

1. Betrose, J. S.

INTERIM REPORT NO. 3

2. THE EFFECTS OF RE-RADIATION

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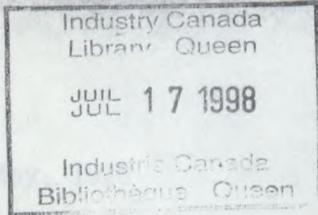
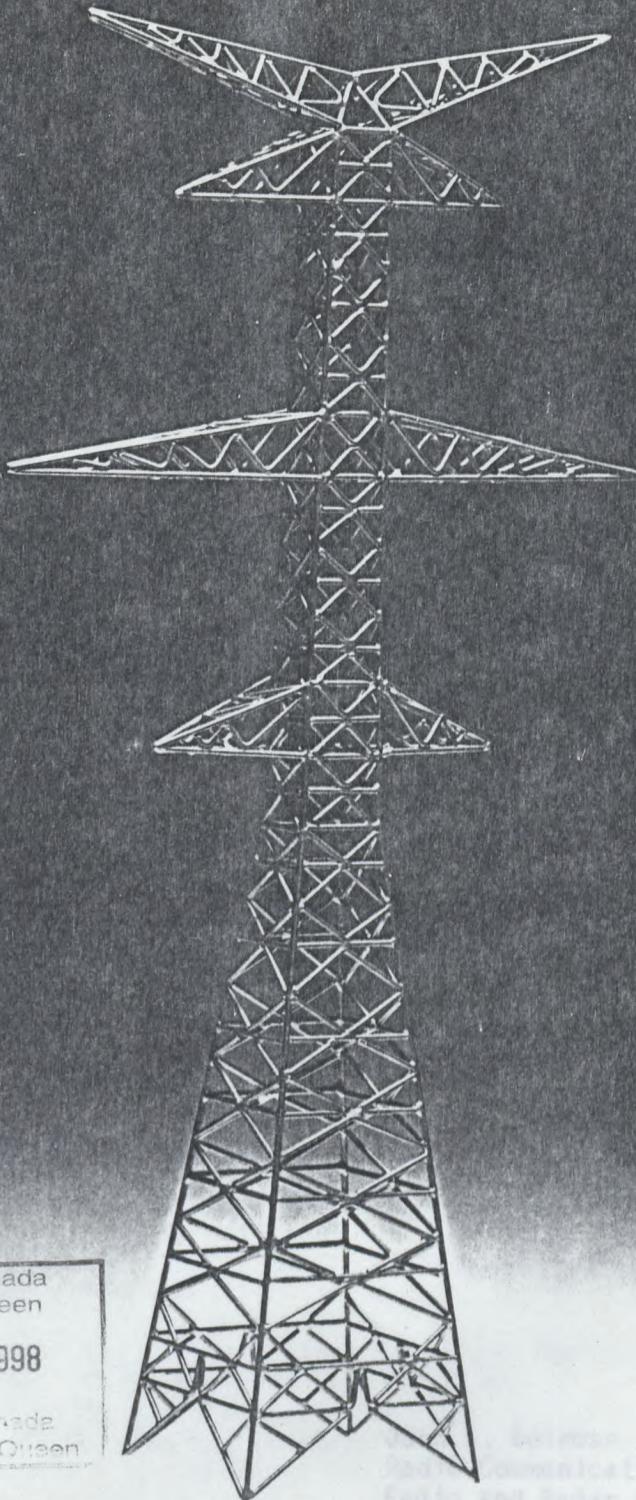
HIGHRISE BUILDINGS, TRANSMISSION LINES, TOWERS AND OTHER STRUCTURES
UPON AM BROADCASTING DIRECTIONAL ARRAYS

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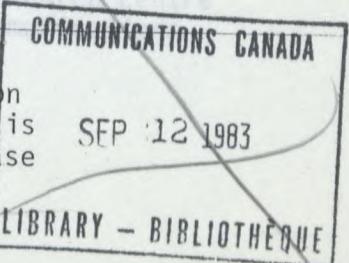
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FRONT PIECE: Scale model of 500KV 2 CCT Type VIS suspension tower. Scale factor 200; i.e., tower height is 10.6 inches, 1-3/4 inches on a side at the base of the tower.

Communications Laboratory
Radio and Radar Research
Electromagnetic
Communication Research Centre



INTERIM REPORT NO. 3

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

(DOC Project No. 4-284-15010)

CONTENTS

1. Introduction
2. Progress to Date
3. Future Work
 - 3.1 Review of Progress to Date
 - 3.2 Work Planned for Current Fiscal Year, 1978/79
 - 3.3 Requirement for a New Antenna Pattern Range

APPENDIX I An Analytical Model for the Scattering Pattern Calculation from an Array of Thin Towers

APPENDIX II Computer Programs for Re-Radiation from an Array of Thin Towers

18 May, 1978

John S. Belrose
Radio Communications Laboratory
Radio and Radar Research
Directorate
Communications Research Centre
Department of Communications

1. INTRODUCTION

This is the third interim report describing a research investigation into the effects of re-radiation from 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 2 February, 1978 until 18 May, 1978 and is prepared for the seventh meeting of a Working Group (Chaired by DOC) on Re-Radiation Problems in AM Broadcasting, scheduled for 18 May, 1978. Reference should be made to the first two interim reports before reading this one.

The overall objectives of the research project, which have been described in the earlier reports, remain the same; viz.: (1) to measure the magnitude of the effects; (2) to numerically model the various experimental situations, the ultimate objective being to predict pattern distortion effects; and (3) to evaluate possible ways and means of alleviating such problems.

The research planning for carrying out these objectives has been in terms of a phased approach, the scope of future phases of the program to be re-assessed after completion of the current phase.

The first phase (in which we are currently working) is to investigate the magnitude of the re-radiation effect employing existing facilities (the NRC antenna pattern range but also measurements made in the University of Toronto's anechoic chamber); to begin work on the initial theoretical/computational approach to the problem; and to plan for the development of a larger antenna pattern range (one that is five times larger than the NRC range).

The second phase is to develop such an antenna pattern range.

The third phase is to utilize the new facility to better study the magnitude of re-radiation from extended structures (power lines and groups of buildings); and to investigate ways and means of reducing or eliminating the effects of re-radiation on the directional pattern of AM broadcast arrays; and to complete the work on the development of a numerical method to predict pattern distortion.

Work on Phase One of the project will continue during the current fiscal year. It is expected that the planning for the development of the larger antenna pattern range will be sufficiently advanced such that a proposal for funding in 1979/80 fiscal year can be presented to DOC Management by September and that if approved in principle, engineering design for the facility can be completed during the winter of 1978/79. It is assumed that the need for such a facility will

be endorsed at the forthcoming meeting of the Working Group on AM Re-Radiation Problems. The requirement for the proposed new facility is reviewed in Section 3 of this report, after a review of progress to date.

2. PROGRESS TO DATE

2.1 NRC Work

Since the NRC facility is an outdoor ground level antenna pattern range, it cannot be used during winter months. Therefore, work during this reporting period has been spent in organizing the measured patterns and in constructing models. The modelling of buildings to date, on the NRC antenna range, has been restricted to buildings having a square cross-section, viz. 100 x 100 feet (4 x 4 inches for a scale factor of 300). Highrise buildings do not usually have a square cross-section, in fact, typically one or both of the side dimensions is that for a city block. A dimension of 100 x 400 feet was mentioned at the last Working Group Meeting, and therefore, a family of buildings, ranging in height from 50-400 feet (2 to 16 inches for a scale factor of 300) have been constructed.

At an earlier Working Group Meeting, photographs of the NRC models were presented. For completeness, Figures 1 to 3 of this report show: the two-element broadcast array, a building, and the modelled power line.

2.2 University of Toronto Work

The final report (Reference 1) covering work to the end of the present contract, has been prepared, and copies of it were distributed to all members of the working group. The report contains a summary of most of the measurements that have been made. Comparison is made with the radiation pattern measurements carried out by the CBC, DOC and Ontario Hydro at the Hornby antenna site (CBL/CJBC), and a start was made on a numerical/computational approach to the problem. The results obtained on the magnitude of the re-radiation effects are closely similar to those measured on the NRC antenna pattern range, which provides confidence in the measurements made. Further reference to this work is included in Section 3.1 (to follow) where we review the progress made so far in the project.

2.3 CRC Work

Some further work has been carried out by Dr. R. Chugh to extend his analytical approach so that a larger number of towers can be handled, by improving the computational efficiency of the computer

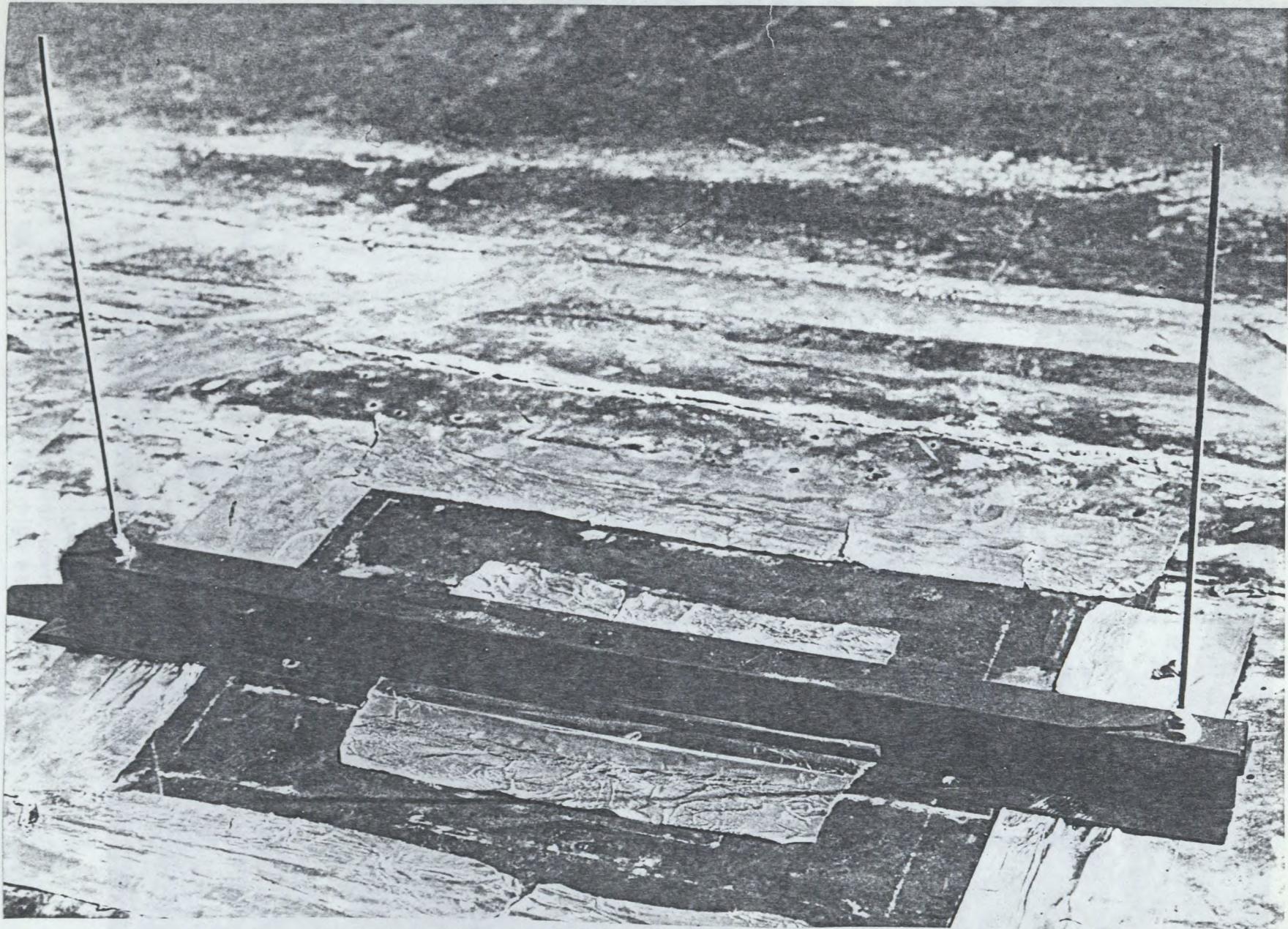


FIGURE 1. Model of 2-tower broadcast array, comprising two quarter wavelength high towers, half wavelength apart (scale factor 300; i.e., masts are 9.4 inches high).

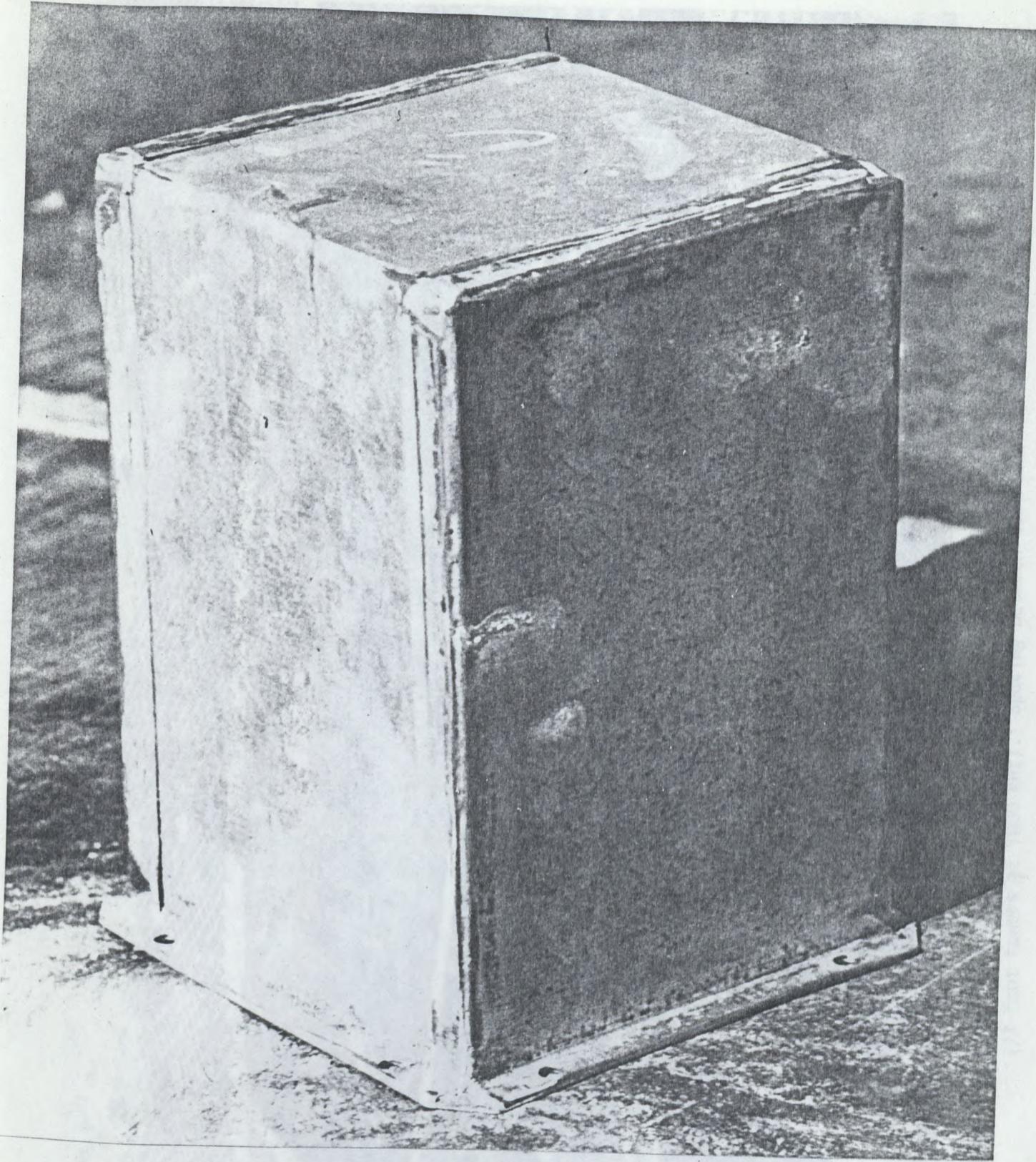


FIGURE 2. Model building (scale factor 300; i.e., model is 4 x 4 inches, 8 inches high corresponding to 100 x 100 feet, 200 feet high at 1000 kHz).

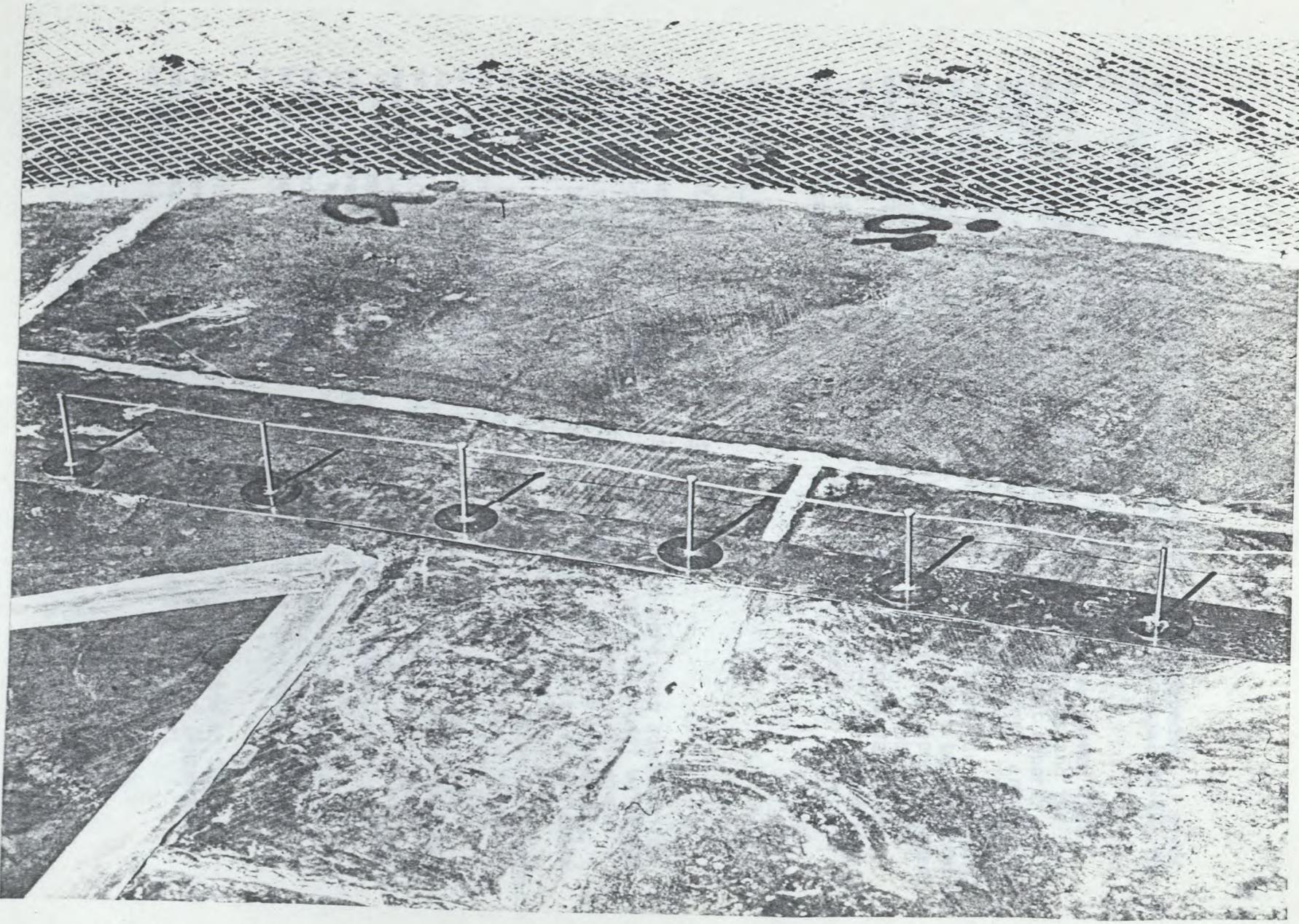


FIGURE 3. Model power line (scale factor 300; i.e., tower height is 3.3 inches corresponding to 177 foot towers at 1000 kHz). Spacing between towers $\lambda/2$ (i.e., 450 feet at 1000 kHz).

program. This work is described in Appendix I, and Appendix II gives a listing of the computer programs that have been developed during the course of this work.

In the Second Interim Report (Appendix III) we showed that there was a good agreement between the analytical results and the measured results for single thin towers. In the present report (Appendix I), this work has been extended to include single and two buildings, even though buildings are not "thin monopoles". The good agreement probably is because the measurements were made for "resonant" building heights. When the work is extended to more than two structures, three and five power line towers (with no top wire) this good agreement between computed and experimental results is absent ... the experimental results show re-radiation effects that are too large for the small (with respect to a quarter wavelength) height of the power line towers (0.18 wavelength). Further work will be necessary to resolve this difficulty.

3. FUTURE WORK

3.1 Review of Progress to Date

The NRC pattern range has proved to be more than adequate for making measurements of re-radiation effects from scale model buildings and transmission lines. These measurements are directly analogous to the real situation, that the directional pattern of a broadcast array has been measured in the far field without and with re-radiating structures. Scale factors of 300 and 600 have been employed and re-radiation from model buildings and from transmission lines have been measured, for full scale distances of up to a mile (distance of the re-radiator(s) from the broadcast array). Frequencies of 300 and 600 MHz were employed to simulate effects at full scale for an AM frequency of 1000 kHz. The University of Toronto work, while somewhat more difficult to relate to the full scale situation, has utilized swept frequency techniques in an anechoic chamber. A scale factor of 1000 was employed, that is frequencies of 500 to 1000 MHz were used which correspond to full scale frequencies of 500 to 1000 kHz. The technique has been shown to be very useful for studying resonance effects and the magnitude of the re-radiation effects was found to be the same as that measured in the far field on the NRC pattern range.

Initial numerical modelling work has been started at CRC by Chugh (Interim Report No. 2 Appendix III) and this report (Appendix I) and by Balmain at the University of Toronto (see his report, Reference 1).

The various results achieved are summarized below:

- (1) Buildings having a fixed cross-sectional dimension, 100 x 100 feet in full scale or 4 inches x 4 inches for a model scale factor of 300 have been modelled, and the resonant height has been determined. The various experiments on the NRC antenna pattern range have been made for resonant building heights (200 feet or 8 inches) and a series of measurements have been made for buildings in the main beam of the antenna, measuring the magnitude of the null filling, of the directional array. The directional array was two quarter-wave monopoles, one half wave-length apart, fed in phase to produce a figure-8 pattern with null depths > 40 db.
- (2) Single buildings have been modelled for distances up to four wavelengths from the antenna array (4000 feet). The buildings were located in the main beam of the antenna array, and scatter signals in db relative to the main beam of -12 to -25 db were measured. The scatter into the array null for two buildings, with various spacings between the buildings was measured for distances up to one wavelength (1000 feet in full scale). The observed effects were as might have been anticipated; i.e., by considering the buildings as a two-element antenna array. The buildings were symmetrically placed with respect to the centre of the main beam (that is they were excited in phase), and the scatter into the null was a minimum for half-wave length spacing (500 feet) and a maximum for wavelength spacing (1000 feet). The magnitude of the effects was found to be closely predictable using a procedure given by Lavrench in the first two interim reports, and by a more rigorous, analytical method given by Chugh in the second interim report and in this one (Appendix I).
- (3) Similar experimental measurements were reported by Balmain (1) who studied resonance effects, and since similar magnitudes of the re-radiation effects were measured, this provides confidence in the two sets of measurements.
- (4) Measurements for single thin towers (heights 200 to 900 feet in full scale) showed a maximum effect for tower heights slightly less than $\lambda/4$ and $3/4\lambda$. These experimental results were closely predicted by the numerical method of Chugh (Interim Report No. 2). The numerical results predict that the tower would have to be located at a distance of > 24 wavelengths

(4.5 miles) in order to have a null fill effect smaller than -40 db.

