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COMPUTATION OF RADIATION AND SCATTERING FROM LOADED BODIES OF REVOLUTION

by

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ABSTRACT

The problem of radiation and scattering from loaded conducting bodies of revolution is considered. A numerical solution is obtained from the integro-differential equations by the method of moments. Computer programs are given for plane-wave scattering, axial incidence, and for aperture radiation, rotationally symmetric excitation. Computations for some representative loaded antennas and loaded scatterers are graphed to illustrate the use of the programs.

CONTENTS

I. INTRODUCTION

A loaded body of revolution is one for which the current is linearly related to the tangential electric field at the surface by an impedance function. The theory and sample computations were given in a previous report.[2] The case of lumped loads on a body can be considered as a special case of continuous loads localized to small sections of the surface. A general theory of loaded antennas and scatterers with lumped loads is available in the literature.[4,5]

In this report computer programs are given for the computation of plane-wave scattering from a loaded body of revolution, axial incidence, and for the aperture radiation from a loaded body of revolution with rotational symmetry. The theory is summarized and some sample computations are presented. Computer programs for the more general cases of nonaxial incidence and apertures without rotational symmetry are not given, but can be constructed by minor modification of the programs according to the general theory.[1,2]

II. METHOD OF SOLUTION

The solution is obtained by applying the method of moments to the potential integral formulation of the problem.[5] This reduces the problem to matrices, which can be identified as generalized network parameters.[5,6] The general method as it applies to radiation and scattering from conducting bodies of revolution is given in the preceeding reports.[1-3] The following is a summary of the theory as it applies to the present problem.

Let $\underset{\sim}{E}^i$ denote the known impressed field and $\underset{\sim}{E}^s$ the scattered field due to currents on the body. Then the total field $\underset{\sim}{E}$ is the sum of the impressed and scattered fields, that is, $\underset{\sim}{E} = \underset{\sim}{E}^i + \underset{\sim}{E}^s$. Let L represent the integro-differential operator which relates the current $\underset{\sim}{J}$ on the surface S of the body to the tangential component of the scattered field on S according to

$$L(\underset{\sim}{J}) = -\underset{\sim}{E}^s_{\text{tan}} \qquad (1)$$

An evaluation of L in terms of the scalar and vector potentials is given in the previous reports.[1-3] We also define an inner product as

$$\langle \mathbf{W}, \mathbf{J} \rangle = \oiint_S \mathbf{W} \cdot \mathbf{J} \, ds \tag{2}$$

as required for the method of moments. Here $\mathbf{W}$ and $\mathbf{J}$ are tangential vectors on the surface S.

A loaded surface S is one for which the total tangential electric field on S is related to the current $\mathbf{J}$ on S by an impedance function of position $\mathcal{Z}$ according to

$$\mathbf{E}_{tan} = \mathbf{E}^i_{tan} + \mathbf{E}^s_{tan} = \mathcal{Z}\mathbf{J} \tag{3}$$

Now $\mathbf{E}^s_{tan}$ is related to the current $\mathbf{J}$ by (1). Hence, by combining (1) and (3), we have

$$L(\mathbf{J}) = \mathbf{E}^i_{tan} - \mathcal{Z}\mathbf{J} \tag{4}$$

When the surface S is a perfect conductor, $\mathcal{Z} = 0$ and (4) reduces to $L(\mathbf{J}) = \mathbf{E}^i_{tan}$, the usual equation for scattering by a conducting body.

Now let $\{\mathbf{J}_j\}$ denote a set of expansion functions, and express the current $\mathbf{J}$ on S as

$$\mathbf{J} = \sum_j I_j \mathbf{J}_j \tag{5}$$

where the I_j are constants to be determined. Let $\{\mathbf{W}_i\}$ denote a set of testing functions on S, and apply the method of moments to (4) in the usual way.[5] The result is a matrix equation

$$[Z][I] = [V] - [Z_L][I] \tag{6}$$

Here [Z], [V], and [I] are matrices of the generalized network parameters[6]

$$[Z] = [\langle \underline{W}_i, L\underline{J}_j \rangle] \tag{7}$$

$$[V] = [\langle \underline{W}_i, \underline{E}^i \rangle] \tag{8}$$

$$[I] = [I_j] \tag{9}$$

and $[Z_L]$ is the load matrix

$$[Z_L] = [\langle \underline{W}_i, \mathcal{Z}\,\underline{J}_j \rangle] \tag{10}$$

The solution to (6) for the current matrix $[I]$ is

$$[I] = [Z + Z_L]^{-1}\,[V] \tag{11}$$

Note the analogy of this solution to two n-port networks connected in series with a voltage source.[6] Once $[I]$ is found, the current on S is given by (5), and any functional of $\underline{J}$ can be computed in the usual way.[5]

The impedance function $\mathcal{Z}$ is zero over those parts of S covered by a perfect electric conductor. If subsectional expansion and testing functions are used, many of the elements of $[Z_L]$ may be zero when the surface S is partially covered by an electric conductor. In such cases the following alternative solution may be computationally faster than (11). Suppose $[Z_L]$ has some zero rows and columns. Let $[Z_L^r]$ be the matrix obtained from $[Z_L]$ be deleting all zero rows, $[Z_L^c]$ by deleting all zero columns, and $[Z_L^{rc}]$ by deleting all zero rows and columns. Other matrices with the same rows and/or columns deleted will be identified by the same superscripts. Then, multiplying (6) by $[Y] = [Z^{-1}]$, and deleting the appropriate rows and columns, we have

$$[I^r] = [Y^r][V] - [Y^{rc}][Z_L^{rc}][I^r] \tag{12}$$

The solution of this for $[Z_L^{rc}][I^r]$ is

$$[Z_L^{rc}][I^r] = [Y^{rc} + Y_L^{rc}]^{-1}\,[Y^r][V] \tag{13}$$

where $[Y_L^{rc}] = [Z_L^{rc}]^{-1}$. The solution is now given by

$$[I] = [Z]^{-1}\,[V'] \tag{14}$$

where $[V']$ is the effective excitation

$$[V'] = [V] + [V_L] \tag{15}$$

and $[V_L]$ is the matrix obtained by adding the appropriate zeros to

$$\begin{aligned}[V_L^r] &= -\,[Z_L^{rc}][I^r] \\ &= -\,[Y^{rc} + Y_L^{rc}]^{-1}\,[Y^r][V] \end{aligned} \tag{16}$$

The effective excitation is thus viewed as the superposition of the impressed voltage $[V]$ plus the load voltage $[V_L]$.

The computations of the next section for loaded antennas and scatterers were made using this second formulation. A problem arises in the case of an open circuit, since then elements of $[Z_L^{rc}]$ may become infinite. However, $[Y_L^{rc}]$ is still well defined, and may be obtained from $[Z_L^{rc}]^{-1}$ by setting the "infinite" elements to some very large number.

Numerical evaluation of the generalized network parameters (7) and (8) is the same as used for unloaded bodies.[2] The load matrix (10) is evaluated by a simple numerical integration when $\mathfrak{z}$ is a given function of position. Further details of the solution can be inferred from the Fortran programs of Section V. The accuracy and limitations of the computer programs are essentially the same as for previous programs, discussed in previous reports.[1,2]

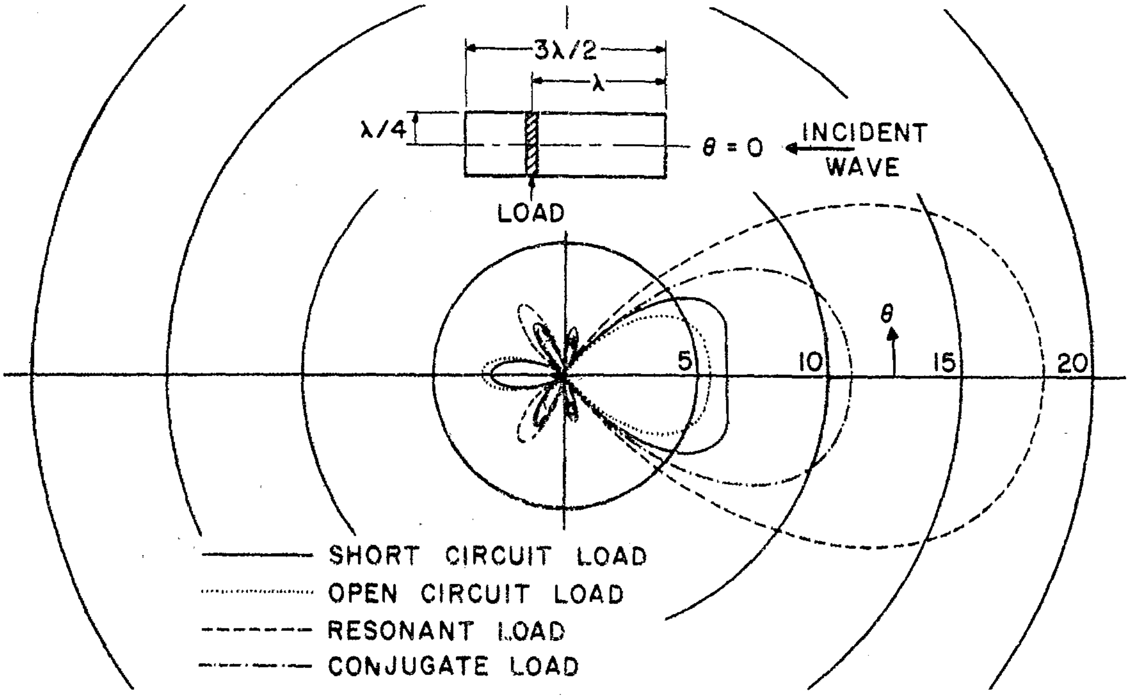
III. REPRESENTATIVE COMPUTATIONS

The graphs of this section illustrate some of the computations that we have made on loaded scatterers and antennas. The first three figures are bistatic radar cross section patterns for loaded conducting bodies, and the final two figures are power gain patterns for loaded aperture antennas. The computer programs and instructions for using them are given in the next two sections of this report. Included in the programs are printer plot routines, so that rough graphs of the computations are available immediately.

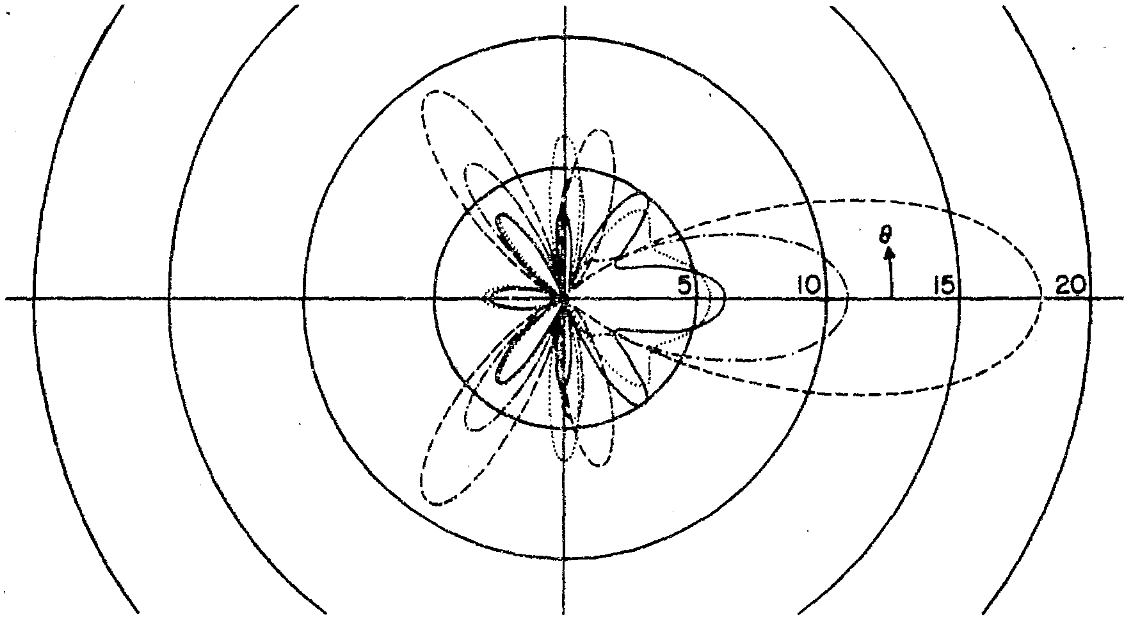
Figures 1 and 2 show bistatic radar cross section patterns (σ/λ^2) for a conducting cylinder (closed ends) of radius $\lambda/4$ and length $3\lambda/2$. It is loaded by a slot a distance λ from the $\theta = 0$ end, which is terminated to present the following loads to the $e^{\pm j\phi}$ modes of current: (a) short circuit load, (b) open circuit load, (c) resonant load ($Z_L = -j X_{in}$), and (d) conjugate load ($Z_L = Z_{in}^*$). Figure 1 is for a plane wave incident along the $\theta = 0$ axis, and Figure 2 is for a plane wave incident along the $\theta = \pi$ axis. In each case both the E-plane and H-plane radar cross section patterns are shown. In the E-plane, the scattered field is θ-polarized, and in the H-plane it is ϕ-polarized.

Figure 3 shows bistatic radar cross section patterns (σ/λ^2) for a conducting hemisphere (closed by a plane) of radius $\lambda/2$. It is loaded by a slot at the plane-to-sphere junction, which is terminated to present the same loads to the $e^{\pm j\phi}$ modes as in the preceeding case. Again both the E-plane (θ-polarized) and H-plane (ϕ-polarized) radar cross section patterns are shown.

Figure 4 shows power gain patterns for a conducting cylinder (closed ends) of radius $\lambda/4$ and length $3\lambda/2$, fed by a voltage V across a central slot. It is symmetrically loaded by two slots, $\lambda/4$ from the cylinder ends, terminated to present the following loads to the e^{j0} mode of current: (a) short circuit load, (b) open circuit load, (c) resonant load ($Z_L = -j X_{in}$), and (d) conjugate load ($Z_L = Z_{in}^*$). The patterns are normalized with respect to total power input, which includes the power dissipated in the loads in case (d). The radiation field is θ-polarized and rotationally symmetric.

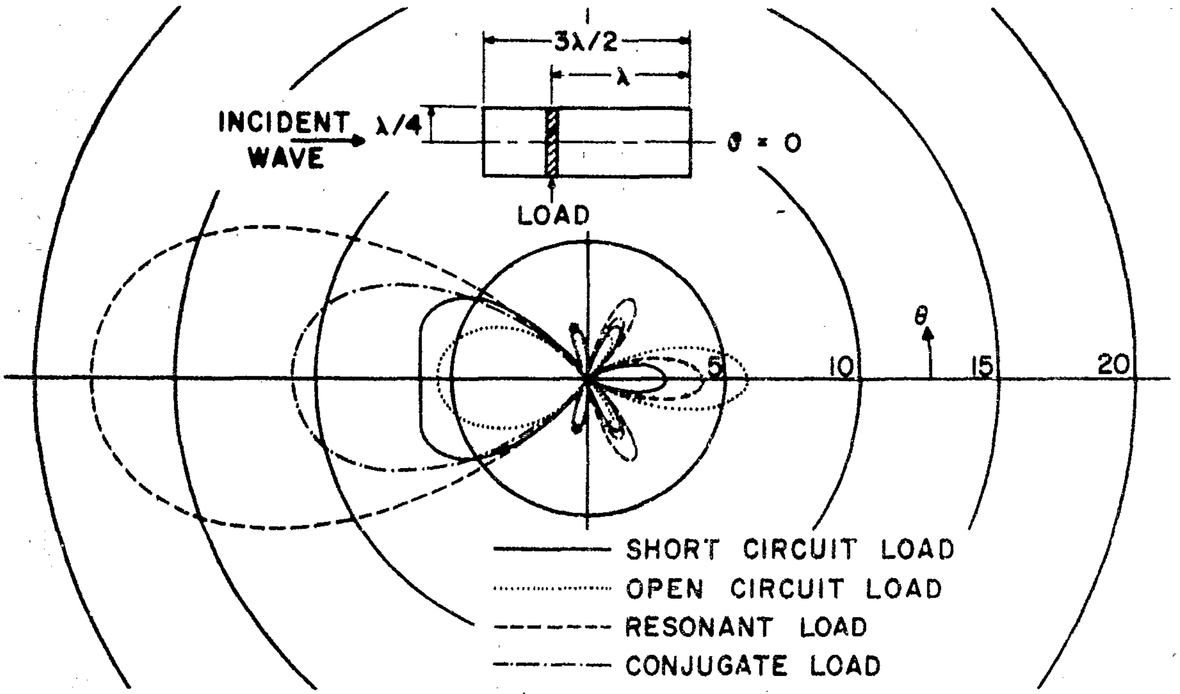


(a) H - PLANE PATTERN (σ_ϕ/λ^2)

