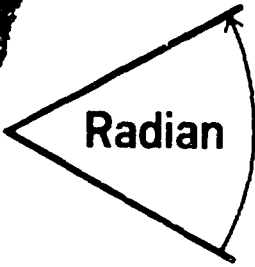


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AUTHORITY
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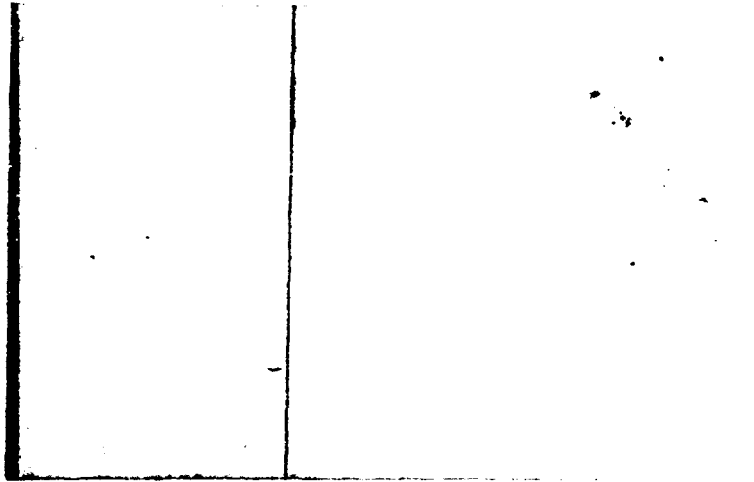
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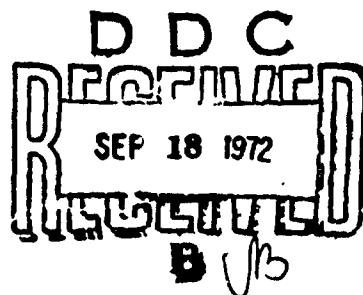
Radian Corporation

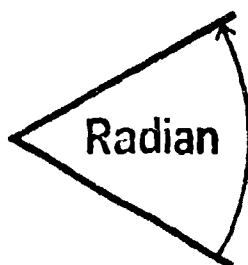
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FINAL REPORT

CONTRACT NO. N00024-71-C-1246 *1/6/72*

SUPPORT TASKS FOR TRANSDUCER ANALYSIS AND DIFFRACTION INVESTIGATIONS

Submitted to:

Commander
Naval Ship Systems Command
Department of the Navy
Washington, D.C.

code 12052

Distribution limited to U.S. Gov't. agencies only;
Test and Evaluation; **18 SEP 1972**
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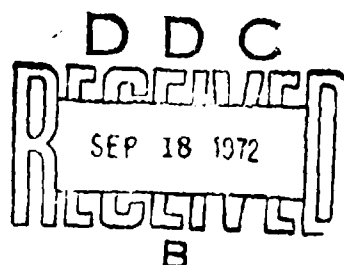


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1.0

INTRODUCTION

This report describes the work performed by Radian Corporation on Contract No. N00024-71-C1246 from 1 July 1971 to 1 September 1972. This work consisted of on-site support to Naval Undersea Research and Development Center (NUC) personnel in the area of sonar transducer analysis and design. In addition, work was performed to investigate the effects of diffraction and transmission characteristics of planar baffles on passive array performance.

2.0

TRANSDUCER ANALYSIS AND DESIGN

This section describes the work performed in the on-site support to the Transducer and Array Systems Division of NUC, San Diego. This work involves the computer-aided transducer analysis and design using SEADUCER (Steady-state Evaluation and Analysis of TransDUCERs). This computer model is designed to model any linear system which can be described as an interconnection of multi-port networks; however, its function for this contract was related strictly to sonar transducers. The on-site support included the following tasks:

- Reformat magnetic tapes supplied to NUC by General Dynamics/Electric Boat Division that contained impedances and velocities to be compatible with SEADUCER input format.
- Design and set up SEADUCER runs to analyze the properties of the 3C5 transducer elements varying the element configuration.
- Review documentation of Modest Improvement Plan (MIP) for the TR-208 active transducer element.
- Convert SEADUCER from UNIVAC 1108 EXEC 8 to UNIVAC 1108 EXEC II, and execute several example runs.

