FOR MEMBERS OF WORKING GROUP
ON RE-RADIATION PROBLEMS IN AM
BROADCASTING

INTERIM REPORT NO. 6

THE EFFECTS OF RE-RADIATION FROM HIGHRISE BUILDINGS, TRANSMISSION LINES, TOWERS AND OTHER STRUCTURES UPON AM BROADCASTING DIRECTIONAL ARRAYS

27 June, 1979

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THE EFFECTS OF RE-RADIATION FROM HIGHRISE BUILDINGS, TRANSMISSION LINES, TOWERS AND OTHER STRUCTURES UPON AM BROADCASTING DIRECTIONAL ARRAYS

(DOC Project No. 4-284-15010)

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Radio Communications Laboratory
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Communications Research Centre
Department of Communications

27 June 1979

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PREFACE

This is the sixth Interim Report describing a research investigation into the effects of highrise buildings, transmission lines, towers and other structures upon the directional pattern of AM broadcast antennas. It describes work that has been carried out during the period 23 March until 20 June, 1979. The report has been prepared for the tenth meeting of the Working Group on Re-Radiation Problems in AM Broadcasting scheduled for 27 June, 1979.

In this reporting period, several advents have occurred and there has been in part some redirection of research effort. At the ninth meeting of the Working Group on 19-20 March, Dr. Andrew Alford, of Andrew Alford Consulting Engineers, conducted a seminar on "Re-Radiation of Towers and Buildings at Broadcast Frequencies". Some of the material presented formed a part of a patent application filed on 23 September, 1952, and this information had not been seen before by the author of this report. As a result of this seminar, a few minor changes were made to our planned measurement program on the NRC Antenna Pattern Range (this program dated 2 April, 1979 is included in this report as Appendix I). Dr. Keith Balmain submitted his final report (reference Balmain, 1979) on numerical modelling. A measurement program on the NRC antenna modelling range has begun (see Appendix II). And, a research contract, jointly funded by the DOC and CBC has been undertaken by Drs.S.J. Kubina and C.W. Trueman, Concordia University (their report is attached as Appendix III of this report).

Dr. J.S. Belrose and Mr. D.E. Jones have not drawn up a proposal for CEA funding, as promised at the last Working Group meeting, partly, in retrospect, because of my uncertainty in regards to what this proposal should be for. As discussed at several Working Group meetings (reference particularly Interim Report No. 4), the suggestion was to propose a research program on the effects, and on methods to minimize re-radiation effects from long, realistically modelled power lines, a program that would involve antenna model measurements (CRC) and investigations at full scale (Ontario Hydro). However, means for obtaining funding for the antenna modelling range have never been resolved, and in fact doubt has been expressed by some (Litchfield, 1979, Alford, 1979 and Balmain, 1979) about the need for such a range. Certainly, cognizant of the financial constraints policy of the new government, we are wasting our time giving further thought, at present, to the acquiring of a new antenna modelling range.

A somewhat unsatisfactory report was submitted by Oliver, Mangione, McCalla & Associates, Ltd. who made an engineering study of various options

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for constructing a suitable large antenna modelling range. We say "somewhat unsatisfactory" because these consultants, being basically construction engineers, proposed several designs built according to the Ontario Building Code standards. Therefore, while we cannot fault the good engineering design practice that went into their proposals, the cost of constructing a large antenna modelling range provided with base and footing and structural steel to support a design load of 100 lbs/square foot, is quite unrealistic. Negative, rather than positive progress has therefore been made in regards to acquiring the proposed new facility.

This interim report therefore describes work done under the modest, present on-going program, and planning for a new program, or termination of the present one remains an objective for the second or third quarter of this fiscal year.

John S. Belrose
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Communications Research Centre
Department of Communications

.../3

REFERENCES

1. Alford, Andrew, Seminar given to the Working Group on Re-Radiation Problems in AM Broadcasting, 19-20 March, 1979.

2. Balmain, K.G., "Analysis of Re-Radiation of AM Broadcast Signals", University of Toronto Report, March, 1979.

3. Litchfield, J., private correspondence, 1979.

4. Oliver, Mangione, McCalla & Associates, Ltd., Report on Proposed Antenna Modelling Range at the Shirley Bay Research Centre, Ottawa, Ontario, March, 1979.

PROPOSED WORK PLAN
NRC PATTERN RANGE
MAY-OCTOBER 1979

COMMENT	PROPOSED EXPERIMENT
Hydro-Power-Lines	
1. The comment has been made that hydro power lines not only affect the polar diagram of AM broadcast antennas but because of ground losses (tower footing resistance and finite earth conductivity) they also dissipate power, and so the integrated power (in the horizontal plane since this is what is measured) is less. Undoubtedly this occurs, but also some of the power may be directed at angles above the horizon.	Two experiments are proposed: a) to simulate "loss", resistances will be inserted in series with the skywires (suggested values 5, 10 and 20 ohms), and the pattern and scattered fields (c.f. Figures 3 and 5 of Interim Report No. 4) will be measured for an omni-directional radiator in the presence of a single power line (that of Figure 2 in Interim Report No. 4); b) the horizontal pattern and the vertical patterns will be measured (for the above configuration with $R_{loss} = 0$) at various frequencies. Measurements will be made at a number of frequencies, corresponding to the 2λ, 3λ and 4λ resonances.
2. What is the resonant frequency for a realistically modelled hydro power line?	The scale model towers (scale factor 200) will be placed on the turntable (we can only get 3-4 of them in the table), and the re-radiation effect will be measured at a number of frequencies, in search of the 2λ, 3λ and 4λ resonances. Measurements will be made of the scalloping of the pattern for an omni-directional array and of the scatter field only (c.f. Interim Report No. 4, Figure 5).
3. What is the resonant frequency of the power line used by Calgary Hydro?	Three or four towers could be constructed and measurements made as in (2) above. In my view, this has lower priority than other experiments suggested (only because of time).
Single Re-Radiators	
4. If single tower re-radiators are to be detuned, we have to insulate them from the ground, or convert them into a folded unipole so they can be detuned. We have made no measurements of not-grounded re-radiators.	For completeness, I propose we should make measurements for a grounded and an insulated monopole of heights λ/4, λ/2, and 3/4 λ. The height should be such that the radiator is resonant (c.f. Interim Report No. 5). Measure the scatter field, only employing an omni-directional radiator. Alford has done this (see attached) but our results would be absolute rather than relative (that is, percent of omni-directional field).

Eliminating or Reducing Re-Radiation Effects

I have repeatedly made the case that a large antenna pattern range is needed (one that one can get underneath) to properly undertake a research program in this area. However, there are certain measurements which could be made on the present range.

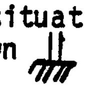
5. It has been suggested that single towers can be tuned such that the maximum of the radiated field is directed upwards at an angle, and a null is maintained along the surface of the ground (King, 1972). Alford has also revealed this fact in a recent seminar and his results were for radiators of height 0.49λ, 0.375λ, and 0.705λ (see attached). King computed values for the required reactance for re-radiator heights of $\lambda/4$ and $\lambda/2$, and he concluded that in order to reduce the scattered field to zero in the equatorial plane, a purely reactive load was not adequate, but a dissipative load was required. If in fact, the field can be reduced to zero, how much is radiated at high angles (this may be undesirably large)?

Suggest we model the two re-radiator heights that Alford studied (0.49 and 0.375λ). His measurements of current distribution indicated that the optimum value of the base-loading reactance was +j87 ohms. Measure (a) re-radiation with grounded radiator; (b) re-radiation with optimum detuning; (c) elevation pattern for this configuration.

6. A practical way to detune a grounded tower is to convert it into a folded monopole.

I have a folded unipole (resonant frequency about 300 MHz). Suggest we measure the scattered field for various values of reactive loading XL = 0, -j50, -j75, -j100, -j250, -j500.

7. Tuning stubs mounted on the side of towers have frequently been suggested as being effective in reducing re-radiation effects. These stubs are in effect a shorted section of quarter-wave length line, with a tuning element at the open end since the stub is usually shorter than a quarter wave. The usual practice seems to be to mount the stub on the sides of towers with the shorted end up, but some workers have suggested that the shorted end down sometimes give better results. Why and in what circumstance?

Measurements of re-radiation effects will be measured for a quarter wave monopole with quarter wave stub for the two situations short up ; and short down  .

Note: In effect when the short is up, the grounded tower and the stub comprise a folded quarter wave monopole. That is, in effect we have converted the tower from a <u>grounded</u> base to an insulated base re-radiator.

8. If we connect a tuning element between the open end of the re-radiator above, what do we accomplish? In effect, we are tuning a folded monopole.

No suggested experiment. This is a similar experiment to (6) above.

9. How effective are stubs on the sides of power line towers?

The experimental arrangement in (2) above will be repeated with stubs on the towers, first a single tower, and then 3-4 towers. Voltage variable tuning elements could be employed to examine the effect of "tuning" the stubs, but fixed values are probably easiest to use.

10. Are there other more effective means of detuning towers?

Employing the same experimental arrangements as in (8) above, the proposed method of Appendix VIII in Interim Report No. 1 will be investigated.

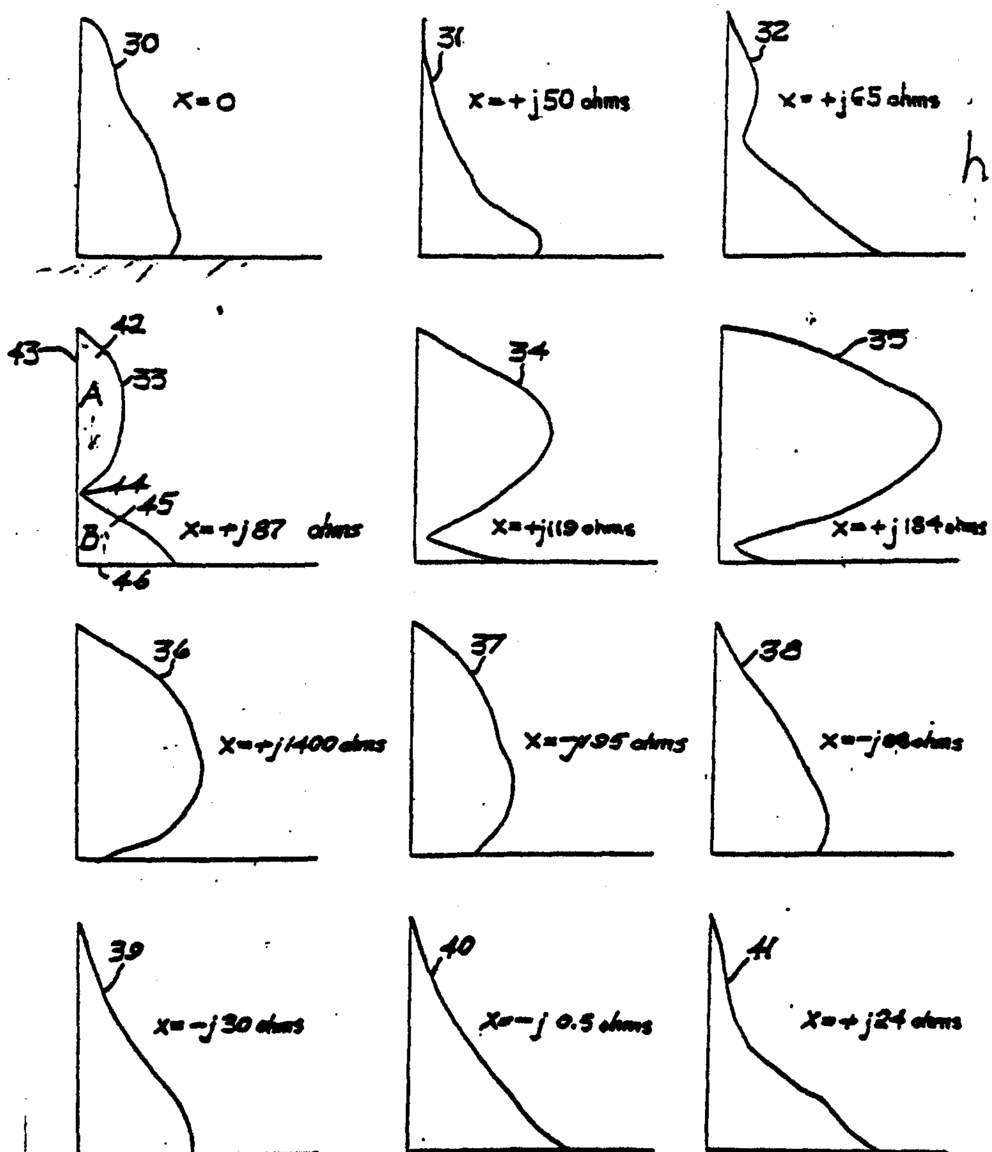
John S. Belrose
April 2, 1979

Reference: R.W.P. King, "Reduction of Re-Radiated Field in the Equatorial Plane of Parasitic Antennas", IEEE Transactions on Antennas and Propagation, pp. 376-379, May, 1972.