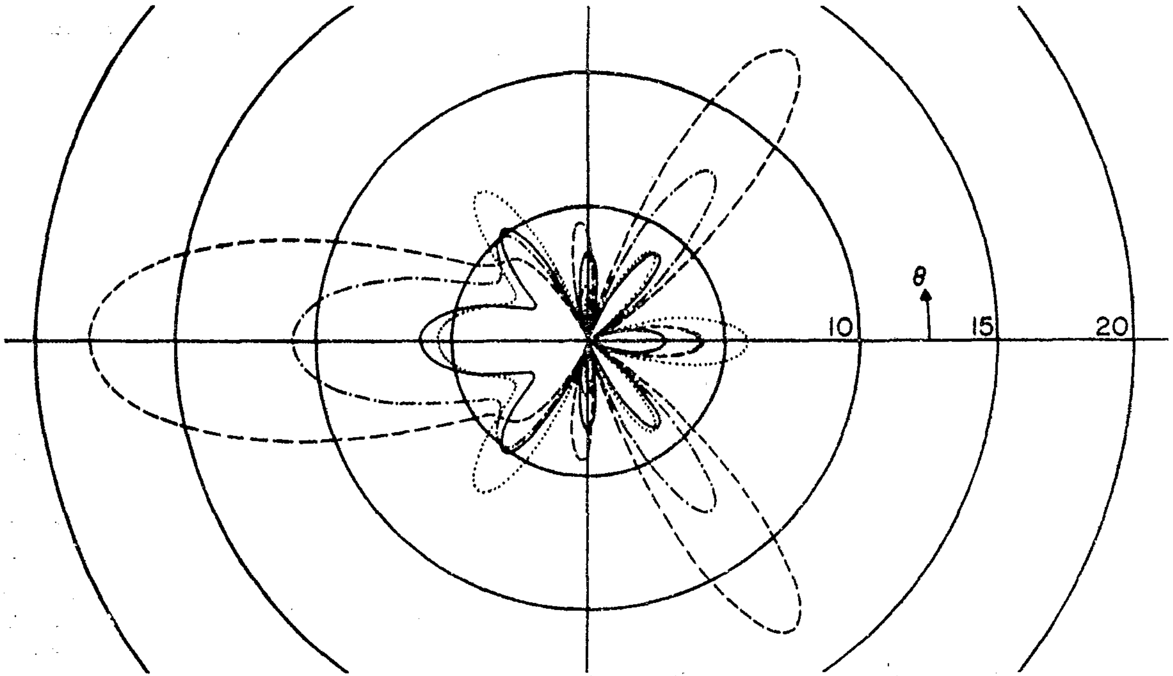


(b) E - PLANE PATTERN (σ_θ/λ^2)

Figure 1. Bistatic radar cross section for a solid conducting cylinder of radius $\lambda/4$, length $3\lambda/2$, loaded by a slot with various terminations. Wave incident along $\theta = 0$.

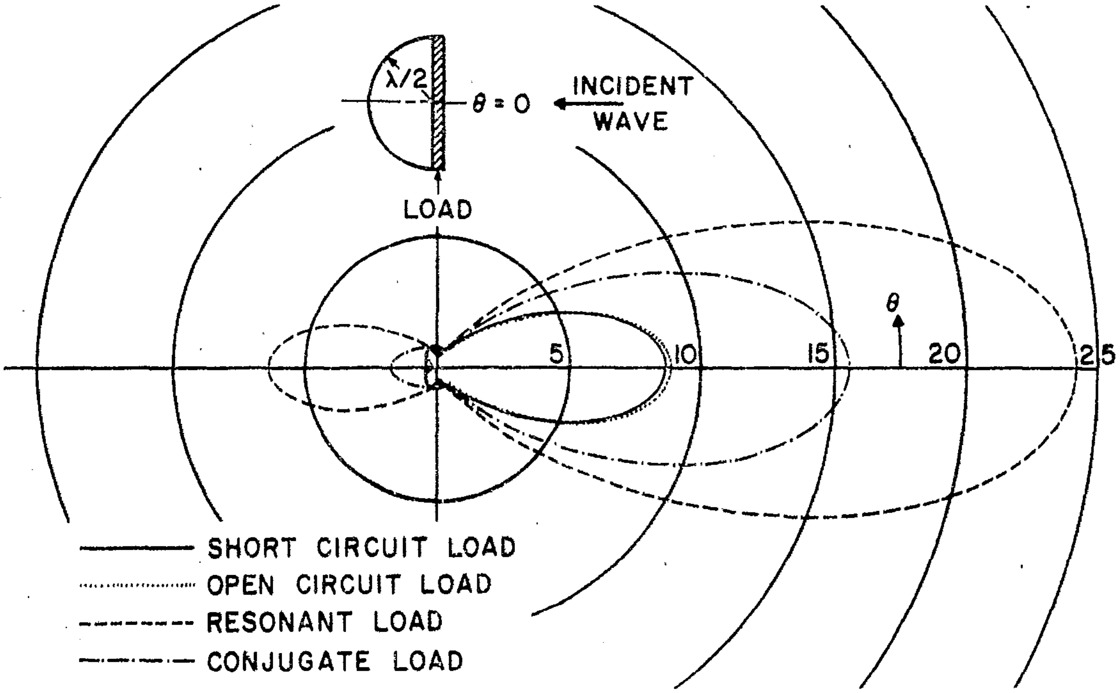


(a) H-PLANE PATTERN (σ_ϕ/λ^2)

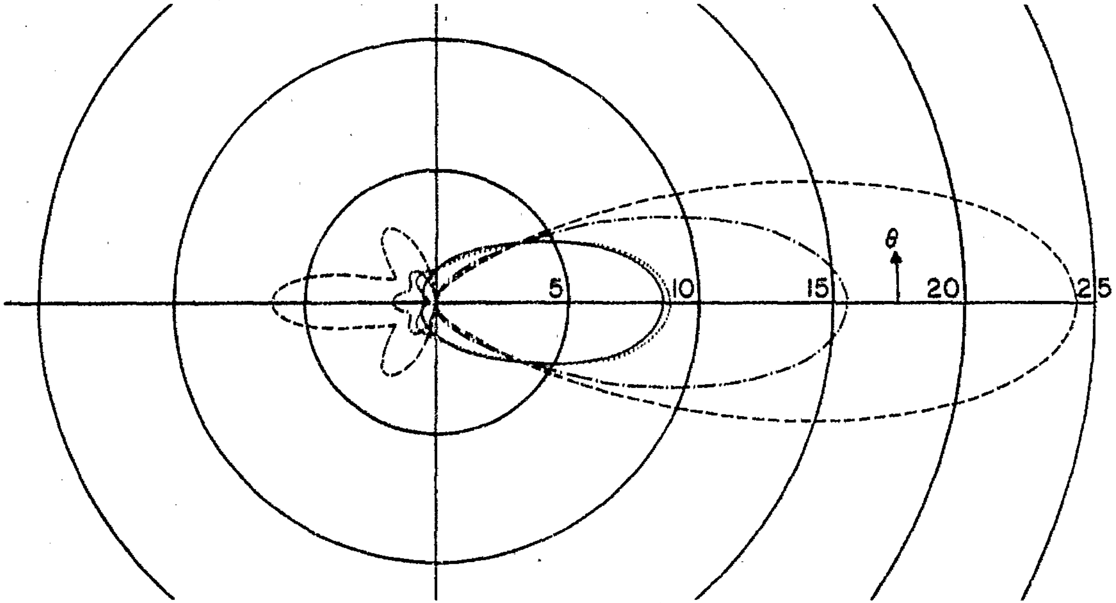


(b) E-PLANE PATTERN (σ_θ/λ^2)

Figure 2. Bistatic radar cross section for a solid conducting cylinder of radius $\lambda/4$, length $3\lambda/2$, loaded by a slot with various terminations. Wave incident along $\theta = \pi$.



(a) H-PLANE PATTERN (σ_ϕ/λ^2)



(b) E-PLANE PATTERN (σ_θ/λ^2)

Figure 3. Bistatic radar cross section for a conducting hemisphere of radius $\lambda/2$, loaded at the plane-to-sphere junction by a slot with various terminations. Wave incident along $\theta = 0$.

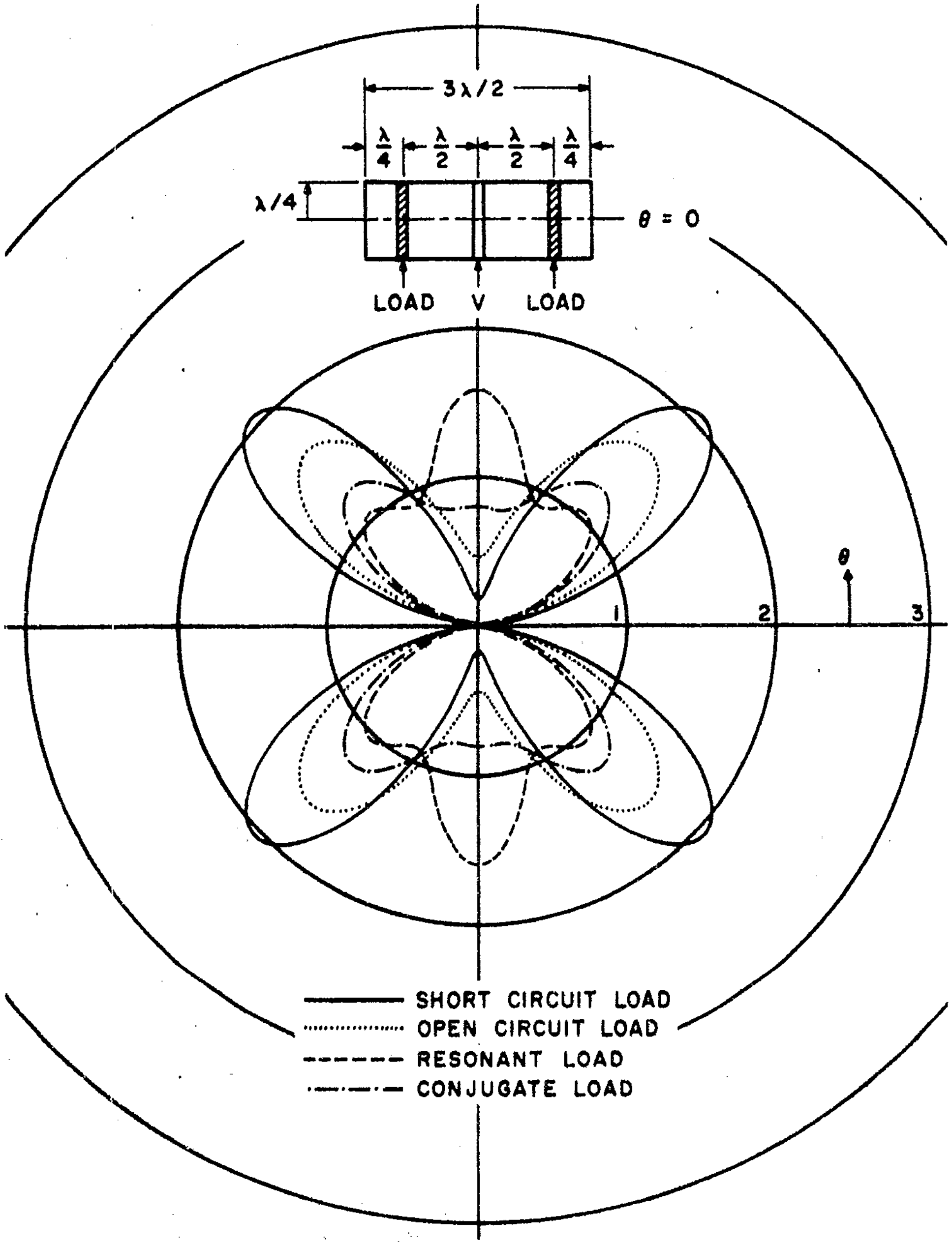


Figure 4. Power gain pattern for a solid conducting cylinder of radius λ/4, length 3λ/2, fed by a central slot, and symmetrically loaded by two slots with various terminations.

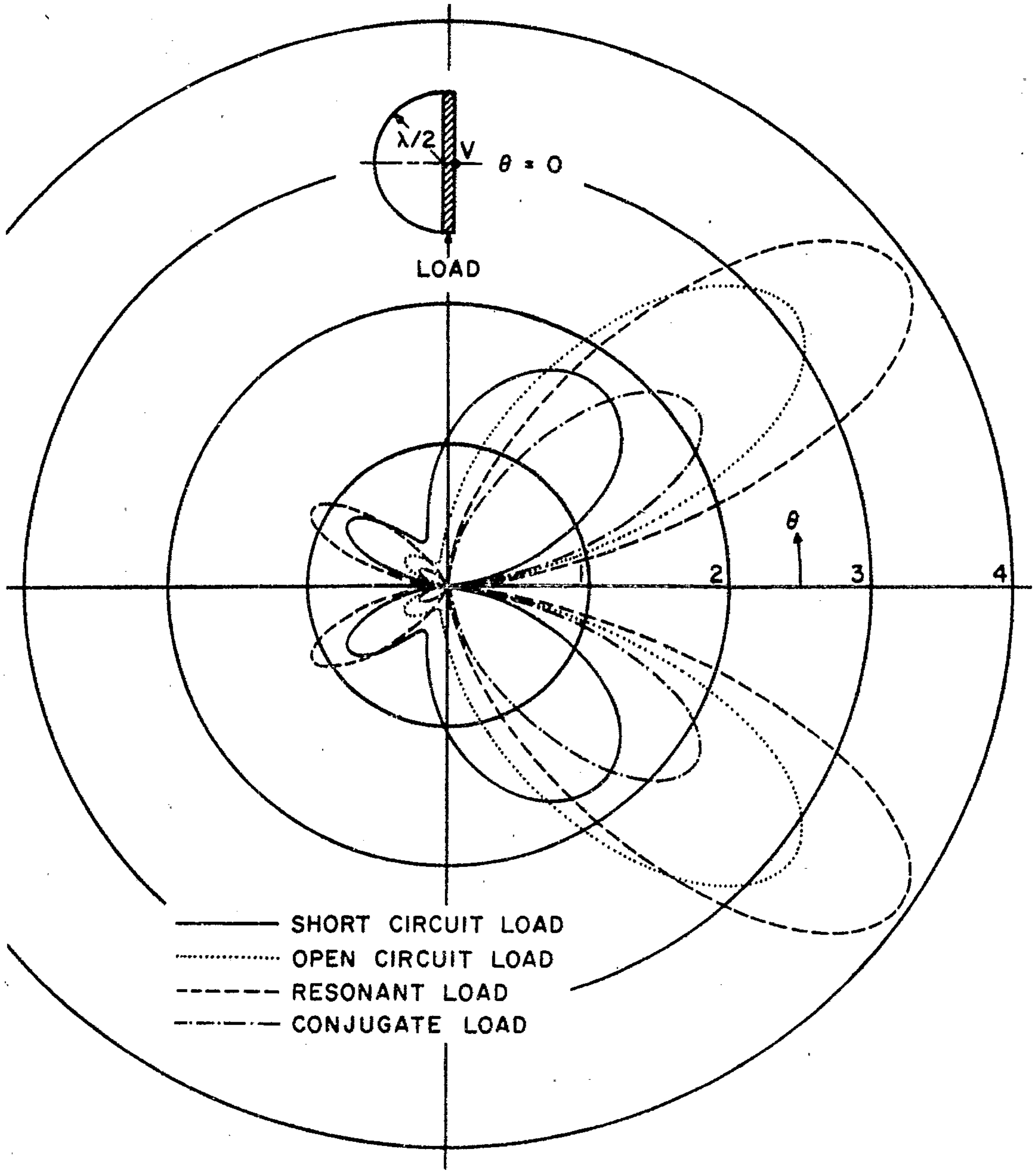


Figure 5. Power gain pattern for a conducting hemisphere of radius λ/2 fed by a small annular slot at the center of the flat end, and loaded at the plane-to-sphere junction by a slot with various loads.

Figure 5 shows power gain patterns for a conducting hemisphere (closed by a plane) of radius $\lambda/2$, fed by a small annular slot at the center of the plane surface. Because of the equivalence of a small annular slot to a perpendicular electric dipole, the patterns are also those for the hemisphere fed by a small axially-directed electric dipole at the center of the plane surface. The hemisphere is loaded by a slot at the plane-to-sphere junction, terminated to present the same loads to the e^{j0} mode as in the preceeding case. Again the patterns are normalized with respect to total power input, and the radiation field is θ-polarized and rotationally symmetric.

Additional examples of radiation and scattering from loaded bodies of revolution are given in a previous report.[2] These examples are (1) scattering from a cone-sphere with resonant loads at various positions along the body, and (2) radiation from a cone-sphere excited by a slot plus resonant loads at various positions along the body. The sample input-output data included in Section V of this report corresponds to two cases of these cone-sphere examples.

