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TRANSFER FUNCTION, IMPULSE RESPONSE AND RERADIATED WAVEFORM FOR--ETC(U)
MAY 67 D A STREMSKY
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TRANSFER FUNCTION, IMPULSE RESPONSE AND REPADIATED WAVEFORM FOR AN ELLIPTICALLY SYMMETRIC RERADIATION FUNCTION OF THE FORM z^{s}, s HALF AN ODD INTEGER (USL PROGRAM NO. 0837)

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by

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254 200

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TRANSFER FUNCTION, IMPULSE RESPONSE AND RERADIATED WAVEFORM FOR AN ELLIPTICALLY SYMMETRIC RERADIATION FUNCTION OF THE FORM ρ^{ν}, ν HALF AN ODD INTEGER (USL PROGRAM NO. 0837)

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USL Technical Memorandum No. 2242-156-67

1 May 1967

INTRODUCTION

A computational program has been prepared by the Information Processing Division to compute a particular Reradiation Function w(χ); Transfer Function W (w,ρ); Impulse Response w (t,ρ); and Reradiated Waveform g (t,ρ) as defined below in terms of the incident plane wave pulse. This IBM 704 program, designated USL Program No. 0837, is in Fortran II language and is described in Appendixes A and B. Similar computational programs are described in USL Technical Memorandum Nos. 2242-111-67 and 2242-157-67.

THEORY

Reference (a) contains a description of the mathematical model constructed and the theory behind considering reflection as a reradiation phenomenon.

This program computes for half-integer values of ν

(a) a_1 a_2 w (χ)

(b) W (w,ρ)

(c) kw (t,ρ)

(d) kg (t,ρ)

where

(1) $$w(\mathbf{X}) = \begin{cases} \dfrac{\nu+1}{a_1 a_2 \pi}\left[1-\left(\dfrac{x_1}{a_1}\right)^2-\left(\dfrac{x_2}{a_2}\right)^2\right]^{\nu}, & \mathbf{X}\in A \\ 0, & \mathbf{X}\notin A \end{cases}$$

$$A: \left(\frac{x_1}{a_1}\right)^2+\left(\frac{x_2}{a_2}\right)^2 \le 1, \quad \nu > -1$$

(2) $$W(\omega,\mathbf{P}) = 2^{\nu+1}\Gamma(\nu+2)\,\frac{J_{\nu+1}(k\omega)}{(k\omega)^{\nu+1}}$$

$$k = \frac{1}{c}\left[(a_1 p_1)^2+(a_2 p_2)^2\right]^{1/2}$$

(3) $$w(t,\mathbf{P}) = \frac{\Gamma(\nu+2)}{k\Gamma(\nu+\frac{3}{2})\sqrt{\pi}}\left[1-(t/k)^2\right]^{\nu+1/2}$$

(4) $$g(t,\mathbf{P}) = \int_{-\infty}^{\infty} f(\tau)\, w(t-\tau,P)\, d\tau$$

$$f(t) = \begin{cases} A(t)\cos\left\{\left[\omega_0+\frac{\Delta\omega}{2}(t/T)\right]t+\varphi\right\}, & |t|\le T \\ 0, & |t|>T \end{cases}$$

Note: Program #0832 as described in USL Tech. Memo. No. 2242-157-67 computes the above mentioned functions for integer values of ν.

COMPUTER PROGRAM DESCRIPTION

A nomenclature listing for USL Program No. 0837 is Appendix A, the flow chart is Appendix B, and the IBM 704 Fortran II Program is Appendix C.

The basic input data deck required by the program consists of four cards.

Table 1

Card Formats

Card No.	Cols.	Contents
1	1-8	a_1
	7-16	a_2
	17-24	x_1
	25-32	x_2
	33-40	c
	41-48	v
	49-51	ν
	52-54	ISKP (set equal to zero to compute Reradiation Function)
	55-57	JSKP (set equal to zero to compute Transfer Function)
	57-60	KSKP (set equal to zero to compute Impulse Response & reradiated waveform) For long jobs requiring the use of a dump tape at least one of the above variables should not be set equal to zero.
	61-63	NSTOP (In reference to Reradiated Waveform Array (k,t), NSTOP is the number of times t is incremented when k has its maximum value.
2	1-8	Initial value of ω
	9-16	Maximum value for ω
	12-24	Initial value for t
	25-32	Initial value of k (if not computed)
	35-36	KK (if set equal to zero, initial value for k will be computed)
	39-46	Maximum value for k
3	1-8	Λ_1 } Components of Λ
	9-16	Λ_2 }
	17-24	N_1 } Components of N
	25-32	N_2 }

Card No.	Cols.	Contents
3	33-40	Δx_1
	41-48	Δx_2
	49-56	Δt
	57-64	Increment of ω
	65-72	Δk
4	1-8	ω_o
	9-16	$\Delta\omega$
	17-24	Maximum value of τ
	25-32	Initial value of τ
	33-40	$\Delta\tau$
	41-48	φ

Formats:

Card No. 1 - Format 6F8.3, 5I3

2 - Format 4F8.3, 2X, I2, 2X, F8.3

3 - Format 9F8.3

4 - Format 6F8.3

Tape Units Required

Tape Unit No.	Tape Identification
3	Data Input
4	Values for Reradiation Function, Transfer Function & Impulse Response.
5	Calcomp Plotter containing values for Reradiation Function
6	Reradiated Waveform Array (k,t)
7	Transfer Function Array (k,w)
8	Impulse Response Array (k,t)
0	Dump Tape

{ 0 SS5 must be down to dump.

