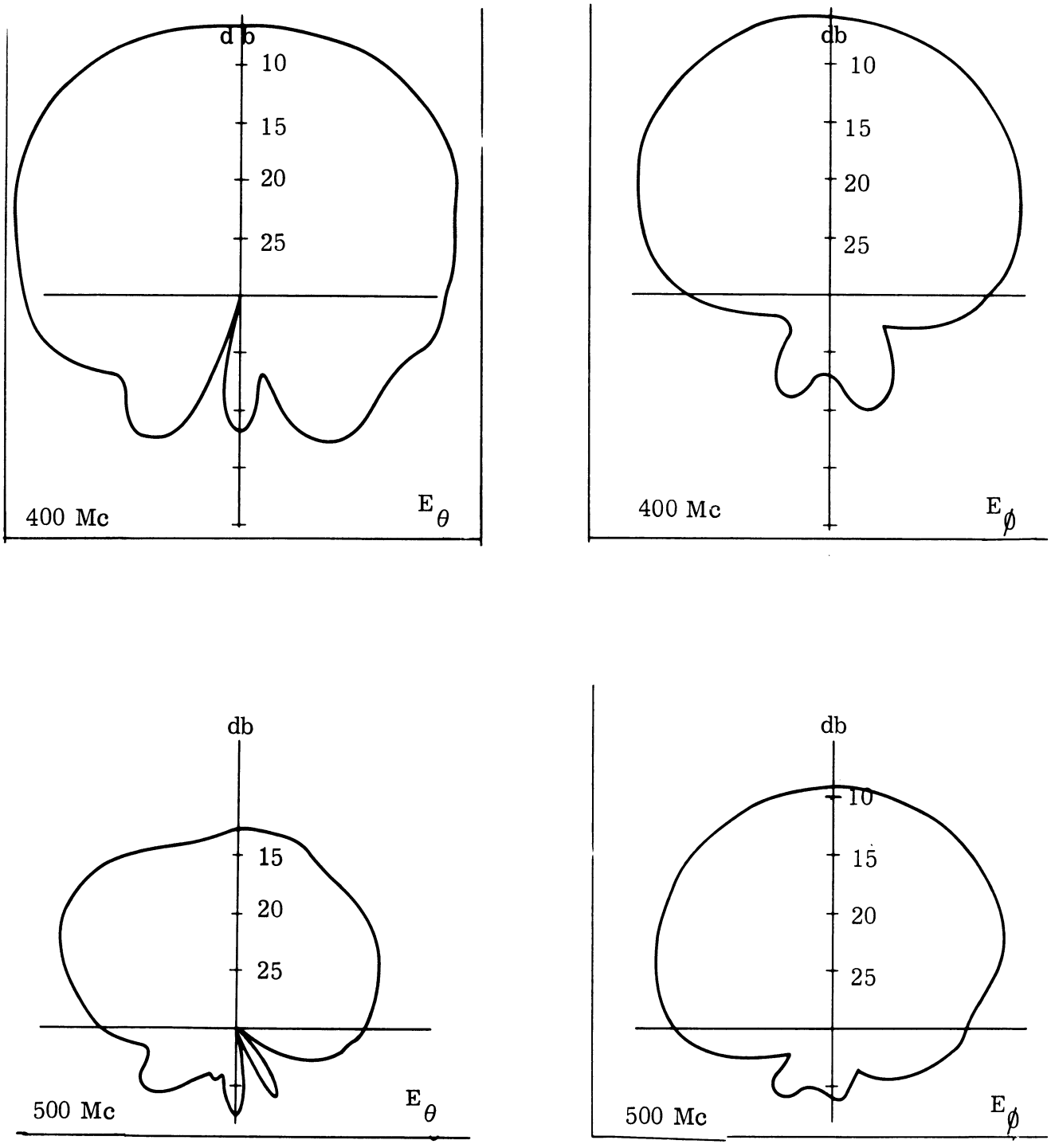
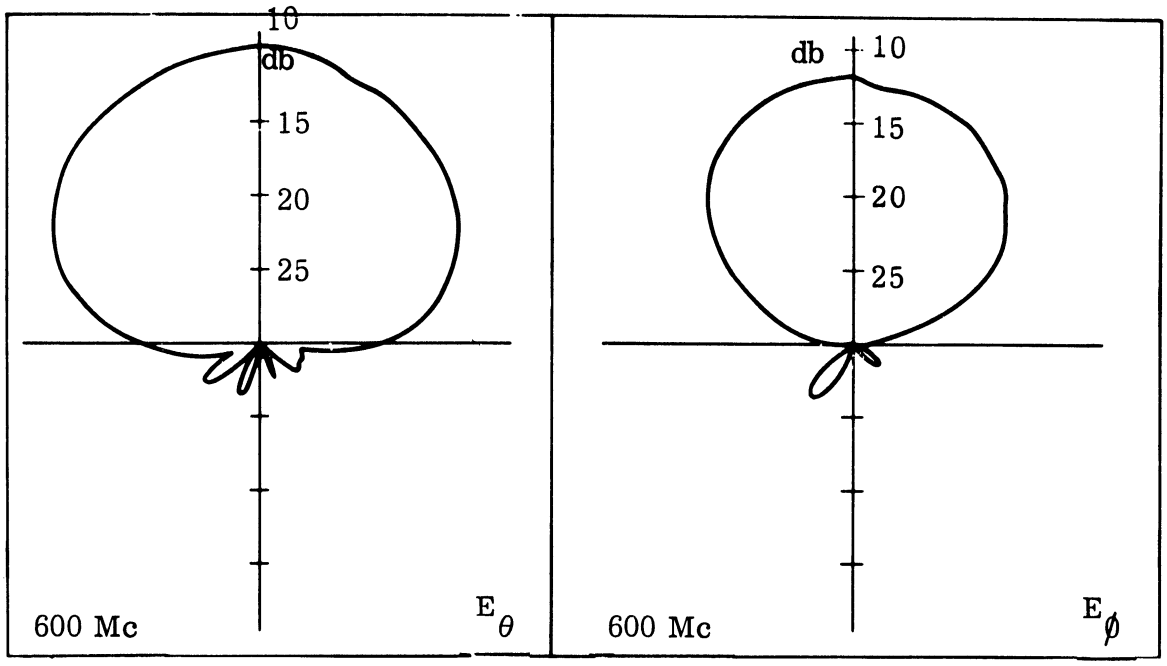