Reformatting the 9 track magnetic tapes to a format compatible with the SEADUCER input format was accomplished via subroutines written for the NUC UNIVAC 1108 facility. The data on the tapes supplied by GD/EB were impedance matrices and

velocities for different heads for the 3C5 transducer. The impedances matrices were reduced to determine an array of unique impedances to be used in the computation of various performance variables as a function of frequency. This process was done to reduce the computation time associated with the performance variables.

Radian assisted NUC personnel in the design and set-up of a single frequency design run to analyze the 3C5 element (Run No. 80168). The analysis consisted of examination of the element without a can, and then adding the can and mounts to determine their effect on the element performance. The 3C5 element was also analyzed with different transducer heads that were designed by GD/EB.

The documentation of the Modest Improvement Plan was reviewed by Radian. This documented work performed by NUC and assisted by Radian for improvement at the performance of the TR-208 active transducer element. The analysis consisted of computed critical performance variables as a function of frequency and displaying these via a Calcomp plotter.

The SEADUCER computer model was implemented at the Radian facility which utilizes a UNIVAC 1108 operating under the EXEC II operating system. This required some minor changes in control cards from the NUC UNIVAC 1108 EXEC 8 version. Radian converted the magnetic tape supplied by NUC using a program supplied by UNIVAC. After conversion of the tape, the model was checked by running the example runs that are included in the SEADUCER model documentation. Two of these example runs are included in Appendix A.

3.0 DIFFRACTION INVESTIGATIONS

This section describes the support effort that Radian has provided in connection with NUC investigations on passive-array baffle design. These efforts have been concerned with developing a computer model to investigate the effects of diffraction and transmission characteristics of planar baffles on passive-array performance.

The modeling efforts represent one facet of an overall exploratory development program whose objective is to provide design guidelines for improved baffles to enhance the low frequency, passive performance of wide aperture arrays. Due to the increased size and weight requirements associated with extending the conventional puffs baffle concept to lower frequencies, the goal of the development effort is to examine possible alternatives to design a functional baffle which is effective in shielding the array from internal machinery noise and simultaneously enhances low frequency, passive-array performance.

In connection with this program, Radian's support efforts have involved development of a computer model to characterize the scattering and transmission properties of planar strip baffles. To date a working computer model has been developed for calculating the pressure field in the vicinity of a planar baffle which accounts for the combined effects of transmission and diffraction from a half plane. A version of this computer program is operational on the UNIVAC 1230 at NUC and is being used in conjunction with an experimental investigation of scattering from rectangular plates of various materials for a wide range of frequencies. In addition, this model is currently being generalized to treat the case of a planar strip baffle according to the approach outlined in Appendix B.

These efforts represent an initial attempt, as part of a continuing investigation, toward the synthesis of a valid composite math model to perform parametric analyses of significant baffle parameters on performance of passive-arrays.

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Appendix A

Examples of SEADUCER Run Under UNIVAC 1108 EXEC II.

This appendix shows examples of the SEADUCER model run under UNIVAC 1108 EXEC II. The purpose of this task was to demonstrate that the SEADUCER model was written in standard FORTRAN and could operate under different operating systems, and also on different types of computers. The task also made available to potential users of the model a version that had compiled and executed correct under the EXEC II operating system.

The first example presented here is a single frequency transducer element design. The transducer element is described by defining network interconnections and specifying individual network types. Then for a variety of tail lengths, ceramic areas, and ceramic lengths, the problem is to determine the number of ceramic pieces required to minimize the voltage-velocity control impedance, Z_{ec} . The second example is strictly a matrix calculation for a given transducer element configuration, and was included since it checks many of the features of the model.

SI 100 CONTROL/5-CONTROL/R
UNIVAC 1108 FORTRAN V LEVEL 225A 0023

16:58:12.341

DATA PROGRAM

STORAGE USED (BLOCK, NAME, LENGTH)

0001	*CODE	001153
0002	*DATA	000000
0003	*CONTROL	000000
0004	*CONTROL	000000
0005	*CONTROL	000000
0006	*CONTROL	000000
0007	*CONTROL	000000
0008	*CONTROL	000000
0009	*CONTROL	000000
0010	*CONTROL	000000
0011	*CONTROL	000000
0012	*CONTROL	000000
0013	*CONTROL	000000
0014	*CONTROL	000000
0015	*CONTROL	000000
0016	*CONTROL	000000
0017	*CONTROL	000000