- (5) In connection with experiments relating to the effects of power lines, measurements were made for three, five and seven towers, the towers being in a straight line and situated in the main beam, employing various orientations of the row of towers. At the present stage of this work, the measured effects are much larger than are predicted by the method of Chugh (see Appendix I of this report).
- (6) The effects of power lines are very complicated. The effects are dependent on the height and distance between the power line suspension towers and the distance and orientation of the row of towers with respect to the directional antenna array. The measurements have so far shown that effects are a maximum when the towers, the connecting skywires and the return path through the ground plane are a full wavelength (a full wave loop). In addition, for certain orientations "specular reflection" from the power line is clearly evident (that is, for an orientation such that a ray from the directional array is reflected from the power line to a receiver located in the null direction, such that the incident and reflected angles of incidence with respect to the plane containing the power line are equal). Scale transmission lines of 3 to 7 towers, with tower spacing ranging from $\frac{1}{2}$ to 1 wavelength (500 to 1000 feet) at distances of 2 to 5 wavelengths (2000 to 5000 feet) from the array have been used. Several orientations of the line relative to the broadcast array have been used. In all cases, the tests were carried out with and without the top wire (skywire) attached to the towers. Tower heights for the NRC measurements were 3.3 inches (177 feet for a scale factor of 600).
- (7) The measured effects clearly demonstrate that removing the skywire completely, or isolating the skywires from some of the towers does not necessarily reduce re-radiation effects, in fact, in some situations the result is exactly opposite to that expected. Broadcasters have to date believed that isolating the skywires from the towers would reduce the re-radiation effects. It is clear from our work to date that this method, although widely used, requires a much greater degree of understanding for more effective application. This procedure can, in fact, reduce re-radiation effects and shift their resonant frequencies, but at the same time, it can introduce strong new resonances at other frequencies.

- (8) It has been demonstrated that power-carrying wires can have significant effects. The effect is particularly noticeable on the additional resonances created by isolating towers from skywires, and the effect takes the form of a decrease in the apparent Q (the sharpness of the resonance and its magnitude) of the resonance. Presumably, this effect is due to wave propagation along the power-carrying wires away from a resonant cell, but the question remains as to whether or not this effect would be noticeable if ground losses were taken into account.
- (9) Computation of re-radiation from power lines has so far indicated only qualitative agreement, but this work has hardly begun (Reference 1).

3.2 Work Planned for Current Fiscal Year, 1978/79

3.2.1 On the NRC Antenna Pattern Range

The modelling of buildings, to date, on the NRC pattern range has been restricted to buildings having a square cross-section, viz. 100 x 100 feet (4 x 4 inches for a scale factor of 300). Highrise buildings are usually not square, the long dimension is typically that for a city block. A dimension of 100 x 400 feet was mentioned at the last Working Group Meeting, and a family of buildings of heights 50 - 400 feet (2 to 16 inches in height) have been constructed, and a series of measurements as for the 100 x 100 foot buildings will be made ... to determine first the resonant height.

While power lines have been modelled, the towers and conducting skywires were not modelled very realistically. Power line towers are very complicated structures, see front piece, which shows a photograph of an exact model of a 500 KV (Type VIS) suspension tower employed by Ontario Hydro. These towers are the ones used near the CBL/CJBC station. A scale factor of 200 was used, i.e., a 177 foot tower becomes a 10.6 inch tower for the model. For a tower spacing of 900 feet (4.5 feet for the model power line) only about 3 towers could be placed on the 20 foot turntable. For a scale factor of 600, power line towers cannot be modelled very realistically, however, further measurements on power lines will employ somewhat more realistic towers, and the effects on an omni-directional radiator for power lines located similar to those for the CBL/CJBC situation will be measured. Power line towers would have a square cross-section of about 0.15 x 0.15 inches at the top, 0.56 x 0.56 inches at the bottom, and the top cross-arm to which the skywires are attached would be 1.7 inches for a scale factor of 600. The tower height as before would be 3.3 inches.

The loss resistance due to a finitely conducting earth, and imperfect connection of re-radiators to the earth is the most difficult parameter to model. A series of measurements will be made for thin towers in which real resistors will be used (simulating ground-loss

resistance referred to the base of the antenna). While such a model is not entirely realistic, nevertheless, such measurements should give some insight into the dependence of re-radiation on the ground loss resistance.

These and other measurements will be made on the NRC pattern range, and a final report, including the results of all measurements will be made.

3.2.2 University of Toronto Work

As a minimum program for 1978/79 fiscal year, it is planned to extend work already started at the University of Toronto. In particular, the proposed work would concentrate on the numerical/computational approach to the problem, which was just begun and on application of this approach to power lines, with and without skywires. While the work will not be limited to analysis of existing data only, the measurement of new data will be limited (determined primarily by the funding available) and will be related to the proposed area of emphasis of the numerical work.

3.2.3 Concordia University

It is planned to undertake some numerical modelling work at Concordia University. Prof. S.J. Kubina has developed wire grid modelling programs which could allow for modelling of complicated structures (building complexes) of considerable size ($\sim 10\lambda$). In addition, provisions can be made for the use of Fresnel coefficients to describe interaction of re-radiating structures with ground surfaces. The proposed work would utilize measurements made on the NRC pattern range, as well as specific measurements suggested by the work. These situations would be numerically modelled, to establish the validity and potential of moment methods for this application. Any inherent limitations of theory would be identified and practical methods for its extension would be outlined. The work will complement that at the University of Toronto.

3.2.4 CRC

It is planned to continue with analytical work already started, and to prepare for more realistic measurements on modelled power lines. The front piece of this report shows a photograph of a modelled transmission line tower employing a scale factor of 200. The model stands 10.6 inches high. Fifteen of these towers are being built by the CRC Model Shop. In the absence of a suitable antenna pattern range (see following), it is planned to make measurements of tower impedance, and impedance measurements of a row of towers connected by skywires.

3.3 Requirement for a New Antenna Pattern Range

We have already discussed the inadequacy of the present range to make measurements for models having considerable extent, power lines and groups of buildings, unless the scaling factor is high. In the case of power line towers which are 177 feet high, we consider that scaling factors must be <200 if the tower is to be realistically modelled ... not only to measure re-radiation effects but to investigate what can be done to reduce re-radiation effects. For a scale factor of 200, the modelled tower is 10.6 inches high, and for 900 foot spacing between towers, the model towers would be 4.5 feet apart. For a twelve tower power line, the horizontal extent of the model would be 49.5 feet.

The NRC pattern range is useful for making measurements of power lines comprising up to 5 towers (7 towers for making measurements of power lines close to the broadcast array). A scale factor of 600 is employed and the towers are only 3.3 inches high. If instead, a scale factor of 200 is employed and if twelve towers are to be modelled, the antenna pattern range must be $600/200 \times 12/7 = 5$ times as large. The NRC antenna pattern range is 70 x 200 feet, and, therefore, the proposed new range should be 350 x 1000 feet. We have examined the relationship for far field requirements, viz., $2d^2/\lambda$ where d is the horizontal dimensions (in meters if λ is in meters) of the antenna and the re-radiators, and we have concluded that the NRC range seems to be optimumly designed. Thence, the proposed new range should be a copy of it, but larger. The new range would be for azimuthal pattern measurement only.

An important requirement for the new range is that the ground screen underneath the 100 foot turntable be elevated, so that it is possible to get underneath the model to make impedance measurements, to make adjustment (on the antenna array for tuning and on re-radiators for detuning). For example, an antenna array is adjusted to provide a pattern having a null of a specified depth in a certain direction. The matching networks are adjusted in accordance with calculations for multi-tower arrays that assume no re-radiators. If the antenna is tuned in this way, what is the pattern distortion. This can be measured. If one now adjusts the current in one or more towers of the array to provide a smaller null field in the "critical direction", how does this affect the total pattern. These kinds of measurements could be made with the new range, but not presently. How best can we detune power lines? If the model is realistic, we can model practical proposed ways to detune power lines and measure the effect (c.f. the method suggested in Appendix VIII of Interim Report No. 1, or detuning stubs which have been tried, see Figure 4 of this report).

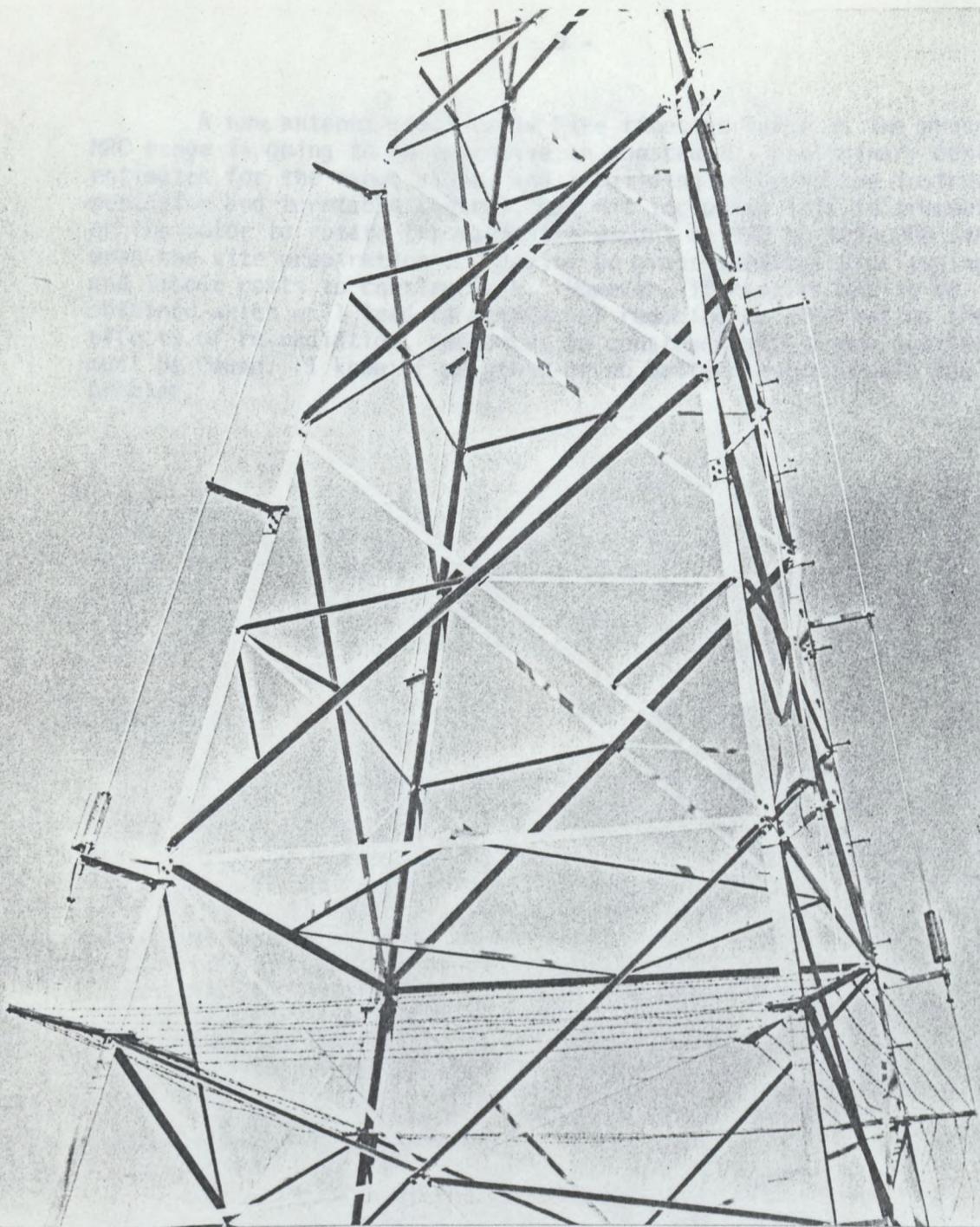


FIGURE 4. Power line tower with tuning stubs on each leg, to reduce currents on tower from nearby AM broadcast station (from Engineering Department, Radio Station CFTR)

A new antenna model range five times as large as the present NRC range is going to be expensive to construct. Preliminary cost estimates for the range alone, and a building to house the instrumentation and turntable control, but not including this instrumentation or the motor to rotate the turntable amount to \$80 to \$250,000 (depending upon the site preparation ... paving or grass seeding) plus engineering and labour costs to construct it. However, if results are to be obtained which will lead to methods of reducing or eliminating the effects of re-radiation, resources to construct such a new facility must be found. I know of no other or no better way to tackle the problem.

REFERENCE

1. Balmain, K.G., The Effect of Re-Radiation of AM Broadcast Signals, Final Report, University of Toronto, March, 1978.

ANALYTICAL MODEL FOR THE SCATTERING
PATTERN CALCULATION FROM AN ARRAY OF THIN TOWERS

ABSTRACT

This report summarizes the progress made in developing an analytical model for the re-radiation from an array of thin towers in the close vicinity of a broadcast array. The results obtained by using this analytical model are compared with the measurements made on the NRC antenna modelling range. As indicated in Figures 1 and 2, the theoretical results provide a good agreement with the measured values. For three towers scattering, the analytical model provided a good agreement with the measurements performed by Nagy [1]. However, the agreement for the cases with more than two towers does not seem to be very good with the measurements performed on the NRC pattern range. This discrepancy between the results cannot be explained until some more measurements are performed on the NRC range.

INTRODUCTION

The determination of the re-radiation from an array of thin towers requires a knowledge of the induced currents on the towers. These currents are induced due to an incident field from a broadcast array. Since the towers are not in the far-field zone of the broadcast array, the incident field on the towers corresponds to an antenna field in the close vicinity. These incident fields are used to calculate the induced currents on the towers by using the integral equation obtained by matching the boundary condition. The solutions of the integral equation, to determine the induced currents, can be obtained by using the method of moments [2]. The numerical procedure of the moment method has the advantages of being able to analyze any number of towers of any heights and at any arbitrary distances from the broadcast array. The calculated values of the induced currents, by using the method of moments, can then be used to calculate the scattered field from the towers.

The calculation of the overall radiation pattern due to a broadcast array and an array of towers can, for simplicity, be divided into the following three steps.

- (1) Determination of the incident field from the broadcast array at any point on the towers.
- (2) Determination of the induced currents on the towers due to an incident field from the broadcast array. And
- (3) Calculation of the scattered field at any observation point due to the broadcast array and thin towers.

These steps are discussed in more detail in the following sections.

INCIDENT FIELD CALCULATION AT ANY POINT
DUE TO THE BROADCAST ARRAY

The broadcast array for the formulation is assumed to be consisting of an array of monopoles above the perfectly conducting ground. These monopoles can have any arbitrary currents at their terminals to provide a particular radiation pattern. The elements of the broadcast array can be located at any position with respect to a preselected origin. Let the n elements of the broadcast have their position specified by co-ordinates (x_{di}, y_{di}) and the current at the terminals be specified by complex currents I_{mi} . In addition, let the heights of these monopoles above the ground be H_{di} .

The radiated field due to any monopole above the perfectly conducting ground plane will have both E_p and E_z components for the electric field at any point in space. However, the only electric field component of interest for determining the re-radiation from the towers perpendicular to the ground plane is E_z . The incident electric field E_{zi}^i at any point P with co-ordinates (x_0, y_0, z_0) due to the i th monopole of height H_{di} is given as [3].

$$E_{zi}^i = -j \frac{30 I_{mi}}{\sin kH_{di}} \left(\frac{e^{-jkR_{1i}}}{R_{1i}} + \frac{e^{-jkR_{2i}}}{R_{2i}} - 2 \frac{e^{-jkR_{0i}}}{R_{0i}} \cos kH_{di} \right) \quad (1)$$

where

$$R_{1i} = \sqrt{(x_{di} - x_0)^2 + (y_{di} - y_0)^2 + (H_{di} - z_0)^2}$$

$$R_{2i} = \sqrt{(x_{di} - x_0)^2 + (y_{di} - y_0)^2 + (H_{di} + z_0)^2}$$

$$R_{0i} = \sqrt{(x_{di} - x_0)^2 + (y_{di} - y_0)^2 + z_0^2}$$

$$k = \text{propagation constant} = 2\pi/\lambda$$

and

$$I_{mi} = I_{mri} + j I_{mai} = \text{complex current at the terminal.}$$

Then the total field at point P due to all the n elements of the broadcast array is given by

$$E_z^i(x_0, y_0, z_0) = \sum_{i=1}^n -j \frac{30 I_{mi}}{\sin kH_{di}} \left(\frac{e^{-jkR_{1i}}}{R_{1i}} + \frac{e^{-jkR_{2i}}}{R_{2i}} - 2 \frac{e^{-jkR_{0i}}}{R_{0i}} \cos kH_{di} \right) \quad (2)$$

APPENDIX I

- 3 -

DETERMINATION OF THE INDUCED CURRENTS ON THE TOWERS

The basic principle used to calculate the induced currents on the towers is to formulate an integral equation in terms of the induced current and the incident field on the tower. The magnetic vector potential due to a volume current distribution $\bar{J}(\bar{r}^1)$ is written as

$$\bar{A}(\bar{r}) = \iiint_V \frac{\bar{J}(\bar{r}^1) e^{-jk|\bar{r} - \bar{r}^1|}}{4\pi |\bar{r} - \bar{r}^1|} dv \quad (3)$$

where \bar{r} and \bar{r}^1 are the position vectors for the observation and source points, respectively. The electric field due to the above magnetic vector potential at any point in space is given by

$$\bar{E} = \frac{1}{j\omega\epsilon} (\nabla \times \nabla \times \bar{A}) \quad (4)$$

where $\omega = 2\pi f$

and ϵ = permittivity of the propagation medium.

If the current is induced by an incident electric field \bar{E}^i , then the boundary condition of zero tangential electric field at the surface of the scatterer along with Equations (3) and (4) gives

$$-\hat{n} \times \bar{E}^i = \frac{1}{j4\pi\omega\epsilon} \hat{n} \times \left[\nabla \times \nabla \times \iiint_V \frac{\bar{J}(\bar{r}^1)}{|\bar{r} - \bar{r}^1|} e^{-jk|\bar{r} - \bar{r}^1|} dv \right] \quad (5)$$

where \hat{n} is the unit vector normal to the surface. Thus knowing the incident field on the scatterer, Equation (5) can be solved to provide the induced currents on the scatterer.

Limiting the attention to thin towers of circular cross-section having a diameter small as compared to the wavelength, the following approximations can be made to simplify the analysis.

- (1) Azimuthal current flow around the tower may be neglected.
- (2) The longitudinal current is independent of the azimuth and may be represented as a filament along the tower axis,
- and (3) The surface integration can be replaced by a line integral along the tower.

APPENDIX I

- 4 -

If the tower axes are along the z-axis, then the above approximations lead to a magnetic vector potential having only a z-component given by

$$A_z = \frac{1}{4\pi} \int I(z^1) \frac{e^{-jk|\bar{r} - \bar{r}^1|}}{|\bar{r} - \bar{r}^1|} dz^1 \quad (6)$$

with $I(z^1)$ being the current along the tower axis. With the above form of magnetic vector potentials, the integral equation for the induced currents on m thin towers reduces to the following form:

$$-E_z^i(\bar{r}) = \frac{1}{4\pi j\omega\epsilon} \sum_{l=1}^m \left(\frac{\partial^2}{\partial z^2} + k^2 \right) \int_{-h_{tl}}^{h_{tl}} I_l(z^1) \frac{e^{-jk|\bar{r} - \bar{r}^1|}}{|\bar{r} - \bar{r}^1|} dz^1 \quad (7)$$

with h_{tl} being the height of the l^{th} tower above the ground and $I_l(z^1)$ being the induced current distribution on the l^{th} tower.

The above integral equation is solved numerically to determine the induced currents on the towers. A numerical solution may perhaps be best undertaken using the method of moments. This is a well-founded mathematical technique for finding the unknown by forcing the integral equation to be satisfied in some prescribed fashion over the range of the integral operator. The basic idea for the method of moments can be found in a book by Harrington (1968).

The proper choice of weight functions and basis functions as well as the subsections of the integral operator is not an obvious one. Although there is some leeway in the matter, a careful consideration of the physics of the problem and the nature of the expected solution will show that some representations will be more efficient as compared to others in terms of computer time and accuracy. It is found from the literature survey that perhaps the best choice for the basis functions are the transcendental functions [4]. In the present formulation, the transcendental functions are used with the delta functions as the weighting function to obtain the solution for the induced currents on the towers.

The transcendental basis functions have the form given by

$$I_n(z^1) = A_n + B_n \sin k(z^1 - z_n) + C_n \cos k(z^1 - z_n) \quad (8)$$

where A_n , B_n and C_n are the constants. If each tower is divided into s number of segments, then substituting the above equation into Equation (7) with delta basis functions leads to 3 sm simultaneous

APPENDIX I

- 5 -

equations for the induced currents on m towers. However, it is not necessary to use the integral equation to find the extra unknowns introduced by the sine and cosine functions. Two of the three constants for each segment may be obtained by requiring the current in the adjacent segments to satisfy some specified mutual conditions. In the present work, the extrapolated current from a given segment is forced to match at the centre current values in two adjacent segments. This can be done for all segments except the end segments on a particular tower due to the absence of adjacent segment on one side. At these end segments, the boundary condition of zero current at the end can be used to calculate the other constants, as shown below.

The current on any segment n of a particular tower is written as

$$I_n(z^1) = A_n + B_n \sin k(z^1 - z_n) + C_n \cos k(z^1 - z_n)$$

Matching the current at the centre points of two adjacent segments z_{n-1} and z_{n+1} leads to the following equations for the currents

$$I_{n-1} = A_n + B_n \sin kd_{n-1} + C_n \cos kd_{n-1} \quad (9)$$

$$I_n = A_n + C_n \quad (10)$$

$$I_{n+1} = A_n + B_n \sin kd_{n+1} + C_n \cos kd_{n+1} \quad (11)$$

where $d_{n-1} = z_{n-1} - z_n$

and $d_{n+1} = z_n - z_{n+1}$

Solving the above equations for the constants A_n , B_n and C_n leads to

$$I_n(z^1) = X_n(z^1)I_{n-1} + Y_n(z^1)I_n + Z_n(z^1)I_{n+1} \quad (12)$$

where

$$\begin{aligned} X_n(z^1) &= \frac{1}{D} \left[\sin kd_{n+1} + (1 - \cos kd_{n+1}) \sin k(z^1 - z_n) \cdot \right. \\ &\quad \left. \sin kd_{n+1} \cos k(z^1 - z_n) \right] \\ Y_n(z^1) &= \frac{1}{D} \left[-\sin k(d_{n+1} + d_{n-1}) + (\cos kd_{n+1} - \cos kd_{n-1}) \cdot \right. \\ &\quad \left. \sin k(z^1 - z_n) + (\sin kd_{n-1} + \sin kd_{n+1}) \cos k(z^1 - z_n) \right] \end{aligned}$$

APPENDIX I

- 6 -

$$Z_n(z^1) = \frac{1}{D} \left[\sin kd_{n-1} + (\cos kd_{n-1} - 1) \sin k(z^1 - z_n) - \sin kd_{n-1} \cos k(z^1 - z_n) \right]$$

with

$$D = \sin kd_{n-1} + \sin kd_{n+1} - \sin k(d_{n-1} + d_{n+1})$$

The above equations are valid for all segments on a particular tower except the end segment. Equating the end current of the segment equal to zero leads to the following equation instead of the equation for I_{n-1} .

$$0 = A_n + B_n \sin k\Delta z_n + C_n \cos k\Delta z_n \quad (13)$$

where Δz_n is the half width of the first segment. Equation (13) when solved along with Equations (10) - (11) leads to

$$I_{ne}(z^1) = Y_{ne}(z^1)I_n + Z_{ne}(z^1)I_{n+1} \quad (14)$$

where

$$\begin{aligned} Y_{ne}(z^1) &= \frac{1}{D_1} \left[-\sin k(d_{n+1} + \Delta z_n) \right. \\ &\quad + (\cos kd_{n+1} - \cos k\Delta z_n) \sin k(z^1 - z_n) \\ &\quad \left. + (\sin kd_{n+1} + \sin k\Delta z_n) \cos k(z^1 - z_n) \right] \end{aligned}$$

$$\begin{aligned} Z_{ne}(z^1) &= \frac{1}{D_1} \sin k\Delta z_n + (\cos \Delta z_n - 1) \sin k(z^1 - z_n) - \\ &\quad \sin k\Delta z_n \cos k(z^1 - z_n) \end{aligned}$$

and $D_1 = \sin k\Delta z_n + \sin kd_{n+1} - \sin k(d_{n+1} + \Delta z_n)$

for the current in the end segment of a particular tower.

