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TRANSFER FUNCTION, IMPULSE RESPONSE AND RERADIATED WAVEFORM FOR--ETC(U)
MAY 67 D A STREMSKY

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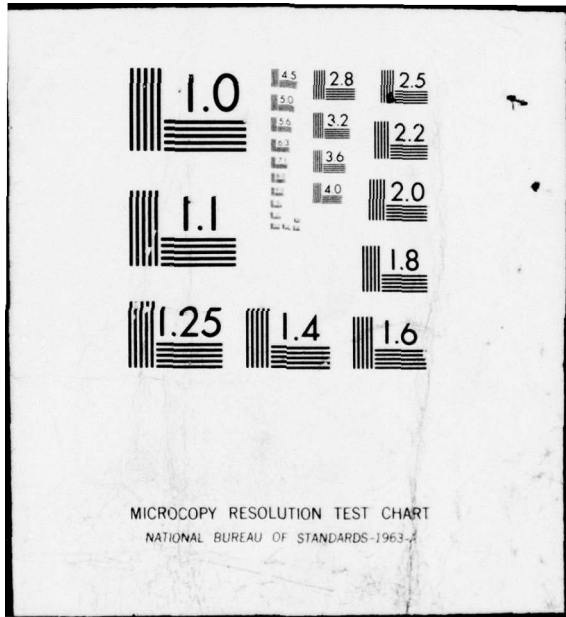
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USL Technical Memorandum
2242-157-67

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9 Technical memos

TRANSFER FUNCTION, IMPULSE RESPONSE AND
RERADIATED WAVEFORM FOR AN ELLIPTICALLY SYMMETRIC
RERADIATION FUNCTION OF THE FORM z^p , INTEGRAL
(USL PROGRAM NO. 0832)

z to the n th power, n

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11 1 May 1967

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by

10 Donald A. Stremsky

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U. S. NAVY UNDERWATER SOUND LABORATORY
FORT TRUMBULL, NEW LONDON, CONNECTICUT

TRANSFER FUNCTION, IMPULSE RESPONSE AND
RERADIATED WAVEFORM FOR AN ELLIPTICALLY SYMMETRIC
RERADIATION FUNCTION OF THE FORM z^{ν} , ν INTEGRAL
(USL PROGRAM NO. 0832)

by

Donald A. Stremsky

USL Technical Memorandum No. 2242-157-67

1 May 1967

INTRODUCTION

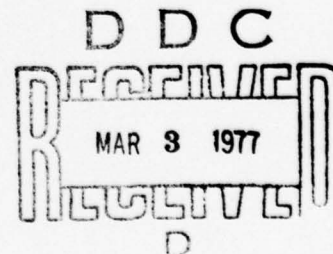
A computational program has been prepared by the Information Processing Division to compute a particular Reradiation Function $w(x)$, Transfer Function $W(w, P)$, Impulse Response $w(t, P)$ and Reradiated Waveform $g(t, P)$ as defined below in terms of the incident plane wave pulse. This IBM 704 Program, designated USL Program No. 0832, is in Fortran II language and is described in Appendixes A and B. Similar computational programs are described in USL Tech. Memo. No. 2242-111-67 and 2242-156-67.

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 integer values of ν

- (a) $a_1 a_2 w(x)$
- (b) $W(w, P)$



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(c) $kw(t, P)$

(d) $kg(t, P)$

where

$$(1) \quad v(x) = \begin{cases} \frac{\nu+1}{a_1 a_2 \pi} \left[1 - \left(\frac{x_1}{a_1} \right)^2 - \left(\frac{x_2}{a_2} \right)^2 \right]^{\nu} & , x \in A \\ 0 & , x \notin A \end{cases}$$