Sept. 23, 1952 A. ALFORD ET AL 2,611,871

ANTENNA DETUNING SYSTEM

Filed Aug. 28, 1947 4 Sheets-Sheet 2



h = 0.49 λ

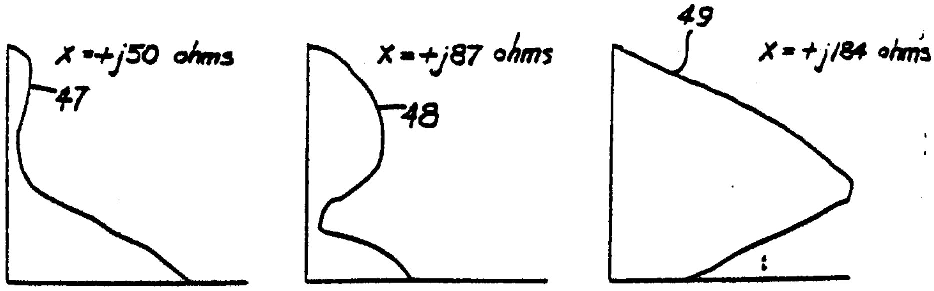
FIG. 2

INVENTOR.
Andrew Alford
Henry Jasik
BY Ezekiel Wolf
Their Attorney

Sept. 23, 1952 A. ALFORD ET AL 2,611,871

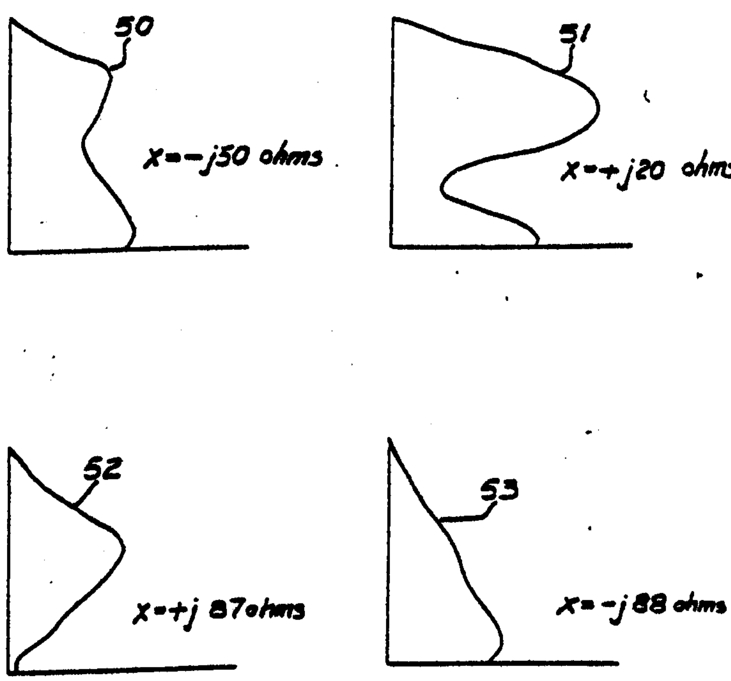
ANTENNA DETUNING SYSTEM

Filed Aug. 28, 1947 4 Sheets-Sheet 3



0.375 λ

FIG. 3



.705 λ

FIG. 4

INVENTOR.
Andrew Alford
Henry Jasik
BY
Ezekiel Wolf
Their Attorney

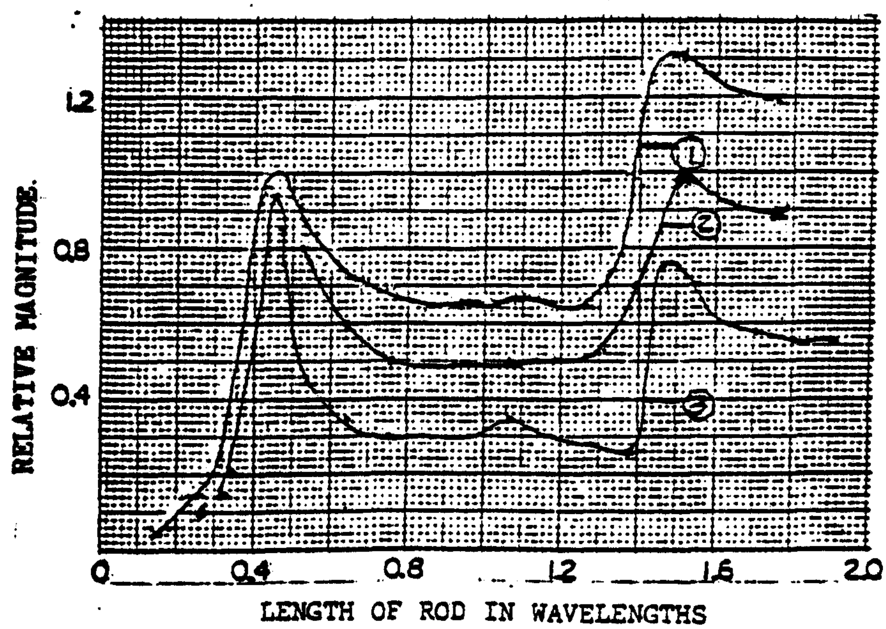


Fig. 1. Relative magnitude of the back-scattered field vs length of a 0.293 inch diameter aluminum rod at 1260 MHz.
Fig. 2. Rod diameter = .078 inch.
Fig. 3. Rod diameter = .008 inch.

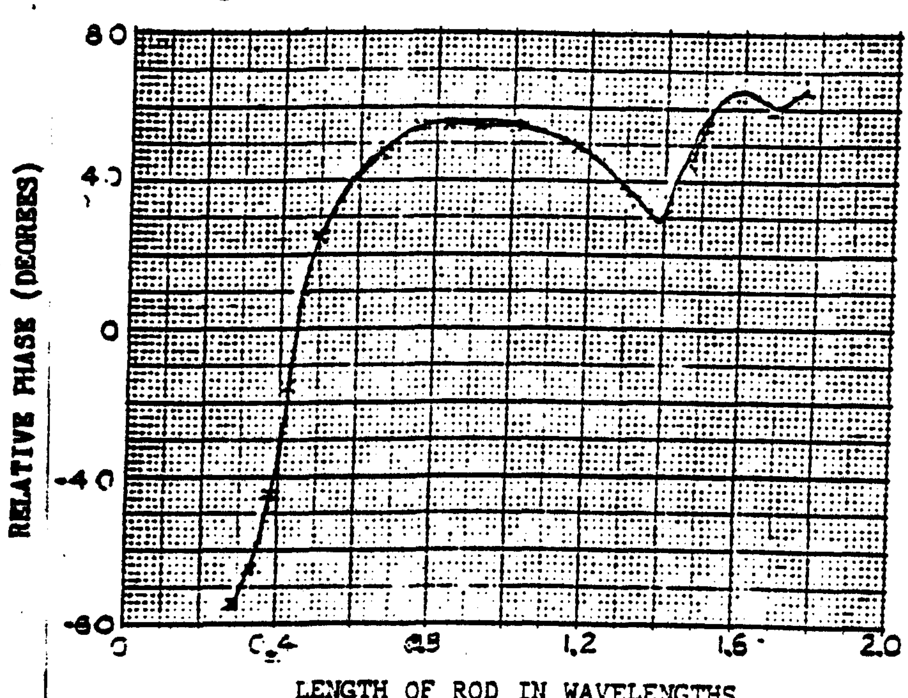


Fig. 4. Relative phase of the back-scattered field vs length of a 0.293 inch diameter rod at 1260 MHz.

INTERIM REPORT #5 ON NRC WORK

Re-Radiation Problems in AM Broadcasting

Introduction

The work described in this report deals entirely with measurements on a transmission line model representing the Hornby site. Previous reports, Interim #3 and #4, detailed tests carried out on a simple model and on a more exact model, respectively. It was apparent that a great deal of information could be gathered by using the simple model - one row of equally spaced towers in a straight line - that use of the more complex model with its two dog-leg lines of variably spaced towers was unnecessarily complicated and hence time consuming.

A further benefit derived from the use of a simple model is that any resonance effects would likely be accentuated thereby making comparisons between experimental results and future theoretical calculations more positive.

As before, the scale factor was 600. This converts the broadcast frequencies to 444 MHz (CBL) and 516 MHz (CJBC). The test layout is shown in Fig. 1 with full size dimensions.

The tests covered in this report are:

1. A frequency run in the vicinity of 516 MHz.

2. Elevation radiation patterns.

3. Resistor loading of the skywire.

Azimuth Pattern Variation with Frequency

Earlier tests (Interim Report #3) showed that the pattern degradation was much larger at 516 MHz than at 444 MHz. If one examines the dimensions of the loops formed by the towers, the skywire and their images in the ground plane, a total loop length of 49.2 inches is obtained. This represents two wavelengths at a frequency of 480 MHz which is almost the geometric mean between 444 and 516 MHz. The fact that the patterns were poorer at 516 indicates that the resonance is at a frequency higher than 480 MHz.

A series of patterns were taken, with a skywire installed, at frequencies ranging from 496 MHz to 521 MHz and typical results are given in Figs. 2 to 4. Based on a comparison of the ratio of maximum to minimum of the patterns, it appears that the worst case is at about 509 MHz. As might be deduced from Figs. 3 and 4, the resonance is not too sharp and indeed, the patterns from about 500 MHz to 521 MHz are not too different.

Elevation Radiation Patterns

All tests to date have dealt with the measurement of azimuth patterns near the horizon. It has been suggested that some undesirable pattern degradation might be taking place in the elevated portion of the radiation. This would be of importance when one considers skywave propagation.

Many elevation patterns were plotted with and without a skywire attached to the transmission line towers. Plots were usually made every 30 degrees in azimuth.

No significant effects were located. If they exist, their presence is being overshadowed by spurious range effects which show up in elevation pattern tests. In any case, the degradation in the elevation patterns appears to be very much smaller compared to what happens to the azimuth pattern.

Resistor Loading of the Skywire

Placing resistors in series with the skywire is in no way meant to duplicate the effect of ground losses or tower footing resistance in the real world, however, it was felt that a knowledge of the effect of loss in the loop would be of some value.

Two sets of tests were made with a resistor installed in series with the skywire in each span, firstly at the mid-point of the span, and then adjacent to a tower. Typical patterns are shown in Figs. 5 to 10.

Some observations to be made are:

1. Resistor values required to produce an appreciable effect were notably larger than had been assumed. Whereas it had been suggested that values of the order of 10 to 20 ohms should be tested, it turned out that this had to be increased to about 100 - 200 ohms before a significant change in the pattern took place. See Figs. 5 - 8.

2. Resistors placed at the mid-point of the span had a greater effect than when the same values were placed next to the towers. Compare Figs. 8 and 9.

3. Probably the most interesting part of all the tests covered in this report appears in Fig. 8. Here the resistors are at the mid-point of the spans - approximately one-half wavelength from the base of a tower. It can be seen that the pattern obtained is far closer to circular than any ever obtained before with different skywire configurations (See Interim Report #4) and in fact is better than obtained with towers alone. See Fig. 10.

   A possible explanation for this result is as follows. The skywire along with its image forms a two-wire transmission line. If a high impedance is placed at the mid-point of the span, then a half wavelength away - at the base of a tower - a high impedance point will exist. This high impedance will then in turn reduce the amount of current that is induced in the tower by the radiating antenna. This line of thinking immediately leads to the speculation of what would happen if not a resistor but a parallel resonant trap were placed in the skywire at a point one-half wavelength from the base of a tower. Needless to say, this will be the next configuration to be tested.

Conclusions

A frequency run in the vicinity of 500 MHz indicates that the loop resonance of the Hornby transmission line is near 509 MHz and is not too sharp.

Elevation patterns indicate that no noteworthy effect is taking place.

Resistor loading of the skywire, though not really representing the effect of ground losses and footing resistances, has produced a rather interesting result. A large value of resistance placed at the mid-point of the span has resulted in an almost circular azimuth radiation pattern. This finding makes the study of resonant traps in the skywire an obvious next step.

