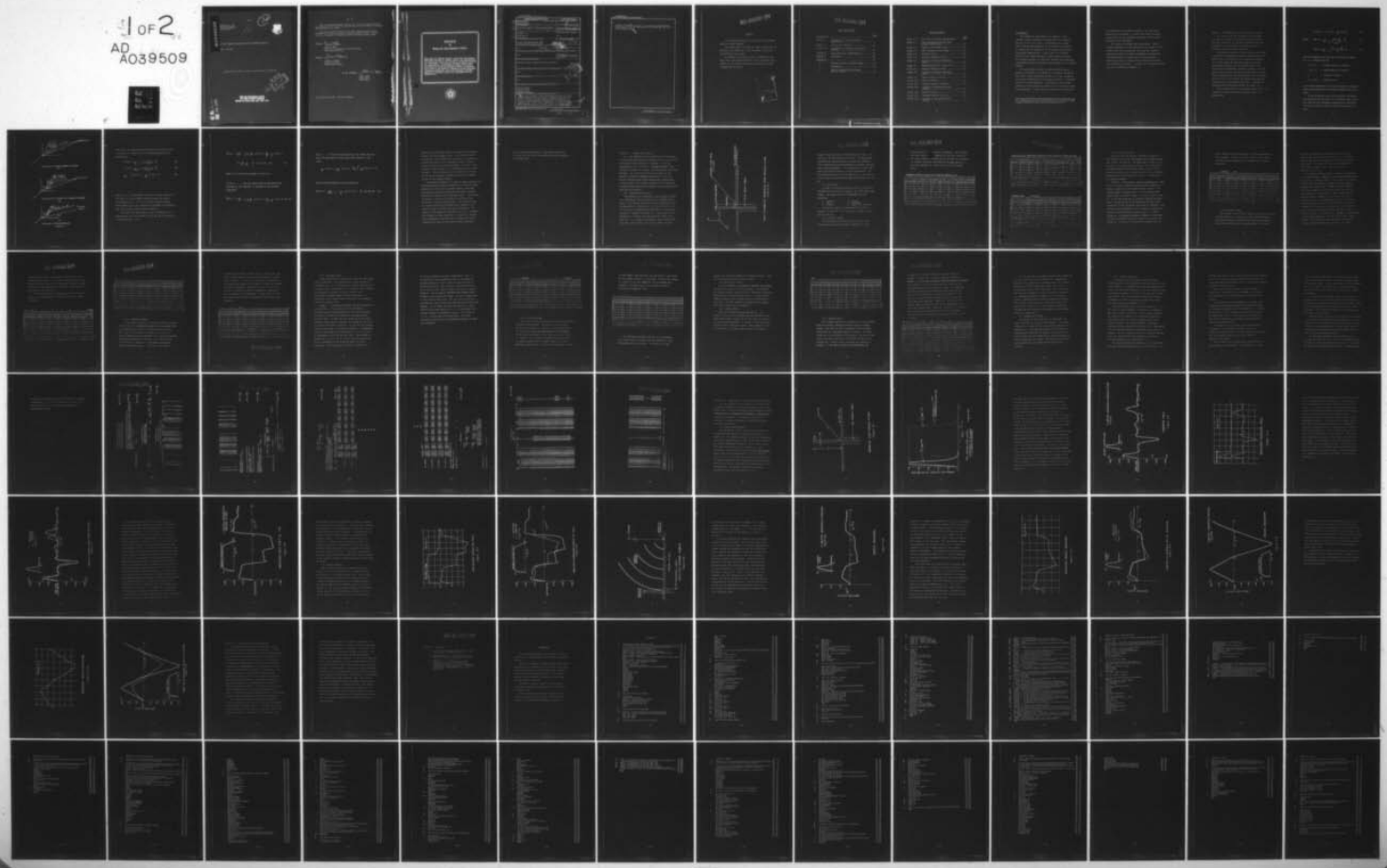
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In-house Report
April 1977

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A TIME DOMAIN PROGRAM FOR WIRE ANTENNA ANALYSIS

John Potenza

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This report discusses a user oriented computer routine to analyze antennas directly in the time domain. A number of sample cases were run and compared to previously published experimental results. A discussion of inputting data and output format is included to guide potential users. For the sake of completeness, a review of the time domain equations as well as the Fortran listing of the programs which were developed by MB Associates under Contracts RADC F30602-72X0008

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PREFACE

The analysis presented in this report was performed under Job Order 45060471.

The author wishes to thank Mr. Donald Harvey for his assistance and criticism in the reduction of data and preparation of the report.

In addition, the author wishes to acknowledge and thank Miss Jane Basenfelder/TIPN for the excellent reproduction of the measured data and the original art work contained in the report.



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TABLE OF CONTENTS

		Page
Introduction		1
SECTION I	Formulation of the Time Domain Equations	3
SECTION II	Sample Case Solution	11
SECTION III	Comparison of Computed and Measured Results	34
SECTION IV	Conclusions and Recommendations	57
SECTION V	References	59
Appendices		60
A	Fortran Listing of TIMDOM Program	A-1
B	Diagnostics	B-1
C	List of Scientific Subroutines used in TIMDOM	C-1

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LIST OF FIGURES

		Page
Figure 1.1	Field Due to Current Distributions	5
Figure 2.1	Thin Cylindrical Monopole Over Perfect Ground Plane	12
Figure 3.1	Monopole Over Ground Plane	35
Figure 3.2	Time Excitation Pulse Shapes	36
Figure 3.3	Radiation Field	38
Figure 3.4	Measured Radiation Field	39
Figure 3.5	Computed vs Measured Radiation Field	41
Figure 3.6	Radiation Field for $(c/h)t = 2.0$	43
Figure 3.7	Measured Radiation Field	45
Figure 3.8	Computed vs Measured Radiation Field	46
Figure 3.9	Receive Antenna Geometry	47
Figure 3.10	Receive Waveform	49
Figure 3.11	Measured Received Waveform	51
Figure 3.12	Computed vs Measured Received Waveform	52
Figure 3.13	Receive Waveform	53
Figure 3.14	Measured Received Waveform	55
Figure 3.15	Computed vs Measured Received Waveform	56

INTRODUCTION

The purpose of this report is to discuss a user-oriented computer routine* to analyze wire-type antennas directly in the time domain. Instructions for program input data and interpretation of the output are presented in concise form to permit use of the program with minimum theoretical understanding. Sample cases are presented which walk the reader through a typical problem solution. The computed results are critically compared with published experimental results to establish the validity of the computer routine.

The time domain approach is the most direct way to obtain the response of an antenna to a transient excitation. The output of the time domain solution is a time history of the current distribution on the antenna caused by a transient voltage or field excitation. Integration of this current provides the time varying far field or the receiving response of the antenna. By using Fourier transform the results can

*The computer routine was developed by ME Associates and has been implemented on computers at RADC, NRL, and NAVSEC under contract N00014-73-C-0099 and RADC F30602-72X0008.

be expressed in the frequency domain as the wide band response of the antenna. A single time domain solution yields data over the bandwidth associated with the time waveform of the excitation.

This report is divided into three parts. First a general description of the formulation is provided. Then program input and instructions for using the computer routines are given, including preparation of input data and interpretation of output for a specific example. Finally the output is discussed and critically compared with experimental results. A listing of the Fortran source program is included as Appendix A.

SECTION I Formulation of the Time Domain Equations

1.0 For the sake of completeness and providing a self-contained report, this section presents without rigorous derivation the integral equations which were developed and used in the Time Domain Program by MB Associates under government contract[1].

This computer routine is based upon the time domain equivalent of Packlington's Integral equation which is widely used for frequency domain numerical solutions. In the time domain the equation becomes an integro-differential equation and the unknown current is a function of two variables, position and time. The time domain equation can be derived by using Maxwell's time varying equations and the representation of the electric field in terms of the vector and scalar potentials and introduction of the retarded potential. Consider the general antenna structure depicted in Figure 1.1.

The electric field at an arbitrary point P $(\bar{r}, \theta, \phi)$ outside the volume current and charged source V' is expressed as

$$\bar{E}\ (\bar{r},t) = -\ \nabla\ \phi\ (\bar{r},t) - \frac{\partial}{\partial t}\ \bar{A}\ (\bar{r},t) \qquad (1)$$

where $$\bar{A}(\bar{r},t) = \frac{\mu}{4\ \pi}\ \int_{V'}\ \frac{J(\bar{r}',t-\frac{R}{C})}{R}\ dv' \qquad (2)$$

$$\phi(\bar{r},t) = \frac{1}{4\pi\epsilon}\ \int_{V'}\ \frac{\rho\ (\bar{r}'\ ,t\ -\ \frac{R}{C})}{R}\ dv' \qquad (3)$$

are the retarded vector and scalar potentials at point $P(\bar{r},\ \theta,\ \phi)$ respectively and

$J\ (\bar{r}',\ t')$ = current density in Volume V'

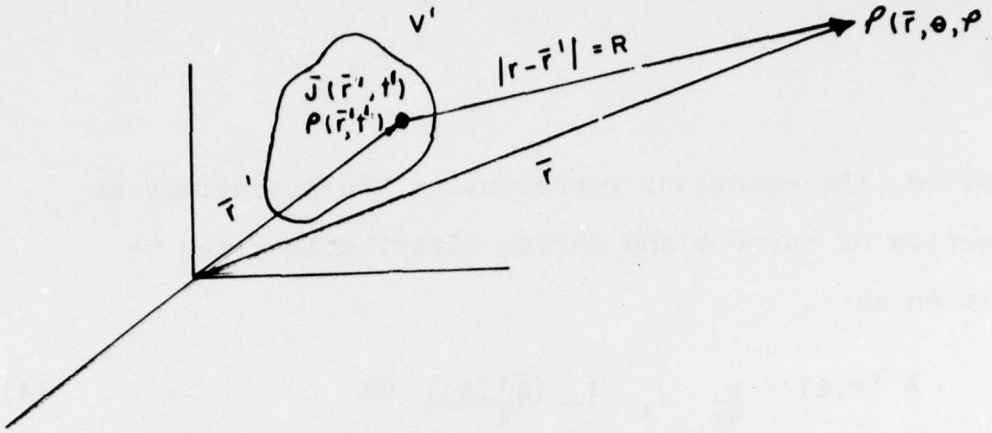
$\rho\ (\bar{r}',\ t')$ = charge density in volume V'

C = velocity of light

$t' = t - \frac{R}{C}$ = retarded time

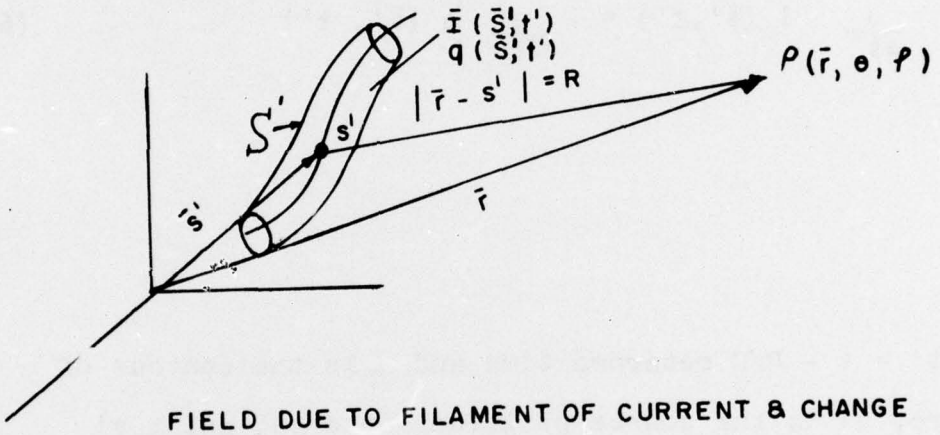
In the above expressions, the primed quantities represent source coordinates and the unprimed represent the field point.

If one considers a thin wire structure the current and charge are now confined to a filamentary path on the wire axis and the integration represented in equations (2) and (3) reduce to contour integrals along the wire axis.



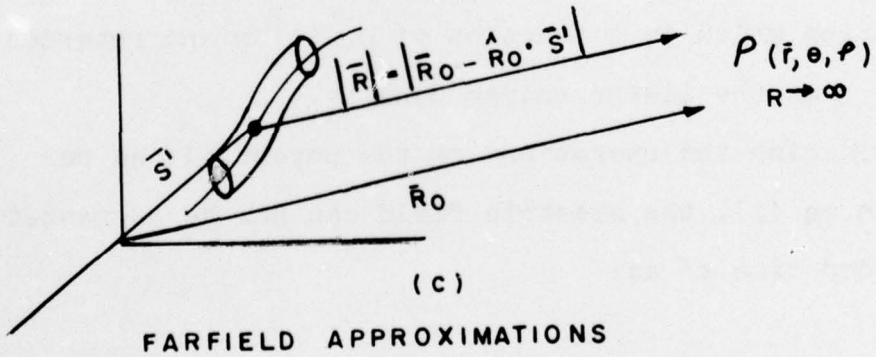
FIELD DUE TO VOLUME CURRENT & CHANGE

(a)



FIELD DUE TO FILAMENT OF CURRENT & CHANGE

(b)



(c)

FARFIELD APPROXIMATIONS

Figure 1.1

Therefore, the equations representing the potentials as a function of current and charge distributions can be rewritten as

$$\bar{A}\,(\bar{r},t) = \frac{\mu}{4\pi} \int_{\ell} \frac{I'\,(\bar{s}',t')}{R}\, ds' \tag{4}$$

$$\phi\,(\bar{r},t) = \frac{1}{4\pi\epsilon} \int_{\ell} \frac{q\,(\bar{s}',\,t')}{R}\, ds' \tag{5}$$

$$\frac{\partial}{\partial s'}\; I\,(\bar{s}',t') = -\frac{\partial}{\partial t'}\; q\,(\bar{s}',\,t') \tag{6}$$

where $t' = t - R/C$ retarded time and ℓ is the contour of the wire, $\bar{s}'$ is the source position vector at point s' (See Figure 1.1b). $I\,(\bar{s}',\,t')$ is the unknown current distribution which is a function of position and retarded time and q is the linear charge density.

Performing the operations on the potentials as required in eq (1), the electric field can now be expressed in retarded time t' as:

$$\bar{E}(\bar{r},t) = -\frac{\mu\hat{s}'}{4\pi}\int_{\ell}\left[\frac{1}{\bar{R}}\frac{\partial}{\partial t'}I(s',t') + \frac{C\bar{R}}{R^2}\frac{\partial}{\partial s'}I(s',t')\right.$$

$$\left.+C^2\frac{\bar{R}}{R^3}\frac{\partial}{\partial s'}\int_{o}^{t_1} I(s',t')dt'\right]ds' \qquad (7)$$

where $\hat{s}'$ is unit vector tangent to wire at s'.

If now, $R \to \infty$ and only those terms are retained which decrease as 1/R, equation (7) reduces to the farfield expression

$$\bar{E}(\bar{r},t) = -\frac{\mu\hat{s}'}{4\pi}\int_{\ell}\left[\frac{1}{\bar{R}}\frac{\partial}{\partial t'}I(s',t') + C\frac{\bar{R}}{R^2}\frac{\partial}{\partial s'}I(s',t')\right]ds' \qquad (8)$$

Since $R \to \infty$ $\bar{R}$ can be replaced by $\bar{R}_o$, the vector from the point of observation to the origin (See Figure 1c), and using

$$\frac{\partial}{\partial s'} I(s',t') = \frac{d}{ds'} I(s',t') - \frac{\hat{R}_o \cdot \hat{s}'}{C} \frac{\partial}{\partial t'} I(s',t') \quad (9)$$

The far field formulation can be written as

$$\bar{E}_r(\bar{r},t) = - \frac{\mu l}{4\pi R_o} \int_{\ell'} \frac{\partial}{\partial t'} I(s',t') [\hat{S}' - (\hat{S}' \cdot R_o) \hat{R}_o] \, ds' \quad (10)$$

Equation 10 is the final form of the integro differential equation for the radiated field. It is obvious that if the current on the antenna is known both as a function of position and time, it is a relatively simple matter to compute the field or received response. The crux of the computer routine herein is the computation of the induced currents. While no attempt will be made in this report to develop the numerical techniques employed, a general outline of the concept follows.

The method of moments[1] is used to reduce equation (7) (with appropriate boundary conditions) to a set of linear equations to solve for the unknown current, involving both position and time rather than the single variable positions as occurs in the frequency domain. Subsectional collocation methods are applied to solve the linear equations for current coefficients. This requires that the antenna structure be divided into a number of segments and time be divided into equal increments. The details of the numerical techniques will not be presented here because of their complexity. However, the effects of the numerical techniques are to compute the current (position and time) at the center of each subsection

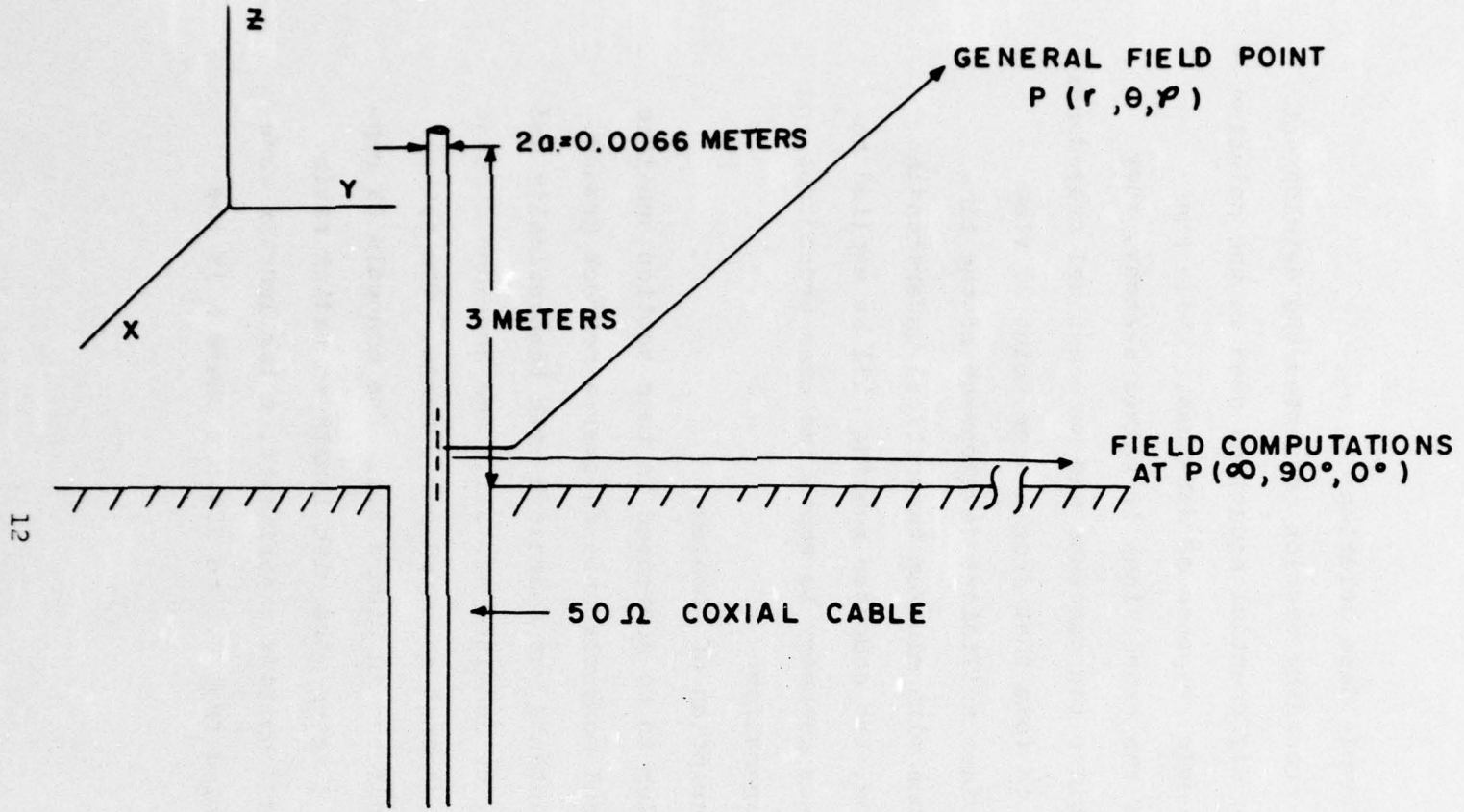
due to impressed excitation. Once these currents are computed the total field is determined through equations (8) through (10).

SECTION II Sample Case Solution

2.0 The preceding section presented the development of the integro differential equations used in the solution of the time domain response of antennas. While the development of the expressions is rather sketchy, they suffice to outline the concepts and mathematical procedures employed. It is felt that from a user point of view Section I provides sufficient development of the time domain equations with minimum theoretical understanding. In this section, the computer routine will be applied to a simple antenna geometry to emphasize user procedures and data input preparation.

2.1 Description of Problem.

The problem to be addressed in this section consists of a cylindrical monopole antenna over a perfect ground plane. This antenna was addressed both theoretically and experimentally by Schmitt, et. al.,[2] and provides a means of comparison against computed performance. The actual geometry is depicted in Figure 2.1. The monopole is represented by a 3 meter wire with length to radius ratio $h/a = 904$. In Schmitt's experiments, pulse lengths were used which varied from 0.2 to 2.0 h/c where h is the



THIN CYLINDRICAL MONOPOLE OVER GROUND PLANE

Figure 2.1

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length of the wire and c is the velocity of light. The rise time for the pulses is 0.05 h/c. The excitations considered are voltage sources to obtain the radiated field response and field excitations to examine receiving time domain performance. The excitations are short base band time waveform voltage and field excitations. The time characteristics of the excitations are 3 db width of 0.16 h/c and 2.0 h/c with rise time on the order of 0.05 h/c.

2.2 Data Input.

In order to input this problem into the Time Domain (TIMDOM) program the problem must be cast into input data format. The input data can be separated into six categories.

1. Comments
2. Data
3. Geometry
4. Loading
5. Excitation
6. Output Data requests

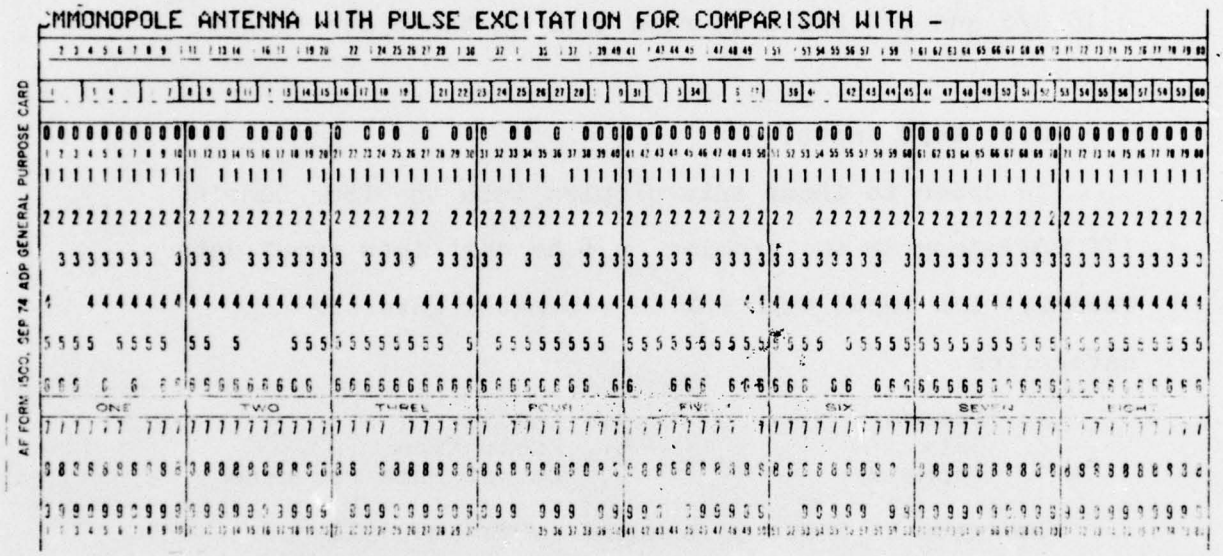
The data is input as punched cards and will be described in the following paragraphs as applied to the example problem.

2.2.1 Comment Cards.

The data card deck must begin with one or more comment cards which may contain a description of the

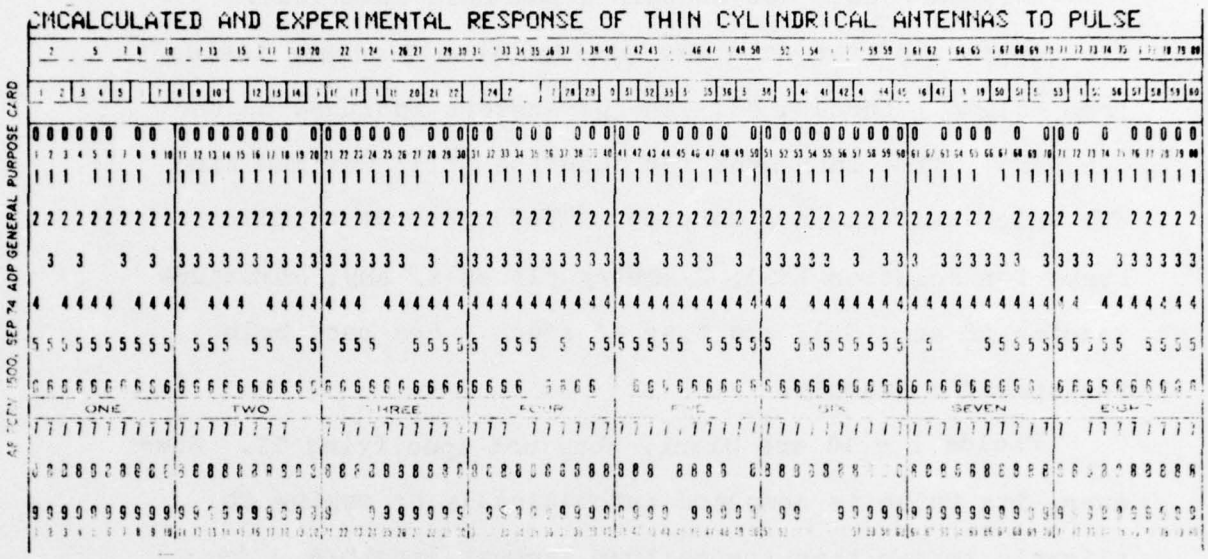
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problem or any other pertinent information. Each comment card must begin with the mnemonic CM and the contents of the card in columns 3 through 80 are printed in the output. All comment cards are read serially and must end with a card with mnemonic CE. This flags the end of comment cards.

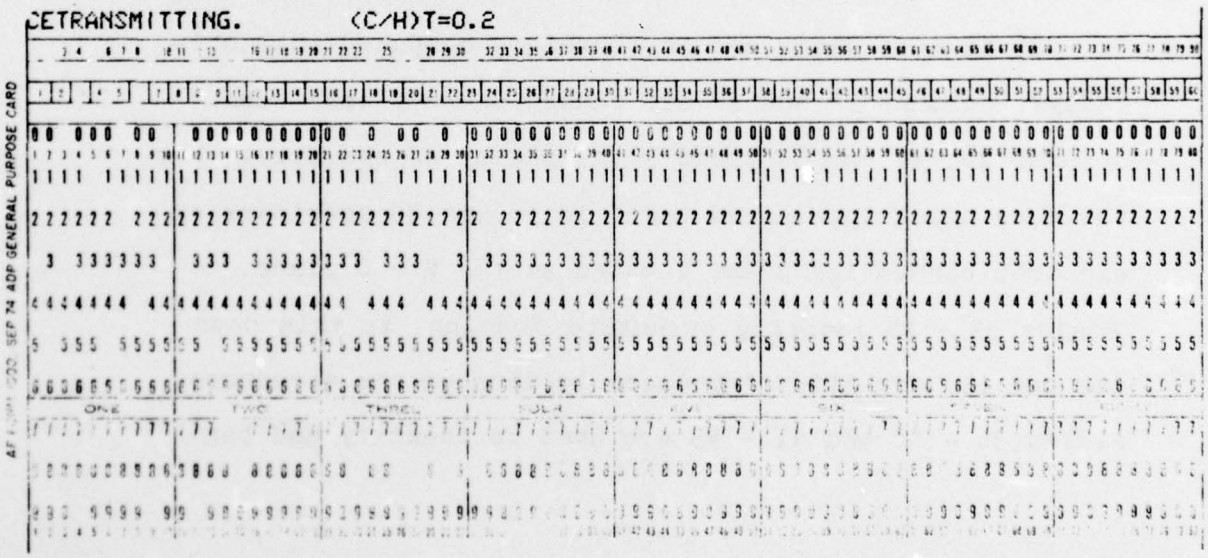


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CMCALCULATED AND EXPERIMENTAL RESPONSE OF THIN CYLINDRICAL ANTENNAS TO PULSE



CETRANSMITTING. (C/H)T=0.2



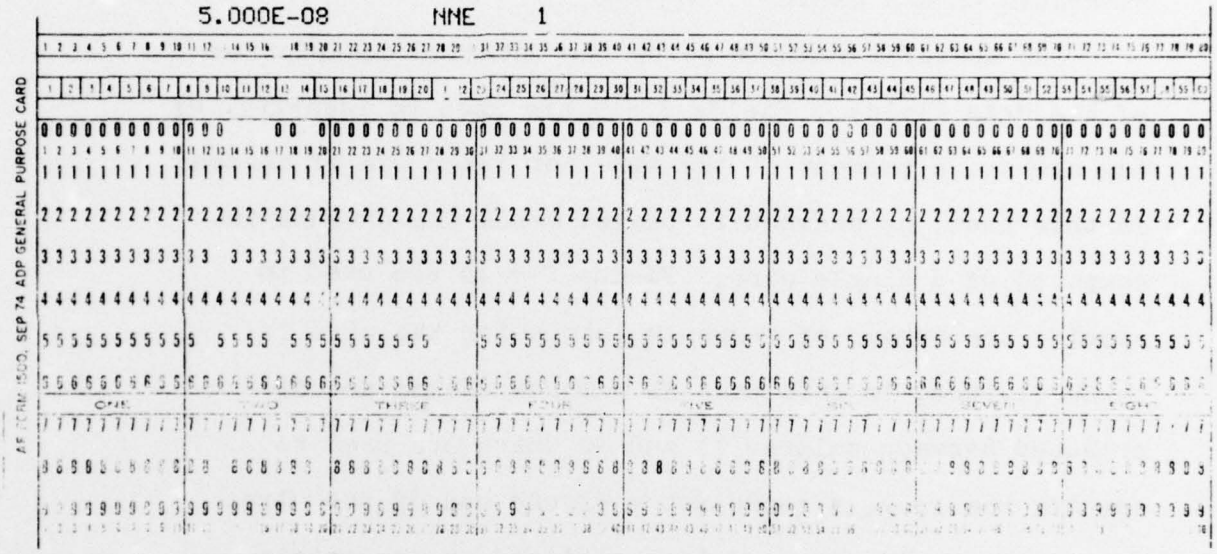
2.2.2 First Data Cards.

This card does not contain a mnemonic identifier. The contents of the card are divided into 7 usable fields from column 1 through 45. The parameters included on the card are: Time increment for solution (TI); Maximum time for which currents are computed (TMAX); Number of time steps for solution (NS); Symmetry planes if any; Structure loading if any (SL); and type of loads. See card below for specific example.

Fields 1 - 10 are blank, thus not specifying TI. However, its value is computed automatically by making it slightly larger than the maximum segment length/c. The integer number occupying field 11 - 20 specifies TMAX. Either TMAX or NS must be input. NS which occupies field 21 - 25 is left blank and is therefore computed automatically. Columns 26 and 27 are unused on this data card. Columns 28, 29 and 30 specify the planes of symmetry. For the case being considered the E in column 30 specifies an electric conducting plane located at the Z = 0 plane. Fields 31 - 35 identify structure loading, in this case the one (1) signifies impedance loading on the structure. Fields 36 - 40 and 41 - 45 are used to identify and tag

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those segments of the wire antenna for which currents are to be printed. In this case where they are left blank, currents will be printed for all segments as a default condition.



2.2.3 Geometry Cards.

The purpose of the geometry cards is to input the antenna structure geometry. Specifically these cards (mnemonic) GW generate lengths of straight wire between two points in space and divide them into an equal number of segments.

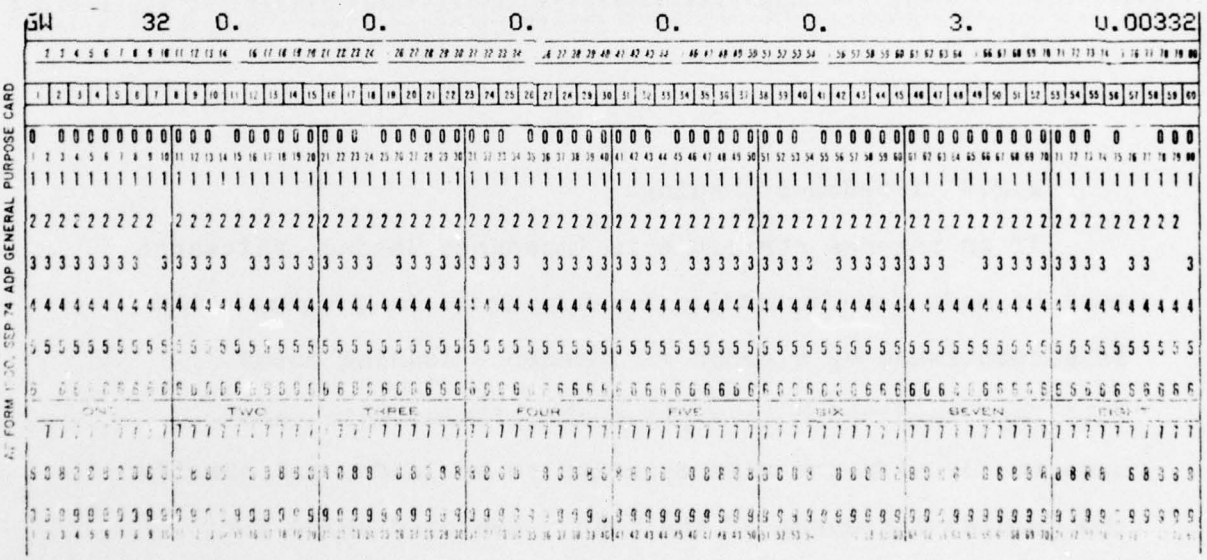
The card is divided into 10 fields which are used to identify the end points of the wire (in x, y, z space), identify the number of segments, and provide the radius of the wire. Any number of wires can be generated in this fashion, however, only a single wire can be generated on one card.

See specific example below for detailed description of the data fields. Fields 3 - 5 are used to identify, by tag number, a segment of the wire for later use if needed. In this case, no segment is tagged since the antenna is composed of a single wire. Fields 6 - 10 are used to specify the number of segments into which the wire is to be divided, in this case 32. Three fields are distributed between columns 11 and 40 which are used to specify the x, y, z coordinates of one end of the wire. In this case the wire end is positioned at the origin. Columns 41 - 70 are used to specify the other end of the wire. The data in column 64 places the wire 3 meters along the Z axis. See Figure 2.1. Fields 71 - 80 are used to specify the radius of the wire in this case 0.00332 meters. Since this case only involves a single wire antenna only one Geometry card is used. If a more

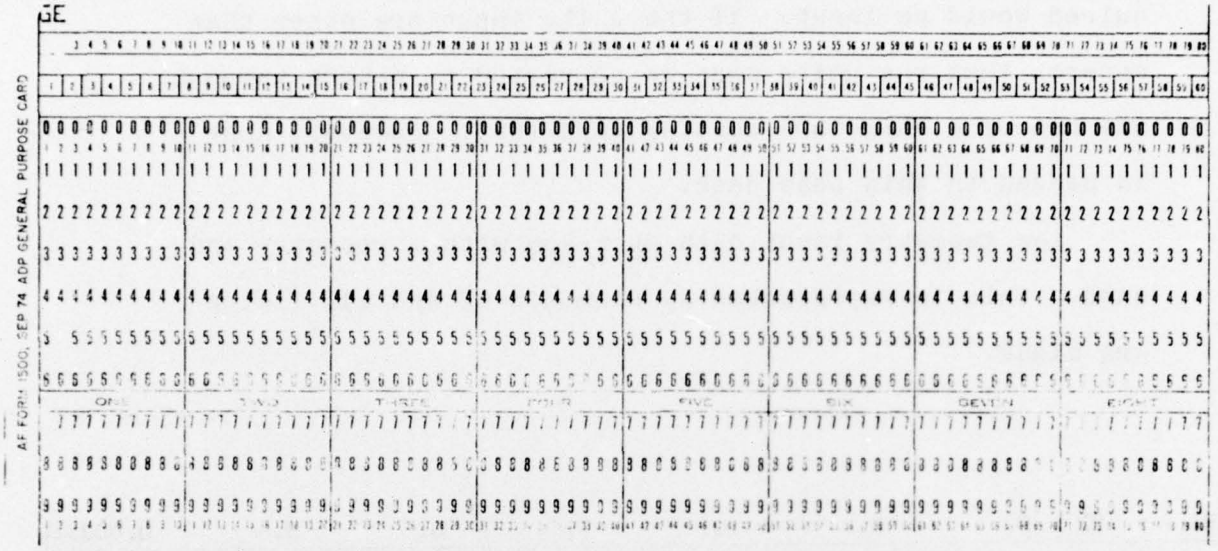
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complex structure is being modeled, as many cards as required would be input. If the units input are other than meters, then the units must be converted to meters through the use of a structure scaling card (GS). However, none is needed in this case deck.

The geometry input data must end with a geometry end card. This is represented by mnemonic GE and all fields are blank.



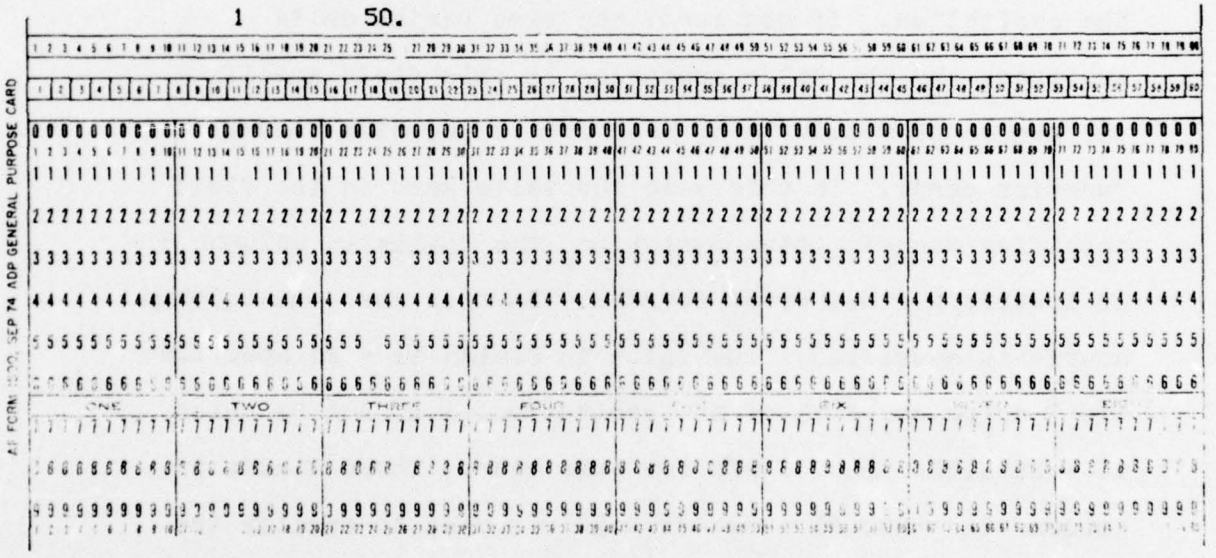
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2.2.4 Impedance Loading.

If an antenna structure is impedance loaded, allowance must be made for inputting the data into the program. This is accomplished by a group of impedance loading cards. This card is divided into six usable fields which are used to identify the wire segments to be loaded and specify the complex impedance of the load. See card below for format details. Fields 1 - 5 are used to specify the number of impedance cards. If non zero, the program

searches for succeeding loading cards. In this case that field is zero implying this is the last impedance loading card. Fields 6 - 10 and 11 - 15 are used to identify, by tag number, the segment to be loaded. In this case segment one (1) is identified. Fields 21 - 30, 31 - 40, 41 - 50 are used to specify in ohms the resistance, inductance, and capacitance of the impedance. In this case, a 50 ohm pure resistance is input to simulate the coax feed point impedance.