Using the expressions for $I_n(z^1)$, given by Equations (12) or (14), depending upon the segment under consideration, in Equation (7) with delta basis functions leads to m simultaneous equations for the induced currents on m towers. It should be noted that the resultant Equation (7) is forced to satisfy at the centre points of the segments. Thus, knowing the incident field at the centre points of these segments, m simultaneous

APPENDIX I

- 7 -

equations so obtained can be solved to provide the induced currents on each of these segments.

It should be noted that the integrals for each of these segments can be performed in the closed form for the sine and cosine currents. The basic principles for the evaluation of these integrals can be found in a book by Stratton (1941).

The simultaneous equations for the induced currents have been solved by using the Crout's method [6]. The currents thus obtained are used to calculate the scattered field due to an array of thin towers by using the procedure given in the following section.

TOTAL RADIATION FIELD CALCULATION

The electric field strength at any observation point with co-ordinates (r, θ, ϕ) is a sum of the fields radiated by the towers and the broadcast array. The radiated field from an array of n monopoles has only a θ component for the electric field. Similarly, the radiated field of thin towers perpendicular to the ground plane has also got only a θ component of the electric field.

It should be noted that the total radiated field will have a variation with both θ and ϕ co-ordinates of the observation point. However, since the main interest in the present work is on the horizontal plane pattern, the angle θ in the calculations will be assumed to be equal to 90° . This value of angle θ results in a considerable simplicity of the analysis.

The radiation field of an i^{th} monopole of height H_{di} , located at a position with co-ordinates (x_{di}, y_{di}) , can be easily found to be given by [7]

$$E_{\theta i}^D (\theta = 90^\circ, \phi) = j60I_{mi} e^{jk(x_{di}\cos\phi + y_{di}\sin\phi)} \frac{e^{-jkr}}{r} \times \tan \frac{\pi H_{di}}{\lambda} \quad (15)$$

using the far-field approximations. Therefore, the total field due to all the n monopoles is given by

$$E_{\theta}^D (\theta = 90^\circ, \phi) = \sum_{i=1}^n E_{\theta i}^D (\theta = 90^\circ, \phi) \quad (16)$$

The field radiated by an l^{th} tower located at a point with co-ordinates (x_{tl}, y_{tl}) is given by

$$E_{\theta l}^W (\theta = 90^\circ, \phi) = j\omega\mu A_{z1} \quad (17)$$

APPENDIX I

- 8 -

where

$$A_{z1} = \frac{1}{4\pi} e^{jk(x_{t1}\cos\phi + y_{t1}\sin\phi)} \frac{e^{-jkr}}{r} \\ \times \int_{-h_{t1}}^{h_{t1}} I_1(z^1) dz^1 \quad (18)$$

with h_{t1} being the height of the 1th tower above the ground plane. With each tower being divided into s segments for the portion above the ground, the magnetic vector potential reduces to the form:

$$A_{z1} = \frac{1}{4\pi} e^{jk(x_{t1}\cos\phi + y_{t1}\sin\phi)} \frac{e^{-jkr}}{r} \\ \times \sum_{n=1}^s 4\Delta z_n I_{n1}(z_n) \quad (19)$$

where

$$\Delta z_n = \text{half width of the } n^{\text{th}} \text{ segment}$$

$$\text{and } I_{n1}(z_n) = \text{induced current at the centre of the } n^{\text{th}} \text{ segment.}$$

Using the above expression for the magnetic vector potential in Equation (12) and adding the total contribution of all the m towers, the total radiated field by the towers is found to be

$$E_{\theta}^W (\theta = 90^\circ, \phi) = j 30 k \frac{e^{-jkr}}{r} \sum_{l=1}^m e^{jk(x_{tl}\cos\phi + y_{tl}\sin\phi)} \\ \times \sum_{n=1}^s 4\Delta z_n I_{nl}(z_n) \quad (20)$$

Therefore, adding the radiated fields by the towers and the broadcast array, the total radiated field at any angle ϕ is given by

$$E_{\theta}(\theta = 90^\circ, \phi) = E_{\theta}^D(\theta = 90^\circ, \phi) + E_{\theta}^W(\theta = 90^\circ, \phi) \quad (21)$$

The above expression for the radiation field has been used to calculate the results given in the next section.

APPENDIX I

- 9 -

RESULTS AND DISCUSSION

The analytical model of the preceding sections has been used to calculate the radiation patterns for a number of test cases. The first case considered corresponds to the scattering from a single thin tower of height 10" or 0.254λ at a distance of 2 meters or 2λ from a two element broadcast array. As indicated in Figure 1, the results obtained by using the present model provide a good agreement with the measurements performed at NRC ship range.

The second case considered, for testing the analytical model, is that of re-radiation from two thick buildings. These buildings have equivalent heights of quarter-wave thin towers and are placed parallel to the broadcast array axis at a distance of 2 meters. The spacing between the two buildings is 20 cms. The results obtained by using the present analytical model (Figure 2), similar to the first test case, have a good agreement with the measurements performed at the NRC ship range. Comparing the agreement of Figure 2 with the agreement of Figure 7 of Interim Report 2, using the transmission line approach, shows the superiority of the present analytical model over the transmission line approach. However, it is felt at this stage that the transmission line approach might not work very well for the towers of heights other than the quarter-wave resonance. This limitation is not there in the present analytical model.

The above two test cases provided a good agreement of the analytical model results with the measurements performed on the NRC modelling range. However, the agreement for the cases with more than two towers does not seem to be good (Figures 3 and 4). A careful examination of the analytical model does not indicate any reason for its failure for cases where there are more than two towers. In order to test the analytical model's validity some more measurements will be performed at the NRC ship range during this summer.

CONCLUSIONS

The first two test cases clearly indicate the possibility of analyzing the re-radiation from an array of thin towers by utilizing the present analytical model. However at this stage, there is some discrepancy between the analytical model results and the measurements for the re-radiation from more than two towers.

Dr. R.K. Chugh
Radar and Radio Research
Communications Research Centre
Ottawa, Ontario

APPENDIX I

- 10 -

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APPENDIX I

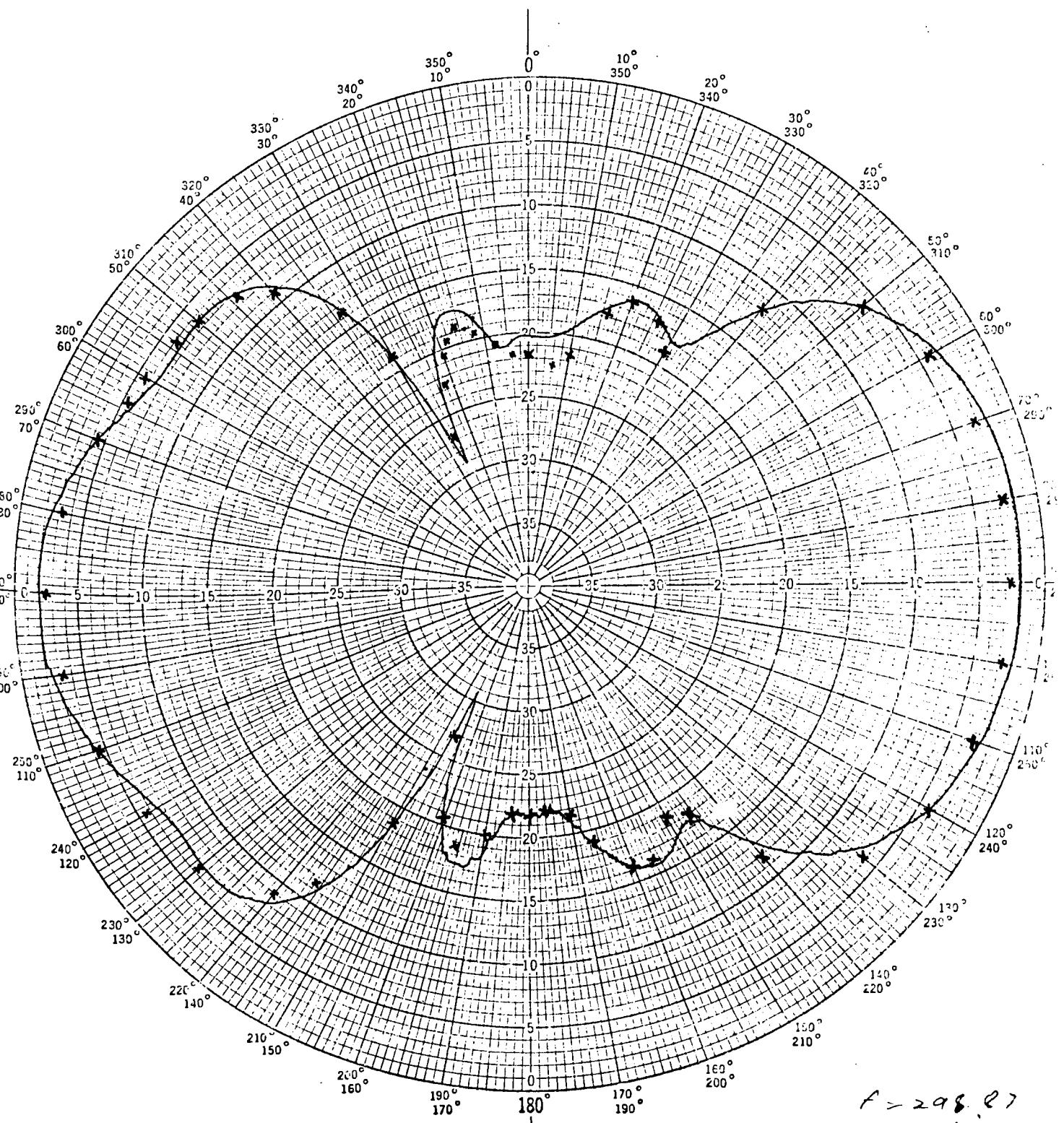


Fig. 1

— Measured Pattern
xxx Calculated Pattern

$f = 298.87$
 10^6 rad/sec
 $C = 0.0021$

19.5

APPENDIX I

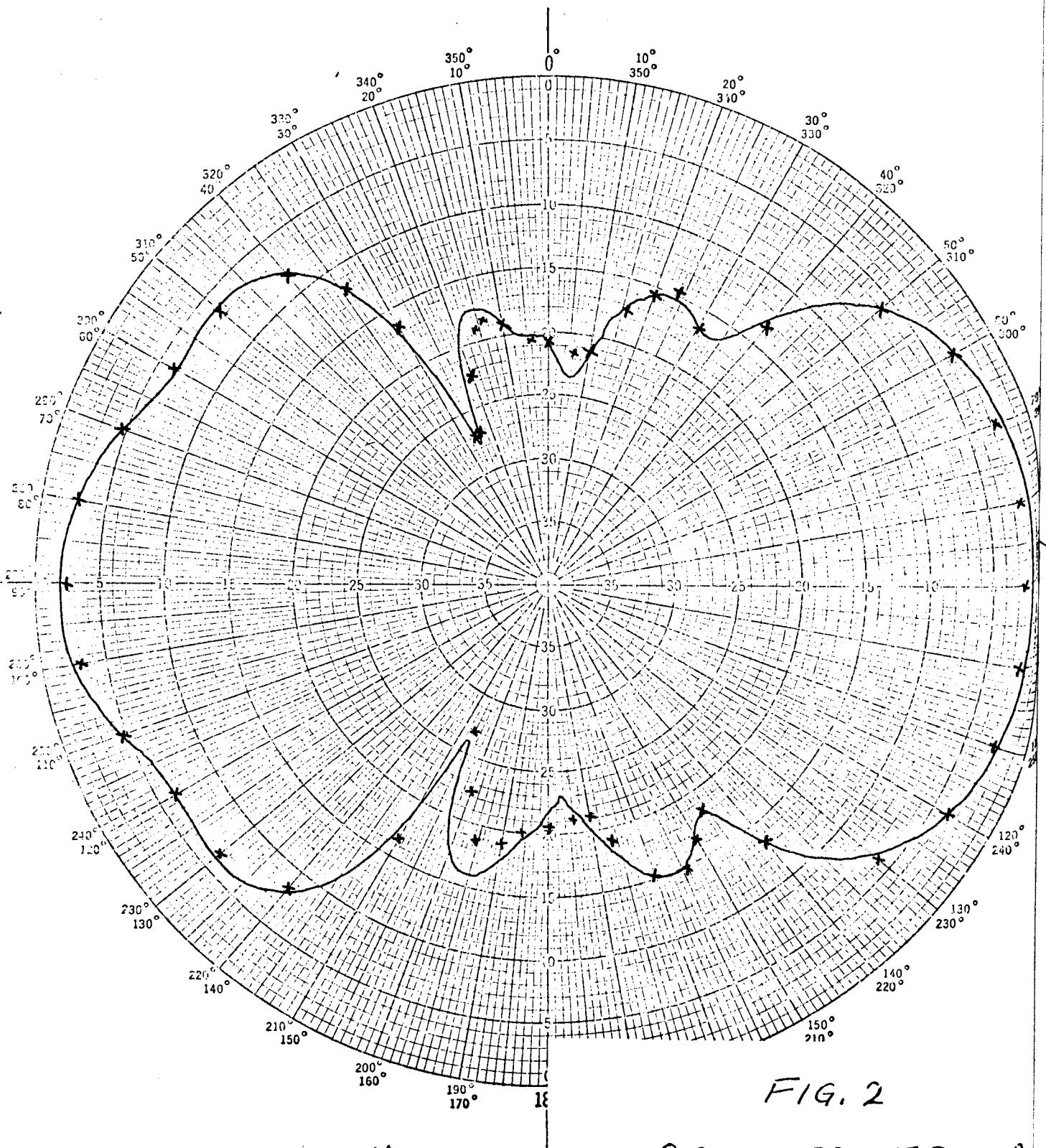


FIG. 2

SCATTER FROM
TWO BUILDINGS

C-C SPACING = 8 INCHES (200

APPENDIX I

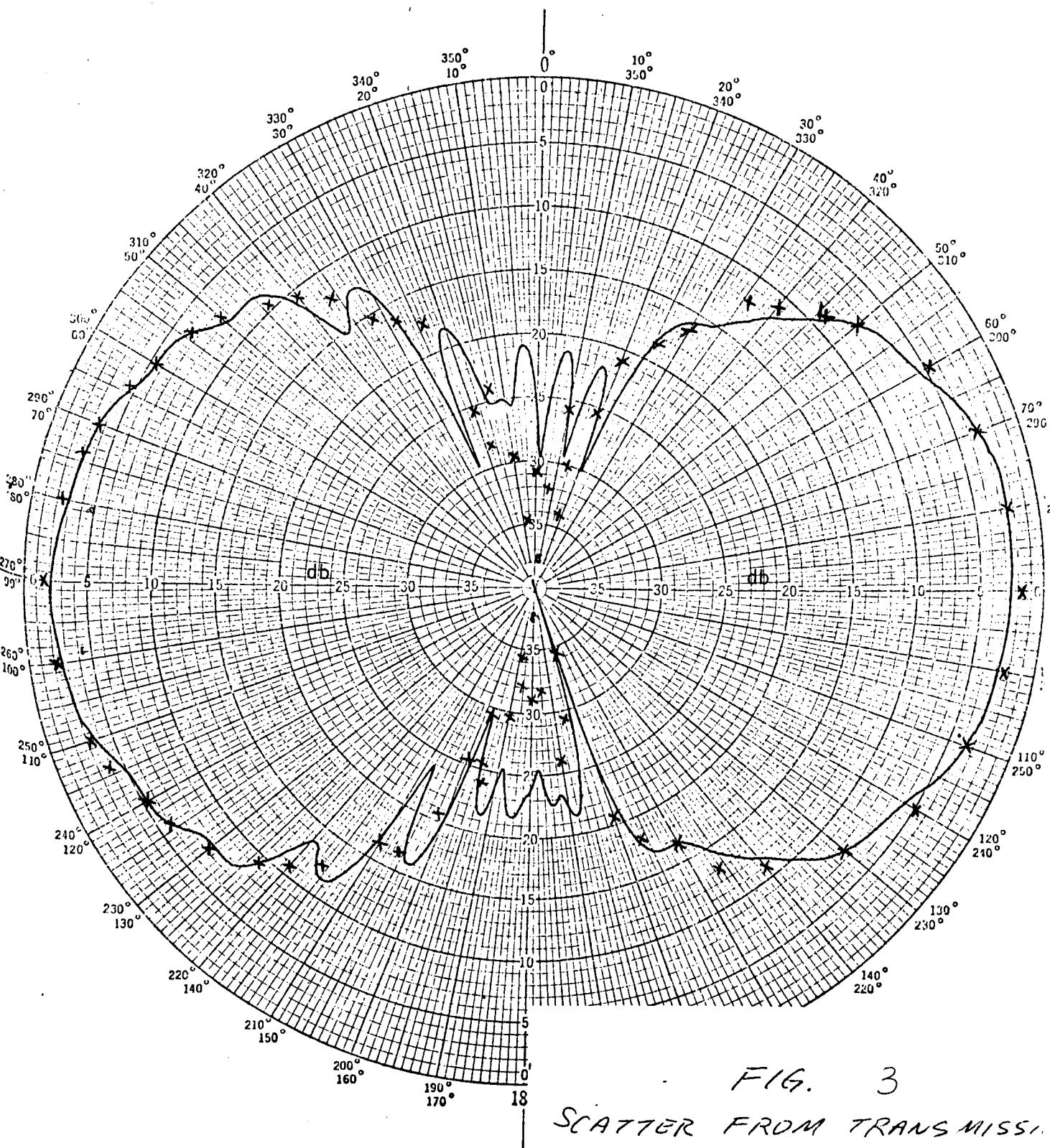


FIG. 3
SCATTER FROM TRANSMISSI.
LINE

3 TOWERS : NO TOP WIR.
SPACING = .5M (1000 FEET)
DISTANCE = 2.5M (5000 FEET)

APPENDIX I

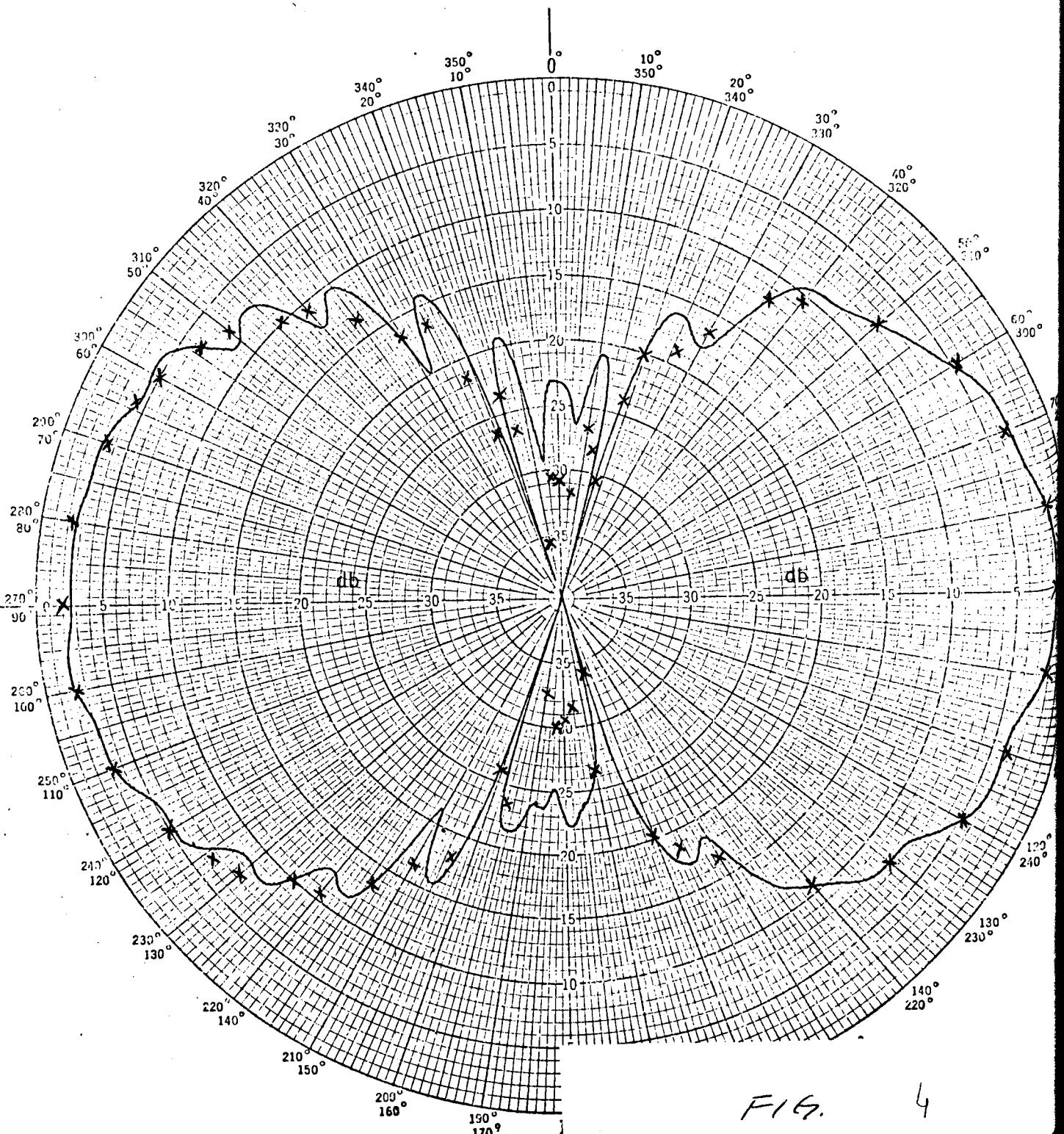


FIG. 4

SCATTER FROM TRANSMISSION LINE

— Measured
XXX Calculated.