W. Lavrench
J. G. Dunn

Electromagnetic Engineering Section
Division of Electrical Engineering
National Research Council of Canada

18 June 1979

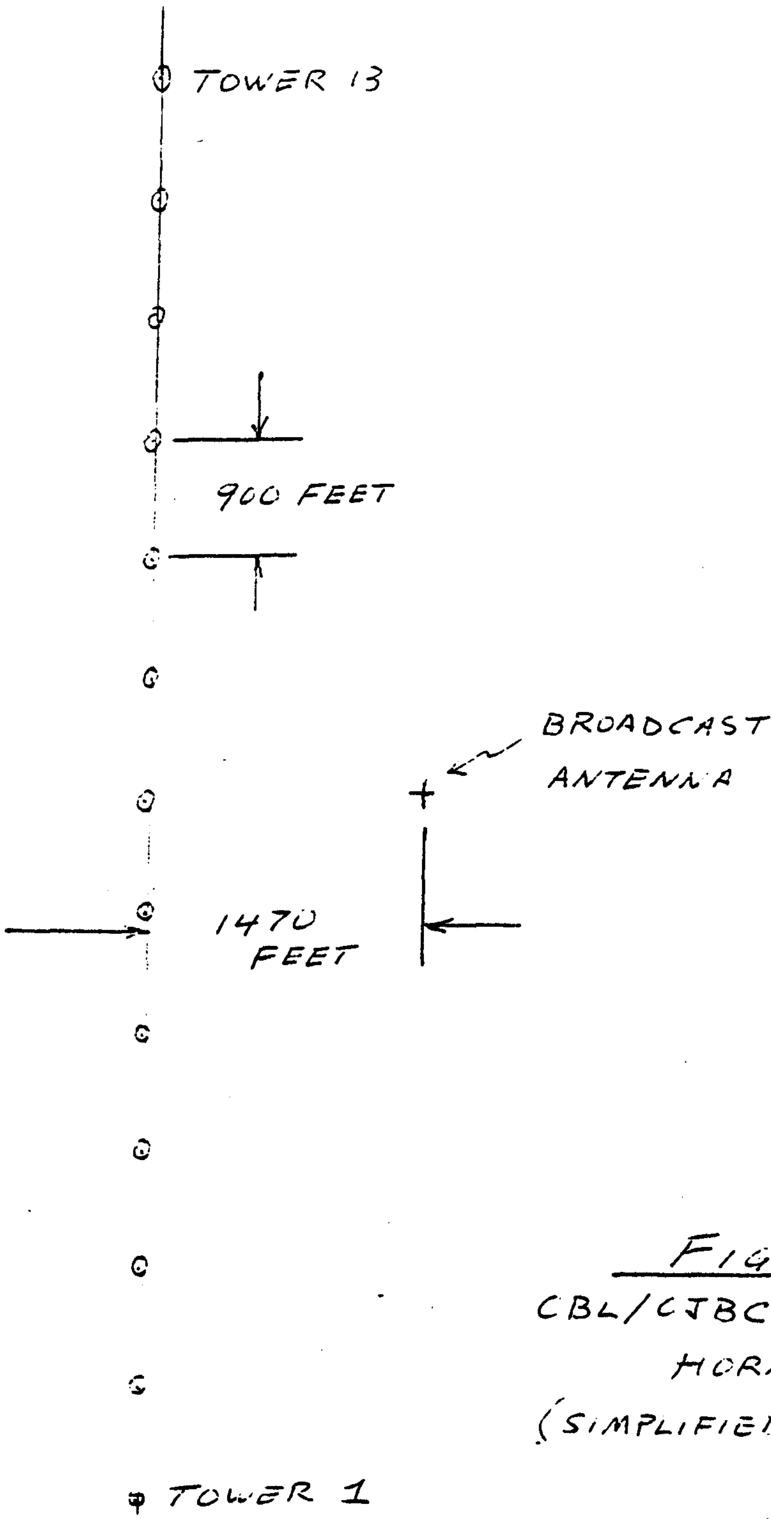


FIG. 1
CBL/CJBC SITE
HORNBY
(SIMPLIFIED MODEL)

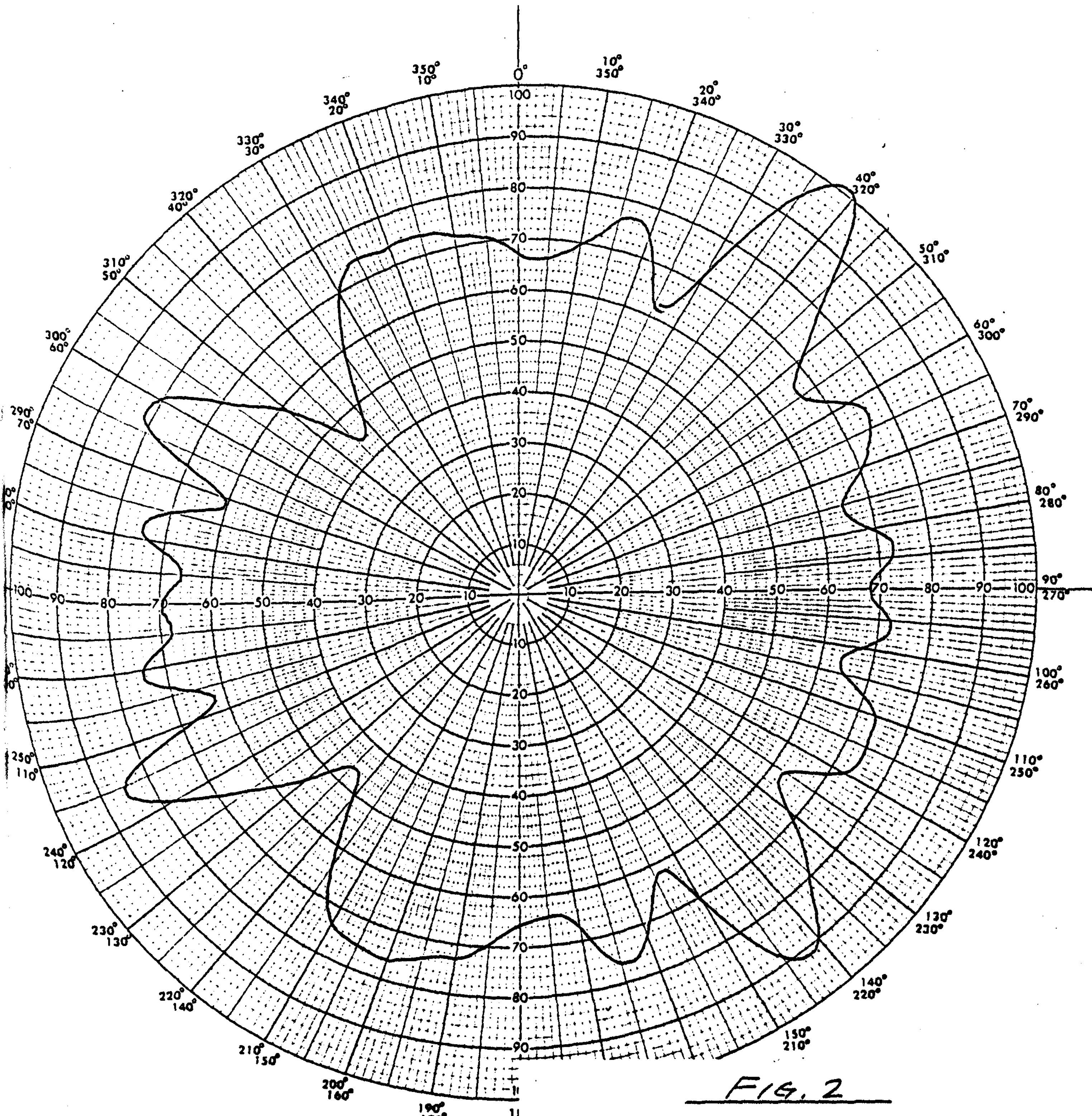


FIG. 2
HORNBY MODEL
SINGLE SKY WIRE
496 MHZ.

GC-127L (GC 1224-R)
GRAPHIC CONTROLS CANADA LTD
Printed in Canada

5 JUNE 1979

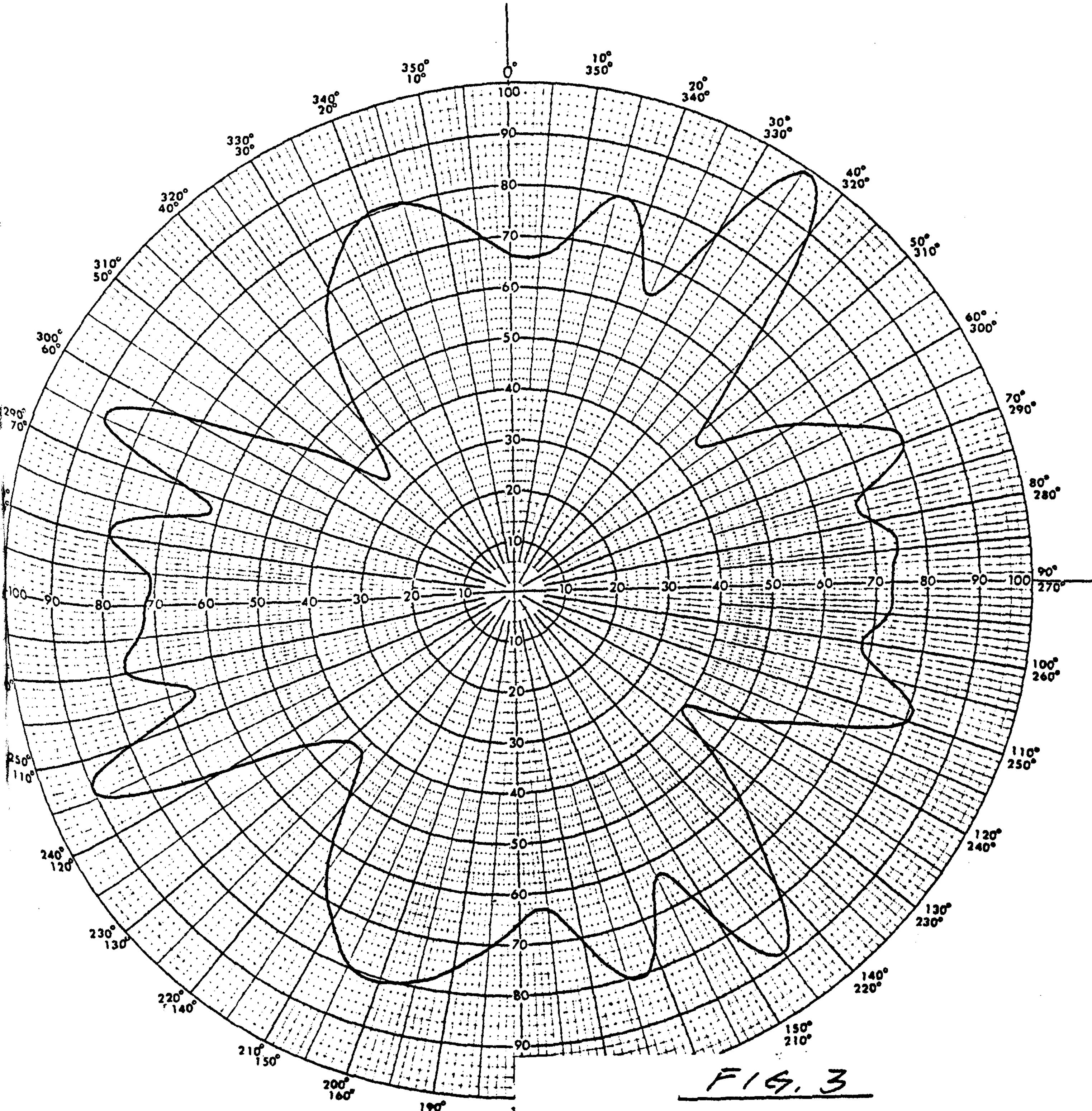


FIG. 3

HORNBY MODEL
SINGLE SKYWIRE
509 MHZ.