No other sense switches are used.

Subroutines Required

Subroutine AMP computes the values for A array referred to under equation (4).

Subroutine SPHJ computes the values of spherical Bessel Functions (see reference (b) and Appendix C).

PROGRAM OUTPUT

Tape #4 contains:

(1) The values for the Z array plus the corresponding values for the Reradiation Function according to Format (1X, F10.5, 5X, F10.5).

(2) The values for the product of k and w plus the corresponding values of the Transfer Function according to Format (1X, F10.5, 5X, F10.5).

(3) The values for t/k plus the corresponding values for the Impulse Response according to Format (1X F10.5, 5X, F10.5).

Tape #5 contains:

The values for the Reradiation Function (Calcomp Plotter tape).

Tape #6 contains:

The Reradiated Waveform Array (k,t) according to Format (F10.5).

Tape #7 contains:

The Transfer Function Array (k,w) with Format (F10.5).

Tape #8 contains:

The Impulse Response Array according to Format (F10.5).

Tape #0 is a dump tape.

Notes: This program contains options to compute or not to compute any of the functions mentioned above. Tapes Unit No's. 6, 7, and 8 can be used as input to USL Program #0809, "Representation of Surfaces: A Computer Program to Plot Contours and Draw Perspective Views", by Edward Beardsworth, Jr.

SUMMARY

An IBM 704 Fortran program, USL Program No. 0837, has been written to compute a particular Reradiation Function, Transfer Function, Impulse Response, and Reradiated Waveform in terms of the incident plane wave pulse.

D. A. Stremsky

D. A. STREMSKY
Mathematician

LIST OF REFERENCES

(a) Edward S. Eby, "Spectra and Waveforms of Bottom Reflected Pulses", USL Tech. Memo. No. 914-160-66, of 10 June 1966.

(b) R. D. Whittaker, USL Memorandum No. 6-2-908-01-00, Ser 907-157, 30 November 1965.

APPENDIX A

NOMENCLATURE LISTING FOR USL PROGRAM NO. 0837

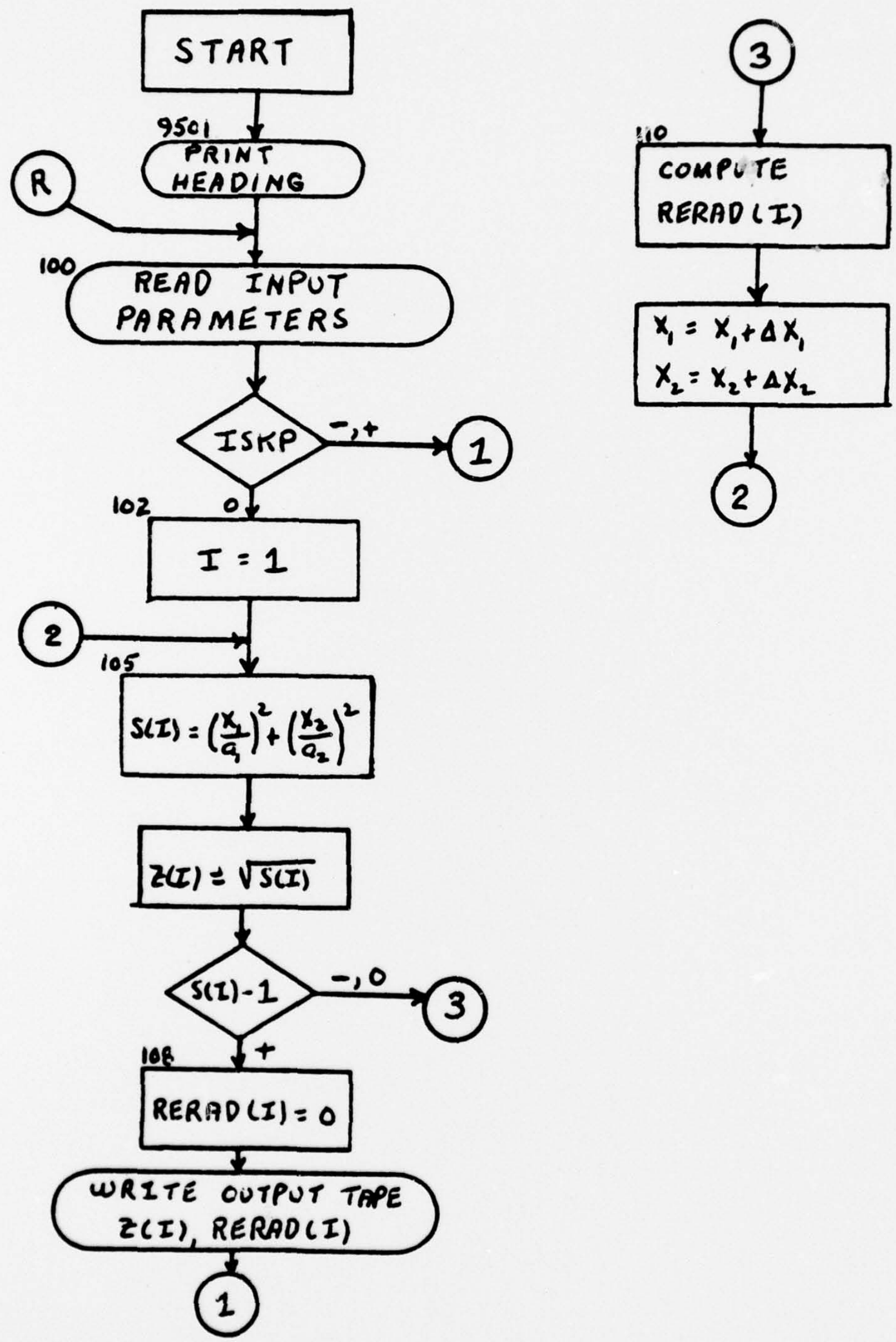
S (I)	$(x_1/a_1)^2+(x_2/a_2)^2$
Z (I)	$\sqrt{S(I)}$
RERAD(I)	Element of Reradiation Function Array
TRFER(I)	Element of Transfer Function Array
AKW(LM,I)	k w
RESP(LM,I)	Element of Impulse Response Array
RATI[illegible]I)	t/k
GS[illegible],J)	Element of Reradiated Waveform Array
A1	a_1
A2	a_2
X1	x_1
X2	x_2
C	c
V	v
N	ν
W	w
WMAX	Maximum value for w