FIG. 2b

No. 301 Air Loaded



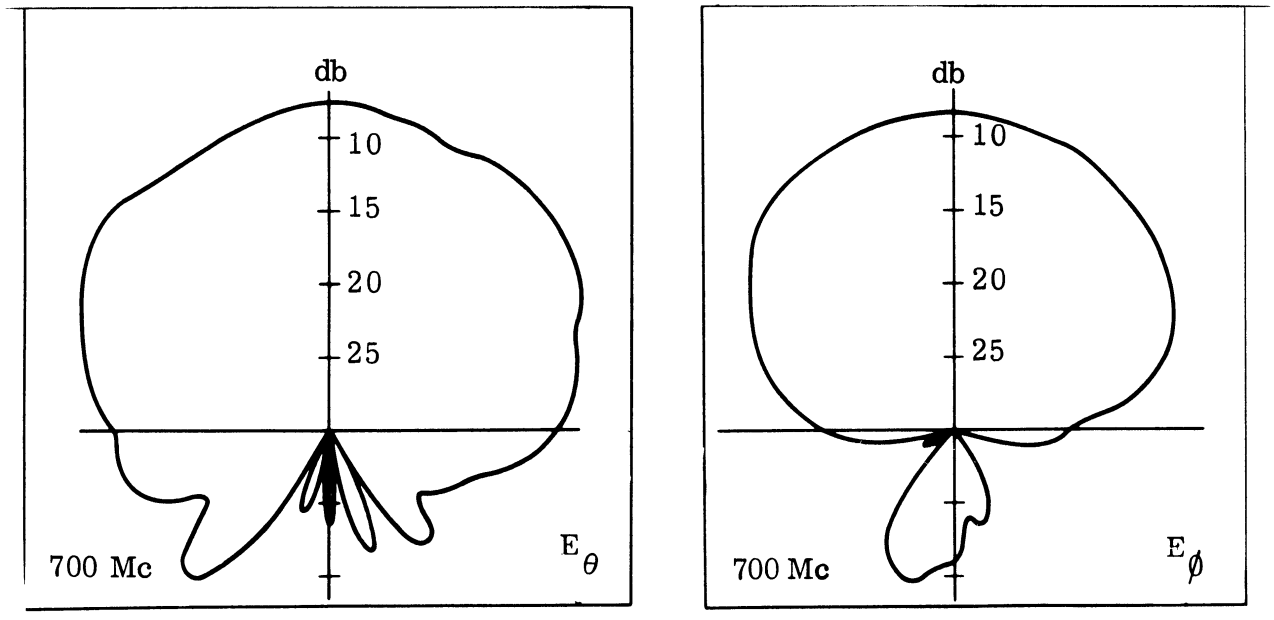


FIG. 2c

No. 301 Air Loaded

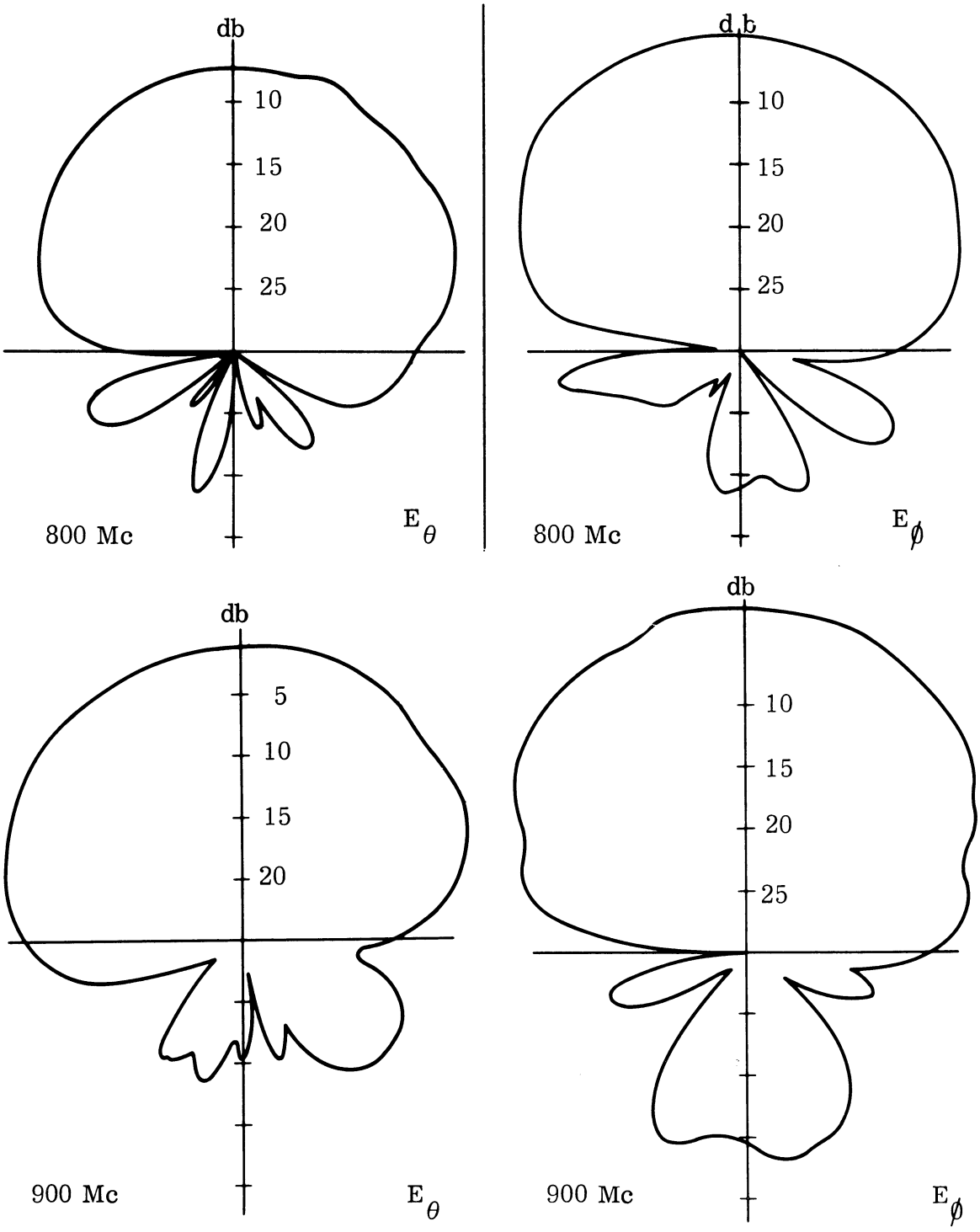


FIG. 2d

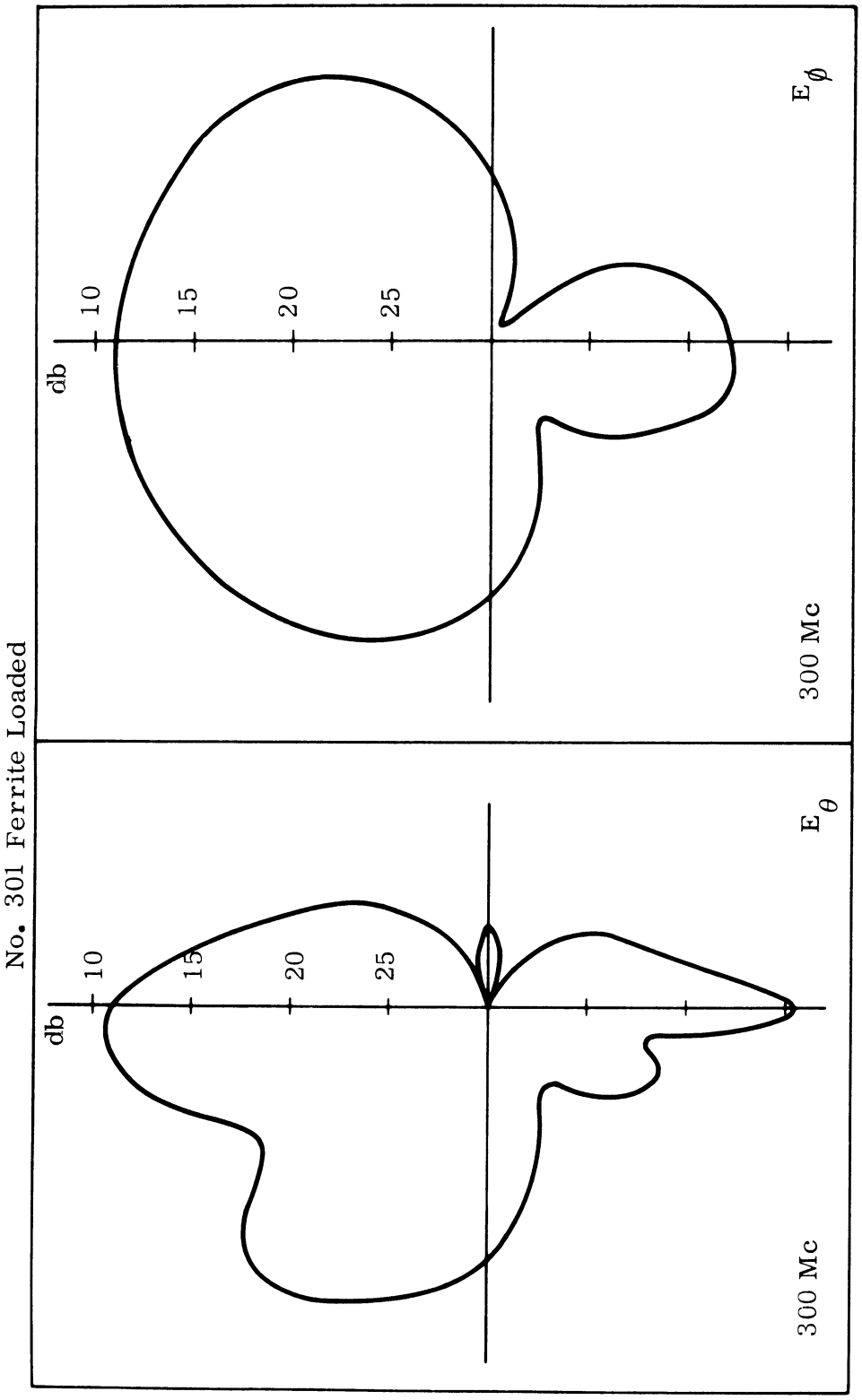