$$A: \left(x_1/a_1 \right)^2 + \left(x_2/a_2 \right)^2 \leq 1, \nu > -1$$

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

$$x = \frac{1}{c} \left[(a_1 p)^2 + (a_2 p)^2 \right]^{\frac{1}{2}}$$

$$(3) \quad v(t, P) = \begin{cases} \frac{\Gamma(\nu+2)}{k(\nu+\frac{1}{2})\pi^{\frac{1}{2}}} \left[1 - \left(\frac{t}{k} \right)^2 \right]^{\nu+\frac{1}{2}} & , |t| \leq k \\ 0 & , |t| > k \end{cases}$$

$$(4) \quad g(t, P) = \int_{-\infty}^{\infty} f(z) w(t-z, P) dz$$

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

Note: Program #0837 as described in USL Tech. Memo. No. 2242-156-67 computes the above mentioned functions for half-integer values of ν .

COMPUTER PROGRAM DESCRIPTION

A nomenclature listing for USL Program No. 0832 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

<u>Card No.</u>	<u>Cols.</u>	<u>Contents</u>
1	1-8	a_1
	9-16	a_2
	17-24	x_1
	25-32	x_2
	33-40	c
	41-48	v
	49-51	\bar{v}
	52-54	ISKP (set equal to zero to compute Reradiation Function)
	55-57	JSKP (set equal to zero to compute Transfer Function)
	58-60	KSKP (set equal to zero to compute Impulse Response and Reradiated Waveform).
2	61-63	For long jobs requiring the use of a dump tape at least one of the above options variables should not be set equal to zero NSTOP (in reference to Reradiated Waveform Array (k,t) NSTOP is the number of times t is incremented when k has its maximum value.
		Initial value of ω Maximum value for ω Initial value of t Initial value of k (if not computed) KK (if set equal to zero, initial value of k will be computed)

<u>Card No.</u>	<u>Cols.</u>	<u>Contents</u>
2	39-46	Maximum value for k
3	1-8	λ_1
	9-16	
	17-24	ν_1
	25-32	
	33-40	Δx_1
	41-48	Δx_2
	49-50	Δt
	57-64	Increment of w
	65-72	Δk
4	1-8	w_0
	9-16	Δw
	17-24	Maximum value of τ
	25-32	Initial value of τ
	33-40	Δz
	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

<u>Tape Unit No.</u>	<u>Tape Identification</u>
3	Data Input
4	Values for Reradiation Function, Transfer Function & Impulse Response.

Tape Units Required (cont'd)

5	Calcomp Plotter containing values for Reradiation Function
6	Reradiated Waveform Array (k,t)
7	Transfer Function Array (k,w)
3	Impulse Response Array (k,t)
{0	Dump Tape

{SS5 must be down to dump
No other sense switches are used

Subroutines Required

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

Subroutine Besgen computes the values of cylindrical 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. Tape Unit Nos. 6,7, and 8 can be used as input to USL Program No. 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. 0832, 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) E. P. Jensen, "Scattering of a Cylindrical Wave by a Symmetric Array of Cylinders", USL Tech. Memo. No. 907-173-64, of 12 October 1964.