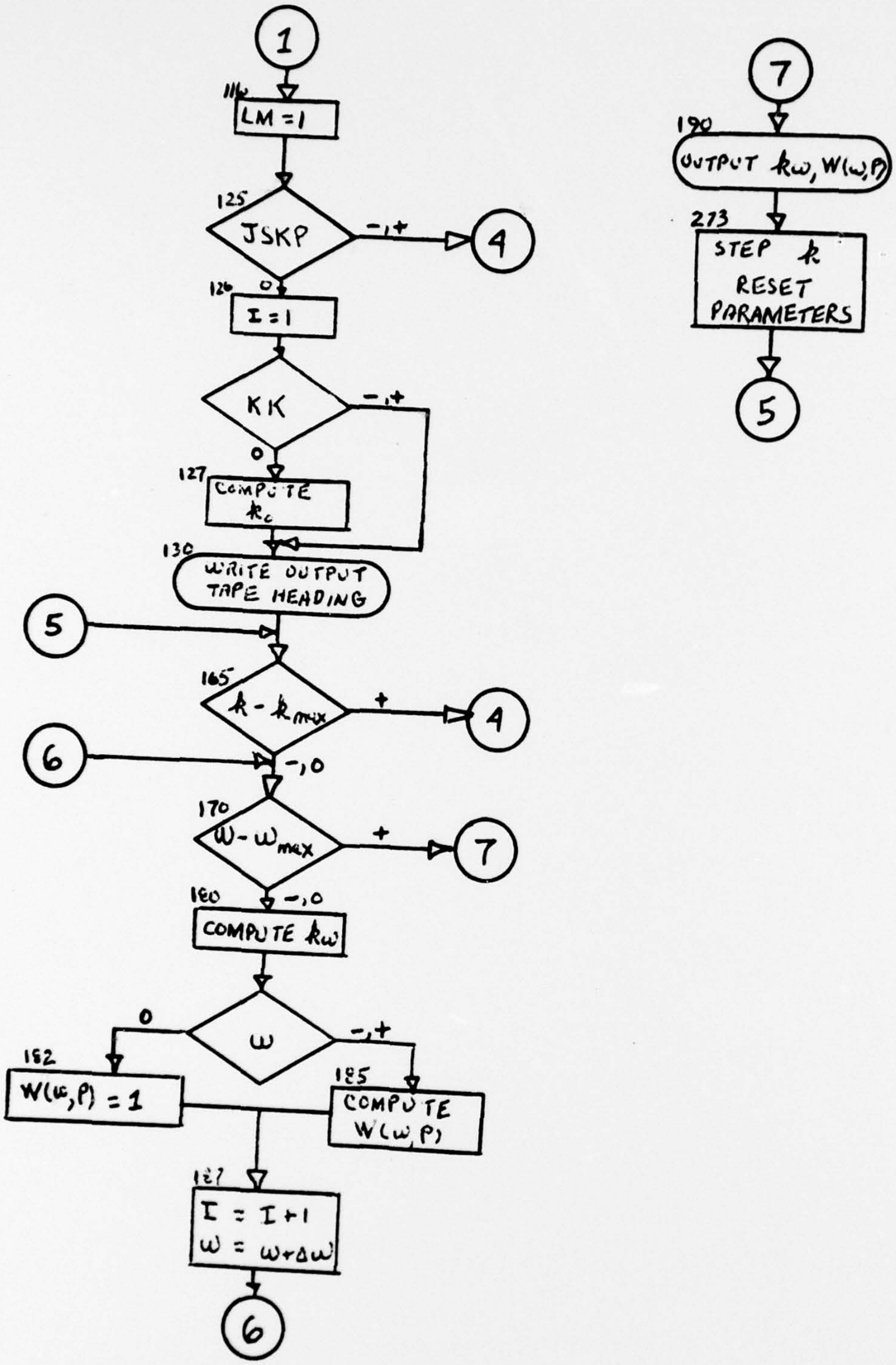
T	Initial value for t
AK	k
AKMAX	Maximum value for k
B1	Λ_1 } components of Λ
B2	Λ_2 } components of Λ
B3	N_1 } components of N
B4	N_2 } components of N
B5	Δx_1
B6	Δx_2
B7	Δt
B8	Increment of w
B10	$\Delta \tau$
B12	Δk
OMEGA	ω_0
DELTA	Δw
TT	Maximum value of τ
TAV	Initial va ue of τ
PHI	ϕ