Polar Chart No. 127D
SCIENTIFIC-ATLANTA, INC.
ATLANTA, GEORGIA

5 TOWERS : NO TOP WIRE
SPACING = .5 M (1000 FEET)
DISTANCE = 2.5 M (5000 FEET)

APPENDIX II

COMPUTER PROGRAMS FOR RE-RADIATION FROM AN ARRAY OF THIN TOWERS

by

Rajinder Kumar Chugh

Communications Research Centre

Ottawa, Ontario

April 1978

FOREWORD

This report gives the Fortran listing of the computer programs for obtaining the results presented in the report titled "Analytical Model for the Scattering Pattern Calculation from an Array of Thin Towers". The theory involved in preparation of these programs can be found in the above mentioned report. After each program listing, a number of test runs are provided in order to check these programs. Wherever possible, a number of comment statements are included to add to the explanation of the logic used in the preparation of these programs. It is anticipated that these features will help the reader to use these programs more efficiently.

TABLE OF CONTENTS

<u>NO.</u>	<u>TITLE</u>	<u>PAGE NO.</u>
	FOREWORD	i
	TABLE OF CONTENTS	ii
1.	Thin tower array re-radiation based on moment method	1
2.	Test run 1	11
3.	Test run 2	17
4.	Test run 3	23
5.	Thin tower array re-radiation based on transmission line approach	29
6.	Test run 1	35
7.	Test run 2	38
8.	Test run 3	42

1. Thin tower array re-radiation based on moment method

TY0-55

```

1.000 C PROGRAM FOR SCATTERING PATTERN CALCULATION FROM AN
2.000 C ARRAY OF THIN TOWERS DUE TO AN INCIDENT FIELD
3.000 C FROM AN ARRAY OF DIPOLES. THE CALCULATIONS ARE BASED
4.000 C ON TRANSCENDENTAL BASIS FUNCTIONS AND POINT MATCHING
5.000 C IN THE MOMENT METHOD.
6.000 C
7.000 C WRITTEN BY R.K.CHUGH
8.000 C APRIL, 1978
9.000 C
10.000 C
11.000 C PARAMETERS
12.000 C
13.000 C NDATA NUMBER OF DATA SETS.
14.000 C NDP NUMBER OF BROADCAST ARRAY ELEMENTS.
15.000 C NTT NUMBER OF THIN TOWERS.
16.000 C WAVE WAVELENGTH IN METERS.
17.000 C XD,YD POSITION OF THE BROADCAST ELEMENTS.
18.000 C HD HEIGHT OF THE BROADCAST ARRAY ELEMENT
19.000 C CMDC COMPLEX CURRENT AT THE BASE OF
20.000 C THE BROADCAST ELEMENTS.
21.000 C XT,YT POSITION OF THE TOWERS.
22.000 C HT HEIGHT OF THE TOWERS.
23.000 C RT RADII OF THE TOWERS.
24.000 C
25.000 C
26.000 C NOTE THAT ALL DISTANCES ARE IN METERS
27.000 C AND ALL ANGLES ARE IN DEGREES.
28.000 C
29.000 C
30.000 C NCBS NUMBER OF OBSERVATIONS FOR THE SCATTERING PATTERN.
31.000 C THS STARTING ANGLE FOR THE RADIATION PATTERN.
32.000 C DTMS INCREMENTAL ANGLE FOR THE RADIATION PATTERN.
33.000 C ESN NORMALIZING FACTOR THE SCATTERING PATTERN.
34.000 C
35.000 C ESN=120.0/(10.0**(-DROP IN DB AT THE MAXIMUM FROM
36.000 C ZERO/20.0))
37.000 C
38.000 C
39.000 C
40.000 C IMPLICIT COMPLEX(C)
41.000 C DIMENSION XD(10),YD(10),CMDC(10)
42.000 C DIMENSION XT(10),YT(10),ZT(10,40),DZT(10,40),HT(10),RT(10)
43.000 C DIMENSION NST(10),HD(10),THSD(400)
44.000 C DIMENSION CZ(100,100),CSUA(10),CI(100),CE(100)
45.000 C REAL COS
46.000 C REAL CABS
47.000 C COMMON /TOWER/ XT,YT,ZT,DZT,RT
48.000 C COMMON /DIPOLE/ XD,YD,HD
49.000 C COMMON /OBSP/ SPHS,PHSC
50.000 C DATA PI,DR,RD/3.14159265358979,0.01745329252,57.29577951/
51.000 C
52.000 C READ AND WRITE VARIOUS PARAMETERS.
53.000 C
54.000 C CJ=CMPLX(0.0E0,1.0E0)
55.000 C WRITE(6,480)

```

```

MAIN0910
MAIN0620
MAIN0930
MAIN0040
MAIN0050
MAIN0060
MAIN0070
MAIN0080
MAIN0090
MAIN0100
MAIN0110
MAIN0120
MAIN0130
MAIN0140
MAIN0150
MAIN0160
MAIN0170
MAIN0180
MAIN0190
MAIN0200
MAIN0210
MAIN0220
MAIN0230
MAIN0240
MAIN0250
MAIN0260
MAIN0270
MAIN0280
MAIN0290
MAIN0300
MAIN0310
MAIN0320
MAIN0330
MAIN0340
MAIN0350
MAIN0360
MAIN0370
MAIN0380
MAIN0390
MAIN0400
MAIN0410
MAIN0420
MAIN0430
MAIN0440
MAIN0450
MAIN0460
MAIN0470
MAIN0480
MAIN0490
MAIN0500
MAIN0510
MAIN0520
MAIN0530
MAIN0540
MAIN0550

```

```

TY56-116
56.000 480 FORMAT(1H ,5X,'SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO//'
57.000 11H ,5X,'AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST'//'
58.000 21H ,5X,'ELEMENTS BASED ON MOMENT METHOD.'//')
59.000 READ(5,10)NDATA
60.000 10 FORMAT(10I4)
61.000 DO 200 ND=1,NDATA
62.000 READ(5,10)NDP,NTT
63.000 READ(5,20)WAVE
64.000 WRITE(6,490)WAVE
65.000 490 FORMAT(1H ,5X,'WAVELLENGTH = ',F10.6//)
66.000 WRITE(6,500)NDP
67.000 WRITE(6,510)NTT
68.000 DO 30 ND=1,NDP
69.000 28 FORMAT(8F10.6)
70.000 C
71.000 C READ AND WRITE THE DATA FOR DIPOLE ELEMENTS.
72.000 C
73.000 READ(5,20)XD(ND),YD(ND),HD(ND),CMDC(ND)
74.000 WRITE(6,520)ND,XD(ND),YD(ND)
75.000 WRITE(6,525)ND,HD(ND)
76.000 525 FORMAT(1H ,5X,'HEIGHT OF THE DIPOLE ELEMENT NUMBER ',I4,' = ',I4,
77.000 1F10.6//)
78.000 30 WRITE(6,530)ND,CMDC(ND)
79.000 C
80.000 C READ AND WRITE THE DATA FOR TOWERS.
81.000 C
82.000 DO 80 NT=1,NTT
83.000 READ(5,20)XT(NT),YT(NT),HT(NT),RT(NT)
84.000 NST(NT)=HT(NT)/0.025
85.000 WRITE(6,540)NT
86.000 WRITE(6,550)NST(NT)
87.000 WRITE(6,560)XT(NT),YT(NT)
88.000 WRITE(6,570)HT(NT)
89.000 WRITE(6,580)RT(NT)
90.000 C
91.000 C CALCULATE THE CENTRE POINTS AND HALF WIDTHS OF
92.000 C THE SEGMENTS.
93.000 C
94.000 DZ=HT(NT)/FLOAT(NST(NT))
95.000 ZT(NT,1)=HT(NT)-DZ/2.0E0
96.000 DZT(NT,1)=DZ/2.0E0
97.000 DO 60 J=2,NST(NT)
98.000 ZT(NT,J)=ZT(NT,J-1)-DZ
99.000 DZT(NT,J)=DZ/2.0E0
100.000 60 CONTINUE
101.000 C
102.000 C
103.000 80 CONTINUE
104.000 C
105.000 C READ AND WRITE THE DATA FOR THE SCATTERING PATTERNS.
106.000 C
107.000 READ(5,10)NOBS
108.000 READ(5,20)THS,DTHS
109.000 READ(5,20)ESN
110.000 WRITE(6,610)NOBS

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```

TV111-165
111.000      WRITE(6,620)          MAIN1110
112.000      PROPC=2.0E0*IPI/WAVE  MAIN1120
113.000      DO 90 I=1,100        MAIN1130
114.000      DO 90 J=1,100        MAIN1140
115.000 90    CZ(I,J)=CMPLX(0.0E0,0.0E0)  MAIN1150
116.000      DO 95 I=1,NBBS        MAIN1160
117.000 95    THSD(I)=THS+DTHS*(FLOAT(I)-1.0E0)  MAIN1170
118.000 C
119.000 C      CALCULATE THE INCIDENT FIELD ON THE TOWER SEGMENTS.  MAIN1180
120.000 C
121.000      NSJ=0              MAIN1190
122.000      DO 100 NT=1,NTT        MAIN1200
123.000      DO 100 J=1,NST(NT)    MAIN1210
124.000      NSJ=NSJ+1           MAIN1220
125.000      CALL IFDA(PROPC,MDP,CMDC,XT(NT),YT(NT),ZT(NT,J),CE(NSJ))  MAIN1230
126.000 100   CONTINUE          MAIN1240
127.000 C
128.000 C      CALCULATE THE MUTUAL COUPLING MATRIX.  MAIN1250
129.000 C
130.000      CALL CZSET(PROPC,NTT,NST,CZ)          MAIN1260
131.000 C
132.000 C      CALCULATE THE INDUCED CURRENTS ON THE TOWER SEGMENTS.  MAIN1270
133.000 C
134.000      CALL CSEOCR(CZ,NSJ,100,2,CE,CI)          MAIN1280
135.000 C
136.000 C      CALCULATE THE SCATTERING PATTERN.  MAIN1290
137.000 C
138.000 115   WRITE(6,650)          MAIN1300
139.000      II=0               MAIN1310
140.000      DO 125 NTS=1,NTT        MAIN1320
141.000      CSWA(NTS)=CMPLX(0.0E0,0.0E0)  MAIN1330
142.000      DO 124 I=1,NST(NTS)    MAIN1340
143.000      II=II+1             MAIN1350
144.000 124   CSWA(NTS)=CSWA(NTS)+CI(II)          MAIN1360
145.000 125   CSWA(NTS)=CSWA(NTS)*4.0*DZT(NTS,1)  MAIN1370
146.000 140   DO 180 NB=1,NBBS        MAIN1380
147.000 150   SPHS=SIN(THSD(NOB)*DR)          MAIN1390
148.000      PHSC=COS(THSD(NOB)*DR)          MAIN1400
149.000 C
150.000 C      CALCULATE THE SCATTERED FIELD DUE TO BROADCAST ARRAY.  MAIN1410
151.000 C
152.000 170   CALL SFDA(PROPC,MDP,CMDC,CSD)          MAIN1420
153.000      ESD=CABS(CSD)          MAIN1430
154.000 C
155.000 C      CALCULATE THE SCATTERED FIELD DUE TO TOWERS.  MAIN1440
156.000 C
157.000 171   CSU=CMPLX(0.0E0,0.0E0)          MAIN1450
158.000      DO 175 NTS=1,NTT        MAIN1460
159.000      PF=PROPC*(PHSC*XT(NTS)+SPHS*YT(NTS))  MAIN1470
160.000      CFP=CJ*3.0E1*PROPC*CEXP(CMPLX(0.0E0,PF))  MAIN1480
161.000 175   CSU=CSU+CSWA(NTS)*CFP          MAIN1490
162.000 177   ESU=CABS(CSU)          MAIN1500
163.000 C
164.000 C      CALCULATE THE SCATTERED FIELD .  MAIN1510
165.000 C