No. 301 Ferrite Loaded
db
10
15
20
25
E_ϕ
300 Mc
db
10
15
20
25
E_θ
300 Mc

FIG. 2e.

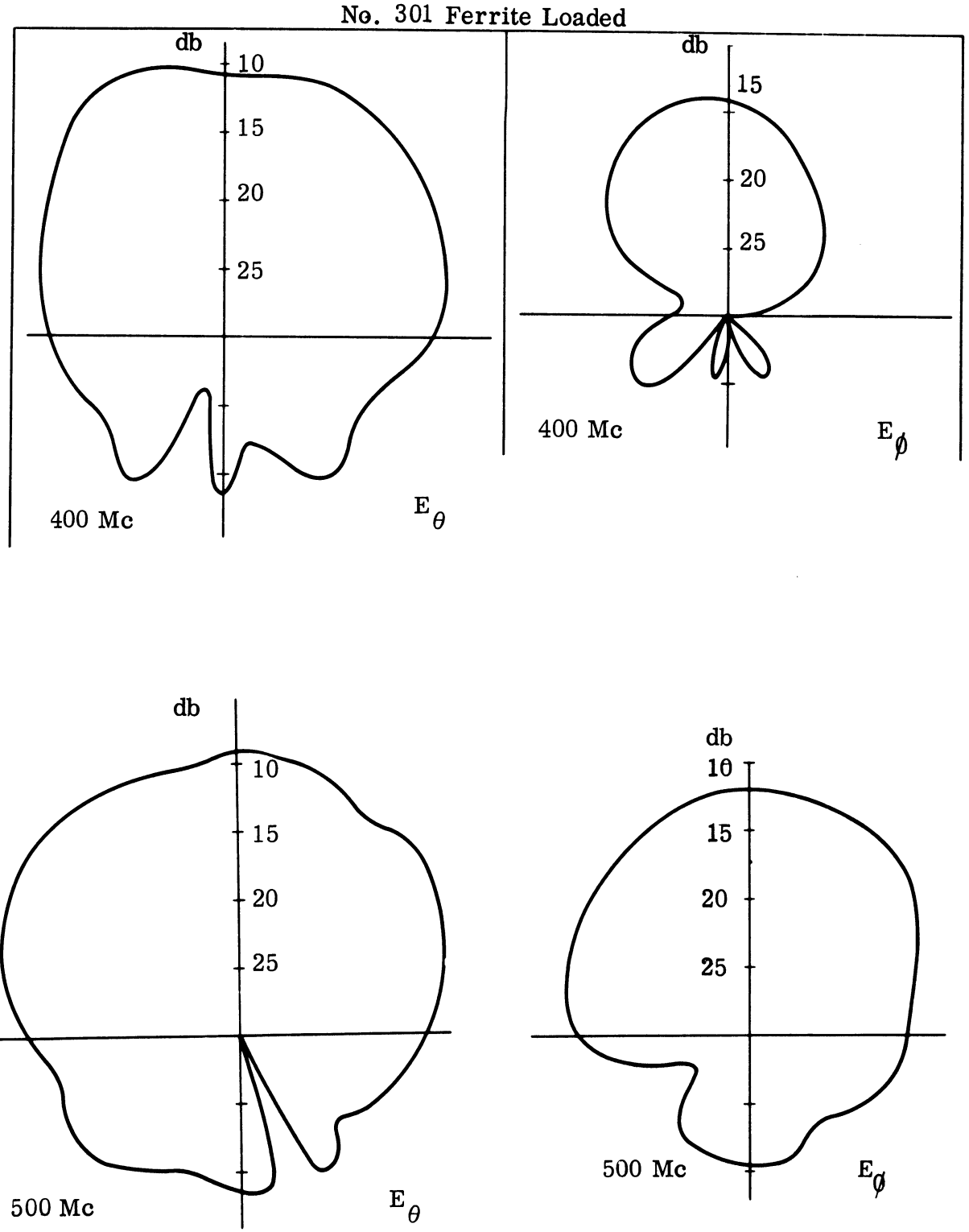
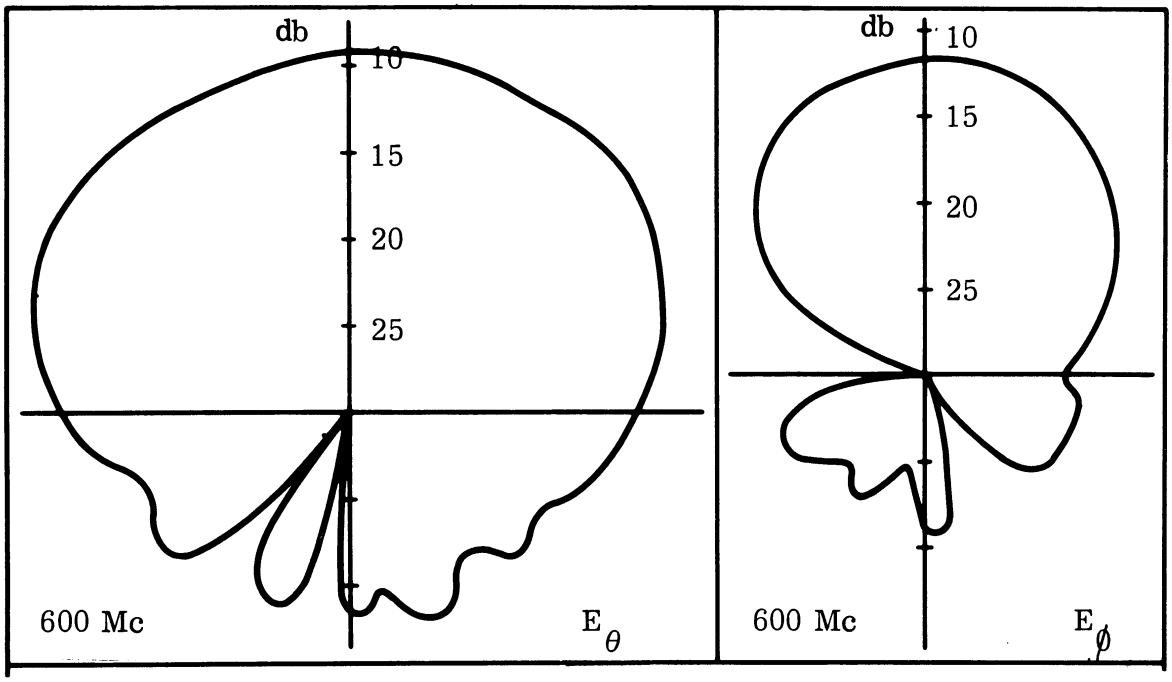