IV. PROGRAM INSTRUCTIONS

A) Plane wave scattering from a loaded body of revolution, axial incidence. This program computes the current on the body and the bistatic radar scattering, given arbitrary loads and axial plane wave excitation.

Punched card data is read early in the main program according to

```
50  READ (1,51,END=52) NN, NP, NT, L1, BK
51  FORMAT (4I3, E14.7)
    READ (1,53)(RH(I), I=1,NP)
    READ (1,53))ZH(I), I=1,NP)
53  FORMAT (10F8.4)
    DO 230 L3=1,L1
    READ (1,51) L2
    IF (L2.EQ.0) GOTO 230
    READ (1,231)(LP(J), J=1,L2)
```

```
231  FORMAT (10I3)
     READ (1,234)(ZL(J), J=1,L2)
234  FORMAT (7E11.4)
230  CONTINUE
```

For axial incidence, NN=1. An odd number NP of data points are taken from the generating curve of the body of revolution. The first and NPth points should be extremities of the generating curve. The receiver angles θ_r are given by

$$(\theta_r)_i = \frac{\pi(i-1)}{NT-1}$$

There are L1 load configurations. BK is the propagation constant $k = \omega\sqrt{\mu\epsilon}$. RH(I) and ZH(I) are respectively the distance ρ from the axis (z axis) of the body of revolution and the corresponding z coordinate at the Ith data point on the generating curve. RH(I) may be zero only when I = 1 or I = NP. If the generating curve closes upon itself, care must be taken to make the coordinates at I = 1 identical to those at I = NP. The index L3 of do loop 230 refers to the L3th load configuration.

Axially symmetric loads do not destroy the orthogonality with respect to $e^{jn\phi}$ functions. In particular, an $e^{j\phi}$ excitation still leads to an $e^{j\phi}$ response. Axially symmetric loading is expressed in terms of a matrix Z_L given by

$$[Z_L] = [\langle \underline{W}_L, \ \mathcal{Z}\,\underline{\mathcal{J}}_j \rangle]$$

where $\mathcal{Z}$ is the surface impedance (impedance per unit length) and

$$\underline{\mathcal{J}}_j = \underline{u}_t \frac{T_j(t)}{\rho} e^{j\phi} \qquad 1 \leq j \leq NM$$

$$\underline{\mathcal{J}}_j = \underline{u}_\phi \frac{T_{j-NM}(t)}{\rho} e^{j\phi} \qquad NM+1 \leq j \leq 2\cdot NM$$

$$\underline{W}_j = \underline{\mathcal{J}}_j^*$$

The functions $T_i(t)$ are defined in a previous report.[2] NM is either $\frac{NP-5}{2}$ or $\frac{NP-3}{2}$ depending upon whether or not the generating curve overlaps on itself. If the surface impedance $\mathcal{Z}$ is assumed to be concentrated at the peaks of the $T_i(t)$ functions, $[Z_L]$ becomes diagonal. The $LP(J)^{th}$ diagonal element of $[Z_L]$ is given by

$$ZL(J) = \frac{2\pi}{\rho_i} \int_{t_i-\Delta}^{t_i+\Delta} \mathcal{Z} \, dt$$

where

$$i = LP(J) \qquad 1 \leq LP(J) \leq NM$$

$$i = LP(J) - NM \qquad NM+1 \leq LP(J) \leq 2 \cdot NM$$

Here, ρ_i and t_i are respectively the cylindrical coordinate radius and t coordinate at the peak of the $T_i(t)$ function. The surface impedance $\mathcal{Z}$ is concentrated in the very narrow region $(t_i-\Delta \leq t \leq t_i+\Delta)$ about t_i. All diagonal elements of $[Z_L]$ not defined by ZL are zero. The definition of ZL implies that the $(I+NM)^{th}$ diagonal element of $[Z_L]$ is equal to the I^{th} diagonal element of $[Z_L]$, but this is really not necessary. For instance, it may be argued that the narrow strip $(t_i-\Delta \leq t \leq t_i+\Delta)$ of surface impedance will not appreciably affect the ϕ directed current because the ϕ directed current, flowing parallel to the strip, can easily avoid the strip.

If the number L2 of loads is zero, the data LP and ZL is skipped, and the unloaded body is considered. If one of the ZL's is originally zero, the program changes it to $.1 \times 10^{-20}$ to avoid a divide check. The absolute value of the corresponding diagonal element of the generalized impedance matrix [Z] is probably much more than $.1 \times 10^{-20}$. An open circuit (infinite impedance) can be obtained by making ZL much larger than the corresponding diagonal element of the impedance matrix Z.

The present program is similar to a previous program treating an unloaded body of revolution.[2] The loads are accounted for by adding $-[Y^{rc} + Y_L^{rc}]^{-1}[Y^r][V]$ to the impressed voltage [V].

Do loop 2 obtains the currents TI for the unloaded body. Do loop 232 puts the matrix $[Y^{rc} + Y_L^{rc}]$ in ZM. The subroutine LINEQ inverts ZM. Do loop 238 puts $[V_L^r]$ in E2. Do loop 240 adds $-[Y^c][V_L^r]$ to the current for the unloaded body.

If a load configuration with L2 > 10 loads is considered, then LP, ZL, and ZM must be redimensioned according to

```
COMPLEX   ZL(L2), ZM(L2*L2)
DIMENSION LP(L2).
```

B) Aperture radiation from a loaded body of revolution. This program computes the current on the body and the radiation field, given arbitrary loads and arbitrary rotationally symmetric aperture excitation.

Punched card data is read early in the main program according to

```
 50  READ (1,51,END=52) KK, NP, NT, L1, BK
 51  FORMAT (4I3, E14.7)
     READ (1,53)(RH(I), I=1, NP)
     READ (1,53)(ZH(I), I=1, NP)
 53  FORMAT (10F8.4)
     NM = (NP-1)/2
     IF ((RH(1)-RH(NP)). NE.0..OR.(ZH(1)-ZH(NP)).NE.0.) NM=NM-1
     IF (KK.EQ.2) GO TO 40
     READ (1,53)(E3(I), I=1, NM)
     IF (KK.EQ.1) TO TO 41
 40  J1 = NM+1
     NM2 = 2*NM
     READ (1,53)(E3(I), I=J1, NM2)
 41  DO 230 L3 = 1, L1
     READ (1,51) L2
     IF (L2.EQ.0) GO TO 230
     READ (1,231)(LP(J), J=1,L2)
231  FORMAT (10I3)
     READ (1,234)(ZL(J), J=1,L2)
234  FORMAT (7E11.4)
230  CONTINUE
```

The applied electric field is assumed to be impulsive at one or more peaks of the functions $T_i(t)$ defined in a previous report.[2] If KK=1, there is never any ϕ directed electric field E_ϕ. If KK=2, there is never any t directed electric field E_t. NP, NT, L1, BK, RH, ZH, L2, LP, and ZL have the same meaning as the variables of the same name appearing in the previous program dealing with plane wave scattering from a loaded body of revolution for axial incidence. The expansion functions will have constant (e^{j0}) dependence, but ZL(J) retains its meaning. E3(I) for $(1 \leq I \leq NM)$ is the driving voltage resulting from E_t at the peak of $T_I(t)$. E3(I) for $(NM+1 \leq I \leq 2*NM)$ is the driving voltage which would be obtained from the electric field $u_t\ E_\phi$ at the peak of $T_{I-NM}(t)$. Notice that E3(I) for $(NM+1 \leq I \leq 2*NM)$ is only a hypothetical voltage because E_ϕ is the component of the electric field in the ϕ direction while u_t is the unit vector in the t direction. NM is (NP-1)/2 or (NP-3)/2 depending on whether or not the generating curve overlaps on itself.

The present program is similar to a previous program treating an unloaded body of revolution.[2] The loads are accounted for by adding $-[Y^{rc} + Y_L]^{-1}\ [Y^r][V]$ to the impressed voltage $[V]$.

Do loop 232 obtains the currents TI for the unloaded body. Do loop 232 puts the matrix $[Y^{rc} + Y_L^{rc}]$ in ZM. The subroutine LINEQ inverts ZM. Do loop 238 puts $[V_L^r]$ in E2. Do loop 240 adds $-Y^cV_L^r$ to the current for the unloaded body. Just after exit from do loop 236, P1 will be the power supplied by the t directed aperture field and P2 the power supplied by the ϕ directed aperture field. For a resistively loaded body of revolution with a t directed aperture field, P1 is the total power radiated plus the power dissipated in the loads. Just after exit from do loop 246, P4 will the total power radiated by the t directed aperture field and P5 the total power radiated by the ϕ directed aperture field. The columns labeled $G\theta$ and $G\phi$ in the printed output are power gains. The two extra columns $D\theta$ and $D\phi$ are directive gains.

If a load configuration with L2 > 10 is considered, then LP, ZL, and ZM must be redimensioned according to

```
COMPLEX   ZL(L2), ZM(L2*L2)
DIMENSION LP(L2) .
```