```

```

TV166-221
166.000 CS=CSD+CSU
167.000 EST=CABS(CS)
168.000 C
169.000 C CALCULATE THE SCATTERED FIELD IN DB.
170.000 C
171.000 ESD=20.*XALOG10(ESU/ESM)
172.000 ESD=20.*XALOG10(ESD/ESM)
173.000 EST=20.*XALOG10(EST/ESM)
174.000 190 WRITE(6,660)THSD(MOB),ESU,ESD,EST
175.000 180
176.000 200
177.000 C
178.000 500 FORMAT(1H ,5X,'NUMBER OF ELEMENTS IN THE BROADCAST ARRAY = ',I4//)
179.000 510
180.000 520 FORMAT(1H ,5X,'NUMBER OF THIN TOWERS = ',I4//)
181.000 520 FORMAT(1H ,5X,'POSITION OF THE DIPOLE ELEMENT NUMBER',I4,' = ',2F10.6//)
182.000 530 FORMAT(1H ,5X,'MAXIMUM CURRENT AT THE BASEOF DIPOLE NUMBER',I4,
1' = ',2F10.6//)
183.000 540 FORMAT(1H ,5X,'DATA FOR TOWER NUMBER',I4//)
184.000 540 FORMAT(1H ,5X,'NUMBER OF SEGMENTS ON THE TOWER = ',I4//)
185.000 550 FORMAT(1H ,5X,'POSITION OF THE TOWER = ',2F10.6//)
186.000 560 FORMAT(1H ,5X,'HEIGHT OF THE TOWER = ',2F10.6//)
187.000 570 FORMAT(1H ,5X,'RADIUS OF THE TOWER = ',F10.6//)
188.000 580
189.000 C
190.000 C
191.000 C
192.000 C
193.000 C
194.000 610 FORMAT(1H ,5X,'NUMBER OF OBSERVATION POINTS FOR THE RADIATION',I4//)
195.000 620
196.000 620 FORMAT(1H ,5X,'HORIZONTAL PLANE PATTERN'////)
197.000 630 FORMAT(1H ,5X,'VERTICAL PLANE PATTERN'////)
198.000 640 FORMAT(1H ,5X,'ANGLE OF OBSERVATION',8X,'TOWERS FIELD',6X,
1'DIPOLES FIELD',8X,'TOTAL FIELD'//)
199.000 660 FORMAT(1H ,4F18.8)
200.000
201.000 STOP
202.000
203.000 END
204.000 C
205.000 C
206.000 C
207.000 C
208.000 C
209.000 C
210.000 C
211.000 C
212.000 C
213.000 C
214.000 C
215.000
216.000
217.000
218.000
219.000
220.000
221.000
          SUBROUTINE CZSET(PROPC,NTT,NST,CZ)
          SUBROUTINE TO SET UP THE MUTUAL COUPLING MATRIX FOR THE
          INDUCED CURRENTS ON THE TOWERS.
          PROPC PROPAGATION CONSTANT.
          NTT NUMBER OF THIN TOWERS.
          NST NUMBER OF SEGMENTS ON THE TOWERS.
          XT,YT POSITION OF THE TOWERS.
          ZT CENTRE POINTS FOR TOWER SEGMENTS.
          RT RADII OF THE TOWERS.
          DZT SEGMENT WIDTHS.
          IMPLICIT COMPLEX(C)
          REAL COS
          DIMENSION NST(10),XT(10),YT(10),RT(10),ZT(10,40)
          DIMENSION DZT(10,40),CZ(100,100)
          COMMON /CEZ/ CERU,CERL,CJ
          COMMON /EZC/ RL,RU,ZH,ZN,ZL,ZU,RADS,PROP,DCDZ,DSDZ,RL3,RU3
          COMMON /TOWER/ XT,YT,ZT,DZT,RT
          MAIN1660
          MAIN1670
          MAIN1680
          MAIN1690
          MAIN1700
          MAIN1710
          MAIN1720
          MAIN1730
          MAIN1740
          MAIN1750
          MAIN1760
          MAIN1770
          MAIN1780
          MAIN1790
          MAIN1800
          MAIN1810
          MAIN1820
          MAIN1830
          MAIN1840
          MAIN1850
          MAIN1860
          MAIN1870
          MAIN1880
          MAIN1890
          MAIN1900
          MAIN1910
          MAIN1920
          MAIN1930
          MAIN1940
          MAIN1950
          MAIN1960
          MAIN1970
          MAIN1980
          MAIN1990
          MAIN2000
          MAIN2010
          MAIN2020
          CZST0010
          CZST0020
          CZST0030
          CZST0040
          CZST0050
          CZST0060
          CZST0070
          CZST0080
          CZST0090
          CZST0100
          CZST0110
          CZST0120
          CZST0130
          CZST0140
          CZST0150
          CZST0160
          CZST0170
          CZST0180
          CZST0190

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222.000      EXTERNAL CCPI,CSFI,CCFI          CZST0200
223.000      CJ=CMPLX(0.0E0,1.0E0)          CZST0210
224.000      PROP=PROPC                  CZST0220
225.000      NSI=0                      CZST0230
226.000      DO 160 NTO=1,NTT            CZST0240
227.000      DO 150 II=1,NST(NTO)        CZST0250
228.000      NSI=NSI+1                  CZST0260
229.000      ZM=ZT(NTO,II)              CZST0270
230.000      DO 140 NTS=1,NTT            CZST0280
231.000      IF(NTS-1)10,10,20          CZST0290
232.000      NSJI=0                  CZST0300
233.000      10 GO TO 40             CZST0310
234.000      20 NSJI=0                  CZST0320
235.000      DO 30 IK=1,NTS-1          CZST0330
236.000      30 NSJI=NSJI+NST(IK)      CZST0340
237.000      40 RADS=(XT(NTS)-XT(NTO))**2+(YT(NTS)-YT(NTO))**2+RT(NTS)**2
238.000      C
239.000      C      CALCULATE THE TRANSCENDENTAL FUNCTION INTERPOLATION
240.000      C      MATRIX FOR EQUAL WIDTH SEGMENTS.          CZST0350
241.000      C
242.000      50 DL=DZT(NTS,1)+DZT(NTS,2)          CZST0360
243.000      SIDL=SIN(PROP*SDL)          CZST0370
244.000      SIDR=SIDL                  CZST0380
245.000      DCIL=SQRT(1.0E0-SIDL*SIDL)      CZST0390
246.000      DCIR=DCIL                  CZST0400
247.000      DET=SIDL+SIDR-SIDL*DCIR-DCIL*SIDR      CZST0410
248.000      DCDZ=COS(DZT(NTS,1)*PROP)          CZST0420
249.000      DSDZ=SIN(DZT(NTS,1)*PROP)          CZST0430
250.000      60 DO 130 JJ=2,NST(NTS)          CZST0440
251.000      C
252.000      C      CALCULATE THE CONTRIBUTION OF THE DIFFERENT SEGMENTS
253.000      C      EXCEPT THE END SEGMENTS.          CZST0450
254.000      C
255.000      70 NSJ=NSJI+JJ              CZST0460
256.000      ZN=ZT(NTS,JJ)              CZST0470
257.000      ZL=ZN-DZT(NTS,JJ)          CZST0480
258.000      ZU=ZN+DZT(NTS,JJ)          CZST0490
259.000      80 RL=SQRT(RADS+(ZN-ZL)**2)*PROP          CZST0500
260.000      RU=SQRT(RADS+(ZN-ZU)**2)*PROP          CZST0510
261.000      CERU=CMPLX(COS(RU),-SIN(RU))      CZST0520
262.000      CERL=CMPLX(COS(RL),-SIN(RL))      CZST0530
263.000      RL3=RL*RL*RL
264.000      RU3=RUXRU*RU
265.000      CZX1=(CCPI(SIDL)+CSFI(1.0E0-DCIL)-CCFI(SIDL))/DET      CZST0540
266.000      CZY1=(CCPI(-SIDL*DCIR-SIDR*DCIL)+CSFI(DCIL-DCIR)+      CZST0550
267.000      1CCFI(SIDL+SIDR))/DET          CZST0560
268.000      CZZ1=(CCPI(SIDR)+CSFI(DCIR-1.0E0)-CCFI(SIDR))/DET      CZST0570
269.000      C
270.000      C      CALCULATE THE CONTRIBUTION OF THE REFLECTION POINT.      CZST0580
271.000      C
272.000      ZN=-ZN
273.000      ZL=ZN-DZT(NTS,JJ)          CZST0590
274.000      ZU=ZN+DZT(NTS,JJ)          CZST0600
275.000      100 RL=SQRT(RADS+(ZN-ZL)**2)*PROP          CZST0610
276.000      RU=SQRT(RADS+(ZN-ZU)**2)*PROP          CZST0620
277.000      CERU=CMPLX(COS(RU),-SIN(RU))      CZST0630

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TV278-333\5\4

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278.000 CERL-CMPLX(COS(RL),-SIN(RL)) CZST0760
279.000 RL3=RL*RL*RL CZST0770
280.000 RU3=RUXRUZRU CZST0780
281.000 CZX2=(CCPI(SIDL)+CSFI(1.0E0-DCIL)-CCFI(SIDL))/DET CZST0790
282.000 CZY2=(CCPI(-SIDL*DCIR-SIDR*DCIL)+CSFI(DCIL-DCIR)+ CCFI(SIDL+SIDR))/DET CZST0800
283.000 CZZ2=(CCPI(SIDR)+CSFI(DCIR-1.0E0)-CCFI(SIDR))/DET CZST0810
284.000 CZ(MSI,MSJ-1)=CZ(NSI,NSJ-1)+CZX1+CZZ2 CZST0820
285.000 CZ(NSI,MSJ)=CZ(NSI,MSJ)+CZY1+CZY2 CZST0830
286.000 IF(IJ-NST(NTS))110,120,110 CZST0840
287.000 CZ(NSI,MSJ+1)=CZ(NSI,MSJ+1)+CZZ1+CZX2 CZST0850
288.000 110 CZ(NSI,MSJ+1)=CZ(NSI,MSJ+1)+CZZ1+CZX2 CZST0860
289.000 GO TO 130 CZST0870
290.000 120 CZ(NSI,MSJ)=CZ(NSI,MSJ)+CZZ1+CZX2 CZST0880
291.000 130 CONTINUE CZST0890
292.000 C CZST0900
293.000 C CALCULATE THE CONTRIBUTION OF THE END SEGMENTS OF CZST0910
294.000 C THE TOWERS. CZST0920
295.000 C CZST0930
296.000 JJ=1 CZST0940
297.000 NSJ=MSJI+JJ CZST0950
298.000 ZM=ZT(NTS,JJ) CZST0960
299.000 ZL=ZM-DZT(NTS,JJ) CZST0970
300.000 ZU=ZM+DZT(NTS,JJ) CZST0980
301.000 DLL=DZT(NTS,JJ)+DZT(NTS,JJ+1) CZST0990
302.000 DLR=DZT(NTS,JJ) CZST1000
303.000 SIDFR=SIN(PROP3DLR) CZST1010
304.000 SIDFL=SIN(PROPIDL) CZST1020
305.000 DCIFR=SORT(1.0E0-SIDFR*SIDFR) CZST1030
306.000 DCIFL=SORT(1.0E0-SIDFL*SIDFL) CZST1040
307.000 DET1=SIDFR+SIDFL*DCIFR-SIDFR*DCIFL CZST1050
308.000 RL=SORT(RADS+(ZM-ZL)**2)*PROP CZST1060
309.000 RU=SORT(RADS+(ZM-ZU)**2)*PROP CZST1070
310.000 CERU-CMPLX(COS(RU),-SIN(RU)) CZST1080
311.000 CERL-CMPLX(COS(RL),-SIN(RL)) CZST1090
312.000 DCDZ=COS(DZT(NTS,JJ)*PROP) CZST1100
313.000 DSDZ=SIN(DZT(NTS,JJ)*PROP) CZST1110
314.000 RL3=RL*RL*RL CZST1120
315.000 RU3=RUXRUZRU CZST1130
316.000 CZY1=(CCPI(-SIDFL*DCIFR-SIDFR*DCIFL)+CSFI(DCIFL-DCIFR)+ CCFI(SIDFL+SIDFR))/DET1 CZST1140
317.000 CZZ1=(CCPI(SIDFR)+CSFI(DCIFR-1.0E0)-CCFI(SIDFR))/DET1 CZST1150
318.000 ZN=ZN CZST1160
319.000 ZL=ZM-DZT(NTS,JJ) CZST1170
320.000 ZU=ZM+DZT(NTS,JJ) CZST1180
322.000 SIDLR=SIDFL CZST1190
323.000 SIDLL=SIDFR CZST1200
324.000 DCILR=DCIFL CZST1210
325.000 DCILL=DCIFR CZST1220
326.000 DET2=SIDLR+SIDLL-SIDLL*DCILR-SIDLR*DCILL CZST1230
327.000 RL=SORT(RADS+(ZM-ZL)**2)*PROP CZST1240
328.000 RU=SORT(RADS+(ZM-ZU)**2)*PROP CZST1250
329.000 CERU-CMPLX(COS(RU),-SIN(RU)) CZST1260
330.000 CERL-CMPLX(COS(RL),-SIN(RL)) CZST1270
331.000 DCDZ=COS(DZT(NTS,JJ)*PROP) CZST1280
332.000 DSDZ=SIN(DZT(NTS,JJ)*PROP) CZST1290
333.000 RL3=RL*RL*RL CZST1300
334.000 RU3=RUXRUZRU CZST1310

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TY335-391
336.000 CZX2=(CCPI(SIDL)+CSFI(1.0E0-DCILL)-CCFI(SIDL))/DET2      CZST1330
336.000 CZY2=(CCPI(-SIDLR*DCILL-SIDL*DCILR)+CSFI(DCI-L-DCILR)+      CZST1340
337.000 1CCFI(SIDL+SIDLR))/DET2      CZST1350
338.000 CZ(MSI,MSJ)=CZ(MSI,MSJ)+CZY1+CZY2      CZST1360
339.000 CZ(MSI,MSJ+1)=CZ(MSI,MSJ+1)+CZZ1+CZX2      CZST1370
340.000 140 CONTINUE      CZST1380
341.000 150 CONTINUE      CZST1390
342.000 160 CONTINUE      CZST1400
343.000 RETURN      CZST1410
344.000 END      CZST1420
345.000 COMPLEX FUNCTION CCFI (RI)      CCFI0010
346.000 C
347.000 C          EXACT INTEGRATION FOR THE COSINE CURRENT      CCFI0020
348.000 C
349.000 IMPLICIT COMPLEX(C)
350.000 REAL COS
351.000 COMMON /EZC/ CERU,CERL,CJ
352.000 COMMON /EZC/ RL,RU,ZM,ZN,ZL,ZU,RADS,PROP,DCDZ,DSDZ,RL3,RU3      CCFI0030
353.000 CCFI=-CERU*DSDZ/RU-CERL*DSDZ/RL      CCFI0040
354.000 1-(1.0E0+CJ*RU)*DCDZ*PROP*(ZM-ZU)*CERU/RU3      CCFI0050
355.000 2+(1.0E0+CJ*RL)*DCDZ*PROP*(ZM-ZL)*CERL/RL3      CCFI0060
356.000 CCFI=CJ*RI*3.0E1*PROP*CCFI      CCFI0070
357.000 RETURN      CCFI0080
358.000 END      CCFI0090
359.000 COMPLEX FUNCTION CCPI (RI)      CCPI0100
360.000 C
361.000 C          INTEGRATION FOR THE CONSTANT CURRENT      CCPI0110
362.000 C
363.000 IMPLICIT COMPLEX(C)
364.000 COMMON /EZC/ CERU,CERL,CJ
365.000 COMMON /EZC/ RL,RU,ZM,ZN,ZL,ZU,RADS,PROP,DCDZ,DSDZ,RL3,RU3      CCPI0120
366.000 EXTERNAL CEXPI
367.000 CALL CGAQ(ZL,ZU,CEXP1,4,CAMS)
368.000 CAMS=CAMS+ALOG((RU/PROP+ZU-ZM)/(RL/PROP+ZL-ZM))      CCPI0130
369.000 CCPI=(1.0E0+CJ*RU)*PROP*(ZM-ZU)*CERU/RU3      CCPI0140
370.000 1-(1.0E0+CJ*RL)*PROP*(ZM-ZL)*CERL/RL3+CAMS      CCPI0150
371.000 CCPI=-CJ*3.0E1*PROP*RI*CCPI      CCPI0160
372.000 RETURN      CCPI0170
373.000 END      CCPI0180
374.000 SUBROUTINE CGAQ(XL,XU,CINT ,NIX,CAMS)      CGAQ0010
375.000 C
376.000 C          WRITTEN BY R.K.CHUGH      CGAQ0020
377.000 C          CRC NOV.,1977      CGAQ0030
378.000 C
379.000 C          SUBROUTINE TO PERFORM NUMERICAL      CGAQ0040
380.000 C          INTEGRATION OF A COMPLEX FUNCTION CINT      CGAQ0050
381.000 C          USING GAUSS QUADRATURE ELEVEN POINT FORMULA.      CGAQ0060
382.000 C
383.000 C          XL    LOWER LIMIT OF INTEGRATION INTERVAL.      CGAQ0070
384.000 C          XU    UPPER LIMIT OF INTEGRATION INTERVAL.      CGAQ0080
385.000 C          CINT   EXTERNAL FUNCTION DEFINING THE INTEGRAND.      CGAQ0090
386.000 C          NIX    NUMBER OF INERVALS FOR THE INTEGRATION RANGE.      CGAQ0100
387.000 C          CAMS   ANSWER OF INTEGRATION.      CGAQ0110
388.000 C
389.000 C          IMPLICIT COMPLEX(C)
390.000 C          DIMENSION T(6),U(6)
391.000 C          EXTERNAL CINT      CGAQ0120

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TY392-448
292.000      DATA T/0.978228658146057,0.887062599768095,0.730152005574049,    CGA00130
293.000      10.519096129206812,0.269543155952345,0.0E0/                                CGA00200
294.000      DATA W/0.556685671161737D-1,0.125580369464905,0.186290210927734,    CGA00210
295.000      10.233193764591990,0.262804544510247,0.272925086777901/    CGA00220
296.000      50      DC=MIX                                              *
297.000      CSUM=CMPLX(0.0E0,0.0E0)                                         CGA00230
298.000      DD=(XU-XL)/DC                                              CGA00240
299.000      DO 60 L=1,MIX                                              CGA00250
300.000      AA=XL+(FLOAT(L)-1.0E0)*DD                               CGA00260
301.000      AB=AA+DD                                              CGA00270
302.000      SCAL1=(AB-AA)/2.0E0                                         CGA00280
303.000      SCAL2=(AB+AA)/2.0E0                                         CGA00290
304.000      DO 60 N=1,6                                              CGA00300
305.000      P1=SCAL1*T(N)+SCAL2                                         CGA00310
306.000      IF(T(N).EQ.0.0E0)GO TO 81                                CGA00320
307.000      82      P2=SCAL1*T(N)+SCAL2                                         CGA00330
308.000      CSI=CINT (P1)+CINT (P2)                                         CGA00340
309.000      GO TO 83                                              CGA00350
310.000      81      CSI=CINT (P1)                                         CGA00360
311.000      83      CSUM=CSUM+SCAL1*X(N)*CSI                           CGA00370
312.000      60      CONTINUE                                           CGA00380
313.000      CAMS=CSUM                                         CGA00390
314.000      RETURN                                              CGA00400
315.000      END                                               CGA00410
316.000      COMPLEX FUNCTION CEXP1 (ZP)                                CGA00420
317.000      C
318.000      C      INTEGRAND FOR THE CONSTANT PART                         CEXP0010
319.000      C
320.000      IMPLICIT COMPLEX(C)                                         CEXP0020
321.000      REAL COS                                              CEXP0030
322.000      COMMON /CEZ/ CERU,CERL,CJ                                CEXP0040
323.000      COMMON /EZC/ RL,RU,ZM,ZN,ZL,ZU,RADS,PROP,DCDZ,DSDZ,RL3,RU3   CEXP0050
324.000      R=SQRT(RADS+(ZM-ZP)**2)*PROP                            CEXP0060
325.000      CEXP1=(CMPLX(COS(R),-SIN(R))-1.0E0)*PROP/R           CEXP0070
326.000      RETURN                                              CEXP0080
327.000      END                                               CEXP0090
328.000      C
329.000      C      SUBROUTINE CSEQCR(A,N,M,MM,B,X)                         CEXP0100
330.000      C
331.000      C      WRITTEN BY R.K.CHUGH                                     CSE0010
332.000      C      CRC NOV.,1977                                         CSE0020
333.000      C
334.000      C      SUBROUTINE TO SOLVE COMPLEX                                CSE0030
335.000      C      SIMULTANEOUS EQUATIONS USING CROUT'S METHOD.          CSE0040
336.000      C
337.000      C      [A][X]=[B]                                              CSE0050
338.000      C
339.000      C      N      NUMBER OF EQUATIONS TO BE SOLVED.          CSE0060
340.000      C      M      MAXIMUM DIMENSION FOR MATRICES A,B,X.       CSE0070
341.000      C      MM     PARAMETER FOR TYPE OF MATRIX A.          CSE0080
342.000      C      MM-1    SYMMETRIC MATRIX A.                      CSE0090
343.000      C      MM-2    NON-SYMMETRIC MATRIX A.                     CSE0100
344.000      C
345.000      C      COMPLEX     A(M,M),B(M),X(M),CSUM                         CSE0110
346.000      C      A(1,1)=A(1,1)                                         CSE0120
347.000      C      DO 10 I=2,M                                         CSE0130
348.000      C      A(I,1)=A(I,1)                                         CSE0140
349.000      C      A(I,1)=A(1,I)/A(1,1)                                     CSE0150
350.000      10      A(I,I)=A(1,I)/A(1,1)                                     CSE0160

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TY449-505

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449.000      B(1)=B(1)/A(1,1)          CSE00220
450.000      DO 100 I=2,N            CSE00230
451.000      II=I-1                CSE00240
452.000      DO 90 J=2,N            CSE00250
453.000      JJ=J-1                CSE00260
454.000      CSUM=CMPLX(0.0E0,0.0E0)  CSE00270
455.000      IF(I-J)20,30,40        CSE00280
456.000 20    DO 25 K=1,II         CSE00290
457.000 25    CSUM=CSUM+A(I,K)*A(K,J)  CSE00300
458.000      A(I,J)=(A(I,J)-CSUM)/A(I,I)  CSE00310
459.000      GO TO 90              CSE00320
460.000 30    DO 35 K=1,II         CSE00330
461.000 35    CSUM=CSUM+A(I,K)*A(K,I)  CSE00340
462.000      A(I,I)=A(I,I)-CSUM       CSE00350
463.000      GO TO 90              CSE00360
464.000 40    DO TO (46,60),MM       CSE00370
465.000 46    A(I,J)=A(J,I)*A(J,J)  CSE00380
466.000      GO TO 90              CSE00390
467.000 60    DO 45 K=1,JJ         CSE00400
468.000 45    CSUM=CSUM+A(I,K)*A(K,J)  CSE00410
469.000      A(I,J)=A(I,J)-CSUM       CSE00420
470.000 90    CONTINUE             CSE00430
471.000      CSUM=CMPLX(0.0E0,0.0E0)  CSE00440
472.000      DO 95 K=1,II         CSE00450
473.000 95    CSUM=CSUM+A(I,K)*B(K)  CSE00460
474.000      B(I)=(B(I)-CSUM)/A(I,I)  CSE00470
475.000 100   CONTINUE             CSE00480
476.000      X(N)=B(N)             CSE00490
477.000      DO 110 J=1,N-1        CSE00500
478.000      I=N-J                CSE00510
479.000      KK=I+1                CSE00520
480.000      CSUM=CMPLX(0.0E0,0.0E0)  CSE00530
481.000      DO 105 K=KK,N        CSE00540
482.000 105   CSUM=CSUM+A(I,K)*X(K)  CSE00550
483.000      X(I)=B(I)-CSUM       CSE00560
484.000 110   CONTINUE             CSE00570
485.000      RETURN               CSE00580
486.000      END                  CSE00590
487.000      COMPLEX FUNCTION CSFI (RI)  CSFI0010
488.000 C      EXACT INTEGRATION FOR THE SINUSOIDAL CURRENT  CSFI0020
489.000 C      IMPLICIT COMPLEX(C)           CSFI0030
490.000 C      COMMON /CEZ/ CERU,CERL,CJ  CSFI0040
491.000      COMMON /EZC/ RL,RU,ZM,ZN,ZL,ZU,RADS,PROP,DCDZ,DSDZ,RL3,RU3  CSFI0050
492.000      CSFI=DCDZ*CERU*RU-DCDZ*CERL/RL-  CSFI0060
493.000      1*(1.0E0+CJ*RU)*DSDZ*PROP*(ZM-ZU)*CERU/RU3  CSFI0070
494.000      2-(1.0E0+CJ*RL)*DSDZ*PROP*(ZM-ZL)*CERL/RL3  CSFI0080
495.000      CSFI=CJ*RI*3.0E1*PROP*CSFI  CSFI0090
496.000      RETURN               CSFI0100
497.000      END                  CSFI0110
498.000      SUBROUTINE IFDA(PROPC,MDP,CMDC,X0,Y0,Z0,CIF)  CSFI0120
499.000      END                  CSFI0130
500.000      IFDA0010
501.000 C      FUNCTION TO CALCULATE THE INCIDENT FIELD AT ANY OBSERVATION POINT IFDA0020
502.000 C      DUE TO A DIPOLE ARRAY.  IFDA0030
503.000 C      PARAMETERS             IFDA0040
504.000 C      IFDA0050
505.000 C      IFDA0060

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506.000 C      PROP    PROPAGATION CONSTANT.          IFDA0070
507.000 C      NDP     NUMBER OF DIPOLES.        IFDA0080
508.000 C      XD,YD  COORDINATE LOCATION OF THE DIPOLE. IFDA0090
509.000 C      CMDC   COMPLEX CURRENT AT THE BASE OF THE DIPOLE IFDA0100
510.000 C      X0,Y0,Z0 OBSERVATION POINT COORDINATES. IFDA0110
511.000 C      CIF    COMPLEX INCIDENT FIELD AT THE OBSERVATION POINT. IFDA0120
512.000 C
513.000 C
514.000 C      IMPLICIT COMPLEX(C)           IFDA0130
515.000 C      REAL COS
516.000 C      DIMENSION XD(10),YD(10),HD(10),CMDC(10) IFDA0140
517.000 C      COMMON /DIPOLE/XD,YD,HD           IFDA0150
518.000 C      CIF=CMPLX(0.0E0,0.0E0)       IFDA0160
519.000 C      PROP=PROPC
520.000 C      DO 70 N=1,NDP
521.000 C      XDO=XD(N)-X0
522.000 C      YDO=YD(N)-Y0
523.000 C      RHOS=XDO*XDO+YDO*YDO
524.000 C      R1M=SQRT(RHOS+(HD(N)-Z0)**2)*PROP
525.000 C      R2N=SQRT(RHOS+(HD(N)+Z0)**2)*PROP
526.000 C      R0N=SQRT(RHOS+Z0*Z0)*PROP
527.000 C      DCH=COS(PROP*HD(N))
528.000 C      DSH=SIN(PROP*HD(N))
529.000 C      X=COS(R1M)/R1M+COS(R2N)/R2N-2.0*COS(R0N)*DCH/R0N
530.000 C      Y=SIN(R1M)/R1M+SIN(R2N)/R2N-2.0*SIN(R0N)*DCH/R0N
531.000 C      CIF=CIF+3.0E1*PROP*CMDC(N)*CMPLX(Y,X)/DSH
532.000 70    CONTINUE
533.000 C      RETURN
534.000 C      END
535.000 C      SUBROUTINE SFDA(PROPC,NDP,CMDC,CSD)
536.000 C
537.000 C      SUBROUTINE TO CALCULATE THE SCATTERED FIELD DUE TO
538.000 C      THE DIPOLE ARRAY.          SFDA0030
539.000 C
540.000 C      PROPC  PROPAGATION CONSTANT.          SFDA0040
541.000 C      NDP   NUMBER OF DIPOLES.        SFDA0050
542.000 C      CMDC  COMPLEX CURRENT AT THE BASE OF THE DIPOLE ELEMENT. SFDA0060
543.000 C      CSD   SCATTERED FIELD AT AN OBSERVATION POINT. SFDA0070
544.000 C
545.000 C
546.000 C      IMPLICIT COMPLEX(C)           SFDA0080
547.000 C      REAL COS
548.000 C      DIMENSION XD(10),YD(10),HD(10),CMDC(10) SFDA0090
549.000 C      COMMON /DIPOLE/XD,YD,HD           SFDA0100
550.000 C      COMMON /OBSP/ SPHS,PHSC          SFDA0110
551.000 C      PI=3.14159265358979/2.0E0
552.000 C      PROP=PROPC
553.000 C      CJ=CMPLX(0.0E0,1.0E0)
554.000 C      CSD=CMPLX(0.0E0,0.0E0)
555.000 C      DO 100 ND=1,NDP
556.000 C      PPF=TAN(PROP*HD(ND)/2.0)
557.000 C      PF=PROPS(XD(ND)*PHSC+YD(ND)*SPHS)
558.000 100   CSD=CSD+CJ*6.0E1*PPF*CMDC(ND)*CEXP(CMPLX(0.0E0,PF)) SFDA0120
559.000 C      RETURN
560.000 C      END
--EOF HIT AFTER 560.
*
```

2. Test run 1

*

INPUT DATA FOR TEST RUN 1

1
2 1
1.00
0.25 0.00 0.25 1.0 0.0
-0.250 0.00 0.250 1.0 0.0
0.0 2.0 0.254 0.003
181
0.0 2.0
151.071049

SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO
AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST
ELEMENTS BASED ON MOMENT METHOD.

WAVELENGTH = 1.000000

NUMBER OF ELEMENTS IN THE BROADCAST ARRAY = 2

NUMBER OF THIN TOWERS = 1

POSITION OF THE DIPOLE ELEMENT NUMBER 1 = .250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 1 = .250000

MAXIMUM CURRENT AT THE BASEOF DIPOLE NUMBER 1 = 1.000000 .000000

POSITION OF THE DIPOLE ELEMENT NUMBER 2 = -.250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 2 = .250000

MAXIMUM CURRENT AT THE BASEOF DIPOLE NUMBER 2 = 1.000000 .000000

DATA FOR TOWER NUMBER 1

NUMBER OF SEGMENTS ON THE TOWER = 10

POSITION OF THE TOWER = .000000 2.000000

HEIGHT OF THE TOWER = .254000

RADIUS OF THE TOWER = .003000

NUMBER OF OBSERVATION POINTS FOR THE RADIATION PATTERN = 181

HORIZONTAL PLANE PATTERN

*

ANGLE OF OBSERVATION	TOWERS FIELD	DIPOLES FIELD	TOTAL FIELD
.00000000	-21.86145020	-136.55137634	-21.86145020
2.00000000	-21.86145020	-62.38383484	-21.89617920
4.00000000	-21.86145020	-50.34434509	-21.85662842
6.00000000	-21.86145020	-43.30484009	-21.53436279
8.00000000	-21.86145020	-38.31352234	-20.88441467
10.00000000	-21.86145020	-34.44592285	-20.07771301
12.00000000	-21.86145020	-31.28929138	-19.35522461
14.00000000	-21.86145020	-28.62429810	-18.90730286
16.00000000	-21.86145020	-26.32008362	-18.86744690
18.00000000	-21.86145020	-24.29222107	-19.35507202
20.00000000	-21.86145020	-22.48318481	-20.52673340
22.00000000	-21.86145020	-20.85200500	-22.61840820
24.00000000	-21.86145020	-19.36856079	-25.69215393
26.00000000	-21.86145020	-18.01010132	-26.77700806
28.00000000	-21.86145020	-16.75898743	-22.79414368
30.00000000	-21.86145020	-15.60137367	-18.73146057
32.00000000	-21.86145020	-14.52610493	-15.66638184
34.00000000	-21.86145020	-13.52424812	-13.34482002
36.00000000	-21.86145020	-12.58838749	-11.55052471
38.00000000	-21.86145020	-11.71245193	-10.14826584
40.00000000	-21.86145020	-10.89133263	-9.05065060
42.00000000	-21.86145020	-10.12078571	-8.19706726
44.00000000	-21.86145020	-9.39720154	-7.54199696
46.00000000	-21.86145020	-8.71748257	-7.04856873
48.00000000	-21.86145020	-8.07907581	-6.68457317
50.00000000	-21.86145020	-7.47972965	-6.42018032
52.00000000	-21.86145020	-6.91751957	-6.22669029
54.00000000	-21.86145020	-6.39079380	-6.07646561
56.00000000	-21.86145020	-5.89813709	-5.94363976
58.00000000	-21.86145020	-5.43832970	-5.80587673
60.00000000	-21.86145020	-5.01030064	-5.64623928
62.00000000	-21.86145020	-4.61314487	-5.45483589
64.00000000	-21.86145020	-4.24606514	-5.22923946
66.00000000	-21.86145020	-3.90837860	-4.97358513
68.00000000	-21.86145020	-3.59948826	-4.69656944
70.00000000	-21.86145020	-3.31890202	-4.40915585
72.00000000	-21.86145020	-3.06617355	-4.12251949
74.00000000	-21.86145020	-2.84093189	-3.84673691
76.00000000	-21.86145020	-2.64285851	-3.59009552
78.00000000	-21.86145020	-2.47169495	-3.35900021
80.00000000	-21.86145020	-2.32721424	-3.15810680
82.00000000	-21.86145020	-2.20923519	-2.99064350
84.00000000	-21.86145020	-2.11761665	-2.85875320
86.00000000	-21.86145020	-2.05225182	-2.76377964
88.00000000	-21.86145020	-2.01306152	-2.70652580
90.00000000	-21.86145020	-2.00000381	-2.68739700
92.00000000	-21.86145020	-2.01306152	-2.70652580
94.00000000	-21.86145020	-2.05224991	-2.76377773
96.00000000	-21.86145020	-2.11761570	-2.85875034
98.00000000	-21.86145020	-2.20923233	-2.99064159
100.00000000	-21.86145020	-2.32720947	-3.15810204
102.00000000	-21.86145020	-2.47169299	-3.35899639