No. 301 Ferrite Loaded
db
10
15
20
25
400 Mc
E_θ
db
15
20
25
400 Mc
E_ϕ
db
10
15
20
25
500 Mc
E_θ
db
10
15
20
25
500 Mc
E_ϕ

FIG. 2f

No. 301 Ferrite Loaded



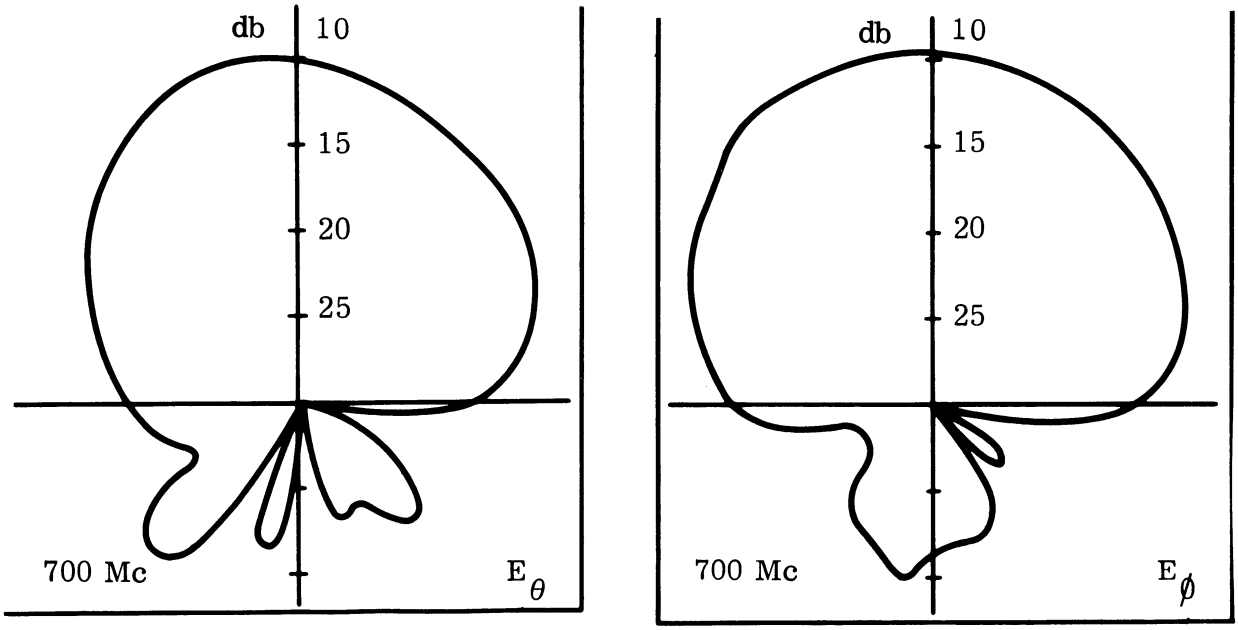


FIG. 2g

No. 301 Ferrite Loaded

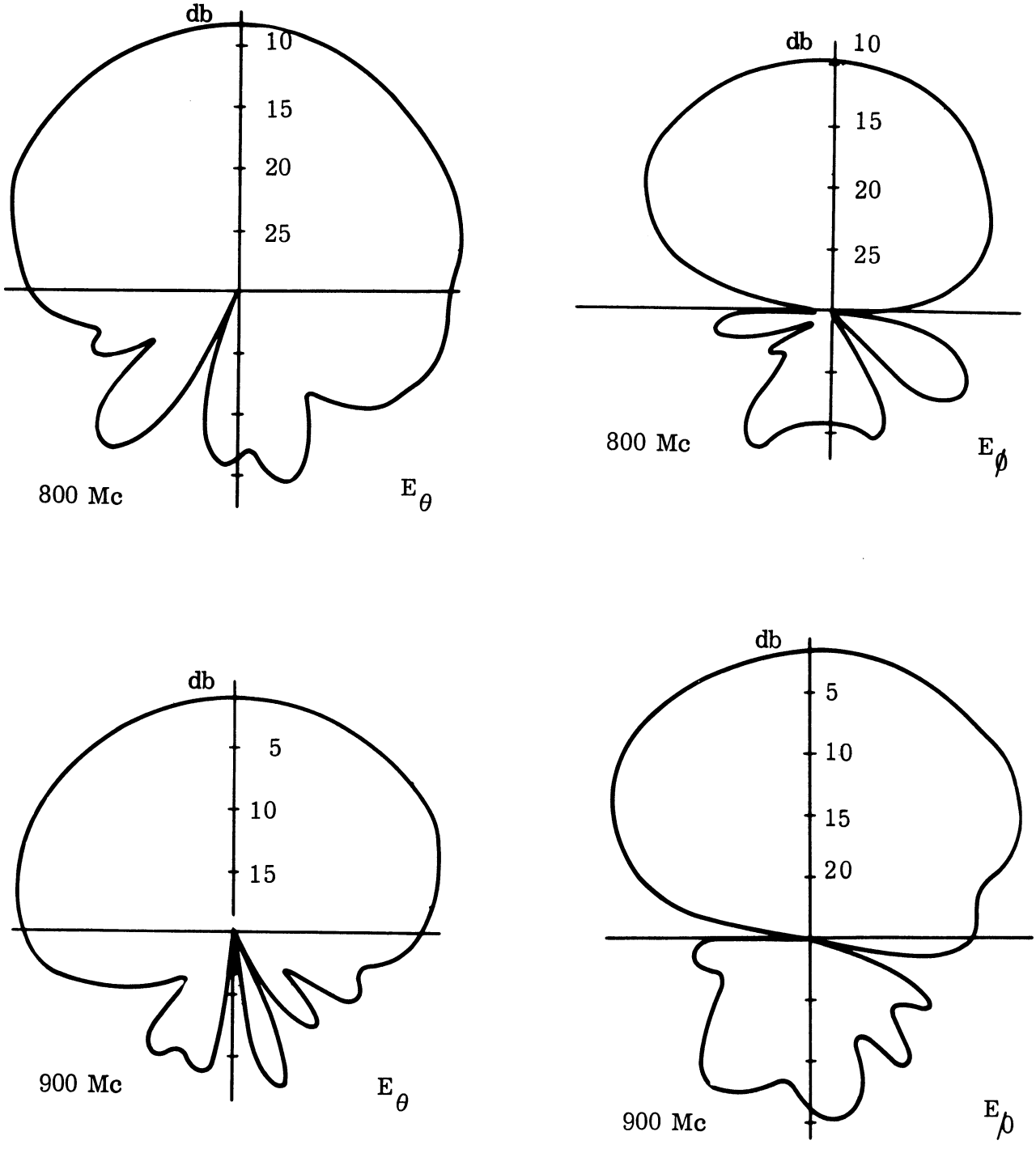


FIG. 2h.

VSWR vs FREQ.
for
Rectangular Ferrite Slot Antenna No. 101 with Permanent Magnets