V. COMPUTER PROGRAMS AND SAMPLE INPUT-OUTPUT DATA

A. Plane Wave Scattering

```
//             (0034,EE,4,2),'MAUTZ,JOE',MSGLEVEL=1
// EXEC FORTGCLG,PARM.FORT='MAP'
//FORT.SYSIN DD *
      SUBROUTINE LINEQ(LL,C)
      COMPLEX C(1),STOR,STO,ST,S
      DIMENSION LR(40)
      DO 20 I=1,LL
      LR(I)=I
   20 CONTINUE
      M1=0
      DO 18 M=1,LL
      K=M
      DO 2 I=M,LL
      K1=M1+I
      K2=M1+K
      IF(CABS(C(K1))-CABS(C(K2))) 2,2,6
    6 K=I
    2 CONTINUE
      LS=LR(M)
      LR(M)=LR(K)
      LR(K)=LS
      K2=M1+K
      STOR=C(K2)
      J1=0
      DO 7 J=1,LL
      K1=J1+K
      K2=J1+M
      STO=C(K1)
      C(K1)=C(K2)
      C(K2)=STO/STOR
      J1=J1+LL
    7 CONTINUE
      K1=M1+M
      C(K1)=1./STOR
      DO 11 I=1,LL
      IF(I-M) 12,11,12
   12 K1=M1+I
      ST=C(K1)
      C(K1)=0.
      J1=0
      DO 10 J=1,LL
      K1=J1+I
      K2=J1+M
      C(K1)=C(K1)-C(K2)*ST
      J1=J1+LL
   10 CONTINUE
   11 CONTINUE
      M1=M1+LL
   18 CONTINUE
      J1=0
      DO 9 J=1,LL
      IF(J-LR(J)) 14,8,14
   14 LRJ=LR(J)
      J2=(LRJ-1)*LL
   21 DO 13 I=1,LL
      K2=J2+I
      K1=J1+I
      S=C(K2)
      C(K2)=C(K1)
      C(K1)=S
```

```
 13 CONTINUE
    LR(J)=LR(LRJ)
    LR(LRJ)=LRJ
    IF(J-LR(J)) 14,8,14
  8 J1=J1+LL
  9 CONTINUE
    RETURN
    END
    SUBROUTINE PLANE(VVR,THR,NT)
    COMPLEX VVR(1),A5,A6,U
    COMMON U,R(42),ZS(42),SV(42),CV(42),BK,NP,NN,T(80),TR(80)
    DIMENSION BJ(126),THR(1),FK(20)
    KG=NP-1
    NM=KG/2-1
    M2=NN+2
    A5=2.*3.141593*U**(NN+1)
    NV=NM*4
    FK(1)=1.
    DO 153 J=1,M2
    J1=J+1
    FK(J1)=FK(J)*J
153 CONTINUE
    DO 156 L=1,NT
    L1=(L-1)*NV
    CS=COS(THR(L))
    SN=SIN(THR(L))
    BCS=BK*CS
    DO 302 J=1,KG
    X=R(J)*BK*SN
    J1=J
    I1=NN
    IF(I1) 303,304,303
304 I1=I1+1
    J1=J1+KG
303 DO 305 JJ=I1,M2
    IF(X-1.E-5) 1,1,2
  1 IF(JJ-1) 3,3,4
  3 BJ(J1)=1.
    GO TO 306
  4 BJ(J1)=0.
    GO TO 306
  2 RH=X/2.
    RH2=RH*RH
    RH3=RH**(JJ-1)
    BJ(J1)=RH3/FK(JJ)
    SS=BJ(J1)
  8 SST=SS*1.E-7
    DO 155 K=1,20
    SS=-SS*RH2/K/(K+JJ-1)
    BJ(J1)=BJ(J1)+SS
    IF(ABS(SS)-SST) 306,306,155
155 CONTINUE
    STOP 155
306 J1=J1+KG
305 CONTINUE
302 CONTINUE
    IF(NN) 307,308,307
308 DO 309 J=1,KG
    J1=J+2*KG
    BJ(J)=-BJ(J1)
```

```
  309 CONTINUE
  307 DO 300 J=1,NM
      J1=J+L1
      J2=J1+NM
      J3=J2+NM
      J4=J3+NM
      VVR(J1)=0.
      VVR(J2)=0.
      VVR(J3)=0.
      VVR(J4)=0.
      DO 301 I=1,4
      I1=2*(J-1)+I
      I4=4*(J-1)+I
      I2=I1+KG
      I3=I2+KG
      A6=(COS(ZS(I1)*BCS)+U*SIN(ZS(I1)*BCS))*A5
      BJ1=(BJ(I3)+BJ(I1))*.5
      BJ2=(BJ(I3)-BJ(I1))*.5
      VVR(J1)=VVR(J1)+A6*(CS*SV(I1)*BJ2+SN*CV(I1)*BJ(I2)*U)*T(I4)
      VVR(J2)=VVR(J2)+A6*CS*BJ1*U*TR(I4)
      VVR(J3)=VVR(J3)-A6*SV(I1)*BJ1*U*T(I4)
      VVR(J4)=VVR(J4)+A6*BJ2*TR(I4)
  301 CONTINUE
  300 CONTINUE
  156 CONTINUE
      RETURN
      END
      SUBROUTINE REORD(K1,K3,L)
      DIMENSION K1(1),K3(1)
      DO 81 J=1,L
      K8=K3(J)
      K6=J
      DO 82 I=J,L
      IF(K3(I)-K8) 82,82,84
   84 K8=K3(I)
      K6=I
   82 CONTINUE
      K3(K6)=K3(J)
      K3(J)=K8
      K8=K1(K6)
      K1(K6)=K1(J)
      K1(J)=K8
   81 CONTINUE
      K3(L+1)=-1
      RETURN
      END
      COMPLEX A3,Y(1600),VVR(5840),TI(40),E3(20),E1(73),E2(73),U
      COMPLEX ZL(10),ZM(100)
      COMMON U,R(42),ZS(42),SV(42),CV(42),BK,NP,NN,T(80),TR(80)
      DIMENSION RH(43),ZH(43),DH(42),TJ(20),INT(11),THR(73)
      DIMENSION AA(105),K1(73),K2(73),K3(74),K4(74)
      DIMENSION LP(10)
      DATA AA(1),AA(104),AA(105)/' ','X','O'/
      DO 107 I=1,102
  107 AA(I+1)=AA(I)
      U=(0.,1.)
      ETA=376.707
      ETA2=ETA*2.
      PI=3.141593
      PR=180./PI
```

```
      REWIND 6
   50 READ(1,51,END=52) NN,NP,NT,L1,BK
   51 FORMAT(4I3,E14.7)
      READ(1,53)(RH(I),I=1,NP)
      READ(1,53)(ZH(I),I=1,NP)
   53 FORMAT(10F8.4)
   76 WRITE(3,54) NN,NP,NT,L1,BK
   54 FORMAT(1X//' NN=',I3,' NP=',I3,' NT=',I3,' L1=',I3,' BK=',E14.7)
      WRITE(3,55)
   55 FORMAT(1X/' RH')
      WRITE(3,46)(RH(I),I=1,NP)
   46 FORMAT(1X,10F8.4)
      WRITE(3,56)
   56 FORMAT(1X/' ZH')
      WRITE(3,46)(ZH(I),I=1,NP)
      KL=1
  126 IF((RH(1)-RH(NP)).NE.0..OR.(ZH(1)-ZH(NP)).NE.0.) GO TO 58
      KL=0
      RH(NP+1)=RH(2)
      ZH(NP+1)=ZH(2)
      RH(NP+2)=RH(3)
      ZH(NP+2)=ZH(3)
      NP=NP+2
   58 DO 57 I=2,NP
      I2=I-1
      RR1=RH(I)-RH(I2)
      RR2=ZH(I)-ZH(I2)
      DH(I2)=SQRT(RR1*RR1+RR2*RR2)
      ZS(I2)=.5*(ZH(I)+ZH(I2))
      R(I2)=.5*(RH(I)+RH(I2))
      SV(I2)=RR1/DH(I2)
      CV(I2)=RR2/DH(I2)
   57 CONTINUE
      DT=PI/(NT-1)
      DO 1 J=1,NT
      THR(J)=DT*(J-1)
    1 CONTINUE
      NM=(NP-3)/2
      NM4=NM*4
      NM2=NM*2
      NZ=NM2*NM2
      DO 74 J=1,NM
      J2=2*(J-1)+1
      J3=J2+1
      J4=J3+1
      J5=J4+1
      J6=4*(J-1)+1
      J7=J6+1
      J8=J7+1
      J9=J8+1
      DEL1=DH(J2)+DH(J3)
      DEL2=DH(J4)+DH(J5)
      T(J6)=DH(J2)*DH(J2)/2./DEL1
      T(J7)=DH(J3)*(DH(J2)+DH(J3)/2.)/DEL1
      T(J8)=DH(J4)*(DH(J5)+DH(J4)/2.)/DEL2
      T(J9)=DH(J5)*DH(J5)/2./DEL2
   74 CONTINUE
      DO 75 J=1,NM4
      TR(J)=T(J)
   75 CONTINUE
```

```
  115 IF(KL.EQ.0) GO TO 78
      IF(RH(1)) 77,23,77
   77 DEL1=DH(1)+DH(2)
      TR(1)=DH(1)*(1.+(DH(2)+DH(1)/2.)/DEL1)
      TR(2)=DH(2)*(1.+DH(2)/2./DEL1)
   23 IF(RH(NP)) 79,78,79
   79 J1=(NM-1)*4+3
      J2=J1+1
      DEL2=DH(NP-2)+DH(NP-1)
      TR(J1)=DH(NP-2)*(1.+DH(NP-2)/2./DEL2)
      TR(J2)=DH(NP-1)*(1.+(DH(NP-2)+DH(NP-1)/2.)/DEL2)
   78 SS=0.
      DO 7 I=1,NM
      I1=2*(I-1)+1
      I2=I1+1
      SS=SS+DH(I1)+DH(I2)
      TJ(I)=SS
    7 CONTINUE
      DEL=TJ(NM)
      IF(KL.NE.0) DEL=DEL+DH(NP-2)+DH(NP-1)
      DEL=DEL/10.
      DO 8 J=1,NM
      TJ(J)=TJ(J)/DEL
    8 CONTINUE
   85 CALL PLANE(VVR,THR,NT)
  127 READ(6)(Y(I),I=1,NZ)
  150 DO 230 L3=1,L1
      READ(1,51) L2
      WRITE(3,243) L2
  243 FORMAT('0L2=',I3)
      IF(L2.EQ.0) GO TO 235
      READ(1,231)(LP(J),J=1,L2)
  231 FORMAT(10I3)
      READ(1,234)(ZL(J),J=1,L2)
  234 FORMAT(7E11.4)
      WRITE(3,244)(LP(J),J=1,L2)
  244 FORMAT('0LP',/(1X,10I3))
      WRITE(3,245)(ZL(J),J=1,L2)
  245 FORMAT('0ZL',/(1X,7E11.4))
  235 DO 108 INC=1,2
      J3=0
      IF(INC.EQ.1) J3=NM4*(NT-1)
      DO 2 J=1,NM2
      TI(J)=0.
      DO 3 I=1,NM
      J1=J+(I-1)*NM2
      J2=J1+NM*NM2
      I1=I+J3
      I2=I1+NM
      TI(J)=TI(J)-Y(J1)*VVR(I1)+Y(J2)*VVR(I2)
    3 CONTINUE
    2 CONTINUE
      IF(L2.EQ.0) GO TO 242
      DO 232 J=1,L2
      J1=(LP(J)-1)*NM2
      J5=(J-1)*L2
      DO 233 I=1,L2
      J2=J1+LP(I)
      J4=J5+I
      ZM(J4)=Y(J2)
```

```
233 CONTINUE
    J4=J5+J
    IF(CABS(ZL(J)).EQ.0.) ZL(J)=.1E-20
    ZM(J4)=ZM(J4)+1./ZL(J)
232 CONTINUE
    CALL LINEQ(L2,ZM)
    DO 238 J=1,L2
    E2(J)=0.
    DO 239 I=1,L2
    J1=(I-1)*L2+J
    J2=LP(I)
    E2(J)=E2(J)+ZM(J1)*TI(J2)
239 CONTINUE
238 CONTINUE
    DO 240 J=1,NM2
    DO 241 I=1,L2
    J2=(LP(I)-1)*NM2+J
    TI(J)=TI(J)-E2(I)*Y(J2)
241 CONTINUE
240 CONTINUE
242 DO 9 J=1,NT
    E1(J)=0.
    E2(J)=0.
    J1=(J-1)*NM4
    DO 10 I=1,NM2
    I1=J1+I
    I2=I1+NM2
    E1(J)=E1(J)+VVR(I1)*TI(I)
    E2(J)=E2(J)+VVR(I2)*TI(I)
 10 CONTINUE
  9 CONTINUE
    J5=(2-INC)*(NT-1)+1
    A3=CABS(E1(J5))/E1(J5)*(BK*BK*ETA/2./PI/SQRT(PI))
    DO 11 J=1,NT
    E1(J)=E1(J)*A3
    E2(J)=E2(J)*U*A3
 11 CONTINUE
    WRITE(3,110)
110 FORMAT('1',2X,'T',4X,'REAL JT',1X,'IMAG JT',2X,'MAG JT',1X,'REAL J
   1O',1X,'IMAG JO',2X,'MAG JO')
    WRITE(3,109)
109 FORMAT('+',37X,'/',7X,'/',7X,'/')
    DO 128 J=1,NM
    J1=J+NM
    J2=2*(J-1)+3
    TI(J)=TI(J)*ETA2/RH(J2)
    E3(J)=TI(J1)*U*ETA2/RH(J2)
128 CONTINUE
    DO 129 J=1,NM
    J1=J+NM
    J3=J-1
    J5=J+1
    IF(J.NE.1.AND.J.NE.NM) GO TO 125
    J3=J
    J5=J
    IF(KL.EQ.1) GO TO 125
    J3=NM
    J5=J+1
    IF(J.EQ.1) GO TO 125
    J3=J-1
```

```
      J5=1
  125 TI(J1)=.25*(E3(J3)+2.*E3(J)+E3(J5))
  129 CONTINUE
      DO 4 J=1,NM
      J1=J+NM
      X2=REAL(TI(J))
      X3=AIMAG(TI(J))
      X4=CABS(TI(J))
      X5=REAL(TI(J1))
      X6=AIMAG(TI(J1))
      X7=CABS(TI(J1))
      WRITE(3,124) TJ(J),X2,X3,X4,X5,X6,X7
  124 FORMAT(1X,F5.2,6F8.3)
    4 CONTINUE
      WRITE(3,112)
  112 FORMAT('1','  0',4X,'SIG XO',2X,'SIG XO',2X,'MAG SXO',1X,'ANG SXO'
     1,1X,'MAG SXO',1X,'ANG SXO',1X,'LSIG XO',1X,'LSIG XO')
      WRITE(3,113)
  113 FORMAT('+',2X,'-',9X,'-',7X,'/',8X,'-',7X,'-',7X,'/',7X,'/',7X,'-'
     1,7X,'/')
      DO 12 J=1,NT
      X1=THR(J)*PR
      X4=CABS(E1(J))
      X6=CABS(E2(J))
      X2=X4*X4
      X3=X6*X6
      X5=PR*ATAN2(AIMAG(E1(J)),REAL(E1(J)))
      X7=PR*ATAN2(AIMAG(E2(J)),REAL(E2(J)))
      X8=ALOG10(X2)
      X9=ALOG10(X3)
      WRITE(3,111) X1,X2,X3,X4,X5,X6,X7,X8,X9
  111 FORMAT(1X,F5.1,3F8.3,F8.1,F8.3,F8.1,2F8.3)
   12 CONTINUE
      DO 13 J=1,NM
      K1(J)=TJ(J)*10.+3.5
      K2(J)=K1(J)
      K3(J)=CABS(TI(J))*10.+.5
      J1=J+NM
      K4(J)=CABS(TI(J1))*10.+.5
   13 CONTINUE
   14 CALL REORD(K1,K3,NM)
   15 CALL REORD(K2,K4,NM)
      DO 104 J=1,11
      INT(J)=J-1
  104 CONTINUE
      K=5
      K5=1
      K6=1
      WRITE(3,106)
  106 FORMAT('1')
      DO 20 J=1,51
      J1=51-J
      WRITE(3,25)
   25 FORMAT('     |',99X,'|')
      IF((J-1)/5*5-(J-1))21,22,21
   22 WRITE(3,123)
  123 FORMAT('+',3X,'--',97X,'--')
      IF((J-1)/10*10-(J-1)) 21,122,21
  122 WRITE(3,24) K
   24 FORMAT('+',I2)
```

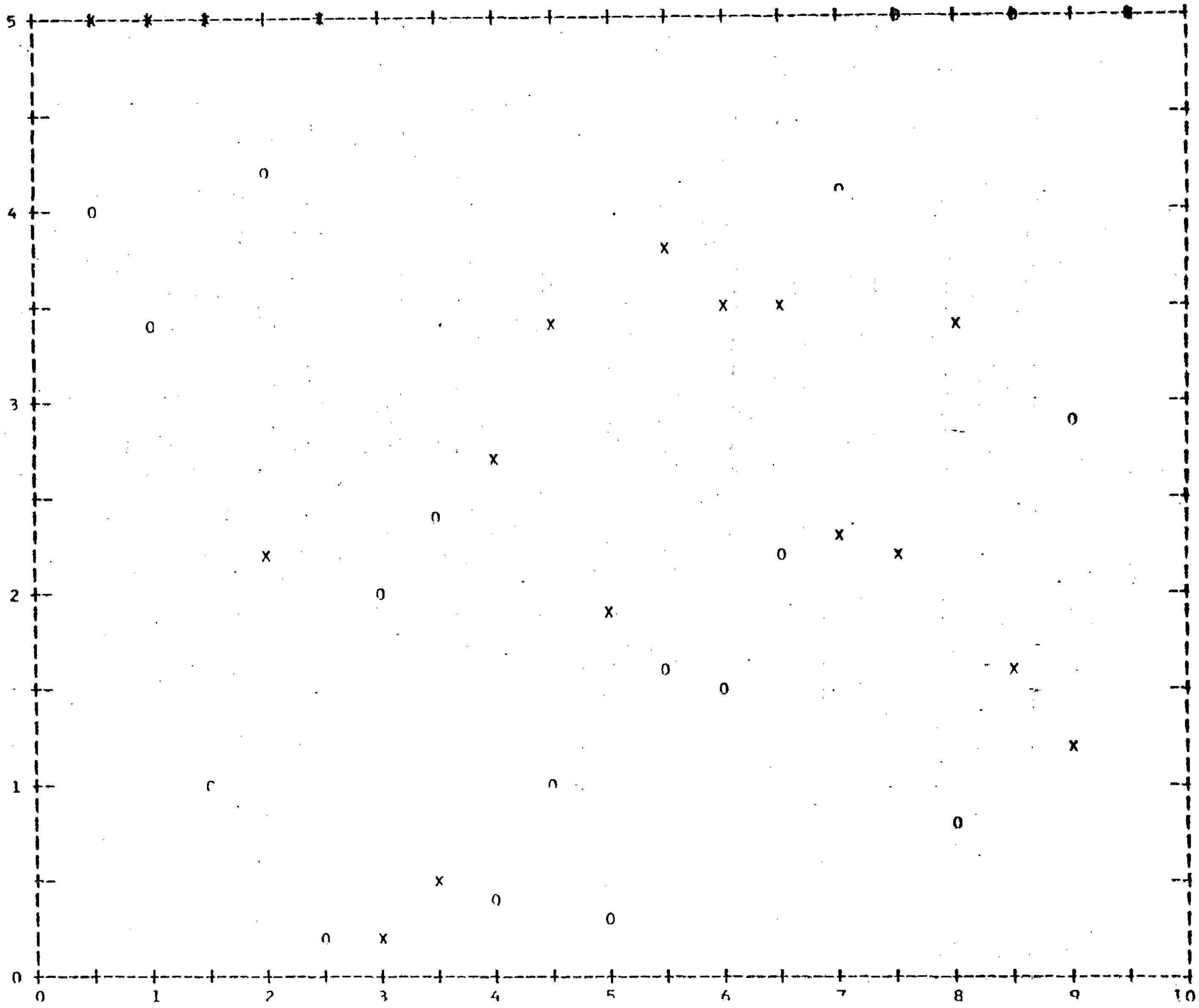
```
      K=K-1
      IF(J.NE.1) GO TO 21
      WRITE(3,116)
  116 FORMAT('+',4X,50('--'))
      WRITE(3,47)
   47 FORMAT('+',8X,19('|',4X))
   21 IF(K3(K5).LT.J1) GO TO 26
   60 K8=K1(K5)
      WRITE(3,48)(AA(I),I=1,K8),AA(104)
   48 FORMAT('+',105A1)
      K5=K5+1
      IF(K3(K5).GE.J1) GO TO 60
   26 IF(K4(K6).LT.J1) GO TO 20
   61 K8=K2(K6)
      WRITE(3,48)(AA(I),I=1,K8),AA(105)
      K6=K6+1
      IF(K4(K6).GE.J1) GO TO 61
   20 CONTINUE
      WRITE(3,47)
      WRITE(3,116)
      WRITE(3,63)(INT(J),J=1,11)
   63 FORMAT(3X,11(I2,8X))
      WRITE(3,64)
   64 FORMAT('0',20X,'X X X  PLOT OF MAGNITUDE OF T DIRECTED CURRENT VER
     1SUS LENGTH T')
      WRITE(3,65)
   65 FORMAT(21X,'O O O  PLOT OF MAGNITUDE OF O DIRECTED CURRENT VERSUS
     1LENGTH T')
      WRITE(3,66)
   66 FORMAT('+',48X,'/')
      DO 80 J=1,NT
      K1(J)=THR(J)*72./PI+8.5
      K2(J)=K1(J)
      K3(J)=20.*ALOG10(CABS(E1(J)))+20.5
      K4(J)=20.*ALOG10(CABS(E2(J)))+20.5
   80 CONTINUE
   16 CALL REORD(K1,K3,NT)
   17 CALL REORD(K2,K4,NT)
      DO 105 J=1,5
      INT(J)=(J-1)*45
  105 CONTINUE
      X1=1000.
      K5=1
      K6=1
      WRITE(3,106)
      DO 87 J=1,51
      J1=51-J
      WRITE(3,88)
   88 FORMAT(9X,'|',71X,'|')
      IF((J-1)/10*10-(J-1))92,90,92
   90 WRITE(3,91) X1
   91 FORMAT('+',F7.2,' --',69X,'--')
      X1=X1/10.
      IF(J.NE.1) GO TO 92
      WRITE(3,93)
   93 FORMAT('+',17X,7('|',8X))
      WRITE(3,97)
   97 FORMAT('+',8X,73('-'))
   92 IF(K3(K5).LT.J1) GO TO 94
   95 K8=K1(K5)
```

```
      WRITE(3,48)(AA(I),I=1,K8),AA(104)
      K5=K5+1
      IF(K3(K5).GE.J1) GO TO 95
   94 IF(K4(K6).LT.J1) GO TO 87
   96 K8=K2(K6)
      WRITE(3,48)(AA(I),I=1,K8),AA(105)
      K6=K6+1
      IF(K4(K6).GE.J1) GO TO 96
   87 CONTINUE
      WRITE(3,93)
      WRITE(3,97)
      WRITE(3,98)(INT(J),J=1,5)
   98 FORMAT(7X,3(I3,15X),I4,15X,I3)
      WRITE(3,99)
   99 FORMAT('0',15X,'X X X  PLOT OF SIGMA XO OVER LAMBDA SQUARED VERSUS
     1 THETA')
      WRITE(3,101)
  101 FORMAT('+',37X,'-')
      WRITE(3,100)
  100 FORMAT(16X,'0 0 0  PLOT OF SIGMA XO OVER LAMBDA SQUARED VERSUS THE
     1TA')
      WRITE(3,102)
  102 FORMAT('+',37X,'/')
      WRITE(3,106)
  108 CONTINUE
  230 CONTINUE
      GO TO 50
   52 STOP
      END
/*
//GO.FT06F001 DD DSNAME=EE0034.REV1,DISP=OLD,UNIT=2314,                 X
//             VOLUME=SER=SU0004,DCB=(RECFM=V,BLKSIZE=1800,LRECL=1796)
//GO.SYSIN DD *
001041073001 0.4659995E+00
  0.0       0.0868  0.1736  0.2605  0.3473  0.4341  0.5209  0.6078  0.6946  0.7814
  0.8682  0.9551  1.0419  1.1287  1.2155  1.3024  1.3892  1.4760  1.5628  1.6497
  1.7365  1.8233  1.9101  1.9970  2.0838  2.1706  2.2574  2.3442  2.4311  2.5179
  2.6047  2.6837  2.6863  2.5969  2.4184  2.1570  1.8216  1.4238  0.9772  0.4971
 -0.0000
  0.0       0.4924  0.9848  1.4772  1.9696  2.4620  2.9544  3.4468  3.9392  4.4316
  4.9240  5.4164  5.9088  6.4013  6.8937  7.3861  7.8785  8.3709  8.8633  9.3557
  9.8481 10.3405 10.8329 11.3253 11.8177 12.3101 12.8025 13.2949 13.7873 14.2797
 14.7721 15.2657 15.7650 16.2562 16.7225 17.1478 17.5177 17.8195 18.0427 18.1798
 18.2260
001
016
 0.0000E+00 0.3131E+04
/*
```