104.0000000	-21.86145020	-2.64285564	-3.59008884
106.0000000	-21.86145020	-2.84092999	-3.84673119
108.0000000	-21.86145020	-3.06617069	-4.12251663
110.0000000	-21.86145020	-3.31889725	-4.40915203
112.0000000	-21.86145020	-3.59948349	-4.69656658
114.0000000	-21.86145020	-3.90837479	-4.97358131
116.0000000	-21.86145020	-4.24605656	-5.22923756
118.0000000	-21.86145020	-4.61313534	-5.45482349
120.0000000	-21.86145020	-5.01028824	-5.64622402
122.0000000	-21.86145020	-5.43832397	-5.80587006
124.0000000	-21.86145020	-5.89814377	-5.94364643
126.0000000	-21.86145020	-6.30979380	-6.07646561
128.0000000	-21.86145020	-6.91751480	-6.22669697
130.0000000	-21.86145020	-7.47972965	-6.42018032
132.0000000	-21.86145020	-8.07907581	-6.68457985
134.0000000	-21.86145020	-8.71748257	-7.04856873
136.0000000	-21.86145020	-9.39720154	-7.54199696
138.0000000	-21.86145020	-10.12078571	-8.19706154
140.0000000	-21.86145020	-10.89132118	-9.05063820
142.0000000	-21.86145020	-11.71243477	-10.14824390
144.0000000	-21.86145020	-12.58838749	-11.55052471
146.0000000	-21.86145020	-13.52424812	-13.34482002
148.0000000	-21.86145020	-14.52610493	-15.66635799
150.0000000	-21.86145020	-15.60133457	-18.73139954
152.0000000	-21.86145020	-16.75898743	-22.79415894
154.0000000	-21.86145020	-18.01010132	-26.77700896
156.0000000	-21.86145020	-19.36856079	-25.69218445
158.0000000	-21.86145020	-20.85192871	-22.61840820
160.0000000	-21.86145020	-22.48318481	-20.52676392
162.0000000	-21.86145020	-24.29231262	-19.35511780
164.0000000	-21.86145020	-26.32008362	-18.86744690
166.0000000	-21.86145020	-28.62429810	-18.90730286
168.0000000	-21.86145020	-31.28929138	-19.35522461
170.0000000	-21.86145020	-34.44592285	-20.07771301
172.0000000	-21.86145020	-38.31352234	-20.88442993
174.0000000	-21.86145020	-43.30484009	-21.53436279
176.0000000	-21.86145020	-50.34434509	-21.85662842
178.0000000	-21.86145020	-62.38383484	-21.89617920
180.0000000	-21.86145020	-136.55137634	-21.86145020
182.0000000	-21.86145020	-62.38383484	-21.94099426
184.0000000	-21.86145020	-50.34434509	-22.18873596
186.0000000	-21.86145020	-43.30484009	-22.46798706
188.0000000	-21.86145020	-38.31352234	-22.44033813
190.0000000	-21.86145020	-34.44592285	-21.78321838
192.0000000	-21.86145020	-31.28929138	-20.56831360
194.0000000	-21.86145020	-28.62429810	-19.17604065
196.0000000	-21.86145020	-26.32008362	-17.92555237
198.0000000	-21.86145020	-24.29231262	-16.97434998
200.0000000	-21.86145020	-22.48318481	-16.38401794
202.0000000	-21.86145020	-20.85200500	-16.17895508
204.0000000	-21.86145020	-19.36856079	-16.37048340
206.0000000	-21.86145020	-18.01010132	-16.95196533
208.0000000	-21.86145020	-16.75901794	-17.84429932
210.0000000	-21.86145020	-15.60137367	-18.73143005
212.0000000	-21.86145020	-14.52610493	-18.87664795
214.0000000	-21.86145020	-13.52424812	-17.70523071
216.0000000	-21.86145020	-12.58838749	-15.70086575

218.0000000	-21.86145020	-11.71247482	-13.60066986
220.0000000	-21.86145020	-10.89133263	-11.72402096
222.0000000	-21.86145020	-10.12078571	-10.13377380
224.0000000	-21.86145020	-9.39720154	-3.81142807
226.0000000	-21.86145020	-8.71748257	-7.72128291
228.0000000	-21.86145020	-8.07907581	-6.82812786
230.0000000	-21.86145020	-7.47972965	-6.10085155
232.0000000	-21.86145020	-6.91751957	-5.51262474
234.0000000	-21.86145020	-6.39079380	-5.04003048
236.0000000	-21.86145020	-5.89814758	-4.66242836
238.0000000	-21.86145020	-5.43832588	-4.36138725
240.0000000	-21.86145020	-5.01029778	-4.12946719
242.0000000	-21.86145020	-4.61313820	-3.92516136
244.0000000	-21.86145020	-4.24606419	-3.76299667
246.0000000	-21.86145020	-3.90837669	-3.62371254
248.0000000	-21.86145020	-3.59948826	-3.49938679
250.0000000	-21.86145020	-3.31889915	-3.38449478
252.0000000	-21.86145020	-3.06617069	-3.27576923
254.0000000	-21.86145020	-2.84093189	-3.17192841
256.0000000	-21.86145020	-2.64285564	-3.07328320
258.0000000	-21.86145020	-2.47169209	-2.98125553
260.0000000	-21.86145020	-2.32721138	-2.89794636
262.0000000	-21.86145020	-2.20923233	-2.82570076
264.0000000	-21.86145020	-2.11761665	-2.76679993
266.0000000	-21.86145020	-2.05225182	-2.72320843
268.0000000	-21.86145020	-2.01306152	-2.69642830
270.0000000	-21.86145020	-2.00000381	-2.68739796
272.0000000	-21.86145020	-2.01306152	-2.69642830
274.0000000	-21.86145020	-2.05225182	-2.72320843
276.0000000	-21.86145020	-2.11761665	-2.76679993
278.0000000	-21.86145020	-2.20923233	-2.82570076
280.0000000	-21.86145020	-2.32721138	-2.89794636
282.0000000	-21.86145020	-2.47169209	-2.98125553
284.0000000	-21.86145020	-2.64285564	-3.07328320
286.0000000	-21.86145020	-2.84093189	-3.17192841
288.0000000	-21.86145020	-3.06617069	-3.27576923
290.0000000	-21.86145020	-3.31889915	-3.38449478
292.0000000	-21.86145020	-3.59948826	-3.49938679
294.0000000	-21.86145020	-3.90837669	-3.62371254
296.0000000	-21.86145020	-4.24606419	-3.76299667
298.0000000	-21.86145020	-4.61313820	-3.92516136
300.0000000	-21.86145020	-5.01029778	-4.12946719
302.0000000	-21.86145020	-5.43832588	-4.36138725
304.0000000	-21.86145020	-5.89814758	-4.66242886
306.0000000	-21.86145020	-6.39079380	-5.04003048
308.0000000	-21.86145020	-6.91751957	-5.51262474
310.0000000	-21.86145020	-7.47972965	-6.10086155
312.0000000	-21.86145020	-8.07907581	-6.82812786
314.0000000	-21.86145020	-8.71748257	-7.72128773
316.0000000	-21.86145020	-9.39720154	-8.81142807
318.0000000	-21.86145020	-10.12078571	-10.13377380
320.0000000	-21.86145020	-10.89133263	-11.72402096
322.0000000	-21.86145020	-11.71243477	-13.600659547
324.0000000	-21.86145020	-12.58838749	-15.70086575
326.0000000	-21.86145020	-13.52424812	-17.70523071
328.0000000	-21.86145020	-14.52610493	-18.87664795
330.0000000	-21.86145020	-15.60137367	-18.73143005

338.0000000	-21.86145020	-16.75901794	-17.84429932
334.0000000	-21.86145020	-18.01010132	-16.95196533
336.0000000	-21.86145020	-19.36856079	-16.37048340
338.0000000	-21.86145020	-20.85200500	-16.17895508
340.0000000	-21.86145020	-22.48318481	-16.38401794
342.0000000	-21.86145020	-24.29231262	-16.97434998
344.0000000	-21.86145020	-26.32008362	-17.92555237
346.0000000	-21.86145020	-28.62429810	-19.17604065
348.0000000	-21.86145020	-31.28929138	-20.56831360
350.0000000	-21.86145020	-34.44592285	-21.78321838
352.0000000	-21.86145020	-38.31410217	-22.44030762
354.0000000	-21.86145020	-43.30484009	-22.46798706
356.0000000	-21.86145020	-50.34434509	-22.18873596
358.0000000	-21.86145020	-62.38383484	-21.94099426
360.0000000	-21.86145020	-136.55137634	-21.86145020

3. Test run 2

INPUT DATA FOR TEST RUN 2

1				
2	2			
1.00				
0.250	0.0	0.25	1.0	0.0
-0.25	0.0	0.25	1.0	0.0
0.10	2.0	0.25	0.003	
-0.10	2.0	0.25	0.003	
181				
0.0	2.0			
151.07105				
*				

SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO
AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST
ELEMENTS BASED ON MOMENT METHOD.

WAVELENGTH = 1.000000

NUMBER OF ELEMENTS IN THE BROADCAST ARRAY = 2

NUMBER OF THIN TOWERS = 2

POSITION OF THE DIPOLE ELEMENT NUMBER 1 = .250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 1 = .250000

MAXIMUM CURRENT AT THE BASEOF DIPOLE NUMBER 1 = 1.000000 .000000

POSITION OF THE DIPOLE ELEMENT NUMBER 2 = -.250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 2 = .250000

MAXIMUM CURRENT AT THE BASEOF DIPOLE NUMBER 2 = 1.000000 .000000

DATA FOR TOWER NUMBER 1

NUMBER OF SEGMENTS ON THE TOWER = 10

POSITION OF THE TOWER = .100000 2.000000

HEIGHT OF THE TOWER = .250000

RADIUS OF THE TOWER = .003000

DATA FOR TOWER NUMBER 2

NUMBER OF SEGMENTS ON THE TOWER = 10

POSITION OF THE TOWER = -.100000 2.000000

HEIGHT OF THE TOWER = .250000

RADIUS OF THE TOWER = .003000

NUMBER OF OBSERVATION POINTS FOR THE RADIATION PATTERN = 181

HORIZONTAL PLANE PATTERN

ANGLE OF OBSERVATION	TOWERS FIELD	Dipoles Field	Total Field
.0000000	-20.50770569	-136.55137634	-20.50773621
2.0000000	-20.50629489	-62.38383484	-20.50685120
4.0000000	-20.49806213	-50.34434509	-20.38323975
6.0000000	-20.48606873	-43.30484009	-20.01835632
8.0000000	-20.46937561	-38.31352234	-19.45776367
10.0000000	-20.44897434	-34.44592285	-18.88044739
12.0000000	-20.42231759	-31.28929138	-18.48652649
14.0000000	-20.39222717	-28.62429810	-18.44354248
16.0000000	-20.35800171	-26.32008362	-18.90708923
18.0000000	-20.31983948	-24.29222107	-20.0789063
20.0000000	-20.27795410	-22.48318481	-22.40658569
22.0000000	-20.23257446	-20.35200600	-27.08132935
24.0000000	-20.18399048	-19.36856079	-38.57228088
26.0000000	-20.13247681	-18.01010132	-26.79718018
28.0000000	-20.07827759	-16.75898743	-20.30003789
30.0000000	-20.02171386	-15.60137367	-16.45120239
32.0000000	-19.96311951	-14.52610483	-13.76736210
34.0000000	-19.90275574	-13.54824812	-11.77963543
36.0000000	-19.84098316	-12.58838749	-10.27063370
38.0000000	-19.77809143	-11.71245193	-9.12107182
40.0000000	-19.71443176	-10.89133863	-8.25652218
42.0000000	-19.65029907	-10.12678571	-7.62532711
44.0000000	-19.58604906	-9.397200154	-7.18772411
46.0000000	-19.52192683	-8.71748257	-6.90961361
48.0000000	-19.45829773	-8.07907581	-6.75860119
50.0000000	-19.39543152	-7.47972965	-6.70104694
52.0000000	-19.33364868	-6.91751957	-6.70045471
54.0000000	-19.27320862	-6.39079380	-6.71754837
56.0000000	-19.21441650	-5.83813709	-6.71263313
58.0000000	-19.15751648	-5.43832970	-6.65086937
60.0000000	-19.10275269	-5.01030064	-6.50859070
62.0000000	-19.05038452	-4.61314487	-6.27820015
64.0000000	-19.00062561	-4.24606514	-5.96824837
66.0000000	-18.95368958	-3.90837860	-5.59892941
68.0000000	-18.90975952	-3.59948826	-5.19532776
70.0000000	-18.86903381	-3.31894202	-4.78166771
72.0000000	-18.83166504	-3.06617365	-4.37796783
74.0000000	-18.79782104	-2.84993189	-3.99906921
76.0000000	-18.76762390	-2.64885851	-3.55502357
78.0000000	-18.74122620	-2.47169495	-3.35212231
80.0000000	-18.71870422	-2.32721424	-3.09392738
82.0000000	-18.70015479	-2.20923619	-2.88219547
84.0000000	-18.68565369	-2.11761665	-2.71759605
86.0000000	-18.67524719	-2.06226182	-2.60022163
88.0000000	-18.66229199	-2.01306152	-2.52991295
90.0000000	-18.65000063	-2.00000381	-2.50649166
92.0000000	-18.63399103	-2.01306152	-2.52991295

94.0000000	-18.67524719	-2.05224991	-2.60021496
95.0000000	-18.68565369	-2.11761570	-2.71759129
96.0000000	-18.70016479	-2.20923233	-2.88218784
100.0000000	-18.71871948	-2.32720947	-3.09391594
102.0000000	-18.74122620	-2.47169209	-3.35210896
104.0000000	-18.76763916	-2.64285564	-3.65500736
106.0000000	-18.79783630	-2.84092999	-3.99905300
108.0000000	-18.83166504	-3.06617069	-4.37795448
110.0000000	-18.869013381	-3.31889725	-4.78165348
112.0000000	-18.90977478	-3.59948349	-5.19531250
114.0000000	-18.95370483	-3.90837479	-5.59891987
116.0000000	-19.00065613	-4.24605656	-5.96824265
118.0000000	-19.05039978	-4.61313534	-6.27818775
120.0000000	-19.10278320	-5.01028824	-6.50859070
122.0000000	-19.15793174	-5.43832397	-6.65087509
124.0000000	-19.21444702	-5.89814377	-6.71266174
126.0000000	-19.27325439	-6.39079380	-6.71757698
128.0000000	-19.33367920	-6.91751480	-6.70049477
130.0000000	-19.39547729	-7.47972965	-6.70107555
132.0000000	-19.45831239	-8.07907581	-6.75864220
134.0000000	-19.52195740	-8.71748257	-6.90964222
136.0000000	-19.58605957	-9.39720154	-7.18774033
138.0000000	-19.65034485	-10.12078571	-7.62534332
140.0000000	-19.71447754	-10.89132118	-8.29651646
142.0000000	-19.77813721	-11.71243477	-9.12104321
144.0000000	-19.84103394	-12.58338749	-10.27060936
146.0000000	-19.90280151	-13.52424812	-11.77959538
148.0000000	-19.96310528	-14.52810493	-13.76724815
150.0000000	-20.02177429	-15.60133457	-16.45101929
152.0000000	-20.07830411	-16.75888743	-20.30865479
154.0000000	-20.138532258	-18.01010132	-26.79676819
156.0000000	-20.18406151	-19.36856079	-31.57310486
158.0000000	-20.23263560	-20.85192871	-27.08186340
160.0000000	-20.27901514	-22.48318481	-22.40687561
162.0000000	-20.31987000	-24.29231262	-20.083005847
164.0000000	-20.35806274	-26.32008362	-18.90719604
166.0000000	-20.39227295	-28.62429810	-18.44363403
168.0000000	-20.42236328	-31.28929138	-18.48660278
170.0000000	-20.44812012	-34.44592285	-18.88049316
172.0000000	-20.46943665	-38.31352234	-19.45780945
174.0000000	-20.48611450	-43.30484009	-20.01840210
176.0000000	-20.49812317	-50.34434509	-20.38330078
178.0000000	-20.50534058	-62.38383484	-20.50691223
180.0000000	-20.50776672	-136.55137634	-20.50776672
182.0000000	-20.50534058	-62.38383484	-20.56037903
184.0000000	-20.49812317	-50.34434509	-20.77449036
186.0000000	-20.48611450	-43.30484009	-21.12220764
188.0000000	-20.46943665	-38.31352234	-21.37771606
190.0000000	-20.44812012	-34.44592285	-21.15196228
192.0000000	-20.42236328	-31.28929138	-20.22987366
194.0000000	-20.39227295	-28.62429810	-18.851633879
196.0000000	-20.35806274	-26.32008362	-17.42112732
198.0000000	-20.31987000	-24.29231262	-16.19776917
200.0000000	-20.27798462	-22.48318481	-15.29293633
202.0000000	-20.23263550	-20.85200500	-14.74760878
204.0000000	-20.18406151	-19.36856079	-14.58066750
206.0000000	-20.13853258	-18.01010132	-14.80750561

208.0000000	-20.07832336	-16.75901794	-15.44019890
210.0000000	-20.02175903	-15.60137367	-16.45101929
212.0000000	-19.96316528	-14.52610493	-17.63377380
214.0000000	-19.90280151	-13.52424812	-18.30245972
216.0000000	-19.84103394	-12.58838749	-17.53015137
218.0000000	-19.77815247	-11.71247482	-15.55140972
220.0000000	-19.71447754	-10.89133263	-13.31844330
222.0000000	-19.65034485	-10.12078571	-11.30281067
224.0000000	-19.58605957	-9.39720154	-9.60011196
226.0000000	-19.52195740	-8.71748257	-8.19669386
228.0000000	-19.45831299	-8.07907581	-7.03306484
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232.0000000	-19.33366394	-6.91751957	-5.31950092
234.0000000	-19.27325439	-6.39079380	-4.70121384
236.0000000	-19.21444702	-5.89814758	-4.20847893
238.0000000	-19.15754700	-5.43832588	-3.82060528
240.0000000	-19.10278320	-5.01029778	-3.51944447
242.0000000	-19.05039978	-4.61313820	-3.28886986
244.0000000	-19.00065613	-4.24606419	-3.11450768
246.0000000	-18.95368958	-3.90837669	-2.98365402
248.0000000	-18.90977478	-3.59948826	-2.88531017
250.0000000	-18.86903381	-3.31889915	-2.81028843
252.0000000	-18.83166504	-3.06617069	-2.75124741
254.0000000	-18.79783630	-2.84093189	-2.70273972
256.0000000	-18.76765442	-2.64285564	-2.66112328
258.0000000	-18.74124146	-2.47169209	-2.62430954
260.0000000	-18.71871948	-2.32721138	-2.59152889
262.0000000	-18.70016479	-2.20923233	-2.56293106
264.0000000	-18.68505369	-2.11761665	-2.53923988
266.0000000	-18.67524719	-2.05225182	-2.52139091
268.0000000	-18.66899109	-2.01306152	-2.51026726
270.0000000	-18.66694663	-2.00000381	-2.50649452
272.0000000	-18.66899109	-2.01306152	-2.51026821
274.0000000	-18.67524719	-2.05225182	-2.52139187
276.0000000	-18.68565369	-2.11761665	-2.53924084
278.0000000	-18.70016479	-2.20923233	-2.56293392
280.0000000	-18.71870422	-2.32721138	-2.59153366
282.0000000	-18.74122620	-2.47169209	-2.62431717
284.0000000	-18.76763916	-2.64285564	-2.66112995
286.0000000	-18.79782104	-2.84093189	-2.70274830
288.0000000	-18.83166504	-3.06617069	-2.75125504
290.0000000	-18.86903381	-3.31889915	-2.81029415
292.0000000	-18.90975952	-3.59948826	-2.88531971
294.0000000	-18.95367432	-3.90837669	-2.98366165
296.0000000	-19.00062561	-4.24606419	-3.11451530
298.0000000	-19.05038452	-4.61313820	-3.28887463
300.0000000	-19.10275269	-5.01029778	-3.51944542
302.0000000	-19.15751648	-5.43832588	-3.82060051
304.0000000	-19.21443176	-5.89814758	-4.20847225
306.0000000	-19.27320862	-6.39079380	-4.70119953
308.0000000	-19.33364868	-6.91751957	-5.31948185
310.0000000	-19.39543152	-7.47972965	-6.08730030
312.0000000	-19.45829773	-8.07907581	-7.03303623
314.0000000	-19.52192688	-8.71748257	-8.19066525
316.0000000	-19.58602905	-9.39720154	-9.60006714
318.0000000	-19.65031433	-10.12078571	-11.30275345
320.0000000	-19.71443176	-10.89133263	-13.31838608

322.0000000	-18.77909143	-11.71243477	-15.55131721
324.0000000	-19.84098916	-12.58838749	-17.53016663
326.0000000	-19.94275574	-13.52424812	-18.30258179
328.0000000	-19.96311951	-14.52610493	-17.63392639
330.0000000	-20.02171326	-15.60137367	-16.45114136
332.0000000	-20.07829285	-16.75901794	-15.44027424
334.0000000	-20.13247681	-18.81010132	-14.80755615
336.0000000	-20.18399048	-19.36856079	-14.58068466
338.0000000	-20.23257446	-20.85200500	-14.74771118
340.0000000	-20.27795410	-22.48318481	-15.29291344
342.0000000	-20.31983948	-24.29231262	-16.19773865
344.0000000	-20.36000171	-26.32008362	-17.42105103
346.0000000	-20.39222717	-28.62429810	-18.89154724
348.0000000	-20.42231750	-31.28929138	-20.22976685
350.0000000	-20.44997434	-34.44592285	-21.19185547
352.0000000	-20.46837561	-38.31410217	-21.37757874
354.0000000	-20.48806873	-43.30484009	-21.12214661
356.0000000	-20.49806213	-50.34434509	-20.77442932
358.0000000	-20.50520430	-62.38383484	-20.56033325
360.0000000	-20.50770569	-136.55137634	-20.50773621

4. Test run 3

INPUT DATA FOR TEST RUN 3

1
1 3
1.0
0.0 0.0 0.2500 1.0 0.0
0.0 0.535 0.238 0.003
-0.248 0.0 0.238 0.003
0.0 -0.535 0.238 0.003
181
0.0 2.0
151.071049
*

SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO
AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST
ELEMENTS BASED ON MOMENT METHOD.