EXTERNAL REFERENCES (BLOCK, NAME)

0020	NAME	0021	STLIN
0025	LDST7	0026	ALOGAT
0032	LDPR59	0033	PLMKL
0037	LOCMT	0040	2TCL
0044	ENFL	0045	PD7MS
0051	PDCTLS	0052	PDCTLS
0056	LDST68	0057	PDCTLS
0022	LDPORT	0023	LDST4
0027	SKPLIN	0030	LDST4
0034	RDCPT	0035	LDST4
0041	PDCTLS	0042	LDST4
0046	PDCTLS	0047	LDST4
0053	PDCTLS	0054	LDST4
0024	LDST4	0031	LDST4
0036	LDST4	0043	LDST4
0043	LDST4	0050	LDST4
0050	LDST4	0055	LDST4
0021	STLIN	0026	ALOGAT
0033	PLMKL	0040	2TCL
0045	PD7MS	0046	PDCTLS
0052	PDCTLS	0057	PDCTLS
0057	PDCTLS	0058	PDCTLS

STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000067	100L	0000	000407	149F	0000	000427	150F	0000	000431	152F
------	--------	------	------	--------	------	------	--------	------	------	--------	------

[illegible]

```

1* 00101 IMPLICIT DOUBLE PRECISION (D)
2* 00102 COMMON / CATALOG / NAME(100), NFR SIZE(100), I PC(100),
3* 00103 1 N PC TOT(100), I TYPE(100), N DT STR(100), LOC(100), I CLG SB
4* 00104 COMMON / BASIC S / D F, D CRESA, D PI
5* 00105 COMMON / STA TOT / MX DATA
6* 00106 COMMON / DATA(100)
7* 00107 COMMON / TOT L / DT L
8* 00108 COMMON / TOT MAX / DT MASS
9* 00109 COMMON / EST OFF / NO EST
10* 00110 COMMON / C FWH B2 / I FWH BR
11* 00111 COMMON / CDESEN / RL P241, RA R221, RA CSD, NP GE MN, RA R201
12* 00112 COMMON / GW EC IC / GECOR, DCECI, DGICR, DGICI, DZECR, DZECI, DZICR, DZICI
13* 00113 COMMON / C RM PCT / DGM, DREACT
14* 00114 COMMON / C SOUTR / MTD GVN
15* 00115 COMMON / FLG SPH / I MY MN, I SC IC, I FLG SP, I FLG LC
16* 00116 COMMON / CWN FWH / MIN SXP, MAX SXP, NI POL Q

```

```

17* DIMENSION T241 L(15)
18* DIMENSION C30 A(15)
19* DIMENSION L NAMES(4)
20* DIMENSION L R201(15)
21* DATA L NAMES(1), L(1,4) / 'TA', 'CO', 'FE', 'YZ' /
22* DATA L R201(1), L(1,3) / 'Y', 'Z', 'C' /
23* DATA C30 A(1), A(1,5) / .0049, .0065, .00752, .0081, .012893 /
24* DATA T241 L(1), L(1,5) /
25* / .0381247, .0762493, .114374, .152499, .190623 /
26* DATA N1 MOD / 1 /
27* *X DATA = 1310
28*
29* CALL PAGE
30* CALL STOP LIN
31* PRINT 5
32* S FORMAT, MOD 8 RUN 80038 APR 23, 1370 S LIKE MOD 7 RUN 70335 /
33* /
34* / DESIGN RUN 87 /
35* / LOWER OF CONSTANT TAIL LENGTHS /
36* / CHARGE TO 10000501 4FRAY DESIGN /
37*
38* CALL LD PORT ( 'S', '1R7D', ->IT1A, ->1R2A, 'S' )
39* CALL LD PORT ( 'S', '2R7D', '1R2E', 'S' )
40* CALL LD PORT ( 'S', '3R7D', '2R2A', 'S' )
41* CALL LD PORT ( 'S', '4R7D', '3R2E', 'S' )
42* CALL LD PORT ( 'S', '5R7D', '4R2A', 'S' )
43* CALL LD PORT ( 'S', '6R7D', ->2R2E, '1V2W', '1V2Z', 'S' )
44* CALL LD PORT ( 'S', '7R7D', ->IT1B, '2R2Z', '2V2W', 'S' )
45*
46* CALL LD PORT ( 'S', '1A6D', '3C2D', 'S' )
47* CALL LD PORT ( 'S', '2A6D', '4R2E', 'S' )
48* CALL LD PORT ( 'S', '3A6D', ->2C2D, '2R5D', 'S' )
49* CALL LD PORT ( 'S', '4A6D', ->1R5D, '1C3D', 'S' )
50* CALL LD PORT ( 'S', '5A6D', ->3R5D, '1R2D', 'S' )
51* CALL LD PORT ( 'S', '6A6D', ->4R5D, '2R2E', 'S' )
52*
53* CALL LD OT1('2241E', 441E, 9C, 1, 44261E-2, 0, 0, 0, .0090693, 4620, 0, 0, 0, 0)
54* RL R241 = .0072454
55* CALL LD OT1('2241E', 7702, 80, 7, 90233E-4, 0, 0, 0, .0072484, 4970, 0, 0, 0, 0)
56* RL R271 = .0002379
57* CALL LD OT1('2241E', 7702, 80, 7, 90233E-4, 0, 0, 0, .0002379, 4970, 0, 0, 0, 0)
58* CALL LD OT1('2241E', 7702, 80, 7, 90233E-4, 0, 0, 0, .0002379, 4970, 0, 0, 0, 0)
59* CALL LD OT1('2241E', 7702, 80, 7, 90233E-4, 0, 0, 0, .0002379, 4970, 0, 0, 0, 0)
60* CALL LD OT1('2241E', 7702, 80, 7, 90233E-4, 0, 0, 0, .0002379, 4970, 0, 0, 0, 0)
61* CALL LD OT1('2241E', 7702, 80, 7, 90233E-4, 0, 0, 0, .0002379, 4970, 0, 0, 0, 0)