GC-127L (GC 1224-R)
GRAPHIC CONTROLS CANADA LTD
Printed in Canada

5 JUNE 1979

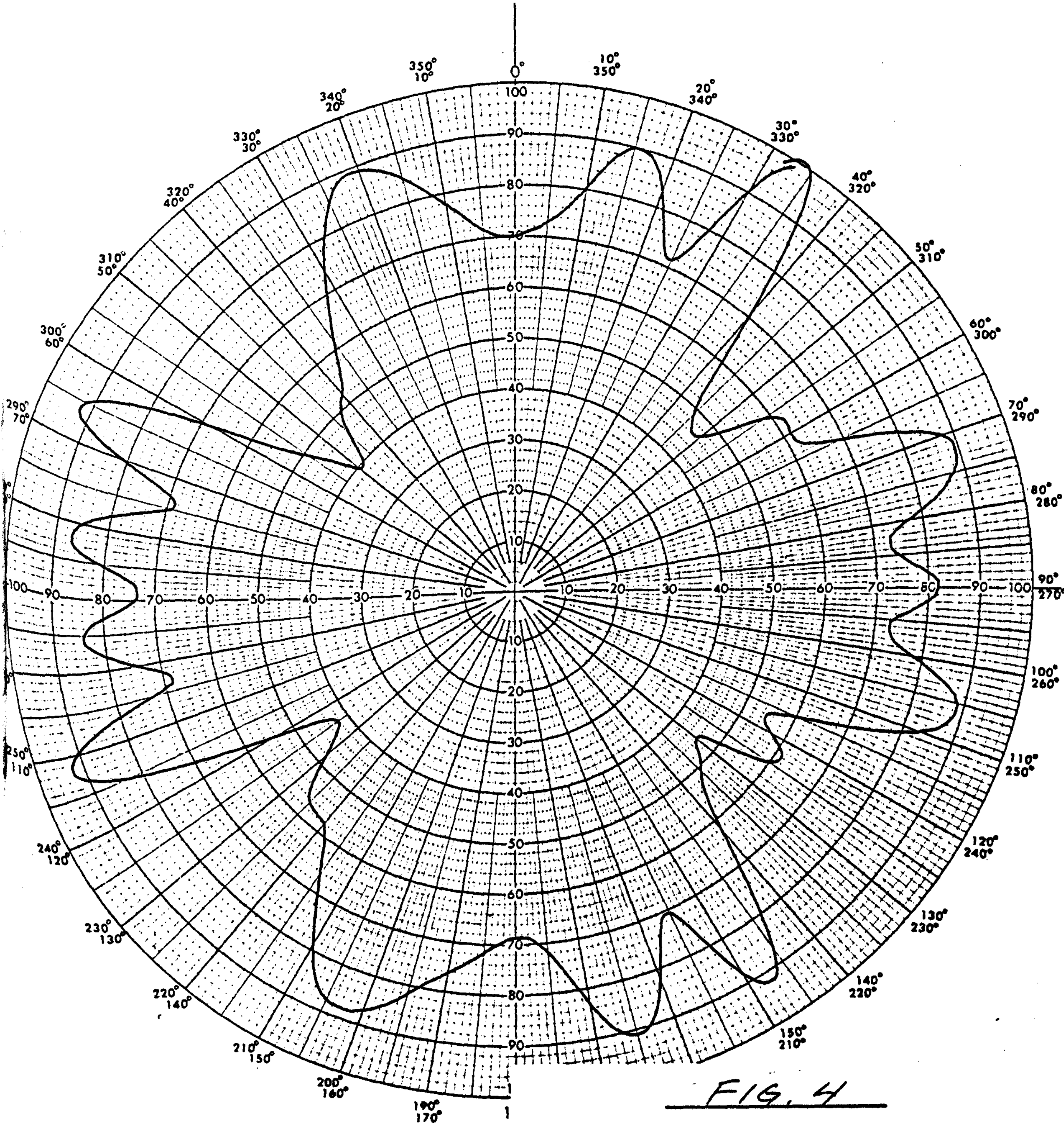


FIG. 4

HORNBY MODEL
SINGLE SKYWIRE
521 MHZ.