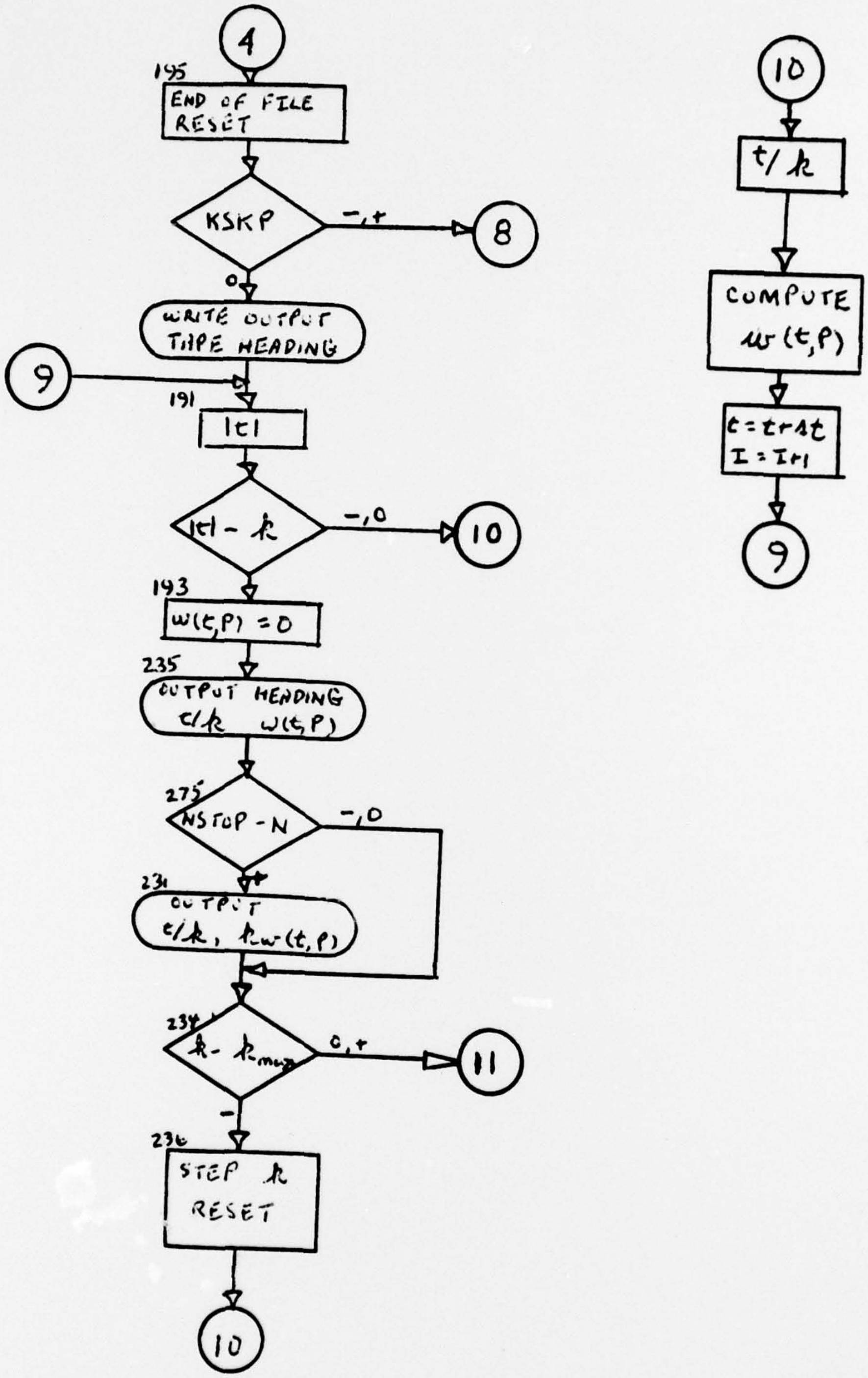
APPENDIX B

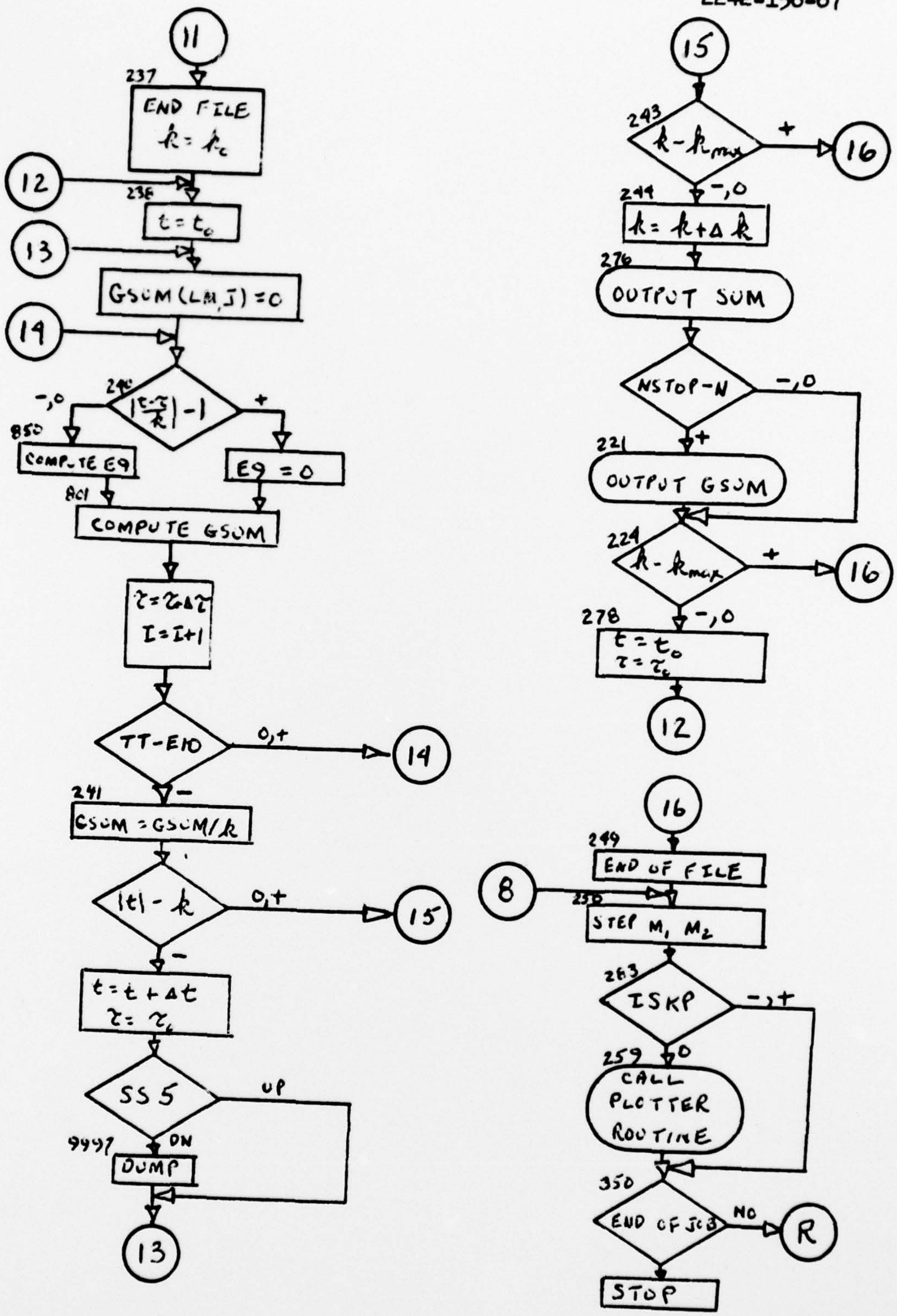
FLOW CHART FOR USL PROGRAM NO. 0837

"RERADIATION FUNCTION, TRANSFER FUNCTION, IMPULSE RESPONSE (CASE 1B)"


START
9501
PRINT HEADING
R
100
READ INPUT PARAMETERS
ISKP
-, +
1
102
0
I = 1
2
105
S(I) = (X1/a1)^2 + (X2/a2)^2
Z(I) = √S(I)
S(I)-1
-, 0
3
108
+
RERAD(I) = 0
WRITE OUTPUT TAPE
Z(I), RERAD(I)
1
3
110
COMPUTE
RERAD(I)
X1 = X1 + ΔX1
X2 = X2 + ΔX2
2