```

```

CALL LD DT1('T24S', 7702.60, 7.302735E-4, 0.0, 0.066793, 4370.0, 0.0)
CALL LD DT1('V2W1S', 4416.50, 1.12775E-2, 0.0, 0.0113701, 4820.0, 0.0)
CALL LD DT1('V2W2S', 4416.50, 1.12775E-2, 0.0, 0.0113701, 4820.0, 0.0)
CALL LD DT1('V2W3S', 7728.40, 2.34984E-3, 0.0, 0.022244, 5116.0, 0.0)
CALL LD DT1('V2T1S', 2712.61, 3.48119E-3, 0.0, 0.0113701, 5255.0, 0.0)
CALL LD DT1('V2T2S', 12.91, 3.48119E-3, 0.0, 0.0113701, 5255.0, 0.0)
CALL LD DT1('V2T3S', 12.91, 3.48119E-3, 0.0, 0.0113701, 5255.0, 0.0)
CALL PAGE
      GRM Y2Z4 = 2.755
      RL Y2Z4 = .04516
      FACTOR = 1.
      IFOR = 0
CALL LD DT 71 'Y2Z4S', FACTOR, I FORM)

      IPUNCH = 1
      IPUNCH = 0
      MAX SKP = 1
      POL G = 1

      CALL ALLOCAT('FS', 2, 8)
      IF2S = LOC(I CLG SB)
      CALL ALLOCAT('DS', 2, 9)
      ID2S = LOC(I CLG SB)
      CALL ALLOCAT('ES', 2, 3)
      IS2S = LOC(I CLG SB)
      CALL SKP LIN(1)
      CALL LD I MTR(IF2S, 2)
      CALL HEAD 24('F2S UNIT MATRIX
      CALL LD I MTR(ID2S, 2)
      CALL HEAD 24('D2S UNIT MATRIX
      CALL LD I MTR(IE2S, 2)
      CALL HEAD 24('S2S UNIT MATRIX

      CALL PAGE
      CALL LD PREG ( 3500.00 )

      DO 200 L = 1, 5
      RPL Y2A1 = Y2A1 L(L)
      CALL LD DT1('T2A1S', 7932.40, 2.17225E-2, 0.0, 0. RL Y2A1, 5116.0, 0.0)

      DO 200 M = 1, 5
      R2 CSD = CSD AP(M)
      RAY2Z3 = RAY2Z3 + C.5