GC-127L (GC 1224-R)
GRAPHIC CONTROLS CANADA LTD
Printed in Canada

5 JUNE 1979

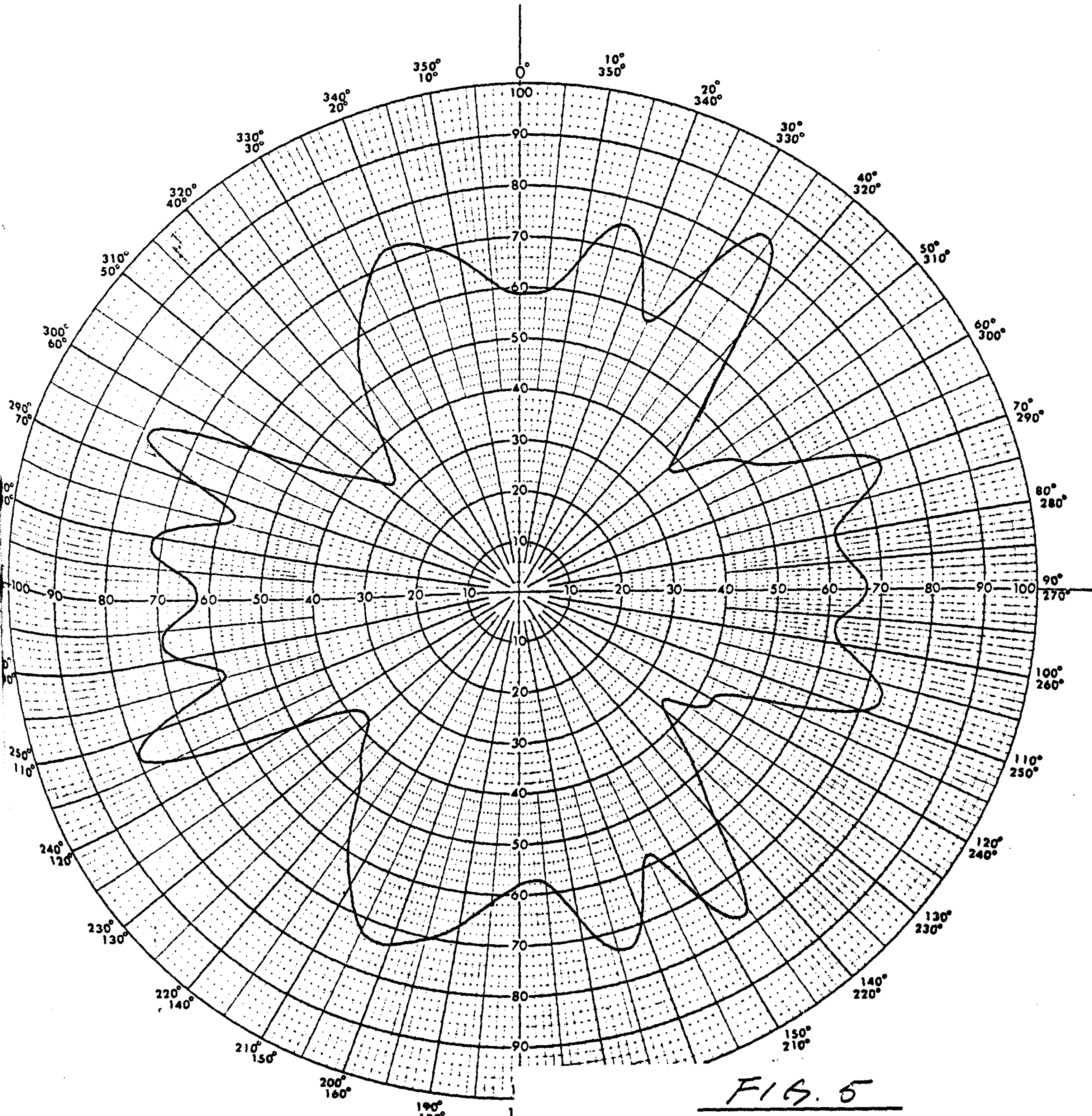


FIG. 5

HORNBY MODEL
SINGLE SKYWIRE
RESISTOR LOADING
516 MHZ R=0

GC-127L (GC 1224-R)
GRAPHIC CONTROLS CANADA LTD
Printed in Canada

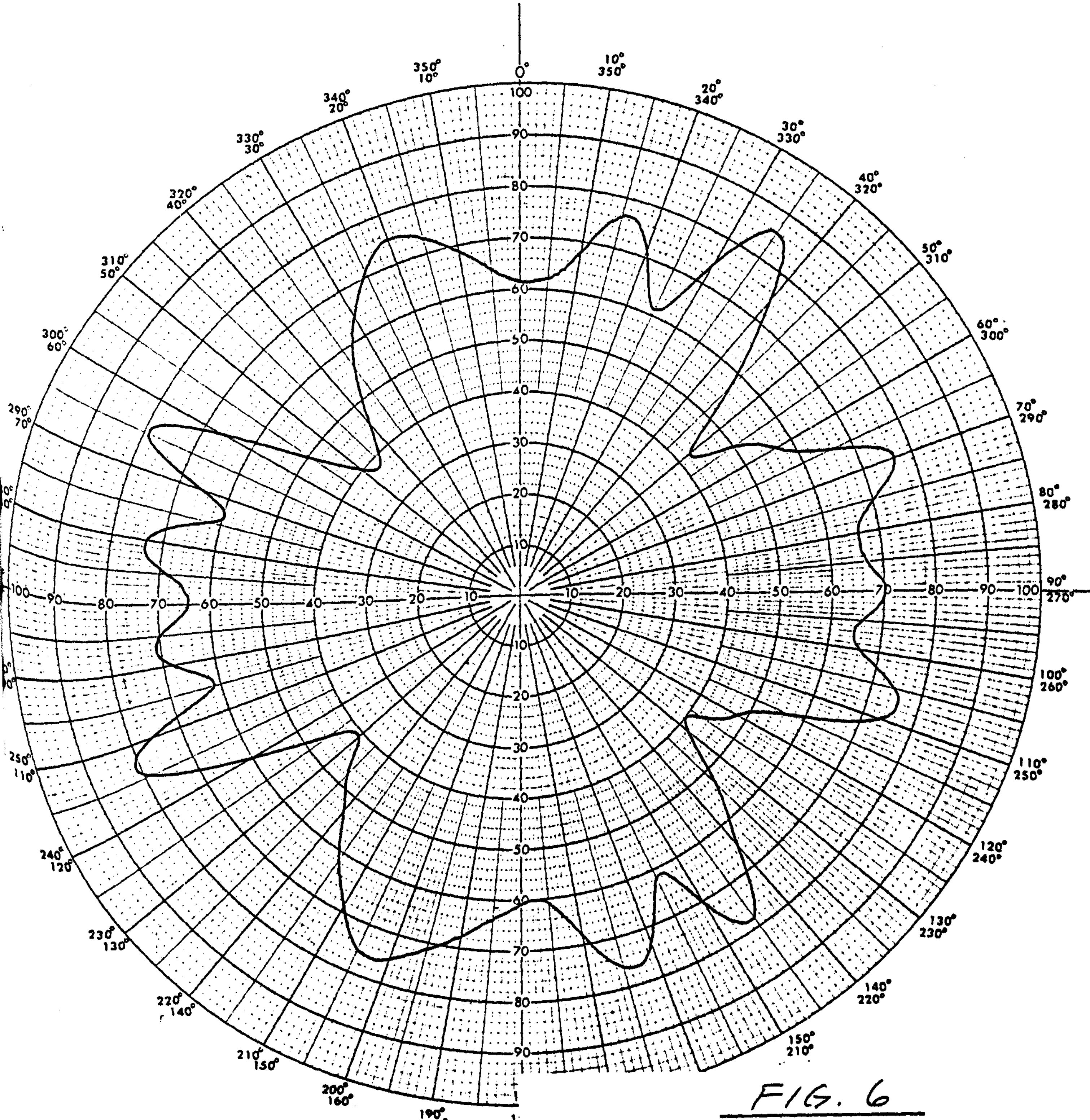


FIG. 6

HORNBY MODEL
SINGLE SKYWIRE
RESISTOR LOADING
516 MHZ R = 22 OHMS

GC-127L (GC 1224-R)
GRAPHIC CONTROLS CANADA LTD

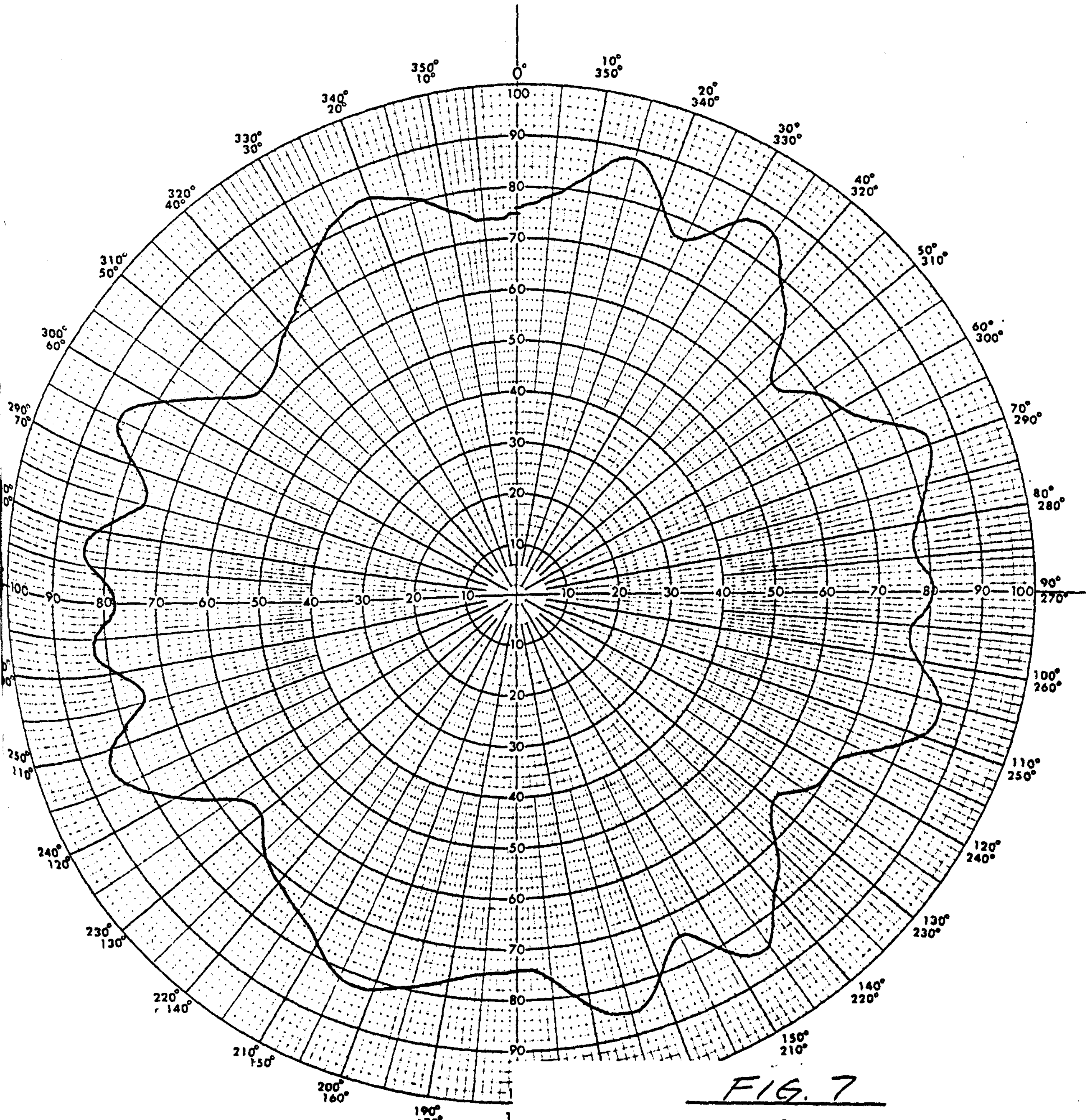


FIG. 7

HORNBY MODEL
SINGLE SKYWIRE
RESISTOR LOADING
516 MHZ R = 220 OHMS

GC-127L (GC 1224-R)
GRAPHIC CONTROLS CANADA LTD
Printed in Canada

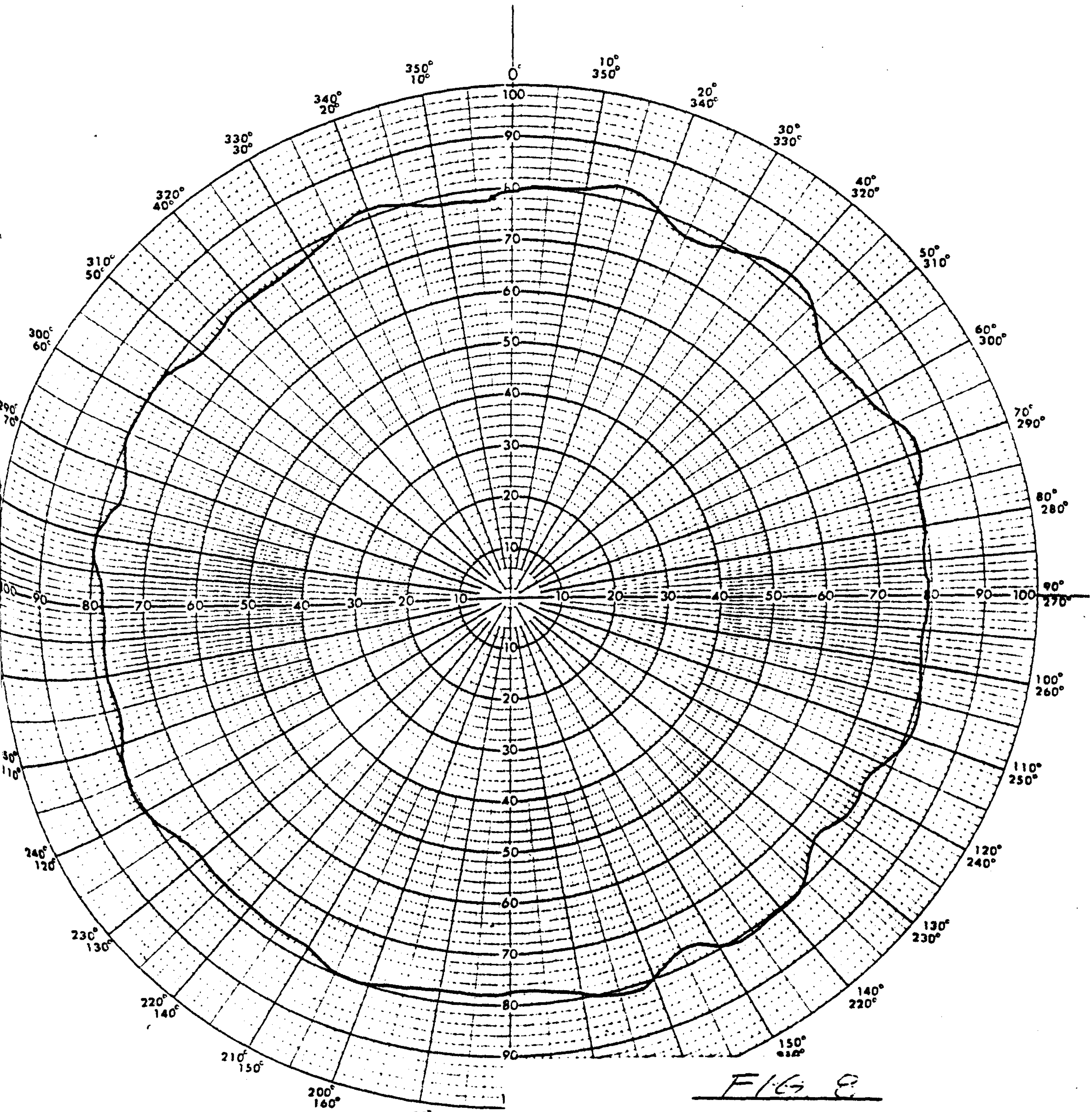


FIG 8

HORNBY MODEL

SINGLE SKYWIRE

RESISTOR LOADING

516 MHZ R = 2200 OHMS

RESISTOR AT MIDSPAN 4 June 1979

GC-127L (GC 1224-R)

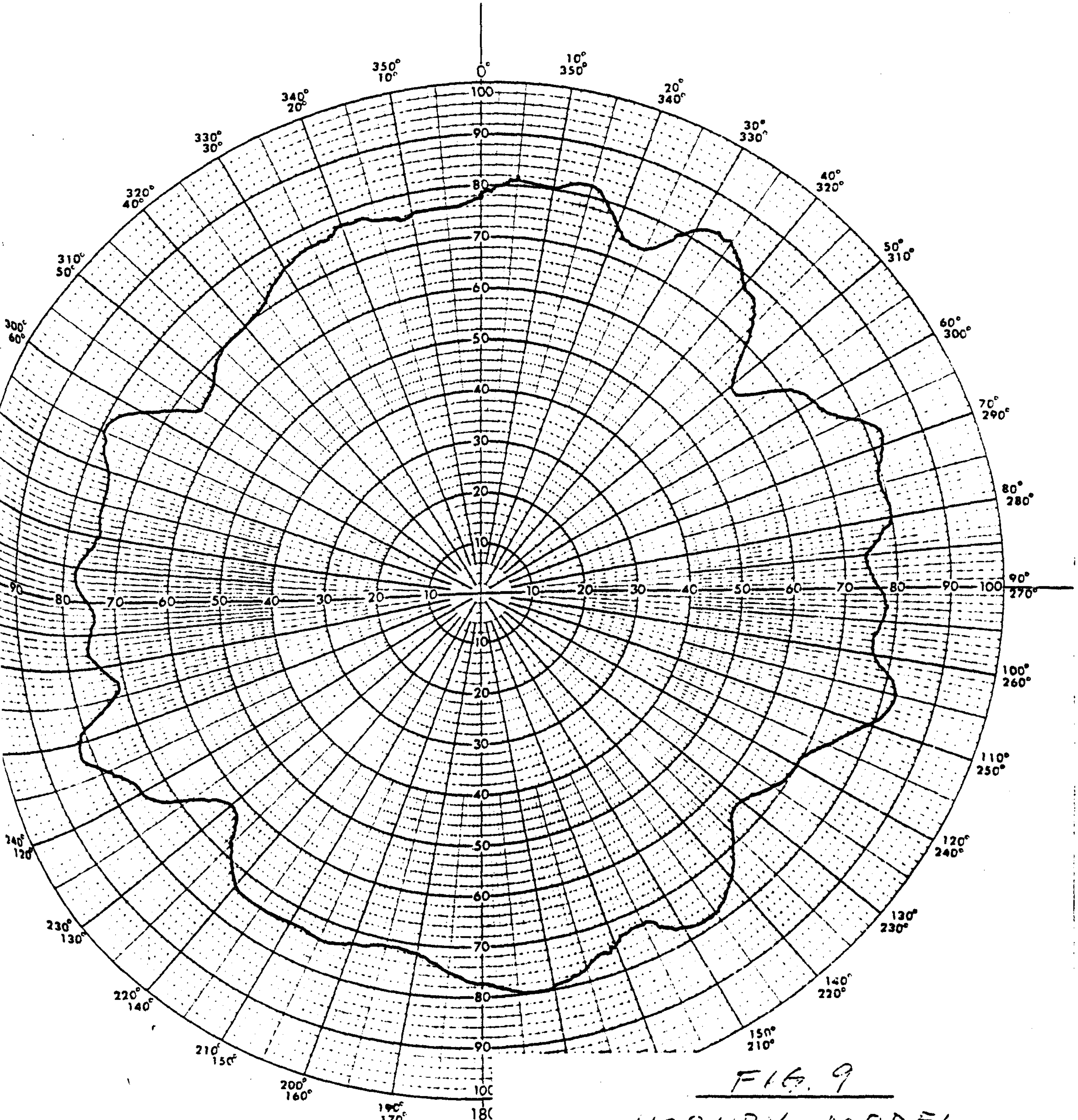


FIG. 9
HORNBY MODEL
SINGLE SKYWIRE
RESISTOR LOADING
516 KHZ R= 2200 OHMS

RESISTOR AT TOWER 4 JUNE 1979

127L (GC 1224-R

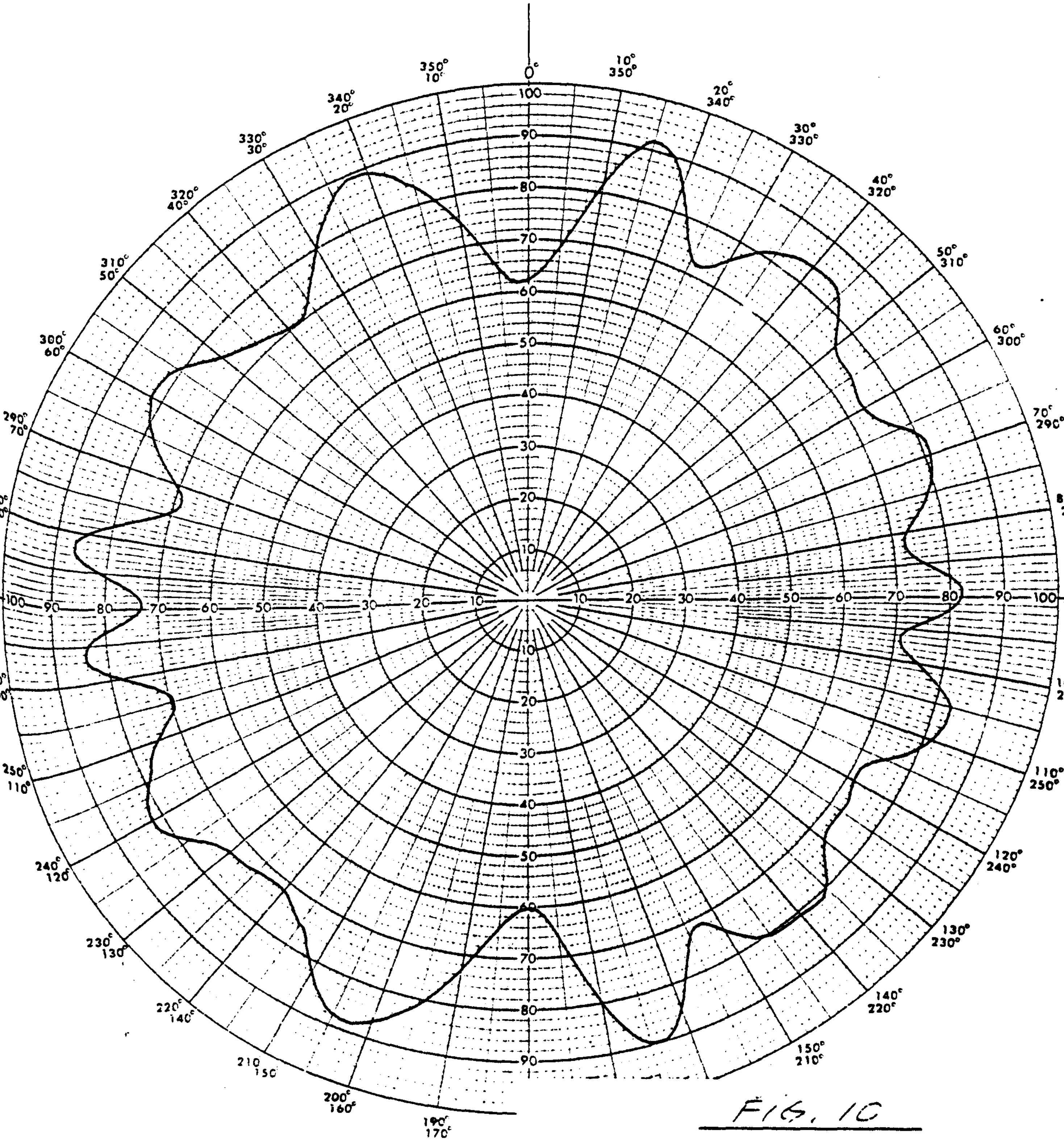


FIG. 10
HORNBY MODEL
TOWERS ONLY
516 MHZ

GC-127L (GC 1224-R)