APPENDIX A

NOMENCLATURE LISTING FOR USL PROGRAM NO. 0832

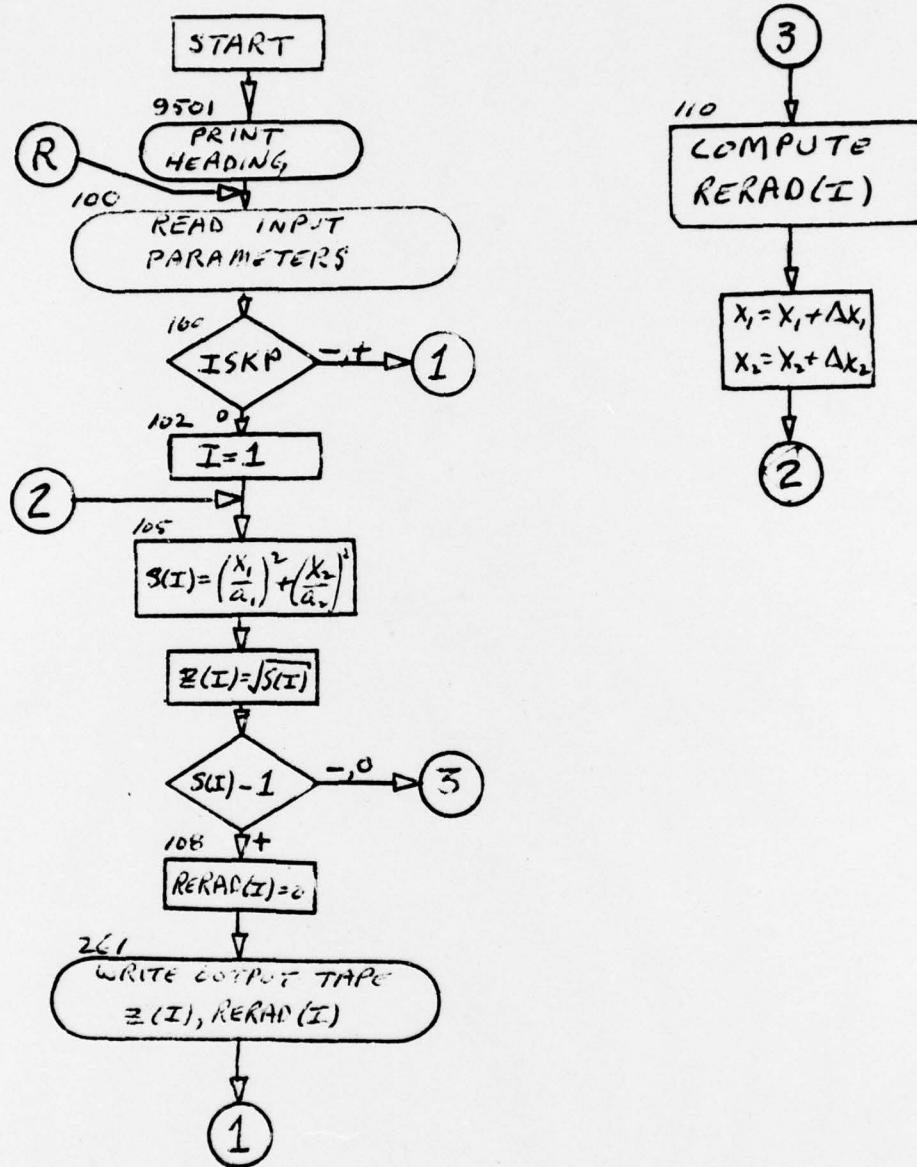
S(I)	$(\tau_1/k_1)^2 + (\tau_2/k_2)^2$
Z(I)	$\sqrt{S(I)}$
RERAD(I)	Element of Reradiation Function Array
TRFER(I)	Element of Transfer Function Array
AKW(LM,I)	<i>kw</i>
RESP(LM,I)	Element of Impulse Response Array
RATIO (LM,I)	t/k
GSUM (LM,J)	Element of Reradiated Waveform Array
A1	a_1
A2	a_2
X1	x_1
X2	x_2
C	c
V	v
N	η
W	w
WMAX	Maximum value for w
T	Initial value for t
AK	k