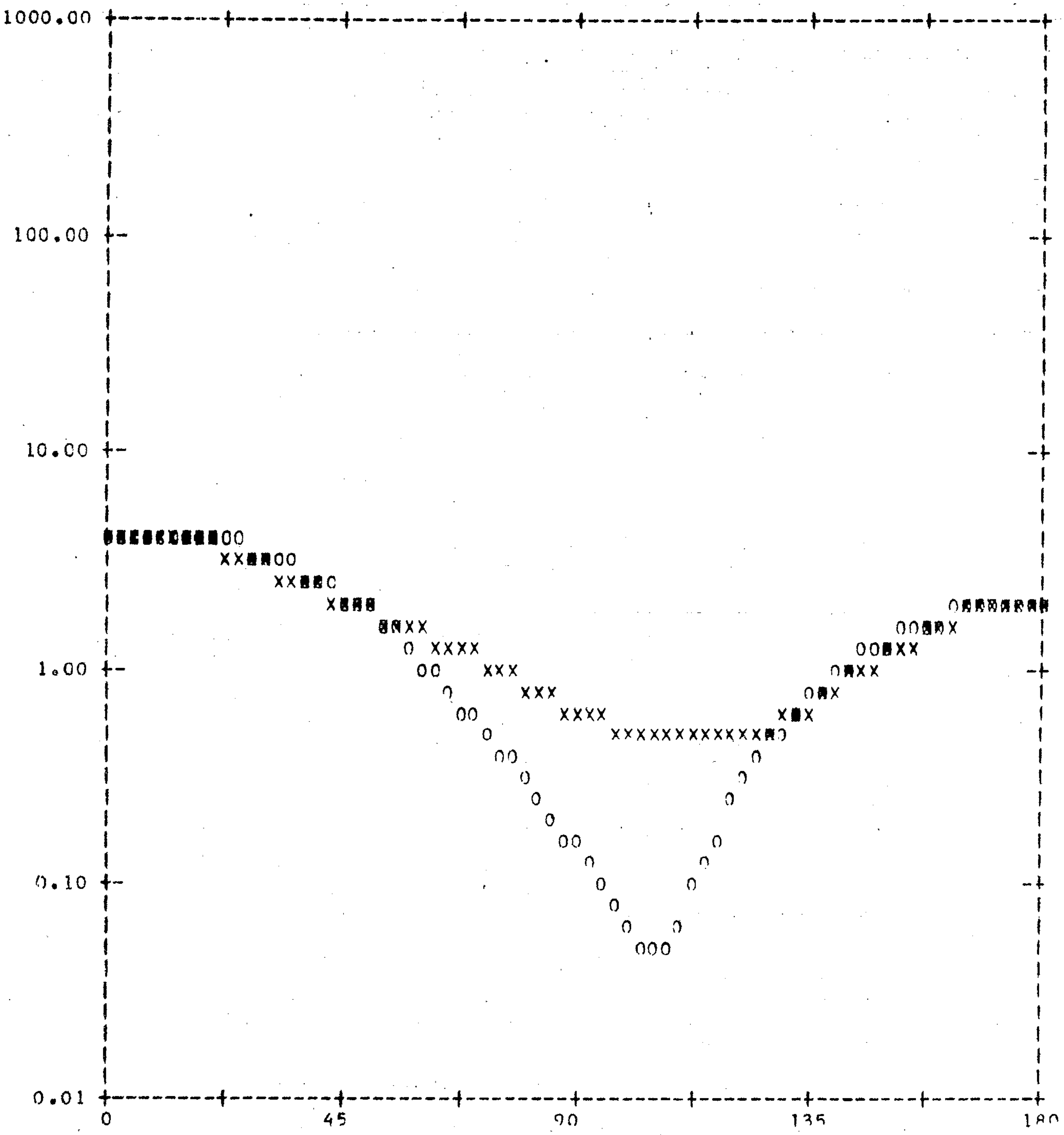
```
NN=  1 NP= 41 NT= 73 L1=  1 BK= 0.4659995E 00

RH
  0.0     0.0868  0.1736  0.2605  0.3473  0.4341  0.5209  0.6078  0.6946  0.7814
  0.8682  0.9551  1.0419  1.1287  1.2155  1.3024  1.3892  1.4760  1.5628  1.6497
  1.7365  1.8233  1.9101  1.9970  2.0838  2.1706  2.2574  2.3442  2.4311  2.5179
  2.6047  2.6837  2.6863  2.5969  2.4184  2.1570  1.8216  1.4238  0.9772  0.4971
  0.0

ZH
  0.0     0.4924  0.9848  1.4772  1.9696  2.4620  2.9544  3.4468  3.9392  4.4316
  4.9240  5.4164  5.9088  6.4013  6.8937  7.3861  7.8785  8.3709  8.8633  9.3557
  9.8481 10.3405 10.8329 11.3253 11.8177 12.3101 12.8025 13.2949 13.7873 14.2797
 14.7721 15.2657 15.7650 16.2562 16.7225 17.1478 17.5177 17.8195 18.0427 18.1799
 18.2260

L2=  1

LP
 16

ZL
 0.0        0.3131E 04




  T     REAL  JT  IMAG  JT   MAG  JT  REAL  J0  IMAG  J0   MAG  J0
 0.50  -18.670  -18.799   26.495    2.828    2.814    3.990
 1.00   -2.844   -4.733    5.521   -2.644   -2.062    3.353
 1.50    6.486    3.534    7.386   -0.872   -0.379    0.951
 2.00   -0.112   -2.214    2.216    2.985    3.022    4.248
 2.50   -5.223   -5.987    7.945    0.004    0.162    0.162
 3.00    0.120   -0.153    0.194   -1.578   -1.277    2.030
 3.50   -0.444    0.155    0.470    1.753    1.698    2.441
 4.00   -2.526   -0.939    2.695   -0.325   -0.241    0.404
 4.50    1.402    3.059    3.365   -0.782   -0.553    0.957
 5.00    0.108    1.916    1.919    0.107    0.325    0.342
 5.50    1.860    3.288    3.778   -1.379   -0.902    1.648
 6.00    2.027    2.914    3.550   -1.280   -0.695    1.457
 6.50    2.288    2.624    3.482   -1.873   -1.158    2.202
 7.00    1.705    1.591    2.332   -3.328   -2.466    4.142
 7.50    1.717    1.419    2.227   -6.828   -5.751    8.827
 8.00   -2.453   -2.340    3.391   -0.741    0.136    0.753
 8.50    0.746    1.443    1.625    5.765    6.550    8.726
 9.00   -0.747    0.918    1.183    1.134    2.664    2.895
 9.50    2.674    4.855    5.543    2.371    4.640    5.211
```

θ	SIG Xθ	SIG XØ	MAG SXθ	ANG SXθ	MAG SXØ	ANG SXØ	LSIG Xθ	LSIG XØ
0.0	4.409	4.409	2.100	116.8	2.100	-63.2	0.644	0.644
2.5	4.396	4.401	2.097	116.4	2.098	-63.6	0.643	0.644
5.0	4.355	4.378	2.087	115.1	2.092	-64.7	0.639	0.641
7.5	4.289	4.340	2.071	113.0	2.083	-66.6	0.632	0.637
10.0	4.198	4.286	2.049	110.0	2.070	-69.2	0.623	0.632
12.5	4.086	4.218	2.021	106.2	2.054	-72.5	0.611	0.625
15.0	3.954	4.135	1.989	101.6	2.033	-76.6	0.597	0.616
17.5	3.807	4.037	1.951	96.2	2.009	-81.3	0.581	0.606
20.0	3.646	3.926	1.910	89.9	1.981	-86.8	0.567	0.594
22.5	3.477	3.802	1.865	82.8	1.950	-92.9	0.541	0.580
25.0	3.302	3.664	1.817	74.9	1.914	-99.7	0.519	0.564
27.5	3.126	3.515	1.768	66.2	1.875	-107.2	0.495	0.546
30.0	2.950	3.354	1.718	56.8	1.831	-115.3	0.470	0.526
32.5	2.779	3.183	1.667	46.7	1.784	-124.0	0.444	0.503
35.0	2.615	3.003	1.617	35.8	1.733	-133.4	0.417	0.478
37.5	2.459	2.816	1.568	24.2	1.678	-143.3	0.391	0.450
40.0	2.312	2.623	1.521	12.1	1.619	-153.8	0.364	0.419
42.5	2.176	2.425	1.475	-0.7	1.557	-164.9	0.338	0.385
45.0	2.049	2.225	1.432	-13.9	1.492	-176.5	0.312	0.347
47.5	1.933	2.026	1.390	-27.6	1.423	171.3	0.286	0.307
50.0	1.825	1.829	1.351	-41.7	1.352	158.6	0.261	0.262
52.5	1.724	1.637	1.313	-56.1	1.279	145.4	0.237	0.214
55.0	1.630	1.452	1.277	-70.8	1.205	131.6	0.212	0.162
57.5	1.541	1.277	1.241	-85.7	1.130	117.3	0.188	0.106
60.0	1.455	1.113	1.206	-100.8	1.055	102.5	0.163	0.047
62.5	1.371	0.963	1.171	-116.0	0.981	87.2	0.137	-0.017
65.0	1.290	0.826	1.136	-131.3	0.909	71.3	0.111	-0.083
67.5	1.211	0.704	1.100	-146.7	0.839	55.0	0.083	-0.152
70.0	1.133	0.597	1.065	-162.1	0.773	38.2	0.054	-0.224
72.5	1.058	0.505	1.029	-177.5	0.711	21.0	0.025	-0.297
75.0	0.986	0.426	0.993	167.0	0.653	3.5	-0.005	-0.371
77.5	0.917	0.359	0.958	151.5	0.599	-14.2	-0.037	-0.445
80.0	0.853	0.302	0.924	136.1	0.550	-32.0	-0.069	-0.520
82.5	0.794	0.254	0.891	120.6	0.504	-49.6	-0.100	-0.595
85.0	0.740	0.213	0.860	105.0	0.462	-66.9	-0.131	-0.672
87.5	0.691	0.177	0.831	89.4	0.421	-83.6	-0.160	-0.751
90.0	0.649	0.146	0.805	73.8	0.382	-99.3	-0.188	-0.836
92.5	0.612	0.118	0.782	58.1	0.344	-113.8	-0.213	-0.927
95.0	0.581	0.094	0.762	42.2	0.307	-126.6	-0.236	-1.025
97.5	0.555	0.074	0.745	26.3	0.273	-136.9	-0.256	-1.128
100.0	0.533	0.059	0.730	10.2	0.243	-144.2	-0.273	-1.228
102.5	0.516	0.050	0.718	-6.1	0.223	-147.8	-0.287	-1.304
105.0	0.503	0.047	0.709	-22.5	0.217	-148.5	-0.298	-1.327
107.5	0.494	0.053	0.703	-39.1	0.230	-148.4	-0.307	-1.278
110.0	0.488	0.068	0.698	-55.9	0.260	-150.1	-0.312	-1.170
112.5	0.485	0.093	0.696	-72.8	0.305	-154.8	-0.314	-1.033
115.0	0.486	0.129	0.697	-89.8	0.359	-161.9	-0.313	-0.891
117.5	0.491	0.175	0.701	-106.9	0.419	-170.9	-0.309	-0.756
120.0	0.500	0.233	0.707	-124.0	0.482	179.0	-0.301	-0.633
122.5	0.514	0.300	0.717	-141.0	0.548	168.1	-0.289	-0.523
125.0	0.535	0.377	0.731	-157.9	0.614	156.9	-0.272	-0.424
127.5	0.562	0.462	0.750	-174.6	0.680	145.4	-0.259	-0.335
130.0	0.597	0.554	0.772	169.1	0.745	134.0	-0.224	-0.256
132.5	0.640	0.652	0.800	153.2	0.808	122.6	-0.194	-0.185
135.0	0.692	0.755	0.832	137.9	0.869	111.5	-0.160	-0.122
137.5	0.754	0.861	0.869	123.2	0.928	100.7	-0.122	-0.065
140.0	0.826	0.969	0.909	109.2	0.984	90.1	-0.083	-0.014
142.5	0.906	1.077	0.952	96.1	1.038	80.0	-0.043	0.032
145.0	0.995	1.185	0.998	83.7	1.088	70.4	-0.002	0.074
147.5	1.092	1.291	1.045	72.1	1.136	61.2	0.038	0.111

150.0	1.194	1.395	1.073	61.4	1.181	52.6	0.077	0.144
152.5	1.301	1.495	1.140	51.6	1.223	44.5	0.114	0.175
155.0	1.409	1.590	1.187	42.6	1.261	37.0	0.149	0.201
157.5	1.517	1.679	1.232	34.5	1.296	30.1	0.181	0.225
160.0	1.622	1.762	1.274	27.3	1.328	23.9	0.210	0.246
162.5	1.723	1.838	1.313	20.9	1.356	18.4	0.235	0.264
165.0	1.815	1.906	1.347	15.3	1.380	13.6	0.257	0.280
167.5	1.898	1.964	1.378	10.6	1.401	9.5	0.278	0.293
170.0	1.969	2.013	1.403	6.8	1.419	6.1	0.294	0.304
172.5	2.026	2.051	1.423	3.9	1.432	3.4	0.307	0.312
175.0	2.068	2.079	1.438	1.7	1.442	1.5	0.316	0.319
177.5	2.093	2.096	1.447	0.4	1.448	0.4	0.321	0.321
180.0	2.102	2.102	1.450	-0.0	1.450	-0.0	0.323	0.323



X X X PLOT OF MAGNITUDE OF T DIRECTED CURRENT VERSUS LENGTH T
O O O PLOT OF MAGNITUDE OF Ø DIRECTED CURRENT VERSUS LENGTH T