WAVELENGTH = 1.000000

NUMBER OF ELEMENTS IN THE BROADCAST ARRAY = 1

NUMBER OF THIN TOWERS = 3

POSITION OF THE DIPOLE ELEMENT NUMBER 1 = .000000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 1 = .250000

MAXIMUM CURRENT AT THE BASE OF DIPOLE NUMBER 1 = 1.000000 .000000

DATA FOR TOWER NUMBER 1

NUMBER OF SEGMENTS ON THE TOWER = 9

POSITION OF THE TOWER = .000000 .535000

HEIGHT OF THE TOWER = .230000

RADIUS OF THE TOWER = .003000

DATA FOR TOWER NUMBER 2

NUMBER OF SEGMENTS ON THE TOWER = 9

POSITION OF THE TOWER = -.243000 .000000

HEIGHT OF THE TOWER = .230000

RADIUS OF THE TOWER = .003000

DATA FOR TOWER NUMBER 3

NUMBER OF SEGMENTS ON THE TOWER = 9

POSITION OF THE TOWER = .000000 -.535000

HEIGHT OF THE TOWER = .230000

RADIUS OF THE TOWER = .003000

NUMBER OF OBSERVATION POINTS FOR THE RADIATION PATTERN = 181

HORIZONTAL PLANE PATTERN

ANGLE OF OBSERVATION	TOWERS FIELD	Dipoles Field	Total Field
.00000000	-4.06966782	-8.02060223	-8.82534897
2.00000000	-4.09452248	-8.02060223	-8.83914202
4.00000000	-4.16901207	-8.02060223	-8.88031602
6.00000000	-4.29285145	-8.02060223	-9.4828188
8.00000000	-4.46555233	-8.02060223	-1.04203415
10.00000000	-4.68644238	-8.02060223	-1.16021347
12.00000000	-4.95459747	-8.02060223	-1.30109310
14.00000000	-5.26887035	-8.02060223	-1.46263599
16.00000000	-5.62784195	-8.02060223	-1.64253521
18.00000000	-6.02983093	-8.02060223	-1.83829784
20.00000000	-6.47290039	-8.02060223	-2.04729176
22.00000000	-6.95482922	-8.02060223	-2.26688957
24.00000000	-7.47329652	-8.02060223	-2.49455070
26.00000000	-8.02547073	-8.02060223	-2.72794342
28.00000000	-8.60904503	-8.02060223	-2.96506600
30.00000000	-9.22152233	-8.02060223	-3.20432472
32.00000000	-9.86008553	-8.02060223	-3.44462872
34.00000000	-10.52570820	-8.02060223	-3.68540382
36.00000000	-11.21564579	-8.02060223	-3.92660332
38.00000000	-11.93157196	-8.02060223	-4.16867924
40.00000000	-12.67590248	-8.02060223	-4.41250134
42.00000000	-13.45316601	-8.02060223	-4.65927696
44.00000000	-14.26943398	-8.02060223	-4.91047955
46.00000000	-15.13300133	-8.02060223	-5.16771984
48.00000000	-16.05371094	-8.02060223	-5.43269920
50.00000000	-17.04228210	-8.02060223	-5.70712185
52.00000000	-18.10815430	-8.02060223	-5.99268150
54.00000000	-19.25480652	-8.02060223	-6.29104328
56.00000000	-20.46885681	-8.02060223	-6.60380554
58.00000000	-21.69750977	-8.02060223	-6.93259716
60.00000000	-22.91051636	-8.02060223	-7.27903938
62.00000000	-23.37327271	-8.02060223	-7.64483166
64.00000000	-23.72753906	-8.02060223	-8.03184509
66.00000000	-23.20787048	-8.02060223	-8.44212818
68.00000000	-22.21345290	-8.02060223	-8.87803745
70.00000000	-21.01237488	-8.02060223	-9.34225845
72.00000000	-19.78468323	-8.02060223	-9.83795643
74.00000000	-18.61534119	-8.02060223	-10.36879253
76.00000000	-17.53399658	-8.02060223	-10.93905735
78.00000000	-16.54510498	-8.02060223	-11.55364227
80.00000000	-15.64299683	-8.02060223	-12.21808243
82.00000000	-14.81870747	-8.02060223	-12.93845844
84.00000000	-14.068290531	-8.02060223	-13.72094727
86.00000000	-13.36689663	-8.02060223	-14.57103348
88.00000000	-12.72309363	-8.02060223	-15.49138069
90.00000000	-12.12495136	-8.02060223	-16.47785950
92.00000000	-11.56699753	-8.02060223	-17.51130676

94.0000000	-11.04471684	-8.02060223	-18.54287720
95.0000000	-10.55445004	-8.02060223	-19.47427368
96.0000000	-10.09334087	-8.02060223	-20.14884949
97.0000000	-9.65918255	-8.02060223	-20.39657593
98.0000000	-9.25639768	-8.02060223	-20.14340210
99.0000000	-8.86594486	-8.02060223	-19.47627258
100.0000000	-8.50624044	-8.02060223	-18.57031250
101.0000000	-8.16814041	-8.02060223	-17.58172607
102.0000000	-7.86483932	-8.02060223	-16.60800171
103.0000000	-7.56581402	-8.02060223	-15.69837379
104.0000000	-7.30183887	-8.02060223	-14.87371254
105.0000000	-7.06327043	-8.02060223	-14.14067078
106.0000000	-6.85305214	-8.02060223	-13.49938679
107.0000000	-6.67064381	-8.02060223	-12.94760418
108.0000000	-6.518003017	-8.02060223	-12.48241901
109.0000000	-6.39466176	-8.02060223	-12.10129738
110.0000000	-6.30005111	-8.02060223	-11.80237865
111.0000000	-6.25368214	-8.02060223	-11.58458996
112.0000000	-6.23605116	-8.02060223	-11.44783497
113.0000000	-6.25365463	-8.02060223	-11.39291000
114.0000000	-6.31046296	-8.02060223	-11.42161846
115.0000000	-6.40634223	-8.02060223	-11.53673363
116.0000000	-6.54346593	-8.02060223	-11.74213123
117.0000000	-6.72063637	-8.02060223	-12.04278946
118.0000000	-6.93804550	-8.02060223	-12.444813280
119.0000000	-7.19465719	-8.02060223	-12.95563793
120.0000000	-7.48782444	-8.02060223	-13.58329582
121.0000000	-7.81404495	-8.02060223	-14.33610058
122.0000000	-8.16747762	-8.02060223	-15.22028065
123.0000000	-8.54012203	-8.02060223	-16.23490906
124.0000000	-8.92136912	-8.02060223	-17.36042786
125.0000000	-9.29828836	-8.02060223	-18.53550720
126.0000000	-9.65887616	-8.02060223	-19.62097168
127.0000000	-9.97873116	-8.02060223	-20.38365173
128.0000000	-10.25301170	-8.02060223	-20.59144592
129.0000000	-10.46384155	-8.02060223	-20.21350098
130.0000000	-10.62250710	-8.02060223	-19.45516968
131.0000000	-10.71719837	-8.02060223	-18.56864929
132.0000000	-10.76231670	-8.02060223	-17.72146606
133.0000000	-10.77129078	-8.02060223	-16.99523926
134.0000000	-10.75897503	-8.02060223	-16.42233276
135.0000000	-10.73911476	-8.02060223	-16.01260376
136.0000000	-10.72260894	-8.02060223	-15.76741219
137.0000000	-10.71630956	-8.02060223	-15.68586349
138.0000000	-10.72259617	-8.02060223	-15.76745224
139.0000000	-10.73910332	-8.02060223	-16.01268005
140.0000000	-10.75894642	-8.02060223	-16.42247009
141.0000000	-10.77125645	-8.02060223	-16.99542236
142.0000000	-10.76227665	-8.02060223	-17.72169495
143.0000000	-10.71714687	-8.02060223	-18.56802395
144.0000000	-10.62243176	-8.02060223	-19.45547485
145.0000000	-10.46875572	-8.02060223	-20.21379089
146.0000000	-10.25290775	-8.02060223	-20.59161377
147.0000000	-9.97861576	-8.02060223	-20.38368225
148.0000000	-9.65574932	-8.02060223	-19.62084961
149.0000000	-9.29815769	-8.02060223	-18.53530884
150.0000000	-8.92126656	-8.02060223	-17.36019897

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214.0000000	-7.48770428	-8.02060223	-13.58307838
216.0000000	-7.19444084	-8.02060223	-12.95543671
218.0000000	-6.93794346	-8.02060223	-12.44466114
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222.0000000	-6.54336262	-8.02060223	-11.74197006
224.0000000	-6.40675640	-8.02060223	-11.53658390
226.0000000	-6.31037521	-8.02060223	-11.42148018
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230.0000000	-6.23498726	-8.02060223	-11.44772053
232.0000000	-6.25363064	-8.02060223	-11.58448696
234.0000000	-6.30799866	-8.02060223	-11.80228043
236.0000000	-6.39662266	-8.02060223	-12.10121632
238.0000000	-6.51799488	-8.02060223	-12.48234367
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242.0000000	-6.85302925	-8.02060223	-13.49933434
244.0000000	-7.06385231	-8.02060223	-14.14062500
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266.0000000	-11.04473877	-8.02060223	-18.54284668
268.0000000	-11.56702614	-8.02060223	-17.51124573
270.0000000	-12.12496948	-8.02060223	-16.47781372
272.0000000	-12.72311687	-8.02060223	-15.49133492
274.0000000	-13.36691475	-8.02060223	-14.57100487
276.0000000	-14.06292248	-8.02060223	-13.72091293
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280.0000000	-15.64300728	-8.02060223	-12.21806049
282.0000000	-16.54512024	-8.02060223	-11.55362606
284.0000000	-17.53399658	-8.02060223	-10.93904591
286.0000000	-18.61532593	-8.02060223	-10.36879253
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292.0000000	-22.21345520	-8.02060223	-8.87804317
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296.0000000	-23.72766113	-8.02060223	-8.03186131
298.0000000	-23.57347107	-8.02060223	-7.64485455
300.0000000	-22.81074524	-8.02060223	-7.27906799
302.0000000	-21.69776917	-8.02060223	-6.93262672
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306.0000000	-19.25502014	-8.02060223	-6.29106712
308.0000000	-18.10838318	-8.02060223	-5.99271965
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312.0000000	-16.05393982	-8.02060223	-5.43274879
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316.0000000	-14.26962948	-8.02060223	-4.91052914
318.0000000	-13.45337868	-8.02060223	-4.65933514
320.0000000	-12.67618847	-8.02060223	-4.41256142

322.0000000	-11.93178940	-8.02060223	-4.16874695
324.0000000	-11.21583020	-8.02060223	-3.92667007
326.0000000	-10.52588703	-8.02060223	-3.68547249
328.0000000	-9.86105537	-8.02060223	-3.44470024
330.0000000	-9.22169971	-8.02060223	-3.20440006
332.0000000	-8.60920525	-8.02060223	-2.96513081
334.0000000	-8.02561951	-8.02060223	-2.72801399
336.0000000	-7.47334480	-8.02060223	-2.49461651
338.0000000	-6.95496750	-8.02060223	-2.26695728
340.0000000	-6.47302723	-8.02060223	-2.04735756
342.0000000	-6.02993488	-8.02060223	-1.83835030
344.0000000	-5.62793446	-8.02060223	-1.64259052
346.0000000	-5.26895523	-8.02060223	-1.46268177
348.0000000	-4.95468900	-8.02060223	-1.30113697
350.0000000	-4.68650436	-8.02060223	-1.16024876
352.0000000	-4.46560001	-8.02060223	-1.04206181
354.0000000	-4.29288578	-8.02060223	-94830376
356.0000000	-4.16003687	-8.02060223	-88033539
358.0000000	-4.02463683	-8.02060223	-83915025
360.0000000	-4.06966377	-8.02060223	-82535332

5. Thin tower array re-radiation based on transmission line approach

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1.000 C COMPUTER PROGRAM FOR SCATTERING PATTERN CALCULATION FROM MAIN0010
2.000 C AN ARRAY OF THIN TOWERS DUE TO AN INCIDENT FIELD MAIN0020
3.000 C FROM THE BROADCAST ARRAY. MAIN0030
4.000 C THIS PROGRAM IS BASED ON TRANSMISSION LINE APPROACH. MAIN0040
5.000 C
6.000 C WRITTEN BY R.K.CHUGH MAIN0050
7.000 C APRIL, 1978 MAIN0060
8.000 C
9.000 C
10.000 C NDATA NUMBER OF DATA SETS. MAIN0100
11.000 C NDP NUMBER OF BROADCAST ARRAY ELEMENTS. MAIN0110
12.000 C NTT NUMBER OF THIN TOWERS. MAIN0120
13.000 C XS,YS POSITION OF THE THIN TOWERS OR BROADCAST ELEMENT. MAIN0130
14.000 C HS HEIGHT OF THE THIN TOWERS AND BROADCAST ELEMENT. MAIN0140
15.000 C
16.000 C
17.000 C NOTE THAT XS,YS,HS DATA IS TO BE FIRST SPECIFIED FOR MAIN0170
18.000 C NDP NUMBER OF BROADCAST ELEMENTS AND THEN FOR THE MAIN0180
19.000 C NTT NUMBER OF THIN TOWERS. MAIN0190
20.000 C
21.000 C
22.000 C NOBS NUMBER OF OBSERVATION POINTS FOR THE SCATTERING PATTERN. MAIN0220
23.000 C THS STARTING ANGLE FOR THE RADIATION PATTERN. MAIN0230
24.000 C DTHS INCREMENTAL ANGLE FOR THE RADIATION PATTERN. MAIN0240
25.000 C
26.000 C
27.000 C
28.000 IMPLICIT REAL*8(A,B,D-H,O-Z),COMPLEX*16(C) MAIN0280
29.000 DIMENSION CZ(10,10),CI(10),CE(10),RM(10,10),XM(10,10) MAIN0290
30.000 DIMENSION XS(10),EST(400),YS(10),HS(10),CS(400) MAIN0300
31.000 DIMENSION CSD(400),CST(400),ESD(400),ES(400) MAIN0310
32.000 REAL*8 CDABS MAIN0320
33.000 COMPLEX*16 DCMPXL MAIN0330
34.000 PROP=2.0D0*3.14159265358979 MAIN0340
35.000 C
36.000 C READ AND WRITE VARIOUS PARAMETERS. MAIN0360
37.000 C
38.000 WRITE(6,490)
39.000 490 FORMAT(1H ,5X,'SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO '//
40.000 11H ,5X,'AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST '//
41.000 21H ,5X,'ELEMENTS BASED ON TRANSMISSION LINE APPROACH.'//) MAIN0400
42.000 READ(5,10)NDATA MAIN0410
43.000 10 FORMAT(10I4) MAIN0420
44.000 DO 200 NDS=1,NDATA MAIN0430
45.000 READ(5,10)NDP,NTT MAIN0440
46.000 WRITE(6,500)NDP MAIN0450
47.000 WRITE(6,510)NTT MAIN0460
48.000 500 FORMAT(1H ,5X,'NUMBER OF BROADCAST ARRAY ELEMENTS = ', MAIN0480
49.000 1 I4//) MAIN0490
50.000 510 FORMAT(1H ,5X,'NUMBER OF THIN TOWERS = ',I4//) MAIN0500
51.000 NTE=NDP+NTT MAIN0510
52.000 DO 20 I=1,NDP MAIN0520
53.000 READ(5,15)XS(I),YS(I),HS(I) MAIN0530
54.000 WRITE(6,520)I,XS(I),YS(I) MAIN0540
55.000 20 WRITE(6,525)I,MS(I) MAIN0550
56.000 520 FORMAT(1H ,5X,'POSITION OF THE DIPOLE ELEMENT NUMBER' MAIN0560

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      57.000 1I4,' - ',2F10.6//)          MAIN0570
      58.000 525 FORMAT(1H ,5X,'WEIGHT OF THE DIPOLE ELEMENT NUMBER'  MAIN0580
      59.000 1I4,' - ',F10.6//)          MAIN0590
      60.000 DO 22 I=1,NTE               MAIN0600
      61.000 KK=I+NDP                  MAIN0610
      62.000 READ(5,15)XS(KK),VS(KK),HS(KK)  MAIN0620
      63.000 WRITE(6,530)I,XS(KK),VS(KK)    MAIN0630
      64.000 530 FORMAT(1H ,5X,'POSITION OF THE THIN TOWER NUMBER'  MAIN0640
      65.000 1I4,' - ',2F10.6//)          MAIN0650
      66.000 22 WRITE(6,535)I,HS(KK)        MAIN0660
      67.000 535 FORMAT(1H ,5X,'WEIGHT OF THE THIN TOWER NUMBER'  MAIN0670
      68.000 1I4,' - ',F10.6//)          MAIN0680
      69.000 15 FORMAT(2F10.6)            MAIN0690
      70.000 READ(5,10)NOBS              MAIN0700
      71.000 WRITE(6,540)NOBS            MAIN0710
      72.000 540 FORMAT(1H ,5X,'NUMBER OF OBSERVATION POINTS FOR THE' MAIN0720
      73.000 1,'SCATTERING PATTERN = ',I4//)  MAIN0730
      74.000 READ(5,15)THS,DTHS           MAIN0740
      75.000 C
      76.000 C
      77.000 C
      78.000 C
      79.000 CALCULATE THE MUTUAL COUPLING BETWEEN THE ELEMENTS.   MAIN0750
      80.000 DO 50 I=1,NTE               MAIN0760
      81.000 DO 50 J=1,NTE               MAIN0770
      82.000 25 IF(I-J)>0,30,25          MAIN0780
      83.000 DS=DSQRT((XS(I)-XS(J))**2+(VS(I)-VS(J))**2)  MAIN0790
      84.000 CALL MCBT(A(HS(I),HS(J),DS,PROP,RM(I,J),XR(I,J))  MAIN0800
      85.000 CZ(I,J)=DCMPLX(RM(I,J),XR(I,J))             MAIN0810
      86.000 GO TO 50                      MAIN0820
      87.000 30 DS=0.1E-6                 MAIN0830
      88.000 CALL MCBT(A(HS(I),HS(J),DS,PROP,RM(I,J),XR(I,J))  MAIN0840
      89.000 CZ(I,J)=DCMPLX(RM(I,J),0.0D0)             MAIN0850
      90.000 GO TO 50                      MAIN0860
      91.000 35 CZ(I,J)=CZ(J,I)          MAIN0870
      92.000 40 FORMAT(1H ,4D16.6)        MAIN0880
      93.000 50 CONTINUE
      94.000 51 DO 60 I=1,NTE           MAIN0890
      95.000 52 IF(I-NDP/52,52,54)       MAIN0900
      96.000 CE(I)=DCMPLX(1.0D0,0.0D0)  MAIN0910
      97.000 GO TO 60                      MAIN0920
      98.000 54 CE(I)=DCMPLX(0.0D0,0.0D0)  MAIN0930
      99.000 60 CONTINUE
      100.000 C
      101.000 C
      102.000 CALL CDSEOCR(CZ,NTE,10,2,CE,CI)  MAIN1000
      103.000 C
      104.000 C
      105.000 C
      106.000 CALCULATE THE INDUCED CURRENTS ON THE THIN TOWERRS.  MAIN1010
      107.000 100 DO 100 I=1,NOBS        MAIN1020
      108.000 THS=THS+(DFLOAT(I)-1.0D0)*DTHS  MAIN1030
      109.000 TMR=TMRE*3.14159265368979/1.0D2  MAIN1040
      110.000 DC5=DCOS(TMR)                MAIN1050
      111.000 DSI=DSIN(TMR)               MAIN1060
      112.000 CS(I)=0.0E0                 MAIN1070
      113.000 CSB(I)=0.0E0                MAIN1080
      114.000 CST(I)=0.0E0                MAIN1090

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114.000      DO 90 NT=NDP+1,NTE          *
115.000      PHASE=PROP*(XS(NT)*DCS+YS(NT)*DSI)
116.000      CST(I)=CST(I)+CI(NT)*CDEXP(DCMPLX(0.0D0,PHASE))
117.000      DO 95 NT=1,NDP          MAIN1140
118.000      PHASE=PROP*(XS(NT)*DCS+YS(NT)*DSI)    MAIN1150
119.000 90    CSD(I)=CSD(I)+CI(NT)*CDEXP(DCMPLX(0.0D0,PHASE))  MAIN1160
120.000      CS(I)=CSD(I)+CST(I)          MAIN1170
121.000      ESD(I)=CDABS(CSD(I))        MAIN1180
122.000      EST(I)=CDABS(CST(I))        MAIN1190
123.000      ES(I)=CDABS(CS(I))         MAIN1200
124.000 100    CONTINUE          MAIN1210
125.000      C                         MAIN1220
126.000      C                         MAIN1230
127.000      C                         MAIN1240
128.000      CALCULATE THE SCATTERED FIELDS IN DB.  MAIN1250
129.000 550    WRITE(6,550)          MAIN1260
130.000      FORMAT(IH,'ANGLE OF OBSERVATION',5X,'TOWERS FIELD',3X,
1'DIPOLES FIELD',3X,'TOTAL FIELD'//)  MAIN1270
131.000      ESM=0.0D0          MAIN1280
132.000      DO 102 I=1,NOBS          MAIN1290
133.000      IF(ES(I).GT.ESM)ESM=ES(I)  MAIN1300
134.000 102    CONTINUE          MAIN1310
135.000      DO 110 I=1,NOBS          MAIN1320
136.000      THD=TMS+(DFLOAT(I)-1.0D0)*DTHS  MAIN1330
137.000      ESA=20.0*DLOG10(ES(I)/ESM)        MAIN1340
138.000      ESDA=20.0*DLOG10(ESD(I)/ESM)       MAIN1350
139.000      ESTA=20.0*DLOG10(EST(I)/ESM)       MAIN1360
140.000      WRITE(6,105)THD,ESTA,ESDA,ESA    MAIN1370
141.000 105    FORMAT(IH,4X,4F16.8)          MAIN1380
142.000 110    CONTINUE          MAIN1390
143.000 200    CONTINUE          MAIN1400
144.000      STOP          MAIN1410
145.000      END          MAIN1420
146.000      SUBROUTINE CISI(X,CIX,SIX)  MAIN1430
147.000      C                         MAIN1440
148.000      C                         MAIN1450
149.000      C                         CISI0010
150.000      C                         CISI0020
151.000      C                         CISI0030
152.000      X     ARGUMENT FOR WHICH COSINE AND SINE INTEGRALS  CISI0040
153.000      ARE TO BE EVALUATED.          CISI0050
154.000      CIX    ANSWER FOR THE COSINE INTEGRAL OF X.  CISI0060
155.000      SIX    ANSWER FOR THE SINE INTEGRAL OF X.  CISI0070
156.000      C                         CISI0080
157.000      C                         CISI0090
158.000      IMPLICIT REAL*8(A-H,O-Z)  CISI0100
159.000      EXTERNAL DCOSIF,SINIF  CISI0110
160.000      CALL GAQD(0.0D0,X,DCOSIF,8,ANSI)  CISI0120
161.000      CIX=0.5772156649+DLOG(X)+ANSI  CISI0130
162.000      CALL GAQD(0.0D0,X,SINIF,8,SIX)  CISI0140
163.000      RETURN          CISI0150
164.000      END          CISI0160
165.000      DOUBLE PRECISION FUNCTION DCOSIF(X)  CISI0170
166.000      C                         CISI0180
167.000      C                         CISI0190
168.000      C                         COSF0010
169.000      C                         COSF0020
170.000      C                         COSF0030
171.000      C                         COSF0040
172.000      C                         COSF0050
173.000      C                         COSF0060

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FUNCTION DEFINING THE INTEGRAND FOR COSINE INTEGRAL.