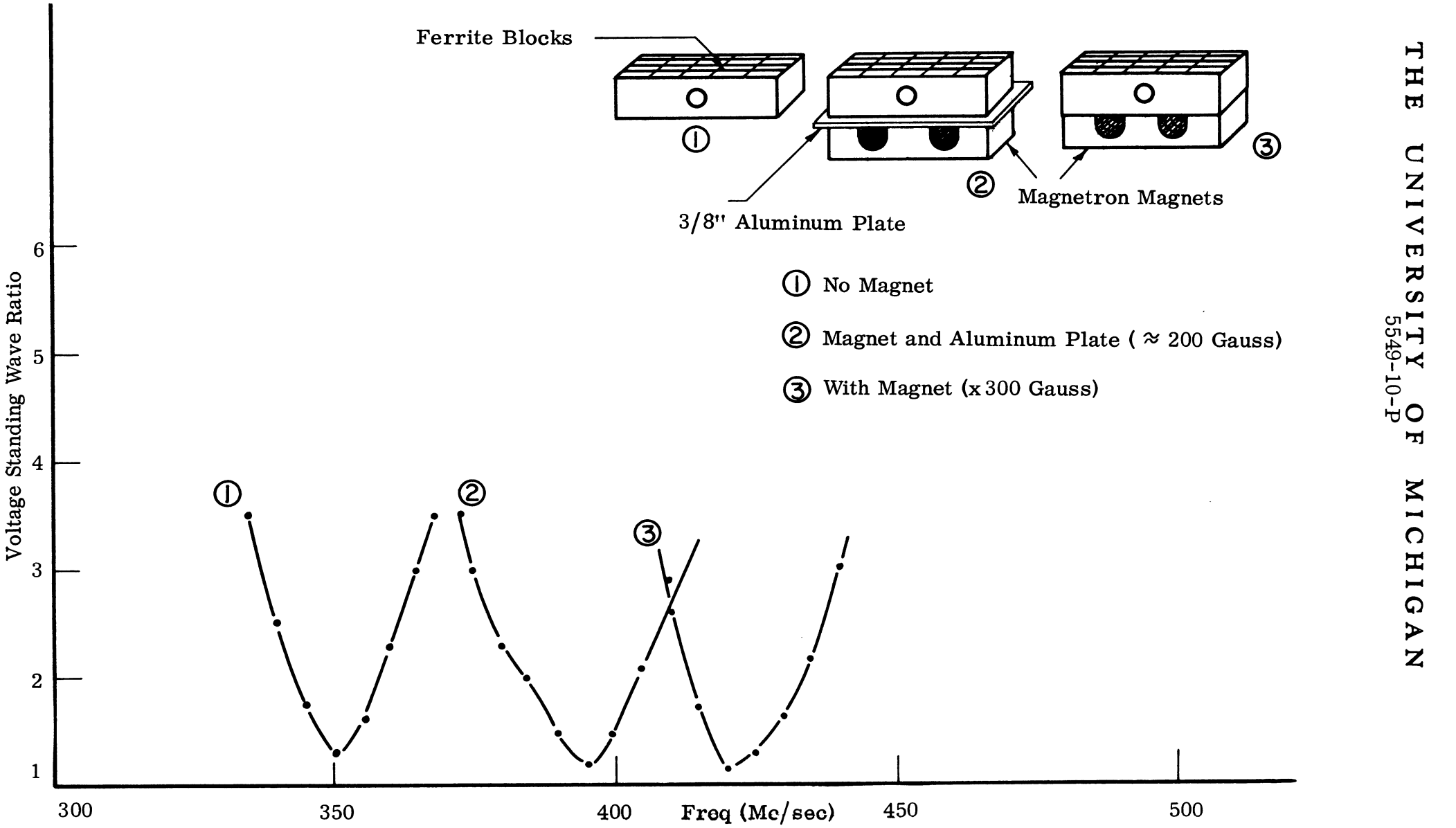
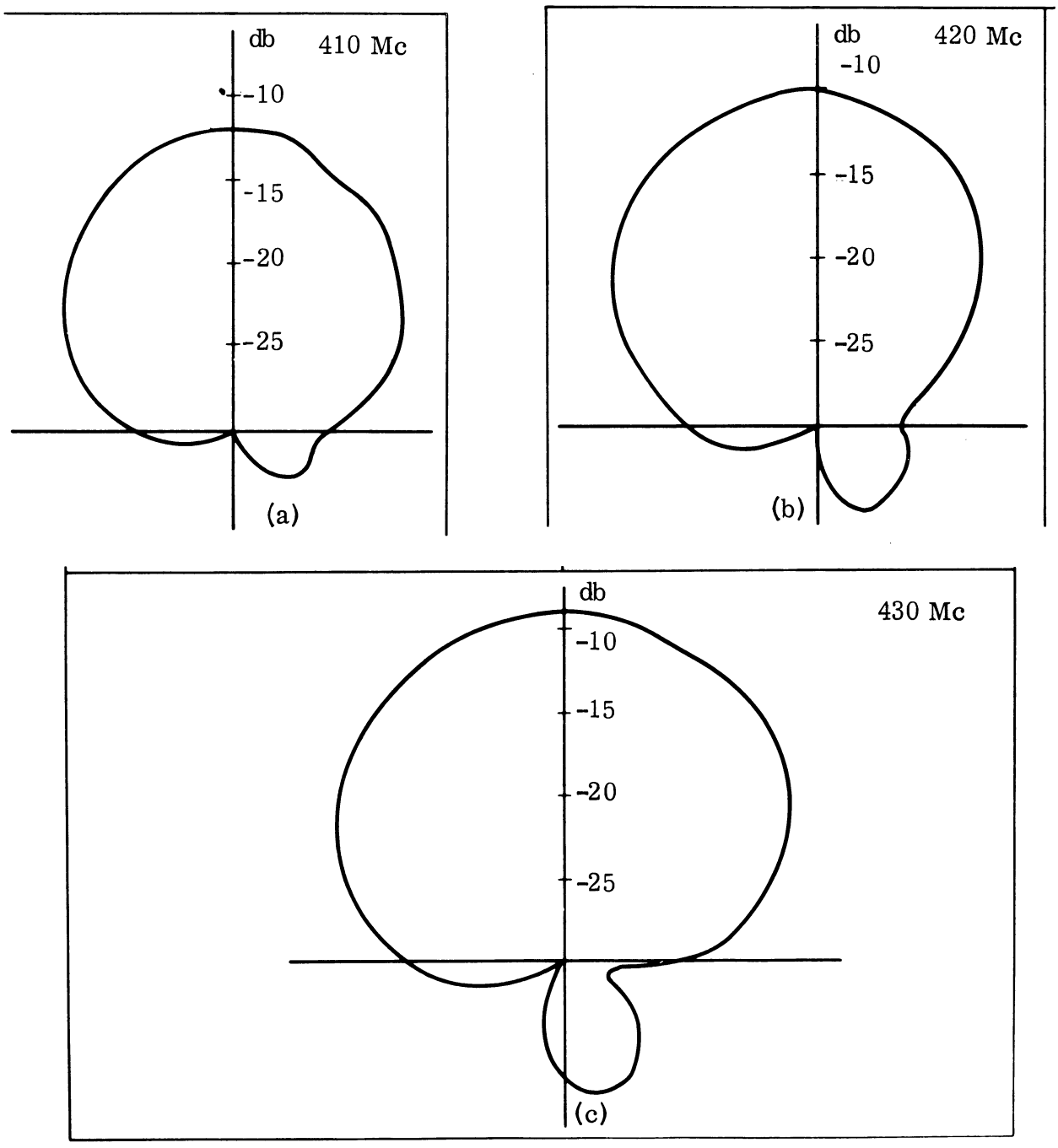