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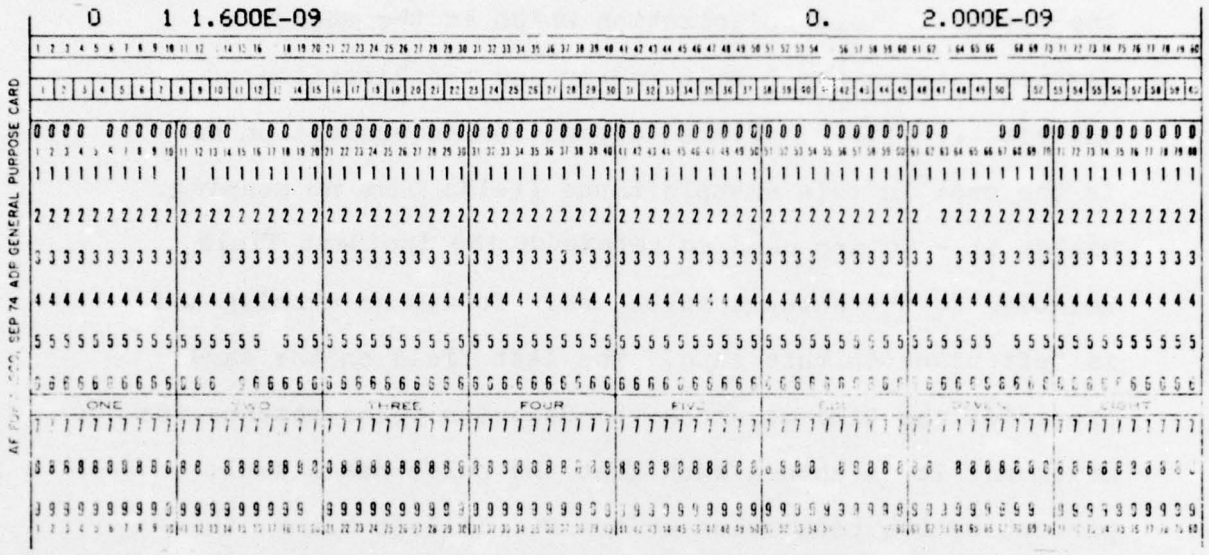
2.2.5 Excitation Card.

Having described the geometry and loads, the excitation must be specified. This information is input through the excitation card. It is divided into 8 fields which are used to specify type of excitation, i.e. voltage or field excitation; number of sources; 3 db pulse width of the excitation; incidence angle for field excitation. A discussion of the various fields references the excitation card of the example case.

Fields 1 - 5 are used to identify the time variation of the excitation. If non zero, the time variation is arbitrary and the value appearing in this field specifies the number of values to be read from succeeding Source Function cards. In this case the value zero in the field specifies Gaussian time variation. The fields in columns 5 - 10 specify the number of sources. In this case one voltage source is specified. The value in Fields 11 - 20 specifies the 3 db pulse width of the excitation, i.e. 1.6 ns which is equivalent to 0.16 h/c for this case. Three fields in columns 21 - 30, 31 - 40, 41 - 50 are used to specify the θ, ϕ, η parameters of the incidence angle for field excitation. The field source position is specified by

θ, and ϕ (convention spherical coordinates), and η is the electric field polarization which is the angle in degrees between the θ unit vector and the direction of the electric field. For a voltage source excitation as is the case in this example these fields have no meaning. Fields 51 - 60 are used to reference the incident field relative to the antenna structure. It has no meaning and is left blank in this case. The last field on the card specifies the time at which the Gaussian pulse reaches its maximum. It is chosen such that the pulse has a small percent of its peak value at $t = 0$. If left blank, the program computes an appropriate value $\approx$ 3% of peak at $t = 0$). In this case it was specified. This card completely specifies all the parameters required to input the excitation.

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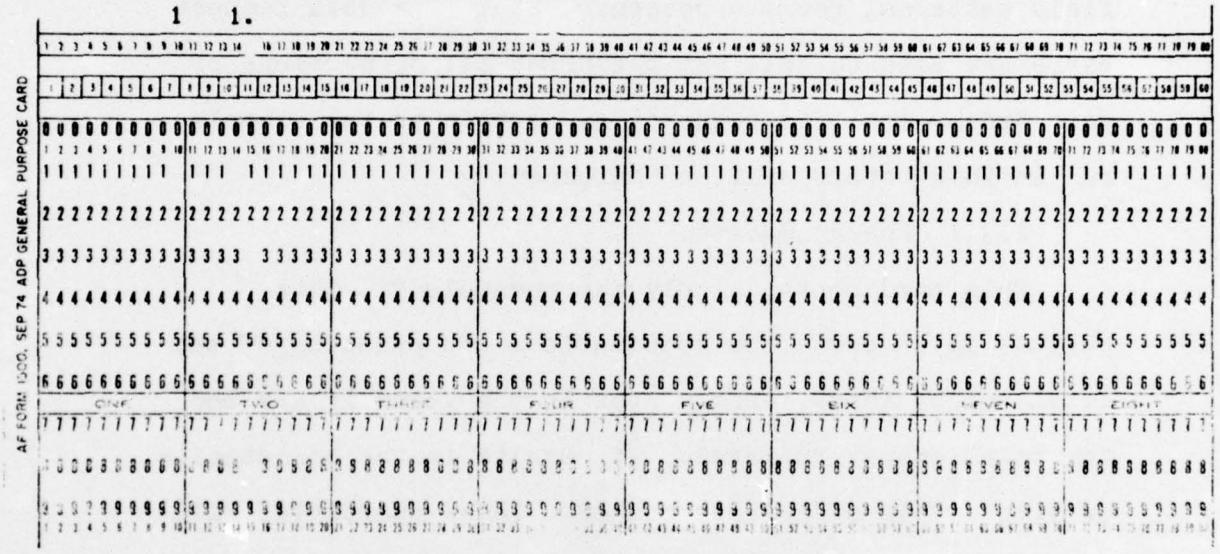


2.2.6 Source Voltage.

This card is used to specify the peak voltages of the individual sources used. It consists of three usable fields which identify the segments on which sources will be located, and input the peak voltage of the sources. On this card (see below) of the input data deck, fields 1 - 5 and 6 - 10 are used to specify the tag number of the source segment and the segment number of a set of segments, respectively. In this case since there is only

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one tag number (only one wire) the tag field is left blank and the segment number 1 is specified. That is, the source is located at the base segment of the 32 segment wire monopole. The peak value of the source is unity as specified in Fields 11 - 20.



The preceding paragraphs describe the preparation of a sample input data deck which was prepared to input the problem into the computer. The next set of data

cards to be discussed pertains to requesting output. This set is referred to as Data Request Cards.

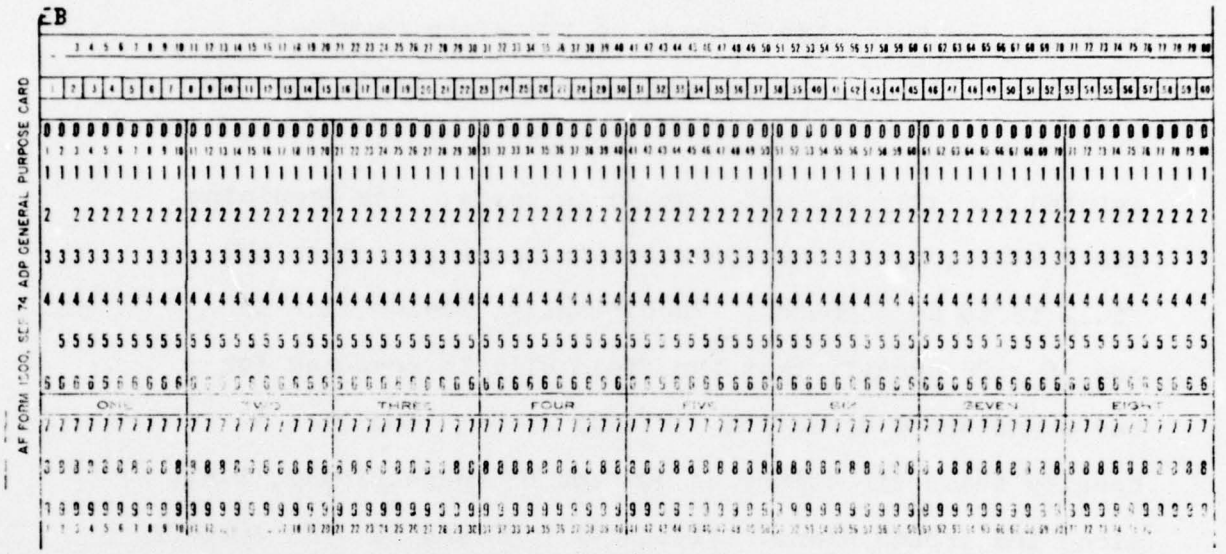
2.3 Data Request Cards.

A set of commands is required to identify and extract the proper data from the output solution. For example, the program computes induced current, impedance, admittance, field patterns, receive response, etc. The data request cards are used to call out and print all or portions of this data. Specific requests as pertain to the example run in this report will be addressed.

2.3.1 Energy Budget.

This card contains only the mnemonic EB. Its purpose is to cause the computations and printing of the total energy input, energy lost in the loads if any and the total energy radiated. It results in the computation of time domain efficiency number. These quantities will be discussed in the output data section of the report.

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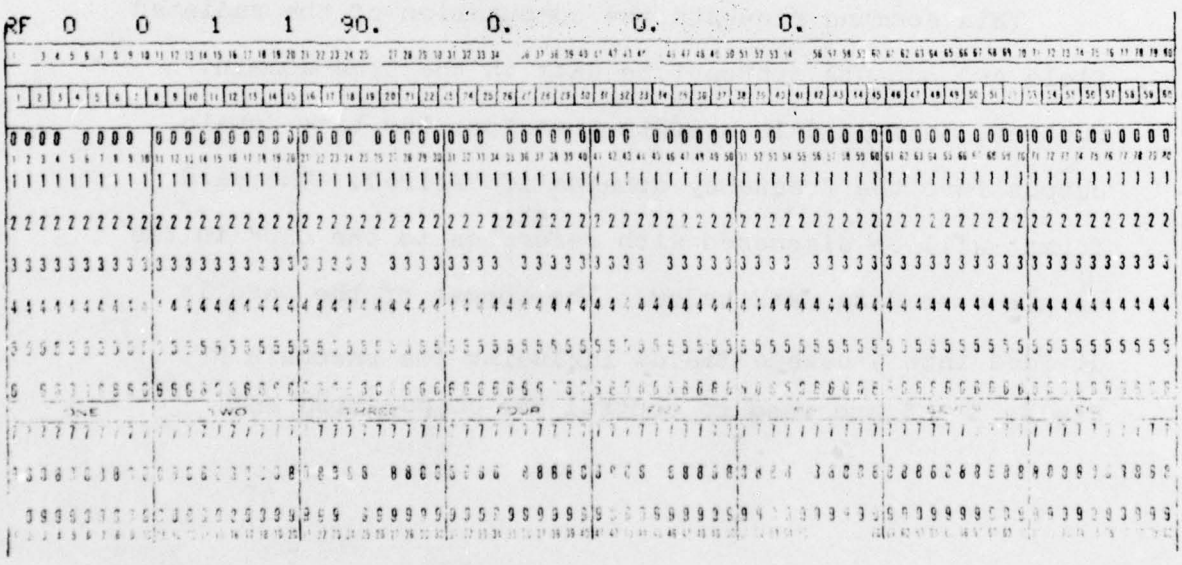


2.3.2 Radiated Field.

This command requests the computation of the radiated field and outputs appropriate data in the time domain. Further, this card is used to transform the time domain output into the frequency domains if desired. The card format will be discussed with reference to the card in the sample case data deck below. The format of the card is divided into 9 usable fields including the mnemonic RF. Fields 3 - 5 are used to control the computation and

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printing of the Fourier Transform and punch cards if desired. In this case 0 means no transform required. Fields 6 - 10 are used to control punching cards for electric field output. In this case the electric field will be printed directly and not punched on cards. The remaining six fields specify the direction in space for which the field is to be computed. Specifically, fields 11 - 15 and 16 - 20 specify that the field will be computed for one θ and one ϕ direction. Fields 21 - 30 and 31 - 40 specify these directions as 90° and 0° respectively, i.e. along the ground plane. Fields 41 - 50 and 51 - 60 specify the θ and ϕ stepping increment for field computation. In this case both are zero since only one direction is of interest.



2.4 The preceding paragraphs describe the preparation of a data input deck for a specific case. Recall the problem was to determine the radiated field of a monopole antenna on a perfect conducting ground plane fed by a 50 ohm coaxial cable (see Figure 2.1). The sample input data deck was presented to input the problem parameters, i.e. geometry, excitation, loading, etc. and request current computation and far field transmitting response. The following paragraphs will present and discuss the output of the sample case. The radiated and received responses will be presented and compared to experimental results in Section III.

2.5 Program Data Output.

The purpose of this portion is to familarize the reader with the raw output of this program. The output presented is a result of the input problem discussed in paragraph 2.1. Although the output of the program is automatically identified by labels, each portion of the sample output has been identified by circled numbers for easy reference by the reader. The sample output which is discussed below is located at the end of this section.

2.5.1 Output Discussion.

The program title Time Domain Antenna Modeling Program appears at (1) automatically with each output as the first heading. The comment cards which were presented as input data follow the heading at (2) and can contain as many statements as desired. At (3) the first data card is read and printed. This card contains various time stepping information as well as any problem symmetry (see input data card discussion paragraph 2.2.2).

Next the geometry input cards are printed at (4). In this case, a single monopole is modeled by 32 segments with wire radius 0.0032 meters. These outputs identify the wires by tag numbers. The parameters specified by the geometry cards are used to determine the segment centers, lengths, and orientation (α, β orientation angles) which are printed in the output at 5. This printout also contains segment interconnection data and tag numbers. The I- I+ notation is used to reference current flow, i.e. current flows from negative to positive. The wire information is summarized at 6.

The table automatically printed out at 7 summarizes the time stepping information used in the solution. It

provides the number of time steps and time stepping interval. If any one of these quantities was not input as data (see first data input card paragraph 2.2.2), it is automatically computed and printed here.

Any options such as symmetry planes, impedance loading, etc. are printed at location (8). This location also identifies the segment for which current will be printed.

The parameters of the excitation are provided at 9. In addition to printing the input excitation data card, the Gaussian characteristic time information is provided. As pointed out in this example, the source has 11.5% of its peak value at t = 0. This value was specified as data input otherwise it would have been automatically computed and printed here.

At location 10, all voltage source information is summarized. It specifies the number of sources, location and peak voltages. If field excitation had been used this section would be replaced by angle of incidence information.

At this point, the program begins the solution for the currents on the segments. The results are printed

out as a block of data at (11). The currents are printed from left to right in order of increasing segment number for each time step. In this case there are 160 time steps of ≈ 0.3 ns each. The value of the source strength at each time step is the final entry of each block, labeled excitation.

The results of the Energy Budget request card are printed at (12). The Time Domain Efficiency is defined as the ratio of the total energy radiated to the total energy input and accounts for any energy lost in loads on the structure. If no loads were present in the problem this efficiency would be 100%.

The next block of data (13) in the output is the result of the request for radiated field computations. It provides the electric field (volts/meter) variation for each time step at a specified point in space (theta and phi). It also provides polarization tilt information which is also a useful performance parameter.

The preceding paragraphs have presented a walk through discussion of the use of the time domain program to input a problem and interpret the output. The program was written to emphasize user-ease with a minimum amount

of previous training in numerical techniques or computer understanding. In the next section the results of the sample problem will be analyzed and compared with experimental results.

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```
**********************************************

   TIME DOMAIN ANTENNA MODELING PROGRAM

**********************************************

MONOPOLE ANTENNA WITH PULSE EXCITATION FOR COMPARISON WITH -

CALCULATED AND EXPERIMENTAL RESPONSE OF THIN CYLINDRICAL ANTENNAS TO PULSE
EXCITATION,  BY H.J. SCHMITT, C.W. HARRISON, JR., AND C.S.WILLIAMS, JR.,
IEEE TRANS. ANT. PROP.,  MARCH 1966,

TRANSMITTING.        (C/W)T=0.2

*** FIRST DATA CARD** 0.          0.50000E-07    0  NNE    1    0    0
```

(1) (2) (3)

```
- - - STRUCTURE SPECIFICATION - - -

   COORDINATES MUST BE INPUT IN
   METERS OR BE SCALED TO METERS
   BEFORE STRUCTURE INPUT IS ENDED
```

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	0.	0.	0.	0.	0.	3.00000	0.00332	32	1	32	0

(4)

```
- - - - SEGMENTATION DATA - - - -
```

(5)

```
COORDINATES IN METERS

I+ AND I- INDICATE THE SEGMENTS BEFORE AND AFTER I
```

SEG. NO.	COORDINATES OF SEG. CENTER X	Y	Z	SEG. LENGTH	ORIENTATION ANGLES ALPHA	BETA	WIRE RADIUS	CONNECTION DATA I-	I	I+	TAG NO.
1	0.	0.	0.04688	0.09375	90.00000	0.	0.00332	20001	1	2	0
2	0.	0.	0.14063	0.09375	90.00000	0.	0.00332	1	2	3	0
3	0.	0.	0.23438	0.09375	90.00000	0.	0.00332	2	3	4	0
4	0.	0.	0.32813	0.09375	90.00000	0.	0.00332	3	4	5	0
5	0.	0.	0.42188	0.09375	90.00000	0.	0.00332	4	5	6	0
6	0.	0.	0.51562	0.09375	90.00000	0.	0.00332	5	6	7	0
7	0.	0.	0.60938	0.09375	90.00000	0.	0.00332	6	7	8	0
8	0.	0.	0.70312	0.09375	90.00000	0.	0.00332	7	8	9	0
9	0.	0.	0.79688	0.09375	90.00000	0.	0.00332	8	9	10	0
10	0.	0.	0.89063	0.09375	90.00000	0.	0.00332	9	10	11	0
11	0.	0.	0.98437	0.09375	90.00000	0.	0.00332	10	11	12	0
12	0.	0.	1.07813	0.09375	90.00000	0.	0.00332	11	12	13	0
13	0.	0.	1.17188	0.09375	90.00000	0.	0.00332	12	13	14	0
14	0.	0.	1.26563	0.09375	90.00000	0.	0.00332	13	14	15	0
15	0.	0.	1.35938	0.09375	90.00000	0.	0.00332	14	15	16	0
16	0.	0.	1.45312	0.09375	90.00000	0.	0.00332	15	16	17	0

17	0.	0.	1.54688	0.09375	90.00000	0.	0.00332	16	17	18	0
18	0.	0.	1.64062	0.09375	90.00000	0.	0.00332	17	18	19	0
19	0.	0.	1.73438	0.09375	90.00000	0.	0.00332	18	19	20	0
20	0.	0.	1.82812	0.09375	90.00000	0.	0.00332	19	20	21	0
21	0.	0.	1.92188	0.09375	90.00000	0.	0.00332	20	21	22	0
22	0.	0.	2.01563	0.09375	90.00000	0.	0.00332	21	22	23	0
23	0.	0.	2.10938	0.09375	90.00000	0.	0.00332	22	23	24	0
24	0.	0.	2.20313	0.09375	90.00000	0.	0.00332	23	24	25	0
25	0.	0.	2.29688	0.09375	90.00000	0.	0.00332	24	25	26	0
26	0.	0.	2.39063	0.09375	90.00000	0.	0.00332	25	26	27	0
27	0.	0.	2.48438	0.09375	90.00000	0.	0.00332	26	27	28	0
28	0.	0.	2.57812	0.09375	90.00000	0.	0.00332	27	28	29	0
29	0.	0.	2.67188	0.09375	90.00000	0.	0.00332	28	29	30	0
30	0.	0.	2.76562	0.09375	90.00000	0.	0.00332	29	30	31	0
31	0.	0.	2.85937	0.09375	90.00000	0.	0.00332	30	31	32	0
32	0.	0.	2.95312	0.09375	90.00000	0.	0.00332	31	32	0	0

NUMBER OF SEGMENTS= 32
TOTAL WIRE LENGTH= 3.00000 M.
MAXIMUM SEGMENT LENGTH= 0.09375 M. ← (6)

****

TIME STEPPING INTERVAL= 0.31300E-09 SEC. ← (7)
MAXIMUM TIME= 0.49767E-07 SEC.
NUMBER OF TIME STEPS= 160

****

OPTIONS SELECTED- - -
THE Z=0 PLANE IS AN ELECTRIC SYMMETRY PLANE ← (8)
MODEL HAS IMPEDANCE LOADING
CURRENTS WILL BE PRINTED FOR SEGMENTS 1 THROUGH 32

- - - - STRUCTURE LOADING - - - -

TAG NO.	INCREMENT	SEG. NO.	RESISTANCE (OHMS)	INDUCTANCE (HENRYS)	CAPACITANCE (FARADS)
0	1	1	0.5000E 02	0.	

*** EXCITATION DATA CARD** 0 1 0.16000E-08 0. 0. 0. 0. 0.20000E-08

- - - - EXCITATION - - - -

TIME DEPENDENCE- GAUSSIAN, PEAK AT TIME=TMAX - - EXP(-(A**2)*(TIME-TMAX)**2) ← (9)

A= 0.73589E 09, TMAX= 0.20000E-08

SOURCE HAS 11.462 PERCENT OF PE

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VOLTAGE SOURCES -

SOURCE NO.	SOURCE SEGMENT TAG NO.	INC.	SEG. NO.	PEAK VOLTAGE (VOLTS)
1	0	1	1	1.0000

(10)

```
LENGTH OF COEFFICIENT ARRAY=     24243
        4 BLOCKS OUTPUT TO FILE 11,          2 BLOCKS OUTPUT TO FILE 12
TIME FOR INITIALIZATION OF CONSTANTS=  485.000 SEC.
SOLUTION WILL USE CURRENTS FROM CORE STORAGE ONLY
LENGTH OF CURRENT OUTPUT BLOCK IS    2304 WORDS,
NUMBER OF TIME STEPS USED DURING SOLUTION=      65
```

- - - - CURRENT SOLUTION - - - -

(11)

STEP NO.	TIME (SEC.)	SEGMENT CURRENTS IN AMPS (READ ACROSS) - - - - - LAST NUMBER IN EACH BLOCK REPRESENTS SOURCE STRENGTH									
1	0.	.296E-03	0.329E-04	0.449E-05	0.595E-06	0.791E-07	0.105E-07	0.140E-08	0.186E-09	0.248E-10	0.329E-11
		.438E-12	0.583E-13	0.775E-14	0.103E-14	0.137E-15	0.182E-16	0.242E-17	0.322E-18	0.429E-19	0.570E-20
		0.759E-21	0.101E-21	0.134E-22	0.178E-23	0.237E-24	0.316E-25	0.420E-26	0.558E-27	0.743E-28	0.988E-29
		0.132E-29	0.186E-30								
		EXCITATION	0.1146E 00								
2	0.31300E-9	.671E-03	0.208E-03	0.465E-04	0.867E-05	0.148E-05	0.241E-06	0.379E-07	0.582E-08	0.878E-09	0.131E-09
		.192E-10	0.280E-11	0.404E-12	0.581E-13	0.829E-14	0.118E-14	0.167E-15	0.236E-16	0.331E-17	0.464E-18
		.649E-19	0.905E-20	0.126E-20	0.175E-21	0.243E-22	0.336E-23	0.465E-24	0.641E-25	0.884E-26	0.122E-26
		0.167E-27	0.238E-28								
		EXCITATION	0.2141E 00								
3	0.62600E-9	.112E-02	0.555E-03	0.199E-03	0.545E-04	0.123E-04	0.250E-05	0.472E-06	0.845E-07	0.146E-07	0.244E-08
		.398E-09	0.638E-10	0.101E-10	0.157E-11	0.241E-12	0.367E-13	0.555E-14	0.832E-15	0.124E-15	0.183E-16
		.27 E-17	0.396E-18	0.577E-19	0.838E-20	0.121E-20	0.175E-21	0.251E-22	0.360E-23	0.515E-24	0.735E-25
		0.105E-25	0.155E-26								
		EXCITATION	0.3597E 00								

```
                    0.190E-04  0.698E-05
                    EXCITATION   0.

197 0.48828E-07  0.775E-04  0.915E-04  0.119E-03  0.144E-03  0.150E-03  0.131E-03  0.921E-04  0.471E-04  0.148E-04  0.117E-04
                 0.466E-04  0.119E-03  0.218E-03  0.331E-03  0.442E-03  0.537E-03  0.606E-03  0.642E-03  0.644E-03  0.616E-03
                 0.562E-03  0.492E-03  0.415E-03  0.338E-03  0.266E-03  0.204E-03  0.151E-03  0.109E-03  0.747E-04  0.486E-04
                 0.280E-04  0.104E-04
                 EXCITATION   0.

198 0.49141E-07  0.539E-04  0.745E-04  0.109E-03  0.141E-03  0.156E-03  0.148E-03  0.117E-03  0.737E-04  0.325E-04  0.832E-05
                 0.125E-04  0.503E-04  0.121E-03  0.217E-03  0.327E-03  0.438E-03  0.534E-03  0.604E-03  0.641E-03  0.643E-03
                 0.613E-03  0.559E-03  0.489E-03  0.412E-03  0.336E-03  0.269E-03  0.202E-03  0.148E-03  0.104E-03  0.693E-04
                 0.405E-04  0.152E-04
                 EXCITATION   0.

199 0.49454E-07  0.512E-04  0.689E-04  0.955E-04  0.122E-03  0.140E-03  0.144E-03  0.130E-03  0.103E-03  0.666E-04  0.322E-04
                 0.110E-04  0.139E-04  0.485E-04  0.116E-03  0.212E-03  0.325E-03  0.437E-03  0.534E-03  0.604E-03  0.639E-03
                 0.644E-03  0.609E-03  0.556E-03  0.487E-03  0.410E-03  0.334E-03  0.261E-03  0.197E-03  0.143E-03  0.966E-04
                 0.573E-04  0.216E-04
                 EXCITATION   0.

160 0.49767E-07  0.632E-04  0.715E-04  0.822E-04  0.955E-04  0.110E-03  0.124E-03  0.130E-03  0.124E-03  0.102E-03  0.690E-04
                 0.331E-04  0.828E-05  0.857E-05  0.432E-04  0.113E-03  0.212E-03  0.329E-03  0.437E-03  0.533E-03  0.601E-03
                 0.636E-03  0.637E-03  0.607E-03  0.553E-03  0.484E-03  0.407E-03  0.329E-03  0.256E-03  0.190E-03  0.131E-03
                 0.788E-04  0.299E-04
                 EXCITATION   0.
TIME FOR CURRENT SOLUTION=-1825.000 SEC.

RUNNING TIME=-1340.000 SEC.

*** DATA CARD**EB  0    0    0    0 0.          0.          0.          0.


                          - - - ENERGY BUDGET - - -                          (12)

                    SOURCES -

                      SOURCE   SEGMENT    ENERGY INPUT
                        NO.       NO.       (JOULES)
                         1         1      0.4881E-11


                    LOADS -
                      SEGMENT    RESISTANCE   ENERGY LOSS
                        NO.        (OHMS)      (JOULES)
                         1     0.5000E 02   0.1787E-11

                     TOTAL ENERGY INPUT = 0.4881E-11 JOULES
                     ENERGY LOST IN LOADS = 0.1787E-11 JOULES
                     TOTAL ENERGY RADIATED = 0.3094E-11 JOULES
                     TIME DOMAIN EFFICIENCY =  63.39 PERCENT

RUNNING TIME=-1329.000 SEC.