```

```

1039 CALL LD DT1('Y2Z3S',2702.61,RV2Z3 ,0.,0.,0353344,S200.,0.,0.,0.)
1040 CALL SLD KKL('9705')
1041 CALL RDC PRT('3 705', '3505' )
1042
1043 DGEOMN = 1.E30
1044 MIN CNT = 0
1045 NP LO = 2
1046 NP HI = 26
1047
1048 DO 100 N = NP LO, NP HI, 2
1049   RL C30 = .0130253
1050   CALL LD DT 11('C30S',N,7503.21, RA C30 ,0.0,0.0, RL C30,
1051     E .141185604, 0.00, -.2418850-2,
1052     G .2452070-1, 0.00, -.1974270-3,
1053     S .9430950-11, 0.00, .1670290-2 )
1054   CALL FND T L ( L R201, 3 )
1055   RL R201 = DT L - RL R201 - RL R221
1056   RA R201 = 5.71140E-4
1057   CALL LD DT1('R201S',7702.90, RA R201 , 0.,0., RL R201,9970.,0.,0.,0.)
1058   IF ( NO PRT .EQ. 0 ) CALL PAGE
1059   NO PRT = 0
1060   NO PRT = 1
1061
1062   CALL SLD KKL('A60S')
1063   CALL RDC PRT('A60S', 'A20S' )
1064
1065   IZA20 = LOC MTR('AD', 2)
1066   IAA20 = IZA20+9
1067   CALL Z TO A(IZA20, IAA20)
1068   IF ( NO PRT .NE. 0 ) GO TO 99
1069   CALL HEAD 24('A A20
1070   CALL PRT MTR(IAA20, 2)
1071
1072   99 CONTINUE
1073
1074   CALL LD A M25
1075   CALL CVP G4M(IAA20)
1076   DGEOMG = DSORT(DGEOM**2+DGEOM**2)
1077   IF ( DGEOMG .GE. DGEOMN ) GO TO 100
1078   DGEOMN = DGEOMG
1079   PLGE MN = RL C30
1080   NPGE MN = N
1081   MIN CNT = MIN CNT + 1
1082
1083   100 CONTINUE

```



```

146. IF( MIN CNT .LT. 2) CALL HEAD24(° NO MIN GAM EC
147. IF ( MIN CNT .LT. 2 ) GO TO 200
148. I FWH PR = 1
149. I FWH PR = 0
150. CL C3D = RL GE MM
151. CALL FWHAL DL C3D, DNONE, DNONE, DL MIN, DSECMN )
152.
153. CALL FND T MS
154. RT MASS = OT MASS + RM Y224
155. CALL FND T L ( L NAMES, 4 )
156. RT L = OT L + RL Y224
157. IF ( NO CRT .EQ. 0 ) CALL PAGE
158. DEN = 1.0-30
159. OF BAND = 3500.00
160. NTR GVN = 1
161. CALL SR MIDB( OF BAND,
162. I FLG LC = 0
163. RGICMG = DSGRT(DSGICR**2*DSICI**2)
164. PREACT = DREACT
165. RPGEVN = NPGEVN
166. RTLC3D = DL MIN + RPGEVN
167. RGECMN = DGECMN
168. IF ( NI HGG .EQ. 0 ) GO TO 160
169. NI HGG = 0
170. CALL SKP LIN(1)
171. PRINT 142
172. IF(IPUNCH.NE.0) PUNCH 5
173. IF(IPUNCH.NE.0) PUNCH 149
174. 149 FORMAT( ' L T2A1 A C3D TOT MASS TOT LENGTH'
/ ' REACTOR SAME IC GAM EC MIN' )
175.
176. 160 CONTINUE
177. IF(IPUNCH.NE.0) PUNCH 150,RL T2A1,RA C3D,RTLC3D,RTMASS,RTL,RREACT,
1 RGICMG,RSECMN
178.
179. PRINT 152, RL T2A1, RA C3D, RTLC3D, RTMASS, RTL, RREACT,
1 RGICMG, RSECMN,NPGEVN
180.
181. 150 FORMAT( 3E10.4)
182. 152 FORMAT( 6E10.4 /21X, 'N =' , I3 )
183.
184. 200 CONTINUE
185. C 200 EXIT C3D AREA LOOP
186.
187. CALL SKP LIN(1)
188. 300 CONTINUE