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INTERIM REPORT NO. 1

AM RE-RADIATION PROJECT

by

C.W. Trueman and S.J. Kubina

Electromagnetics Laboratory
Technical Note EMC-79-01
8 June 1979

Supported by

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Electromagnetics Laboratory
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PREFACE AND ACKNOWLEDGEMENTS

The material presented in this Technical Note covers the work done in the first three weeks ending 1 June 1979. The work was initiated with the authorization of the CBC portion of the project by Mr. Jack Litchfield on 7 May 1979. The main portion of the project is funded by CRC/DSS Research Contract No. 9-9509 to Concordia University for which Dr. J.S. Belrose of CRC serves as Scientific Authority and Dr. S.J. Kubina as Principal Investigator. The Primary Research Associate on the project is Mr. Christopher W. Trueman.

The timing of the report has been coordinated with Dr. Belrose's requirements to report at the forthcoming meeting of the Working Group on Re-Radiation Problems in AM Broadcasting. The approach is outlined in the proposal letters to CRC and CBC which have been enclosed as appendices.

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Interim Report No. 1
AM RE-RADIATION PROJECT

1.0 INTRODUCTION

This brief report summarizes the work done in the initial three weeks of the CRC/CBC contract on AM Re-Radiation. Section 2 describes the software that is being developed to facilitate the interpretation of the output of the Antenna Modelling Program (AMP, Ref. 1) which is currently being used for this work. A preliminary application of AMP to a "towers only" model of the line is described in Section 3. The results of AMP are compared with those of another wire antenna analysis program called "Wire Grid Version Three" (WG3, Ref. 2), and also with Bill Lavrench's measured result. Section 4 of this report describes the power line models that are proposed for further study.

2.0 SOFTWARE DEVELOPMENT

For large structures, antenna modelling programs such as "AMP" or "WG3" use a lot of memory and consume a large amount of CPU time, and are therefore run on the University CDC Cyber 172 computer. The output of such programs consists of: (i) the phasor current amplitude on each wire segment of the computer model; and (ii) the radiation patterns for the antenna. The PDP-11/20 "MIDAS" minicomputer with its Tektronix 613 storage-type graphics display allows the radiation pattern to be drawn as a polar diagram, and the current to be displayed in graphical form. This facilitates the job of interpreting the result of any given model of the antenna and power line. Thus the output of AMP is transferred from the CDC to the PDP-11 computer for display. This section describes the software being developed for both the CDC and the PDP-11 computer.

Figures 1 and 2 show the programs and data files used for this project on the CDC and the PDP-11 computers, respectively.

On the CDC computer, a "model generator" program must be written to create an input file for the AMP program, that describes the particular antenna and power line model being used. This input file is called "AMPIN". To run the AMP program, the "SUBMIT" file called "RUNAMP" is executed by the command "SUBMIT RUNAMP". This causes the computer to fetch the AMP program and the input data file "AMPIN", execute AMP, and generate a file containing the solution to the problem, called "AMPOUT". This file is too large for efficient direct transfer to the PDP-11 ("spooling"), and so the program called "REDUCE" is executed. This program reads the file "AMPOUT", extracts the radiation patterns and the current amplitudes, and creates a smaller data file called "SOLN". This file is "spooled" to the PDP-11 over a 1200 baud line, for permanent storage, and for use with the display programs described below. The input sequence has been designed with a view to its effective use in this research as well as its subsequent execution by other users such as the CBC.

The program "PLOT" reads a measured pattern from file "MEAS", and a "SOLN" file, and produces a file called "DATA" comparing the measurement and calculation. "DATA" must be printed on a decwriter. The "MEAS" file is created on the PDP-11 and "spooled out" to the CDC. "PLOT" allows a run to be compared with measured results directly on the CDC computer, without having to spool to the PDP-11. There are currently nine measured patterns stored on the CDC account.

On the PDP-11 computer, the programs of Figure 2 are used to display the computations. The "SOLN" file is stored on the PDP-11 with the "RUN NAME" as the file name. Thus the 25th run of the LINE-1 model is called "LINE 1.25". These files are permanently stored on dectape.

Program "MODEL" is a general purpose program for displaying wire antenna models by reading the input data for "AMP".

"MODEL" produces a picture of the wire antenna on the TEK 613 graphics screen.

Program "CRNT1" and "CMPH1" display the magnitude only, and the magnitude phase, respectively, of the current distribution on the "LINE-1" model. These are special purpose programs and must be altered to display the current on other models.

Program "PLOT" is similar to the CDC version of "PLOT" but adds the ability to plot calculated values only, with no measured pattern comparison. "PLOT" on the PDP-11/20 is also useful for obtaining printer plots of data files stored on tape.

"PATN" is a general purpose program which reads a data file with the "SOLN" format, and displays each radiation pattern on the TEK 613 screen. Each pattern is individually normalized to unity. "PATN" is useful for a quick look at the results of running "AMP". "PATN" accepts any combination of E- or H- plane patterns, frequency sweeps, etc. that may be present in the "SOLN" file.

"PAT C" compares one computed H-plane pattern with a digitized pattern, using "area normalization".

"MEAS" inputs a manually digitized H-plane pattern and creates a "MEAS.m" pattern file for input to "PLOT" or "PAT C".

3.0 RESULTS: TOWERS ONLY MODEL

This section compares computations using a "towers only" (no skywires) model with Bill Lavrench's measurements. The geometry is that of Ref. 3, Appendix 1, Figure 9, while at the full scale frequency of 860 kHz, the H-plane pattern is given in Figure 10 of that report. The physical model does not include any skywires or phase wires. The measured pattern was "digitized" on the PDP-11/20 using the program "MEAS" of Figure 2.

Figure 3 is a sketch of the computational model. Using the "WG3" wire antenna analysis program, and 13 towers (as used in the measurement), the H-plane pattern is found to be in good agreement with Lavrench's measurement, as shown in Figure 4. Near the angle of 180 degrees the patterns differ somewhat, but otherwise are remarkably similar.

With 9 towers, the agreement is almost as good, as shown in Figure 5. This reduction in the number of towers represents a considerable computational economy.

For comparison, the model with nine towers was run with the "AMP" program, and the result is shown in Figure 6. The agreement is about the same as in Figure 5. "AMP" is a more general, more flexible and less expensive program than "WG3", and will be preferred for most of the numerical calculations in this project. Comparison with other computer codes will be undertaken in later reports.

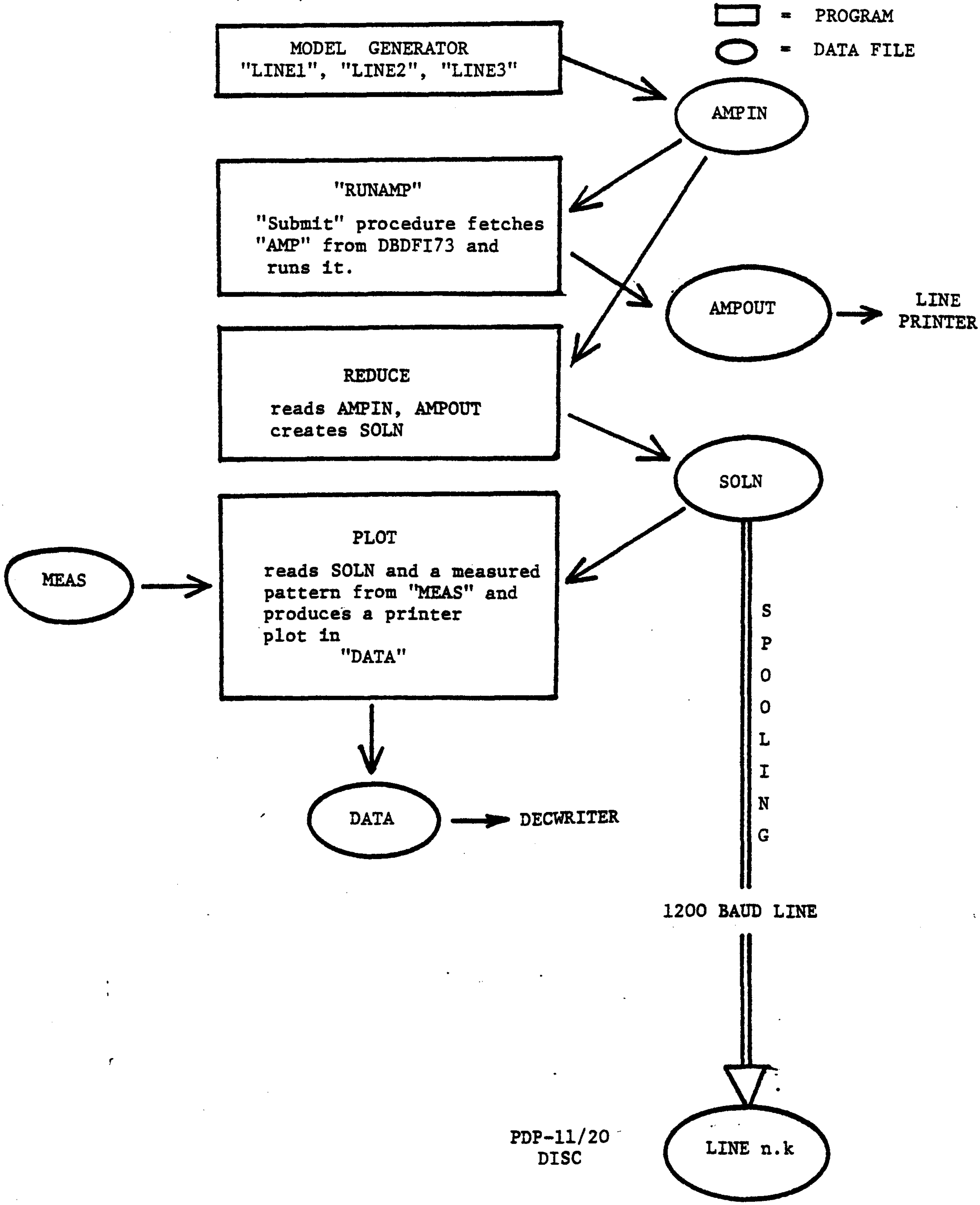
4.0 POWER LINE MODELS FOR FURTHER INVESTIGATION

It is proposed that the "single wire towers with skywires" model of Figure 7, called "LINE-1", and that the "A-frame towers with skywires" model of Figure 8, called "LINE-2", be investigated. The dependence of the H-plane pattern on the number of towers, tower and skywire radii, tower height, numerical segmentation, and on the frequency will be studied for these models.