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171.000      IMPLICIT REAL*8(A-H,O-Z)
172.000      DCOSIF=(DCOS(X)-1.0D0)/X
173.000      RETURN
174.000      END
175.000      DOUBLE PRECISION FUNCTION SINIF(X)
176.000      C
177.000      C
178.000      C
179.000      C
180.000      C
181.000      IMPLICIT REAL*8 (A-H,O-Z)
182.000      SINIF=DSIM(X)/X
183.000      RETURN
184.000      END
185.000      SUBROUTINE GAQD (XL,XU,FCNC,MIX,ANS)
186.000      C
187.000      C
188.000      C
189.000      C
190.000      C
191.000      C
192.000      C
193.000      C
194.000      C
195.000      XL    LOWER LIMIT OF INTEGRATION.
196.000      XU    UPPER LIMIT OF INTEGRATION.
197.000      FCNC   EXTERNAL FUNCTION DEFINING THE INTEGRAND.
198.000      MIX    NUMBER OF INTERVALS FOR THE INTEGRATION RANGE.
199.000      ANS    ANSWER OF INTEGRATION.
200.000      C
201.000      C
202.000      IMPLICIT REAL*8 (A-H,O-Z)
203.000      C
204.000      DIMENSION T(6),U(6)
205.000      EXTERNAL FCNC
206.000      DATA T/0.978228658146057,0.887062599763095,0.730152005574049,
207.000      10.519096129206812,0.269543155052345,0.0D0/
208.000      DATA U/0.556685671161737D-1,0.125580369464905,0.186290210927734,
209.000      10.233193764591990,0.262804544510247,0.272925086777901/
210.000      50    CD=MIX
211.000      SUM=0.0D0
212.000      DD=(XU-XL)/CD
213.000      DO 60 L=1,MIX
214.000      CI=L
215.000      AA=XL+(CI-1.0D0)*DD
216.000      AB=AA+DD
217.000      SCAL1=(AB-AA)/2.0D0
218.000      SCAL2=(AB+AA)/2.0D0
219.000      DO 60 N=1,6
220.000      P1=-SCAL1*T(N)+SCAL2
221.000      Z=FCNC(P1)
222.000      IF(T(N).EQ.0.0D0)GO TO 81
223.000      82    P2=SCAL1*T(N)+SCAL2
224.000      ZZ=FCNC(P2)
225.000      GO TO 83
226.000      81    ZZ=0.0D0
227.000      83    SUM=SUM+SCAL1*XU(N)*(Z+ZZ)

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228.000 60  CONTINUE
229.000      AHS=SUM
230.000      RETURN
231.000      END
232.000      SUBROUTINE MCBTA(H1,H2,D,PROP,RM,XM)
233.000 C
234.000      SUBROUTINE FOR CALCULATING THE MUTUAL COUPLING
235.000 C      BETWEEN TWO ELEMENT OF HEIGHTS H1 AND H2
236.000 C      DISPLACED BY A DISTANCE D.
237.000 C
238.000 C      PROP  PROPAGATION CONSTANT.
239.000 C      RM   MUTUAL RESISTANCE BETWEEN THE TWO DIPOLES.
240.000 C      XM   MUTUAL REACTANCE BETWEEN TWO DIPOLES.
241.000 C
242.000 C
243.000 C
244.000 IMPLICIT REAL*8 (A-H,O-Z)
245.000 CL=H2+H1
246.000 DEL=H2-H1
247.000 U0=PROP*(DSORT(D*D+H1*H1)-H1)
248.000 U1=PROP*(DSORT(D*D+DEL*DEL)+DEL)
249.000 U0=PROP*(DSORT(D*D+H1*H1)+H1)
250.000 U1=PROP*(DSORT(D*D+DEL*DEL)-DEL)
251.000 W1=PROP*(DSORT(D*D+CL*CL)+CL)
252.000 X1=PROP*(DSORT(D*D+CL*CL)-CL)
253.000 Y0=PROP*Z
254.000 Y1=PROP*(DSORT(D*D+H2*H2)+H2)
255.000 S1=PROP*(DSORT(D*D+H2*H2)-H2)
256.000 CALL CISI(U0,CIU0,SIU0)
257.000 CALL CISI(U1,CIU1,SIU1)
258.000 CALL CISI(V0,CIV0,SV0)
259.000 CALL CISI(V1,CIV1,SV1)
260.000 CALL CISI(W1,CIW1,SW1)
261.000 CALL CISI(X1,CIX1,SX1)
262.000 CALL CISI(Y0,CIY0,SY0)
263.000 CALL CISI(Y1,CIY1,SY1)
264.000 CALL CISI(S1,CIS1,SIS1)
265.000 RM=(1.5D1/(DSIN(PROP*H1)))*(
266.000 1+DCOS(PROP*DEL)*(CIU1-CIU0+CIV1-CIV0+2.0D0*CIY0-CIY1-CIS1)
267.000 2+DSIN(PROP*DEL)*(SIU1-SIU0+SIU0-SIU1-SIV1+SIS1)
268.000 3+DCOS(PROP*CL)*(CIU1-CIU0+CIX1-CIX0+2.0D0*CIY0-CIY1-CIS1)
269.000 4+DSIN(PROP*CL)*(SIU1-SIU0+SIU0-SIX1-SIV1+SIS1))
270.000 XM=(1.5D1/(DSIN(PROP*H1)))*(
271.000 1+DCOS(PROP*DEL)*(SIU0-SIU1+SIU0-SIU1+SIY1-2.0D0*SIY0+SIS1)
272.000 2+DSIN(PROP*DEL)*(CIU1-CIU0+CIU0-CIU1-CIY1+CIS1)
273.000 3+DCOS(PROP*CL)*(SIU0-SIU1+SIU0-SIX1+SIY1-2.0D0*SIY0+SIS1)
274.000 4+DSIN(PROP*CL)*(CIU1-CIU0+CIU0-CIX1-CIY1+CIS1))
275.000 RETURN
276.000 END
277.000 C      SUBROUTINE CDSEQCR(A,N,M,MM,B,X)
278.000 C
279.000 C      WRITTEN BY R.K.CHUGH
280.000 C      CRC NOV., 1977
281.000 C
282.000 C      SUBROUTINE TO SOLVE COMPLEX DOUBLE PRECISION
283.000 C      SIMULTANEOUS EQUATIONS USING CROUT'S METHOD.
284.000 C

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TY284-348

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284.000 C          [A][X]-[B]          CDSQ0080
285.000 C          N                 CDSQ0090
286.000 C          M                 CDSQ0100
287.000 C          MM                CDSQ0110
288.000 C          MAXIMUM DIMENSION FOR MATRICES A,B,X.
289.000 C          MM               PARAMETER FOR TYPE OF MATRIX A.
290.000 C          MM-1              SYMMETRIC MATRIX A.
291.000 C          MM-2              NON-SYMMETRIC MATRIX A.
292.000 C          SUBROUTINE CDSEOCR(A,M,N,MM,B,X)
293.000           COMPLEX816 A(M,M),B(N),X(N),CSUM
294.000           A(1,1)=A(1,1)
295.000           DO 10 I=2,N
296.000           A(I,1)=A(I,1)
297.000           A(I,I)=A(I,I)/A(1,1)
298.000   10        B(1)=B(1)/A(1,1)
299.000           DO 100 I=2,N
300.000           II=I-1
301.000           DO 50 J=2,N
302.000           JJ=J-1
303.000           CSUM=0.0
304.000           IF(I-J)20,30,40
305.000           DO 25 K=1,II
306.000   20        CSUM=CSUM+A(I,K)*A(K,J)
307.000   25        A(I,J)=(A(I,J)-CSUM)/A(I,I)
308.000           GO TO 30
309.000   30        DO 35 K=1,II
310.000   35        CSUM=CSUM+A(I,K)*A(K,I)
311.000           A(I,I)=A(I,I)-CSUM
312.000           GO TO 50
313.000           GO TO 10 (46,50),MM
314.000   40        A(I,J)=A(J,I)*A(J,J)
315.000   45        GO TO 50
316.000           DO 45 K=1,JJ
317.000   50        CSUM=CSUM+A(I,K)*A(K,J)
318.000   45        A(I,J)=A(I,J)-CSUM
319.000           CONTINUE
320.000   50        CSUM=0.0
321.000           DO 95 K=1,II
322.000   55        CSUM=CSUM+A(I,K)*B(K)
323.000   95        B(I)=(B(I)-CSUM)/A(I,I)
324.000           CONTINUE
325.000   100       X(N)=B(N)
326.000           DO 110 J=1,N-1
327.000           I=N-J
328.000           KK=I+1
329.000           CSUM=0.0
330.000           DO 105 K=KK,N
331.000   105       CSUM=CSUM+A(I,K)*X(K)
332.000           X(I)=B(I)-CSUM
333.000           CONTINUE
334.000   110       RETURN
335.000           END
336.000           --EOF HIT AFTER 336.

```

6. Test run 1

INPUT DATA FOR TEST RUN 1

1		
2	1	
0.25	0.0	0.25
-0.25	0.0	0.25
0.0	2.0	0.254
73		
0.0	5.0	
*		

SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO
AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST
ELEMENTS BASED ON TRANSMISSION LINE APPROACH.

NUMBER OF BROADCAST ARRAY ELEMENTS = 2

NUMBER OF THIN TOWERS = 1

POSITION OF THE DIPOLE ELEMENT NUMBER 1 = .250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 1 = .250000

POSITION OF THE DIPOLE ELEMENT NUMBER 2 = -.250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 2 = .250000

POSITION OF THE THIN TOWER NUMBER 1 = .000000 2.000000

HEIGHT OF THE THIN TOWER NUMBER 1 = .254000

NUMBER OF OBSERVATION POINTS FOR THE SCATTERING PATTERN = 73

ANGLE OF OBSERVATION	TOWERS FIELD	Dipoles Field	Total Field
.0000000	-17.89865813	-294.53542469	-17.89865813
5.0000000	-17.89865813	-44.30533515	-17.57990258
10.0000000	-17.89865813	-32.28145000	-16.47357760
15.0000000	-17.89865813	-25.26870673	-16.85924287
20.0000000	-17.89865813	-20.31865162	-22.49190757
25.0000000	-17.89865813	-16.51037376	-24.83846601
30.0000000	-17.89865813	-13.43682483	-13.00240757
35.0000000	-17.89865813	-10.88393305	-8.37636057
40.0000000	-17.89865813	-8.72679654	-6.13398351
45.0000000	-17.89865813	-6.88749407	-5.23292700
50.0000000	-17.89865813	-5.31519736	-5.06038822
55.0000000	-17.89865813	-3.97575105	-4.97263431
60.0000000	-17.89865813	-2.84576331	-4.41769404
65.0000000	-17.89865813	-1.90904483	-3.37825590
70.0000000	-17.89865813	-1.15436261	-2.22755406
75.0000000	-17.89865813	-.57397687	-1.25039687
80.0000000	-17.89865813	-.16267196	-.54996027
85.0000000	-17.89865813	.08288256	-.13680324
90.0000000	-17.89865813	.16453665	-.00000000

95.0000000	-17.89865813	.08288266	-.13580324
100.0000000	-17.89865813	-.16267196	-.54906027
105.0000000	-17.89865813	-.57397687	1.25039687
110.0000000	-17.89865813	-1.15436261	2.22755406
115.0000000	-17.89865813	-1.90904483	3.37825590
120.0000000	-17.89865813	-2.84576331	4.41769404
125.0000000	-17.89865813	-3.97575105	4.97263431
130.0000000	-17.89865813	-5.31519736	5.06038822
135.0000000	-17.89865813	-6.88749407	5.23292700
140.0000000	-17.89865813	-8.72679654	6.13398351
145.0000000	-17.89865813	-10.88393305	8.37636057
150.0000000	-17.89865813	-13.43682483	13.00240757
155.0000000	-17.89865813	-16.51037376	24.83846601
160.0000000	-17.89865813	-20.31865162	22.49190757
165.0000000	-17.89865813	-25.26870673	16.85924287
170.0000000	-17.89865813	-32.28145000	16.47357760
175.0000000	-17.89865813	-44.30533515	17.57990258
180.0000000	-17.89865813	-294.72887941	17.89865813
185.0000000	-17.89865813	-44.30533515	18.30863810
190.0000000	-17.89865813	-32.28145000	18.99383294
195.0000000	-17.89865813	-25.26870673	16.26854933
200.0000000	-17.89865813	-20.31865162	13.04740201
205.0000000	-17.89865813	-16.51037376	11.88610441
210.0000000	-17.89865813	-13.43682483	13.00240757
215.0000000	-17.89865813	-10.88393305	14.97943774
220.0000000	-17.89865813	-8.72679654	11.82063985
225.0000000	-17.89865813	-6.88749407	7.35066756
230.0000000	-17.89865813	-5.31519736	4.36587678
235.0000000	-17.89865813	-3.97575105	2.52704349
240.0000000	-17.89865813	-2.84576331	1.43763985
245.0000000	-17.89865813	-1.90904483	.81670095
250.0000000	-17.89865813	-1.15436261	.46508637
255.0000000	-17.89865813	-.57397687	.25314012
260.0000000	-17.89865813	-.16267196	.11449586
265.0000000	-17.89865813	.08288266	.02943082
270.0000000	-17.89865813	.16453665	.00000000
275.0000000	-17.89865813	.08288266	.02943082
280.0000000	-17.89865813	-.16267196	.11449586
285.0000000	-17.89865813	-.57397687	.25314012
290.0000000	-17.89865813	-1.15436261	.46508637
295.0000000	-17.89865813	-1.90904483	.81670095
300.0000000	-17.89865813	-2.84576331	1.43763925
305.0000000	-17.89865813	-3.97575105	2.52704349
310.0000000	-17.89865813	-5.31519736	4.36587678
315.0000000	-17.89865813	-6.88749407	7.35066756
320.0000000	-17.89865813	-8.72679654	11.82063985
325.0000000	-17.89865813	-10.88393305	14.97943774
330.0000000	-17.89865813	-13.43682483	13.00240757
335.0000000	-17.89865813	-16.51037376	11.88610441
340.0000000	-17.89865813	-20.31865162	13.04740201
345.0000000	-17.89865813	-25.26870673	16.26854933
350.0000000	-17.89865813	-32.28145000	18.99383294
355.0000000	-17.89865813	-44.30533515	18.30863810
360.0000000	-17.89865813	-294.53642469	-17.89865813

--EOF HIT AFTER 110.

8

7. Test run 2

INPUT DATA FOR TEST RUN 2

1		
2	2	
0.25	0.0	0.25
-0.25	0.0	0.25
0.10	2.0	0.25
-0.10	2.0	0.25
73		
0.0	5.0	
*		

SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO
AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST
ELEMENTS BASED ON TRANSMISSION LINE APPROACH.

NUMBER OF BROADCAST ARRAY ELEMENTS = 2

NUMBER OF THIN TOWERS = 2

POSITION OF THE DIPOLE ELEMENT NUMBER 1 = .250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 1 = .250000

POSITION OF THE DIPOLE ELEMENT NUMBER 2 = -.250000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 2 = .250000

POSITION OF THE THIN TOWER NUMBER 1 = .100000 2.000000

HEIGHT OF THE THIN TOWER NUMBER 1 = .250000

POSITION OF THE THIN TOWER NUMBER 2 = -.100000 2.000000

HEIGHT OF THE THIN TOWER NUMBER 2 = .250000

NUMBER OF OBSERVATION POINTS FOR THE SCATTERING PATTERN = 73

ANGLE OF OBSERVATION	TOWERS FIELD	DIPOLES FIELD	TOTAL FIELD
.00000000	-18.44531287	-294.78894626	-18.44531287
5.00000000	-18.43026232	-44.46951773	-18.06569795
10.00000000	-18.38567578	-32.44563257	-16.98758940
15.00000000	-18.31321553	-25.43288931	-17.66156040
20.00000000	-18.21554565	-20.48283420	-24.54002757
25.00000000	-18.09618518	-16.67455633	-22.68230837
30.00000000	-17.95932524	-13.60100741	-12.53997766
35.00000000	-17.80962760	-11.04811563	-8.25865439
40.00000000	-17.65202134	-8.89097911	-6.20912539
45.00000000	-17.49151113	-7.05167665	-5.47891837
50.00000000	-17.33306656	-5.47937993	-5.47780317
55.00000000	-17.18117787	-4.13993363	-5.49711047
60.00000000	-17.04403398	-3.00004588	-4.88877155

			x
65.0000000	-16.91435856	-2.07322741	-3.69183373
70.0000000	-16.80659016	-1.31854519	-2.39940833
75.0000000	-16.71982704	-.73815944	-1.33172630
80.0000000	-16.65626795	-.32685453	-.58033783
85.0000000	-16.61749603	-.08129992	-.14291680
90.0000000	-16.60446577	.09035407	-.00000000
95.0000000	-16.61749603	-.08129992	-.14291680
100.0000000	-16.65626795	-.32685453	-.58033783
105.0000000	-16.71982704	-.73815944	-1.33172630
110.0000000	-16.80659016	-1.31854519	-2.39940833
115.0000000	-16.91435856	-2.07322741	-3.69183373
120.0000000	-17.04033026	-3.00994588	-4.88877155
125.0000000	-17.18117787	-4.13993363	-5.49711047
130.0000000	-17.33300656	-5.47937993	-5.47780317
135.0000000	-17.49151113	-7.05167665	-5.47891837
140.0000000	-17.65202134	-8.89097911	-6.20912539
145.0000000	-17.80962760	-11.04811563	-8.25865439
150.0000000	-17.95932524	-13.60100741	-12.53997766
155.0000000	-18.09618518	-16.67455633	-22.68230837
160.0000000	-18.21554565	-20.48283420	-24.54002757
165.0000000	-18.31321553	-25.43288931	-17.66156040
170.0000000	-18.38567578	-32.44563257	-16.98758940
175.0000000	-18.43026232	-44.46961773	-18.06569795
180.0000000	-18.44531287	-294.72124094	-18.44531287
185.0000000	-18.43026232	-44.46961773	-18.83683493
190.0000000	-18.38567578	-32.44563257	-19.73757141
195.0000000	-18.31321553	-25.43288931	-16.98979615
200.0000000	-18.21554565	-20.48283420	-13.37891645
205.0000000	-18.09618518	-16.67455633	-11.83297688
210.0000000	-17.95932524	-13.60100741	-12.53997766
215.0000000	-17.80962760	-11.04811563	-14.62651054
220.0000000	-17.65202134	-8.89097911	-12.49914665
225.0000000	-17.49151113	-7.05167665	-7.90879008
230.0000000	-17.33300656	-5.47937993	-4.67157149
235.0000000	-17.18117787	-4.13993363	-2.64662295
240.0000000	-17.04033026	-3.00994588	-1.43569055
245.0000000	-16.91435856	-2.07322741	-.75023106
250.0000000	-16.80659016	-1.31854519	-.38218315
255.0000000	-16.71982704	-.73815944	-.18698431
260.0000000	-16.65626795	-.32685453	-.07869956
265.0000000	-16.61749603	-.08129992	-.01953603
270.0000000	-16.60446577	.09035407	-.00000000
275.0000000	-16.61749603	-.08129992	-.01953603
280.0000000	-16.65626795	-.32685453	-.07869956
285.0000000	-16.71982704	-.73815944	-.18698431
290.0000000	-16.80659016	-.1.31854519	-.38218315
295.0000000	-16.91435856	-2.07322741	-.75023106
300.0000000	-17.04033026	-3.00994588	-1.43569055
305.0000000	-17.18117787	-4.13993363	-2.64662295
310.0000000	-17.33300656	-5.47937993	-4.67157149
315.0000000	-17.49151113	-7.05167665	-7.90879008
320.0000000	-17.65202134	-8.89097911	-12.49914665
325.0000000	-17.80962760	-11.04811563	-14.62651054
330.0000000	-17.95932524	-13.60100741	-12.53997766
335.0000000	-18.09618518	-16.67455633	-11.83297688
340.0000000	-18.21554565	-20.48283420	-13.37891645
345.0000000	-18.31321553	-25.43288931	-16.98979615

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360.0000000
365.0000000
360.0000000

-18.39567578
-18.43086232
-18.44531287

-32.44563257
-44.46951773
-294.78894026

-19.73757141
-18.83683493
-18.44531287

--EOF HIT AFTER 116.

x

8. Test run 3

INPUT DATA FOR TEST RUN 3

1	3	
1	3	
0.0	0.0	0.25
0.0	0.535	0.238
-0.248	0.0	0.238
0.0	-0.535	0.238
73		
0.0	5.0	
*		

SCATTERING FROM AN ARRAY OF THIN TOWERS DUE TO
AN INCIDENT FIELD FROM AN ARRAY OF BROADCAST
ELEMENTS BASED ON TRANSMISSION LINE APPROACH.

NUMBER OF BROADCAST ARRAY ELEMENTS = 1

NUMBER OF THIN TOWERS = 3

POSITION OF THE DIPOLE ELEMENT NUMBER 1 = .000000 .000000

HEIGHT OF THE DIPOLE ELEMENT NUMBER 1 = .250000

POSITION OF THE THIN TOWER NUMBER 1 = .000000 .535000

HEIGHT OF THE THIN TOWER NUMBER 1 = .238000

POSITION OF THE THIN TOWER NUMBER 2 = -.248000 .000000

HEIGHT OF THE THIN TOWER NUMBER 2 = .238000

POSITION OF THE THIN TOWER NUMBER 3 = .000000 -.535000

HEIGHT OF THE THIN TOWER NUMBER 3 = .238000

NUMBER OF OBSERVATION POINTS FOR THE SCATTERING PATTERN = 73

ANGLE OF OBSERVATION	TOWERS FIELD	DIPOLES FIELD	TOTAL FIELD
.0000000	-2.56714927	-6.27488997	.00000000
5.0000000	-2.70003436	-6.27488997	-.07167720
10.0000000	-3.09418074	-6.27488997	-.27945196
15.0000000	-3.73520315	-6.27488997	-.60289897
20.0000000	-4.59942048	-6.27488997	-1.01272660
25.0000000	-5.05542061	-6.27488997	-1.47817889
30.0000000	-6.36616250	-6.27488997	-1.97609837
35.0000000	-8.20768346	-6.27488997	-2.49808897
40.0000000	-9.65697943	-6.27488997	-3.05220578
45.0000000	-11.20964543	-6.27488997	-3.65887734
50.0000000	-12.83890700	-6.27488997	-4.34447840
55.0000000	-14.41110198	-6.27488997	-5.13662872
60.0000000	-15.55673436	-6.27488997	-6.06320737

		x
85.0000000	-15.76128436	-6.27488997
70.0000000	-14.94962790	-6.27488997
75.0000000	-13.60576301	-6.27488997
80.0000000	-12.17215106	-6.27488997
85.0000000	-10.83688706	-6.27488997
90.0000000	-9.639065590	-6.27488997
95.0000000	-8.57437147	-6.27488997
100.0000000	-7.62630612	-6.27488997
105.0000000	-6.78579875	-6.27488997
110.0000000	-6.05393506	-6.27488997
115.0000000	-5.44113243	-6.27488997
120.0000000	-4.96459674	-6.27488997
125.0000000	-4.64539789	-6.27488997
130.0000000	-4.50661818	-6.27488997
135.0000000	-4.56628637	-6.27488997
140.0000000	-4.83813174	-6.27488997
145.0000000	-5.32450103	-6.27488997
150.0000000	-5.99050729	-6.27488997
155.0000000	-6.79666125	-6.27488997
160.0000000	-7.59744065	-6.27488997
165.0000000	-8.26557464	-6.27488997
170.0000000	-8.57368771	-6.27488997
175.0000000	-8.86630775	-6.27488997
180.0000000	-8.91576342	-6.27488997
185.0000000	-8.96630775	-6.27488997
190.0000000	-8.67368771	-6.27488997
195.0000000	-8.26557464	-6.27488997
200.0000000	-7.59744065	-6.27488997
205.0000000	-6.79666125	-6.27488997
210.0000000	-5.99050729	-6.27488997
215.0000000	-5.32450103	-6.27488997
220.0000000	-4.83813174	-6.27488997
225.0000000	-4.56628637	-6.27488997
230.0000000	-4.50661818	-6.27488997
235.0000000	-4.64539789	-6.27488997
240.0000000	-4.96459674	-6.27488997
245.0000000	-5.44113243	-6.27488997
250.0000000	-6.05393506	-6.27488997
255.0000000	-6.78579875	-6.27488997
260.0000000	-7.62630612	-6.27488997
265.0000000	-8.57437147	-6.27488997
270.0000000	-9.639065590	-6.27488997
275.0000000	-10.83688706	-6.27488997
280.0000000	-12.17215106	-6.27488997
285.0000000	-13.60576301	-6.27488997
290.0000000	-14.94962790	-6.27488997
295.0000000	-15.76128436	-6.27488997
300.0000000	-15.55673436	-6.27488997
305.0000000	-14.41110198	-6.27488997
310.0000000	-12.8380700	-6.27488997
315.0000000	-11.20964543	-6.27488997
320.0000000	-9.65697943	-6.27488997
325.0000000	-8.20768346	-6.27488997
330.0000000	-6.86816250	-6.27488997
335.0000000	-6.65548261	-6.27488997
340.0000000	-4.59949048	-6.27488997
345.0000000	-3.73628315	-6.27488997

350.0000000	-3.09418074	-6.27488997	.27945196
355.0000000	-2.70008436	-6.27488997	-.07167720
360.0000000	-2.56714927	-6.27488997	.00000000

CACC / CCAC



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QUEEN P 91 .C655 B485 1978 v
Belrose, J. S.
The effects of re-radiation

BELROSE, J.S.

The effects of re-radiation from highrise buildings, transmission lines, towers and other structures upon AM broadcasting directional ...

P
91
C655
B485
v. 3

DATE DUE
DATE DE RETOUR

LOWE-MARTIN No. 1137