```

00418	180*	C GOO EXIT T2L LENGTH LOOP				
00419	190*	CALL FND NAM(*YZ*LYZ)				
00420	191*	IAY274 = LOC(LYZ*4)				
00421	192*	IZY224 = IAY274 * 8				
00422	193*	CALL SKPLIN(2)				
00423	194*	CALL FND 24(* 4 Y274				
00424	195*	CALL PRY MTR(IA Y274*2)				
00425	196*	CALL SKPLIN(2)				
00426	197*	CALL FND 24(* 2 Y274				
00427	198*	CALL PRY MTR(IY Y274*2)				
00428	199*					
00429	200*	CALL PAGE				
00430	201*	CALL PR PTBL				
00431	202*	CALL PAGE				
00432	203*	CALL PR CTLG				
00433	204*	CALL PAGE				
00434	205*	STOP				
00435	206*	END				
00436	207*					
00437						

END OF UNIVAC 1108 FORTRAN V COMPILATION.	Q *DIAGNOSTIC* MESSAGE(S)		
CONTROL S	23 JUN 71 14:23:29	0	00273476
CONTROL R	23 JUN 71 14:23:29	1	00276142
		0	00276222

94	(DELETED)
1	(DELETED)
70	

14
48
14

1 FOR PLIMNG/S, PLIMNG/S, PLIMNG/R
 CIVIC 110F FORTRAN V LEVEL 2206 0023

SUBROUTINE PLIMNG ENTRY POINT 000167

STORAGE USED (BLOCK, NAME, LENGTH)

0001	*CODE	000205
0002	*DATA	000124
0003	*BLANK	000310
0004	COMMON	000001
0005	PRIOFF	000001
0006	TOTL	000002
0007	GHECIC	000020
0008	GHESSN	000005

EXTERNAL REFERENCES (BLOCK, NAME)

0010	DSORT	0021	PAGE	0012	LOC111	0013	FNDTL	0014	LDOT1
0015	BLDVKL	0016	RECPRT	0017	LOCNTR	0020	ZTGA	0021	HEAD24
0022	PRMTR	0023	LOIM25	0024	CRPSAM	0025	PRMARI	0026	NERR35

STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000121	9L	0002	0	000000	DATA	0006	0	000002	DGECI
0006	0	000006	DSICI	0006	0	000004	DSICR	0010	0	000000
0006	0	000012	DZECI	0006	0	000013	DZECR	0006	0	000014
0006	0	000013	YAA2D	0003	0	000000	IFMNR	0006	0	000012
0006	0	000005	L	0017	0	000005	LOCNTR	0000	0	000012
0006	0	000006	NERR35	0004	0	000000	RECPRT	0000	0	000007
0007	0	000004	RAR2D1	0000	0	000000	LR2D1	0007	0	000002
0007	0	000001	RUR2Z1	0000	0	000000	RUR2A1	0000	0	000011
				0006	0	000000	DGECR	0005	0	000000
				0006	0	000016	DZICR	0006	0	000012
				0000	0	000007	INJPS	0000	0	000007
				0007	0	000003	NPGEMN	0007	0	000002
				0007	0	000000	RUR2A1	0000	0	000011

00180 4F*
00180 4F*

RETURN
END

END OF UNIVAC 1108 FORTPAN V COMPILATION.
SYMBOLIC
RELOCATABLE

C *DIAGNOSTIC* MESSAGE(S)