S.J. Kubina, Eng.
Principal Investigator

C.W. Trueman, Eng.
Primary Research Associate

June 8, 1979



<u>Figure 1</u>

CDC Programs and Data Files

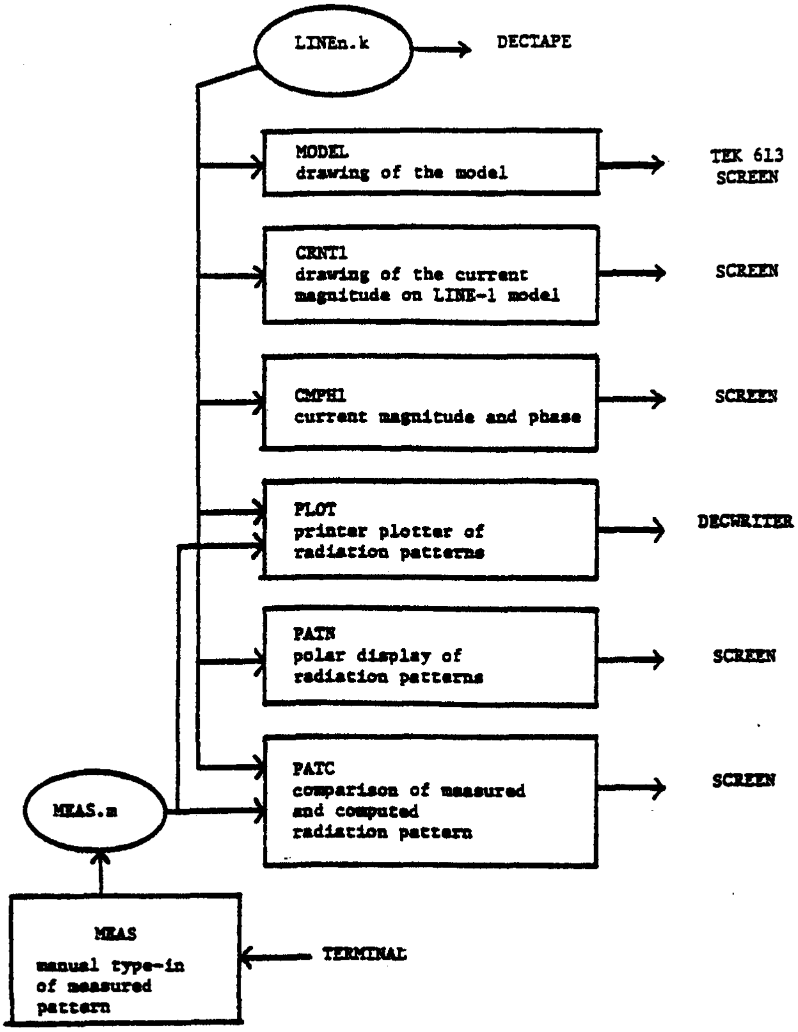


Figure 2

PDP-11/20 Data Files and Programs

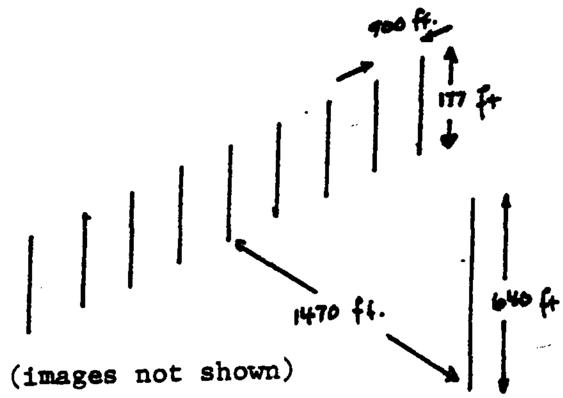


Figure 3

Towers Only Model

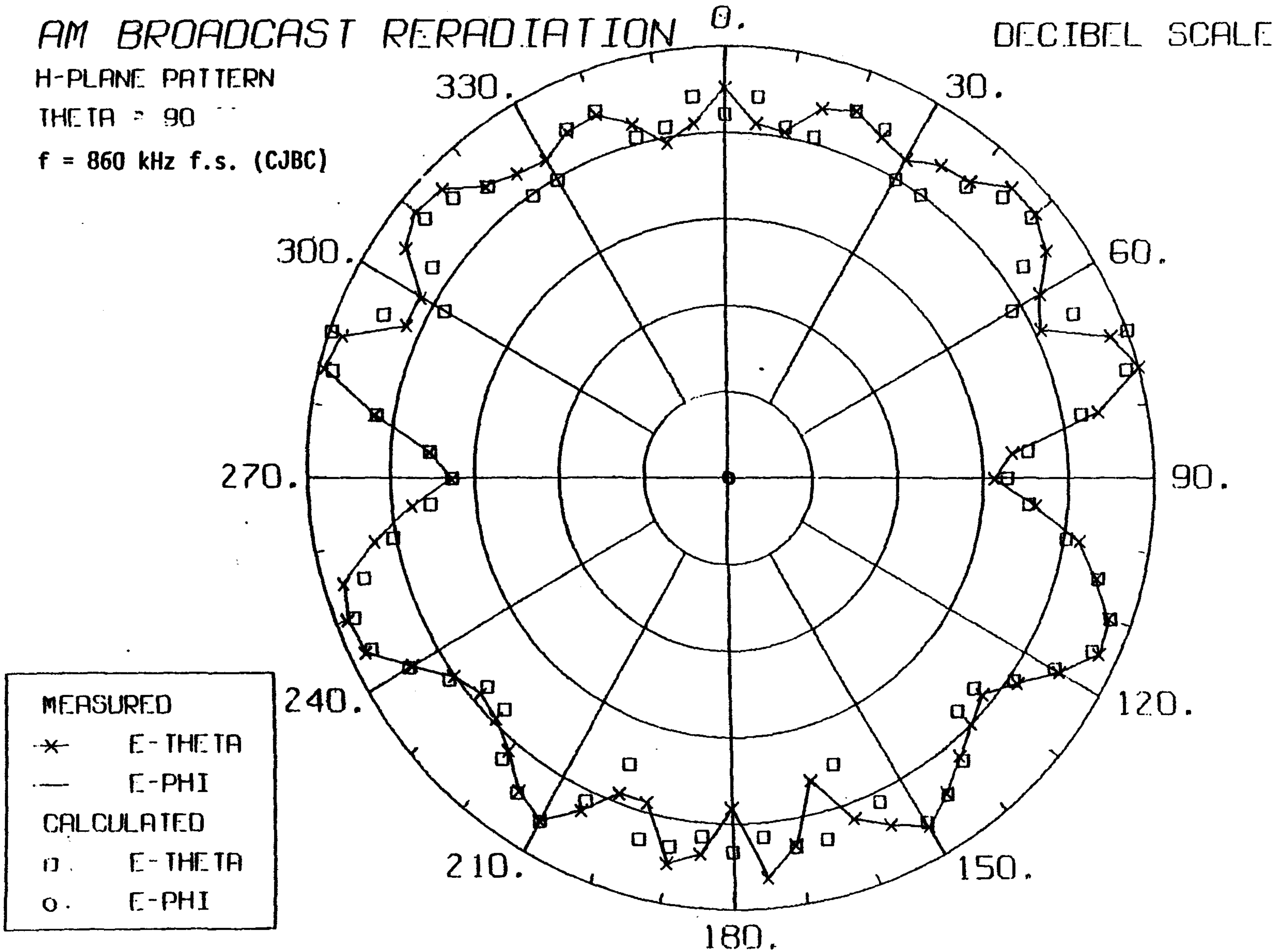


Figure 4

Calc.: 13 Towers, No Skywires (WG3) vs Measured Results

(ρ_{rad}=2m, ρ_{tow}=5m)

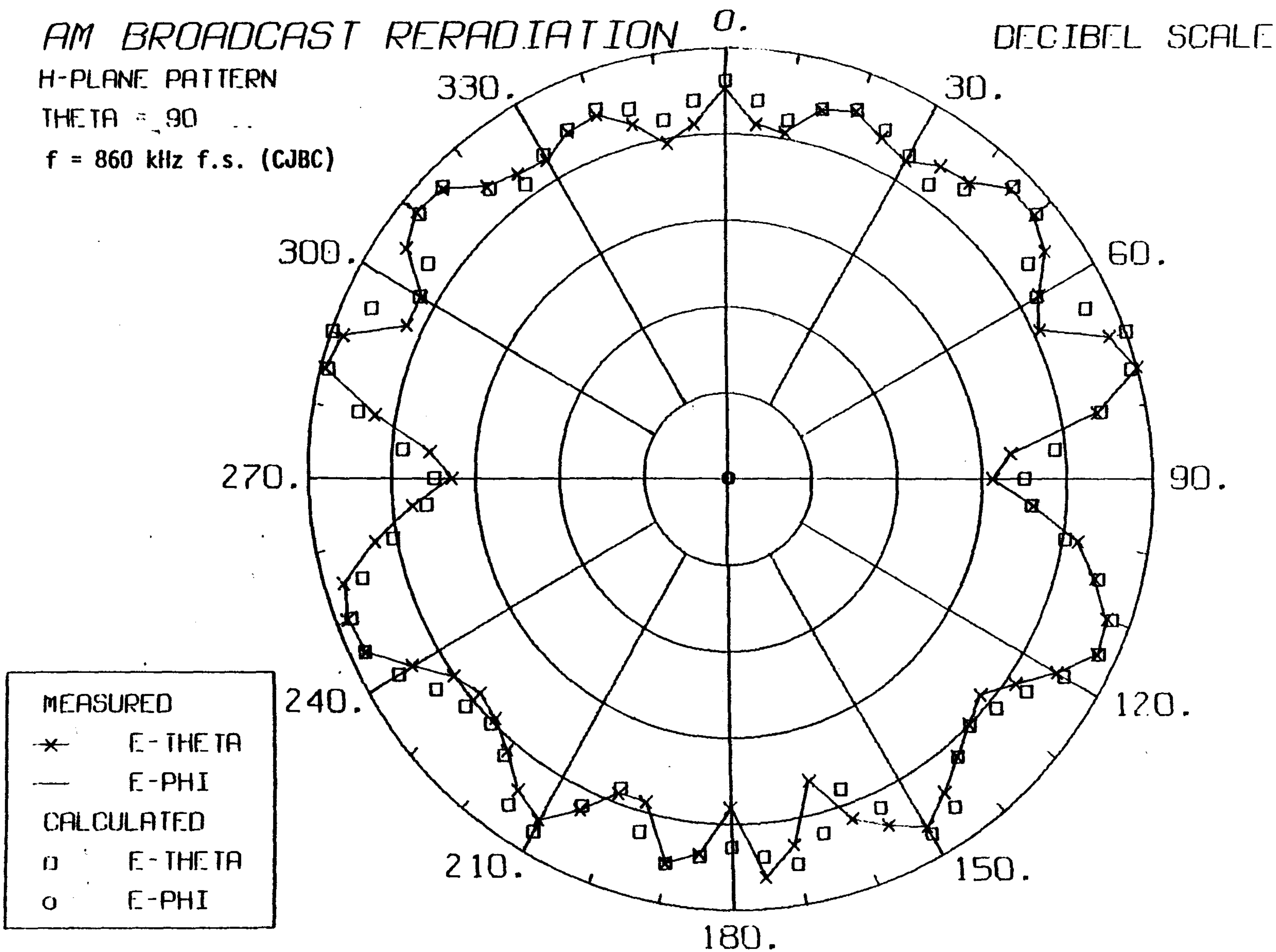


Figure 5

Calc.: 9 Towers, No Skywires (WG3) vs Measured Results

(ρ_{rad}=5m, ρ_{tow}=2m)