*** DATA CARD**RF  0    0    1    1 0.90000E 02 0.          0.          0.
```

- - - - RADIATED FIELD - - - -

(13)

THETA= 90.000
PHI = 0.

STEP NO.	TIME (SEC.)	ELECTRIC FIELD (V/M) THETA	PHI	POL. (DEG.)	STEP NO.	TIME (SEC.)	ELECTRIC FIELD (V/M) THETA	PHI	POL. (DEG.)
1	-0.31300E-09	0.9718E-02	0.	0.	81	0.24727E-07	-0.3706E-02	0.	180.000
2	0.	0.2805E-01	0.	0.	82	0.25040E-07	-0.3845E-02	0.	180.000
3	0.31300E-09	0.4855E-01	0.	0.	83	0.25353E-07	-0.2718E-02	0.	180.000
4	0.62600E-09	0.7540E-01	0.	0.	84	0.25666E-07	-0.1039E-02	0.	180.000
5	0.93900E-09	0.1058E 00	0.	0.	85	0.25979E-07	0.4977E-03	0.	0.
6	0.12520E-08	0.1334E 00	0.	0.	86	0.26292E-07	0.1431E-02	0.	0.
7	0.15650E-08	0.1509E 00	0.	0.	87	0.26605E-07	0.1640E-02	0.	0.
8	0.18780E-08	0.1527E 00	0.	0.	88	0.26918E-07	0.1311E-02	0.	0.
9	0.21910E-08	0.1373E 00	0.	0.	89	0.27231E-07	0.8030E-03	0.	0.
10	0.25040E-08	0.1084E 00	0.	0.	90	0.27544E-07	0.4713E-03	0.	0.
11	0.28170E-08	0.7343E-01	0.	0.	91	0.27857E-07	0.5387E-03	0.	0.
12	0.31300E-08	0.4007E-01	0.	0.	92	0.28170E-07	0.1070E-02	0.	0.
13	0.34430E-08	0.1376E-01	0.	0.	93	0.28483E-07	0.2048E-02	0.	0.
14	0.37560E-08	-0.3551E-02	0.	180.000	94	0.28796E-07	0.3493E-02	0.	0.
15	0.40690E-08	-0.1277E-01	0.	180.000	95	0.29109E-07	0.5576E-02	0.	0.
16	0.43820E-08	-0.1622E-01	0.	180.000	96	0.29422E-07	0.8655E-02	0.	0.
17	0.46950E-08	-0.1638E-01	0.	180.000	97	0.29735E-07	0.1323E-01	0.	0.
18	0.50080E-08	-0.1508E-01	0.	180.000	98	0.30048E-07	0.1985E-01	0.	0.
19	0.53210E-08	-0.1339E-01	0.	180.000	99	0.30361E-07	0.2894E-01	0.	0.
20	0.56340E-08	-0.1180E-01	0.	180.000	100	0.30674E-07	0.4074E-01	0.	0.
21	0.59470E-08	-0.1045E-01	0.	180.000	101	0.30987E-07	0.5508E-01	0.	0.
22	0.62600E-08	-0.9345E-02	0.	180.000	102	0.31300E-07	0.7136E-01	0.	0.
23	0.65730E-08	-0.8448E-02	0.	180.000	103	0.31613E-07	0.8840E-01	0.	0.
24	0.68860E-08	-0.7708E-02	0.	180.000	104	0.31926E-07	0.1045E 00	0.	0.
25	0.71990E-08	-0.7092E-02	0.	180.000	105	0.32239E-07	0.1175E 00	0.	0.
26	0.75120E-08	-0.6591E-02	0.	180.000	106	0.32552E-07	0.1251E 00	0.	0.
27	0.78250E-08	-0.6219E-02	0.	180.000	107	0.32865E-07	0.1255E 00	0.	0.
28	0.81380E-08	-0.6053E-02	0.	180.000	108	0.33178E-07	0.1177E 00	0.	0.
29	0.84510E-08	-0.6281E-02	0.	180.000	109	0.33491E-07	0.1020E 00	0.	0.
30	0.87640E-08	-0.7299E-02	0.	180.000	110	0.33804E-07	0.7997E-01	0.	0.
31	0.90770E-08	-0.9834E-02	0.	180.000	111	0.34117E-07	0.5473E-01	0.	0.
32	0.93900E-08	-0.1506E-01	0.	180.000	112	0.34430E-07	0.2992E-01	0.	0.
33	0.97030E-08	-0.2462E-01	0.	180.000	113	0.34743E-07	0.9106E-02	0.	0.
34	0.10016E-07	-0.4039E-01	0.	180.000	114	0.35056E-07	-0.5082E-02	0.	180.000
35	0.10329E-07	-0.6388E-01	0.	180.000	115	0.35369E-07	-0.1158E-01	0.	180.000
36	0.10642E-07	-0.9547E-01	0.	180.000	116	0.35682E-07	-0.1108E-01	0.	180.000
37	0.10955E-07	-0.1335E 00	0.	180.000	117	0.35995E-07	-0.5785E-02	0.	180.000
38	0.11268E-07	-0.1739E 00	0.	180.000	118	0.36308E-07	0.1373E-02	0.	0.
39	0.11581E-07	-0.2104E 00	0.	180.000	119	0.36621E-07	0.7593E-02	0.	0.
40	0.11894E-07	-0.2356E 00	0.	180.000	120	0.36934E-07	0.1100E-01	0.	0.
41	0.12207E-07	-0.2432E 00	0.	180.000	121	0.37247E-07	0.1107E-01	0.	0.
42	0.12520E-07	-0.2297E 00	0.	180.000	122	0.37560E-07	0.8514E-02	0.	0.
43	0.12833E-07	-0.1997E 00	0.	180.000	123	0.37873E-07	0.4819E-02	0.	0.
44	0.13146E-07	-0.1470E 00	0.	180.000	124	0.38186E-07	0.1524E-02	0.	0.
45	0.13459E-07	-0.9225E-01	0.	180.000	125	0.38499E-07	-0.3670E-03	0.	180.000
46	0.13772E-07	-0.4159E-01	0.	180.000	126	0.38812E-07	-0.6699E-03	0.	180.000
47	0.14085E-07	-0.3141E-02	0.	180.000	127	0.39125E-07	0.9255E-04	0.	0.
48	0.14398E-07	0.1901E-01	0.	0.	128	0.39438E-07	0.1026E-02	0.	0.
49	0.14711E-07	0.2571E-01	0.	0.	129	0.39751E-07	0.1350E-02	0.	0.
50	0.15024E-07	0.2177E-01	0.	0.	130	0.40064E-07	0.6890E-03	0.	0.

52	0.15650E-07	0.6660E-02	0.	0.	132	0.40690E-07	-0.2897E-02	0.	180.000
53	0.15963E-07	0.3446E-02	0.	0.	133	0.41003E-07	-0.4966E-02	0.	180.000
54	0.16276E-07	0.3655E-02	0.	0.	134	0.41316E-07	-0.6778E-02	0.	180.000
55	0.16589E-07	0.5311E-02	0.	0.	135	0.41629E-07	-0.8266E-02	0.	180.000
56	0.16902E-07	0.6508E-02	0.	0.	136	0.41942E-07	-0.9497E-02	0.	180.000
57	0.17215E-07	0.6486E-02	0.	0.	137	0.42255E-07	-0.1052E-01	0.	180.000
58	0.17528E-07	0.5639E-02	0.	0.	138	0.42568E-07	-0.1126E-01	0.	180.000
59	0.17841E-07	0.4779E-02	0.	0.	139	0.42881E-07	-0.1150E-01	0.	180.000
60	0.18154E-07	0.4409E-02	0.	0.	140	0.43194E-07	-0.1103E-01	0.	180.000
61	0.18467E-07	0.4510E-02	0.	0.	141	0.43507E-07	-0.9703E-02	0.	180.000
62	0.18780E-07	0.4816E-02	0.	0.	142	0.43820E-07	-0.7599E-02	0.	180.000
63	0.19093E-07	0.5185E-02	0.	0.	143	0.44133E-07	-0.4990E-02	0.	180.000
64	0.19406E-07	0.5734E-02	0.	0.	144	0.44446E-07	-0.2273E-02	0.	180.000
65	0.19719E-07	0.6706E-02	0.	0.	145	0.44759E-07	0.1406E-03	0.	0.
66	0.20032E-07	0.8291E-02	0.	0.	146	0.45072E-07	0.1933E-02	0.	0.
67	0.20345E-07	0.1054E-01	0.	0.	147	0.45385E-07	0.2931E-02	0.	0.
68	0.20658E-07	0.1339E-01	0.	0.	148	0.45698E-07	0.3128E-02	0.	0.
69	0.20971E-07	0.1670E-01	0.	0.	149	0.46011E-07	0.2658E-02	0.	0.
70	0.21284E-07	0.2018E-01	0.	0.	150	0.46324E-07	0.1763E-02	0.	0.
71	0.21597E-07	0.2340E-01	0.	0.	151	0.46637E-07	0.7325E-03	0.	0.
72	0.21910E-07	0.2580E-01	0.	0.	152	0.46950E-07	-0.1571E-03	0.	180.000
73	0.22223E-07	0.2681E-01	0.	0.	153	0.47263E-07	-0.7175E-03	0.	180.000
74	0.22536E-07	0.2598E-01	0.	0.	154	0.47576E-07	-0.8972E-03	0.	180.000
75	0.22849E-07	0.2319E-01	0.	0.	155	0.47889E-07	-0.7945E-03	0.	180.000
76	0.23162E-07	0.1866E-01	0.	0.	156	0.48202E-07	-0.6232E-03	0.	180.000
77	0.23475E-07	0.1302E-01	0.	0.	157	0.48515E-07	-0.6453E-03	0.	180.000
78	0.23788E-07	0.7129E-02	0.	0.	158	0.48828E-07	-0.1099E-02	0.	180.000
79	0.24101E-07	0.1931E-02	0.	0.	159	0.49141E-07	-0.2152E-02	0.	180.000
80	0.24414E-07	-0.1809E-02	0.	180.000	160	0.49454E-07	-0.3899E-02	0.	180.000

TOTAL ENERGY RADIATED = 0.4833E-12 JOULES/STERADIAN (THETA= 90.000 DEG., PHI= 0. DEG.)
TIME DOMAIN POWER GAIN = -10.[illegible] DB
TIME DOMAIN DIRECTIVE GAIN = -8.02 DB

RUNNING TIME=-1304.000 SEC.

••• DATA CARD••[illegible] 0 [illegible] 0.0. 0. 0. 0.

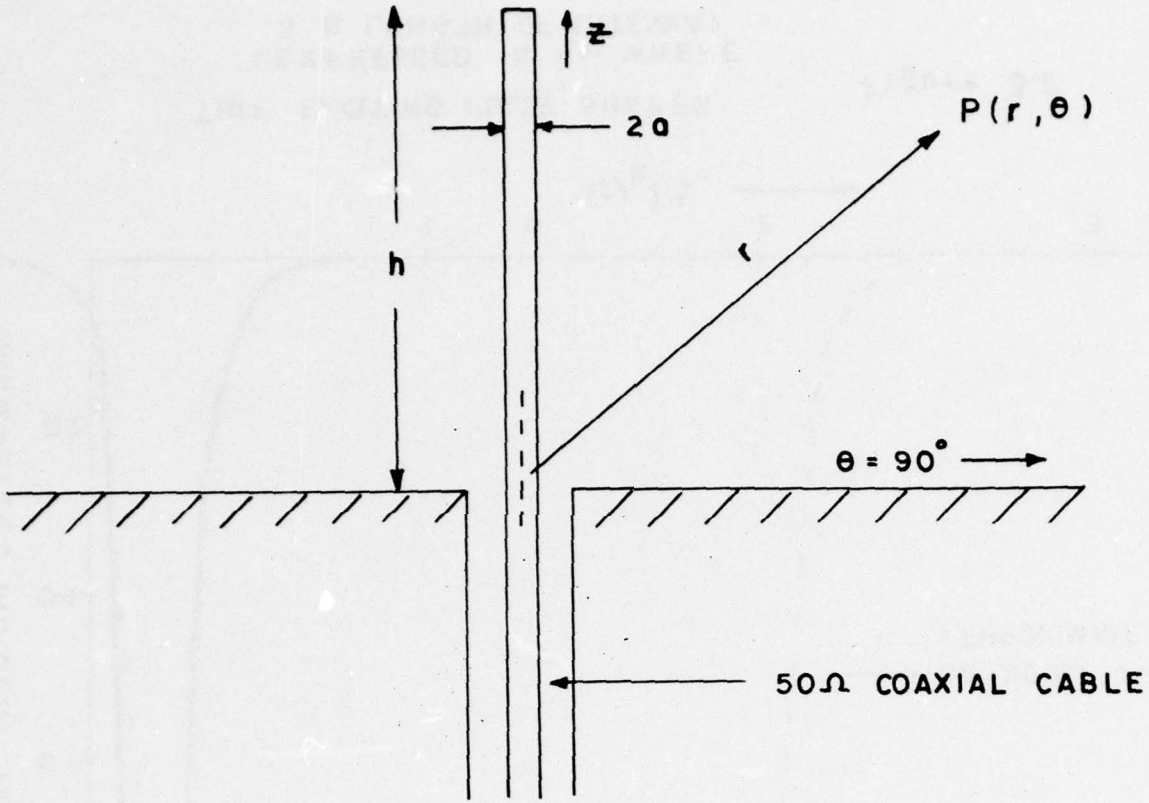
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SECTION III Comparison of Computed and Measured Results

3.0 The purpose of this section is to present and analyze the response of a monopole antenna to short base-band pulses. Both the transmitting and receiving computed responses will be presented and compared to measurements previously published.[2] The computed results were obtained by plotting the output of the TIMDOM program previously discussed.

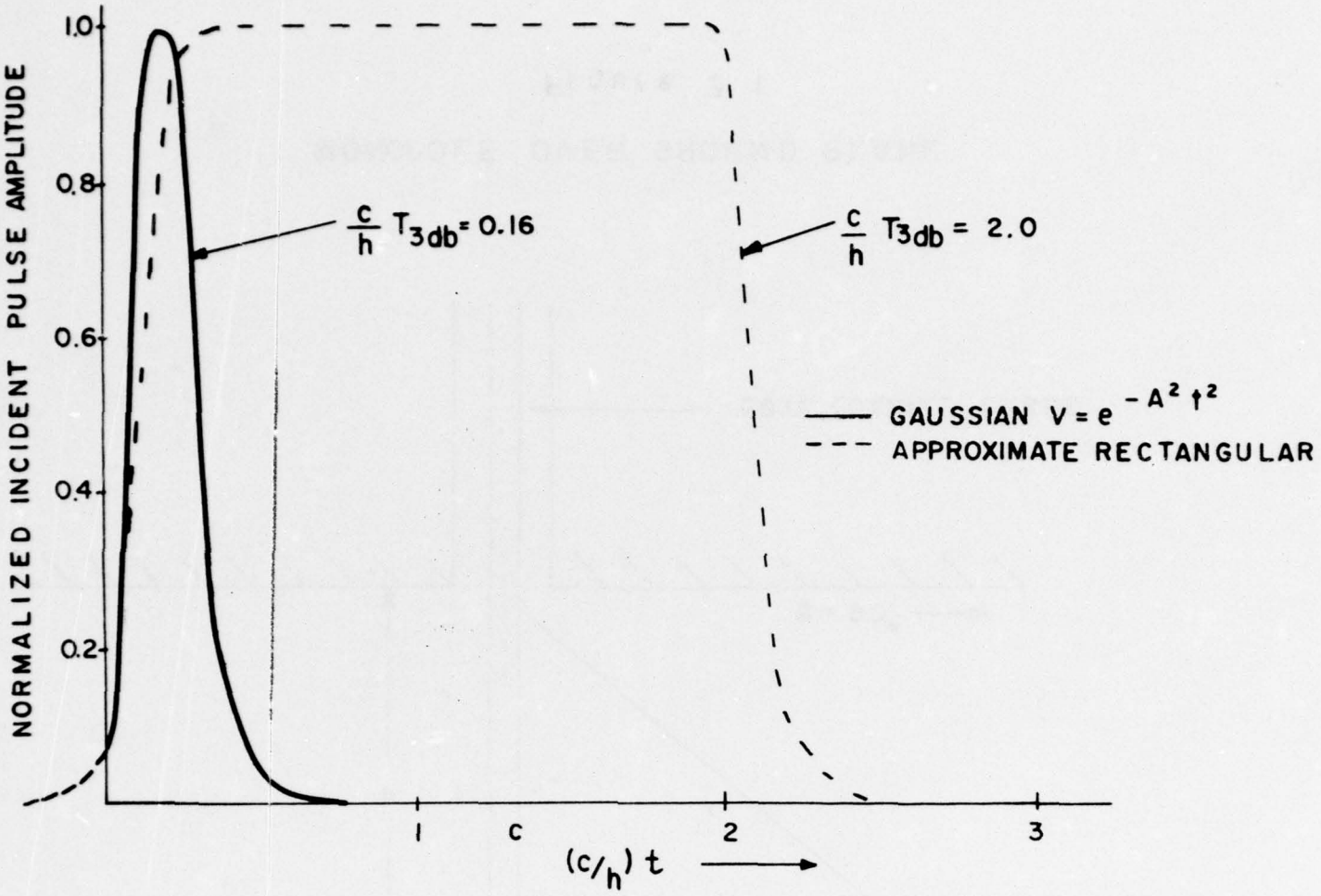
3.1 Transmitting Response.

The cylindrical monopole and its zero resistivity ground plane and coaxial feed geometry are shown in Figure 3.1. The specific antenna geometry and excitation used in the computation was scaled in the time domain to the actual measurement geometry.[2] Two dc pulse excitations were used and are shown in Figure 3.2. The excitations are plotted with respect to h/c, the one-way travel time on the antenna where "h" is the monopole length and "c" is the free space velocity of propagation. The narrow excitation is a Gaussian pulse with 3db pulse width of 0.16 h/c (1.6 ns) since h is three meters in the computed case. The broader excitation represents a rectangular pulse with 3db width of 2.0 h/c.



MONOPOLE OVER GROUND PLANE

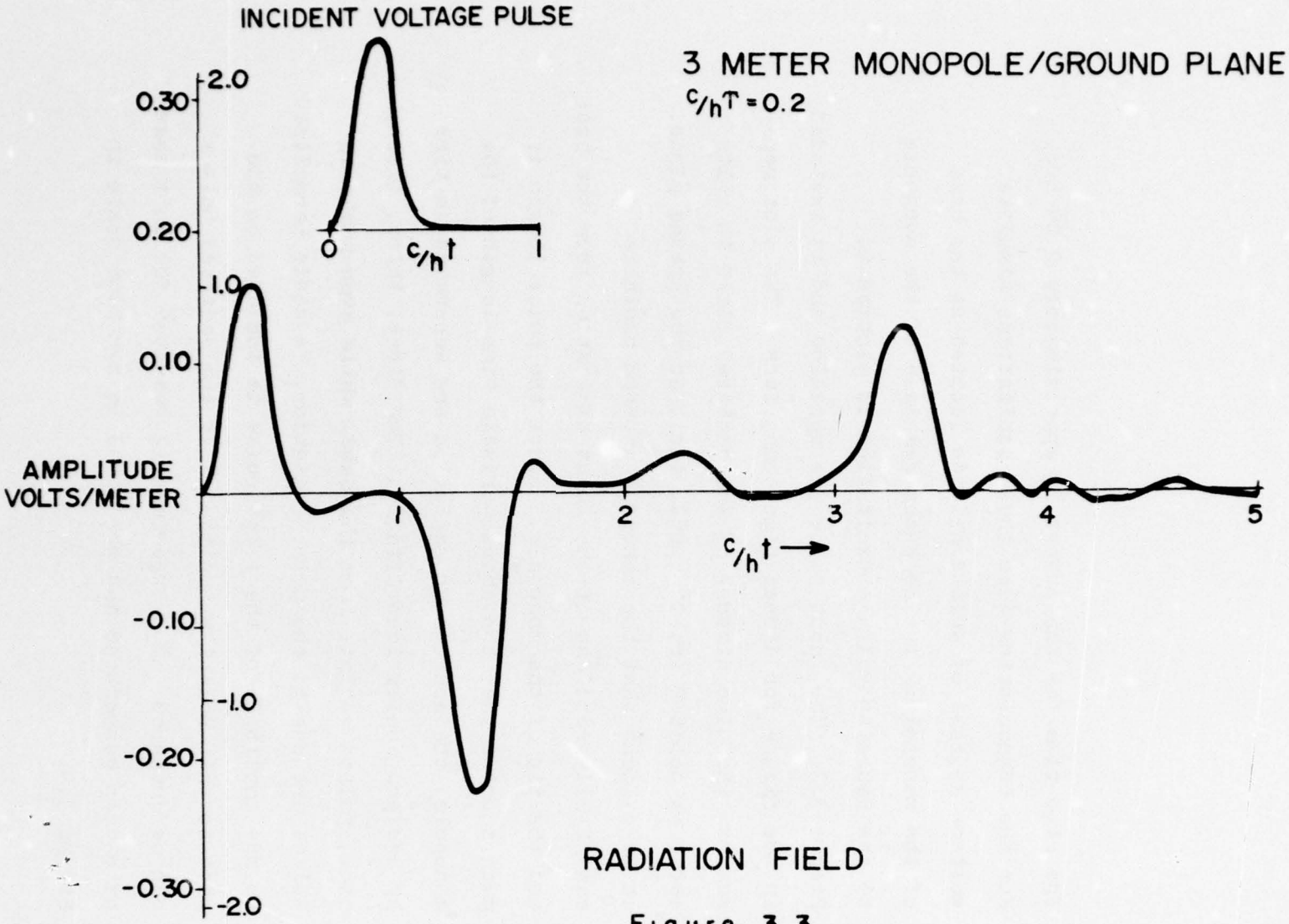
Figure 3.1



TIME EXCITING PULSE SHAPES
(EXPRESSED IN h/c WHERE
h IS LENGTH OF ANTENNA)

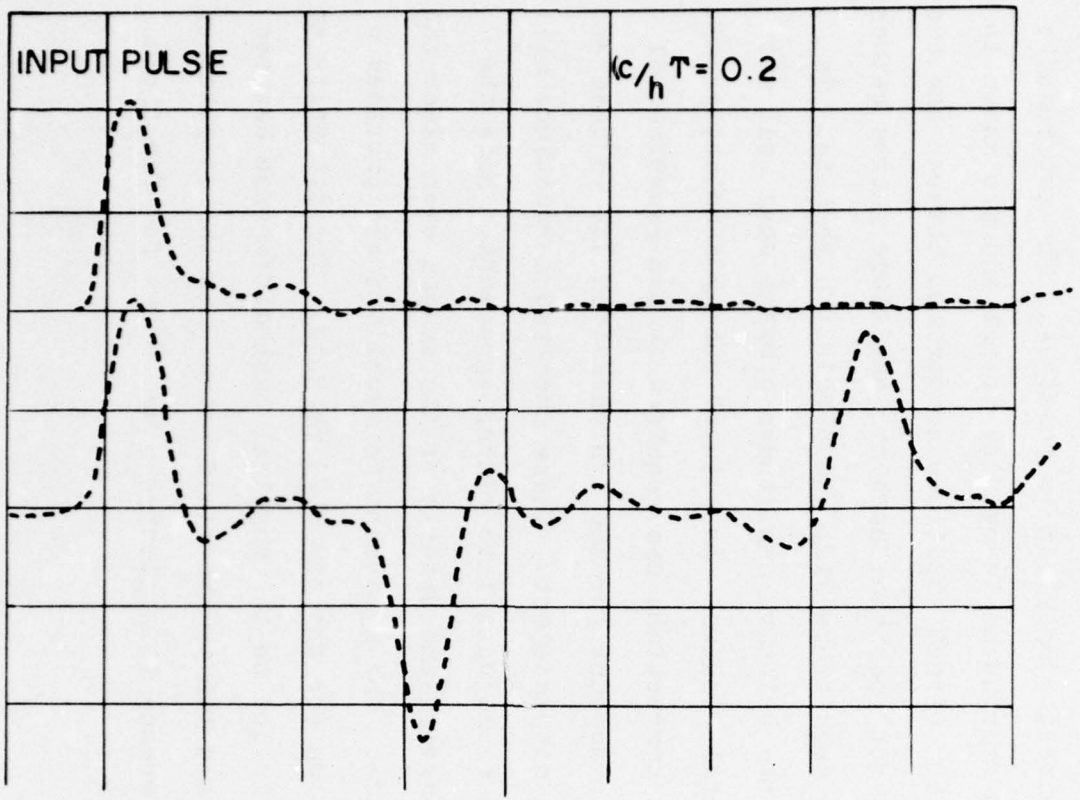
Figure 3.2

The rise time for the pulses is approximately 0.05 h/c. For the transmitting case these excitations simulate voltage sources of unit amplitude located at the base of the monopole. The computed response of the monopole to the Gaussian voltage excitation is plotted in Figure 3.3. The input pulse was rescaled and is included in the figure for direct time comparison. The plot represents the time history of the radiated field in volts/meter at point P (r, 90^{o}, 0^{o}), i.e., at the ground plane. It is evident that the monopole antenna radiates essentially replicas of the input excitation from the base and the tip of the monopole. Since the pulse length is much shorter than the characteristic time-length of the monopole, the sources of radiation are separated in time by h/c and easily identifiable. The first, third, fifth, etc., pulses radiate from the base, while even-numbered pulses are due to end point radiation. A scale normalized to the amplitude of the first pulse is included on the plot so that relative amplitudes of the radiated pulses can be compared. The experimental results[2] for this case have been reproduced and replotted in h/c time scale in Figure 3.4.



RADIATION FIELD

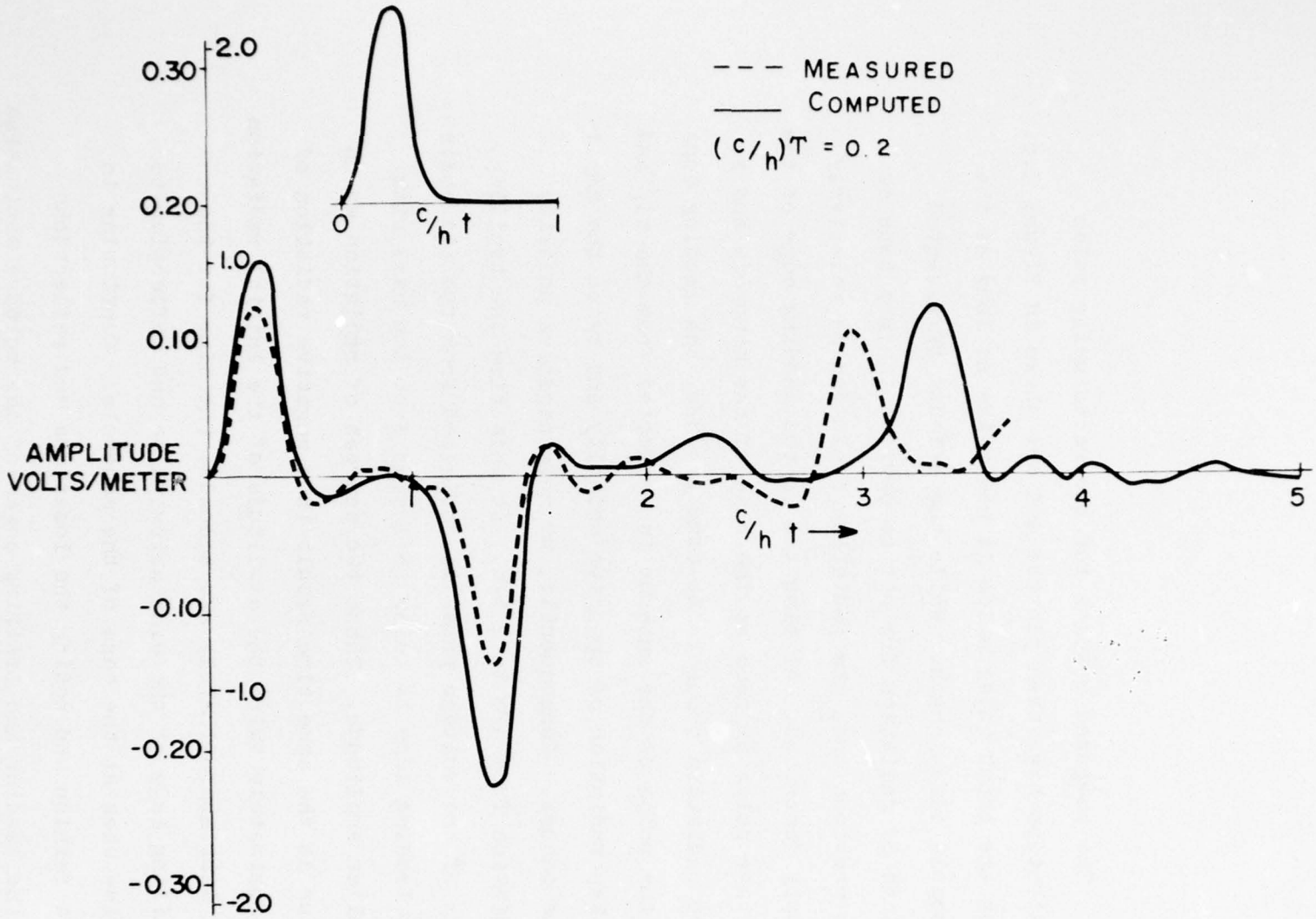
Figure 3.3



MEASURED RADIATION FIELD

FIGURE 3.4

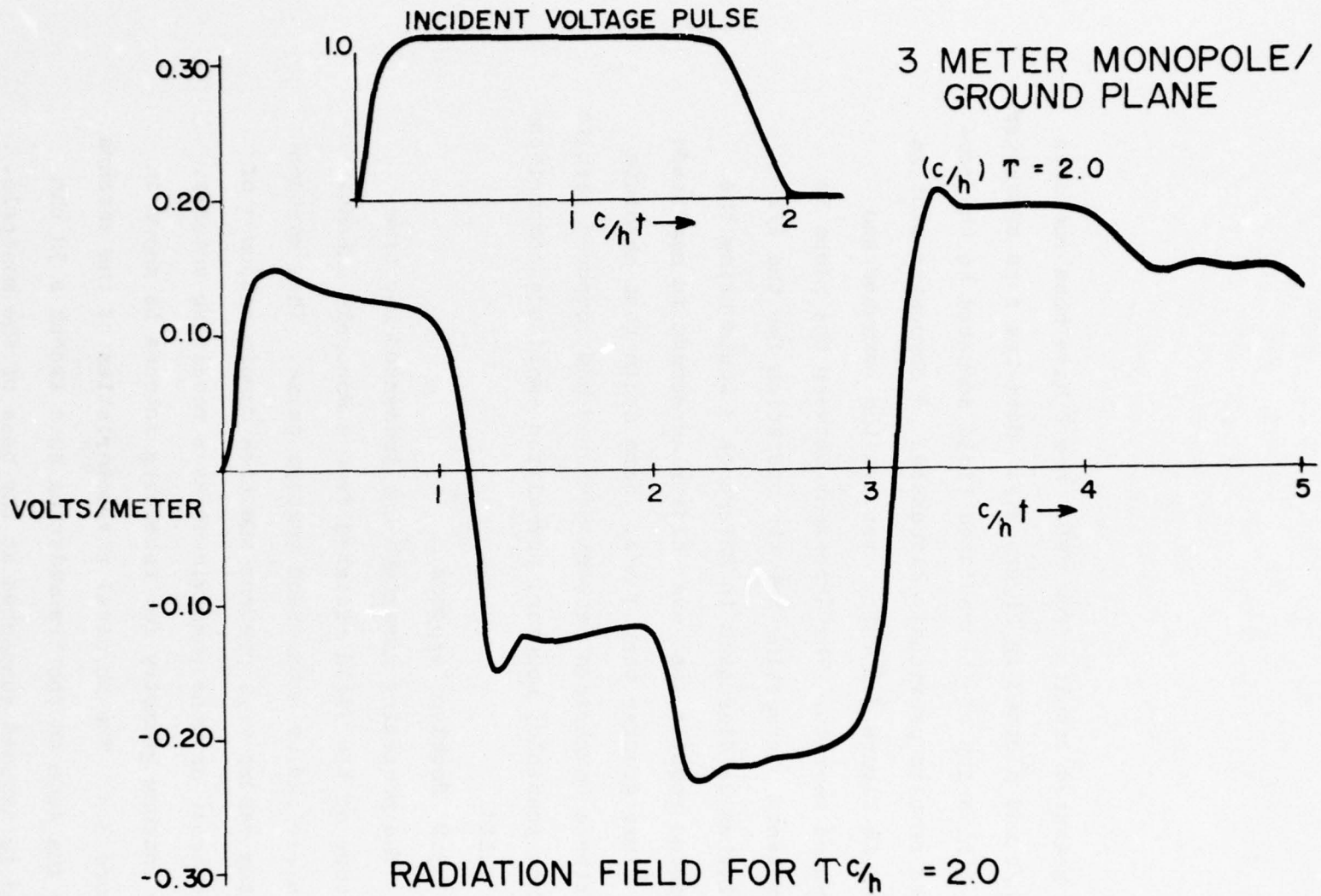
Since both computed and measured results have been plotted in h/c, direct comparison is possible. The two results have been reproduced in overlay format and are shown in Figure 3.5. Direct amplitude comparison between the two traces is not possible; however, amplitude ratios between pulses in each trace will yield relative results. In general, the relative amplitudes compare very well with experimental results. As pointed out by Schmitt, et al., Page 122, corrections are required in the experimental results to account for the 1/R variation due to base and end point displacement. These required corrections will bring the amplitudes into closer agreement. Note the zero crossovers and details of the pulses even after the third pulse. The agreement is excellent and provides a verification for the computed results. The disparity at time t=3 is due to the physical path difference between the base and tip to the field point. In the computation, this difference is neglected since $R \to \infty$ for far field calculations.



COMPUTED **vs** MEASURED RADIATION FIELD

Figure 3.5

The computed results for the rectangular pulse excitation have been plotted and are shown in Figure 3.6. Note the input pulse which is now twice as long as the monopole time-length. While the effects of isolated points of radiation are not as obvious in this case as the previous one, the radiation field can be relatively simply described. At time t = 0, the leading edge of the voltage pulse emerges at the base of the monopole and a step radiation occurs. At time t = h/c, the leading edge of the pulse on the antenna is reflected from the tip and a step radiation of opposite polarity and twice the amplitude occurs. Consequently, we note negative polarity radiation from h/c to 2 h/c. At this time the trailing edge of the voltage pulse is reflected from the tip while the leading edge is being reflected from the base with smaller amplitude. These two sources of radiation which occur at the same time result in a negative radiation of approximately twice the amplitude of the initial radiation and last approximately h/c seconds, the time for the trailing edge of the excitation pulse and reflection to arrive back at the base of the monopole. Continuing in this fashion and noting the locations and reflections of the leading and trailing edges of the voltage excitation predicts the radiated field from 3 h/c to 5 h/c.



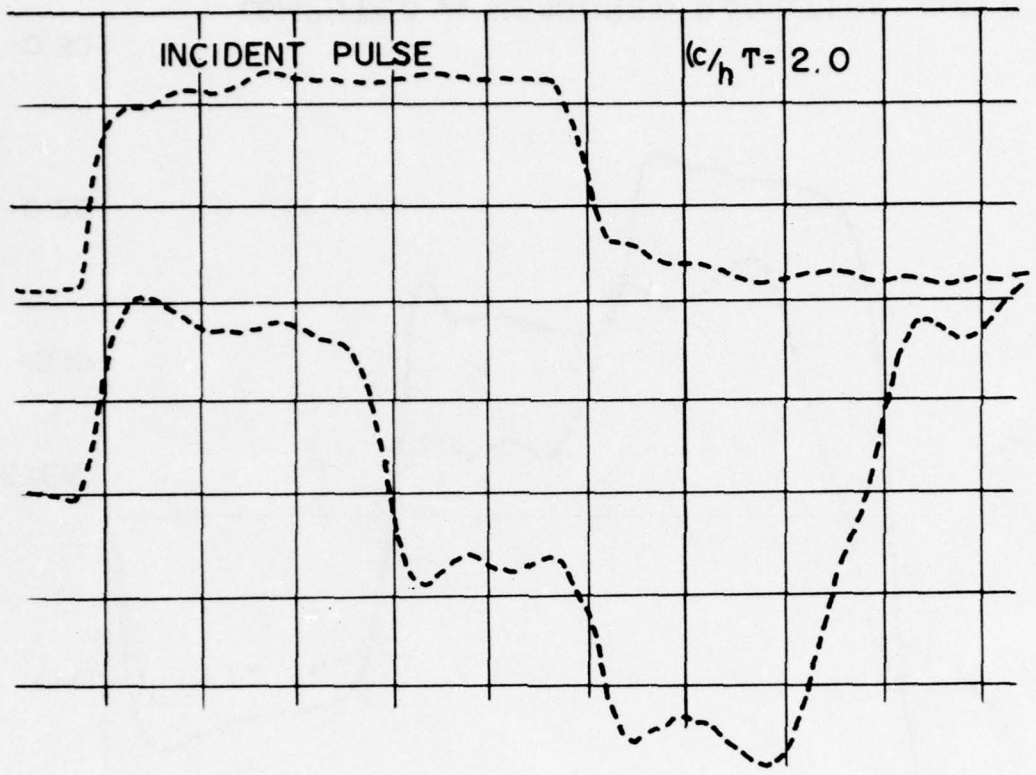
RADIATION FIELD FOR $T\,c/h = 2.0$

Figure 3.6

The measured results from Reference 2 have been rescaled in h/c and plotted in Figure 3.7. Note the zero crossover and similarity of the radiated field compared to the computed results previously discussed. A composite plot is shown in Figure 3.8 which overlays the computed and measured results. The agreement between the plots is excellent. Correcting the tip radiation for the 1/R variation as discussed in Reference 3 would bring the computed results into even closer agreement in amplitude for times greater than 3 h/c. Note again that absolute amplitude comparison between measured and computed results is not possible; however, normalized amplitude comparisons are valid.

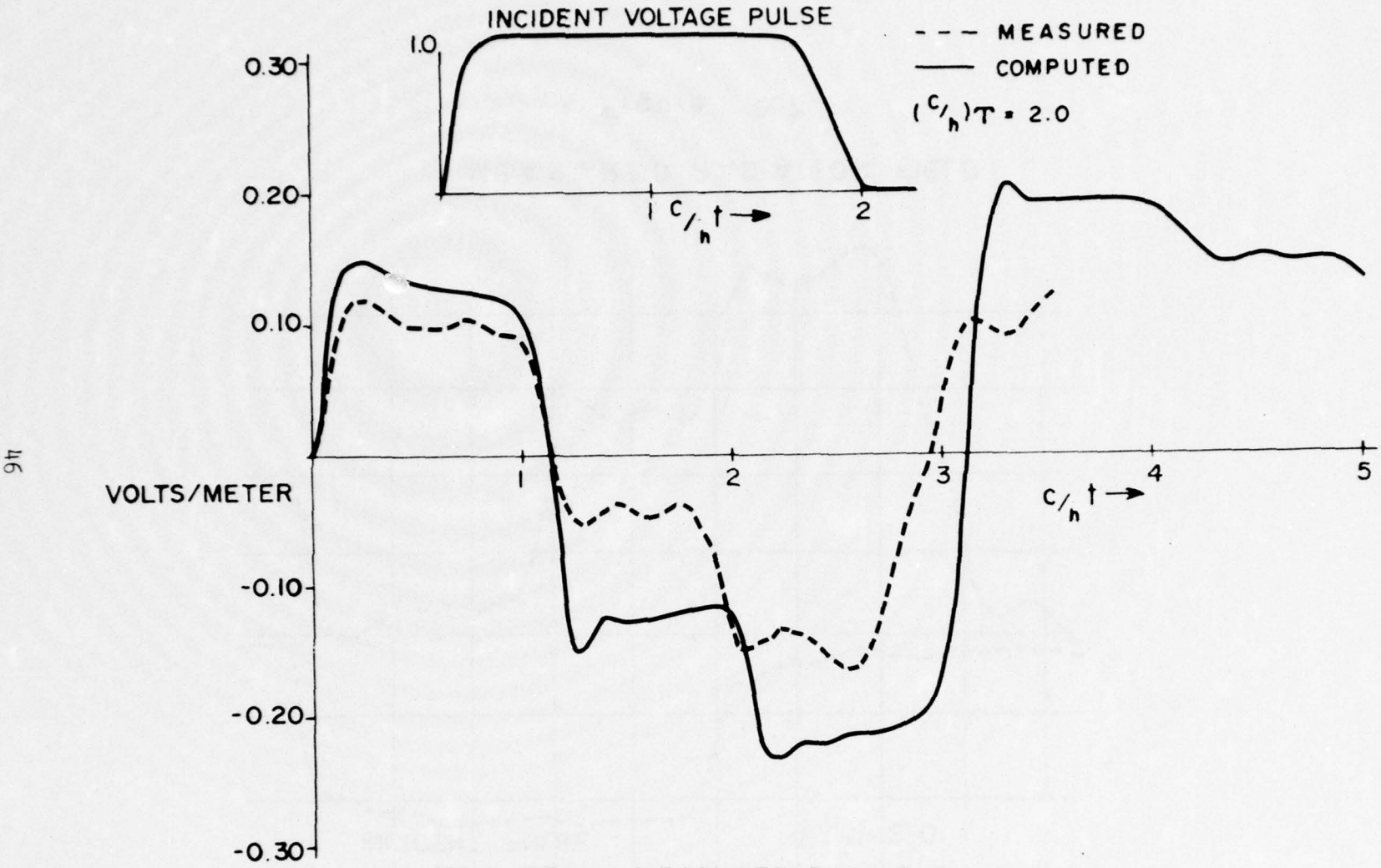
3.2 Receive Response.

The preceding paragraph has presented the time history of the field radiated from a monopole antenna when excited by a baseband voltage pulse. This section of the report will present the time domain response of a monopole antenna when viewed as a receiving antenna. The antenna geometry for receiving antenna is shown in Figure 3.9. The physical characteristics of the antenna are the same as the transmitting case except a 50 ohm load is assumed connected at the base of the monopole.



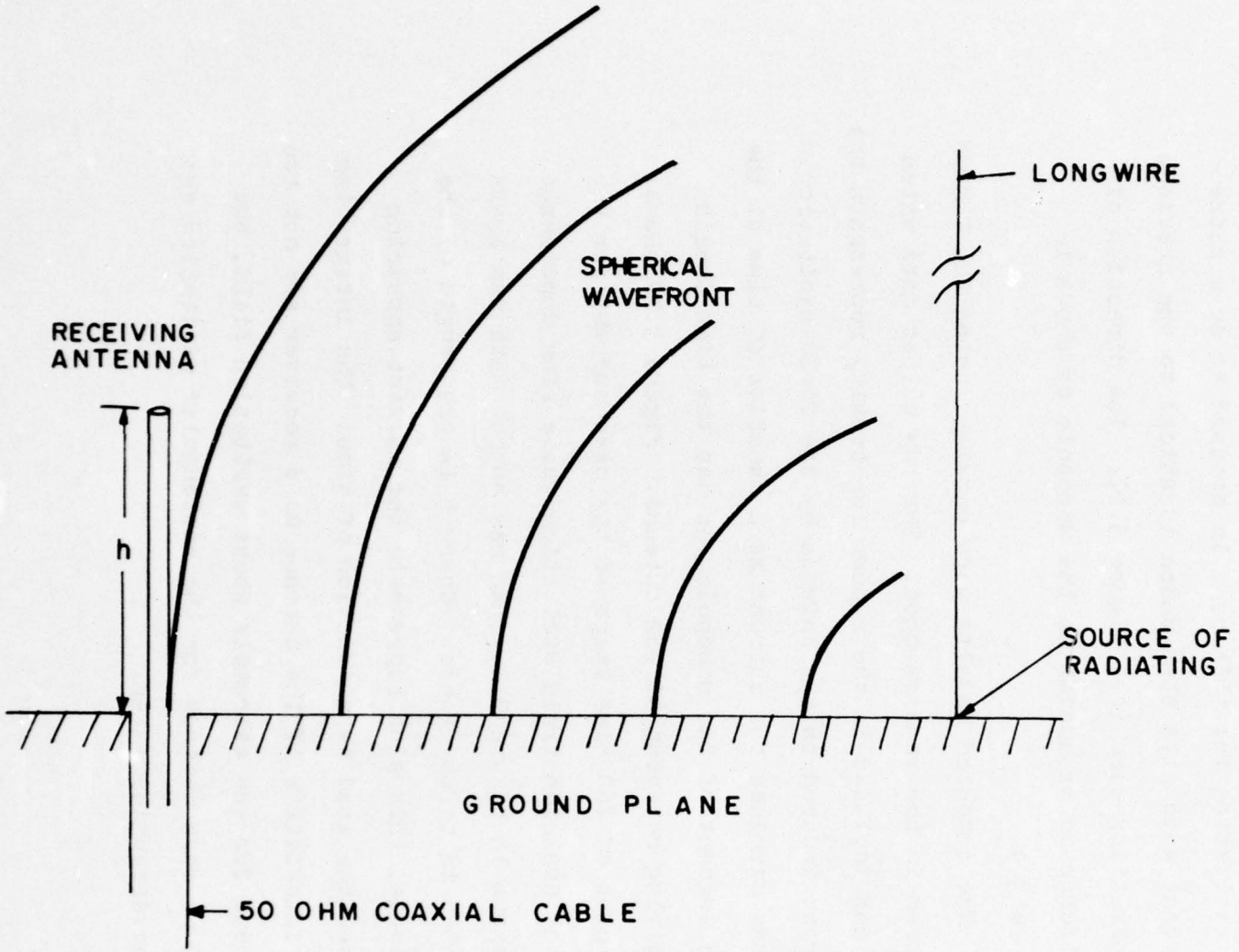
MEASURED RADIATION FIELD

Figure 3.7



COMPUTED vs MEASURED RADIATION FIELD

Figure 3.8



RECEIVING ANTENNA GEOMETRY

Figure 3.9

The excitation for this case is assumed to be a plane incident wave with time shape identical to the previous transmitting case (see Figure 3.2). The direction of incidence is broadside to the monopole as shown in Figure 3.9.

The computed results were obtained using the TIMDOM program in the receive mode. The raw output data which was not included in the report for brevity represents the current induced on the antenna by the field excitation. If one examines the current as a function of time at the base segment of the monopole, he has the time domain receiving response of the antenna. Figure 3.10 shows the plot of 160 time steps of the base current for the narrow Gaussian field excitation whose time dependence is shown in Figure 3.2. The raw output data was again plotted in terms of h/c. Where h is the length of the monopole, this plot represents the current appearing across the load as a function of time. The integrating characteristics of the antenna as a receiver are not too obvious for the extremely short excitation field, but will be more obvious for the rectangular excitation case to be discussed later.

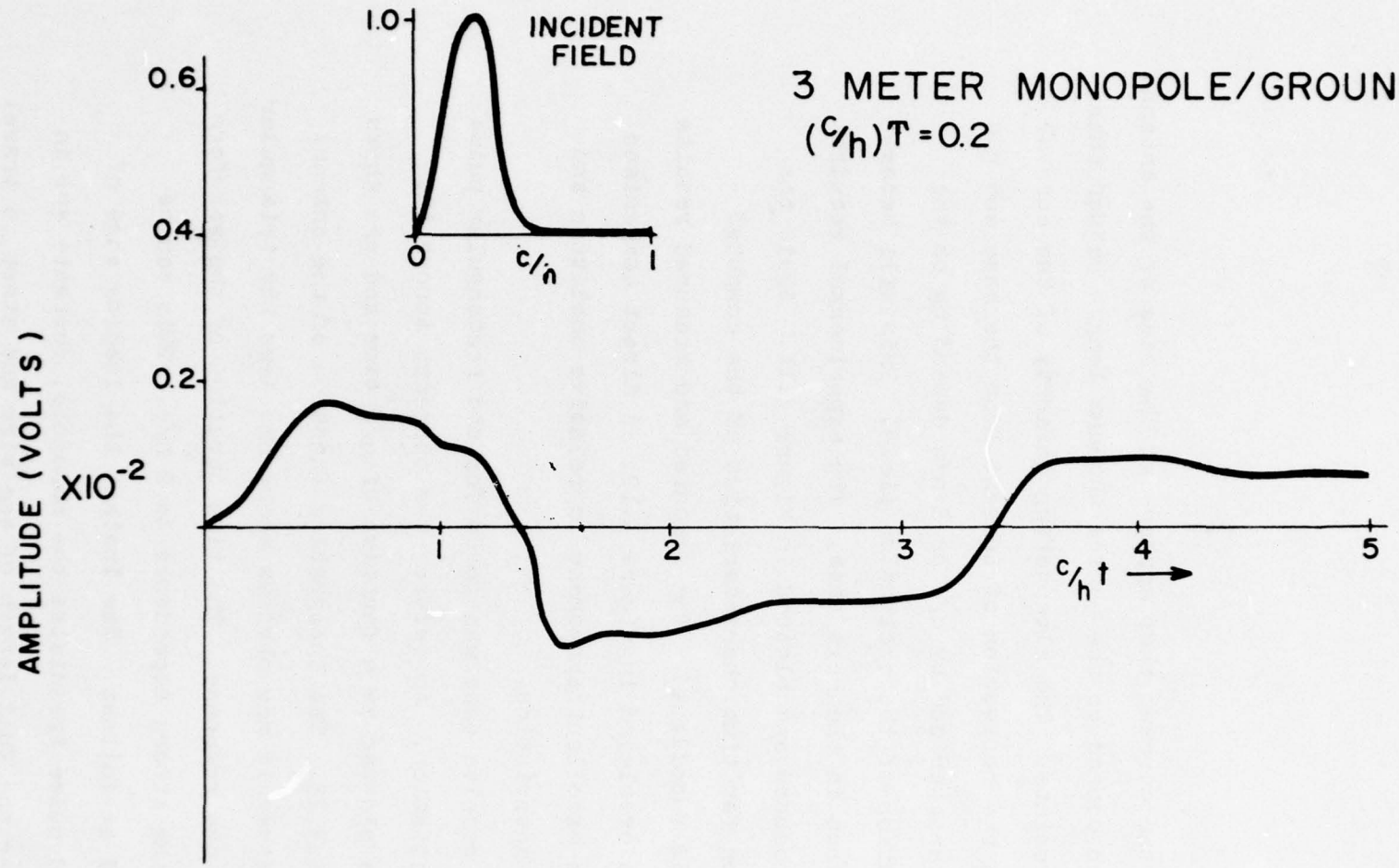
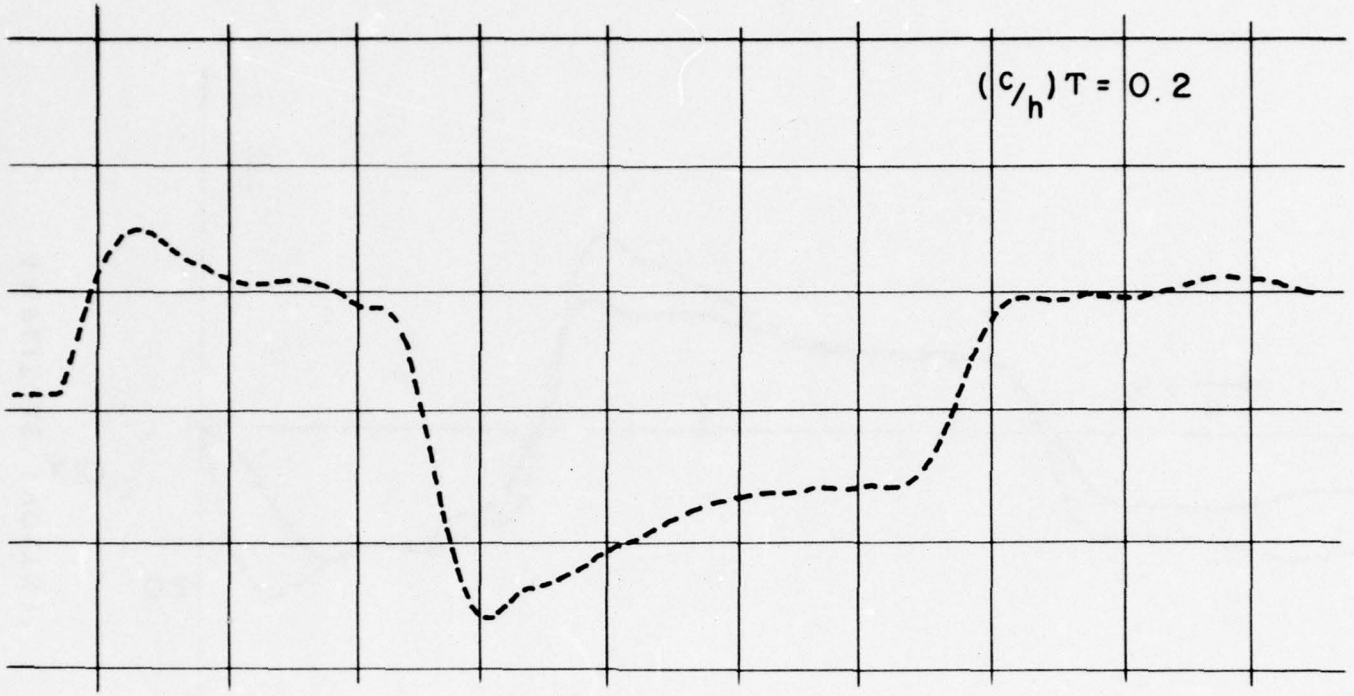

INCIDENT FIELD
1.0
0
c/h
1
3 METER MONOPOLE/GROUND
(c/h)T = 0.2
0.6
0.4
0.2
AMPLITUDE (VOLTS)
X10-2
1
2
3
4
5
c/h t
RECEIVE WAVEFORM

Figure 3.10

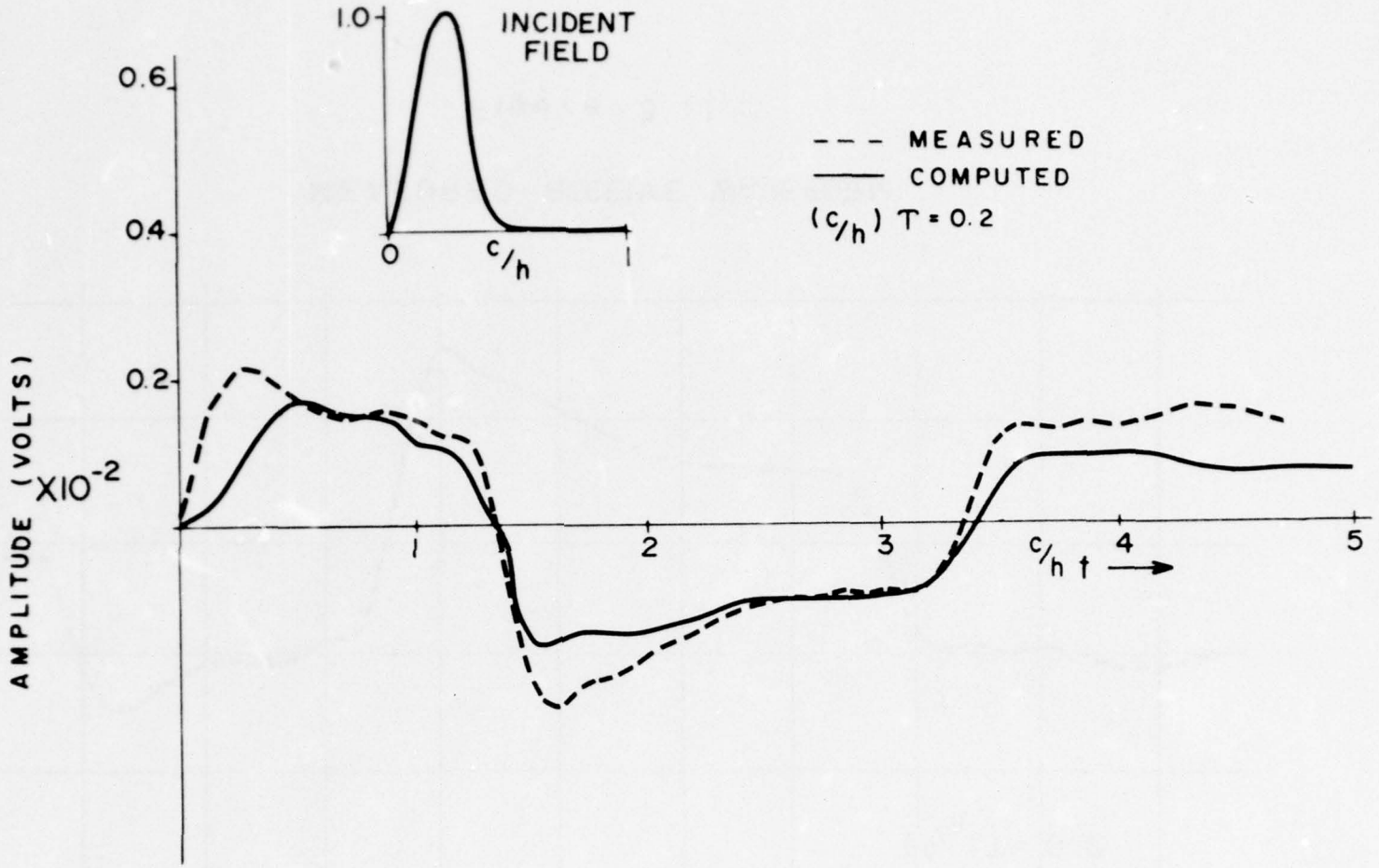
However, the current that appears at the base of the antenna is seen to depend on the entire antenna length rather than isolated points. The alternating polarity of the current is due to the reflection of current from the base and tip and is characterized by h/c or 2 h/c depending on the time duration of the excitation field. This will become more obvious in the next case. The experimental results were reproduced and plotted in Figure 3.11. Again the comparison for time characteristics of the computed results is excellent. The computed and measured results have been overlayed in Figure 3.12. A direct comparison shows the excellent agreement in relative amplitude and time characteristics.

The receive case was rerun for the rectangular pulse field excitation. As before, the currents across the load were plotted as a function of h/c time and are shown in Figure 3.13. The integrating function of the antenna as a receiver is now obvious where one sees the triangular shape of the response. The time duration of the waveform reveals the strong dependence on 2 h/c. This can be explained as follows. The instant the leading edge of the field pulse irradiates the monopole, currents are induced over the full length of the wire and start to travel in both directions along the wire axis.



MEASURED RECEIVE WAVEFORM

Figure 3.11



COMPUTED VS MEASURED RECEIVE WAVEFORM

Figure 3.12

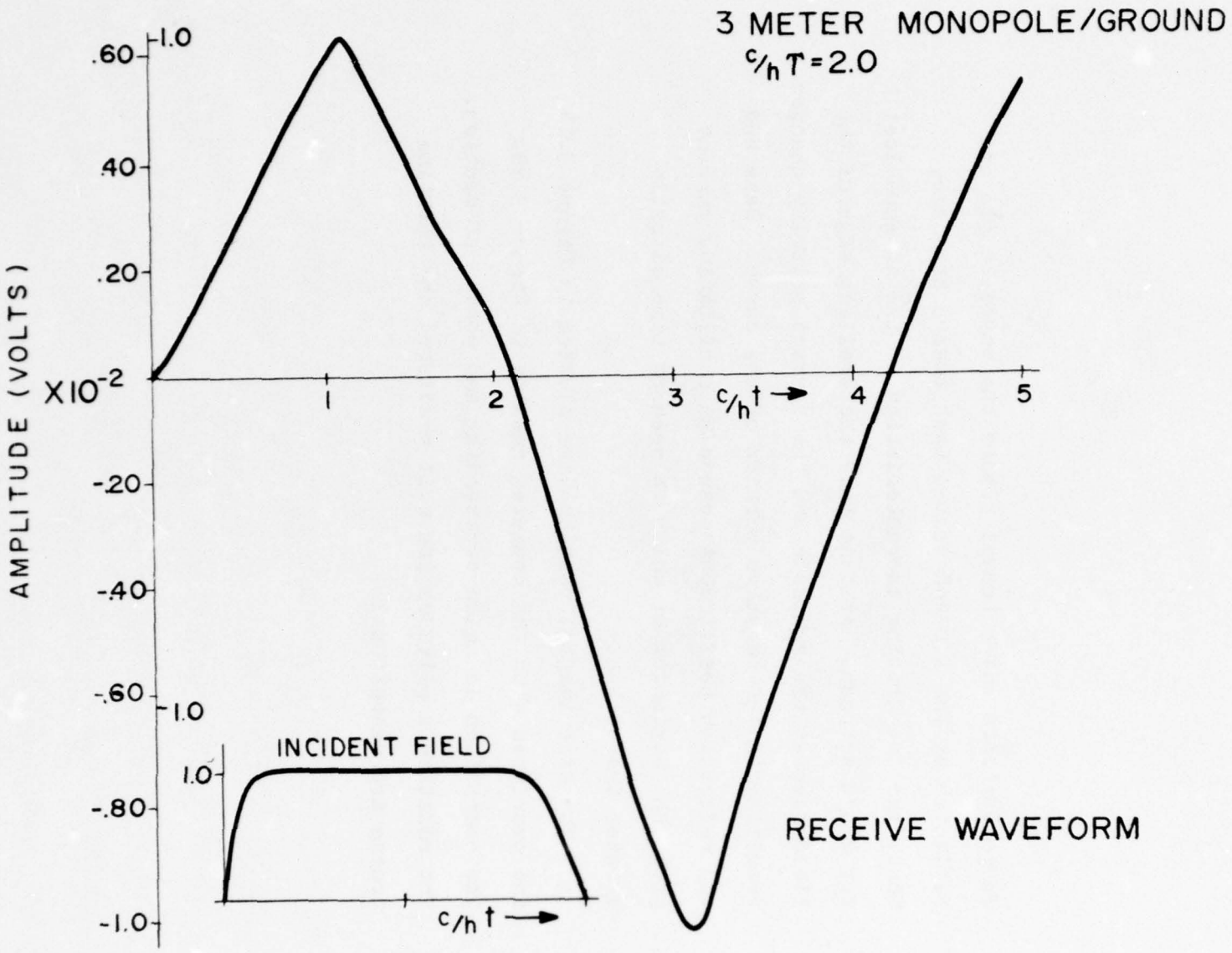
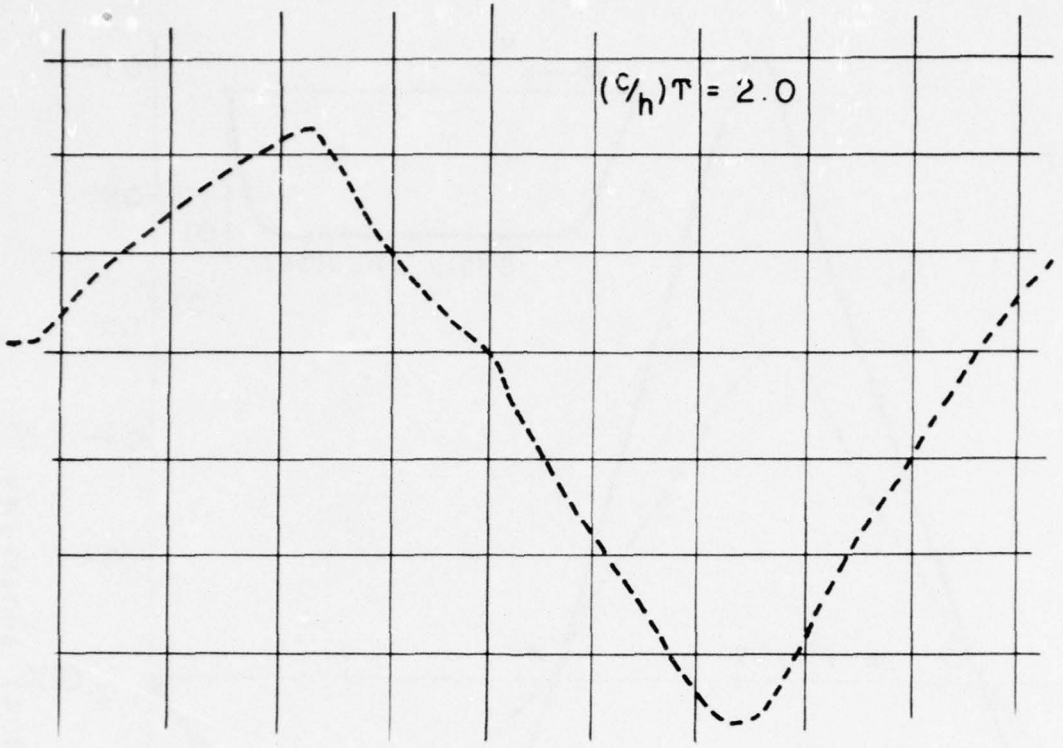

3 METER MONOPOLE/GROUND
c/h T = 2.0
AMPLITUDE (VOLTS)
X10-2
1.0
.60
.40
.20
-.20
-.40
-.60
-.80
-1.0
1
2
3
4
5
c/h t →
INCIDENT FIELD
1.0
c/h t →
RECEIVE WAVEFORM

Figure 3.13

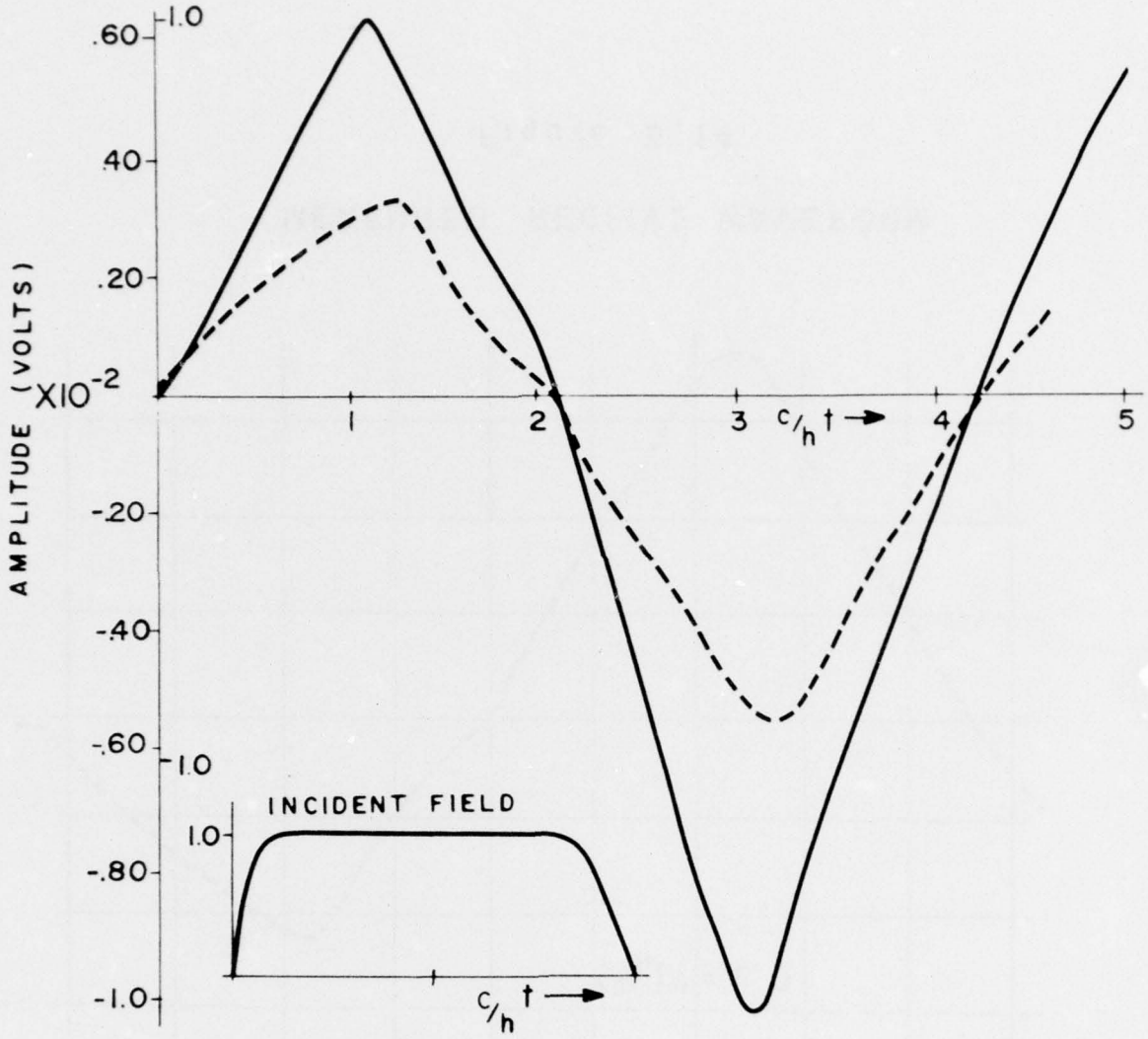
Those currents which travel toward the monopole tip are reflected at the tip and travel back toward the base. Thus, the integrating characteristics of the antenna last for 2 h/c seconds. At that time the trailing edge of the field reaches the monopole and the current polarity changes resulting in the negative portion of the curve. Base and tip reflection coefficients cause an oscillating current plot, the beginning of which is seen at time slightly greater than 4 h/c.

The experimental results were plotted in Figure 3.14 and overlayed with the computed results in Figure 3.15. The comparison is again outstanding and worthy of mention. The relative amplitudes are well predicted and the time traces are exceptional.



MEASURED RECEIVE WAVEFORM

Figure 3.14



COMPUTED VS MEASURED RECEIVE WAVEFORM
Figure 3.15

SECTION IV Conclusions and Recommendations

A computer routine based upon direct time domain calculations has been presented and discussed. A walk-through description of inputting the data and interpreting the output has been provided through an example case to familiarize the reader with the ease of user interface. The computer results have been discussed and critically compared with experimentation. The comparison is exceptional and establishes the validity of the program. The program can be used to predict the transmitting and receiving properties of the class of thin wire antennas directly in the time domain. In addition, although not done in this report, the scattered field can also be obtained through the program. The scattered field is the field reradiated from the antenna when irradiated by a field. It results from the radiation caused by the currents induced on the structure due to the field irradiation.

The utility of direct time domain solutions for pulse excitations is receiving more and more consideration in antenna and scatterer analysis. Although this report has not attempted to establish the utility of direct time domain solutions, its importance as an analytical tool

should not be overlooked. It offers considerably more information concerning the broadband frequency performance of an antenna than does c.w. analysis. In addition, the Fourier transform of the time response (an option in the TIMDOM program) can be used to obtain the frequency response of the antennas modeled. If one is concerned with short pulse excitations and time waveform distortions the time domain offers a direct evalution of antenna response. However, if characteristics such as beam width, impedance, admittance, etc., are important, then the frequency domain offers analytical advantages. Nevertheless, it is apparent that direct time domain solutions offer a new look at antenna performance and should be useful to the antenna analyst and designer. A Fortran listing of the TIMDOM program is included in this report as Appendix A. It must be reemphasized that the computer routine was prepared for user-oriented ease of operation and can be used with only minimal theoretical or numerical techniques understanding.

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SECTION V References

(1) "Time Domain Antenna Study" (Final Report), NRL Contract N00014-73-C-0099

(2) Harrington, R.F., "Field Computations By Method of Moments", MacMillan, NY, 1968

(3) Schmitt, H.J., Harrison, C.W., and Williams, Jr. C.S., "Calculated and Experimental Response of Thin Cylindrical Antennas to Pulse Excitation", IEEE Trans. on Antennas & Propagation, Vol. AP-14, March 1966

APPENDICES

The following appendices are included for those interested in implementation of the program on specific machines.

Appendix A contains a Fortran listing of the TIMDOM program which was written by MB Associates under joint sponsorship by the Navy and Air Force under Contracts N00014-73-C-0099 and F30602-72X0008. The listing contains all subroutines in alphabetical order and all are written in Fortran.

Appendix B contains a listing of all machine independent diagnostics which appear in the program to aid the user.

Machine dependent subroutines employed in the program which are specific to the Honeywell/GE635 computer, are identified and listed in Appendix C.

APPENDIX A