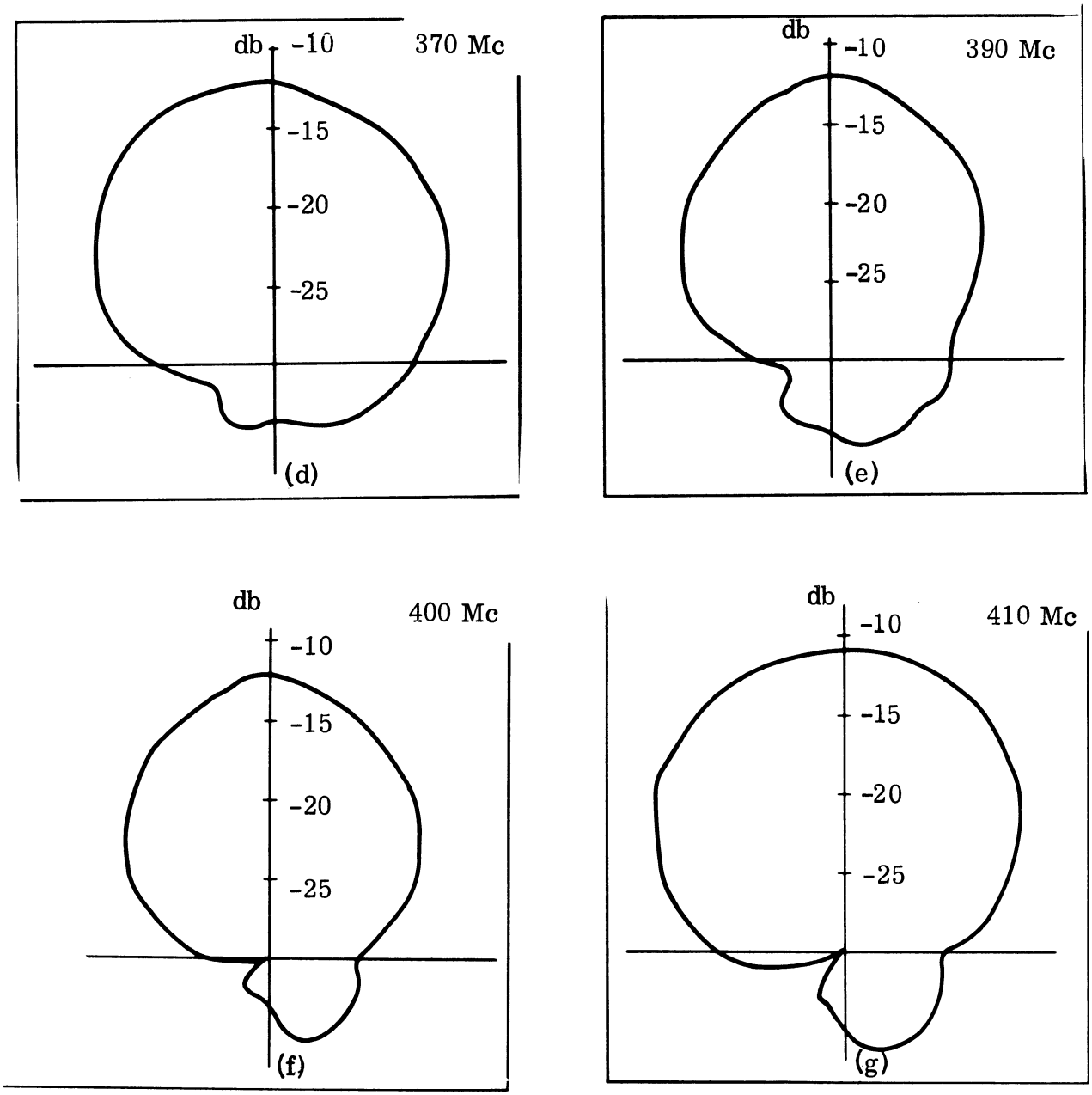