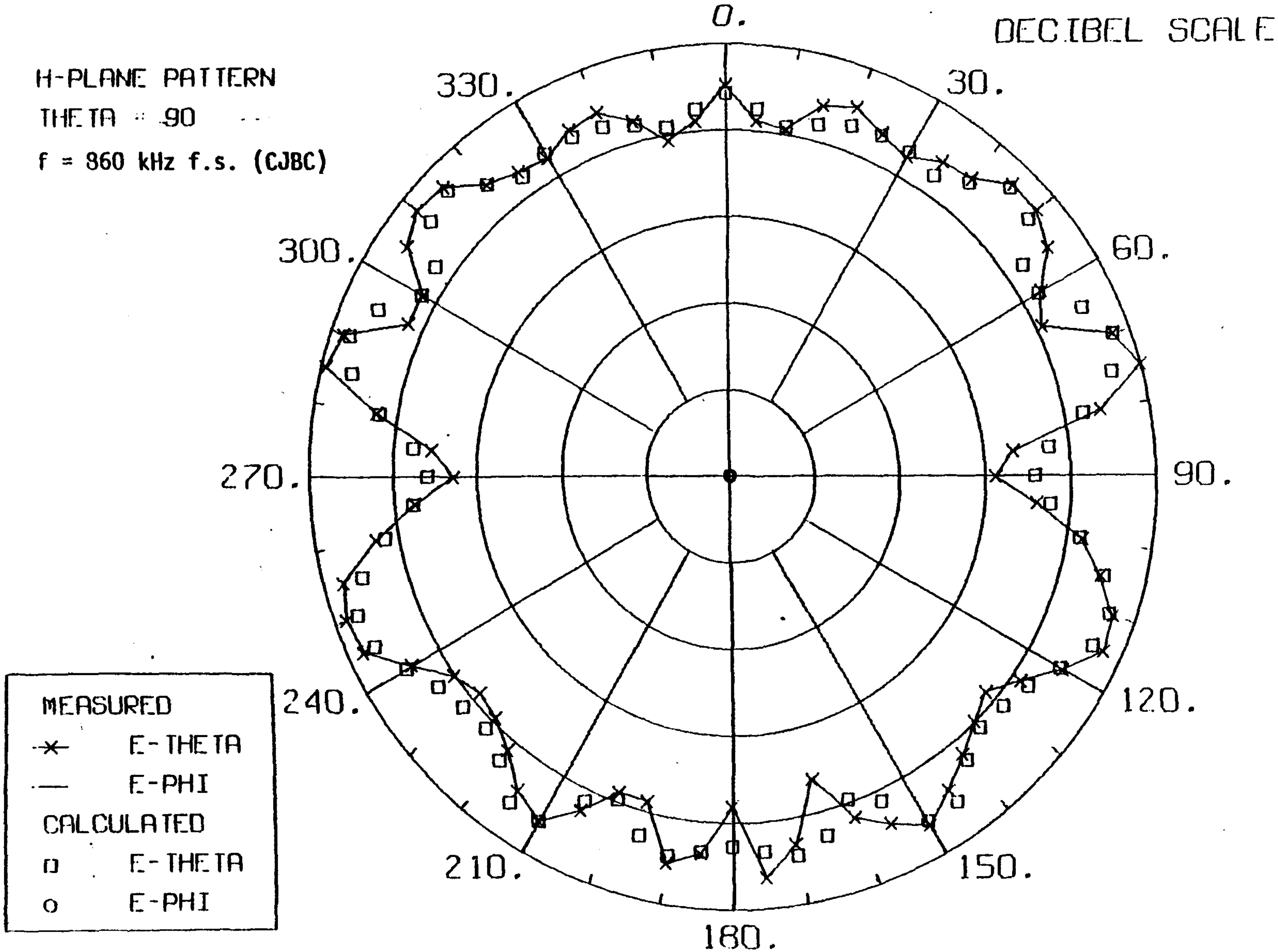


Figure 6

Calc.: 9 Towers, No Skywires (AMP) vs Measured Results

$(\rho_{rad}=5m, \rho_{tow}=2m)$

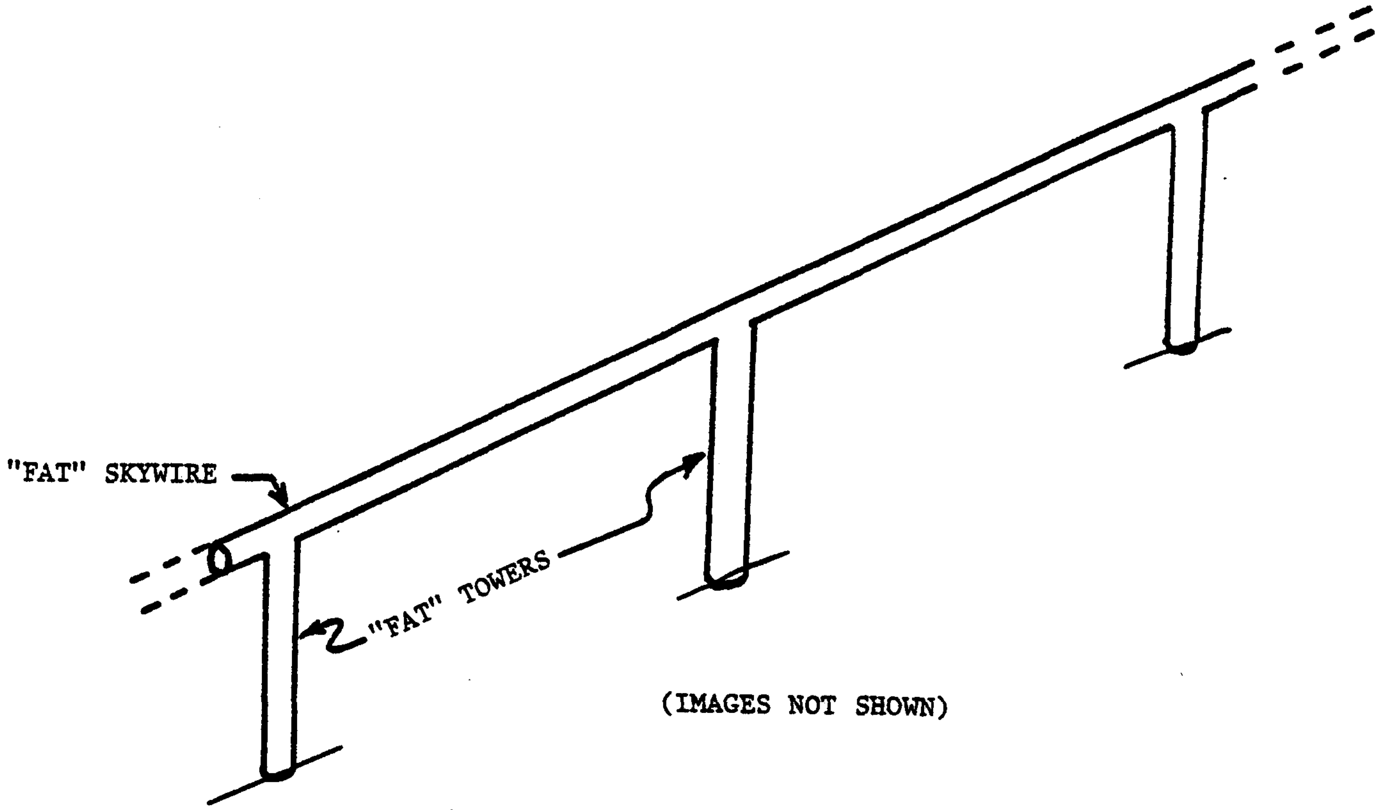


Figure 7
"LINE1" Model of the Power Line

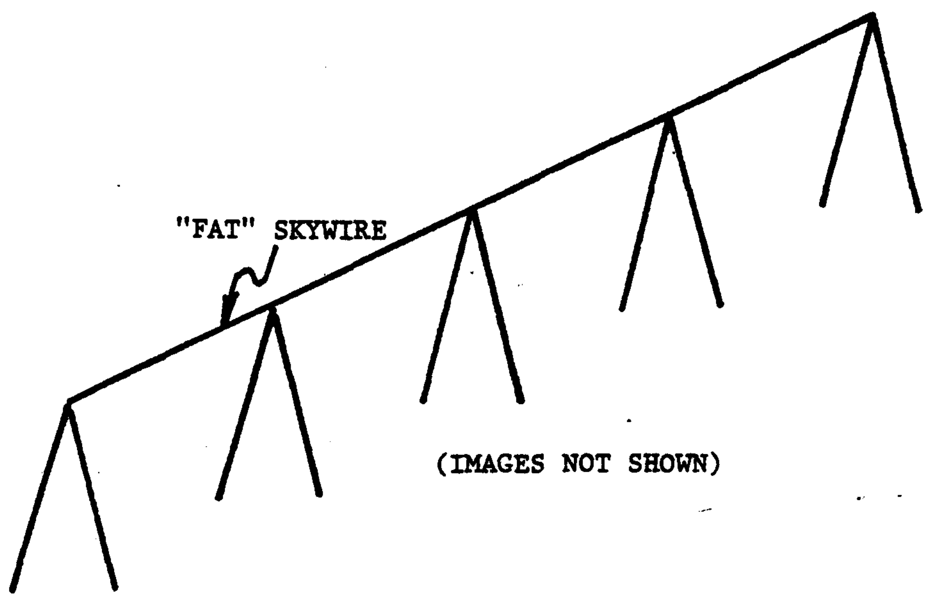


Figure 8
The "LINE2" Model with 5 Towers

18 April 1979 Dr. S.J. Kubina, Eng.

APPENDIX A

- C O P Y -

Proposal For

Research Project

Re-Radiation of Broadcast Signals: Analysis by Computer Methods

OBJECTIVE: To provide the CBC with a method of analyzing the re-radiation of broadcast signals from power transmission lines.

APPROACH:

Antennas on complex bodies or complex antenna configurations can be analyzed by means of Pocklington's Electric Field integral equation. A solution in closed form is available only for simple configurations. Computer solutions using numerical techniques based on the moment method are available in several variants. Such computer codes are presently available at Concordia and are being used to study aircraft antennas in the HF (2-30MHz) frequency range. Complex surfaces are represented as a network of interconnected elements of specified radius on the surface of which a boundary condition is enforced. The application of these computer programs to the valid modelling of complex systems by an appropriate choice of parameters for the wire grid has been found to be a non-trivial problem.

The proposed research is closely interlinked with that to be funded this year by the Communications Research Centre. This effort is expected to produce an understanding of how the computer techniques can be used to model the ensemble of broadcast radiators and nearby transmission lines. Validation of the computer modelling will be by comparison with the results of measurements conducted on the NRC model range.

This proposed CBC-funded project will support a small portion of the core effort in finding valid computer models, but in the main will be directed to produce a user-oriented version of the selected computer program which could be executed by CBC engineers via a computer terminal for appropriate radiator/transmission line geometries. Guidelines for the choice of parameters of the numerical model would be provided (i.e. wire segment lengths, location and radius). It is possible that the geometry input portion of the computer code could be written in interactive form to simplify the generation of the input wire grid required by the program from more general descriptive data used by the broadcast engineer. Since one of the presently-used computer codes allows for the inclusion of discrete impedances at wire grid elements, it is envisioned that this feature will be useful in the specification of transmission tower base impedances if these are known.

The project is to be carried out on the research computer network with its interactive graphics system which is available on the Loyola Campus of Concordia University. Should it be of advantage to the CBC, it can also be made available to CBC engineers for such analysis.

SCHEDULE OF WORK:

The research work sponsored by the CRC is expected to take place in the period May 1979 to 31 March 1980. The CBC portion would extend over a 12-month period also starting in May 1979. The expenditure rate would be light initially until model validation is assured. At this point, approximately in early August, the rate would be intensified in an attempt to make a software package available to the CBC by the end of 1979 under tutorial assistance. The remainder of the period would be devoted to any de-bugging, casual assistance and the production of a final report.

ANTICIPATED RESULTS:

Valid computer modelling of complex electromagnetic systems has already been carried out at Concordia and elsewhere. Thus the risk in achieving the objective stated above is expected to be small, although always present in research work of this kind.

A validated computer model can also be used to generate design graphs and charts* which can be used for a quick assessment of radiation pattern fine structure (scalloping). Towards the end of the proposed project, the CBC might wish to consider studies of such additional "spin-off" potential of computer modelling.

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* Christopher W. Trueman, Tomas J.F. Pavlasek, and Stanley J. Kubina, Parametric and Synoptic Charts for Determining the Patterns of an Elemental Dipole with a Scattering Mirror or Cylinder, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19, No. 4, November 1977.

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- C O P Y -

March 26, 1979

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Communications Research Centre
Radio Communications Laboratory
P.O. Box 11490, Station "H"
Shirley Bay
Ottawa, Ontario
K2H 8S2

SUBJECT: Proposal for Study of Effects of Re-Radiation of Broadcast Signals Based on Moment Method Analysis

Dear Dr. Belrose,

Accompanying this letter, our Research Office has included the proposed budget for the subject study. We have been exercising with some success, four separate wire-grid modelling codes on complex body problems dealing with aircraft antennas in the HF frequency range. Our purpose in this program has been to develop suitable analytical and design tools to complement scale modelling and full scale measurements. Our global approach on your project would be identical.

We would hope to validate the computer models first on the more simple configurations you have measured on the NRC range, and then to proceed to the modelling of the broadcast array over a perfectly conducting ground near transmission lines with and without skywires or near groups of buildings. At some point we can consider representing am imperfect ground by the use of codes which allow the specification of appropriate Fresnel coefficients.

The existing software will be adapted to plot the radiation patterns and current distributions on our PDP-11-driven graphics display to allow rapid and meaningful evaluation of computation results. Such displays also allow overlay comparison with

.../2

corresponding measurement results when these are available as appropriate data files. We might suggest that you consider having NRC use their digital recording as well as analog output in order to facilitate such comparison.

It has been our experience that the plotting of computed current distributions provides a productive mechanism for the understanding of the physical mechanisms of interaction and the consequence far-field pattern detail.

The budgetary estimate has been kept low by pricing my own involvement as a fixed honorarium rather than a per diem rate. My colleague Chris Trueman has accepted this research project as his major research undertaking during 1979-80. As you know, he is well versed in moment method techniques. Assistance would be provided by our student(s) working under Chris Trueman's or my direction. Other aspects of the estimate are self-explanatory.

I would be pleased to discuss additional details at your convenience and especially to obtain your perceptive overview on the technical status of the project and on the priorities of outstanding problems.

Yours truly,

Dr. S.J. Kubina, Eng.
Professor
Electrical Engineering

encl.

SJK/pjf

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