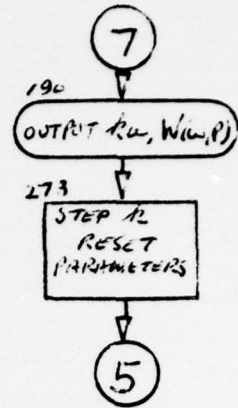
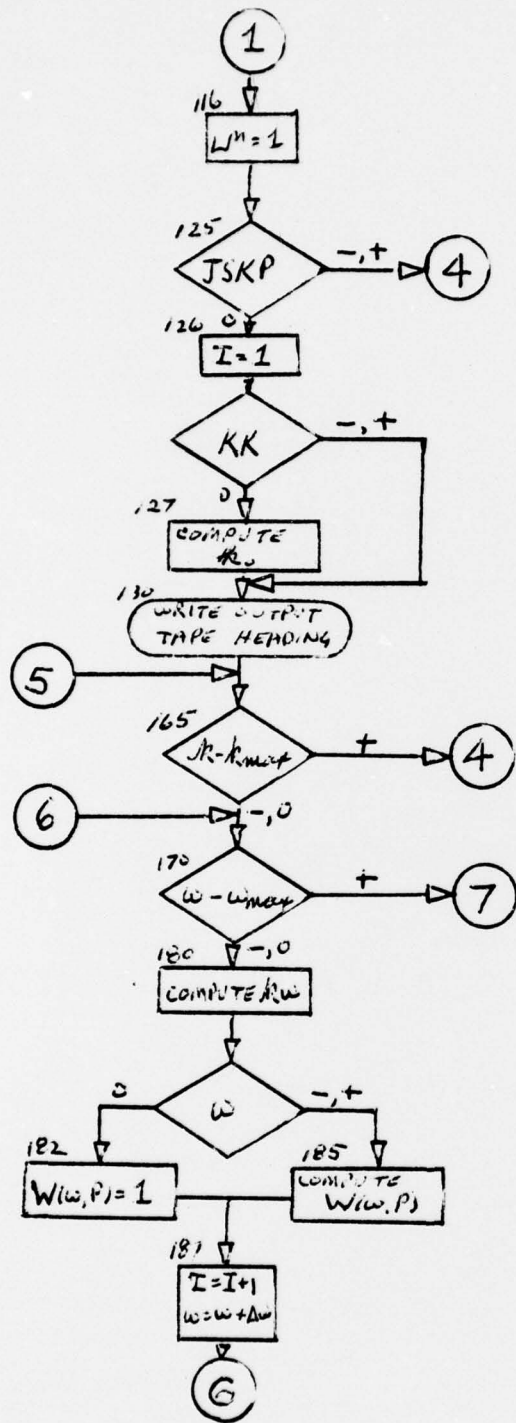
AKMAX	Maximum value for k
B1	λ_1 }
B2	λ_2 } components of Λ
B3	ν_1 }
B4	ν_2 } components of N
B5	Δx_1
B6	Δx_2
B7	Δt
B8	Increment of w
B10	Δz
B12	Δk
OMEGA	w_0
DELTA	Δw
TT	Maximum value of z
TAV	Initial value of z
PHI	ψ