```
C     TIME DOMAIN ANTENNA MODELING PROGRAM                                    TW   1
      COMMON /DATA/  N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),      TW   2
     1    BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ                TW   3
      COMMON /SCOMP/  SX(200),SY(200),SZ(200)                                 TW   4
      COMMON /CONST/  CDT,VEL,DT,NTSTEP                                       TW   5
      COMMON /LOAD/  RES(200),ELD(200),CAP(200),ILOAD                         TW   6
      COMMON /IOFLG/  NCFMX,NCQMX,IOC,IOCQ,NTMAX,NBOUT,JP1,JP2                TW   7
      COMMON /MATPAR/  NBLOKS,NPBLK,NLAST,INX                                 TW   8
      COMMON /ARRAY/  CQ(6400)                                                TW   9
      COMMON /ESORC/  ESORC(1024),IFST,NTRAN,MTRAN,NTNX,DFRQ,ENIN,ENRD,I      TW  10
     1FEN                                                                     TW  11
      COMMON /ASORC/  EMAG(10),ISRC(10),NSRC                                  TW  12
      COMMON /CMAT/  CURF(1600),IP(200),IX(200)                               TW  13
      DIMENSION COM(13,5), ITST(8)                                            TW  14
      INTEGER  HX,HY,HZ                                                       TW  15
      DATA    HX,HY,HZ/1HX,1HY,1HZ/                                           TW  16
      DATA    ITST/2HCM,2HCE,2HAT,2HRF,2HPC,2HNX,2HEN,2HEB/                   TW  17
      RTM1=0.                                                                 TW  18
      RTM2=0.                                                                 TW  19
      RTM3=0.                                                                 TW  20
      CALL SECOND (RTM1)                                                      TW  21
      NCFMX=17600                                                             TW  22
      NCQMX=6400                                                              TW  23
      IRESRV=1600                                                             TW  24
      VEL=2.998E+8                                                            TW  25
      PI=3.1415926                                                            TW  26
      TA=PI/180.                                                              TW  27
      TD=180./PI                                                              TW  28
      NTNX=1024                                                               TW  29
1     PRINT 57                                                                TW  30
      CALL SECOND (RTM2)                                                      TW  31
      IFEN=0                                                                  TW  32
      IFST=0                                                                  TW  33
      JCOM=0                                                                  TW  34
C                                                                             TW  35
C     READ AND PRINT COMMENT CARDS                                            TW  36
C                                                                             TW  37
2     JCOM=JCOM+1                                                             TW  38
      IF (JCOM.GT.5) JCOM=5                                                   TW  39
      READ 58,  INA,(COM(I,JCOM),I=1,13)                                      TW  40
      PRINT 59,  (COM(I,JCOM),I=1,13)                                         TW  41
      IF (INA.EQ.ITST(1)) GO TO 2                                             TW  42
      IF (INA.EQ.ITST(2)) GO TO 3                                             TW  43
      PRINT 77                                                                TW  44
      STOP                                                                    TW  45
C                                                                             TW  46
C     READ AND PRINT FIRST DATA CARD                                          TW  47
C                                                                             TW  48
3     READ 63,  DT,TMAX,NTSTEP,IPX,IPY,IPZ,ILOAD,JP1,JP2                      TW  49
      PRINT 64,  DT,TMAX,NTSTEP,IPX,IPY,IPZ,ILOAD,JP1,JP2                     TW  50
      CALL IFEH (IPX)                                                         TW  51
      CALL IFEH (IPY)                                                         TW  52
      CALL IFEH (IPZ)                                                         TW  53
C                                                                             TW  54
C     CALL DATAGN TO SET UP STRUCTURE GEOMETRY                                TW  55
C                                                                             TW  56
```