1
LM = 1
125
JSKP
-,+
4
0
I = 1
KK
-,+
0
127
COMPUTE k_c
130
WRITE OUTPUT TAPE HEADING
5
165
$k - k_{max}$
+
4
6
-,0
170
$\omega - \omega_{max}$
+
7
-,0
COMPUTE $k\omega$
ω
0
-,+
182
$W(\omega,P) = 1$
185
COMPUTE $W(\omega,P)$
$I = I+1$
$\omega = \omega + \Delta\omega$
6
7
190
OUTPUT $k\omega$, $W(\omega,P)$
273
STEP k
RESET PARAMETERS
5


4
195
END OF FILE
RESET
KSKP
-,+
8
0
WRITE OUTPUT
TAPE HEADING
9
191
|t|
|t| - k
-,0
10
193
w(t,P) = 0
235
OUTPUT HEADING
t/k w(t,P)
275
NSTOP - N
-,0
+
231
OUTPUT
t/k, kw(t,P)
234
k - kmax
0,+
11
-
236
STEP k
RESET
10
10
t/k
COMPUTE
w(t,P)
t = t+Δt
I = I+1
9


11
237
END FILE
12
t = t₀
13
GSUM (LM,J) = 0
14
-,0
+
850
COMPUTE E9
E9 = 0
801
COMPUTE GSUM
I = I+1
TT-E10
0,+
14
241
GSUM = GSUM/k
|t| - k
0,+
15
-
t = t + Δt
SS 5
UP
9997
ON
DUMP
13
15
243
+
16
244
-,0
276
OUTPUT SUM
NSTOP-N
-,0
+
221
OUTPUT GSUM
224
+
16
278
-,0
12
16
249
END OF FILE
8
250
STEP M, M₂
263
ISKP
-,+
259
0
CALL PLOTTER ROUTINE
350
END OF JOB
NO
R
STOP