23 JUN 71	14:25:41	0	00613172	14	40	(DELETED)
23 JUN 71	14:25:41	1	00614252	36	1	(DELETED)
		0	0061431E	14	10	

BLANK COMMON 156704 153777

STARTING ADDRESS 014000

COPE LIMITS 014000 050240 156676 156703

CONTRL/R	NSOTPS/PL22	OSORT /RL22	NERRS /RL23	SORT /RL22
0 100000-100564	1 015153-015164	1 015155-015222	0 100577-100736	1 015757-016021
1 014000-015152		2 100565-100576	1 015223-015756	2 100737-100744
NIER\$ /RL23	MFMTS /RL23	NFTVS /RL22	MCNVT\$ /RL23	NOTINS/RL23
0 100745-100745	1 015321-017204	1 017205-017227	1 017230-017447	1 017450-020036
1 016022-016320	2 101040-101053		2 101054-101140	2 101141-101203
2 100746-101037				
NIOINS/RL22	NOUTS /RL23	NTAB\$ /RL22	NBOCV\$ /RL23	PRCTLG/R
1 020037-020105	0 101235-101242	0 101261-101620	0 101621-102004	0 102005-102063
2 101204-101234	1 020106-021027			1 021030-021104
	2 101243-101260			
PRPTBL/R	FNDNAM/R	SRMIOB/R	DACMUL/R	DCMUL/R
0 102064-102143	0 102144-102156	0 102157-102531	0 102532-102541	0 102542-102551
1 021156-021163	1 021164-021227	1 021230-022562	1 022563-022623	1 022624-022660
MYRMJL/R	CASCDE/R	AT0Z /R	L22BY2/R	LA2BY2/R
0 102552-102652	0 102653-102672	0 102673-102733	0 102734-102745	0 102746-102757
1 022661-023123	1 023124-023360	1 023361-023806	1 023607-023636	1 023637-023666
MYPMCV/R	TYPICAL/R	TYPE25/P	TYPE24/R	DCRCIP/R
0 102765-102776	0 102777-103024	0 103025-103045	0 103046-103066	0 103067-103076
1 023567-023735	1 023736-024217	1 024220-024301	1 024302-024401	1 024402-024434
TYPE22/R	TYPE21/R	TYPE20/R	TYPE15/R	TP1415/R
0 103077-103117	0 103120-103140	0 103141-103227	0 103230-103235	0 103236-103323
1 024435-024533	1 024534-024614	1 024615-025050	1 025051-025075	1 025076-025642

DCSNCS/R	DSHCH /R	DEXP /RL23	FHATHA/RL22	DSINCO/RL22
C 103324-103343	C 103344-103361	C 103362-103383	1 026124-026176	1 026177-026412
1 025643-025725	1 025726-025764	1 025765-026123	2 103475-103510	2 103511-103562
DCM214/R	Y14155/R	DCQ27/R	CS1415/*****	LZ39Y3/R
C 103563-103576	C 103577-103623	C 103624-103662	0 103663-103666	C 103667-103700
1 026413-026460	1 026461-026723	1 026724-027155		1 027156-027205
LS1415/R	CESSFP/*****	CM1415/*****	CMN15C/*****	TYPE14/R
C 103701-103714	C 103715-103722	C 103723-103754	0 103755-103756	0 103757-103754
1 027206-027254			0 027255-027301	1 027255-027301
TYPE11/R	DCSHCH/R	DCACSH/R	DCANG1/R	DATAN /RL22
C 103765-104056	0 104057-104076	0 104077-104122	0 104123-104153	1 030621-031016
1 027302-030316	1 030317-030376	1 030377-030470	1 030471-030620	2 104154-104305
DL06 /RL22	T11565/R	LDS311/R	CZ33Y3/*****	TYPE7 /R
1 031017-031060	0 104372-104427	0 104430-104443	0 104444-104465	0 104466-104565
2 104306-104371	1 031061-031355	1 031356-031424	0 105435-105436	1 031425-032261
DECOM3/R	DL0610/RL22	DCMSOL/*****	DECOND/*****	VALDET/*****
C 104566-105005	1 034154-034202	0 105017-105434	0 105435-105436	0 105437-105442
1 032262-034163	2 105006-105016			
TYPE2 /R	TYPE1 /R	BLDMTR/R	FNDMTR/R	UNPACK/R
C 105443-105564	0 105565-105657	0 105660-105712	0 105713-105726	0 105727-106054
1 034203-034540	1 034541-034755	1 034756-035254	1 035255-035332	1 035333-036146
NEXP15/RL22	C3LD /*****	CMPS /R	PRMARI/R	FNDTMS/R
1 036147-036202	0 106056-106056	0 106057-106077	0 106100-106141	0 106142-106172
2 106055-106055		1 036203-036235	1 036236-036340	1 036341-036450
FMFN /R	PRBFIT/R	RLIMMG/R	CGMNPR/*****	POLEO /R
0 106173-106213	C 106214-106265	C 106266-106371	0 106372-106372	C 106373-106526
1 036451-036571	1 036572-036734	1 036735-037141		1 037142-037504
CMPGAM/R	PRGMTP/*****	CMNZS /*****	LD2M2S/R	CFLGAZ/*****
C 106527-106624	0 106625-106625	C 106626-106631	0 106632-106714	0 106715-106715
1 037505-037755			1 037756-040261	
SRCHE5/*****	PRMTMP/R	ZT04 /R	CZ28Y2/*****	CA28Y2/*****
0 106716-106725	0 106726-106754	0 106755-107015	0 107016-107025	0 107026-107035