```
      CALL   DATAGN                                                     TW  57
      NP=N                                                              TW  58
      PRINT 60                                                          TW  59
      PRINT 61                                                          TW  60
      SSUM=0.                                                           TW  61
      SMAX=0.                                                           TW  62
      DO 4 I=1,N                                                        TW  63
      AD=ALP(I)*TD                                                      TW  64
      BD=BET(I)*TD                                                      TW  65
      SII=SI(I)                                                         TW  66
      PRINT 62,  I,X(I),Y(I),Z(I),SII,AD,BD,BI(I),ICON1(I),I,ICON2(I),  TW  67
     1 ITAG(I)                                                          TW  68
      SSUM=SSUM+SII                                                     TW  69
      IF (SII.GT.SMAX) SMAX=SII                                         TW  70
4     CONTINUE                                                          TW  71
      PRINT 65,  N,SSUM,SMAX                                            TW  72
C                                                                       TW  73
C     DETERMINE TIME STEPPING INTERVAL, DT                              TW  74
C                                                                       TW  75
      IF (DT.GT.1.E-25) GO TO 5                                         TW  76
      DT=SMAX/VEL                                                       TW  77
      SII=10.**(INT(ALOG10(DT))-3)                                      TW  78
      DT=AINT(DT/SII+.999)*SII                                          TW  79
5     NTMAX=INT(TMAX/DT)+1                                              TW  80
      IF (NTMAX.GT.1) GO TO 6                                           TW  81
      IF (NTSTEP.EQ.0) GO TO 39                                         TW  82
      GO TO 8                                                           TW  83
6     IF (NTSTEP.GT.0) GO TO 7                                          TW  84
      NTSTEP=NTMAX                                                      TW  85
      GO TO 8                                                           TW  86
7     IF (NTMAX.LT.NTSTEP) NTSTEP=NTMAX                                 TW  87
8     TMAX=DT*FLOAT(NTSTEP-1)                                           TW  88
      NTRAN=NTSTEP                                                      TW  89
      IF (NTRAN.GT.NTNX) NTRAN=NTNX                                     TW  90
      CDT=DT*VEL                                                        TW  91
      PRINT 73,  DT,TMAX,NTSTEP                                         TW  92
      IF (JP1.LT.1) GO TO 9                                             TW  93
      IF (JP2.LT.JP1) JP2=JP1                                           TW  94
      GO TO 10                                                          TW  95
9     JP1=1                                                             TW  96
      JP2=N                                                             TW  97
10    PRINT 66                                                          TW  98
      IF (IPX) 11,13,12                                                 TW  99
11    PRINT 67,  HX                                                     TW 100
      GO TO 13                                                          TW 101
12    PRINT 68,  HX                                                     TW 102
13    IF (IPY) 14,16,15                                                 TW 103
14    PRINT 67,  HY                                                     TW 104
      GO TO 16                                                          TW 105
15    PRINT 68,  HY                                                     TW 106
16    IF (IPZ) 17,19,18                                                 TW 107
17    PRINT 67,  HZ                                                     TW 108
      GO TO 19                                                          TW 109
18    PRINT 68,  HZ                                                     TW 110
19    IF (ILOAD.NE.0) PRINT 69                                          TW 111
      IF (ILOAD.EQ.0) PRINT 70                                          TW 112
      PRINT 71,  JP1,JP2                                                TW 113
      IF (ILOAD.EQ.0) GO TO 24                                          TW 114
C                                                                       TW 115
C     READ IMPEDANCE LOADING CARDS                                      TW 116
```

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C                                                                       TW 117
      PRINT 74                                                          TW 118
      DO 20 I=1,N                                                       TW 119
      RES(I)=0.                                                         TW 120
      ELD(I)=0.                                                         TW 121
20    CAP(I)=0.                                                         TW 122
21    READ 75,  J,ITG,II,RESI,ELDI,CAPI                                 TW 123
      I=ISEGNO(ITG,II)                                                  TW 124
      IF (ABS(CAPI),LT.1.E-20) GO TO 22                                 TW 125
      PRINT 76,  ITG,II,I,RESI,ELDI,CAPI                                TW 126
      GO TO 23                                                          TW 127
22    PRINT 76,  ITG,II,I,RESI,ELDI                                     TW 128
23    RES(I)=RESI                                                       TW 129
      ELD(I)=ELDI                                                       TW 130
      CAP(I)=CAPI                                                       TW 131
      IF (J.NE.0) GO TO 21                                              TW 132
24    CALL   CONSET                                                     TW 133
C                                                                       TW 134
C     CALL ESET (ENTRY POINT OF EINCF) TO READ EXCITATION DATA CARDS    TW 135
C                                                                       TW 136
      CALL ESET (RESI)                                                  TW 137
      CALL FBLOCK (NBLOKS,NPBLK,NLAST,IRESRV,N,INX)                     TW 138
      CALL COFS (CURF,CURF,N)                                           TW 139
      CALL FACIO (CURF,CURF,N,IX,IP)                                    TW 140
      CALL SECOND (RTM3)                                                TW 141
      RTM=RTM3-RTM2                                                     TW 142
      PRINT 46,  RTM                                                    TW 143
C                                                                       TW 144
C     SOLVE FOR STRUCTURE CURRENTS                                      TW 145
C                                                                       TW 146
      CALL TSOL (CURF,IX,IP,N)                                          TW 147
      CALL SECOND (RTM)                                                 TW 148
      RTM=RTM-RTM3                                                      TW 149
      PRINT 47,  RTM                                                    TW 150
25    READ 40,  INA,ITM1,ITM2,ITM3,ITM4,TM1,TM2,TM3,TM4                 TW 151
      CALL SECOND (RTM)                                                 TW 152
      RTM=RTM-RTM1                                                      TW 153
      PRINT 48,  RTM                                                    TW 154
      PRINT 41,  INA,ITM1,ITM2,ITM3,ITM4,TM1,TM2,TM3,TM4                TW 155
      IF (INA.EQ.ITST(3)) GO TO 26                                      TW 156
      IF (INA.EQ.ITST(4)) GO TO 27                                      TW 157
      IF (INA.EQ.ITST(5)) GO TO 28                                      TW 158
      IF (INA.EQ.ITST(6)) GO TO 1                                       TW 159
      IF (INA.EQ.ITST(7)) STOP                                          TW 160
      IF (INA.EQ.ITST(8)) GO TO 29                                      TW 161
      PRINT 42                                                          TW 162
      STOP                                                              TW 163
C                                                                       TW 164
C     COMPUTE ANTENNA INPUT ADMITTANCE                                  TW 165
C                                                                       TW 166
26    I=ISEGNO(ITM1,ITM2)                                               TW 167
      CALL ANTRAN (I,TM1,ITM3)                                          TW 168
      GO TO 25                                                          TW 169
C                                                                       TW 170
C     COMPUTE RADIATED FIELDS                                           TW 171
C                                                                       TW 172
27    CALL REPAT (ITM1,ITM2,ITM3,ITM4,TM1,TM2,TM3,TM4)                  TW 173
      GO TO 25                                                          TW 174
C                                                                       TW 175
C     PUNCH CURRENTS                                                    TW 176
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C                                                                       TW 177
28    I=ISEGNO(ITM1,ITM2)                                               TW 178
      CALL CGET (I,CURF,NTRAN)                                          TW 179
      PUNCH 43,  (COM(J,1),J=1,13)                                      TW 180
      PUNCH 44,  NTSTEP,I,ITM1,ITM2                                     TW 181
      PUNCH 45,  (CURF(J),J=1,NTSTEP)                                   TW 182
      GO TO 25                                                          TW 183
C                                                                       TW 184
C     COMPUTE ENERGY BUDGET                                             TW 185
C                                                                       TW 186
29    PRINT 49                                                          TW 187
      ITM2=0                                                            TW 188
      ENIN=0.                                                           TW 189
      ENLS=0.                                                           TW 190
      IF (NSRC.LT.1) GO TO 33                                           TW 191
      IF (IFST.NE.0) GO TO 32                                           TW 192
      IFEN=1                                                            TW 193
      PRINT 50                                                          TW 194
      DO 31 I=1,NSRC                                                    TW 195
      IS=ISRC(I)                                                        TW 196
      VLT=EMAG(I)*SI(IS)                                                TW 197
      CALL CGET (IS,CURF,NTRAN)                                         TW 198
      SUM=0.                                                            TW 199
      DO 30 J=1,NTRAN                                                   TW 200
      RESI=ESORC(J)                                                     TW 201
      IF (RESI.LT.1.E-20) GO TO 30                                      TW 202
      SUM=SUM+RESI*CURF(J)                                              TW 203
30    CONTINUE                                                          TW 204
      SUM=SUM*DT*VLT                                                    TW 205
      PRINT 51,  I,IS,SUM                                               TW 206
31    ENIN=ENIN+SUM                                                     TW 207
      GO TO 33                                                          TW 208
32    PRINT 56                                                          TW 209
33    IF (ILOAD.EQ.0) GO TO 37                                          TW 210
      DO 36 I=1,N                                                       TW 211
      IF (RES(I).LT.1.E-20) GO TO 36                                    TW 212
      IF (ITM2.EQ.1) GO TO 34                                           TW 213
      PRINT 52                                                          TW 214
      ITM2=1                                                            TW 215
34    CALL CGET (I,CURF,NTRAN)                                          TW 216
      SUM=0.                                                            TW 217
      DO 35 J=1,NTRAN                                                   TW 218
35    SUM=SUM+CURF(J)*CURF(J)                                           TW 219
      SUM=SUM*DT*RES(I)                                                 TW 220
      PRINT 53,  I,RES(I),SUM                                           TW 221
      ENLS=ENLS+SUM                                                     TW 222
36    CONTINUE                                                          TW 223
37    ENRD=ENIN-ENLS                                                    TW 224
      PRINT 54,  ENIN,ENLS,ENRD                                         TW 225
      IF (ENRD.LT.1.E-20) IFEN=0                                        TW 226
      IF (ENIN.GT.1.E-20) GO TO 38                                      TW 227
      IFEN=0                                                            TW 228
      GO TO 25                                                          TW 229
38    TM1=100.*ENRD/ENIN                                                TW 230
      PRINT 55,  TM1                                                    TW 231
      GO TO 25                                                          TW 232
39    PRINT 72                                                          TW 233
      STOP                                                              TW 234
C                                                                       TW 235
C                                                                       TW 236
```

```
40    FORMAT  (A2,I3,3I5,6E10.3)                                        TW 237
41    FORMAT  ( //,1X,15H*** DATA CARD**,A2,I3,3I5,6E12.5)              TW 238
42    FORMAT  (  //,1X,38HINVALID DATA CARD LABEL AFTER SOLUTION)       TW 239
43    FORMAT  (13A6)                                                    TW 240
44    FORMAT  (I5,21HCURRENTS FROM SEGMENT,I5,6X,4HTAG=,I5,2X,10HINCREME TW 241
     1NT=,I5)                                                           TW 242
45    FORMAT  (6E12.5)                                                  TW 243
46    FORMAT  (  1X,37HTIME FOR INITIALIZATION OF CONSTANTS=,F9.3,5H SEC TW 244
     1.)                                                                TW 245
47    FORMAT  (  1X,26HTIME FOR CURRENT SOLUTION=,F9.3,5H SEC.)         TW 246
48    FORMAT  (  /,1X,13HRUNNING TIME=,F9.3,5H SEC.)                    TW 247
49    FORMAT  (  ///,36X,25H- - - ENERGY BUDGET - - -)                  TW 248
50    FORMAT  (  //,33X,9HSOURCES -,//,35X,15HSOURCE  SEGMENT,3X,12HENER TW 249
     1GY INPUT,/,37X,3HNO.,,6X,3HNO.,,6X,8H(JOULES))                   TW 250
51    FORMAT  (35X,I5,4X,I5,5X,E11.4)                                   TW 251
52    FORMAT  (  //,33X,7HLOADS -,/,35X,7HSEGMENT,3X,10HRESISTANCE,2X,11 TW 252
     1HENERGY LOSS,/,38X,3HNO.,7X,6H(OHMS),5X,8H(JOULES))              TW 253
53    FORMAT  (36X,I5,2X,2E12.4)                                        TW 254
54    FORMAT  (  /,36X,20HTOTAL ENERGY INPUT =,E11.4,7H JOULES,/,36X,22H TW 255
     1ENERGY LOST IN LOADS =,E11.4,7H JOULES,/,36X,23HTOTAL ENERGY RADIA TW 256
     2TED =,E11.4,7H JOULES)                                            TW 257
55    FORMAT  (  36X,24HTIME DOMAIN EFFICIENCY =,F7.2,8H PERCENT)       TW 258
56    FORMAT  (  /,59HINPUT ENERGY NOT COMPUTED SINCE SOURCE HAS BEEN TR TW 259
     1ANSFORMED)                                                        TW 260
57    FORMAT  (1H1,  /,28X,42H**********************************************TW 261
     1,/ /,31X,36HTIME DOMAIN ANTENNA MODELING PROGRAM,//,28X,42H******** TW 262
     2**********************************,////)                          TW 263
58    FORMAT  (A2,13A6)                                                 TW 264
59    FORMAT  (28X,13A6)                                                TW 265
60    FORMAT  (////   33X,33H- - - - SEGMENTATION DATA - - - -, //,40X,  TW 266
     1  21HCOORDINATES IN METERS,//,25X,                                TW 267
     2  50HI+ AND I- INDICATE THE SEGMENTS BEFORE AND AFTER I,//)       TW 268
61    FORMAT  (2X,4HSEG.,3X,26HCOORDINATES OF SEG. CENTER,5X,4HSEG.,    TW 269
     1  5X,18HORIENTATION ANGLES,4X,4HWIRE,5X,15HCONNECTION DATA,4X,    TW 270
     2    3HTAG,/,2X,3HNO.,7X,1HX,9X,1HY,9X,1HZ,7X,6HLENGTH,5X,5HALPHA,  TW 271
     3  5X,4HBETA,6X,6HRADIUS,4X,2HI-,4X,1HI,5X,2HI+,4X,3HNO.)         TW 272
62    FORMAT  (1X,I5,4F10.5,1X,3F10.5,3I6,2X,I5)                        TW 273
63    FORMAT  (2E10.3,I5,2X,3A1,3I5)                                    TW 274
64    FORMAT  (  //,1X,21H*** FIRST DATA CARD**,2E12.5,I5,2X,3A1,3I5)   TW 275
65    FORMAT  (  //,1X,19HNUMBER OF SEGMENTS=,I7,/,1X,18HTOTAL WIRE LENG TW 276
     1TH=,F10.5,3H M.,/,1X,23HMAXIMUM SEGMENT LENGTH=,F10.5,3H M.)      TW 277
66    FORMAT  (  ///,1X,21HOPTIONS SELECTED- - -,/)                     TW 278
67    FORMAT  (  5H THE ,A1,37H=0 PLANE IS A MAGNETIC SYMMETRY PLANE)   TW 279
68    FORMAT  (  5H THE ,A1,38H=0 PLANE IS AN ELECTRIC SYMMETRY PLANE)  TW 280
69    FORMAT  (  1X,27HMODEL HAS IMPEDANCE LOADING)                     TW 281
70    FORMAT  (  1X,19HMODEL IS NOT LOADED)                             TW 282
71    FORMAT  (  1X,37HCURRENTS WILL BE PRINTED FOR SEGMENTS,I5,8H THROU TW 283
     1GH ,I5)                                                           TW 284
72    FORMAT  (1X,25HZERO TIME STEPS REQUESTED)                         TW 285
73    FORMAT  (  ///,1X,40H**************************************,//,1  TW 286
     1X, 23HTIME STEPPING INTERVAL=,E12.5,5H SEC.,/,1X,13HMAXIMUM TIME=, TW 287
     2  E12.5,5H SEC.,/,1X,21HNUMBER OF TIME STEPS=,I6,//,41H **********TW 288
     3******************************)                                   TW 289
74    FORMAT  (  ///,35X,33H- - - - STRUCTURE LOADING - - - -,//,23X,   TW 290
     1  60HTAG  INCREMENT  SEG.  RESISTANCE  INDUCTANCE  CAPACITANCE    TW 291
     2,/ ,23X,3HNO.,,14X,3HNO.,,5X,6H(OHMS),6X,8H(HENRYS),6X,8H(FARADS)) TW 292
75    FORMAT  (3I5,5X,3E10.3)                                           TW 293
76    FORMAT  (21X,I5,5X,I5,2X,I5,3X,E10.4,3X,E10.4,4X,E10.4)           TW 294
77    FORMAT  (1X,34HINCORRECT LABEL FOR A COMMENT CARD)                TW 295
      END                                                               TW 296-
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```
      SUBROUTINE ANTRAN (ISEG,ANOR,IPCH)                                AN    1
C                                                                       AN    2
C     ANTRAN COMPUTES AND PRINTS THE INPUT ADMITTANCE AND IMPEDANCE AT  AN    3
C     SEGMENT ISEG                                                      AN    4
C                                                                       AN    5
      COMMON /DATA/  N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200), AN    6
     1    BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ          AN    7
      COMMON /ESORC/  ESORC(1024),IFST,NTRAN,MTRAN,NTNX,DFRQ,ENIN,ENRD,I AN    8
     1FEN                                                               AN    9
      COMMON /CMAT/  CURF(1600),IP(200),IX(200)                         AN   10
      COMMON /CONST/  CDT,VEL,DT,NTSTEP                                 AN   11
      COMMON /ASORC/  EMAG(10),ISRC(10),NSRC                            AN   12
      COMMON /SCRATM/ PWR(512)                                          AN   13
      COMPLEX   YMIT,ZPED,ZNOR                                          AN   14
      DATA   TSMIN/5./                                                  AN   15
      IF (IFST.EQ.1) GO TO 2                                            AN   16
C                                                                       AN   17
C     FOURIER TRANSFORM SOURCE                                          AN   18
C                                                                       AN   19
      MTRAN=ALOG(FLOAT(NTRAN))/.69314718+1.5                            AN   20
      CALL ITOF (ESORC,NTRAN,MTRAN,1,1,NTNX,NTNR)                       AN   21
      IFST=1                                                            AN   22
      DFRQ=1./(DT*FLOAT(2**MTRAN))                                      AN   23
      NTNR=NTNR/2                                                       AN   24
      DO 1 I=1,NTNR                                                     AN   25
1     PWR(I)=0.                                                         AN   26
2     CALL CGET (ISEG,CURF,NTRAN)                                       AN   27
C                                                                       AN   28
C     FOURIER TRANSFORM CURRENT                                         AN   29
C                                                                       AN   30
      CALL ITOF (CURF,NTRAN,MTRAN,0,0,NTNX,NTNR)                        AN   31
      INOR=0                                                            AN   32
      IF (ABS(ANOR).GT.1.E-20) INOR=1                                   AN   33
      IF (NSRC.LT.1) GO TO 4                                            AN   34
      DO 3 I=1,NSRC                                                     AN   35
      I1=I                                                              AN   36
      IF (ISRC(I).EQ.ISEG) GO TO 5                                      AN   37
3     CONTINUE                                                          AN   38
4     VLT=1.                                                            AN   39
      ISPR=0                                                            AN   40
      GO TO 6                                                           AN   41
5     VLT=EMAG(I1)*SI(ISEG)                                             AN   42
      ISPR=1                                                            AN   43
6     PRINT 10,  ISEG,VLT                                               AN   44
      IF (INOR.EQ.1) PRINT 11,  ANOR                                    AN   45
      PRINT 12                                                          AN   46
      DF=DFRQ*1.E-6                                                     AN   47
      F=-DF                                                             AN   48
      FMAX=1.E-6/(TSMIN*DT)                                             AN   49
      NTNR=NTNR/2                                                       AN   50
      IF (IPCH.NE.0) PUNCH 15                                           AN   51
      DO 8 I=1,NTNR                                                     AN   52
      F=F+DF                                                            AN   53
      IF (F.GT.FMAX) GO TO 9                                            AN   54
      I2=2*I                                                            AN   55
      I1=I2-1                                                           AN   56
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```
      YMIT=CMPLX(ESORC(I1),ESORC(I2))*VLT                                    AN  57
      SPCT=CABS(YMIT)                                                        AN  58
      YMIT=CMPLX(CURF(I1),CURF(I2))/YMIT                                     AN  59
      ZPED=1./YMIT                                                           AN  60
      IF (ISPR.EQ.1) PWR(I)=PWR(I)+.5*VLT*VLT*REAL(YMIT)                     AN  61
      IF (IPCH.NE.0) PUNCH 14, I,F,ZPED,YMIT                                 AN  62
      IF (INOR.EQ.0) GO TO 7                                                 AN  63
      ZNOR=ZPED/ANOR                                                         AN  64
      PRINT 13,  I,F,ZPED,YMIT,ZNOR,SPCT                                     AN  65
      GO TO 8                                                                AN  66
7     PRINT 14,  I,F,ZPED,YMIT,SPCT                                          AN  67
8     CONTINUE                                                               AN  68
9     RETURN                                                                 AN  69
C                                                                            AN  70
C                                                                            AN  71
10    FORMAT  (  //,24X,50H- - - ANTENNA INPUT IMPEDANCE AND ADMITTANCE      AN  72
     1- - -,//,31X,23HSOURCE SEGMENT NUMBER =,I5,/,31X,21HPEAK SOURCE VO    AN  73
     2LTAGE =,E11.4,6H VOLTS)                                                AN  74
11    FORMAT  (31X,32HIMPEDANCE NORMALIZATION FACTOR =,E11.4,5H OHMS)        AN  75
12    FORMAT  (  /,1X,4HSTEP,4X,9HFREQUENCY,6X,16HIMPEDANCE (OHMS),10X,     AN  76
     1   17HADMITTANCE (MHOS),7X,20HNORMALIZED IMPEDANCE,6X,6HSOURCE,/,     AN  77
     2 2X,3HNO.,6X,5H(MHZ),3(8X,4HREAL,8X,5HIMAG.,1X),8X,8HSPECTRUM)         AN  78
13    FORMAT  (1X,I4,2E13.4,E12.4,2(E14.4,E12.4),2X,E11.4)                   AN  79
14    FORMAT (1X,I4,2E13.4,E12.4,E14.4,E12.4,28X,E11.4)                      AN  80
15    FORMAT (9X,9HFREQUENCY,9X,9HIMPEDANCE,18X,10HADMITTANCE)               AN  81
      END                                                                    AN  82-
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```
      FUNCTION ATGN2 (X,Y)                                                  AT    1
C                                                                           AT    2
C     ATGN2 IS ARCTANGENT FUNCTION MODIFIED TO RETURN 0. WHEN X=Y=0.        AT    3
C                                                                           AT    4
      IF (X) 3,1,3                                                          AT    5
1     IF (Y) 3,2,3                                                          AT    6
2     ATGN2=0.                                                              AT    7
      RETURN                                                                AT    8
3     ATGN2=ATAN2(X,Y)                                                      AT    9
      RETURN                                                                AT   10
      END                                                                   AT   11
```

```
      SUBROUTINE CGET (ISEG,CSEG,NLM)                                    CG    1
C                                                                        CG    2
C     CGET FILLS ARRAY CSEG WITH THE CURRENT ON SEGMENT ISEG FOR ALL     CG    3
C     TIME STEPS                                                         CG    4
C                                                                        CG    5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),  CG    6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ            CG    7
      COMMON /ARRAY/ CQ(6400)                                            CG    8
      COMMON /IOFLG/ NCFMX,NCGMX,IOC,IOCQ,NTMAX,NBOUT,JP1,JP2            CG    9
      DIMENSION CSEG(1024)                                               CG   10
      II=N*2                                                             CG   11
      IB=2*ISEG-1                                                        CG   12
      I=IB-II                                                            CG   13
      NOCQ=999999                                                        CG   14
      IF (IOCQ.EQ.0) GO TO 1                                             CG   15
      REWIND  11                                                         CG   16
      READ (11) NOCQ,(CQ(K),K=1,NOCQ)                                    CG   17
1     DO 3 J=1,NLM                                                       CG   18
      I=I+II                                                             CG   19
      IF (I.LE.NOCQ) GO TO 2                                             CG   20
      READ (11) NOCQ,(CQ(K),K=1,NOCQ)                                    CG   21
      I=IB                                                               CG   22
2     CSEG(J)=CQ(I)                                                      CG   23
3     CONTINUE                                                           CG   24
      IF (IOCQ.NE.0) REWIND  11                                          CG   25
      RETURN                                                             CG   26
      END                                                                CG   27
```

```
      SUBROUTINE COFS (CURF,CURL,NDIM)                                  CF    1
C                                                                       CF    2
C     COFS SETS UP THE ARRAYS OF INTERACTION COEFFICIENTS FOR BOTH      CF    3
C     PRESENT TIME AND RETARDED TIME INTERACTION                        CF    4
C                                                                       CF    5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200), CF    6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ           CF    7
      COMMON /SCOMP/ SX(200),SY(200),SZ(200)                            CF    8
      COMMON /CONST/ CDT,VEL,DT,NTSTEP                                  CF    9
      COMMON /ARRAY/ CQ(6400)                                           CF   10
      COMMON /ARRAX/ QI1,QI2,QI3,EC(200,5),EQ(200,5),IRET(200),BFR(15400 CF   11
     1)                                                                 CF   12
      COMMON /EMATS/ EMX(3,3),EMY(3,3),EMZ(3,3),QMX(3,3),QMY(3,3),QMZ(3, CF   13
     13)                                                                CF   14
      COMMON /LOAD/ RES(200),ELD(200),CAP(200),ILOAD                    CF   15
      COMMON /IOFLG/ NCFMX,NCQMX,IOC,IOCQ,NTMAX,NBOUT,JP1,JP2           CF   16
      COMMON /MATPAR/ NBLOKS,NPBLK,NLAST,INT                            CF   17
      DIMENSION CURF(NDIM,NDIM), CURL(1)                                CF   18
      DIMENSION COF(17600), ICOF(17600), SRT(6400), ISRT(6400)          CF   19
      DIMENSION ALFA(3,3), BETA(3,3)                                    CF   20
      EQUIVALENCE (COF,EC), (ICOF,EC), (SRT,CQ), (ISRT,CQ)              CF   21
      LPX=1                                                             CF   22
      LPY=1                                                             CF   23
      LPZ=1                                                             CF   24
      IF (IPX.NE.0) LPX=2                                               CF   25
      IF (IPY.NE.0) LPY=2                                               CF   26
      IF (IPZ.NE.0) LPZ=2                                               CF   27
      ICNTC=0                                                           CF   28
      ICNTS=0                                                           CF   29
      ICTOT=0                                                           CF   30
      IOC=0                                                             CF   31
      IOS=0                                                             CF   32
      ICOF(NCFMX)=9898989                                               CF   33
      ISRT(NCQMX)=9898989                                               CF   34
      IST=2*N*LPX*LPY*LPZ                                               CF  34A
      ICMAX=NCFMX-IST                                                   CF   35
      ISMAX=NCQMX-IST                                                   CF   36
      IST=1                                                             CF   37
      NTMAX=0                                                           CF   38
      IF (INT.EQ.0) GO TO 1                                             CF   39
      REWIND  13                                                        CF   40
      NOBLKS=NBLOKS                                                     CF   41
      I2=NPBLK*N                                                        CF   42
      IT=NPBLK                                                          CF   43
      GO TO 2                                                           CF   44
1     NOBLKS=1                                                          CF   45
      IT=N                                                              CF   46
2     I=0                                                               CF   47
C                                                                       CF   48
C     BEGIN LOOP OVER FIELD EVALUATION POINTS                           CF   49
C                                                                       CF   50
      DO 30 IOBLKS=1,NOBLKS                                             CF   51
      IF (INT.EQ.0) GO TO 3                                             CF   52
      IF (IOBLKS.EQ.NOBLKS) IT=NLAST                                    CF   53
3     DO 29 IB=1,IT                                                     CF   54
      I=I+1                                                             CF   55
```

```
      XI=X(I)                                                          CF  56
      YI=Y(I)                                                          CF  57
      ZI=Z(I)                                                          CF  58
      SXI=SX(I)                                                        CF  59
      SYI=SY(I)                                                        CF  60
      SZI=SZ(I)                                                        CF  61
      DO 4 J=1,N                                                       CF  62
4     CURF(J,IB)=0.                                                    CF  63
      IFL=0                                                            CF  64
C                                                                      CF  65
C     BEGIN LOOP OVER SOURCE SEGMENTS INCLUDING IMAGES                 CF  66
C                                                                      CF  67
      DO 29 JX=1,LPX                                                   CF  68
      RFX=FLOAT(3-JX*2)                                                CF  69
      SFX=RFX                                                          CF  70
      IF (IPX.LT.0) SFX=1.                                             CF  71
      DO 29 JY=1,LPY                                                   CF  72
      RFY=FLOAT(3-JY*2)                                                CF  73
      SFY=RFY                                                          CF  74
      IF (IPY.LT.0) SFY=1.                                             CF  75
      DO 29 JZ=1,LPZ                                                   CF  76
      RFZ=FLOAT(3-JZ*2)                                                CF  77
      SFZ=RFZ                                                          CF  78
      IF (IPZ.LT.0) SFZ=1.                                             CF  79
      RFL=SFX*SFY*SFZ                                                  CF  80
      NTL=0                                                            CF  81
      DO 5 J=1,N                                                       CF  82
      RX=XI-X(J)*RFX                                                   CF  83
      RY=YI-Y(J)*RFY                                                   CF  84
      RZ=ZI-Z(J)*RFZ                                                   CF  85
      R=SQRT(RX*RX+RY*RY+RZ*RZ)                                        CF  86
      K=R/CDT+.5                                                       CF  87
      IF (K.EQ.0) K=1                                                  CF  88
      IRET(J)=K                                                        CF  89
      IF (K.GT.NTL) NTL=K                                              CF  90
      DO 5 M=1,5                                                       CF  91
      EC(J,M)=0.                                                       CF  92
5     EQ(J,M)=0.                                                       CF  93
      DO 21 J=1,N                                                      CF  94
      RX=XI-X(J)*RFX                                                   CF  95
      RY=YI-Y(J)*RFY                                                   CF  96
      RZ=ZI-Z(J)*RFZ                                                   CF  97
      R2=RX*RX+RY*RY+RZ*RZ                                             CF  98
      R=SQRT(R2)                                                       CF  99
      K=IRET(J)                                                        CF 100
      TAU=DT*FLOAT(K)                                                  CF 101
      SXJ=SX(J)*RFX                                                    CF 102
      SYJ=SY(J)*RFY                                                    CF 103
      SZJ=SZ(J)*RFZ                                                    CF 104
      CALL EMAT (RX,RY,RZ,R2,TAU,SXJ,SYJ,SZJ,J)                        CF 105
      DO 6 L=1,3                                                       CF 106
      DO 6 M=1,3                                                       CF 107
      ALFA(L,M)=(EMX(L,M)*SXI+EMY(L,M)*SYI+EMZ(L,M)*SZI)*RFL           CF 108
6     BETA(L,M)=(QMX(L,M)*SXI+QMY(L,M)*SYI+QMZ(L,M)*SZI)*RFL           CF 109
      JC1=ICON1(J)                                                     CF 110
      IF (JC1.NE.0) GO TO 7                                            CF 111
      KKM=0                                                            CF 112
      GO TO 11                                                         CF 113
7     IF (JC1.LT.19000) GO TO 8                                        CF 114
      SIG1=FLOAT(JC1-20000)                                            CF 115
```

```
      JC1=J                                                              CF 116
      GO TO 10                                                           CF 117
8     IF (ICON2(JC1),NE,J) GO TO 9                                       CF 118
      SIG1=1,                                                            CF 119
      GO TO 10                                                           CF 120
9     IF (ICON1(JC1),NE,J) GO TO 44                                      CF 121
      SIG1=-1,                                                           CF 122
10    KM=IRET(JC1)                                                       CF 123
      KKM=KM-K                                                           CF 124
      IF (IABS(KKM),LE,1) GO TO 11                                       CF 125
      PRINT 45, I,J,JC1,KKM                                              CF 126
      STOP                                                               CF 127
11    JC2=ICON2(J)                                                       CF 128
      IF (JC2,NE,0) GO TO 12                                             CF 129
      KKP=0                                                              CF 130
      GO TO 16                                                           CF 131
12    IF (JC2,LT,19000) GO TO 13                                         CF 132
      SIG2=FLOAT(JC2-20000)                                              CF 133
      JC2=J                                                              CF 134
      GO TO 15                                                           CF 135
13    IF (ICON1(JC2),NE,J) GO TO 14                                      CF 136
      SIG2=1,                                                            CF 137
      GO TO 15                                                           CF 138
14    IF (ICON2(JC2),NE,J) GO TO 44                                      CF 139
      SIG2=-1,                                                           CF 140
15    KP=IRET(JC2)                                                       CF 141
      KKP=KP-K                                                           CF 142
      IF (IABS(KKP),LE,1) GO TO 16                                       CF 143
      PRINT 45, I,J,JC2,KKP                                              CF 144
      STOP                                                               CF 145
16    DO 20 M=1,3                                                        CF 146
      KXX=M+1                                                            CF 147
      KMX=KKM+KXX                                                        CF 148
      KPX=KKP+KXX                                                        CF 149
      KK=K-M+2                                                           CF 150
      IF (KK,EQ,0) GO TO 18                                              CF 151
      IF (JC1,EQ,0) GO TO 17                                             CF 152
      EC(JC1,KMX)=EC(JC1,KMX)+ALFA(1,M)*SIG1                             CF 153
      EQ(JC1,KMX)=EQ(JC1,KMX)+BETA(1,M)*SIG1                             CF 154
17    EC(J,KXX)=EC(J,KXX)+ALFA(2,M)                                      CF 155
      EQ(J,KXX)=EQ(J,KXX)+BETA(2,M)                                      CF 156
      IF (JC2,EQ,0) GO TO 20                                             CF 157
      EC(JC2,KPX)=EC(JC2,KPX)+ALFA(3,M)*SIG2                             CF 158
      EQ(JC2,KPX)=EQ(JC2,KPX)+BETA(3,M)*SIG2                             CF 159
      GO TO 20                                                           CF 160
18    IF (JC1,EQ,0) GO TO 19                                             CF 161
      CURF(JC1,IB)=CURF(JC1,IB)-(ALFA(1,3)+BETA(1,3)*QI3)*SIG1           CF 162
      EQ(JC1,KMX)=EQ(JC1,KMX)+BETA(1,M)*SIG1                             CF 163
19    CURF(J,IB)=CURF(J,IB)-ALFA(2,3)-BETA(2,3)*QI3                      CF 164
      EQ(J,KXX)=EQ(J,KXX)+BETA(2,M)                                      CF 165
      IF (JC2,EQ,0) GO TO 20                                             CF 166
      CURF(JC2,IB)=CURF(JC2,IB)-(ALFA(3,3)+BETA(3,3)*QI3)*SIG2           CF 167
      EQ(JC2,KPX)=EQ(JC2,KPX)+BETA(3,M)*SIG2                             CF 168
20    CONTINUE                                                           CF 169
21    CONTINUE                                                           CF 170
C                                                                        CF 171
C     ADD TERMS DUE TO LOADING                                           CF 172
C                                                                        CF 173
      IF (ILOAD,EQ,0) GO TO 22                                           CF 174
      IF (IFL,EQ,1) GO TO 22                                             CF 175
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```
      EC(I,2)=EC(I,2)-ELD(I)*.5/(DT*SI(I))                              CF 176
      EC(I,3)=EC(I,3)+ELD(I)*2./(DT*SI(I))                              CF 177
      CURF(I,IH)=CURF(I,IB)+(RES(I)+ELD(I)*1.5/DT)/SI(I)                CF 178
      IF (CAP(I).LT.1.E-20) GO TO 22                                    CF 179
      CURF(I,IB)=CURF(I,IB)+QI3/(CAP(I)*SI(I))                          CF 180
      EQ(I,4)=EQ(I,4)-1./(CAP(I)*SI(I))                                 CF 181
22    NTL=NTL+2                                                         CF 182
      IF (NTL.GT.NTMAX) NTMAX=NTL                                       CF 183
C                                                                       CF 184
C     SORT COEFFICIENTS FOR FIELD EVALUATION SEGMENT I                  CF 185
C                                                                       CF 186
      DO 28 LL=1,NTL                                                    CF 187
      L=NTL-LL                                                          CF 188
      IHDG=0                                                            CF 189
      J=0                                                               CF 190
23    J=J+1                                                             CF 191
      IF (J.GT.N) GO TO 28                                              CF 192
      K=IRET(J)                                                         CF 193
      KDIF=K-L                                                          CF 194
      IF (IABS(KDIF).GT.2) GO TO 23                                     CF 195
      IF (IHDG.EQ.1) GO TO 24                                           CF 196
      IHDG=1                                                            CF 197
      ISRT(IST)=-(L*10000+I)                                            CF 198
      IST=IST+1                                                         CF 199
24    KK=J                                                              CF 200
      KKP=IST                                                           CF 201
      IST=IST+1                                                         CF 202
25    SRT(IST)=EC(J,KDIF+3)                                             CF 203
      SRT(IST+1)=EQ(J,KDIF+3)                                           CF 204
      IST=IST+2                                                         CF 205
      J=J+1                                                             CF 206
      IF (J.GT.N) GO TO 26                                              CF 207
      K=IRET(J)                                                         CF 208
      KDIF=K-L                                                          CF 209
      IF (IABS(KDIF).LT.3) GO TO 25                                     CF 210
26    ISRT(KKP)=20000*(J-KK)+2*KK-1                                     CF 211
      IF (IST.LT.ISMAX) GO TO 23                                        CF 212
      IF (IOS.EQ.1) GO TO 27                                            CF 213
      IOS=1                                                             CF 214
      REWIND  11                                                        CF 215
27    IST=IST-1                                                         CF 216
      WRITE (11) IST,(SRT(K),K=1,IST)                                   CF 217
      ICNTS=ICNTS+1                                                     CF 218
      IST=1                                                             CF 219
      GO TO 23                                                          CF 220
28    CONTINUE                                                          CF 221
      IFL=1                                                             CF 222
29    CONTINUE                                                          CF 223
      IF (INT.EQ.0) GO TO 30                                            CF 224
      WRITE (13) (CURL(I),I=1,I2)                                       CF 225
30    CONTINUE                                                          CF 226
      IF (INT.NE.0) REWIND  13                                          CF 227
C                                                                       CF 228
C     SORT ALL COEFFICIENTS ACCORDING TO RETARDED TIME                  CF 229
C                                                                       CF 230
      ISRT(IST)=0                                                       CF 231
      IF (IOS.EQ.0) GO TO 31                                            CF 232
      WRITE (11) IST,(SRT(J),J=1,IST)                                   CF 233
      ICNTS=ICNTS+1                                                     CF 234
      REWIND  11                                                        CF 235
```

```
31    ICF=1                                                          CF 236
      DO 40 LL=1,NTMAX                                               CF 237
      L=NTMAX-LL                                                     CF 238
      IST=1                                                          CF 239
      ISL=9999999                                                    CF 240
      IF (IOS.EQ.0) GO TO 34                                         CF 241
      ISL=0                                                          CF 242
      REWIND  11                                                     CF 243
      GO TO 34                                                       CF 244
32    IF (-INDX/10000.EQ.L) GO TO 33                                 CF 245
      IHDG=0                                                         CF 246
      GO TO 34                                                       CF 247
33    IHDG=1                                                         CF 248
      ICOF(ICF)=INDX                                                 CF 249
      ICF=ICF+1                                                      CF 250
34    IF (IST.LE.ISL) GO TO 35                                       CF 251
      READ (11) ISL,(SRT(J),J=1,ISL)                                 CF 252
      IST=1                                                          CF 253
35    INDX=ISRT(IST)                                                 CF 254
      IST=IST+1                                                      CF 255
      IF (INDX) 32,40,36                                             CF 256
36    KK=INDX/10000                                                  CF 257
      IF (IHDG.EQ.0) GO TO 39                                        CF 258
      ICOF(ICF)=INDX                                                 CF 259
      ICF=ICF+1                                                      CF 260
      KKP=IST                                                        CF 261
      DO 37 J=1,KK                                                   CF 262
      COF(ICF)=SRT(KKP)                                              CF 263
      ICF=ICF+1                                                      CF 264
37    KKP=KKP+1                                                      CF 265
      IF (ICF.LT.ICMAX) GO TO 39                                     CF 266
      IF (IOC.EQ.1) GO TO 38                                         CF 267
      IOC=1                                                          CF 268
      REWIND  12                                                     CF 269
38    ICF=ICF-1                                                      CF 270
      WRITE (12) ICF,L,(COF(J),J=1,ICF)                              CF 271
      ICTOT=ICTOT+ICF                                                CF 272
      ICNTC=ICNTC+1                                                  CF 273
      ICF=1                                                          CF 274
39    IST=IST+KK                                                     CF 275
      GO TO 34                                                       CF 276
40    CONTINUE                                                       CF 277
      ICOF(ICF)=0                                                    CF 278
      IF (IOC.EQ.0) GO TO 41                                         CF 279
      WRITE (12) ICF,L,(COF(J),J=1,ICF)                              CF 280
      ICTOT=ICTOT+ICF                                                CF 281
      ICNTC=ICNTC+1                                                  CF 282
      REWIND  12                                                     CF 283
41    IF (IOS.EQ.1) REWIND  11                                       CF 284
      IF (ISRT(NCOMX).NE.9898989) GO TO 42                           CF 285
      IF (ICOF(NCFMX).NE.9898989) GO TO 43                           CF 286
      IF (ICNTC.EQ.0) ICTOT=ICF                                      CF 287
      PRINT 49, ICTOT,ICNTS,ICNTC                                    CF 288
      RETURN                                                         CF 289
42    PRINT 46                                                       CF 290
      STOP                                                           CF 291
43    PRINT 47                                                       CF 292
      STOP                                                           CF 293
44    PRINT 48, J                                                    CF 294
      STOP                                                           CF 295
```

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C                                                                       CF 296
45    FORMAT (1X,27HRETARDED TIMES FROM SEGMENT,I5,12H TO SEGMENTS,I5,  CF 297
     1  4H AND,I5,10H DIFFER BY,I5,11H TIME STEPS)                      CF 298
46    FORMAT (1X,29HOVERFLOW IN FILLING ARRAY SRT)                      CF 299
47    FORMAT (1X,29HOVERFLOW IN FILLING ARRAY COF)                      CF 300
48    FORMAT (1X,29HSEGMENT CONNECTION ERROR.  J=,I5)                   CF 301
49    FORMAT ( //,29H LENGTH OF COEFFICIENT ARRAY=,I10,/,1X,I10,1X,     CF 302
     1 25HBLOCKS OUTPUT TO FILE 11,,1X,I10,1X,24HBLOCKS OUTPUT TO FILE 1 CF 303
     22,/)                                                              CF 304
      END                                                               CF 305-
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```
      SUBROUTINE  CONECT                                                    CT    1
C                                                                           CT    2
C     CONNECT SETS UP SEGMENT CONNECTION DATA IN ARRAYS ICON1 AND ICON2     CT    3
C     BY SEARCHING FOR SEGMENT ENDS THAT ARE IN CONTACT.                    CT    4
C                                                                           CT    5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),     CT    6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ               CT    7
      DIMENSION X2(1), Y2(1), Z2(1)                                         CT    8
      EQUIVALENCE (X2(1),SI(1)), (Y2(1),ALP(1)), (Z2(1),BET(1))             CT    9
      SMIN=1.E-3                                                            CT   10
      JNO=0                                                                 CT   11
      DO 1 I=1,N                                                            CT   12
      ICON1(I)=0                                                            CT   13
1     ICON2(I)=0                                                            CT   14
      DO 33 I=1,N                                                           CT   15
      XI1=X(I)                                                              CT   16
      YI1=Y(I)                                                              CT   17
      ZI1=Z(I)                                                              CT   18
      XI2=X2(I)                                                             CT   19
      YI2=Y2(I)                                                             CT   20
      ZI2=Z2(I)                                                             CT   21
      SLEN=SQRT((XI2-XI1)**2+(YI2-YI1)**2+(ZI2-ZI1)**2)                     CT   22
C                                                                           CT   23
C     DETERMINE CONNECTION DATA FOR END 1 OF SEGMENT.                       CT   24
C                                                                           CT   25
      IF (IPX.EQ.0) GO TO 3                                                 CT   26
      SEP=XI1/SLEN                                                          CT   27
      SEP2=XI2/SLEN                                                         CT   28
      IF (SEP.GT.SMIN) GO TO 2                                              CT   29
      IF (SEP.LT.-SMIN) GO TO 34                                            CT   30
      IF (SEP2.LE.SMIN) GO TO 34                                            CT   31
      ICON1(I)=20000+IPX                                                    CT   32
      GO TO 20                                                              CT   33
2     IF (SEP2.GT.SMIN) GO TO 3                                             CT   34
      IF (SEP2.LT.-SMIN) GO TO 34                                           CT   35
      ICON2(I)=20000+IPX                                                    CT   36
      GO TO 7                                                               CT   37
3     IF (IPY.EQ.0) GO TO 5                                                 CT   38
      SEP=YI1/SLEN                                                          CT   39
      SEP2=YI2/SLEN                                                         CT   40
      IF (SEP.GT.SMIN) GO TO 4                                              CT   41
      IF (SEP.LT.-SMIN) GO TO 34                                            CT   42
      IF (SEP2.LE.SMIN) GO TO 34                                            CT   43
      ICON1(I)=20000+IPY                                                    CT   44
      GO TO 20                                                              CT   45
4     IF (SEP2.GT.SMIN) GO TO 5                                             CT   46
      IF (SEP2.LT.-SMIN) GO TO 34                                           CT   47
      ICON2(I)=20000+IPY                                                    CT   48
      GO TO 7                                                               CT   49
5     IF (IPZ.EQ.0) GO TO 7                                                 CT   50
      SEP=ZI1/SLEN                                                          CT   51
      SEP2=ZI2/SLEN                                                         CT   52
      IF (SEP.GT.SMIN) GO TO 6                                              CT   53
      IF (SEP.LT.-SMIN) GO TO 34                                            CT   54
      IF (SEP2.LE.SMIN) GO TO 34                                            CT   55
      ICON1(I)=20000+IPZ                                                    CT   56
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```
      GO TO 20                                                          CT  57
6     IF (SEP2.GT.SMIN) GO TO 7                                         CT  58
      IF (SEP2.LT.-SMIN) GO TO 34                                       CT  59
      ICON2(I)=20000+IPZ                                                CT  60
7     IF (ICON1(I).NE.0) GO TO 20                                       CT  61
      DO 9 IC=1,N                                                       CT  62
      IF (IC.EQ.I) GO TO 9                                              CT  63
      ISEG=IC                                                           CT  64
      IF (ICON1(IC).NE.0) GO TO 8                                       CT  65
      SEP=(ABS(XI1-X(IC))+ABS(YI1-Y(IC))+ABS(ZI1-Z(IC)))/SLEN           CT  66
      IF (SEP.LT.SMIN) GO TO 10                                         CT  67
8     IF (ICON2(IC).NE.0) GO TO 9                                       CT  68
      SEP=(ABS(XI1-X2(IC))+ABS(YI1-Y2(IC))+ABS(ZI1-Z2(IC)))/SLEN        CT  69
      IF (SEP.LT.SMIN) GO TO 15                                         CT  70
9     CONTINUE                                                          CT  71
      GO TO 20                                                          CT  72
10    IF (ICON1(ISEG)) 12,11,13                                         CT  73
11    ICON1(I)=ISEG                                                     CT  74
      ICON1(ISEG)=I                                                     CT  75
      GO TO 20                                                          CT  76
12    ICON1(I)=ICON1(ISEG)                                              CT  77
      GO TO 20                                                          CT  78
13    JNO=JNO-1                                                         CT  79
      ICON1(I)=JNO                                                      CT  80
      IX=ICON1(ISEG)                                                    CT  81
      ICON1(ISEG)=JNO                                                   CT  82
      IF (ICON1(IX).EQ.ISEG) GO TO 14                                   CT  83
      ICON2(IX)=JNO                                                     CT  84
      GO TO 20                                                          CT  85
14    ICON1(IX)=JNO                                                     CT  86
      GO TO 20                                                          CT  87
15    IF (ICON2(ISEG)) 17,16,18                                         CT  88
16    ICON1(I)=ISEG                                                     CT  89
      ICON2(ISEG)=I                                                     CT  90
      GO TO 20                                                          CT  91
17    ICON1(I)=ICON2(ISEG)                                              CT  92
      GO TO 20                                                          CT  93
18    JNO=JNO-1                                                         CT  94
      ICON1(I)=JNO                                                      CT  95
      IX=ICON2(ISEG)                                                    CT  96
      ICON2(ISEG)=JNO                                                   CT  97
      IF (ICON1(IX).EQ.ISEG) GO TO 19                                   CT  98
      ICON2(IX)=JNO                                                     CT  99
      GO TO 20                                                          CT 100
19    ICON1(IX)=JNO                                                     CT 101
C                                                                       CT 102
C     DETERMINE CONNECTION DATA FOR END 2 OF SEGMENT.                   CT 103
C                                                                       CT 104
20    IF (ICON2(I).NE.0) GO TO 33                                       CT 105
      DO 22 IC=1,N                                                      CT 106
      IF (IC.EQ.I) GO TO 22                                             CT 107
      ISEG=IC                                                           CT 108
      IF (ICON1(IC).NE.0) GO TO 21                                      CT 109
      SEP=(ABS(XI2-X(IC))+ABS(YI2-Y(IC))+ABS(ZI2-Z(IC)))/SLEN           CT 110
      IF (SEP.LT.SMIN) GO TO 23                                         CT 111
21    IF (ICON2(IC).NE.0) GO TO 22                                      CT 112
      SEP=(ABS(XI2-X2(IC))+ABS(YI2-Y2(IC))+ABS(ZI2-Z2(IC)))/SLEN        CT 113
      IF (SEP.LT.SMIN) GO TO 28                                         CT 114
22    CONTINUE                                                          CT 115
      GO TO 33                                                          CT 116
```

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23    IF (ICON1(ISEG)) 25,24,26                                          CT 117
24    ICON2(I)=ISEG                                                      CT 118
      ICON1(ISEG)=I                                                      CT 119
      GO TO 33                                                           CT 120
25    ICON2(I)=ICON1(ISEG)                                               CT 121
      GO TO 33                                                           CT 122
26    JNO=JNO-1                                                          CT 123
      ICON2(I)=JNO                                                       CT 124
      IX=ICON1(ISEG)                                                     CT 125
      ICON1(ISEG)=JNO                                                    CT 126
      IF (ICON1(IX),EQ,ISEG) GO TO 27                                    CT 127
      ICON2(IX)=JNO                                                      CT 128
      GO TO 33                                                           CT 129
27    ICON1(IX)=JNO                                                      CT 130
      GO TO 33                                                           CT 131
28    IF (ICON2(ISEG)) 30,29,31                                          CT 132
29    ICON2(I)=ISEG                                                      CT 133
      ICON2(ISEG)=I                                                      CT 134
      GO TO 33                                                           CT 135
30    ICON2(I)=ICON2(ISEG)                                               CT 136
      GO TO 33                                                           CT 137
31    JNO=JNO-1                                                          CT 138
      ICON2(I)=JNO                                                       CT 139
      IX=ICON2(ISEG)                                                     CT 140
      ICON2(ISEG)=JNO                                                    CT 141
      IF (ICON1(IX),EQ,ISEG) GO TO 32                                    CT 142
      ICON2(IX)=JNO                                                      CT 143
      GO TO 33                                                           CT 144
32    ICON1(IX)=JNO                                                      CT 145
33    CONTINUE                                                           CT 146
      RETURN                                                             CT 147
34    PRINT 35, I                                                        CT 148
      STOP                                                               CT 149
C                                                                        CT 150
35    FORMAT (1X,7HSEGMENT,I4,33H LIES IN OR BEHIND SYMMETRY PLANE)      CT 151
      END                                                                CT 152-
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      SUBROUTINE  CONSET                                                    CO   1
C                                                                           CO   2
C     CONSET COMPUTES INTERPOLATION CONSTANTS FOR USE IN EVALUATING         CO   3
C     THE FIELDS                                                            CO   4
C                                                                           CO   5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),     CO   6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ               CO   7
      COMMON /INTERP/ AT(3,200),BT(3,200),CT(3,200),ES(3),FS(3),GS(3),      CO   8
     1   E(3),H(3)                                                         CO   9
      COMMON /ARRAX/ QI1,QI2,QI3,EC(200,5),EQ(200,5),IRET(200),BFR(15400    CO  10
     1)                                                                    CO  11
      COMMON /SCOMP/ SX(200),SY(200),SZ(200)                                CO  12
      COMMON /CONST/ CUT,VEL,DT,NTSTEP                                      CO  13
      DO 5 I=1,N                                                            CO  14
      CALF=COS(ALP(I))                                                      CO  15
      SX(I)=CALF*COS(BET(I))                                                CO  16
      SY(I)=CALF*SIN(BET(I))                                                CO  17
      SZ(I)=SIN(ALP(I))                                                     CO  18
      IM=ICON1(I)                                                           CO  19
      IP=ICON2(I)                                                           CO  20
      IF (IM.GT.19000) IM=I                                                 CO  21
      IF (IP.GT.19000) IP=I                                                 CO  22
      S=SI(I)                                                               CO  23
      IF (IM.EQ.0) GO TO 1                                                  CO  24
      DM=.5*(S+SI(IM))                                                      CO  25
      GO TO 2                                                               CO  26
1     DM=.5*S                                                               CO  27
2     IF (IP.EQ.0) GO TO 3                                                  CO  28
      DP=.5*(S+SI(IP))                                                      CO  29
      GO TO 4                                                               CO  30
3     DP=.5*S                                                               CO  31
4     D1=DM*(DM+DP)                                                         CO  32
      D2=-DM*DP                                                             CO  33
      D3=DP*(DM+DP)                                                         CO  34
      AT(1,I)=1./D1                                                         CO  35
      AT(2,I)=1./D2                                                         CO  36
      AT(3,I)=1./D3                                                         CO  37
      BT(1,I)=-DP/D1                                                        CO  38
      BT(2,I)=(DM-DP)/D2                                                    CO  39
      BT(3,I)=DM/D3                                                         CO  40
      CT(1,I)=0.                                                            CO  41
      CT(2,I)=-DP*DM/D2                                                     CO  42
5     CT(3,I)=0.                                                            CO  43
      ES(1)=1./(2.*DT*DT)                                                   CO  44
      ES(2)=-2.*ES(1)                                                       CO  45
      ES(3)=ES(1)                                                           CO  46
      FS(3)=.5/DT                                                           CO  47
      FS(1)=-FS(3)                                                          CO  48
      FS(2)=0.                                                              CO  49
      GS(1)=0.                                                              CO  50
      GS(2)=1.                                                              CO  51
      GS(3)=0.                                                              CO  52
      C2=1./(VEL*VEL)                                                       CO  53
      E(1)=ES(1)*C2                                                         CO  54
      E(2)=ES(2)*C2                                                         CO  55
      E(3)=ES(3)*C2                                                         CO  56
```

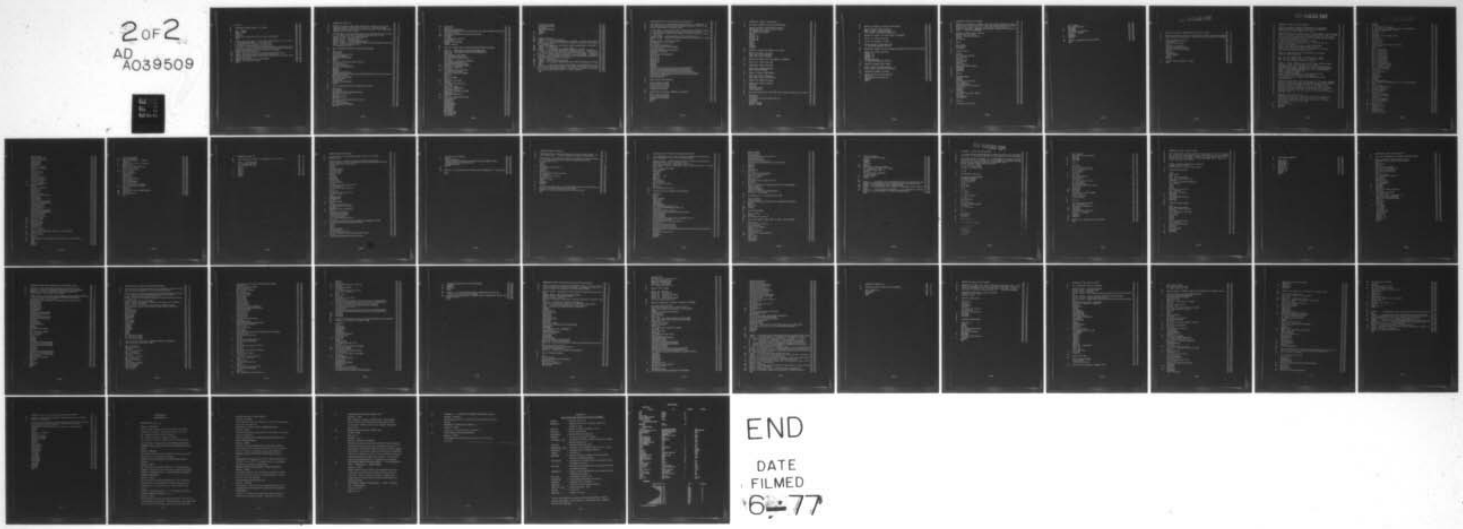
```
      C2=-2./VEL                                                        CO  57
      M(1)=ES(1)*C2                                                     CO  58
      M(2)=ES(2)*C2                                                     CO  59
      M(3)=ES(3)*C2                                                     CO  60
      QI1=((ES(1)*DT/3.+.5*FS(1))*DT+GS(1))*DT                          CO  61
      QI2=((ES(2)*DT/3.+.5*FS(2))*DT+GS(2))*DT                          CO  62
      QI3=((ES(3)*DT/3.+.5*FS(3))*DT+GS(3))*DT                          CO  63
      RETURN                                                            CO  64
      END                                                               CO  65-
```

```
      SUBROUTINE  CONVRT                                                    CV    1
C                                                                           CV    2
C     CONVERT CHANGES GEOMETRY DATA FROM THE FORM STATING X,Y,Z             CV    3
C     COORDINATES OF EACH SEGMENT END TO X,Y,Z OF THE SEGMENT CENTER        CV    4
C     PLUS SEGMENT LENGTH AND ORIENTATION ANGLES AS REQUIRED IN MAIN        CV    5
C     PROGRAM.                                                              CV    6
C                                                                           CV    7
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),     CV    8
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ               CV    9
      DIMENSION X2(1), Y2(1), Z2(1)                                         CV   10
      EQUIVALENCE (X2(1),SI(1)), (Y2(1),ALP(1)), (Z2(1),BET(1))             CV   11
      DO 1 I=1,N                                                            CV   12
      XA=X(I)                                                               CV   13
      YA=Y(I)                                                               CV   14
      ZA=Z(I)                                                               CV   15
      XB=X2(I)                                                              CV   16
      YB=Y2(I)                                                              CV   17
      ZB=Z2(I)                                                              CV   18
      X(I)=(XA+XB)*.5                                                       CV   19
      Y(I)=(YA+YB)*.5                                                       CV   20
      Z(I)=(ZA+ZB)*.5                                                       CV   21
      XA=XB-XA                                                              CV   22
      YA=YB-YA                                                              CV   23
      ZA=ZB-ZA                                                              CV   24
      SI(I)=SQRT(XA*XA+YA*YA+ZA*ZA)                                         CV   25
      ALP(I)=ASIN(ZA/SI(I))                                                 CV   26
1     BET(I)=ATAN2(YA,XA)                                                   CV   27
      RETURN                                                                CV   28
      END                                                                   CV   29-
```

```
      SUBROUTINE  DATAGN                                                    DA    1
C                                                                           DA    2
C     DATAGN IS THE MAIN ROUTINE FOR INPUT OF GEOMETRY DATA.                DA    3
C                                                                           DA    4
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),     DA    5
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ               DA    6
      DIMENSION X2(1), Y2(1), Z2(1)                                         DA    7
      DIMENSION ATST(4)                                                     DA    8
      INTEGER  GM,ATST                                                      DA    9
      EQUIVALENCE (X2(1),SI(1)), (Y2(1),ALP(1)), (Z2(1),BET(1))             DA   10
      DATA  ATST/2HGW,2HGS,2HGE,2HGM/                                       DA   11
      DATA  TA/.017453292/                                                  DA   12
      NWIRE=0                                                               DA   13
      N=0                                                                   DA   14
      PRINT 8                                                               DA   15
      PRINT 9                                                               DA   16
C                                                                           DA   17
C     READ GEOMETRY DATA CARD AND BRANCH TO SECTION FOR OPERATION           DA   18
C     REQUESTED                                                             DA   19
C                                                                           DA   20
1     READ 10, GM,ITG,NS,XW1,YW1,ZW1,XW2,YW2,ZW2,RAD                        DA   21
      IF (GM.EQ.ATST(1)) GO TO 2                                            DA   22
      IF (GM.EQ.ATST(2)) GO TO 3                                            DA   23
      IF (GM.EQ.ATST(3)) GO TO 6                                            DA   24
      IF (GM.EQ.ATST(4)) GO TO 5                                            DA   25
      GO TO 7                                                               DA   26
C                                                                           DA   27
C     GENERATE SEGMENT DATA FOR STRAIGHT WIRE.                              DA   28
C                                                                           DA   29
2     NWIRE=NWIRE+1                                                         DA   30
      I1=N+1                                                                DA   31
      I2=N+NS                                                               DA   32
      PRINT 11, NWIRE,XW1,YW1,ZW1,XW2,YW2,ZW2,RAD,NS,I1,I2,ITG              DA   33
      CALL WIRE (XW1,YW1,ZW1,XW2,YW2,ZW2,RAD,NS,ITG)                        DA   34
      GO TO 1                                                               DA   35
C                                                                           DA   36
C     SCALE STRUCTURE DIMENSIONS BY FACTOR XW1.                             DA   37
C                                                                           DA   38
3     DO 4 I=1,N                                                            DA   39
      X(I)=X(I)*XW1                                                         DA   40
      Y(I)=Y(I)*XW1                                                         DA   41
      Z(I)=Z(I)*XW1                                                         DA   42
      X2(I)=X2(I)*XW1                                                       DA   43
      Y2(I)=Y2(I)*XW1                                                       DA   44
      Z2(I)=Z2(I)*XW1                                                       DA   45
4     BI(I)=BI(I)*XW1                                                       DA   46
      PRINT 12, XW1                                                         DA   47
      GO TO 1                                                               DA   48
C                                                                           DA   49
C     MOVE STRUCTURE OR REPRODUCE ORIGINAL STRUCTURE IN NEW POSITIONS.      DA   50
C                                                                           DA   51
5     PRINT 13, ITG,NS,XW1,YW1,ZW1,XW2,YW2,ZW2,RAD                          DA   52
      XW1=XW1*TA                                                            DA   53
      YW1=YW1*TA                                                            DA   54
      ZW1=ZW1*TA                                                            DA   55
      CALL MOVE (XW1,YW1,ZW1,XW2,YW2,ZW2,INT(RAD+.5),NS,ITG)                DA   56
```