APPENDIX C

FORTRAN PROGRAM NO. 0837

```
C      RERADIATION FUNCTION,TRANSFER FUNCTION,IMPULSE RESPONSE (CASE 1B)
C      D.A.STREMSKY
       DIMENSION Z(500),RERAD(500),APPLE(500),AKW(50,50),TRFER(50,50),RES
      1P(50,50),RATIO(50,50),B(150),S(500),GSUM(50,50),R(1000),IDUMP(18)
       DIMENSION BUFFER(1024),XAXIS(500),YAXIS(500)
STDJN  ALF    *0837
STECD  ALF    *
       WRITE OUTPUT TAPE 4,9501
 9501  FORMAT(1H1)
       READ INPUT TAPE 3,9502,DI
 9502  FORMAT(A5)
       IF(TDJN-DI)9503,9504,9503
 9503  PAUSE 6
 9504  WRITE OUTPUT TAPE 4,9502,DI
       WRITE OUTPUT TAPE 4,9505
 9505  FORMAT(10X32HD.A.STREMSKY,ROOM 3126,CODE 2242)
       READ INPUT TAPE 3,100,A1,A2,X1,X2,C,V,N,ISKP,JSKP,KSKP,NSTOP
  100  FORMAT(6F8.3,5I3)
       READ INPUT TAPE 3,101,W,WMAX,T,AK,KK,AKMAX
  101  FORMAT(4F8.3,2X,I2,2X,F8.3)
       READ INPUT TAPE 3,103,B1,B2,B3,B4,B5,B6,B7,B8,B12
  103  FORMAT(9F8.3)
       READ INPUT TAPE 3,104,AMEGA,DELTA,TT,TAU,B10,PHI
  104  FORMAT(6F8.3)
       W1=W
       AK1=AK
       T1=T
       TAU1=TAU
       NSTOP=NSTOP+1
       PIE=3.1415
       DEG=180./PIE
       C6=1.7724
       C1=N+1
       NP1=N+1
       NP2=N+2
       X=N
       C3=X+3./2.
       C10=X+1./2.
       C2=N+2
       C4=2.**C3
       C5=2.**C2
       C7=C4*C6/C5
       MPROD=1
       DO 160 I=1,NP2
       MNEW=2I-1
       MPROD=MPROD*MNEW
  160  CONTINUE
       PROD=MPROD
       IF(ISKP)116,102,116
  102  I=1
  105  S(I)=(X1/A1)**2+(X2/A2)**2
       SX=S(I)
       Z(I)=SQRTF(SX)
       ZM1=S(I)-1.
       IF(ZM1)110,110,108
  108  RERAD(I)=0.
       N1=I-1
```

```
      GC TC 261
  110 APPLE(I)=1.-S(I)
      PEAR=APPLE(I)**C10
      RERAD(I)=PEAR*C3/PIE
  115 X1=X1+B5
      X2=X2+B6
      I=I+1
      GC TC 105
  261 WRITE OUTPUT TAPE 4,251
  251 FCRMAT(1X36HZ                  RERADIATION FUNCTION)
      WRITE OUTPUT TAPE 4,252,(Z(I),RERAD(I),I=1,N1)
  252 FCRMAT(1X,F10.5,5X,F10.5)
      WRITE OUTPUT TAPE 4,253
  253 FCRMAT(///)
  116 LM=1
  125 IF(JSKP)195,126,195
  126 I=1
      IF(KK)130,127,130
  127 P1=B1-C*B3/V
      P2=B2-C*B4/V
      RB=(A1*P1)**2+(A2*P2)**2
      AK=SQRTF(RB)/C
  130 I=1
  194 WRITE OUTPUT TAPE 4,254
  254 FCRMAT(1X34HKW                   TRANSFER FUNCTION)
  165 IF(AK-AKMAX)170,170,195
  170 IF(W-WMAX)180,180,190
  180 AKW(LM,I)=AK*W
      IF(W)185,182,185
  182 TRFER(LM,I)=1.00000
      GC TC 187
  185 BOP=AKW(LM,I)
      CALL SPHJ(BOP,B)
      BANG=BOP**C3
      TRFER(LM,I)=C7*PROD*B(NP2)/BANG
  187 I=I+1
      W=W+B8
      GC TC 170
  190 N2=I-1
      N4=LM
      WRITE OUTPUT TAPE 4,255,((AKW(LM,I),TRFER(LM,I),I=1,N2),LM=N4,N4)
  255 FCRMAT(1X,F10.5,5X,F10.5)
  280 WRITE OUTPUT TAPE 7,273,((TRFER(LM,I),I=1,N2),LM=N4,N4)
  273 FCRMAT(F10.5)
      I=1
      W=W1
      LM=LM+1
      AK=AK+B12
      GC TC 165
  195 I=1
      END FILE 7
      END FILE 7
      LM=1
      AK=AK1
      IF(KSKP)250,265,250
  265 WRITE OUTPUT TAPE 4,257
  257 FCRMAT(1X34HT/K                  IMPULSE RESPONSE)
  191 ABSFT=ABSF(T)
```

```
      IF(ABSFT-AK)199,199,193
  193 RESP(LM,I)=0.
      N3=I-1
      GO TO 235
  199 NPROD=1
  200 DO 220 J=1,NP1
      NEWJ=J
      NPROD=NPROD*NEWJ
  220 CONTINUE
      PROD2=NPROD
      RATIO(LM,I)=T/AK
      G2=RATIO(LM,I)**2
      G3=1.-G2
      G4=G3**C1
      DEN=C5*PROD2
      RESP(LM,I)=PROD*G4/DEN
      T=T+B7
      I=I+1
      GO TO 191
  235 N3=I-1
      N4=LM
      WRITE OUTPUT TAPE 4,258,((RATIO(LM,I),RESP(LM,I),I=1,N3),LM=N4,N4)
  258 FORMAT(1X,F10.5,5X,F10.5)
  282 WRITE OUTPUT TAPE 8,275,((RESP(LM,I),I=1,N3),LM=N4,N4)
  275 FORMAT(F10.5)
      N3P1=N3+1
      IF(NSTOP-N3P1)234,234,231
  231 DO 232 I=N3P1,NSTOP
      RESP(N4,I)=0.0
  232 CONTINUE
      WRITE OUTPUT TAPE 8,233,((RESP(LM,I),I=N3P1,NSTOP),LM=N4,N4)