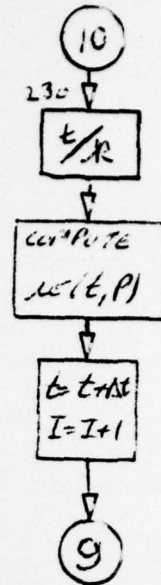
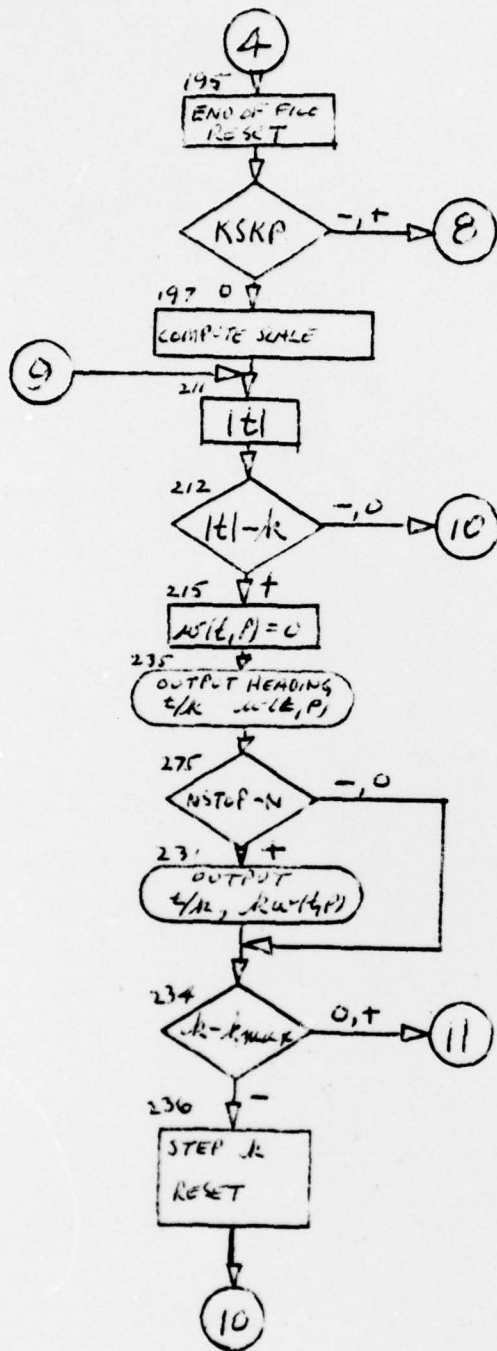
APPENDIX B

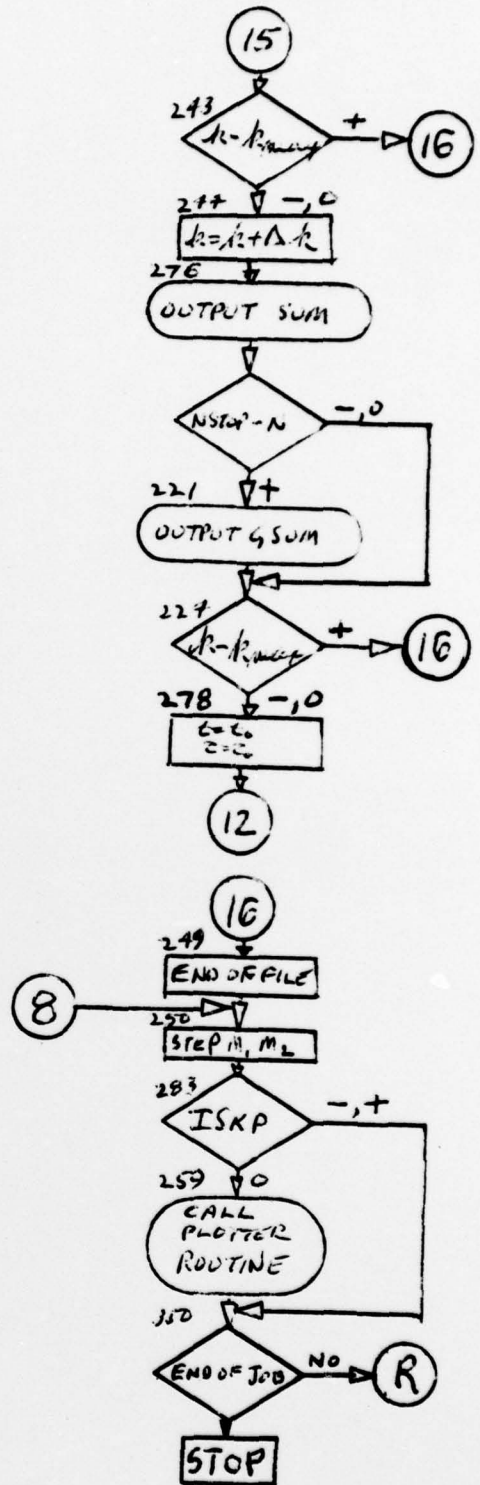
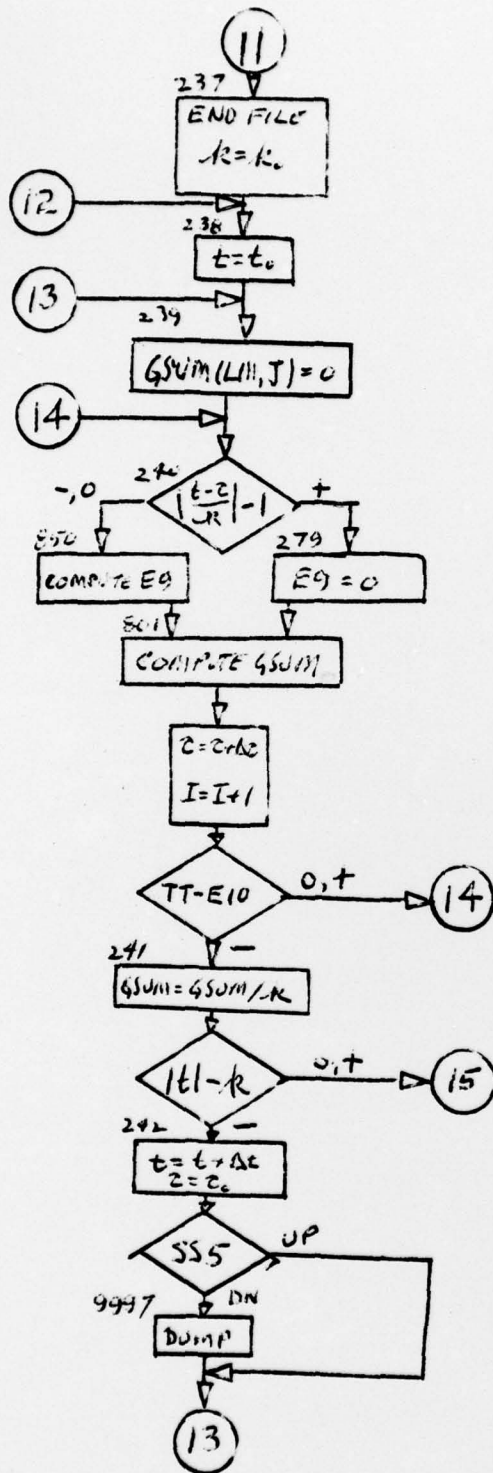
FLOW CHART FOR USL PROGRAM NO. 0832