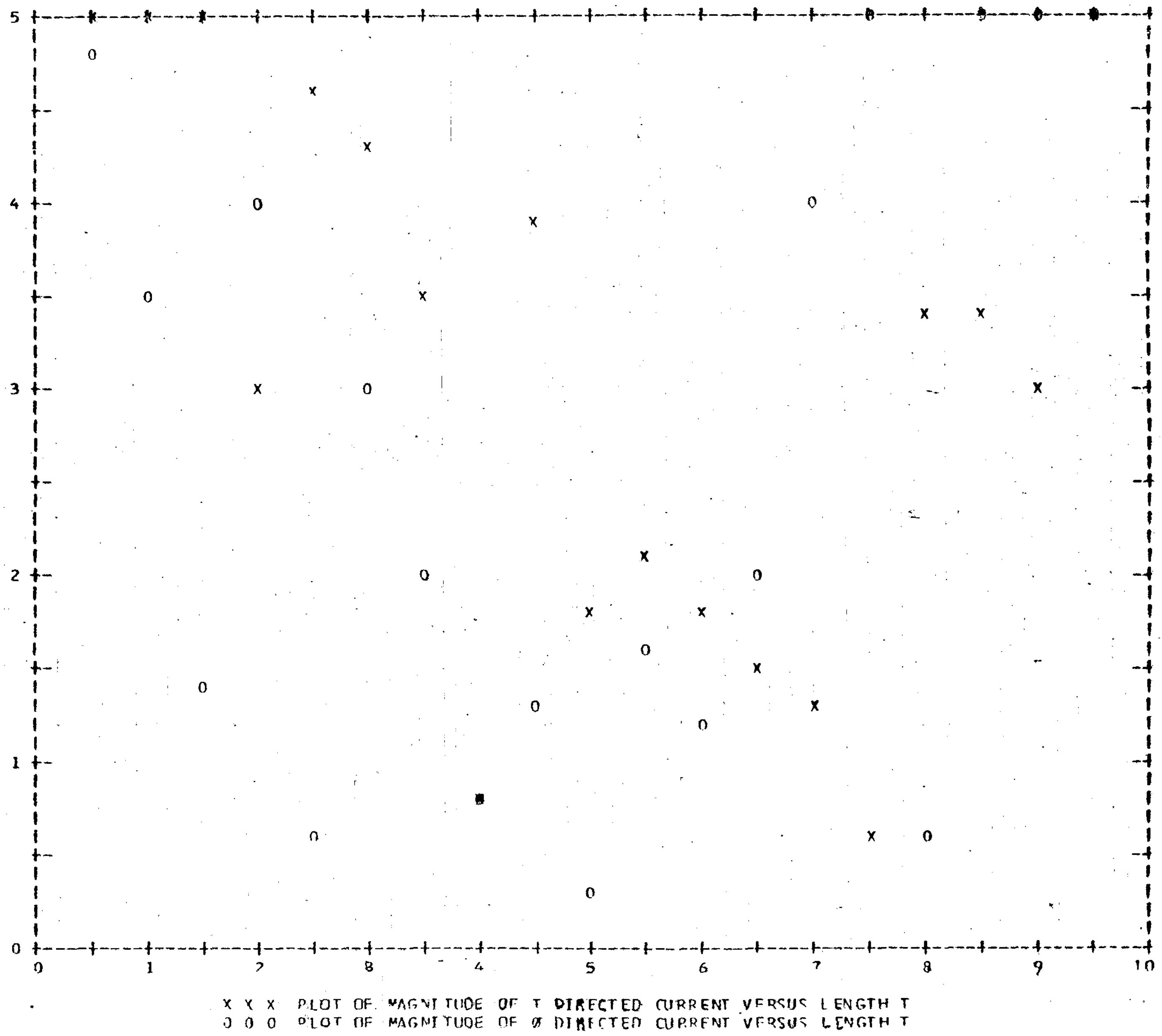


X X X PLOT OF SIGMA X0 OVER LAMBDA SQUARED VERSUS THETA
0 0 0 PLOT OF SIGMA X0 OVER LAMBDA SQUARED VERSUS THETA

```
 T     REAL JT IMAG JT  MAG JT REAL J0 IMAG J0  MAG J0
0.50   26.780 -15.725  31.055  -4.147   2.494   4.840
1.00    6.593  -2.264   6.971   2.758  -2.111   3.473
1.50   -6.383   6.689   9.246   0.898  -1.136   1.448
2.00   -0.175   2.946   2.951  -3.580   1.739   3.980
2.50    4.570  -0.720   4.626   0.183  -0.542   0.572
3.00   -2.965   3.159   4.332   2.248  -1.911   2.951
3.50   -2.764   2.146   3.499  -1.812   0.744   1.959
4.00    0.094  -0.783   0.788   0.568  -0.621   0.841
4.50   -3.764   0.813   3.850   0.969  -0.869   1.302
5.00   -0.910  -1.505   1.759  -0.333   0.070   0.341
5.50   -1.626  -1.295   2.079   1.291  -0.889   1.568
6.00   -0.712  -1.657   1.803   1.056  -0.645   1.237
6.50   -0.383  -1.475   1.524   1.748  -0.947   1.988
7.00    0.244  -1.238   1.262   3.554  -1.883   4.022
7.50   -0.524  -0.211   0.565   7.820  -4.153   8.854
8.00    2.954  -1.746   3.431   0.350   0.548   0.650
8.50   -2.798   1.868   3.364  -8.300   5.802  10.127
9.00   -2.480   1.649   2.978  -4.092   3.072   5.117
9.50   -7.340   4.436   8.576  -7.008   4.277   8.210
```

θ	SIG Xθ	SIG XØ	MAG SXθ	ANG SXθ	MAG SXØ	ANG SXØ	LSIG Xθ	LSIG XØ
0.0	3.078	3.078	1.754	0.0	1.754	-180.0	0.488	0.488
2.5	3.067	3.070	1.751	-0.4	1.752	179.6	0.487	0.487
5.0	3.035	3.045	1.742	-1.6	1.745	178.3	0.482	0.484
7.5	2.983	3.005	1.727	-3.6	1.733	176.2	0.475	0.478
10.0	2.910	2.949	1.706	-6.3	1.717	173.3	0.464	0.470
12.5	2.820	2.879	1.679	-9.8	1.697	169.5	0.450	0.459
15.0	2.713	2.795	1.647	-14.1	1.672	164.9	0.433	0.446
17.5	2.591	2.700	1.610	-19.2	1.643	159.4	0.414	0.431
20.0	2.457	2.594	1.568	-25.0	1.610	153.2	0.390	0.414
22.5	2.313	2.478	1.521	-31.5	1.574	146.1	0.364	0.394
25.0	2.162	2.355	1.470	-38.8	1.535	138.2	0.335	0.372
27.5	2.005	2.227	1.416	-46.7	1.492	129.5	0.302	0.348
30.0	1.846	2.094	1.359	-55.3	1.447	120.0	0.266	0.321
32.5	1.686	1.959	1.299	-64.6	1.400	109.8	0.227	0.292
35.0	1.529	1.824	1.236	-74.5	1.350	98.8	0.184	0.261
37.5	1.375	1.689	1.173	-85.0	1.300	87.0	0.138	0.228
40.0	1.228	1.557	1.108	-96.0	1.248	74.4	0.089	0.192
42.5	1.088	1.428	1.043	-107.5	1.195	61.2	0.037	0.155
45.0	0.958	1.305	0.979	-119.5	1.142	47.2	-0.019	0.116
47.5	0.837	1.187	0.915	-132.0	1.089	32.4	-0.077	0.074
50.0	0.726	1.075	0.852	-144.7	1.037	17.0	-0.139	0.032
52.5	0.627	0.971	0.792	-157.8	0.985	1.0	-0.203	-0.013
55.0	0.538	0.873	0.734	-171.0	0.935	-15.8	-0.269	-0.059
57.5	0.461	0.783	0.679	175.7	0.885	-33.1	-0.336	-0.106
60.0	0.394	0.699	0.628	162.4	0.836	-51.0	-0.404	-0.156
62.5	0.337	0.621	0.581	149.3	0.788	-69.6	-0.472	-0.207
65.0	0.290	0.549	0.539	136.5	0.741	-88.7	-0.537	-0.261
67.5	0.253	0.481	0.503	124.0	0.694	-108.3	-0.597	-0.317
70.0	0.224	0.419	0.473	111.9	0.647	-128.6	-0.651	-0.378
72.5	0.203	0.360	0.450	100.2	0.600	-149.5	-0.693	-0.444
75.0	0.189	0.306	0.435	88.8	0.553	-171.2	-0.723	-0.515
77.5	0.182	0.256	0.427	77.5	0.506	166.1	-0.739	-0.592
80.0	0.182	0.212	0.427	66.1	0.460	142.1	-0.739	-0.674
82.5	0.188	0.175	0.433	54.2	0.418	116.3	-0.727	-0.757
85.0	0.197	0.147	0.444	41.7	0.384	88.4	-0.704	-0.832
97.5	0.211	0.131	0.459	28.4	0.362	58.2	-0.676	-0.882
90.0	0.227	0.130	0.476	14.4	0.360	26.5	-0.645	-0.887
92.5	0.243	0.145	0.493	-0.3	0.381	-5.2	-0.614	-0.837
95.0	0.260	0.181	0.510	-15.8	0.425	-35.0	-0.586	-0.742
97.5	0.274	0.239	0.524	-32.0	0.489	-62.1	-0.562	-0.622
100.0	0.287	0.320	0.535	-48.9	0.565	-86.8	-0.543	-0.495
102.5	0.296	0.425	0.544	-66.4	0.652	-109.3	-0.529	-0.372
105.0	0.302	0.553	0.550	-84.7	0.743	-130.2	-0.520	-0.258
107.5	0.306	0.702	0.554	-103.6	0.838	-149.8	-0.514	-0.153
110.0	0.310	0.871	0.557	-123.2	0.933	-168.4	-0.508	-0.060
112.5	0.316	1.055	0.562	-143.5	1.027	173.8	-0.501	0.023
115.0	0.326	1.251	0.571	-164.4	1.118	156.7	-0.487	0.097
117.5	0.344	1.453	0.587	174.4	1.205	140.2	-0.463	0.162
120.0	0.374	1.659	0.612	153.1	1.288	124.2	-0.427	0.220
122.5	0.420	1.864	0.648	132.2	1.365	108.7	-0.377	0.270
125.0	0.484	2.064	0.696	112.0	1.437	93.7	-0.315	0.315
127.5	0.570	2.258	0.755	92.7	1.503	79.1	-0.244	0.354
130.0	0.679	2.443	0.824	74.6	1.563	64.9	-0.168	0.388
132.5	0.813	2.619	0.902	57.6	1.618	51.3	-0.090	0.418
135.0	0.973	2.784	0.986	41.8	1.669	38.0	-0.012	0.445
137.5	1.156	2.940	1.075	27.1	1.715	25.3	0.063	0.468
140.0	1.362	3.087	1.167	13.4	1.757	13.1	0.134	0.490
142.5	1.588	3.226	1.260	0.7	1.796	1.5	0.201	0.509
145.0	1.830	3.357	1.353	-11.1	1.832	-9.6	0.262	0.526
147.5	2.084	3.481	1.443	-21.9	1.866	-20.1	0.312	0.542

150.0	2.345	3.600	1.531	-32.0	1.897	-30.0	0.370	0.556
152.5	2.609	3.712	1.615	-41.2	1.927	-39.2	0.416	0.570
155.0	2.871	3.819	1.694	-49.5	1.954	-47.7	0.458	0.582
157.5	3.125	3.919	1.768	-57.1	1.980	-55.4	0.495	0.593
160.0	3.367	4.012	1.835	-63.9	2.003	-62.4	0.527	0.603
162.5	3.592	4.098	1.895	-69.8	2.024	-68.7	0.555	0.613
165.0	3.796	4.176	1.948	-75.0	2.044	-74.1	0.579	0.621
167.5	3.976	4.244	1.994	-79.4	2.060	-78.8	0.599	0.628
170.0	4.127	4.301	2.032	-83.0	2.074	-82.6	0.616	0.634
172.5	4.248	4.347	2.061	-85.8	2.085	-85.6	0.628	0.638
175.0	4.336	4.380	2.082	-97.8	2.093	-87.7	0.637	0.641
177.5	4.389	4.400	2.095	-89.0	2.098	-89.0	0.642	0.643
180.0	4.407	4.407	2.099	-89.4	2.099	-89.4	0.644	0.644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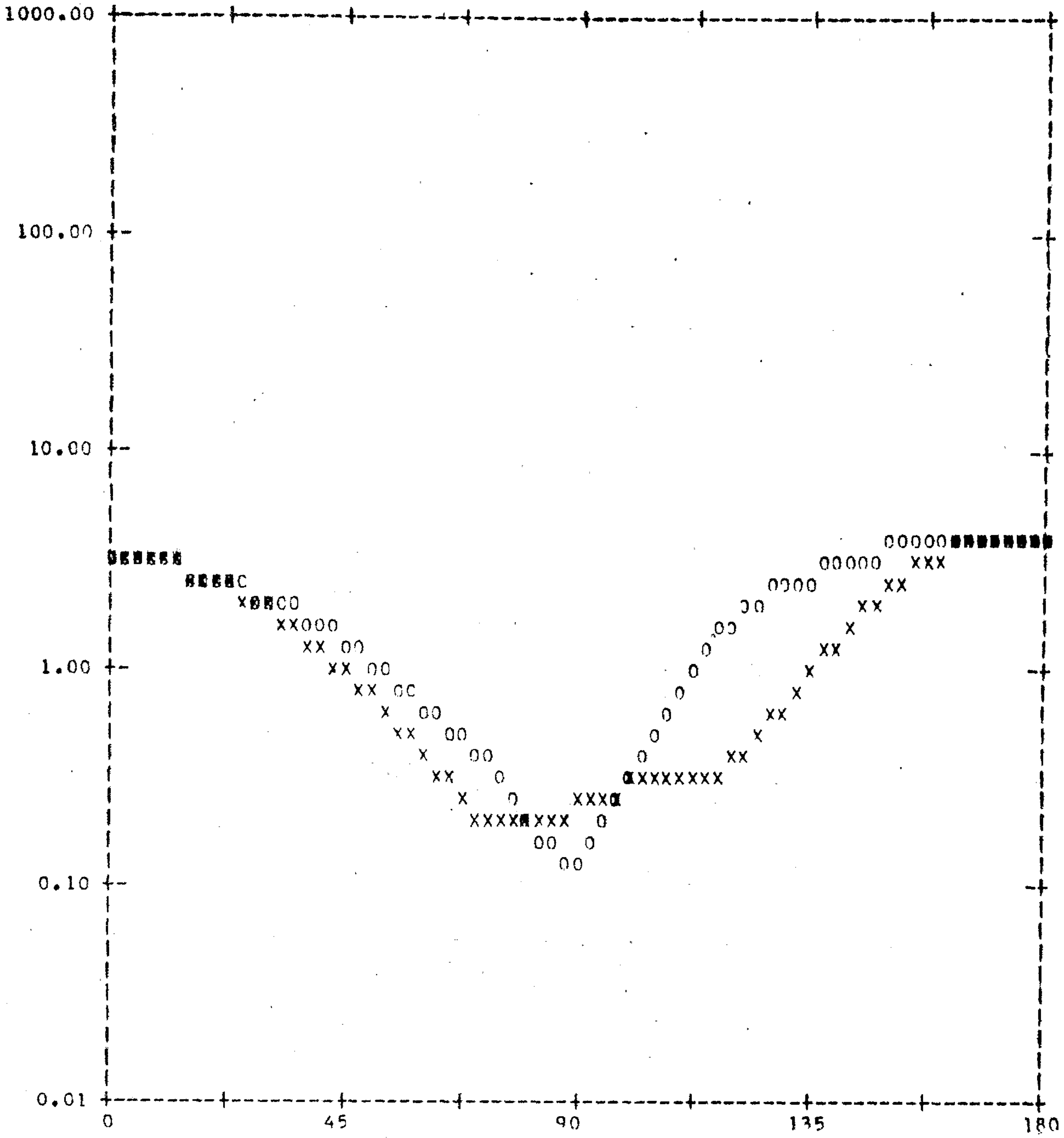
X X X PLOT OF MAGNITUDE OF T DIRECTED CURRENT VERSUS LENGTH T
0 0 0 PLOT OF MAGNITUDE OF Ø DIRECTED CURRENT VERSUS LENGTH T