  233 FORMAT (F10.5)
  234 IF(AK-AKMAX)236,237,237
  236 AK=AK+B12
      LM=LM+1
      I=1
      T=T1
      GO TO 199
  237 LM=1
      END FILE 8
      END FILE 8
      N5=0
      AK=AK1
      I=1
  238 D11=B7/AK
      T=T1
      J=1
      D12=ABSF(D11)
  239 GSUM(LM,J)=0.
  240 FRACT=TAU/TT
      E1=AMEGA+DELTA*FRACT/2.0
      E2=E1*TAU
      E3=E2+PHI
      E4=COSF(E3/DEG)
      CALL AMP(TAU,R)
      FCN=R(I)*E4
      TDIF=(T-TAU)/AK
      GRAPE=ABSF(TDIF)
```

```
      PLUM=GRAPE-1.0
      IF(PLUM)850,850,279
  279 E9=0.0
      GO TO 801
  850 E5=GRAPE/D12
      NE5=E5
      IA=NE5+1
      IB=NE5+2
      E6=GRAPE-RATIO(LM,IA)
      E7=E6/D11
      E8=1.0-E7
      RSPN=E7*RESP(LM,IB)+E8*RESP(LM,IA)
      E9=FCN*RSPN*B10
  801 GSUM(LM,J)=GSUM(LM,J)+E9
      TAU=TAU+B10
      I=I+1
      E10=ABSF(TAU)
      IF(TT-E10)241,240,240
  241 GSUM(LM,J)=GSUM(LM,J)/AK
      ABSFT=ABSF(T)
      IF(ABSFT-AK)242,243,243
  242 T=T+B7
      J=J+1
      TAU=TAU1
      IF(SENSE SWITCH 5)9997,9999
 9997 DO 9998 LK=1,15
      IDUMP(LK)=+0
 9998 CONTINUE
      IDUMP(16)=-6
      IDUMP(17)=+0
      IDUMP(18)=N5
      CALL DUMP(IDUMP)
 9999 GO TO 239
  243 IF(AK-AKMAX)244,244,249
  244 AK=AK+B12
      N3=J-1
      N4=LM
  276 WRITE OUTPUT TAPE 6,277,((GSUM(LM,I),I=1,N3),LM=N4,N4)
  277 FORMAT(F10.5)
      N3P1=N3+1
      IF(NSTOP-N3P1)224,224,221
  221 DO 222 I=N3P1,NSTOP
      GSUM(N4,I)=0.00000
  222 CONTINUE
      WRITE OUTPUT TAPE 6,223,((GSUM(LM,I),I=N3P1,NSTOP),LM=N4,N4)
  223 FORMAT (F10.5)
  224 N5=N5+J+NSTOP-N3
      IF(AK-AKMAX)278,278,249
  278 LM=LM+1
      T=T1
      TAU=TAU1
      I=1
      GO TO 238
  249 END FILE 6
      END FILE 6
  250 M1=N1+1
      M2=N1+2
  283 IF(ISKP)350,259,350
```

```
259 CALL PLOTS(BUFFER(1024),1024,5)
    DC 260 J=1,N1
    XAXIS(J)=Z(J)
    YAXIS(J)=RERAD(J)
260 CONTINUE
    CALL PLOT (0.0,5.0,-3)
    CALL SCALE (YAXIS,5.0,N1,1,10.0)
    CALL SCALE (XAXIS,10.0,N1,1,10.0)
    CALL LINE (XAXIS,YAXIS,N1,1,1,11)
    CALL AXIS (0.0,0.0,20HRERADIATICN FUNCTION,20,5.0,90.0,YAXIS(M1),Y
   1AXIS(M2),10.0)
    CALL AXIS (0.0,0.0,1HZ,-1,10.0,0.0,XAXIS(M1),XAXIS(M2),10.0)
    CALL PLOT (0.0,0.0,999)
350 READ INPUT TAPE 3,9502,ED
    IF (ED-TECD)9503,9509,9503
9509 WRITE OUTPUT TAPE 4,9511
9511 FCRMAT(4HCEND)
    END FILE 4
9510 STCP 5
    END(1,1,0,1,1)
```

```
C      SPHERICAL BESSEL FUNCTION J .       R. D. WHITTAKER          0614
C
       SUBROUTINE SPHJ (X,B)
       DIMENSION B(200),BL(200),SC(4),A(2)
       BE=1.0E-10
       DO 5 I=1,200
       BL(I)=0.0
     5 B(I)=0.0
       X=X*1.0
S      STO A(2)
S      STQ XL
S      STQ A(1)
       IF (X-.05) 45,6,6
     6 IF (X-100.) 7,7,45
     7 IF (X-10.) 8,15,15
     8 RN=72./(4.02-LOGF(X))
       GO TO 20
    15 RN=1.51*X+25.
    20 MAX=RN+1.0
       N=MAX-2
       B(MAX-1)=BE*1.0
S      STQ BL(MAX-1)
       DO 35 I=1,N
       J=MAX-I+1
       AN=(2*J-3)
       AN=AN*1.0
       CALL DPA1
S      CLA B(J-1)
S      LDQ BL(J-1)
       CALL DPA13
S      STO VH
S      STQ VL
S      CLA X
S      LDQ XL
       CALL DPA1
S      CLA VH
S      LDQ VL
       CALL DPA14
S      STO VH
S      STQ VL
S      CLA B(J)
S      LDQ BL(J)
       CALL DPA1
S      CLA VH
S      LDQ VL
       CALL DPA12
S      STO B(J-2)
S      STQ BL(J-2)
    35 CONTINUE
       CALL DPSC (A(2),SC(4),IDUMMY)
S      CLA X
S      LDQ XL
       CALL DPA1
S      CLA B(1)
S      LDQ BL(1)
       CALL DPA13
       CALL DPA1
S      CLA SC(4)
```

```
S       LDG SC(3)
        CALL DPA14
S       STO VH
S       STQ VL
        MAX=MAX-2
        DO 40 I=1,MAX
S       CLA VH
S       LDQ VL
        CALL DPA1
S       CLA B(I)
S       LDQ BL(I)
        CALL DPA13
S       STO B(I)
     40 CONTINUE
        B(MAX+1)=0.0
     45 RETURN
        END(1,1,0,1,1)
```