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









USL Tech. Memo.
2242-157-67

APPENDIX C
FORTRAN PROGRAM NO. 0832


```

C   RERADIATION FUNCTION,TRANSFER FUNCTION,IMPULSE RESPONSE (CASE 1A)
C   D.A.STREMSKY
    DIMENSION Z(500),RERAD(500),APPLE(500),AKW(50,50),B(200),TRFER(50,
150),RESP(50,50),RATIO(50,50),S(500),GSUM(50,50),R(1000),IDUMP(18)
    DIMENSION BUFFER(1024),XAXIS(500),YAXIS(500)
STDJN ALF   *0832
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
    NSTCP=NSTOP+1
    NP1=N+1
    NP2=N+2
    C1=N+1
    PIE=3.1415
    DEG=180./PIE
    C2=2.**C1
    C3=N+2
    NPRCD=1
150   DC 160 I=1,NP1
    NEWI=I
    NPRCD=NPRCD*NEWI
160   CONTINUE
    PROD=NPROD
    C4=C2*PROD
    IF(ISKP)116,102,116
102   I=1
105   S(I)=(X1/A1)**2+(X2/A2)**2
    SX=S(I)
    Z(I)=SQRT(SX)
    ZM1=S(I)-1.0
    IF(ZM1)110,110,108
108   RERAD(I)=0.
    N1=I-1
    GO TO 261
110   APPLE(I)=1.-S(I)
    IF(N)112,111,112
111   PEAR=1.0
    GO TO 113
112   PEAR=APPLE(I)**N