AD-A039 509 ROME AIR DEVELOPMENT CENTER GRIFFISS AFB N Y F/G 9/5
A TIME DOMAIN PROGRAM FOR WIRE ANTENNA ANALYSIS.(U)
APR 77 J POTENZA
UNCLASSIFIED RADC-TR-77-123 NL

2 OF 2
AD A039509



END
DATE FILMED
6-77

```
      GO TO 1                                                          DA  57
C                                                                      DA  58
C     TERMINATE STRUCTURE GEOMETRY INPUT.                              DA  59
C                                                                      DA  60
6     CALL  CONECT                                                     DA  61
      CALL  CONVRT                                                     DA  62
      RETURN                                                           DA  63
7     PRINT 14                                                         DA  64
      PRINT 15, GM,ITG,NS,Xw1,Yw1,Zw1,Xw2,Yw2,Zw2,RAD                  DA  65
      STOP                                                             DA  66
C                                                                      DA  67
8     FORMAT (////,33X,35H- - - STRUCTURE SPECIFICATION - - -,//,37X,   DA  68
     1  28HCOORDINATES MUST BE INPUT IN,/,37X,                         DA  69
     2  29HMETERS OR BE SCALED TO METERS,/,37X,                        DA  70
     3  31HBEFORE STRUCTURE INPUT IS ENDED,//)                         DA  71
9     FORMAT (   2X,4HWIRE,79X,6HNO. OF,4X,5HFIRST,2X,4HLAST,5X,3HTAG, DA  72
     1 /,2X,3HNO.,8X,2HX1,9X,2HY1,9X,2HZ1,10X,2HX2,9X,2HY2,9X,2HZ2,6X,  DA  73
     2 6HRADIUS,3X,4HSEG.,5X,4HSEG.,3X,4HSEG.,5X,3HNO.)                 DA  74
10    FORMAT (A2,I3,I5,7F10.5)                                         DA  75
11    FORMAT (1X,I5,3F11.5,1X,4F11.5,2X,I5,4X,I5,1X,I5,3X,I5)          DA  76
12    FORMAT (6X,26HSTRUCTURE SCALED BY FACTOR,F10.5)                  DA  77
13    FORMAT (6X,49HTHE STRUCTURE HAS BEEN MOVED, MOVE DATA CARD IS -/ DA  78
     1 6X,I3,I5,7F10.5)                                               DA  79
14    FORMAT (25H GEOMETRY DATA CARD ERROR)                            DA  80
15    FORMAT (1X,A2,I3,I5,7F10.5)                                      DA  81
      END                                                              DA  82-
```

```
      SUBROUTINE EINCF (T)                                                    EI    1
C                                                                             EI    2
C     EINCF IS CALLED AT EACH TIME STEP TO FILL ARRAY EINC WITH THE           EI    3
C     APPLIED FIELD ON EACH SEGMENT AT TIME T.  THIS ROUTINE USES A           EI    4
C     GAUSSIAN PULSE OF FORM EXP(-(A**2)*(T-TMAX)**2)  OR GENERAL TIME        EI    5
C     DEPENDENCE FROM INPUT TABLE)                                            EI    6
C                                                                             EI    7
      COMMON /DATA/  N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),      EI    8
     1    BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ                EI    9
      COMMON /SCOMP/  SX(200),SY(200),SZ(200)                                 EI   10
      COMMON /CONST/  CDT,VEL,DT,NTSTEP                                       EI   11
      COMMON /EINC/  EINC(200),ESRC                                           EI   12
      COMMON /ASORC/  EMAG(10),ISRC(10),NSRC                                  EI   13
      COMMON /ENSET/  A,TMAX,EIX,PX,PY,PZ,EX,EY,EZ,VLT(200),TW,IARB,TAMX      EI   14
      DATA   TA/0.017453292/,XW/0.1/                                          EI   15
      IF (NSRC.EQ.0) GO TO 8                                                  EI   16
C                                                                             EI   17
C     SET UP APPLIED FIELD FOR TRANSMITTING ANTENNA                           EI   18
C                                                                             EI   19
      DO 1 I=1,N                                                              EI   20
1     EINC(I)=0.                                                              EI   21
      IF (IARB.NE.0) GO TO 2                                                  EI   22
      ESRC=A*(T-TMAX)                                                         EI   23
      ESRC=EXP(-ESRC*ESRC)                                                    EI   24
      GO TO 6                                                                 EI   25
2     TD=T                                                                    EI   26
3     IF (TD.LT.0..OR.TD.GT.TAMX) GO TO 4                                     EI   27
      IS=TD/TW+1.5                                                            EI   28
      IF (IS.LT.2) IS=2                                                       EI   29
      IF (IS.EQ.IARB) IS=IS-1                                                 EI   30
      GO TO 5                                                                 EI   31
4     ESRC=0.                                                                 EI   32
      RETURN                                                                  EI   33
5     TD=TD-TW*FLOAT(IS-1)                                                    EI   34
      ESRC=(.5*TD*((TD-TW)*VLT(IS-1)+(TD+TW)*VLT(IS+1))-(TD+TW)*(TD-TW)*      EI   35
     1VLT(IS))/(TW*TW)                                                        EI   36
      IF (NSRC.EQ.0) RETURN                                                   EI   37
6     DO 7 IS=1,NSRC                                                          EI   38
      I=ISRC(IS)                                                              EI   39
7     EINC(I)=EMAG(IS)*ESRC                                                   EI   40
      RETURN                                                                  EI   41
C                                                                             EI   42
C     SET UP APPLIED FIELD FOR INCIDENT PLANE WAVE                            EI   43
C                                                                             EI   44
8     TCON=T-EIX                                                              EI   45
      DO 13 I=1,N                                                             EI   46
      TD=TCON-(X(I)*PX+Y(I)*PY+Z(I)*PZ)                                       EI   47
      IF (IARB.NE.0) GO TO 9                                                  EI   48
      TD=TD*A                                                                 EI   49
      ESRC=EXP(-TD*TD)                                                        EI   50
      GO TO 12                                                                EI   51
9     IF (TD.LT.0..OR.TD.GT.TAMX) GO TO 10                                    EI   52
      IS=TD/TW+1.5                                                            EI   53
      IF (IS.LT.2) IS=2                                                       EI   54
      IF (IS.EQ.IARB) IS=IS-1                                                 EI   55
      GO TO 11                                                                EI   56
```

```
10    EINC(I)=0.                                                          EI  57
      GO TO 13                                                            EI  58
11    TD=TD-TW*FLOAT(IS-1)                                                EI  59
      ESRC=(.5*TD*((TD-TW)*VLT(IS-1)+(TD+TW)*VLT(IS+1))-(TD+TW)*(TD-TW)*  EI  60
     1VLT(IS))/(TW*TW)                                                    EI  61
12    EINC(I)=ESRC*(SX(I)*EX+SY(I)*EY+SZ(I)*EZ)                           EI  62
13    CONTINUE                                                            EI  63
      TD=TCON                                                             EI  64
      IF (IARB.NE.0) GO TO 3                                              EI  65
      ESRC=A*TCON                                                         EI  66
      ESRC=EXP(-ESRC*ESRC)                                                EI  67
      RETURN                                                              EI  68
      ENTRY   ESET(T)                                                     EI  69
C                                                                         EI  70
C     READ DATA CARDS AND INITIALIZE CONSTANTS FOR EXCITATION             EI  71
C                                                                         EI  72
      READ 25,  IARB,NSRC,TW,THET,PHI,ET,RZERO,TMAX                       EI  73
      PRINT 31,  IARB,NSRC,TW,THET,PHI,ET,RZERO,TMAX                      EI  74
      PRINT 26                                                            EI  75
      IF (IARB.NE.0) GO TO 15                                             EI  76
      A=SQRT(-ALOG(XW))/(TW*.5)                                           EI  77
      IF (TMAX.GT.1.E-20) GO TO 14                                        EI  78
      EIN=0.03                                                            EI  79
      IF (TMAX.LT.(-1.E-20)) EIN=-TMAX                                    EI  80
      TMAX=SQRT(-ALOG(EIN))/A                                             EI  81
      TMAX=(AINT(TMAX/DT)+1.)*DT                                          EI  82
14    EIX=EXP(-A*A*TMAX*TMAX)*100.                                        EI  83
      PRINT 27, A,TMAX,EIX                                                EI  84
      GO TO 17                                                            EI  85
15    IF (IARB.GT.200) GO TO 20                                           EI  86
      TAMX=TW*FLOAT(IARB-1)                                               EI  87
      READ 21, (VLT(I),I=1,IARB)                                          EI  88
      PRINT 23                                                            EI  89
      T=-TW                                                               EI  90
      DO 16 I=1,IARB                                                      EI  91
      T=T+TW                                                              EI  92
16    PRINT 22, I,T,VLT(I)                                                EI  93
      TMAX=0.                                                             EI  94
17    IF (NSRC.EQ.0) GO TO 19                                             EI  95
      PRINT 28                                                            EI  96
      DO 18 IS=1,NSRC                                                     EI  97
      READ 29,  ITG,II,VMAG                                               EI  98
      I=ISEGNO(ITG,II)                                                    EI  99
      PRINT 30,  IS,ITG,II,I,VMAG                                         EI 100
      ISRC(IS)=I                                                          EI 101
18    EMAG(IS)=VMAG/SI(I)                                                 EI 102
      RETURN                                                              EI 103
19    PRINT 32, RZERO,THET,PHI,ET                                         EI 104
      THET=THET*TA                                                        EI 105
      PHI=PHI*TA                                                          EI 106
      ET=ET*TA                                                            EI 107
      ST=SIN(THET)                                                        EI 108
      CT=COS(THET)                                                        EI 109
      SP=SIN(PHI)                                                         EI 110
      CP=COS(PHI)                                                         EI 111
      SE=SIN(ET)                                                          EI 112
      CE=COS(ET)                                                          EI 113
      PX=-ST*CP/VEL                                                       EI 114
      PY=-ST*SP/VEL                                                       EI 115
      PZ=-CT/VEL                                                          EI 116
```

```
      EX=CT*CP*CE-SP*SE                                                 EI 117
      EY=CT*SP*CE+CP*SE                                                 EI 118
      EZ=-ST*CE                                                         EI 119
      EIX=TMAX+RZERO/VEL                                                EI 120
      RETURN                                                            EI 121
20    PRINT 24                                                          EI 122
      STOP                                                              EI 123
C                                                                       EI 124
C                                                                       EI 125
21    FORMAT (6E12.5)                                                   EI 126
22    FORMAT (30X,I5,E13.5,E14.5)                                       EI 127
23    FORMAT (   31X,52HTIME DEPENCENCE - GENERAL,  SET BY INPUT TABLE B EI 128
     1ELOW,//,31X,4HSTEP,7X,4HTIME,9X, 6HSOURCE,/,32X,3HNO.,6X,6H(SEC.), EI 129
     2  7X,8HSTRENGTH)                                                 EI 130
24    FORMAT (52H NUMBER OF EXCITATION VALUES EXCEEDS ARRAY DIMENSION)  EI 131
25    FORMAT  (2I5,6E10.3)                                              EI 132
26    FORMAT  ( //,38X,26H- - - - EXCITATION - - - -,//)                EI 133
27    FORMAT (  31X,78HTIME DEPENDENCE- GAUSSIAN, PEAK AT TIME=TMAX = - EI 134
     1  EXP(-(A**2)*(TIME-TMAX)**2),//,31X,2HA=,E12.5,9H,   TMAX=,E12.5, EI 135
     2 //,31X,10HSOURCE HAS,F8.3,33H PERCENT OF PEAK VALUE AT TIME=0.)  EI 136
28    FORMAT ( //,31X,17HVOLTAGE SOURCES -,//,31X,23HSOURCE   SOURCE SEG EI 137
     1MENT,6X,12HPEAK VOLTAGE,/,33X,3HNO.,4X,3HTAG,2X,4HINC.,2X,4HSEG.,  EI 138
     2 8X,7H(VOLTS),/,40X,3HNO.,9X,3HNO.)                              EI 139
29    FORMAT  (2I5,E10.3)                                               EI 140
30    FORMAT  (31X,I5,I7,2I6,5X,F10.4)                                  EI 141
31    FORMAT  ( //,1X,26H*** EXCITATION DATA CARD**,2I5,E12.5,4F10.5,E12 EI 142
     1.5)                                                               EI 143
32    FORMAT (  //,31X,22HINCIDENT PLANE PULSE -,/,31X,65HAT TIME = 0. L EI 144
     1EADING EDGE OF PULSE IS SHIFTED BACK FROM ORIGIN BY,F10.5,7H METER EI 145
     2S, //,31X,26HINCIDENCE ANGLES -  THETA=,F10.5,5H DEG.,/,51X,6HPHI  EI 146
     3 =,F10.5,5H DEG.,/,51X,6HETA  =,F10.5,5H DEG.,/)                  EI 147
      END                                                               EI 148
```

```
      SUBROUTINE EMAT (RX,RY,RZ,R2,TAU,SXJ,SYJ,SZJ,J)                    EM    1
C                                                                        EM    2
C     EMAT COMPUTES THE COEFFICIENTS WHICH MULTIPLY A 3 SEGMENT BY 3     EM    3
C     TIME STEP PATCH OF CURRENT AND INTEGRAL OF CURRENT TO YIELD THE    EM    4
C     VECTOR COMPONENTS OF ELECTRIC FIELD                                EM    5
C                                                                        EM    6
      COMMON /DATA/  N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200), EM    7
     1    BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ           EM    8
      COMMON /INTERP/  AT(3,200),BT(3,200),CT(3,200),ES(3),FS(3),GS(3),  EM    9
     1    E(3),H(3)                                                      EM   10
      COMMON /INTG/  X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11,X12              EM   11
      COMMON /EMATS/  EMX(3,3),EMY(3,3),EMZ(3,3),QMX(3,3),QMY(3,3),QMZ(3 EM   12
     1,3)                                                               EM   13
      COMMON /CONST/  CDT,VEL,DT,NTSTEP                                  EM   14
      DIMENSION P(3), G(3), F(3)                                         EM   15
      DO 1 L=1,3                                                         EM   16
      P(L)=2.*ES(L)*TAU+FS(L)                                            EM   17
      G(L)=(ES(L)*TAU+FS(L))*TAU+GS(L)                                   EM   18
1     F(L)=-P(L)/VEL                                                     EM   19
      BCON=-2.*(RX*SXJ+RY*SYJ+RZ*SZJ)                                    EM   20
      CCON=R2+BI(J)*BI(J)                                                EM   21
      SJ=SI(J)                                                           EM   22
      CALL INTEG (SJ,BCON,CCON)                                          EM   23
      DO 2 L=1,3                                                         EM   24
      AL=AT(L,J)                                                         EM   25
      BL=BT(L,J)                                                         EM   26
      CL=CT(L,J)                                                         EM   27
      DO 2 M=1,3                                                         EM   28
      EM=E(M)                                                            EM   29
      FM=F(M)                                                            EM   30
      GM=G(M)                                                            EM   31
      T1=H(M)*(AL*X9+CL*X1)+P(M)*(AL*X10+BL*X6+CL*X2)                    EM   32
      T2=2.*AL*(FM*X6+GM*X7)+BL*(EM*X1+FM*X2+GM*X3)                      EM   33
      T3=2.*AL*(EM*X9+FM*X10+GM*X11)+BL*(FM*X6+GM*X7)                    EM   34
      T4=2.*AL*(EM*X6+FM*X7+GM*X8)+BL*(EM*X2+FM*X3+GM*X4)                EM   35
      T5=2.*AL*(EM*X10+FM*X11+GM*X12)+BL*(EM*X6+FM*X7+GM*X8)             EM   36
      T1=-(T1-VEL*T3)*1.E-7                                              EM   37
      T2=-VEL*T2*1.E-7                                                   EM   38
C                                                                        EM   39
C     COEFFICIENTS FOR CURRENTS                                          EM   40
C                                                                        EM   41
      EMX(L,M)=SXJ*T1+RX*T2                                              EM   42
      EMY(L,M)=SYJ*T1+RY*T2                                              EM   43
      EMZ(L,M)=SZJ*T1+RZ*T2                                              EM   44
      T4=-VEL*VEL*T4*1.E-7                                               EM   45
      T5=VEL*VEL*T5*1.E-7                                                EM   46
C                                                                        EM   47
C     COEFFICIENTS FOR TIME INTEGRAL OF CURRENTS                         EM   48
C                                                                        EM   49
      QMX(L,M)=RX*T4+SXJ*T5                                              EM   50
      QMY(L,M)=RY*T4+SYJ*T5                                              EM   51
2     QMZ(L,M)=RZ*T4+SZJ*T5                                              EM   52
      RETURN                                                             EM   53
      END                                                                EM   54
```

```
      SUBROUTINE FACIO (A,AR,N,IX,IP)                                    FO   1
C                                                                        FO   2
C     S/R WHICH CONTROLS I/O FOR FACTORIZATION                           FO   3
C                                                                        FO   4
      COMMON /MATPAR/ NBLOKS,NPBLK,NLAST,INT                             FO   5
      DIMENSION A(N,N), IP(N), IX(N), AR(1)                              FO   6
      IF (NBLOKS.GT.2) GO TO 1                                           FO   7
      CALL FACTR (N,A,IP,N)                                              FO   8
      RETURN                                                             FO   9
1     REWIND  11                                                         FO  10
      REWIND  13                                                         FO  11
      REWIND  14                                                         FO  12
      IT=NPBLK*N                                                         FO  13
      I1=1                                                               FO  14
      ITWO=2                                                             FO  15
      I2=IT                                                              FO  16
      I3=I2+1                                                            FO  17
      I4=2*IT                                                            FO  18
C                                                                        FO  19
C     BUFFER IN BLOCK1 AND BLOCK2 FROM TAPE 1                            FO  20
C                                                                        FO  21
      READ (13) (AR(I),I=I1,I2)                                          FO  22
      READ (13) (AR(I),I=I3,I4)                                          FO  23
      CALL LFACTR (A,N,1,2,IP)                                           FO  24
C                                                                        FO  25
C     BUFFER OUT BLOCK1 TO TAPE2 (BLOCK1 FACTORED)                       FO  26
C                                                                        FO  27
      WRITE (11) (AR(I),I=I1,I2)                                         FO  28
C                                                                        FO  29
C     BUFFER OUT BLOCK2 TO FILE3                                         FO  30
C                                                                        FO  31
      WRITE (14) (AR(I),I=I3,I4)                                         FO  32
      DO 2 IXBLK2=3,NBLOKS                                               FO  33
C                                                                        FO  34
C     BUFFER IN BLOCK2 FROM TAPE1                                        FO  35
C                                                                        FO  36
      READ (13) (AR(I),I=I3,I4)                                          FO  37
      CALL LFACTR (A,N,1,IXBLK2,IP)                                      FO  38
C                                                                        FO  39
C     BUFFER OUT BLOCK2 TO FILE3                                         FO  40
C                                                                        FO  41
      WRITE (14) (AR(I),I=I3,I4)                                         FO  42
2     CONTINUE                                                           FO  43
      IXBLK1=1                                                           FO  44
3     IXBLK1=IXBLK1+1                                                    FO  45
      IXBLK2=IXBLK1+1                                                    FO  46
C                                                                        FO  47
C     WITH THE EXCEPTION OF THE FIRST PASS, IFILE3 BECOMES IFILE4 AND VI FO  48
C                                                                        FO  49
      IFILE3=13                                                          FO  50
      IFILE4=14                                                          FO  51
      IF (2*(IXBLK1/2).NE.IXBLK1) GO TO 4                                FO  52
      IFILE3=14                                                          FO  53
      IFILE4=13                                                          FO  54
4     REWIND  IFILE3                                                     FO  55
      REWIND  IFILE4                                                     FO  56
```

```
C                                                                       FO  57
C     BUFFER IN BLOCK1 AND BLOCK2 FROM IFILE3                           FO  58
C                                                                       FO  59
      READ (IFILE3) (AR(I),I=I1,I2)                                     FO  60
      READ (IFILE3) (AR(I),I=I3,I4)                                     FO  61
      CALL LFACTR (A,N,IXBLK1,IXBLK2,IP)                                FO  62
C                                                                       FO  63
C     BUFFER OUT BLOCK1 TO TAPE2 (BLOCK1 FACTORED)                      FO  64
C                                                                       FO  65
      WRITE (11) (AR(I),I=I1,I2)                                        FO  66
C                                                                       FO  67
C     BUFFER OUT BLOCK2 TO IFILE4                                       FO  68
C                                                                       FO  69
      WRITE (IFILE4) (AR(I),I=I3,I4)                                    FO  70
      IF (IXBLK2.NE.NBLOKS) GO TO 5                                     FO  71
C                                                                       FO  72
C     BUFFER OUT BLOCK2 TO TAPE2 (BLOCK1 FACTORED--FACTORIZATION FINISHE FO  73
C                                                                       FO  74
      WRITE (11) (AR(I),I=I3,I4)                                        FO  75
      REWIND  11                                                        FO  76
      REWIND  13                                                        FO  77
      REWIND  14                                                        FO  78
      GO TO 6                                                           FO  79
5     IXBLK2=IXBLK2+1                                                   FO  80
      IF (IXBLK2.GT.NBLOKS) GO TO 3                                     FO  81
C                                                                       FO  82
C     BUFFER IN BLOCK2 FROM IFILE3                                      FO  83
C                                                                       FO  84
      READ (IFILE3) (AR(I),I=I3,I4)                                     FO  85
      CALL LFACTR (A,N,IXBLK1,IXBLK2,IP)                                FO  86
C                                                                       FO  87
C     BUFFER OUT BLOCK2 TO FILE4                                        FO  88
C                                                                       FO  89
      WRITE (IFILE4) (AR(I),I=I3,I4)                                    FO  90
      GO TO 5                                                           FO  91
6     CALL LUNSCR (A,AR,N,IX,IP)                                        FO  92
      RETURN                                                            FO  93
      END                                                               FO  94
```

```
      SUBROUTINE FACTR (N,A,P,NDIM)                                     FA    1
C                                                                       FA    2
C     SUBROUTINE TO FACTOR A MATRIX INTO A UNIT LOWER TRIANGULAR MATRIX  FA    3
C     AND AN UPPER TRIANGULAR MATRIX USING THE GAUSS-DOOLITTLE ALGORITHM FA    4
C     PRESENTED ON PAGES 411-416 OF A. RALSTON--A FIRST COURSE IN       FA    5
C     NUMERICAL ANALYSIS.  COMMENTS BELOW REFER TO COMMENTS IN RALSTONS  FA    6
C     TEST.    (MATRIX TRANSPOSED)                                      FA    7
C                                                                       FA    8
      DIMENSION A(NDIM,NDIM), P(NDIM)                                   FA    9
      COMMON /SCRATM/ D(200)                                            FA   10
      INTEGER  R,P,RM1,RP1,PJ,PR                                        FA   11
      IFLG=0                                                            FA   12
      DO 9 R=1,N                                                        FA   13
C                                                                       FA   14
C     STEP 1                                                            FA   15
C                                                                       FA   16
      DO 1 K=1,N                                                        FA   17
      D(K)=A(R,K)                                                       FA   18
1     CONTINUE                                                          FA   19
C                                                                       FA   20
C     STEPS 2 AND 3                                                     FA   21
C                                                                       FA   22
      RM1=R-1                                                           FA   23
      IF (RM1.LT.1) GO TO 4                                             FA   24
      DO 3 J=1,RM1                                                      FA   25
      PJ=P(J)                                                           FA   26
      A(R,J)=D(PJ)                                                      FA   27
      D(PJ)=D(J)                                                        FA   28
      JP1=J+1                                                           FA   29
      DO 2 I=JP1,N                                                      FA   30
      D(I)=D(I)-A(J,I)*A(R,J)                                           FA   31
2     CONTINUE                                                          FA   32
3     CONTINUE                                                          FA   33
4     CONTINUE                                                          FA   34
C                                                                       FA   35
C     STEP 4                                                            FA   36
C                                                                       FA   37
      DMAX=ARS(D(R))                                                    FA   38
      P(R)=R                                                            FA   39
      RP1=R+1                                                           FA   40
      IF (RP1.GT.N) GO TO 6                                             FA   41
      DO 5 I=RP1,N                                                      FA   42
      ELMAG=ABS(D(I))                                                   FA   43
      IF (ELMAG.LT.DMAX) GO TO 5                                        FA   44
      DMAX=ELMAG                                                        FA   45
      P(R)=I                                                            FA   46
5     CONTINUE                                                          FA   47
6     CONTINUE                                                          FA   48
      IF (DMAX.LT.1.E-10) IFLG=1                                        FA   49
      PR=P(R)                                                           FA   50
      A(R,R)=D(PR)                                                      FA   51
      D(PR)=D(R)                                                        FA   52
C                                                                       FA   53
C     STEP 5                                                            FA   54
C                                                                       FA   55
      IF (RP1.GT.N) GO TO 8                                             FA   56
```

```
      DO 7 I=RP1,N                                                      FA  57
      A(R,I)=U(I)/A(R,R)                                                FA  58
7     CONTINUE                                                          FA  59
8     CONTINUE                                                          FA  60
      IF (IFLG.EQ.0) GO TO 9                                            FA  61
      PRINT 10,  R,DMAX                                                 FA  62
      IFLG=0                                                            FA  63
9     CONTINUE                                                          FA  64
      RETURN                                                            FA  65
C                                                                       FA  66
10    FORMAT (1X,6HPIVOT(,I3,2H)=,E16.8)                                FA  67
      END                                                               FA  68=
```