FIG. 3



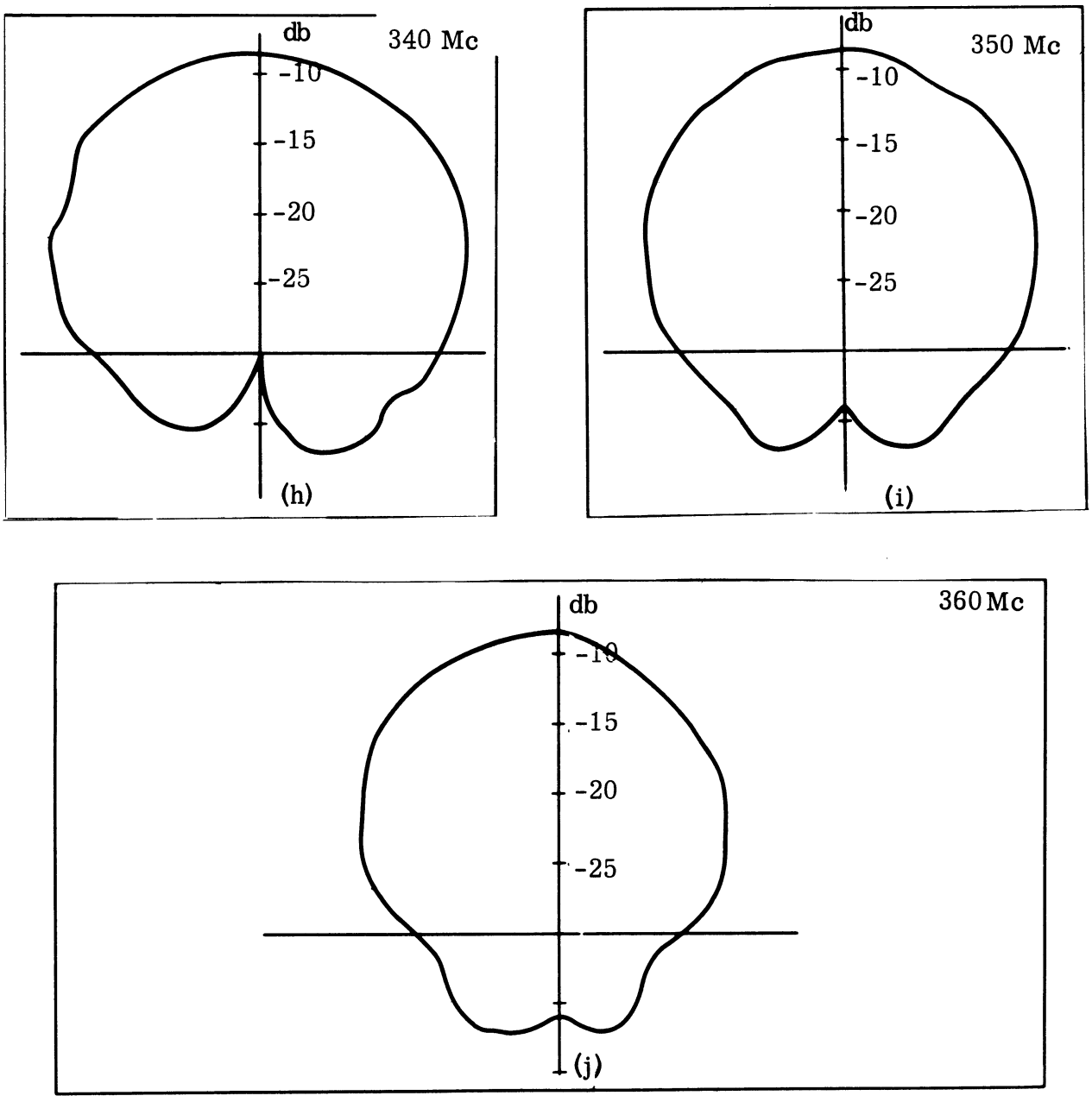
Resonant Frequency = 420 Mc

FIG. 4a - 4c: Radiation Patterns (E_{ϕ}) for Antenna No. 101 with Magnet



Resonant Frequency = 395 Mc

FIG. 4d-4g: Radiation Patterns (E_ϕ) for Antenna No. 101 with Magnet and Aluminum Plate