X X X PLOT OF SIGMA X8 OVER LAMBDA SQUARED VERSUS THETA
0 0 0 PLOT OF SIGMA X0 OVER LAMBDA SQUARED VERSUS THETA

B. Aperture Radiation

```
//              (0639,EE,4,2),'MAUTZ,JOE',MSGLEVEL=1
// EXEC FORTGCLG,PARM.FORT='MAP'
//FORT.SYSIN DD *
      SUBROUTINE LINEQ(LL,C)
      COMPLEX C(1),STOR,STO,ST,S
      DIMENSION LR(58)
      DO 20 I=1,LL
      LR(I)=I
   20 CONTINUE
      M1=0
      DO 18 M=1,LL
      K=M
      DO 2 I=M,LL
      K1=M1+I
      K2=M1+K
      IF(CABS(C(K1))-CABS(C(K2))) 2,2,6
    6 K=I
    2 CONTINUE
      LS=LR(M)
      LR(M)=LR(K)
      LR(K)=LS
      K2=M1+K
      STOR=C(K2)
      J1=0
      DO 7 J=1,LL
      K1=J1+K
      K2=J1+M
      STO=C(K1)
      C(K1)=C(K2)
      C(K2)=STO/STOR
      J1=J1+LL
    7 CONTINUE
      K1=M1+M
      C(K1)=1./STOR
      DO 11 I=1,LL
      IF(I-M) 12,11,12
   12 K1=M1+I
      ST=C(K1)
      C(K1)=0.
      J1=0
      DO 10 J=1,LL
      K1=J1+I
      K2=J1+M
      C(K1)=C(K1)-C(K2)*ST
      J1=J1+LL
   10 CONTINUE
   11 CONTINUE
      M1=M1+LL
   18 CONTINUE
      J1=0
      DO 9 J=1,LL
      IF(J-LR(J)) 14,8,14
   14 LRJ=LR(J)
      J2=(LRJ-1)*LL
   21 DO 13 I=1,LL
      K2=J2+I
      K1=J1+I
      S=C(K2)
      C(K2)=C(K1)
      C(K1)=S
```

```
   13 CONTINUE
      LR(J)=LR(LRJ)
      LR(LRJ)=LRJ
      IF(J-LR(J)) 14,8,14
    8 J1=J1+LL
    9 CONTINUE
      RETURN
      END
      SUBROUTINE PLANE(VVR,THR,NT)
      COMPLEX VVR(1),A5,A6,U
      COMMON U,R(42),ZS(42),SV(42),CV(42),BK,NP,T(80),TR(80)
      DIMENSION BJ(84),THR(1)
      KG=NP-1
      NM=KG/2-1
      A5=2.*3.141593*U
      NV=NM*2
      DO 156 L=1,NT
      L1=(L-1)*NV
      CS=COS(THR(L))
      SN=SIN(THR(L))
      BCS=BK*CS
      DO 302 J=1,KG
      J1=J
      X=R(J)*BK*SN
      DO 305 JJ=1,2
      IF(X-1.E-5) 1,1,2
    1 IF(JJ-1) 3,3,4
    3 BJ(J1)=1.
      GO TO 306
    4 BJ(J1)=0.
      GO TO 306
    2 RH=X/2
      RH2=RH*RH
      RH3=RH**(JJ-1)
      BJ(J1)=RH3
      SS=BJ(J1)
    8 SST=SS*1.E-7
      DO 155 K=1,20
      SS=-SS*RH2/K/(K+JJ-1)
      BJ(J1)=BJ(J1)+SS
      IF(ABS(SS)-SST) 306,306,155
  155 CONTINUE
      STOP 155
  306 J1=J1+KG
  305 CONTINUE
  302 CONTINUE
      DO 300 J=1,NM
      J1=J+L1
      J2=J1+NM
      VVR(J1)=0.
      VVR(J2)=0.
      DO 301 I=1,4
      I1=2*(J-1)+I
      I4=4*(J-1)+I
      I2=I1+KG
      A6=(COS(ZS(I1)*BCS)+U*SIN(ZS(I1)*BCS))*A5
      VVR(J1)=VVR(J1)+A6*(CS*SV(I1)*BJ(I2)+SN*CV(I1)*BJ(I1)*U)*T(I4)
      VVR(J2)=VVR(J2)+A6*BJ(I2)*TR(I4)
  301 CONTINUE
  300 CONTINUE
```

```
  156 CONTINUE
      RETURN
      END
      SUBROUTINE REORD(K1,K3,L)
      DIMENSION K1(1),K3(1)
      DO 81 J=1,L
      K8=K3(J)
      K6=J
      DO 82 I=J,L
      IF(K3(I)-K8) 82,82,84
   84 K8=K3(I)
      K6=I
   82 CONTINUE
      K3(K6)=K3(J)
      K3(J)=K8
      K8=K1(K6)
      K1(K6)=K1(J)
      K1(J)=K8
   81 CONTINUE
      K3(L+1)=-1
      RETURN
      END
      COMPLEX A3,Y(1600),VVR(2920),TI(40),E3(40),E1(73),E2(73),U
      COMPLEX ZL(10),ZM(100)
      COMMON U,R(42),ZS(42),SV(42),CV(42),BK,NP,T(80),TR(80)
      DIMENSION RH(43),ZH(43),DH(42),TJ(20),INT(11),THR(73)
      DIMENSION AA(110),K1(73),K2(20),K3(74),K4(21)
      DIMENSION LP(10)
      DATA AA(1),AA(109),AA(110)/' ','X','0'/
      DO 107 I=1,107
  107 AA(I+1)=AA(I)
      U=(0.,1.)
      ETA=376.707
      PI=3.141593
      PR=180./PI
      WRITE(3,106)
      REWIND 6
   50 READ(1,51,END=52) KK,NP,NT,L1,BK
   51 FORMAT(4I3,E14.7)
      READ(1,53)(RH(I),I=1,NP)
      READ(1,53)(ZH(I),I=1,NP)
   53 FORMAT(10F8.4)
      WRITE(3,54) KK,NP,NT,L1,BK
   54 FORMAT(1X//' KK=',I3,' NP=',I3,' NT=',I3,' L1=',I3,' BK=',E14.7)
      WRITE(3,55)
   55 FORMAT(1X/' RH')
      WRITE(3,46)(RH(I),I=1,NP)
   46 FORMAT(1X,10F8.4)
      WRITE(3,56)
   56 FORMAT(1X/' ZH')
      WRITE(3,46)(ZH(I),I=1,NP)
      KL=1
  126 IF((RH(1)-RH(NP)).NE.0..OR.(ZH(1)-ZH(NP)).NE.0.) GO TO 58
      KL=0
      RH(NP+1)=RH(2)
      ZH(NP+1)=ZH(2)
      RH(NP+2)=RH(3)
      ZH(NP+2)=ZH(3)
      NP=NP+2
   58 NM=(NP-3)/2
```

```
      NM4=NM*4
      NM2=NM*2
      NZ=NM2*NM2
      DO 144 J=1,NM2
      E3(J)=0.
  144 CONTINUE
      IF(KK.EQ.2) GO TO 40
      READ(1,53)(E3(I),I=1,NM)
      WRITE(3,131)
  131 FORMAT(1X/' VO')
      WRITE(3,132)
  132 FORMAT('+ -')
      WRITE(3,46)(E3(I),I=1,NM)
      IF(KK.EQ.1) GO TO 41
      J1=NM+1
   40 READ(1,53)(E3(I),I=J1,NM2)
      WRITE(3,131)
      WRITE(3,133)
  133 FORMAT('+ /')
      WRITE(3,46)(E3(I),I=J1,NM2)
   41 X1=2.*PI
      DO 45 J=1,NM2
      E3(J)=E3(J)*X1
   45 CONTINUE
      DO 57 I=2,NP
      I2=I-1
      RR1=RH(I)-RH(I2)
      RR2=ZH(I)-ZH(I2)
      DH(I2)=SQRT(RR1*RR1+RR2*RR2)
      ZS(I2)=.5*(ZH(I)+ZH(I2))
      R(I2)=.5*(RH(I)+RH(I2))
      SV(I2)=RR1/DH(I2)
      CV(I2)=RR2/DH(I2)
   57 CONTINUE
      DT=PI/(NT-1)
      DO 1 J=1,NT
      THR(J)=DT*(J-1)
    1 CONTINUE
      DO 74 J=1,NM
      J2=2*(J-1)+1
      J3=J2+1
      J4=J3+1
      J5=J4+1
      J6=4*(J-1)+1
      J7=J6+1
      J8=J7+1
      J9=J8+1
      DEL1=DH(J2)+DH(J3)
      DEL2=DH(J4)+DH(J5)
      T(J6)=DH(J2)*DH(J2)/2./DEL1
      T(J7)=DH(J3)*(DH(J2)+DH(J3)/2.)/DEL1
      T(J8)=DH(J4)*(DH(J5)+DH(J4)/2.)/DEL2
      T(J9)=DH(J5)*DH(J5)/2./DEL2
   74 CONTINUE
      DO 75 J=1,NM4
      TR(J)=T(J)
   75 CONTINUE
  115 IF(KL.EQ.0.) GO TO 78
      IF(RH(1))77,23,77
   77 DEL1=DH(1)+DH(2)
```

```
      TR(1)=DH(1)*(1.+(DH(2)+DH(1)/2.)/DEL1)
      TR(2)=DH(2)*(1.+DH(2)/2./DEL1)
   23 IF(RH(NP))79,78,79
   79 J1=(NM-1)*4+3
      J2=J1+1
      DEL2=DH(NP-2)+DH(NP-1)
      TR(J1)=DH(NP-2)*(1.+DH(NP-2)/2./DEL2)
      TR(J2)=DH(NP-1)*(1.+(DH(NP-2)+DH(NP-1)/2.)/DEL2)
   78 SS=0.
      DO 7 I=1,NM
      I1=2*(I-1)+1
      I2=I1+1
      SS=SS+DH(I1)+DH(I2)
      TJ(I)=SS
    7 CONTINUE
      DEL=TJ(NM)
      IF(KL.NE.0.) DEL=DEL+DH(NP-2)+DH(NP-1)
      DEL=DEL/10.
      DO 8 J=1,NM
      TJ(J)=TJ(J)/DEL
    8 CONTINUE
  185 READ(6)(Y(I),I=1,NZ)
      CALL PLANE(VVR,THR,NT)
      DO 230 L3=1,L1
      DO 134 J=1,NM
      J1=J+NM
      TI(J)=0.
      TI(J1)=0.
      DO 135 I=1,NM
      I2=(I-1)*NM2+J
      I3=I2+(NM2+1)*NM
      I4=I+NM
      TI(J)=TI(J)+Y(I2)*E3(I)
      TI(J1)=TI(J1)+Y(I3)*E3(I4)
  135 CONTINUE
  134 CONTINUE
      READ(1,51) L2
      WRITE(3,243) L2
  243 FORMAT('0L2=',I3)
      IF(L2.EQ.0) GO TO 235
      READ(1,231)(LP(J),J=1,L2)
  231 FORMAT(10I3)
      READ(1,234)(ZL(J),J=1,L2)
  234 FORMAT(7E11.4)
      WRITE(3,244)(LP(J),J=1,L2)
  244 FORMAT('0LP',/(1X,10I3))
      WRITE(3,245)(ZL(J),J=1,L2)
  245 FORMAT('0ZL',/(1X,7E11.4))
      DO 232 J=1,L2
      J1=(LP(J)-1)*NM2
      J5=(J-1)*L2
      DO 233 I=1,L2
      J2=J1+LP(I)
      J4=J5+I
      ZM(J4)=Y(J2)
  233 CONTINUE
      J4=J5+J
      IF(CABS(ZL(J)).EQ.0.) ZL(J)=.1E-20
      ZM(J4)=ZM(J4)+1./ZL(J)
  232 CONTINUE
```

```
      CALL LINEQ(L2,ZM)
      DO 238 J=1,L2
      F2(J)=0.
      DO 239 I=1,L2
      J1=(I-1)*L2+J
      J2=LP(I)
      F2(J)=F2(J)+ZM(J1)*TI(J2)
  239 CONTINUE
  238 CONTINUE
      DO 240 J=1,NM2
      DO 241 I=1,L2
      J2=(LP(I)-1)*NM2+J
      TI(J)=TI(J)-F2(I)*Y(J2)
  241 CONTINUE
  240 CONTINUE
  235 P1=0.
      P2=0.
      DO 236 J=1,NM
      J1=J+NM
      P1=P1+CONJG(TI(J))*F3(J)
      P2=P2+CONJG(TI(J1))*F3(J1)
  236 CONTINUE
      P4=P1
      P5=P2
      DO 246 J=1,L2
      J1=LP(J)
      IF(J1-NM) 247,247,248
  247 P4=P4-CONJG(TI(J1))*F2(J)
      GO TO 246
  248 P5=P5-CONJG(TI(J1))*F2(J)
  246 CONTINUE
      WRITE(3,184) P1,P2,P4,P5
  184 FORMAT(//1X,7E11.4)
      P3=4.*PI/BK/BK/ETA
      IF(P1.EQ.0.) GO TO 249
      P4=P1/P4
      P1=1./SQRT(ABS(P1)*P3)
  249 IF(P2.EQ.0.) GO TO 242
      P5=P2/P5
      P2=1./SQRT(ABS(P2)*P3)
  242 DO 9 J=1,NT
      F1(J)=0.
      F2(J)=0.
      J1=(J-1)*NM2
      DO 10 I=1,NM
      I1=J1+I
      I2=I1+NM
      I3=I+NM
      F1(J)=F1(J)+VVR(I1)*TI(I)
      F2(J)=F2(J)+VVR(I2)*TI(I3)
   10 CONTINUE
  190 F1(J)=F1(J)*P1
  191 F2(J)=F2(J)*P2
    9 CONTINUE
      F1(1)=1.E-10
      F2(1)=1.E-10
      F1(NT)=1.E-10
      F2(NT)=1.E-10
      DO 139 J=1,NM
      J2=2*(J-1)+3
```

```
      J1=J+NM
      TI(J)=TI(J)/RH(J2)
      TI(J1)=TI(J1)/RH(J2)
  139 CONTINUE
      GO TO(145,146,137),KK
  145 J1=0
      WRITE(3,138)
  138 FORMAT('1',2X,'T',5X,'REAL JT',4X,'IMAG JT')
      GO TO 147
  146 J1=NM
      WRITE(3,148)
  148 FORMAT('1',2X,'T',5X,'REAL JO',4X,'IMAG JO')
      WRITE(3,149)
  149 FORMAT('+',14X,'/',10X,'/')
  147 DO 140 J=1,NM
      J2=J1+J
      WRITE(3,124) TJ(J),TI(J2)
  124 FORMAT(1X,F5.2,4E11.3)
  140 CONTINUE
      GO TO 150
  137 WRITE(3,110)
  110 FORMAT('1',2X,'T',5X,'REAL JT',4X,'IMAG JT',4X,'REAL JO',4X,'IMAG
     1JO')
      WRITE(3,109)
  109 FORMAT('+',36X,'/',10X,'/')
      DO 143 J=1,NM
      J1=J+NM
      WRITE(3,124) TJ(J),TI(J),TI(J1)
  143 CONTINUE
  150 GO TO (151,152,153),KK
  151 WRITE(3,155)
  155 FORMAT('1  0',6X,'GO',6X,'EO',4X,'ANG EO',3X,'DO')
      WRITE(3,154)
  154 FORMAT('+  -',7X,'-',7X,'-',9X,'-',4X,'-')
      DO 156 J=1,NT
      X3=CABS(E1(J))
      X1=THR(J)*PR
      X2=X3*X3
      X5=X2*P4
      X4=PR*ATAN2(AIMAG(E1(J)),REAL(E1(J)))
      WRITE(3,111) X1,X2,X3,X4,X5
  111 FORMAT(1X,F5.1,2F8.3,F8.1,2F8.3,F8.1,2F8.3)
  156 CONTINUE
      GO TO 157
  152 WRITE(3,155)
      WRITE(3,158)
  158 FORMAT('+  /',7X,'/',7X,'/',9X,'/',4X,'/')
      DO 159 J=1,NT
      X3=CABS(E2(J))
      X1=THR(J)*PR
      X2=X3*X3
      X4=PR*ATAN2(AIMAG(E2(J)),REAL(E2(J)))
      X5=X2*P5
      WRITE(3,111) X1,X2,X3,X4,X5
  159 CONTINUE
      GO TO 157
  153 WRITE(3,160)
  160 FORMAT('1  0',6X,'GO',6X,'EO',4X,'ANG EO',4X,'GO',6X,'EO',4X,'ANG
     1EO',3X,'DO',6X,'DO')
      WRITE(3,161)
```