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```
      SUBROUTINE FBLOCK (NBLOKS,NPBLK,NLAST,IMAX,N,INT)                  FB    1
C                                                                        FB    2
C     FBLOCK DETERMINES BLOCK SIZE AND NUMBER OF BLOCKS WHEN OUT-OF-CORE FB    3
C     MATRIX STORAGE IS REQUIRED.  INT=0 RETURNED IF MATRIX FITS IN CORE FB    4
C                                                                        FB    5
      IF (N*N.LE.IMAX) GO TO 1                                           FB    6
      NPBLK=IMAX/(2*N)                                                   FB    7
      IF (NPBLK.LT.1) STOP                                               FB    8
      INT=1                                                              FB    9
      NBLOKS=(N-1)/NPBLK+1                                               FB   10
      NLAST=N-(NBLOKS-1)*NPBLK                                           FB   11
      PRINT 2, NBLOKS,NPBLK,NLAST                                        FB   12
      RETURN                                                             FB   13
1     NBLOKS=2                                                           FB   14
      NPBLK=(N+1)/2                                                      FB   15
      NLAST=N-NPBLK                                                      FB   16
      INT=0                                                              FB   17
      RETURN                                                             FB   18
C                                                                        FB   19
2     FORMAT (1X,11H BLOCKING  ,4I5/)                                    FB   20
      END                                                                FB   21-
```

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```
      SUBROUTINE FORT (A,M,S,IFS,IFERR)                                  FT   1
C                                                                        FT   2
C     FOURIER TRANSFORM SUBROUTINE, PROGRAMMED IN SYSTEM/360,            FT   3
C     BASIC PROGRAMMING SUPPORT, FORTRAN IV, FORM C28-6504               FT   4
C     THIS DECK SET UP FOR IBSYS ON IBM 7094,                            FT   5
C                                                                        FT   6
C     DOES EITHER FOURIER SYNTHESIS,I.E.,COMPUTES COMPLEX FOURIER SERIES FT   7
C     GIVEN A VECTOR OF N COMPLEX FOURIER AMPLITUDES,OR, GIVEN A VECTOR  FT   8
C     OF COMPLEX DATA X DOES FOURIER ANALYSIS, COMPUTING AMPLITUDES,     FT   9
C     A IS A COMPLEX VECTOR OF LENGTH N=2**M COMPLEX NOS. OR 2*N REAL    FT  10
C     NUMBERS, A IS TO BE SET BY USER,                                   FT  11
C     M  IS AN INTEGER 0.LT.M.LE.13, SET BY USER,                        FT  12
C     S IS A VECTOR S(J)= SIN(2*PI*J/NP ), J=1,2,....,NP/4-1,            FT  13
C     COMPUTED BY PROGRAM,                                               FT  14
C     IFS IS A PARAMETER TO BE SET BY USER AS FOLLOWS-                   FT  15
C     IFS=0 TO SET NP=2**M AND SET UP SINE TABLE,                        FT  16
C     IFS=1 TO SET N=NP=2**M, SET UP SIN TABLE, AND DO FOURIER           FT  17
C     SYNTHESIS, REPLACING THE VECTOR A BY                               FT  18
C                                                                        FT  19
C     X(J)= SUM OVER K=0,N-1 OF A(K)*EXP(2*PI*I/N)**(J*K),               FT  20
C     J=0,N-1, WHERE I=SQRT(-1)                                          FT  21
C                                                                        FT  22
C     THE  X'S  ARE STORED WITH   RE X(J) IN CELL  2*J+1                 FT  23
C     AND  IM X(J)  IN CELL  2*J+2  FOR  J=0,1,2,...,N-1.                FT  24
C     THE  A'S  ARE STORED IN THE SAME MANNER,                           FT  25
C                                                                        FT  26
C     IFS=-1   TO SET  N=NP=2**M,SET UP SIN TABLE, AND DO FOURIER        FT  27
C     ANALYSIS, TAKING THE INPUT VECTOR A AS X AND                       FT  28
C     REPLACING IT BY THE A  SATISFYING THE ABOVE FOURIER SERIES,        FT  29
C     IFS=+2 TO DO FOURIER SYNTHESIS ONLY, WITH A PRE-COMPUTED S.        FT  30
C     IFS=-2 TO DO FOURIER ANALYSIS ONLY, WITH A PRE-COMPUTED S.         FT  31
C     IFERR   IS SET BY PROGRAM TO-                                      FT  32
C     =0 IF NO ERROR DETECTED.                                           FT  33
C     =1 IF M IS OUT OF RANGE., OR, WHEN IFS=+2,-2, THE                  FT  34
C     PRE-COMPUTED S TABLE IS NOT LARGE ENOUGH,                          FT  35
C     =-1 WHEN IFS =+1,-1, MEANS ONE IS RECOMPUTING S TABLE              FT  36
C     UNNECESSARILY,                                                     FT  37
C                                                                        FT  38
C     NOTE- AS STATED ABOVE, THE MAXIMUM VALUE OF M FOR THIS PROGRAM     FT  39
C     ON THE IBM 7094 IS 13, FOR 360 MACHINES HAVING GREATER STORAGE     FT  40
C     CAPACITY, ONE MAY INCREASE THIS LIMIT BY REPLACING 13 IN           FT  41
C     STATEMENT 3 BELOW BY LOG2 N, WHERE N IS THE MAX, NO, OF            FT  42
C     COMPLEX NUMBERS ONE CAN STORE IN HIGH-SPEED CORE,  ONE MUST        FT  43
C     ALSO ADD MORE  DO  STATEMENTS TO THE BINARY SORT ROUTINE           FT  44
C     FOLLOWING STATEMENT  24  AND CHANGE THE EQUIVALENCE STATEMENTS     FT  45
C     FOR THE  K'S.                                                      FT  46
C                                                                        FT  47
      DIMENSION A(1), S(1), K(14)                                        FT  48
      EQUIVALENCE (K(13),K1), (K(12),K2), (K(11),K3), (K(10),K4)         FT  49
      EQUIVALENCE (K(9),K5), (K(8),K6), (K(7),K7), (K(6),K8)             FT  50
      EQUIVALENCE (K(5),K9), (K(4),K10), (K(3),K11), (K(2),K12)          FT  51
      EQUIVALENCE (K(1),K13), (K(1),N2)                                  FT  52
      IF (M) 2,2,1                                                       FT  53
1     IF (M-13) 4,4,2                                                    FT  54
2     IFERR=1                                                            FT  55
3     RETURN                                                             FT  56
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```
4       IFERR=0                                                          FT  57
        N=2**M                                                           FT  58
        IF (IABS(IFS)-1) 25,25,5                                         FT  59
C       WE ARE DOING TRANSFORM ONLY. SEE IF PRE-COMPUTED                 FT  60
C       S TABLE IS SUFFICIENTLY LARGE                                    FT  61
5       IF (N-NP) 7,7,6                                                  FT  62
6       IFERR=1                                                          FT  63
        GO TO 25                                                         FT  64
C       SCRAMBLE A, BY SANDE'S METHOD                                    FT  65
7       K(1)=2*N                                                         FT  66
        DO 8 L=2,M                                                       FT  67
8       K(L)=K(L-1)/2                                                    FT  68
        DO 9 L=M,12                                                      FT  69
9       K(L+1)=2                                                         FT  70
C       NOTE EQUIVALENCE OF KL AND K(14-L)                               FT  71
C       BINARY SORT-                                                     FT  72
        IJ=2                                                             FT  73
        DO 11 J1=2,K1,2                                                  FT  74
        DO 11 J2=J1,K2,K1                                                FT  75
        DO 11 J3=J2,K3,K2                                                FT  76
        DO 11 J4=J3,K4,K3                                                FT  77
        DO 11 J5=J4,K5,K4                                                FT  78
        DO 11 J6=J5,K6,K5                                                FT  79
        DO 11 J7=J6,K7,K6                                                FT  80
        DO 11 J8=J7,K8,K7                                                FT  81
        DO 11 J9=J8,K9,K8                                                FT  82
        DO 11 J10=J9,K10,K9                                              FT  83
        DO 11 J11=J10,K11,K10                                            FT  84
        DO 11 J12=J11,K12,K11                                            FT  85
        DO 11 JI=J12,K13,K12                                             FT  86
        IF (IJ-JI) 10,11,11                                              FT  87
10      T=A(IJ-1)                                                        FT  88
        A(IJ-1)=A(JI-1)                                                  FT  89
        A(JI-1)=T                                                        FT  90
        T=A(IJ)                                                          FT  91
        A(IJ)=A(JI)                                                      FT  92
        A(JI)=T                                                          FT  93
11      IJ=IJ+2                                                          FT  94
        IF (IFS) 12,2,14                                                 FT  95
C       DOING FOURIER ANALYSIS,SO DIV. BY N AND CONJUGATE.               FT  96
12      FN=N                                                             FT  97
        DO 13 I=1,N                                                      FT  98
        A(2*I-1)=A(2*I-1)/FN                                             FT  99
13      A(2*I)=-A(2*I)/FN                                                FT 100
C       SPECIAL CASE- L=1                                                FT 101
14      DO 15 I=1,N,2                                                    FT 102
        T=A(2*I-1)                                                       FT 103
        A(2*I-1)=T+A(2*I+1)                                              FT 104
        A(2*I+1)=T-A(2*I+1)                                              FT 105
        T=A(2*I)                                                         FT 106
        A(2*I)=T+A(2*I+2)                                                FT 107
15      A(2*I+2)=T-A(2*I+2)                                              FT 108
        IF (M-1) 2,3,16                                                  FT 109
C       SET FOR L=2                                                      FT 110
16      LEXP1=2                                                          FT 111
C       LEXP1=2**(L-1)                                                   FT 112
        LEXP=8                                                           FT 113
C       LEXP=2**(L+1)                                                    FT 114
        NPL=2**MT                                                        FT 115
C       NPL = NP* 2**-L                                                  FT 116
```

```
      DO 22 L=2,M                                                       FT 117
C     SPECIAL CASE- J=0                                                 FT 118
      DO 17 I=2,N2,LEXP                                                 FT 119
      I1=I+LEXP1                                                        FT 120
      I2=I1+LEXP1                                                       FT 121
      I3=I2+LEXP1                                                       FT 122
      T=A(I-1)                                                          FT 123
      A(I-1)=T+A(I2-1)                                                  FT 124
      A(I2-1)=T-A(I2-1)                                                 FT 125
      T=A(I)                                                            FT 126
      A(I)=T+A(I2)                                                      FT 127
      A(I2)=T-A(I2)                                                     FT 128
      T=-A(I3)                                                          FT 129
      TI=A(I3-1)                                                        FT 130
      A(I3-1)=A(I1-1)-T                                                 FT 131
      A(I3)=A(I1)-TI                                                    FT 132
      A(I1-1)=A(I1-1)+T                                                 FT 133
17    A(I1)=A(I1)+TI                                                    FT 134
      IF (L-2) 21,21,18                                                 FT 135
18    KLAST=N2-LEXP                                                     FT 136
      JJ=NPL                                                            FT 137
      DO 20 J=4,LEXP1,2                                                 FT 138
      NPJJ=NT-JJ                                                        FT 139
      UR=S(NPJJ)                                                        FT 140
      UI=S(JJ)                                                          FT 141
      ILAST=J+KLAST                                                     FT 142
      DO 19 I= J,ILAST,LEXP                                             FT 143
      I1=I+LEXP1                                                        FT 144
      I2=I1+LEXP1                                                       FT 145
      I3=I2+LEXP1                                                       FT 146
      T=A(I2-1)*UR-A(I2)*UI                                             FT 147
      TI=A(I2-1)*UI+A(I2)*UR                                            FT 148
      A(I2-1)=A(I-1)-T                                                  FT 149
      A(I2)=A(I)-TI                                                     FT 150
      A(I-1)=A(I-1)+T                                                   FT 151
      A(I)=A(I)+TI                                                      FT 152
      T=-A(I3-1)*UI-A(I3)*UR                                            FT 153
      TI=A(I3-1)*UR-A(I3)*UI                                            FT 154
      A(I3-1)=A(I1-1)-T                                                 FT 155
      A(I3)=A(I1)-TI                                                    FT 156
      A(I1-1)=A(I1-1)+T                                                 FT 157
19    A(I1)=A(I1)+TI                                                    FT 158
C     END OF I LOOP                                                     FT 159
20    JJ=JJ+NPL                                                         FT 160
C     END OF J LOOP                                                     FT 161
21    LEXP1=2*LEXP1                                                     FT 162
      LEXP=2*LEXP                                                       FT 163
22    NPL=NPL/2                                                         FT 164
C     END OF L LOOP                                                     FT 165
      IF (IFS) 23,2,3                                                   FT 166
C     DOING FOURIER ANALYSIS, REPLACE A BY CONJUGATE.                   FT 167
23    DO 24 I=1,N                                                       FT 168
24    A(2*I)=-A(2*I)                                                    FT 169
      GO TO 3                                                           FT 170
C     RETURN                                                            FT 171
C     MAKE TABLE OF S(J)=SIN(2*PI*J/NP),J=1,2,...,NT-1,NT=NP/4          FT 172
25    NP=N                                                              FT 173
      MP=M                                                              FT 174
      NT=N/4                                                            FT 175
      MT=M-2                                                            FT 176
```

```
      IF (MT) 31,31,26                                                  FT 177
26    THETA=.785398163                                                  FT 178
C     THETA=PI/2**(L+1)     FOR L=1                                     FT 179
      JSTEP=NT                                                          FT 180
C     JSTEP = 2**( MT-L+1 ) FOR L=1                                     FT 181
      JDIF=NT/2                                                         FT 182
C     JDIF = 2**(MT-L)  FOR L=1                                         FT 183
      S(JDIF)=SIN(THETA)                                                FT 184
      IF (MT-2) 31,27,27                                                FT 185
27    DO 30 L=2,MT                                                      FT 186
      THETA=THETA/2.                                                    FT 187
      JSTEP2=JSTEP                                                      FT 188
      JSTEP=JDIF                                                        FT 189
      JDIF=JDIF/2                                                       FT 190
      S(JDIF)=SIN(THETA)                                                FT 191
      JC1=NT-JDIF                                                       FT 192
      S(JC1)=COS(THETA)                                                 FT 193
      JLAST=NT-JSTEP2                                                   FT 194
      IF (JLAST-JSTEP) 30,28,28                                         FT 195
28    DO 29 J=JSTEP,JLAST,JSTEP                                         FT 196
      JC=NT-J                                                           FT 197
      JD=J+JDIF                                                         FT 198
29    S(JD)=S(J)*S(JC1)+S(JDIF)*S(JC)                                   FT 199
30    CONTINUE                                                          FT 200
31    IF (IFS) 7,3,7                                                    FT 201
      END                                                               FT 202-
```

```
      SUBROUTINE IFEM (I)                                              IF    1
C                                                                      IF    2
C     IFEM CONVERTS I FROM E, M, OR BLANK TO 1, -1, OR 0.              IF    3
C                                                                      IF    4
      DATA   IE,IM/1HE,1HM/                                            IF    5
      IF (I.EQ.IE) GO TO 1                                             IF    6
      IF (I.EQ.IM) GO TO 2                                             IF    7
      I=0                                                              IF    8
      RETURN                                                           IF    9
1     I=1                                                              IF   10
      RETURN                                                           IF   11
2     I=-1                                                             IF   12
      RETURN                                                           IF   13
      END                                                              IF   14
```

```
      SUBROUTINE INTEG (EL,B,C)                                          IN    1
C                                                                        IN    2
C     INTEG COMPUTES 12 INTEGRALS NEEDED TO SET UP THE FIELD             IN    3
C     COEFFICIENTS                                                       IN    4
C                                                                        IN    5
      COMMON /INTG/  X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11,X12              IN    6
      DOUBLE PRECISION  S2,S1,R1S,R2S,R1,R2,B2,HB,DE1,DE2,DIS,ALR,DIM,   IN    7
     1  DE1S,DE2S,T1,T2,D2,D3,D4,D8                                       IN    8
      S2=EL*.5                                                           IN    9
      S1=-S2                                                             IN   10
      R1S=(S1+B)*S1+C                                                    IN   11
      R2S=(S2+B)*S2+C                                                    IN   12
      R1=DSQRT(R1S)                                                      IN   13
      R2=DSQRT(R2S)                                                      IN   14
      B2=B*B                                                             IN   15
      HB=.5*B                                                            IN   16
      DE1=S1+HB                                                          IN   17
      DE2=S2+HB                                                          IN   18
      DIS=4.*C-B2                                                        IN   19
      ALR=DLOG(R2/R1)                                                    IN   20
      LIM=0                                                              IN   21
      IF (ABS(B).LT.1.E-27) GO TO 2                                      IN   22
      XLIM=DIS/ABS(B)                                                    IN   23
      IF (XLIM.GT.1.E-5) GO TO 2                                         IN   24
      LIM=1                                                              IN   25
      DIM=0.D+0                                                          IN   26
      IF (DE1*DE2.GT.0.) GO TO 1                                         IN   27
      PRINT 10,  B,C                                                     IN   28
      STOP                                                               IN   29
1     DE1S=DE1*DE1                                                       IN   30
      DE2S=DE2*DE2                                                       IN   31
      GO TO 3                                                            IN   32
2     DIM=DSQRT(DIS)                                                     IN   33
3     X1=EL                                                              IN   34
      IF (DE1.LT.0.) GO TO 4                                             IN   35
      D2=DLOG((R2+DE2)/(R1+DE1))                                         IN   36
      GO TO 5                                                            IN   37
4     D2=DLOG((R1-DE1)/(R2-DE2))                                         IN   38
5     X2=D2                                                              IN   39
      IF (LIM.EQ.1) GO TO 6                                              IN   40
      T2=DATAN(2.*DE2/DIM)                                               IN   41
      T1=DATAN(2.*DE1/DIM)                                               IN   42
      D3=2.*(T2-T1)/DIM                                                  IN   43
      D4=4.*(DE2/R2-DE1/R1)/DIS                                          IN   44
      GO TO 7                                                            IN   45
6     D3=(DIS/(12.*DE2*DE2)-1.)/DE2-(DIS/(12.*DE1*DE1)-1.)/DE1           IN   46
      D4=.5*DABS((DE2/DE1-DE1/DE2)/(R1*R2))                              IN   47
7     X3=D3                                                              IN   48
      X4=D4                                                              IN   49
      X5=0.                                                              IN   50
      X6=R2-R1-HB*D2                                                     IN   51
      X7=ALR-HB*D3                                                       IN   52
      IF (LIM.EQ.1) GO TO 8                                              IN   53
      D8=-2.*((B*S2+2.*C)/R2-(B*S1+2.*C)/R1)/DIS                         IN   54
      GO TO 9                                                            IN   55
8     D8=.25*(B/DE2S-B/DE1S)+1./DE1-1./DE2                               IN   56
```

```
      IF (DE1.LT.0.) D8=-D8                                                IN  57
9     X8=D8                                                                IN  58
      X9=EL*EL*EL/12.                                                      IN  59
      X10=.5*((S2-1.5*B)*R2-(S1-1.5*B)*R1)+.125*(3.*B2-4.*C)*D2            IN  60
      X11=S2-S1-B*ALK+.5*(B2-2.*C)*D3                                      IN  61
      X12=D2-B*D8-C*D4                                                     IN  62
      RETURN                                                               IN  63
C                                                                          IN  64
C                                                                          IN  65
10    FORMAT (1X,45HINTEGRATION ATTEMPTED OVER SINGULARITY,  B,C=,2E15.6   IN  66
     1)                                                                    IN  67
      END                                                                  IN  68-
```

```
      FUNCTION ISEGNO (ITAGI,M)                                          IS   1
C                                                                        IS   2
C     ISEGNO RETURNS THE SEGMENT NUMBER OF THE MTH SEGMENT HAVING THE    IS   3
C     TAG NUMBER ITAGI.  IF ITAGI=0 SEGMENT NUMBER M IS RETURNED.        IS   4
C                                                                        IS   5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),  IS   6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ            IS   7
      IF (M.GT.0) GO TO 1                                                IS   8
      PRINT 5                                                            IS   9
      STOP                                                               IS  10
1     ICNT=0                                                             IS  11
      IF (ITAGI.NE.0) GO TO 2                                            IS  12
      ISEGNO=M                                                           IS  13
      RETURN                                                             IS  14
2     DO 3 I=1,N                                                         IS  15
      IF (ITAG(I).NE.ITAGI) GO TO 3                                      IS  16
      ICNT=ICNT+1                                                        IS  17
      IF (ICNT.EQ.M) GO TO 4                                             IS  18
3     CONTINUE                                                           IS  19
      PRINT 6, ITAGI                                                     IS  20
      STOP                                                               IS  21
4     ISEGNO=I                                                           IS  22
      RETURN                                                             IS  23
C                                                                        IS  24
5     FORMAT (4X,91HCHECK DATA, PARAMETER SPECIFYING SEGMENT POSITION IN IS  25
     1 A GROUP OF EQUAL TAGS MUST NOT BE ZERO)                           IS  26
6     FORMAT (///,10X,26HNO SEGMENT HAS AN ITAG OF ,I5)                  IS  27
      END                                                                IS  28-
```

```
      SUBROUTINE ITOF (TRAN,NT,M,NOE,NOC,NTNX,NTNR)                          IT    1
C                                                                            IT    2
C     ITOF PROCESSES DATA IN ARRAY TRAN FOR FOURIER TRANSFORMING AND         IT    3
C     CALLS SUBROUTINE FORT TO DO THE TRANSFORMING                           IT    4
C                                                                            IT    5
      COMMON /ARRAX/  GI1,GI2,GI3,ET(200,5,8),EP(200,5,8),IWET(200,8)       IT    6
      DIMENSION TRAN(1024), A(4096), S(511)                                  IT    7
      DIMENSION TZERO(100), AMAX(100), TEXT(100)                             IT    8
      EQUIVALENCE (A,GI1), (TZERO,EP(1,1,2)), (AMAX,EP(1,1,3)), (TEXT,EP     IT    9
     1(1,1,4))                                                               IT   10
      DATA   MMAX,ITZX/0,100/                                                IT   11
      PI=3.1415926                                                           IT   12
      TP=2.*PI                                                               IT   13
      IFERR=0                                                                IT   14
      N=2**M                                                                 IT   15
      PRINT 24,  NT,N                                                        IT   16
      N2=N*2                                                                 IT   17
      NTP=NT+1                                                               IT   18
      DO 1 I=1,NT                                                            IT   19
1     A(I)=TRAN(I)                                                           IT   20
      IF (NT.LT.N) GO TO 2                                                   IT   21
      NT=N                                                                   IT   22
      GO TO 12                                                               IT   23
2     IF (NOE.NE.0) GO TO 12                                                 IT   24
C                                                                            IT   25
C     EXAMINE DATA FOR POSSIBLE EXTRAPOLATION                                IT   26
C                                                                            IT   27
      NTM=NT-1                                                               IT   28
      ITZ=0                                                                  IT   29
      ITM=0                                                                  IT   30
      DO 4 I=3,NTM                                                           IT   31
      TRA=A(I-1)                                                             IT   32
      TRB=A(I)                                                               IT   33
      TRC=A(I+1)                                                             IT   34
      ATRA=ABS(TRA)                                                          IT   35
      IF (ATRA.LT.1.E-35) GO TO 3                                            IT   36
      IF (1.E+10*TRA*TRB.GT.0.) GO TO 3                                      IT   37
      ITZ=ITZ+1                                                              IT   38
      IF (ITZ.GT.ITZX) GO TO 11                                              IT   39
      TZERO(ITZ)=FLOAT(I-2)+ABS(TRA/(TRA-TRB))                               IT   40
3     ATRA=ABS(TRA)                                                          IT   41
      ATRB=ABS(TRB)                                                          IT   42
      ATRC=ABS(TRC)                                                          IT   43
      IF ((ATRB.LE.ATRA).OR.(ATRB.LT.ATRC)) GO TO 4                          IT   44
      TMAXI=TRA-2.*TRB+TRC                                                   IT   45
      IF (ABS(TMAXI).LT.1.E-35) GO TO 4                                      IT   46
      ITM=ITM+1                                                              IT   47
      IF (ITM.GT.ITZX) GO TO 11                                              IT   48
      TMAXI=-.5*(TRC-TRA)/TMAXI                                              IT   49
      TEXT(ITM)=TMAXI+FLOAT(I-1)                                             IT   50
      AMAX(ITM)=(.5*TRA-TRB+.5*TRC)*TMAXI*TMAXI+(TRC-TRA)*.5*TMAXI+TRB       IT   51
4     CONTINUE                                                               IT   52
      IF (ITM.LT.3) GO TO 11                                                 IT   53
      ALFA=0.                                                                IT   54
      ICOUNT=0                                                               IT   55
      ISSS=2                                                                 IT   56
```

```
      AMAXL=AMAX(2)                                                     IT  57
      DO 7 I=5,ITM                                                      IT  58
      AMAXI=AMAX(I)                                                     IT  59
      IF (AMAXI*AMAXL.GE.0.) GO TO 5                                    IT  60
      ICOUNT=ICOUNT+1                                                   IT  61
      AMAXR=-AMAXI/AMAXL                                                IT  62
      IF (AMAXR.GT.1.) GO TO 5                                          IT  63
      ALFA=ALFA+ALOG(AMAXR)/(TEXT(I-1)-TEXT(I))                         IT  64
      GO TO 6                                                           IT  65
5     ICOUNT=0                                                          IT  66
      ISSS=I                                                            IT  67
      ALFA=0.                                                           IT  68
6     AMAXL=AMAXI                                                       IT  69
7     CONTINUE                                                          IT  70
      IF (ICOUNT.LT.3) GO TO 11                                         IT  71
      ALFA=ALFA/FLOAT(ICOUNT)                                           IT  72
      TMAXI=TEXT(ISSS)                                                  IT  73
      DO 8 I=1,ITZ                                                      IT  74
      ICOUNT=I                                                          IT  75
      IF (TZERO(I).GT.TMAXI) GO TO 9                                    IT  76
8     CONTINUE                                                          IT  77
      GO TO 11                                                          IT  78
9     PERI=2.*(TZERO(ITZ)-TZERO(ICOUNT))/FLOAT(ITZ-ICOUNT)              IT  79
      OMEGA=TP/PERI                                                     IT  80
      TZERX=TZERO(ITZ)                                                  IT  81
      TEND=FLOAT(NT-1)                                                  IT  82
      AMX=A(NT)/SIN(OMEGA*(TEND-TZERX))                                 IT  83
      PRINT 21,  ALFA,OMEGA                                             IT  84
C                                                                       IT  85
C     EXTRAPOLATE WITH ATTENUATED SINE WAVE                             IT  86
C                                                                       IT  87
      DO 10 I=NTP,N                                                     IT  88
      TIM=FLOAT(I-1)                                                    IT  89
10    A(I)=AMX*EXP(-ALFA*(TIM-TEND))*SIN(OMEGA*(TIM-TZERX))             IT  90
      NTX=N                                                             IT  91
      GO TO 14                                                          IT  92
11    PRINT 22                                                          IT  93
12    NTX=NT                                                            IT  94
C                                                                       IT  95
C     NO EXTRAPOLATION                                                  IT  96
C                                                                       IT  97
      DO 13 I=NTP,N                                                     IT  98
13    A(I)=0.                                                           IT  99
14    IF (NOC.NE.0) GO TO 16                                            IT 100
C                                                                       IT 101
C     APPLY HALF COSINE BELL TAPER TO LAST 1/10 OF POINTS               IT 102
C                                                                       IT 103
      NTP=NTX/10                                                        IT 104
      IF (NTP.LT.1) GO TO 16                                            IT 105
      NTM=NTX-NTP+1                                                     IT 106
      TRA=PI/FLOAT(NTP+1)                                               IT 107
      TRB=0.                                                            IT 108
      DO 15 I=NTM,NTX                                                   IT 109
      TRB=TRB+TRA                                                       IT 110
15    A(I)=A(I)*(1.+COS(TRB))*.5                                        IT 111
16    NTP=N+1                                                           IT 112
      DO 17 I=1,N                                                       IT 113
      ITZ=NTP-I                                                         IT 114
      ITM=2*ITZ                                                         IT 115
      A(ITM)=0.                                                         IT 116
```

```
17    A(ITM-1)=A(ITZ)                                                    IT 117
      IF (M.LE.MMAX) GO TO 18                                            IT 118
      MMAX=M                                                             IT 119
      S(1)=0.                                                            IT 120
      IFS=-1                                                             IT 121
      GO TO 19                                                           IT 122
18    IFS=-2                                                             IT 123
19    CALL FORT (A,M,S,IFS,IFERR)                                        IT 124
      IF (IFERR.NE.0) PRINT 23,  IFERR                                   IT 125
      IF (IFERR.EQ.1) STOP                                               IT 126
      NTNR=N                                                             IT 127
      IF (N.GT.NTNX) NTNR=NTNX                                           IT 128
      DO 20 I=1,NTNR                                                     IT 129
20    TRAN(I)=A(I)                                                       IT 130
      RETURN                                                             IT 131
C                                                                        IT 132
C                                                                        IT 133
21    FORMAT  (  1X,84HINPUT DATA EXTRAPOLATED USING ATTENUATED SINE FUN IT 134
     1CTION EXP(-A*T)*SIN(W*T) WITH A*DT=,E12.5,10H AND W*DT=,E12.5)      IT 135
22    FORMAT  (1X,27HINPUT DATA NOT EXTRAPOLATED)                        IT 136
23    FORMAT  (//,1X,46HERROR FLAG RETURNED BY SUBROUTINE FORT, IFERR=,I IT 137
     14,/)                                                               IT 138
24    FORMAT  (  /,1X,21HFOURIER TRANSFORM - -,/,1X,23HNUMBER OF POINTS  IT 139
     1INPUT=,I7,/,1X,29HNUMBER OF POINTS TRANSFORMED=,I7)                IT 140
      END                                                                IT 141-
```

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```
      SUBROUTINE LFACTR (A,N,IX1,IX2,P)                                  LF    1
C                                                                        LF    2
C     S/R WHICH PERFORMS GAUSS-DOOLITTLE MANIPULATIONS ON THE TWO BLOCKS LF    3
C     UNFACTORED OR PARTIALLY-FACTORED MATRIX WHICH IS IN THE CORE STORA LF    4
C                                                                        LF    5
C     THE MANIPULATIONS ARE BASED ON THE GAUSS-DOOLITTLE ALGORITHM PRESE LF    6
C     PAGES 411-416 OF A. RALSTON -- A FIRST COURSE IN NUMERICAL ANALYSI LF    7
C     COMMENTS BELOW REFER TO COMMENTS IN RALSTONS TEXT.                 LF    8
      COMMON /MATPAR/ NBLOKS,NPBLK,NLAST,INT                             LF    9
      COMMON /SCRATM/ D(200)                                             LF   10
      DIMENSION A(N,N), P(N)                                             LF   11
      INTEGER  R,R1,R2,P,PJ,PR                                           LF   12
                                                                         LF   13
      IFLG=0                                                             LF   14
C                                                                        LF   15
C     INITIALIZE R1,R2,J1,J2                                             LF   16
C                                                                        LF   17
      L1=IX1.EQ.1.AND.IX2.EQ.2                                           LF   18
      L2=(IX2-1).EQ.IX1                                                  LF   19
      L3=IX2.EQ.NBLOKS                                                   LF   20
      IF (L1) GO TO 1                                                    LF   21
      GO TO 2                                                            LF   22
1     R1=1                                                               LF   23
      R2=2*NPBLK                                                         LF   24
      J1=1                                                               LF   25
      J2=-1                                                              LF   26
      GO TO 5                                                            LF   27
2     R1=NPBLK+1                                                         LF   28
      R2=2*NPBLK                                                         LF   29
      J1=((IX1-1)*NPBLK+1                                                LF   30
      IF (L2) GO TO 3                                                    LF   31
      GO TO 4                                                            LF   32
3     J2=J1+NPBLK-2                                                      LF   33
      GO TO 5                                                            LF   34
4     J2=J1+NPBLK-1                                                      LF   35
5     IF (L3) R2=NPBLK+NLAST                                             LF   36
      J2P2S=J2+2                                                         LF   37
      DO 16 R=R1,R2                                                      LF   38
C                                                                        LF   39
C     STEP 1                                                             LF   40
C                                                                        LF   41
      DO 6 K=J1,N                                                        LF   42
      D(K)=A(K,R)                                                        LF   43
6     CONTINUE                                                           LF   44
C                                                                        LF   45
C     STEPS 2 AND 3                                                      LF   46
C                                                                        LF   47
      IF (L1.OR.L2) J2=J2+1                                              LF   48
      IF (L1.OR.J2) GO TO 9                                              LF   49
      IXJ=0                                                              LF   50
      DO 8 J=J1,J2                                                       LF   51
      IXJ=IXJ+1                                                          LF   52
      PJ=P(J)                                                            LF   53
      A(J,R)=D(PJ)                                                       LF   54
      D(PJ)=D(J)                                                         LF   55
      JP1=J+1                                                            LF   56
```

```
      DO 7 I=JP1,N                                                      LF  57
      D(I)=D(I)-A(I,IXJ)*A(J,R)                                         LF  58
7     CONTINUE                                                          LF  59
8     CONTINUE                                                          LF  60
9     CONTINUE                                                          LF  61
C                                                                       LF  62
C     STEP 4                                                            LF  63
C                                                                       LF  64
      J2P1=J2+1                                                         LF  65
      IF (L1.OR.L2) GO TO 11                                            LF  66
      IF (N.LT.J2P1) GO TO 16                                           LF  67
      DO 10 I=J2P1,N                                                    LF  68
      A(I,R)=D(I)                                                       LF  69
10    CONTINUE                                                          LF  70
      GO TO 16                                                          LF  71
11    DMAX=ABS(D(J2P1))                                                 LF  72
      P(J2P1)=J2P1                                                      LF  73
      J2P2=J2+2                                                         LF  74
      IF (J2P2.GT.N) GO TO 13                                           LF  75
      DO 12 I=J2P2,N                                                    LF  76
      ELMAG=ABS(D(I))                                                   LF  77
      IF (ELMAG.LT.DMAX) GO TO 12                                       LF  78
      DMAX=ELMAG                                                        LF  79
      P(J2P1)=I                                                         LF  80
12    CONTINUE                                                          LF  81
13    CONTINUE                                                          LF  82
      IF (DMAX.LT.1.E-10) IFLG=1                                        LF  83
      PR=P(J2P1)                                                        LF  84
      A(J2P1,R)=D(PR)                                                   LF  85
      D(PR)=D(J2P1)                                                     LF  86
C                                                                       LF  87
C     STEP 5                                                            LF  88
C                                                                       LF  89
      IF (J2P2.GT.N) GO TO 15                                           LF  90
      DO 14 I=J2P2,N                                                    LF  91
      A(I,R)=D(I)/A(J2P1,R)                                             LF  92
14    CONTINUE                                                          LF  93
15    CONTINUE                                                          LF  94
      IF (IFLG.EQ.0) GO TO 16                                           LF  95
      PRINT 17,  J2,DMAX                                                LF  96
      IFLG=0                                                            LF  97
16    CONTINUE                                                          LF  98
      RETURN                                                            LF  99
C                                                                       LF 100
17    FORMAT (1H ,'PIVOT(',I3,')=',E16.8)                               LF 101
      END                                                               LF 102-
```

```
      SUBROUTINE LTSOLV (A,AR,N,IX,B)                                    LT    1
C                                                                        LT    2
C     S/R TO SOLVE THE MATRIX EQUATION Y(R)*LU(T)=B(R) WHERE (R) DENOTES  LT    3
C     ROW VECTOR AND LU(T) DENOTES THE LU DECOMPOSITION OF THE TRANSPOSE  LT    4
C     OF THE ORIGINAL COEFFICIENT MATRIX.  THE LU(T) DECOMPOSITION IS     LT    5
C     STORED ON FILE 13 IN BLOCKS IN ASCENDING ORDER AND ON FILE 14 IN    LT    6
C     BLOCKS OF DESCENDING ORDER.                                        LT    7
C                                                                        LT    8
C                                                                        LT    9
      COMMON /MATPAR/ NBLOKS,NPBLK,NLAST,INT                             LT   10
      COMMON /SCRATM/ Y(200)                                             LT   11
      DIMENSION A(N,N), B(N), IX(N), AR(1)                               LT   12
C                                                                        LT   13
C     FORWARD SUBSTITUTION                                               LT   14
C                                                                        LT   15
      I1=1                                                               LT   16
      I2=NPBLK*N                                                         LT   17
      J=0                                                                LT   18
      DO 4 IXBLK1=1,NBLOKS                                               LT   19
      READ (13) (AR(I),I=I1,I2)                                          LT   20
      K2=NPBLK                                                           LT   21
      IF (IXBLK1.EQ.NBLOKS) K2=NLAST                                     LT   22
      DO 3 K=1,K2                                                        LT   23
      JM1=J                                                              LT   24
      J=J+1                                                              LT   25
      SUM=0.                                                             LT   26
      IF (JM1.LT.1) GO TO 2                                              LT   27
      DO 1 I=1,JM1                                                       LT   28
      SUM=SUM+A(I,K)*Y(I)                                                LT   29
1     CONTINUE                                                           LT   30
2     CONTINUE                                                           LT   31
      Y(J)=(B(J)-SUM)/A(J,K)                                             LT   32
3     CONTINUE                                                           LT   33
4     CONTINUE                                                           LT   34
C                                                                        LT   35
C     BACKWARD SUBSTITUTION                                              LT   36
C                                                                        LT   37
      J=N+1                                                              LT   38
      DO 8 IXBLK1=1,NBLOKS                                               LT   39
      READ (14) (AR(I),I=I1,I2)                                          LT   40
      K2=NPBLK                                                           LT   41
      IF (IXBLK1.EQ.1) K2=NLAST                                          LT   42
      DO 7 K=1,K2                                                        LT   43
      KP=K2-K+1                                                          LT   44
      JP1=J                                                              LT   45
      J=J-1                                                              LT   46
      SUM=0.                                                             LT   47
      IF (N.LT.JP1) GO TO 6                                              LT   48
      DO 5 I=JP1,N                                                       LT   49
      SUM=SUM+A(I,KP)*B(I)                                               LT   50
5     CONTINUE                                                           LT   51
6     CONTINUE                                                           LT   52
      B(J)=Y(J)-SUM                                                      LT   53
7     CONTINUE                                                           LT   54
8     CONTINUE                                                           LT   55
C                                                                        LT   56
```

```
C       UNSCRAMBLE SOLUTION                                          LT  57
C                                                                    LT  58
        DO 9 I=1,N                                                   LT  59
        IXI=IX(I)                                                    LT  60
        Y(IXI)=B(I)                                                  LT  61
9       CONTINUE                                                     LT  62
        DO 10 I=1,N                                                  LT  63
10      B(I)=Y(I)                                                    LT  64
        REWIND  13                                                   LT  65
        REWIND  14                                                   LT  66
        RETURN                                                       LT  67
        END                                                          LT  68-
```

```
      SUBROUTINE LUNSCR (A,AR,N,IX,IP)                                  LU   1
C                                                                       LU   2
C     S/R WHICH UNSCRAMBLES, SCRAMBLED FACTORED MATRIX                  LU   3
C                                                                       LU   4
      COMMON /MATPAR/ NBLOKS,NPBLK,NLAST,INT                            LU   5
      DIMENSION A(N,N), IP(N), IX(N), AR(1)                             LU   6
      I1=1                                                              LU   7
      I2=NPBLK*N                                                        LU   8
      NM1=N-1                                                           LU   9
      DO 4 IXBLK1=1,NBLOKS                                              LU  10
      READ (11) (AR(I),I=I1,I2)                                         LU  11
      K1=(IXBLK1-1)*NPBLK+2                                             LU  12
      IF (NM1.LT.K1) GO TO 3                                            LU  13
      J2=0                                                              LU  14
      DO 2 K=K1,NM1                                                     LU  15
      IF (J2.LT.NPBLK) J2=J2+1                                          LU  16
      IPK=IP(K)                                                         LU  17
      DO 1 J=1,J2                                                       LU  18
      TEMP=A(K,J)                                                       LU  19
      A(K,J)=A(IPK,J)                                                   LU  20
      A(IPK,J)=TEMP                                                     LU  21
1     CONTINUE                                                          LU  22
2     CONTINUE                                                          LU  23
3     CONTINUE                                                          LU  24
      WRITE (13) (AR(I),I=I1,I2)                                        LU  25
4     CONTINUE                                                          LU  26
      DO 5 IXBLK1=1,NBLOKS                                              LU  27
      BACKSPACE  13                                                     LU  28
      IF (IXBLK1.NE.1) BACKSPACE  13                                    LU  29
      READ (13) (AR(I),I=I1,I2)                                         LU  30
      WRITE (14) (AR(I),I=I1,I2)                                        LU  31
5     CONTINUE                                                          LU  32
      DO 6 I=1,N                                                        LU  33
      IX(I)=I                                                           LU  34
6     CONTINUE                                                          LU  35
      DO 7 I=1,N                                                        LU  36
      IPI=IP(I)                                                         LU  37
      IXT=IX(I)                                                         LU  38
      IX(I)=IX(IPI)                                                     LU  39
      IX(IPI)=IXT                                                       LU  40
7     CONTINUE                                                          LU  41
      REWIND  11                                                        LU  42
      REWIND  13                                                        LU  43
      REWIND  14                                                        LU  44
      RETURN                                                            LU  45
      END                                                               LU  46
```

```
      SUBROUTINE MOVE (ROX,ROY,ROZ,XS,YS,ZS,ITS,NRPT,ITGI)                MO   1
C                                                                         MO   2
C     SUBROUTINE MOVE MOVES THE STRUCTURE WITH RESPECT TO ITS             MO   3
C     COORDINATE SYSTEM OR REPRODUCES STRUCTURE IN NEW POSITIONS.         MO   4
C     STRUCTURE IS ROTATED ABOUT X,Y,Z AXES BY ROX,ROY,ROZ                MO   5
C     RESPECTIVELY, THEN SHIFTED BY XS,YS,ZS                              MO   6
C                                                                         MO   7
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),   MO   8
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ             MO   9
      DIMENSION X2(1), Y2(1), Z2(1)                                       MO  10
      EQUIVALENCE (X2(1),SI(1)), (Y2(1),ALP(1)), (Z2(1),BET(1))           MO  11
      SPS=SIN(ROX)                                                        MO  12
      CPS=COS(ROX)                                                        MO  13
      STH=SIN(ROY)                                                        MO  14
      CTH=COS(ROY)                                                        MO  15
      SPH=SIN(ROZ)                                                        MO  16
      CPH=COS(ROZ)                                                        MO  17
      XX=CPH*CTH                                                          MO  18
      XY=CPH*STH*SPS-SPH*CPS                                              MO  19
      XZ=CPH*STH*CPS+SPH*SPS                                              MO  20
      YX=SPH*CTH                                                          MO  21
      YY=SPH*STH*SPS+CPH*CPS                                              MO  22
      YZ=SPH*STH*CPS-CPH*SPS                                              MO  23
      ZX=-STH                                                             MO  24
      ZY=CTH*SPS                                                          MO  25
      ZZ=CTH*CPS                                                          MO  26
      I1=ISEGNO(ITS,1)                                                    MO  27
      IX=I1                                                               MO  28
      NRP=NRPT                                                            MO  29
      IF (NRPT.EQ.0) NRP=1                                                MO  30
      K=N                                                                 MO  31
      IF (NRPT.EQ.0) K=I1-1                                               MO  32
      DO 2 IR=1,NRP                                                       MO  33
      DO 1 I=I1,N                                                         MO  34
      K=K+1                                                               MO  35
      XI=X(I)                                                             MO  36
      YI=Y(I)                                                             MO  37
      ZI=Z(I)                                                             MO  38
      X(K)=XI*XX+YI*XY+ZI*XZ+XS                                           MO  39
      Y(K)=XI*YX+YI*YY+ZI*YZ+YS                                           MO  40
      Z(K)=XI*ZX+YI*ZY+ZI*ZZ+ZS                                           MO  41
      XI=X2(I)                                                            MO  42
      YI=Y2(I)                                                            MO  43
      ZI=Z2(I)                                                            MO  44
      X2(K)=XI*XX+YI*XY+ZI*XZ+XS                                          MO  45
      Y2(K)=XI*YX+YI*YY+ZI*YZ+YS                                          MO  46
      Z2(K)=XI*ZX+YI*ZY+ZI*ZZ+ZS                                          MO  47
      BI(K)=BI(I)                                                         MO  48
      ITAG(K)=ITAG(I)+ITGI                                                MO  49
1     CONTINUE                                                            MO  50
      I1=N+1                                                              MO  51
      N=K                                                                 MO  52
2     CONTINUE                                                            MO  53
      RETURN                                                              MO  54
      END                                                                 MO  55
```