Resonant Frequency = 350 Mc

FIG 4h-4j: Radiation Patterns (E_ϕ) for Antenna No. 101 Without Magnet

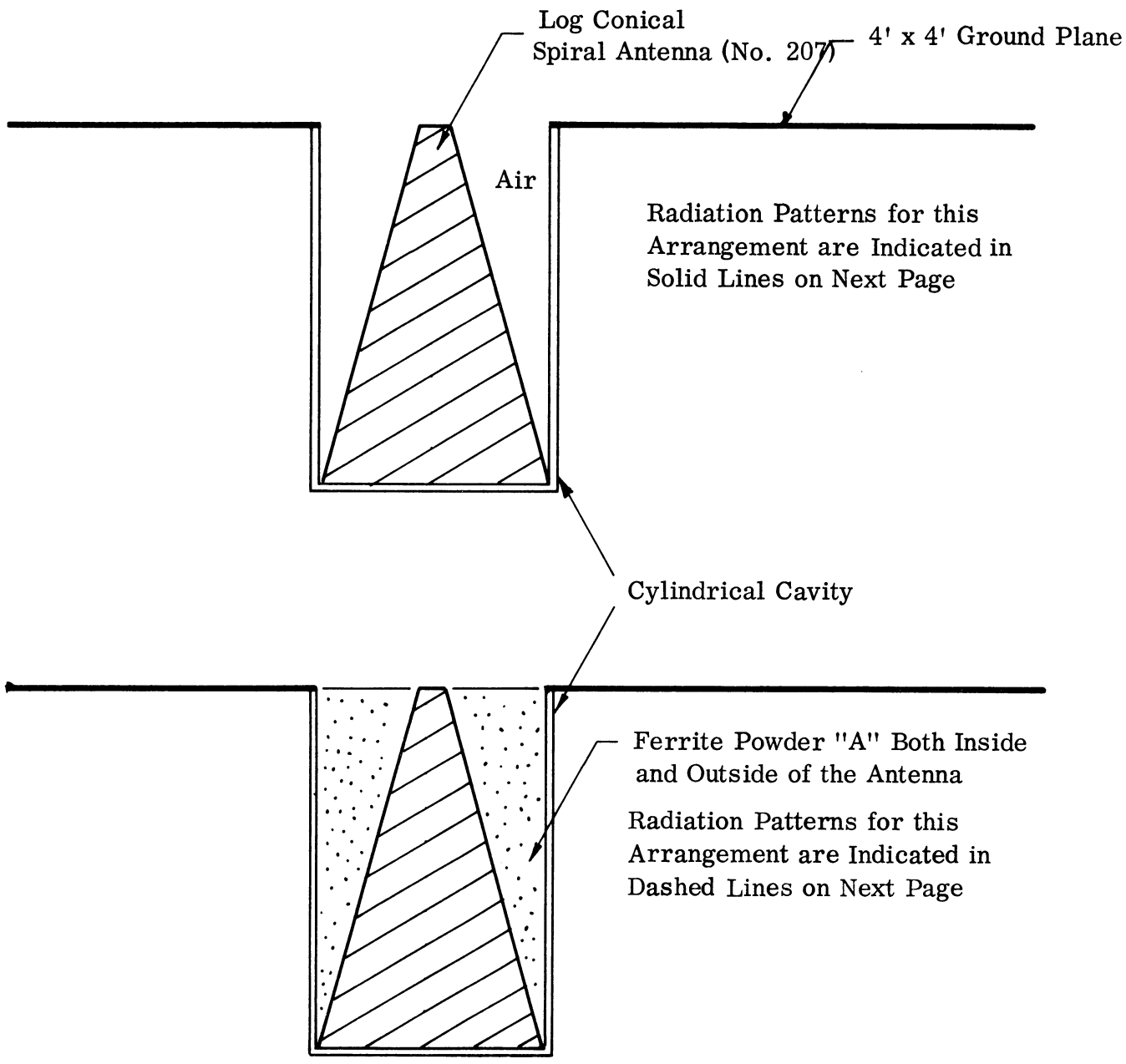


FIG. 5a: Antenna Arrangements

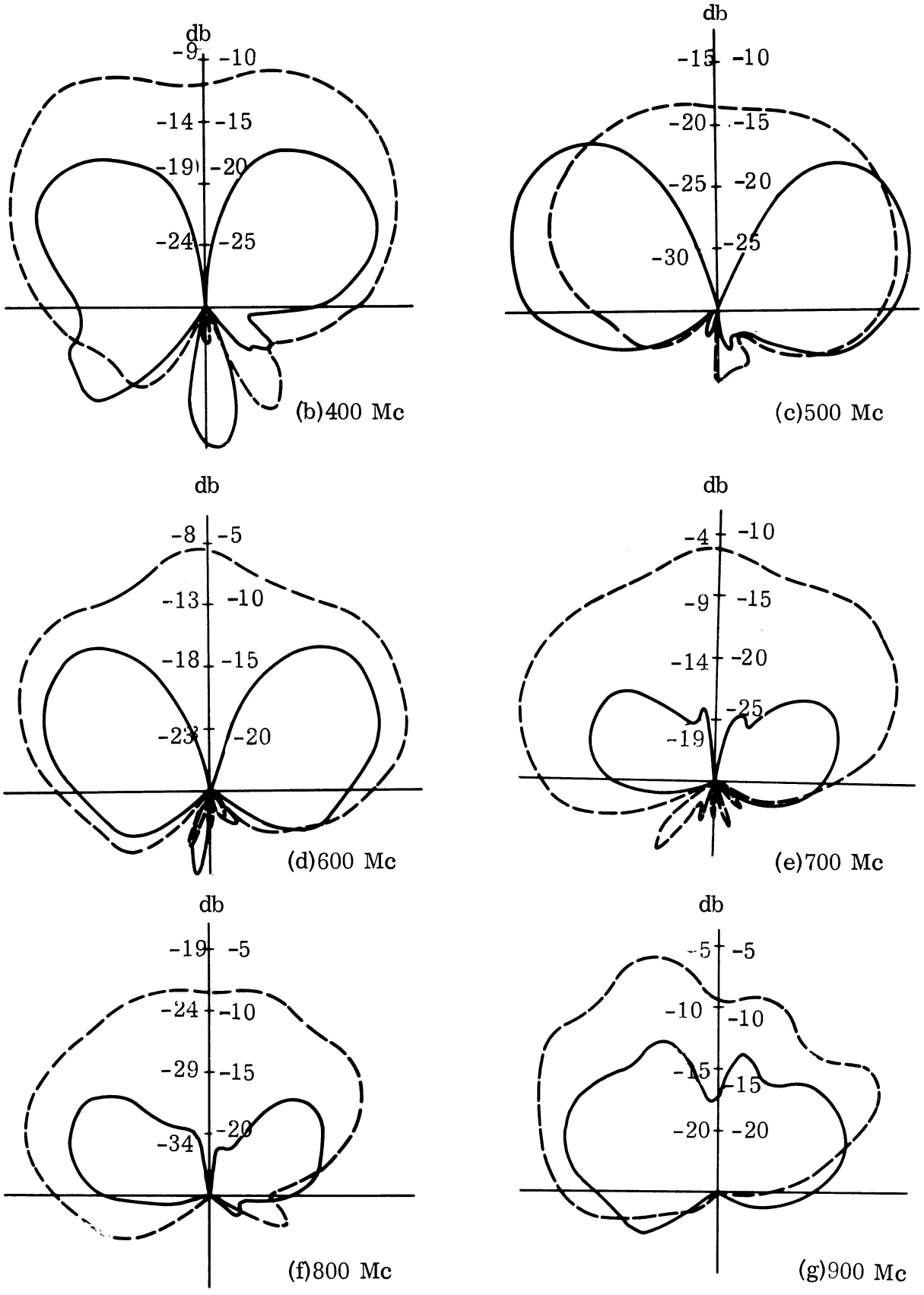


FIG. 5b-5g: Radiation Patterns (E_θ) for Antenna No. 207.
Numbers on Right Indicate Ferrite Loaded.
Numbers on Left Indicate Air Loaded