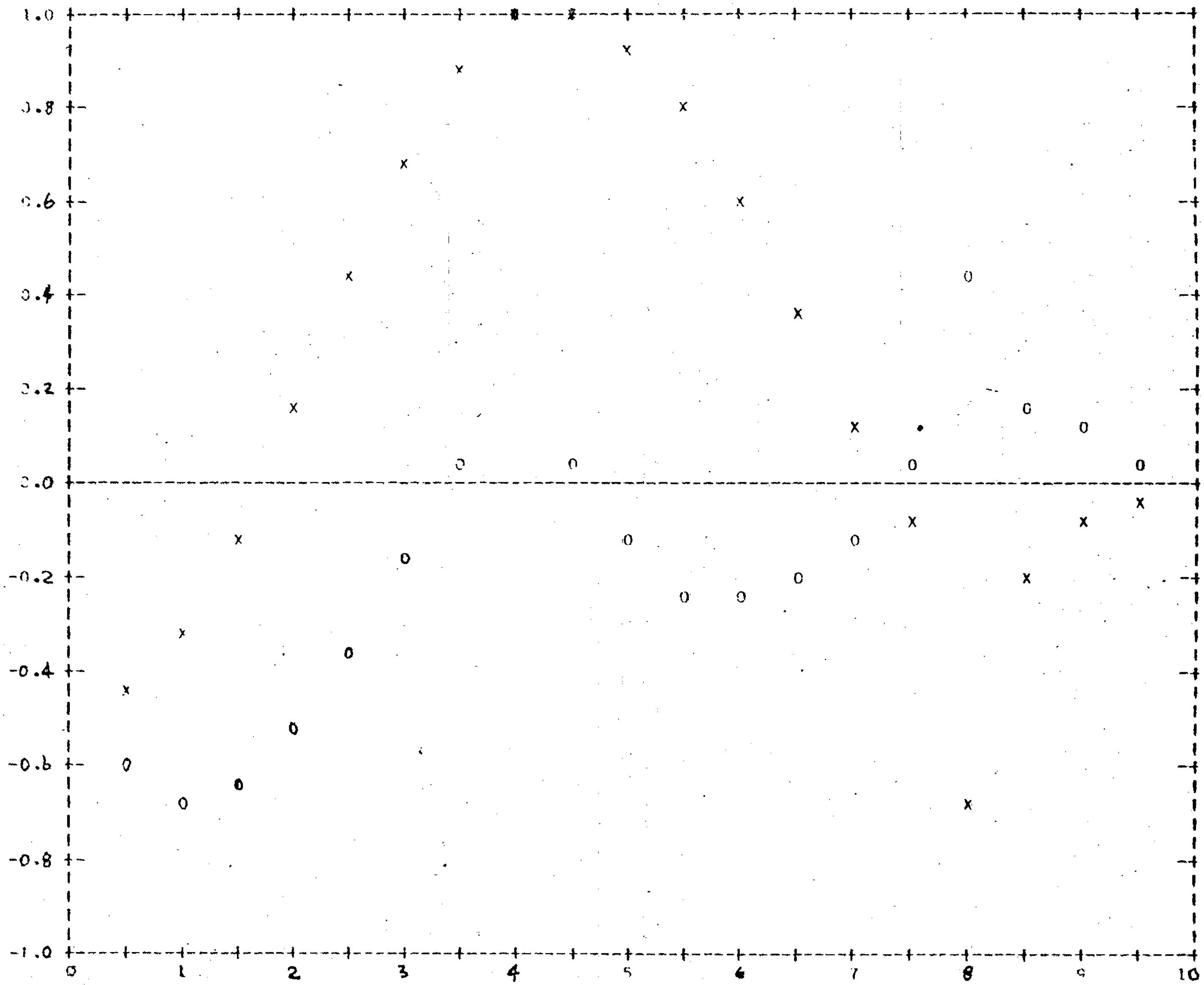
```
161 FORMAT('+  -',7X,'-',7X,'-',9X,'-',5X,'/',7X,'/',9X,'/',4X,'-',7X,
   1'/')
    DO 167 J=1,NT
    X3=CABS(E1(J))
    X1=THR(J)*PR
    X2=X3*X3
    X4=PR*ATAN2(AIMAG(E1(J)),REAL(E1(J)))
    X6=CABS(E2(J))
    X5=X6*X6
    X8=X2*P4
    X9=X5*P5
    X7=PR*ATAN2(AIMAG(E2(J)),REAL(E2(J)))
    WRITE(3,111) X1,X2,X3,X4,X5,X6,X7,X8,X9
167 CONTINUE
157 M1=1
    M2=2
    IF(KK.EQ.1) M2=1
    IF(KK.EQ.2) M1=2
    DO 171 M=M1,M2
    M3=(M-1)*NM
    X1=ABS(REAL(TI(M3+1)))
    X2=ABS(AIMAG(TI(M3+1)))
    DO 172 J=1,NM
    J1=J+M3
    X3=ABS(REAL(TI(J1)))
    X4=ABS(AIMAG(TI(J1)))
    IF((X3-X1).GT.0.) X1=X3
    IF((X4-X2).GT.0.) X2=X4
172 CONTINUE
    DO 13 J=1,NM
    J1=J+M3
    K1(J)=TJ(J)*10.+8.5
    K2(J)=K1(J)
    K3(J)=25.*REAL(TI(J1))/X1+25.5
    K4(J)=25.*AIMAG(TI(J1))/X2+25.5
 13 CONTINUE
    CALL REORD(K1,K3,NM)
    CALL REORD(K2,K4,NM)
    DO 104 J=1,11
    INT(J)=J-1
104 CONTINUE
    X1=1.
    K5=1
    K6=1
    WRITE(3,106)
106 FORMAT('1')
    DO 20 J=1,51
    J1=51-J
    WRITE(3,25)
 25 FORMAT(9X,'|',99X,'|')
    IF((J-1)/5*5-(J-1)) 21,22,21
 22 WRITE(3,123)
123 FORMAT('+',8X,'--',97X,'--')
122 WRITE(3,24) X1
 24 FORMAT('+',F7.1)
    X1=X1-.2
    IF(J.NE.1) GO TO 173
    WRITE(3,116)
116 FORMAT('+',9X,50('--'))
    WRITE(3,47)
```

```
 47 FORMAT('+',13X,19('|',4X))
173 IF(J.NE.26) GO TO 21
    WRITE(3,116)
 21 IF(K3(K5).LT.J1) GO TO 26
 60 K8=K1(K5)
    WRITE(3,48)(AA(I),I=1,K8),AA(109)
 48 FORMAT('+',110A1)
    K5=K5+1
    IF(K3(K5).GE.J1) GO TO 60
 26 IF(K4(K6).LT.J1) GO TO 20
 61 K8=K2(K6)
    WRITE(3,48)(AA(I),I=1,K8),AA(110)
    K6=K6+1
    IF(K4(K6).GE.J1) GO TO 61
 20 CONTINUE
    WRITE(3,47)
    WRITE(3,116)
    WRITE(3,63)(INT(J),J=1,11)
 63 FORMAT(8X,11(I2,8X)/,1X)
    WRITE(3,174)
174 FORMAT(32X,'X X X  PLOT OF  (REAL J )/MAX''REAL J ''  VERSUS LENGT
   1H T')
    IF(M.EQ.1) WRITE(3,175)
175 FORMAT('+',54X,'T',12X,'T')
    IF(M.EQ.2) WRITE(3,176)
176 FORMAT('+',54X,'O',12X,'O'/'+',54X,'/',12X,'/')
    WRITE(3,180)
180 FORMAT(32X,'O O O  PLOT OF  (IMAG J )/MAX''IMAG J ''  VERSUS LENGT
   1H T')
    IF(M.EQ.1) WRITE(3,175)
    IF(M.EQ.2) WRITE(3,176)
163 DO 80 J=1,NT
    K1(J)=THR(J)*72./PI+8.5
    IF(M.EQ.1) K3(J)=20.*ALOG10(CABS(E1(J)))+30.5
    IF(M.EQ.2) K3(J)=20.*ALOG10(CABS(E2(J)))+30.5
 80 CONTINUE
    CALL REORD(K1,K3,NT)
    DO 105 J=1,5
    INT(J)=(J-1)*45
105 CONTINUE
    X1=100.
    K5=1
    WRITE(3,106)
    DO 87 J=1,51
    J1=51-J
    WRITE(3,88)
 88 FORMAT(9X,'|',71X,'|')
    IF((J-1)/10*10-(J-1))92,90,92
 90 WRITE(3,91) X1
 91 FORMAT('+',F7.3,' --',69X,'--')
    X1=X1/10.
    IF(J.NE.1) GO TO 92
    WRITE(3,93)
 93 FORMAT('+',17X,7('|',8X))
    WRITE(3,97)
 97 FORMAT('+',8X,73('-'))
 92 IF(K3(K5).LT.J1) GO TO 87
 95 K8=K1(K5)
    WRITE(3,48)(AA(I),I=1,K8),AA(109)
    K5=K5+1
```

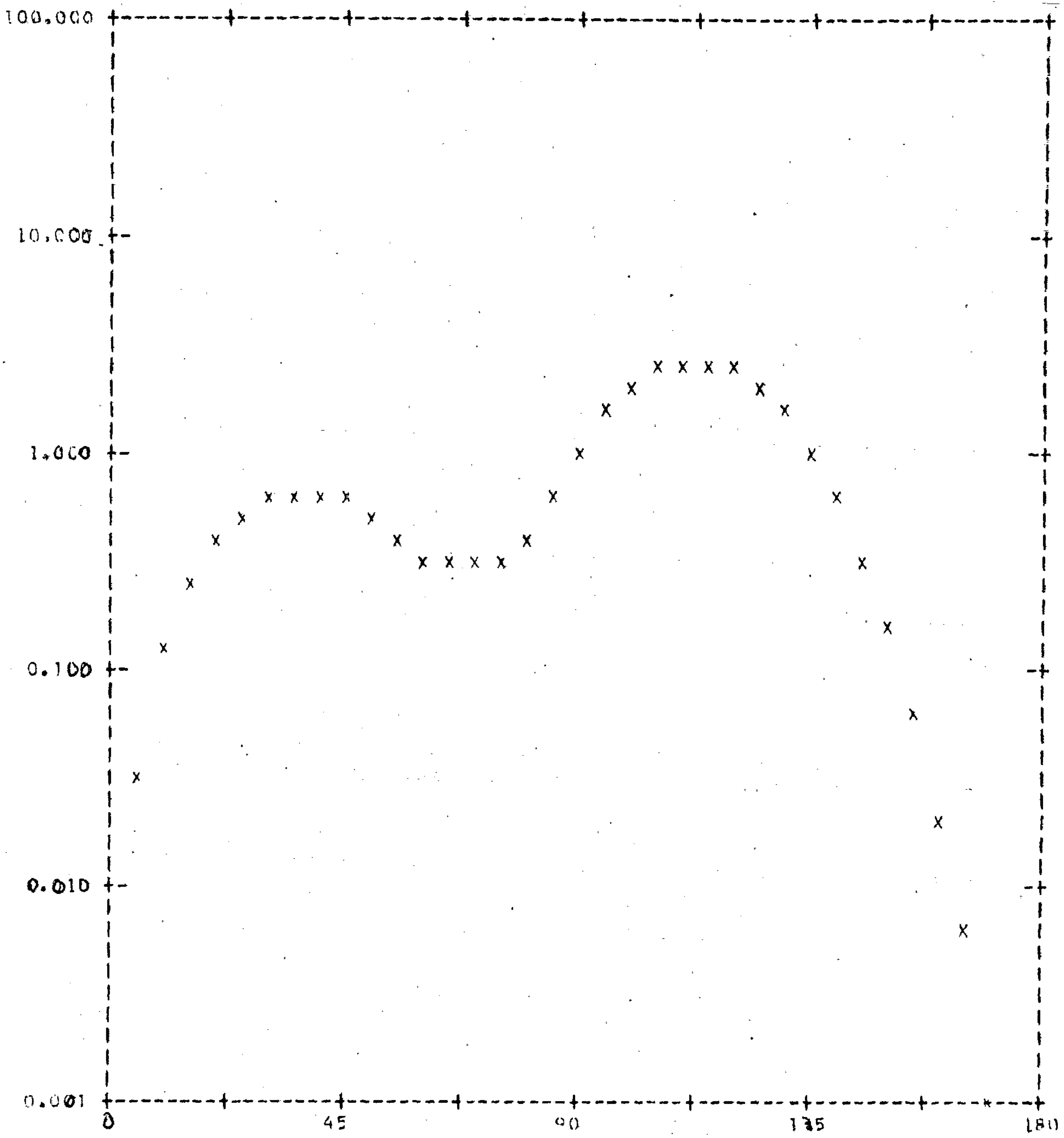
```
      IF(K3(K5).GE.J1) GO TO 95
   87 CONTINUE
      WRITE(3,93)
      WRITE(3,97)
      WRITE(3,98)(INT(J),J=1,5)
   98 FORMAT(7X,3(I3,15X),I4,15X,I3/,1X)
      WRITE(3,177)
  177 FORMAT(34X,'PLOT OF GO VERSUS THETA')
      IF(M.EQ.1) WRITE(3,178)
  178 FORMAT('+',42X,'-')
      IF(M.EQ.2) WRITE(3,179)
  179 FORMAT('+',42X,'/')
  171 CONTINUE
  170 WRITE(3,106)
  230 CONTINUE
      DIMENSION JK(4)
      JK(1)=1
      JK(2)=NM+1
      JK(3)=NM2*NM+1
      JK(4)=JK(3)+NM
      DO 693 J=1,4
      J1=JK(J)
      WRITE(3,624) J
  624 FORMAT(1X/' Y',I1)
      DO 692 I=1,NM
      J2=J1+NM-1
  696 WRITE(3,688)(Y(K),K=J1,J2)
  688 FORMAT(1X,10G11.4)
      J1=J1+NM2
  692 CONTINUE
  693 CONTINUE
      GO TU 50
   52 STOP
      END
/*
//GO.FT06F001 DD DSNAME=EE0034.REV1,DISP=OLD,UNIT=2314,                   X
//               VOLUME=SER=SU0004,DCB=(RECFM=V,BLKSIZE=1800,LRECL=1796)
//GO.SYSIN DD *
001041037001 0.4659995E+00
  0.0      0.0868   0.1736   0.2605   0.3473   0.4341   0.5209   0.6078   0.6946   0.7814
  0.8682   0.9551   1.0419   1.1287   1.2155   1.3024   1.3892   1.4760   1.5628   1.6497
  1.7365   1.8233   1.9101   1.9970   2.0838   2.1706   2.2574   2.3442   2.4311   2.5179
  2.6047   2.6837   2.6863   2.5969   2.4184   2.1570   1.8216   1.4238   0.9772   0.4971
 -0.0000
  0.0      0.4924   0.9848   1.4772   1.9696   2.4620   2.9544   3.4468   3.9392   4.4316
  4.9240   5.4164   5.9088   6.4013   6.8937   7.3861   7.8785   8.3709   8.8633   9.3557
  9.8481  10.3405  10.8329  11.3253  11.8177  12.3101  12.8025  13.2949  13.7873  14.2797
 14.7721  15.2657  15.7650  16.2562  16.7225  17.1478  17.5177  17.8195  18.0427  18.1798
 18.2260
  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
  0.0000   0.0000   0.0000   0.0000  16.9400   0.0000   0.0000   0.0000   0.0000   0.0000
  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
001
016
 0.0000E+00 0.8120E+03
/*
```

```
KK=   1 NP=  41 NT=  27 L1=   1 BK= 0.4659995E 00

RH
  0.0      0.0868  0.1736  0.2605  0.3473  0.4341  0.5209  0.6078  0.6946  0.7814
  0.8682   0.9551  1.0419  1.1287  1.2155  1.3024  1.3892  1.4760  1.5628  1.6497
  1.7365   1.8233  1.9101  1.9970  2.0838  2.1706  2.2574  2.3442  2.4311  2.5179
  2.6047   2.6837  2.6863  2.5969  2.4184  2.1570  1.8216  1.4238  0.9772  0.4971
  0.0

ZH
  0.0      0.4924  0.9848  1.4772  1.9696  2.4620  2.9544  3.4468  3.9392  4.4316
  4.9240   5.4164  5.9088  6.4013  6.8937  7.3861  7.8785  8.3709  8.8633  9.3557
  9.8481  10.3405 10.8329 11.3253 11.8177 12.3101 12.8025 13.2949 13.7873 14.2797
 14.7721  15.2657 15.7650 16.2562 16.7225 17.1478 17.5177 17.8195 18.0427 18.1798
 18.2260

Ve
  0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  0.0      0.0      0.0      0.0     16.9400   0.0      0.0      0.0      0.0      0.0
  0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

L2=   1

LP
 16

ZL
 0.0           0.8120E 03


 0.1554E 01 0.0           0.1554E 01 0.0


     T      REAL JT    IMAG JT
    0.50 -0.483E-02 -0.241E-01
    1.00 -0.354E-02 -0.264E-01
    1.50 -0.117E-02 -0.246E-01
    2.00  0.170E-02 -0.203E-01
    2.50  0.465E-02 -0.139E-01
    3.00  0.730E-02 -0.578E-02
    3.50  0.932E-02  0.170E-02
    4.00  0.105E-01  0.389E-01
    4.50  0.107E-01  0.113E-02
    5.00  0.998E-02 -0.495E-02
    5.50  0.848E-02 -0.903E-02
    6.00  0.641E-02 -0.980E-02
    6.50  0.404E-02 -0.806E-02
    7.00  0.149E-02 -0.413E-02
    7.50 -0.825E-03  0.881E-03
    8.00 -0.724E-02  0.167E-01
    8.50 -0.200E-02  0.618E-02
    9.00 -0.107E-02  0.473E-02
    9.50 -0.272E-03  0.188E-02
```

```
  θ        Gθ       Eφ     ANG Eφ     Dθ
  0.0    0.000    0.000      0.0    0.000
  5.0    0.035    0.187     66.3    0.035
 10.0    0.133    0.364     62.8    0.133
 15.0    0.273    0.523     57.0    0.273
 20.0    0.427    0.653     48.8    0.427
 25.0    0.561    0.745     38.3    0.561
 30.0    0.650    0.804     25.4    0.650
 35.0    0.677    0.823     10.0    0.677
 40.0    0.644    0.802     -7.9    0.644
 45.0    0.570    0.755    -28.6    0.570
 50.0    0.481    0.693    -51.9    0.481
 55.0    0.402    0.634    -77.1    0.402
 60.0    0.345    0.588   -102.7    0.345
 65.0    0.313    0.560   -126.1    0.313
 70.0    0.305    0.552   -144.8    0.305
 75.0    0.332    0.577   -158.0    0.332
 80.0    0.430    0.655   -168.0    0.430
 85.0    0.639    0.799   -178.7    0.639
 90.0    0.988    0.994    167.7    0.988
 95.0    1.456    1.207    151.5    1.456
100.0    1.968    1.403    133.5    1.968
105.0    2.408    1.552    114.5    2.408
110.0    2.663    1.632     95.2    2.663
115.0    2.666    1.633     75.9    2.666
120.0    2.423    1.557     57.1    2.423
125.0    2.000    1.414     38.9    2.000
130.0    1.498    1.224     21.5    1.498
135.0    1.016    1.008      5.1    1.016
140.0    0.620    0.787    -10.2    0.620
145.0    0.337    0.580    -24.2    0.337
150.0    0.160    0.400    -37.0    0.160
155.0    0.065    0.255    -48.7    0.065
160.0    0.022    0.148    -59.4    0.022
165.0    0.006    0.076    -69.8    0.006
170.0    0.001    0.033    -80.6    0.001
175.0    0.000    0.012    -91.5    0.000
180.0    0.000    0.000      0.0    0.000
```



X X X PLOT OF (REAL JT)/MAX'REAL JT' VERSUS LENGTH T
0 0 0 PLOT OF (IMAG JT)/MAX'IMAG JT' VERSUS LENGTH T



PLOT OF GA VERSUS THETA

VI. REFERENCES

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