```
      SUBROUTINE RFLD (THET,PHI,ETH,EPH,TSTRT,KLM)                      RF    1
C                                                                       RF    2
C     RFLD COMPUTES THE RADIATED FIELD IN THE DIRECTION THETA, PHI FOR   RF    3
C     ALL TIME STEPS POSSIBLE WITH THE AVAILABLE CURRENTS               RF    4
C                                                                       RF    5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),  RF    6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ           RF    7
      COMMON /SCOMP/ SX(200),SY(200),SZ(200)                            RF    8
      COMMON /INTERP/ AT(3,200),BT(3,200),CT(3,200),ES(3),FS(3),GS(3),  RF    9
     1   E(3),H(3)                                                      RF   10
      COMMON /CONST/ CDT,VEL,DT,NTSTEP                                  RF   11
      COMMON /ARRAX/ QI1,QI2,QI3,ET(200,5,8),EP(200,5,8),IWET(200,8)    RF   12
      COMMON /ARRAY/ CO(6400)                                           RF   13
      COMMON /IOFLG/ NCFMX,NCOMX,IOC,IOCQ,NTMAX,NBOUT,JP1,JP2           RF   14
      DIMENSION A(3), B(3), C(3), P(3), ETH(1), EPH(1), ALFA(3,3)       RF   15
      N2=N*2                                                            RF   16
      STH=SIN(THET)                                                     RF   17
      CTH=COS(THET)                                                     RF   18
      SP=SIN(PHI)                                                       RF   19
      CP=COS(PHI)                                                       RF   20
      ERX=STH*CP                                                        RF   21
      ERY=STH*SP                                                        RF   22
      ERZ=CTH                                                           RF   23
      THX=CTH*CP                                                        RF   24
      THY=CTH*SP                                                        RF   25
      THZ=-STH                                                          RF   26
      PHX=-SP                                                           RF   27
      PHY=CP                                                            RF   28
      KMN=9999                                                          RF   29
      IPLAN=0                                                           RF   30
      LPX=1                                                             RF   31
      LPY=1                                                             RF   32
      LPZ=1                                                             RF   33
      IF (IPX.NE.0) LPX=2                                               RF   34
      IF (IPY.NE.0) LPY=2                                               RF   35
      IF (IPZ.NE.0) LPZ=2                                               RF   36
C                                                                       RF   37
C     BEGIN LOOP OVER SEGMENTS, INCLUDING IMAGES, TO COMPUTE            RF   38
C     COEFFICIENTS FOR RADIATED FIELD                                   RF   39
C                                                                       RF   40
      DO 17 JX=1,LPX                                                    RF   41
      RFX=FLOAT(3-JX*2)                                                 RF   42
      SFX=RFX                                                           RF   43
      IF (IPX.LT.0) SFX=1.                                              RF   44
      DO 17 JY=1,LPY                                                    RF   45
      RFY=FLOAT(3-JY*2)                                                 RF   46
      SFY=RFY                                                           RF   47
      IF (IPY.LT.0) SFY=1.                                              RF   48
      DO 17 JZ=1,LPZ                                                    RF   49
      RFZ=FLOAT(3-JZ*2)                                                 RF   50
      SFZ=RFZ                                                           RF   51
      IF (IPZ.LT.0) SFZ=1.                                              RF   52
      RFL=SFX*SFY*SFZ                                                   RF   53
      RFL=-1.E-7*RFL                                                    RF   54
      IPLAN=IPLAN+1                                                     RF   55
      DO 1 J=1,N                                                        RF   56
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      AL=-(ERX*X(J)*RFX+ERY*Y(J)*RFY+ERZ*Z(J)*RFZ)                    RF  57
      TRET=AL/VEL                                                    RF  58
      K=TRET/DT+SIGN(.5,TRET)                                        RF  59
      IRET(J,IPLAN)=K                                                RF  60
      IF (K.LT.KMN) KMN=K                                            RF  61
      DO 1 M=1,5                                                     RF  62
      ET(J,M,IPLAN)=0.                                               RF  63
1     EP(J,M,IPLAN)=0.                                               RF  64
      DO 16 J=1,N                                                    RF  65
      XJ=X(J)*RFX                                                    RF  66
      YJ=Y(J)*RFY                                                    RF  67
      ZJ=Z(J)*RFZ                                                    RF  68
      SXJ=SX(J)*RFX                                                  RF  69
      SYJ=SY(J)*RFY                                                  RF  70
      SZJ=SZ(J)*RFZ                                                  RF  71
      AL=-(ERX*XJ+ERY*YJ+ERZ*ZJ)                                     RF  72
      BA=-(ERX*SXJ+ERY*SYJ+ERZ*SZJ)                                  RF  73
      K=IRET(J,IPLAN)                                                RF  74
      TAU=DT*FLOAT(K)                                                RF  75
      DO 2 L=1,3                                                     RF  76
      A(L)=AT(L,J)                                                   RF  77
      B(L)=BT(L,J)                                                   RF  78
      C(L)=CT(L,J)                                                   RF  79
2     P(L)=2.*ES(L)*TAU+FS(L)                                        RF  80
      EL=SI(J)                                                       RF  81
      ELC=EL*EL*EL/12.                                               RF  82
      SDOTT=SXJ*THX+SYJ*THY+SZJ*THZ                                  RF  83
      SDOTP=SXJ*PHX+SYJ*PHY                                          RF  84
      DO 3 M=1,3                                                     RF  85
      T1=H(M)*AL+P(M)                                                RF  86
      T2=H(M)*BA                                                     RF  87
      DO 3 L=1,3                                                     RF  88
3     ALFA(L,M)=((A(L)*T1+B(L)*T2)*ELC+C(L)*T1*EL)*RFL               RF  89
      JC1=ICON1(J)                                                   RF  90
      IF (JC1.NE.0) GO TO 4                                          RF  91
      KKM=0                                                          RF  92
      GO TO 8                                                        RF  93
4     IF (JC1.LT.19000) GO TO 5                                      RF  94
      SIG1=FLOAT(JC1-20000)                                          RF  95
      JC1=J                                                          RF  96
      GO TO 7                                                        RF  97
5     IF (ICON2(JC1).NE.J) GO TO 6                                   RF  98
      SIG1=1.                                                        RF  99
      GO TO 7                                                        RF 100
6     IF (ICON1(JC1).NE.J) GO TO 23                                  RF 101
      SIG1=-1.                                                       RF 102
7     KM=IRET(JC1,IPLAN)                                             RF 103
      KKM=KM-K                                                       RF 104
      IF (IABS(KKM).LE.1) GO TO 8                                    RF 105
      PRINT 24, J,JC1,KKM                                            RF 106
      STOP                                                           RF 107
8     JC2=ICON2(J)                                                   RF 108
      IF (JC2.NE.0) GO TO 9                                          RF 109
      KKP=0                                                          RF 110
      GO TO 13                                                       RF 111
9     IF (JC2.LT.19000) GO TO 10                                     RF 112
      SIG2=FLOAT(JC2-20000)                                          RF 113
      JC2=J                                                          RF 114
      GO TO 12                                                       RF 115
10    IF (ICON1(JC2).NE.J) GO TO 11                                  RF 116
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      SIG2=1.                                                          RF 117
      GO TO 12                                                         RF 118
11    IF (ICON2(JC2),NE,J) GO TO 23                                    RF 119
      SIG2=-1.                                                         RF 120
12    KP=IRET(JC2,IPLAN)                                               RF 121
      KKP=KP-K                                                         RF 122
      IF (IABS(KKP),LE,1) GO TO 13                                     RF 123
      PRINT 24, J,JC2,KKP                                              RF 124
      STOP                                                             RF 125
13    DO 15 M=1,5                                                      RF 126
      KXX=M+1                                                          RF 127
      IF (JC1,EQ,0) GO TO 14                                           RF 128
      KMX=KKM+KXX                                                      RF 129
      ET(JC1,KMX,IPLAN)=ET(JC1,KMX,IPLAN)+ALFA(1,M)*SDOTT*SIG1         RF 130
      EP(JC1,KMX,IPLAN)=EP(JC1,KMX,IPLAN)+ALFA(1,M)*SDOTP*SIG1         RF 131
14    ET(J,KXX,IPLAN)=ET(J,KXX,IPLAN)+ALFA(2,M)*SDOTT                  RF 132
      EP(J,KXX,IPLAN)=EP(J,KXX,IPLAN)+ALFA(2,M)*SDOTP                  RF 133
      IF (JC2,EQ,0) GO TO 15                                           RF 134
      KPX=KKP+KXX                                                      RF 135
      ET(JC2,KPX,IPLAN)=ET(JC2,KPX,IPLAN)+ALFA(3,M)*SDOTT*SIG2         RF 136
      EP(JC2,KPX,IPLAN)=EP(JC2,KPX,IPLAN)+ALFA(3,M)*SDOTP*SIG2         RF 137
15    CONTINUE                                                         RF 138
16    CONTINUE                                                         RF 139
17    CONTINUE                                                         RF 140
C                                                                      RF 141
C     COMPUTE RADIATED FIELD AT ALL TIME STEPS POSSIBLE WITH SUMMATION RF 142
C     PROCEEDING IN ORDER OF RETARDED TIMES                            RF 143
C                                                                      RF 144
      KMN=KMN-1                                                        RF 145
      KKM=1                                                            RF 146
      KKP=NTSTEP                                                       RF 147
      KM=KKM+KMN                                                       RF 148
      KP=KKP+KMN                                                       RF 149
      KXX=KM-1                                                         RF 150
      KLM=KP-KXX                                                       RF 151
      TSTRT=DT*FLOAT(KXX)                                              RF 152
      DO 18 K=1,KLM                                                    RF 153
      ETH(K)=0.                                                        RF 154
18    EPH(K)=0.                                                        RF 155
      KTS=1                                                            RF 156
      NOCQ=9999999                                                     RF 157
      IF (IOCQ,EQ,0) GO TO 19                                          RF 158
      REWIND  11                                                       RF 159
      READ (11) NOCQ,(CQ(J),J=1,NOCQ)                                  RF 160
19    DO 22 KC=KKM,KKP                                                 RF 161
20    KCB=(KC-1)*N2-KTS                                                RF 162
      IF ((KCB+1),LT,NOCQ) GO TO 21                                    RF 163
      KTS=KTS+NOCQ                                                     RF 164
      READ (11) NOCQ,(CQ(J),J=1,NOCQ)                                  RF 165
      GO TO 20                                                         RF 166
21    KKB=KC-KXX+3                                                     RF 167
      DO 22 IPLNE=1,IPLAN                                              RF 168
      DO 22 J=1,N                                                      RF 169
      KCC=KCB+2*J                                                      RF 170
      K=KKB+IRET(J,IPLNE)                                              RF 171
      DO 22 M=1,5                                                      RF 172
      KPX=K-M                                                          RF 173
      IF (KPX,LT,1) GO TO 22                                           RF 174
      IF (KPX,GT,KLM) GO TO 22                                         RF 175
      ETH(KPX)=ETH(KPX)+ET(J,M,IPLNE)*CQ(KCC)                          RF 176
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      EPH(KPX)=EPH(KPX)+EP(J,M,IPLNE)*CQ(KCC)                          RF 177
22    CONTINUE                                                         RF 178
      RETURN                                                           RF 179
23    PRINT 25                                                         RF 180
      STOP                                                             RF 181
C                                                                      RF 182
24    FORMAT (  /,1X,26HRETARDED TIMES TO SEGMENTS,I5,4H AND,I5,       RF 183
     1  10H DIFFER BY,I5,11H TIME STEPS)                              RF 184
25    FORMAT (/,1X,62H***ERROR - ROUTINE RFLD-- INCONSISTENT SEGMENT CON RF 185
     1NECTION DATA)                                                   RF 186
      END                                                              RF 187
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      SUBROUTINE RFPAT (ITRAN,IPCH,NTH,NPH,THET,PHI,DTH,DPH)                RP    1
C                                                                           RP    2
C     RFPAT CALLS RFLD TO COMPUTE THE RADIATED FIELD AT A SET OF ANGLES,    RP    3
C     THETA AND PHI, AND PRINTS THE RESULTS.  THE COMPUTED FIELD CAN        RP    4
C     ALSO BE FOURIER TRANSFORMED TO THE FREQUENCY DOMAIN                   RP    5
C                                                                           RP    6
      COMMON /ESORC/  ESORC(1024),IFST,NTRAN,MTRAN,NTNX,DFRQ,ENIN,ENRD,I    RP    7
     1FEN                                                                   RP    8
      COMMON /CMAT/  CURF(1600),IP(200),IX(200)                             RP    9
      COMMON /CONST/  CDT,VEL,DT,NTSTEP                                     RP   10
      COMMON /SCRATM/ PWR(512)                                              RP   11
      DIMENSION ETH(1024), EPH(1024), ETC(512), EPC(512), ESC(512), IPOL    RP   12
     1(3)                                                                   RP   13
      COMPLEX    TPJ,CARG,FAZ,ETHC,EPHC,ETC,EPC,ESC                         RP   14
      EQUIVALENCE (ETH,CURF), (ETC,CURF), (EPC,EPH), (ESC,ESORC)            RP   15
      DATA    TA,TSMIN,TPJ/,017453292.5,,(0,,6.2831853)/                    RP   16
      DATA    IPOL/6HLINEAR,5HRIGHT,4HLEFT/,IBLK/1H /                       RP   17
      TSTRT=0.                                                              RP   18
      NFLD=0                                                                RP   19
      TH=THET-DTH                                                           RP   20
      DO 15 IT=1,NTH                                                        RP   21
      TH=TH+DTH                                                             RP   22
      THA=TH*TA                                                             RP   23
      PH=PHI-DPH                                                            RP   24
      DO 15 IPH=1,NPH                                                       RP   25
      PH=PH+DPH                                                             RP   26
      PHA=PH*TA                                                             RP   27
      PRINT 18,  TH,PH                                                      RP   28
      CALL RFLD (THA,PHA,ETH,EPH,TSTRT,NFLD)                                RP   29
      NPRT=NFLD/2                                                           RP   30
      NADD=NPRT                                                             RP   31
      IF (2*NPRT.NE.NFLD) NADD=NPRT+1                                       RP   32
      TIM=TSTRT-DT                                                          RP   33
      TADD=DT*FLOAT(NADD)                                                   RP   34
      DO 1 I1=1,NPRT                                                        RP   35
      I2=I1+NADD                                                            RP   36
      TIM=TIM+DT                                                            RP   37
      TIM2=TIM+TADD                                                         RP   38
      POL1=ATGN2(EPH(I1),ETH(I1))/TA                                        RP   39
      POL2=ATGN2(EPH(I2),ETH(I2))/TA                                        RP   40
1     PRINT 19,  I1,TIM,ETH(I1),EPH(I1),POL1,I2,TIM2,ETH(I2),EPH(I2),POL   RP   41
     12                                                                     RP   42
      IF (NADD.EQ.NPRT) GO TO 2                                             RP   43
      POL1=ATGN2(EPH(NADD),ETH(NADD))/TA                                    RP   44
      TIM=TSTRT+DT*FLOAT(NPRT)                                              RP   45
      PRINT 19,  NADD,TIM,ETH(NADD),EPH(NADD),POL1                          RP   46
C                                                                           RP   47
C     COMPUTE RADIATED ENERGY                                               RP   48
C                                                                           RP   49
2     F=0.                                                                  RP   50
      DO 3 I=1,NFLD                                                         RP   51
3     F=F+ETH(I)*ETH(I)+EPH(I)*EPH(I)                                       RP   52
      F=F*DT/376.73                                                         RP   53
      PRINT 21,  F,TH,PH                                                    RP   54
      IF (IFEN.EQ.0) GO TO 4                                                RP   55
      POL1=F/ENIN                                                           RP   56
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      POL2=F/ENRD                                                       RP  57
      IF (POL1.LT.1.E-20) GO TO 4                                       RP  58
      POL1=10.*ALOG10(POL1)                                             RP  59
      POL2=10.*ALOG10(POL2)                                             RP  60
      PRINT 20,  POL1,POL2                                              RP  61
4     IF (IPCH.EQ.0) GO TO 5                                            RP  62
C                                                                       RP  63
C     PUNCH FIELD VALUES                                                RP  64
C                                                                       RP  65
      PUNCH 26, TSTRT,DT                                                RP  66
      PUNCH 22,  NFLD,TH,PH                                             RP  67
      PUNCH 23,  (ETH(I),I=1,NFLD)                                      RP  68
      PUNCH 24,  NFLD,TH,PH                                             RP  69
      PUNCH 23,  (EPH(I),I=1,NFLD)                                      RP  70
5     IF (ITRAN.EQ.0) GO TO 15                                          RP  71
C                                                                       RP  72
C     FOURIER TRANSFORM TO OBTAIN FREQUENCY RESPONSE                    RP  73
C                                                                       RP  74
      IF (IFST.EQ.1) GO TO 7                                            RP  75
      MTRAN=ALOG(FLOAT(NTRAN))/.69314718+1.5                            RP  76
      CALL ITOF (ESORC,NTRAN,MTRAN,1,1,NTNX,NTNR)                       RP  77
      IFST=1                                                            RP  78
      DFRQ=1./(DT*FLOAT(2**MTRAN))                                      RP  79
      NTNR=NTNR/2                                                       RP  80
      DO 6 I=1,NTNR                                                     RP  81
6     PWR(I)=0.                                                         RP  82
7     CALL ITOF (ETH,NTRAN,MTRAN,0,0,NTNX,NTNR)                         RP  83
      CALL ITOF (EPH,NTRAN,MTRAN,0,0,NTNX,NTNR)                         RP  84
      NTNR=NTNR/2                                                       RP  85
      FMAX=1./(TSMIN*DT)                                                RP  86
      CARG=-TPJ*TSTRT                                                   RP  87
      PRINT 17                                                          RP  88
      IF (ITRAN.GT.1) PUNCH 25, TH,PH                                   RP  89
      F=-DFRQ                                                           RP  90
      DO 14 I=1,NTNR                                                    RP  91
      F=F+DFRQ                                                          RP  92
      IF (F.GT.FMAX) GO TO 15                                           RP  93
      FQ=F*1.E-6                                                        RP  94
      FAZ=CEXP(CARG*F)/ESC(I)                                           RP  95
      ETHC=ETC(I)*FAZ                                                   RP  96
      EPHC=EPC(I)*FAZ                                                   RP  97
      ETHM2=REAL(ETHC*CONJG(ETHC))                                      RP  98
      EPHM2=REAL(EPHC*CONJG(EPHC))                                      RP  99
      ETHM=SQRT(ETHM2)                                                  RP 100
      EPHM=SQRT(EPHM2)                                                  RP 101
      ETHA=ATGN2(AIMAG(ETHC),REAL(ETHC))/TA                             RP 102
      EPHA=ATGN2(AIMAG(EPHC),REAL(EPHC))/TA                             RP 103
      IF (ETHM2.GT.1.E-20.OR.EPHM2.GT.1.E-20) GO TO 8                   RP 104
      TILTA=0.                                                          RP 105
      EMAJR2=0.                                                         RP 106
      EMINR2=0.                                                         RP 107
      AXRAT=0.                                                          RP 108
      ISENS=IBLK                                                        RP 109
      GO TO 13                                                          RP 110
8     DFAZ=EPHA-ETHA                                                    RP 111
      IF (EPHA.LT.0.) GO TO 9                                           RP 112
      DFAZ2=DFAZ-360.                                                   RP 113
      GO TO 10                                                          RP 114
9     DFAZ2=DFAZ+360.                                                   RP 115
10    IF (ABS(DFAZ).GT.ABS(DFAZ2)) DFAZ=DFAZ2                           RP 116
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      CDFAZ=COS(DFAZ*TA)                                                RP 117
      TS1=ETHM2-EPHM2                                                   RP 118
      TS2=2.*EPHM*ETHM*CDFAZ                                            RP 119
      TILTA=.5*ATAN2(TS2,TS1)                                           RP 120
      STILTA=SIN(TILTA)                                                 RP 121
      TS1=TS1*STILTA*STILTA                                             RP 122
      TS2=TS2*STILTA*COS(TILTA)                                         RP 123
      EMAJR2=-TS1+TS2+ETHM2                                             RP 124
      EMINR2=TS1-TS2+EPHM2                                              RP 125
      IF (EMINR2.LT.0.) EMINR2=0.                                       RP 126
      AXRAT=SQRT(EMINR2/EMAJR2)                                         RP 127
      TILTA=TILTA/TA                                                    RP 128
      IF (AXRAT.GT.1.E-5) GO TO 11                                      RP 129
      ISENS=IPOL(1)                                                     RP 130
      GO TO 13                                                          RP 131
11    IF (DFAZ.GT.0.) GO TO 12                                          RP 132
      ISENS=IPOL(2)                                                     RP 133
      GO TO 13                                                          RP 134
12    ISENS=IPOL(3)                                                     RP 135
13    WLAM=F                                                            RP 136
      IF (WLAM.LT.1.E-25) WLAM=1.E-25                                   RP 137
      WLAM=2.998E+8/WLAM                                                RP 138
      POR=PWR(I)                                                        RP 139
      IF (POR.LT.1.E-25) POR=.0013273*WLAM*WLAM                         RP 140
      GTOT=.01668*(ETHM2+EPHM2)/POR                                     RP 141
      IF (GTOT.LT.1.E-20) GTOT=1.E-20                                   RP 142
      GTOT=10.*ALOG10(GTOT)                                             RP 143
      ETHM=ETHM/WLAM                                                    RP 144
      EPHM=EPHM/WLAM                                                    RP 145
      PRINT 16,  I,FQ,ETHM,ETHA,EPHM,EPHA,AXRAT,TILTA,ISENS,GTOT        RP 146
      IF (ITRAN.GT.1) PUNCH 16, I,FQ,ETHM,ETHA,EPHM,EPHA                RP 147
14    CONTINUE                                                          RP 148
15    CONTINUE                                                          RP 149
      RETURN                                                            RP 150
C                                                                       RP 151
C                                                                       RP 152
16    FORMAT  (1X,I5,E12.4,E13.4,F9.3,E15.4,F9.3,F11.5,F9.2,2X,A6,F14.3) RP 153
17    FORMAT  (  ///,33X,43H- - - FREQUENCY DOMAIN RADIATED FIELD - - -,  RP 154
     1   //,2X,4HSTEP,2X,9HFREQUENCY,3X,20H- - - E(THETA) - - -,4X,      RP 155
     2   18H- - - E(PHI) - - -,6X,24H- - - POLARIZATION - - -,5X,        RP 156
     3         10HPOWER GAIN,/,3X,3HNO.,4X,5H(MHZ),6X,9HMAGNITUDE,4X,    RP 157
     4   5HPHASE,6X,9HMAGNITUDE,4X,5HPHASE,7X,5HAXIAL,5X,4HTILT,3X,      RP 158
     5   5HSENSE,9X,4H(DB),/,22X,7HVOLTS/M,4X,7HDEGREES,6X,7HVOLTS/M,    RP 159
     6   4X,7HDEGREES,6X,5HRATIO,5X,4HDEG.)                             RP 160
18    FORMAT  (  //,42X,30H- - - - RADIATED FIELD - - - -.//,47X,6HTHETA RP 161
     1=, F8.3,/,47X,6HPHI  =,F8.3,//,2(2X,4HSTEP,6X,4HTIME,8X,20HELECTRI RP 162
     2C FIELD (V/M),4X,4HPOL.,8X),/,2(3X,3HNO.,5X,6H(SEC.),8X,5HTHETA,9X RP 163
     3,  3HPHI,5X,6H(DEG.),7X))                                         RP 164
19    FORMAT  (2(1X,I5,E13.5,E13.4,E12.4,F9.3,7X))                      RP 165
20    FORMAT  (  1X,24HTIME DOMAIN POWER GAIN =,F7.2,3H DB,/,1X,28HTIME RP 166
     1DOMAIN DIRECTIVE GAIN =,F7.2,3H DB,//)                            RP 167
21    FORMAT  (  //,1X,23HTOTAL ENERGY RADIATED =,E11.4,17H JOULES/STERA RP 168
     1DIAN,3X,7H(THETA=,F8.3,12H DEG.,  PHI=,F8.3,6H DEG.))             RP 169
22    FORMAT  (I5,2X,26HRADIATED FIELDS FOR THETA=,F8.3,11H DEG.,  PHI=,F RP 170
     18.3,18H DEG.,  THETA POL.)                                        RP 171
23    FORMAT  (6E12.5)                                                  RP 172
24    FORMAT  (I5,2X,26HRADIATED FIELDS FOR THETA=,F8.3,11H DEG.,  PHI=,F RP 173
     18.3,16H DEG.,  PHI POL.)                                          RP 174
25    FORMAT (23HRADIATED FIELD.  THETA=,F10.5,6H  PHI=,F10.5)          RP 175
26    FORMAT (14HSTARTING TIME=,E12.5,3X,15HTIME INCREMENT=,E12.5)      RP 176
      END                                                               RP 177-
```

```
      SUBROUTINE SECOND (T)                                          SE    1
C                                                                    SE    2
C     RETURNS CURRENT RUNNING TIME IN SECONDS                        SE    3
C                                                                    SE    4
      CALL TUSEOM (I)                                                SE    5
      T=I/1000.                                                      SE    6
      RETURN                                                         SE    7
      END                                                            SE    8
```

```
      SUBROUTINE SOLVE (N,A,P,B,NDIM)                                    SO   1
C                                                                        SO   2
C     SUBROUTINE TO SOLVE THE MATRIX EQUATION LU*X=B WHERE L IS A UNIT   SO   3
C     LOWER TRIANGULAR MATRIX AND U IS AN UPPER TRIANGULAR MATRIX BOTH   SO   4
C     OF WHICH ARE STORED IN A.  THE RHS VECTOR B IS INPUT AND THE       SO   5
C     SOLUTION IS RETURNED THROUGH VECTOR B.      (MATRIX TRANSPOSED)    SO   6
C                                                                        SO   7
      DIMENSION A(NDIM,NDIM), P(NDIM), B(NDIM)                           SO   8
      COMMON /SCRATM/ Y(200)                                             SO   9
      INTEGER  P,PI                                                      SO  10
C                                                                        SO  11
C     FORWARD SUBSTITUTION                                               SO  12
C                                                                        SO  13
      DO 3 I=1,N                                                         SO  14
      PI=P(I)                                                            SO  15
      Y(I)=B(PI)                                                         SO  16
      B(PI)=B(I)                                                         SO  17
      IP1=I+1                                                            SO  18
      IF (IP1.GT.N) GO TO 2                                              SO  19
      DO 1 J=IP1,N                                                       SO  20
      B(J)=B(J)-A(I,J)*Y(I)                                              SO  21
1     CONTINUE                                                           SO  22
2     CONTINUE                                                           SO  23
3     CONTINUE                                                           SO  24
C                                                                        SO  25
C     BACKWARD SUBSTITUTION                                              SO  26
C                                                                        SO  27
      DO 6 K=1,N                                                         SO  28
      I=N-K+1                                                            SO  29
      SUM=0.                                                             SO  30
      IP1=I+1                                                            SO  31
      IF (IP1.GT.N) GO TO 5                                              SO  32
      DO 4 J=IP1,N                                                       SO  33
      SUM=SUM+A(J,I)*B(J)                                                SO  34
4     CONTINUE                                                           SO  35
5     CONTINUE                                                           SO  36
      B(I)=(Y(I)-SUM)/A(I,I)                                             SO  37
6     CONTINUE                                                           SO  38
      RETURN                                                             SO  39
      END                                                                SO  40
```

```
      SUBROUTINE TSOL (CURF,IX,IP,N)                                    TS    1
C                                                                       TS    2
C     TSOL COMPUTES STRUCTURE CURRENTS                                  TS    3
C                                                                       TS    4
      COMMON /CONST/  CDT,VEL,DT,NTSTEP                                 TS    5
      COMMON /EINC/  EINC(200),ESRC                                     TS    6
      COMMON /ARRAY/  CQ(6400)                                          TS    7
      COMMON /ARMAX/  QI1,QI2,QI3,EC(200,5),EQ(200,5),IRET(200),BFR(1540 TS    8
     10)                                                                TS    9
      COMMON /IOFLG/  NCFMX,NCQMX,IOC,IOCQ,NTMAX,NBOUT,JP1,JP2          TS   10
      COMMON /MATPAR/  NBLOKS,NPBLK,NLAST,INT                           TS   11
      COMMON /ESORC/  ESORC(1024),IFST,NTRAN,MTRAN,NTNX,DFRQ,ENIN,ENRD,I TS   12
     1FEN                                                               TS   13
      DIMENSION ICOF(17600), COF(17600)                                 TS   14
      EQUIVALENCE (COF,EC), (ICOF,EC)                                   TS   15
      N2=N*2                                                            TS   16
      N4P=2*N2+1                                                        TS   17
      IC1=N2                                                            TS   18
      IC2=N4P                                                           TS   19
      ICL=9999999                                                       TS   20
      IOLIM=9999999                                                     TS   21
      LCQ=NCQMX/N2                                                      TS   22
      NOCQ=LCQ-NTMAX+1                                                  TS   23
      IF (NOCQ.LT.1) GO TO 1                                            TS   24
      LCQ=LCQ*N2                                                        TS   25
      NOCQ=NOCQ*N2                                                      TS   26
      L1=1                                                              TS   27
      L2=NOCQ                                                           TS   28
      NSFT=LCQ-NOCQ                                                     TS   29
      PRINT 36                                                          TS   30
      GO TO 2                                                           TS   31
1     NOCQ=(LCQ/2)*N2                                                   TS   32
      IF (NOCQ.LT.N2) GO TO 35                                          TS   33
      LCQ=2*NOCQ                                                        TS   34
      L1=NOCQ+1                                                         TS   35
      L2=LCQ                                                            TS   36
      PRINT 37                                                          TS   37
2     IOCQ=0                                                            TS   38
      NBAS=0                                                            TS   39
      ICFLG=0                                                           TS   40
      NELO=0                                                            TS   41
      NBOUT=0                                                           TS   42
      PRINT 38,  NOCQ,NTMAX                                             TS   43
      PRINT 39                                                          TS   44
      PRINT 40                                                          TS   45
      DO 3 I=2,N2,2                                                     TS   46
3     CQ(I)=0.                                                          TS   47
      TIME=-DT                                                          TS   48
C                                                                       TS   49
C     BEGIN TIME LOOP                                                   TS   50
C                                                                       TS   51
      DO 31 ITIME=1,NTSTEP                                              TS   52
      TIME=TIME+DT                                                      TS   53
      ITLOC=(ITIME-1)*N2                                                TS   54
C                                                                       TS   55
C     SET UP APPLIED FIELD AT PRESENT TIME                              TS   56
```

```
C                                                                       TS  57
      CALL EINCF (TIME)                                                 TS  58
      IF (ITIME.EQ.1) GO TO 18                                          TS  59
      IF (ICFLG.EQ.0) GO TO 5                                           TS  60
C                                                                       TS  61
C     COMPUTE FIELD AT PRESENT TIME DUE TO CURRENTS AT RETARDED TIMES   TS  62
C                                                                       TS  63
      NBKS=((NTMAX-K)*N2+NELO+NOCQ-1)/NOCQ+1                            TS  64
      IF (NBKS.GT.NBOUT) NBKS=NBOUT                                     TS  65
      NBAS=NELO-NBKS*NOCQ+NOCQ                                          TS  66
      DO 4 J=1,NBKS                                                     TS  67
4     BACKSPACE   11                                                    TS  68
      READ (11)  NIN,(CQ(J),J=1,NOCQ)                                   TS  69
      NBIN=1                                                            TS  70
5     IF (IOC.EQ.0) GO TO 7                                             TS  71
      REWIND   12                                                       TS  72
6     READ (12)  ICL,LEND,(COF(J),J=1,ICL)                              TS  73
      IF (ITIME.LE.LEND) GO TO 6                                        TS  74
7     ESCAT=0.                                                          TS  75
      ICF=1                                                             TS  76
      I=1                                                               TS  77
8     INDX=ICOF(ICF)                                                    TS  78
      ICF=ICF+1                                                         TS  79
      IF (INDX.LT.0) GO TO 9                                            TS  80
      ICF=ICF+INDX/10000                                                TS  81
      GO TO 8                                                           TS  82
9     IF (ITIME.LE.(-INDX/10000)) GO TO 8                               TS  83
      GO TO 11                                                          TS  84
10    EINC(I)=EINC(I)+ESCAT                                             TS  85
      ESCAT=0.                                                          TS  86
11    IF (INDX.EQ.0) GO TO 18                                           TS  87
      INDX=-INDX                                                        TS  88
      K=INDX/10000                                                      TS  89
      I=INDX-K*10000                                                    TS  90
      K=ITIME-K                                                         TS  91
12    ICQB=(K-1)*N2-NBAS                                                TS  92
      IF (ICQB.LT.IOLIM) GO TO 14                                       TS  93
      IF (NBIN.EQ.NBKS) GO TO 14                                        TS  94
      READ (11)  NIN,(CQ(J),J=1,NOCQ)                                   TS  95
      NBIN=NBIN+1                                                       TS  96
      NBAS=NBAS+NOCQ                                                    TS  97
      GO TO 12                                                          TS  98
13    IF (ICF.LE.ICL) GO TO 14                                          TS  99
      READ (12)  ICL,LEND,(COF(J),J=1,ICL)                              TS 100
      ICF=1                                                             TS 101
14    INDX=ICOF(ICF)                                                    TS 102
      ICF=ICF+1                                                         TS 103
      IF (INDX.LE.0) GO TO 10                                           TS 104
      J1=INDX/10000                                                     TS 105
      J2=INDX-J1*10000                                                  TS 106
      ICQ=ICQB+J2                                                       TS 107
      IF (K.EQ.ITIME) GO TO 16                                          TS 108
      DO 15 J=1,J1                                                      TS 109
      ESCAT=ESCAT+COF(ICF)*CQ(ICQ)                                      TS 110
      ICQ=ICQ+1                                                         TS 111
15    ICF=ICF+1                                                         TS 112
      GO TO 13                                                          TS 113
16    ICQ=ICQ+1                                                         TS 114
      ICF=ICF+1                                                         TS 115
      DO 17 J=1,J1,2                                                    TS 116
```

```
      ESCAT=ESCAT+COF(ICF)*CQ(ICQ)                                      TS 117
      ICQ=ICQ+2                                                         TS 118
17    ICF=ICF+2                                                         TS 119
      ICF=ICF-1                                                         TS 120
      GO TO 13                                                          TS 121
C                                                                       TS 122
C     SOLVE MATRIX EQUATION FOR CURRENTS AT PRESENT TIME                TS 123
C                                                                       TS 124
18    IF (INT.EQ.0) GO TO 19                                            TS 125
      CALL LTSOLV (CURF,CURF,N,IX,EINC)                                 TS 126
      GO TO 20                                                          TS 127
19    CALL SOLVE (N,CURF,IP,EINC,N)                                     TS 128
20    PRINT 41,  ITIME,TIME,(EINC(I),I=JP1,JP2)                         TS 129
      PRINT 43, ESRC                                                    TS 130
      IF (ITIME.GT.NTRAN) GO TO 21                                      TS 131
      ESORC(ITIME)=ESRC                                                 TS 132
21    ICQ=ITLOC-1-NELO                                                  TS 133
      DO 22 I=1,N                                                       TS 134
      ICQ=ICQ+2                                                         TS 135
      ICQB=ICQ+1                                                        TS 136
      CQ(ICQ)=EINC(I)                                                   TS 137
22    CQ(ICQB)=CQ(ICQB)+QI3*EINC(I)                                     TS 138
      IF (ITIME.EQ.NTSTEP) GO TO 31                                     TS 139
      IF (ICQB.LT.LCQ) GO TO 26                                         TS 140
      IF (IOCQ.EQ.1) GO TO 23                                           TS 141
      IOCQ=1.                                                           TS 142
      REWIND   11                                                       TS 143
      IF (L1.EQ.1) GO TO 23                                             TS 144
      WRITE (11)  NOCQ,(CQ(I),I=1,NOCQ)                                 TS 145
      NBOUT=NBOUT+1                                                     TS 146
      ICFLG=1                                                           TS 147
      IOLIM=NOCQ                                                        TS 148
23    WRITE (11)  NOCQ,(CQ(I),I=L1,L2)                                  TS 149
      NBOUT=NBOUT+1                                                     TS 150
      NELO=NELO+NOCQ                                                    TS 151
      IF (L1.EQ.1) GO TO 24                                             TS 152
      IC1=N2-NOCQ                                                       TS 153
      IC2=N4P-NOCQ                                                      TS 154
      GO TO 26                                                          TS 155
24    DO 25 I=1,NSFT                                                    TS 156
      INDX=I+NOCQ                                                       TS 157
25    CQ(I)=CQ(INDX)                                                    TS 158
      NBAS=NELO                                                         TS 159
26    ICQ=ITLOC-NELO+N2                                                 TS 160
C                                                                       TS 161
C     COMPUTE COMPONENT OF TIME INTEGRAL OF CURRENT AT NEXT TIME STEP   TS 162
C     THAT DEPENDS ON PRESENT AND PAST VALUES OF CURRENT AND            TS 163
C     TIME INTEGRAL OF CURRENT                                          TS 164
C                                                                       TS 165
      IF (ITIME.EQ.1) GO TO 28                                          TS 166
      DO 27 J=1,N                                                       TS 167
      ICQ=ICQ+2                                                         TS 168
      ICQX=ICQ-IC1                                                      TS 169
      ICQY=ICQ-IC2                                                      TS 170
27    CQ(ICQ)=CQ(ICQX)+QI1*CQ(ICQY)+QI2*EINC(J)                         TS 171
      GO TO 30                                                          TS 172
28    DO 29 J=1,N                                                       TS 173
      ICQ=ICQ+2                                                         TS 174
      ICQX=ICQ-IC1                                                      TS 175
29    CQ(ICQ)=CQ(ICQX)+QI2*EINC(J)                                      TS 176
```

```
30    IF (IC1.EQ.N2) IC2=N4P                                                TS 177
      IC1=N2                                                                TS 178
31    CONTINUE                                                              TS 179
      IF (IOCQ.EQ.0) GO TO 34                                               TS 180
32    IF (L2.GE.ICQB) GO TO 33                                              TS 181
      WRITE (11)  NOCQ,(CQ(I),I=L1,L2)                                      TS 182
      NBOUT=NBOUT+1                                                         TS 183
      L1=L2+1                                                               TS 184
      L2=L2+NOCQ                                                            TS 185
      GO TO 32                                                              TS 186
33    NOCQ=ICQB-L1+1                                                        TS 187
      WRITE (11)  NOCQ,(CQ(I),I=L1,ICQB)                                    TS 188
      NBOUT=NBOUT+1                                                         TS 189
      REWIND   11                                                           TS 190
34    IF (IOC.NE.0) REWIND   12                                             TS 191
      RETURN                                                                TS 192
35    PRINT 42,  N                                                          TS 193
      STOP                                                                  TS 194
C                                                                           TS 195
C                                                                           TS 196
36    FORMAT  (   1X,49HSOLUTION WILL USE CURRENTS FROM CORE STORAGE ONL    TS 197
     1Y)                                                                    TS 198
37    FORMAT  (   1X,44HSOLUTION WILL USE CURRENTS FROM FILE STORAGE)       TS 199
38    FORMAT  (1X,33HLENGTH OF CURRENT OUTPUT BLOCK IS,I8,1X,6HWORDS,,/,    TS 200
     11X,42HNUMBER OF TIME STEPS USED DURING SOLUTION=,I8,//)               TS 201
39    FORMAT  (   44X,32H- - - - CURRENT SOLUTION - - - -,/)                TS 202
40    FORMAT  (1X,4HSTEP,6X,4HTIME,5X,52HSEGMENT CURRENTS IN AMPS (READ     TS 203
     1ACROSS) -  -  -  -  -,/,2X,3HNO.,5X,6H(SEC.),4X,52HLAST NUMBER IN    TS 204
     2EACH BLOCK REPRESENTS SOURCE STRENGTH)                                TS 205
41    FORMAT  (/,1X,I4,E12.5,10E11.3,/,(17X,10E11.3))                       TS 206
42    FORMAT  (1X,72H***ERROR - ROUTINE TSOL-- INSUFFICIENT STORAGE FOR     TS 207
     1SEGMENT CURRENTS.  N=,I10)                                            TS 208
43    FORMAT (19X,10HEXCITATION,E13.4)                                      TS 209
      END                                                                   TS 210-
```

```
      SUBROUTINE WIRE (XW1,YW1,ZW1,XW2,YW2,ZW2,RAD,NS,ITG)                WI    1
C                                                                         WI    2
C     SUBROUTINE WIRE GENERATES SEGMENT GEOMETRY DATA FOR A STRAIGHT      WI    3
C     WIRE OF NS SEGMENTS.                                                WI    4
C                                                                         WI    5
      COMMON /DATA/ N,NP,X(200),Y(200),Z(200),SI(200),BI(200),ALP(200),   WI    6
     1   BET(200),ICON1(200),ICON2(200),ITAG(200),IPX,IPY,IPZ             WI    7
      DIMENSION X2(1), Y2(1), Z2(1)                                       WI    8
      EQUIVALENCE (X2(1),SI(1)), (Y2(1),ALP(1)), (Z2(1),BET(1))           WI    9
      IST=N+1                                                             WI   10
      N=N+NS                                                              WI   11
      NP=N                                                                WI   12
      IF (NS.LT.1) RETURN                                                 WI   13
      FNS=NS                                                              WI   14
      XD=(XW2-XW1)/FNS                                                    WI   15
      YD=(YW2-YW1)/FNS                                                    WI   16
      ZD=(ZW2-ZW1)/FNS                                                    WI   17
      XS1=XW1                                                             WI   18
      YS1=YW1                                                             WI   19
      ZS1=ZW1                                                             WI   20
      DO 1 I=IST,N                                                        WI   21
      ITAG(I)=ITG                                                         WI   22
      XS2=XS1+XD                                                          WI   23
      YS2=YS1+YD                                                          WI   24
      ZS2=ZS1+ZD                                                          WI   25
      X(I)=XS1                                                            WI   26
      Y(I)=YS1                                                            WI   27
      Z(I)=ZS1                                                            WI   28
      X2(I)=XS2                                                           WI   29
      Y2(I)=YS2                                                           WI   30
      Z2(I)=ZS2                                                           WI   31
      BI(I)=RAD                                                           WI   32
      XS1=XS2                                                             WI   33
      YS1=YS2                                                             WI   34
1     ZS1=ZS2                                                             WI   35
      RETURN                                                              WI   36
      END                                                                 WI   37
```

APPENDIX B
DIAGNOSTICS

1. BLOCKING N_1 N_2 N_3

   Routine: FBLOCK

   This is printed when matrix factorization and solution requires file storage. It does not indicate an error.

   N_1 = number of blocks on file storage

   N_2 = number of matrix columns per block

   N_3 = number of matrix columns in last block ($N_3 \leq N_2$)

2. CHECK DATA, PARAMETER SPECIFYING SEGMENT POSITION IN A GROUP OF EQUAL TAGS MUST NOT BE ZERO

   Routine: ISEGNO

   The number following the tag number reference on a data card was zero. Execution terminated.

3 ERROR FLAG RETURNED BY SUBROUTINE FORT, IFERR = ---

   Routine: ITOF

   This indicates a program malfunction. The meaning of IFERR is explained in the comments in subroutine FORT.

4. ERROR - ROUTINE RFLD -- INCONSISTENT SEGMENT CONNECTION DATA

   Routine: RFLD

   This indicates a program malufnction. The connection information in arrays ICON1 and ICON2 was found to be contradictory. A possible cause is an overflow of an array.

5. ERROR - ROUTINE TSOL -- INSUFFICIENT STORAGE FOR SEGMENT CURRENTS. N = ---

   Routine: TSOL

   The dimension of array CQ must be at least 4 x N where N is the number of segments. This dimension is presently 6400 for the GE 635/645 computer and 5184 for the CDC 3800.

6. GEOMETRY DATA CARD ERROR

Routine: DATAGN

An invalid mnemonic was found on a card where a geometry data card was expected.

7. INCORRECT LABEL FOR A COMMENT CARD

Routine: MAIN

An invalid mnemonic was found on a card where a comment card was expected.

8. INPUT ENERGY NOT COMPUTED SINCE SOURCE HAS BEEN TRANSFORMED

Routine: MAIN

Request for energy budget must preceed any requests involving Fourier transforms since the Fourier transform writes over the record of the source time function.

9. INTEGRATION ATTEMPTED OVER SINGULARITY.

B, C = ---

Singularity due to R going to zero in range of integration ($R = \left| s^2 + Bs + C \right|^{1/2}$). Possible cause is overlapping segments in geometry specification.

10. INVALID DATA CARD LABEL AFTER SOLUTION

Routine: MAIN

An invalid mnemonic was found on a card where a data request card was expected. Valid mnemonics are EB, PC, AT, RF, NX, and EN

11. NO SEGMENT HAS AN ITAG OF ---

Routine: ISEGNO

TAG number used to refer to a segment does not exist.

12. NUMBER OF EXCITATION VALUES EXCEEDS ARRAY DIMENSION

Number of voltage sources cannot be greater than the dimensions of EMAG and ISRC. Dimension is now 10.

13. OVERFLOW IN FILLING ARRAY COF
Routine: COFS
This indicates a program malfunction. May possibly be corrected by increasing IST at statement CF 34A in subroutine COFS to cause more frequent dumping of data to file.

14. OVERFLOW IN FILLING ARRAY SRT
Routine COFS
Same as 13.

15. PIVOT(---) = ---
Routine: FACTR or LFACTR
This will be printed during Gauss Doolittle factoring of the interaction matrix when a pivot element less than 10^{-10} is encountered, and indicates that the matrix is nearly singular. The number in parenthesis shows on which pass through the matrix the condition occurred. This is usually an abnormal condition although execution will continue. It may result from coinciding segments or a segment of zero length.

16. RETARDED TIMES FROM SEGMENT --- TO SEGMENTS --- AND--- DIFFER BY---TIME STEPS
Routine: COFS
Retarded times from a point to two segments which are connected to each other cannot differ by more than one time step. This is usually caused by a segment with length greater than the time increment multiplied by the velocity of light.

17. RETARDED TIMES TO SEGMENTS ---AND---DIFFER BY---TIME STEPS
Routine: RFLD
Same as 16.

18. SEGMENT --- LIES IN OR BEHIND SYMMETRY PLANE

Routine: CONECT

All segments must lie on the positive side of any symmetry planes.

19. SEGMENT CONNECTION ERROR. J = ---

Routine: COFS

Same as 4. Error detected at segment J.

20. ZERO TIME STEPS REQUESTED

Routine: MAIN

Both TMAX and NTSTEP on First data card were zero or blank.

Appendix C

List of Scientific Subroutines Used in TIMDOM

ABS(X)	=	absolute value of X
AIMAG(Z)	=	imaginary part of the complex number Z, (result is real)
AINT(X)	=	integer truncation (result is real)
ALOG(X)	=	the natural log of X
ALOG10(X)	=	the log to the base ten of X
ASIN(X)*	=	arcsine of X, result in radians
ATAN2(X_1, X_2)	=	arctangent of X_1/X_2, result in radians covering all four quadrants.
CEXP(Z)	=	complex exponential (e^Z)
CMPLX (X_1, X_2)	=	formation of a complex number ($Z = X_1 + j X_2$)
CONJG (Z)	=	conjugate of the complex number Z
COS (X)	=	cosine of X
DABS (X)	=	absolute value of a double precision number (result is double precision)
DATAN (X)	=	arctangent of a double precision number (result is double precision)
DLOG (X)	=	natural log of a double precision number (result is double precision)
DSQRT (X)	=	square root of a double precision number (result is double precision)
EXP (X)	=	exponential function (e^x)
FLOAT (K)	=	real number equivalent of integer K
IABS (I)	=	absolute value of integer I
REAL (Z)	=	real part of the complex number Z
SIGN (X_1, X_2)	=	sign of X_2 times $\|X\|$.
SIN (X)	=	sine of X
SQRT (X)	=	square root of X

* Note, this routine is not found in the Honeywell/GE scientific library; therefore, it is included as a subroutine in the TIMDOM deck for this machine.

METRIC SYSTEM

BASE UNITS:

Quantity	Unit	SI Symbol	Formula
length	metre	m	...
mass	kilogram	kg	...
time	second	s	...
electric current	ampere	A	...
thermodynamic temperature	kelvin	K	...
amount of substance	mole	mol	...
luminous intensity	candela	cd	...

SUPPLEMENTARY UNITS:

plane angle	radian	rad	...
solid angle	steradian	sr	...

DERIVED UNITS:

Acceleration	metre per second squared	...	m/s
activity (of a radioactive source)	disintegration per second	...	(disintegration)/s
angular acceleration	radian per second squared	...	rad/s
angular velocity	radian per second	...	rad/s
area	square metre	...	m
density	kilogram per cubic metre	...	kg/m
electric capacitance	farad	F	A·s/V
electrical conductance	siemens	S	A/V
electric field strength	volt per metre	...	V/m
electric inductance	henry	H	V·s/A
electric potential difference	volt	V	W/A
electric resistance	ohm		V/A
electromotive force	volt	V	W/A
energy	joule	J	N·m
entropy	joule per kelvin	...	J/K
force	newton	N	kg·m/s
frequency	hertz	Hz	(cycle)/s
illuminance	lux	lx	lm/m
luminance	candela per square metre	...	cd/m
luminous flux	lumen	lm	cd·sr
magnetic field strength	ampere per metre	...	A/m
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m
magnetomotive force	ampere	A	...
power	watt	W	J/s
pressure	pascal	Pa	N/m
quantity of electricity	coulomb	C	A·s
quantity of heat	joule	J	N·m
radiant intensity	watt per steradian	...	W/sr
specific heat	joule per kilogram-kelvin	...	J/kg·K
stress	pascal	Pa	N/m
thermal conductivity	watt per metre-kelvin	...	W/m·K
velocity	metre per second	...	m/s
viscosity, dynamic	pascal-second	...	Pa·s
viscosity, kinematic	square metre per second	...	m/s
voltage	volt	V	W/A
volume	cubic metre	...	m
wavenumber	reciprocal metre	...	(wave)/m
work	joule	J	N·m

SI PREFIXES:

Multiplication Factors	Prefix	SI Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto*	h
10 = 10^{1}	deka*	da
0.1 = 10^{-1}	deci*	d
0.01 = 10^{-2}	centi*	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

* To be avoided where possible.