```

```

113 RERAD(I)=PEAR*C1/PIE
115 X1=X1+B5
      X2=X2+B6
      I=I+1
      GO TO 105
261 WRITE OUTPUT TAPE 4.251
251 FORMAT(1X36HZ          RERADIATION FUNCTION)
      WRITE OUTPUT TAPE 4.252.(Z(I)*RERAD(I),I=1,N1)
252 FORMAT(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
263 WRITE OUTPUT TAPE 4.254
254 FORMAT(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
      GO TO 187
185 BCP=AKW(LM,I)
      CALL BESGEN(BOP,B)
      BANG=BOP**C1
      TRFER(LM,I)=C4*B(NP2)/BANG
187 I=I+1
      W=W+B8
      GO TO 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 FORMAT(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
      GO TO 165
195 I=1
      END FILE 7
      END FILE 7
      LM=1
      AK=AK1
      IF(KSKP)250,197,250
197 MPROC=1
      DO 210 M=1,NP1
      MNEW=2M-1
      MPROC=MPROC*MNEW
210 CCNTINUE
      PROC2=MPROC

```

```

      C5=C4/(PIE*PRCD2)
265 WRITE OUTPUT TAPE 4,257
257 FORMAT(1X34HT/K
211 ABSFT=ABSF(T)
212 IF (ABSFT-AK)230,230,215
215 RESP(LM,I)=0.
      N3=I-1
      GO TO 235
230 RATIO(LM,I)=T/AK
      G2=RATIO(LM,I)**2
      G3=1.-G2
      FN=N
      EXP=FN+.5
      G4=G3**EXP
      RESP(LM,I)=C5*G4
      T=T+B7
      I=I+1
      GO TO 211
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)
262 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 DC 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 230
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 CSUM(LM,J)=0.
240 FRACT=TAU/TT
      E1=AMEGA*DELTA*FRACT/2.0
      E2=E1*TAU
      E3=E2*PHI
      E4=CCSF(E3/DEG)
      CALL AMP(TAU,R)
      FCN=R(I)*E4
      TDIF=(T-TAU)/AK
      GRAPE=ABSF(TDIF)
      PLUM=GRAPE-1.0

```

IMPULSE RESPONSE)

```

      IF (PLUM) 850,850,279
279  E9=0.0
      GC TO 801
850  E5=GRAPE/D12
      NE5=F5
      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=ARSF(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  DC 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
      GC 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)

```



```
DO 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 (0.0,0.0,20HRERADIATION 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-TEOD)9503,9509,9503
9509 WRITE OUTPUT TAPE 4,9511
9511 FORMAT(4HOEND)
END FILE 4
9510 STOP 5
END(1,1,0,1,1)
```



```

SUBROUTINE BESGEN (X,B)
DIMENSION B(200)
BE = 1.0E-5
Y=SINF(1.0)
Z=CCSF(1.0)
D=SGRTF(2.0)
DC 5 I=1,200
5 B(I)=0.0
  IF (X-10.) 6,7,7
6 RN=35.0/(3.5-LOGF(X))
  GC TO 8
7 RN=1.05*X+25.
8 N=RN
  IF (N-198) 9,9,206
206 B(200) =0.0
  B(199) = BE
207 AN = N
  STORE = 2.0*AN*B(199)/X-B(200)
  B(200) = B(199)
  B(199) = STORE
  N=N-1
  IF (N-198) 280,280,207
9 B(N+2)=0.0
  B(N+1)=BE
280 MAX=N+2
  DO 10 I=1,N
  J=MAX-I+1
  AN=J-2
  B(J-2)=2.0*AN*B(J-1)/X-B(J)
10 CONTINUE
  CALL JO(X,BES)
  C1=BES/B(1)
  DO 15 I=1,MAX
  B(I)=B(I)*C1
15 CONTINUE
16 RETURN
  END(1,1,0,1,1)

```