1	040262-040366	1	040367-040614
LDCMTR/R	FNDTL /R	LDDT11/R	LDDRIM/R
0 107076-107052	0 107053-107114	0 107115-107276	0 107277-107311
1 040615-040671	1 040672-041075	1 041077-041534	1 041535-041515
AIDOP /R	CCMNI1/*****	RDCPR1/P	BLDKKL/R
0 107331-107355	0 107356-107416	0 107417-107542	0 107543-107631
1 041647-042047		1 042050-043073	1 043074-043513
FNDNET/R	CMAGIC/*****	CPRTIN/*****	CNMROD/*****
0 107663-107710	0 107711-107711	0 107712-107713	0 107714-107715
1 040330-044211			
HEAD24/R	LDMTR/R	SKPLIN/R	ALOCAT/R
0 107733-107755	0 107756-110002	0 110003-110014	0 110015-110042
1 044243-044355	1 044366-044455	1 044457-044512	1 044513-044575
NINPTS/RL23	NININS/RL23	LDDT4 /R	LDDT1 /R
0 110304-110305	1 046427-046566	0 110428-110513	0 110514-110636
1 045500-046426	2 110341-110417	1 046567-047063	1 047064-047465
2 110306-110340			
LDPCT7/R	UPPTL/R	CPTMRD/*****	PRITBL/*****
0 110540-110730	0 110731-110756	0 110757-110760	0 110761-113075
1 047466-050011	1 050012-050206		
PAGE /R	CMNFMN/*****	FLGSRH/*****	CSRMTR/*****
0 113123-113131	0 113132-113134	0 113135-113140	0 113141-113141
1 050224-050240			
GMERIC/*****	COESGN/*****	CFMNP/R/*****	PRTOFF/*****
0 113146-113165	0 113166-113172	0 113173-113173	0 113174-113174
TOTL /*****	DTATOT/*****	BASIC3/*****	CATLG/*****
0 113177-113200	0 113201-113201	0 113202-113207	0 113210-114504

END OF ALLOCATION 1103 0039A 0

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MOD 9 RUN 80039 APR 23, 1970 S LIKE MOD 7 RUN 70335
 DESIGN RUN S
 LINES OF CONSTANT TAIL LENGTHS
 CHARGE TO 16000501 ARRAY DESIGN

***** 9D 7 NETWORK TABLE *****

S 1970.	-+111A.	-+1R24.S			
S 2970.	1E2E.S				
S 3970.	2R24.S				
S 4970.	1R2Z.S				
S 5970.	2Y2Z.S				
S 6970.	-+2E2E.	1V2W.	1V2Z.S		
S 7970.	-+111B.	2R2Z.	2V2W.S		

***** AD 6 NETWORK TABLE *****

S 1A6D.	3C3D.S				
S 2A6D.	5S5D.S				
S 3A6D.	-+2C3D.	2B5D.S			
S 4A6D.	-+1B5D.	1C3D.S			
S 5A6D.	-+3B5D.	1R2D.S			
S 6A6D.	-+4B5D.	2R2D.S			

TYPE 1	RHO	AREA	ID	OD	LENGTH
E2E1S	4416.90	-148261-01	-000000	-137394	-009070
	C REAL	C IMAG	C MULT		
	4820.00	-000000	-000000		
				MASS	-59394

TYPE 1	RHO	AREA	ID	OD	LENGTH
R2A1S	7712.80	-790233-03	-000000	-031720	-007248
	C REAL	C IMAG	C MULT		
	4970.00	-000000	-000000		
				MASS	-09412

TYPE 1	RHO	AREA	ID	OD	LENGTH
--------	-----	------	----	----	--------

SC21S
7702.80
C REAL
4970.00
790233-03
C IMAG
.000000
.000000
-031720
-000000
-000838
MASS
.00510

TYPE 1
7231S
RHO
7730.00
C REAL
4970.00
AREA
-228639-02
C IMAG
.000000
ID
-000000
OD
-053955
C MULT
-000000
LENGTH
-003257
MASS
.05933

TYPE 1
7232S
RHO
7724.87
C REAL
4970.00
AREA
-102402-02
C IMAG
.000000
ID
-000000
OD
-046303
C MULT
-000000
LENGTH
-003314
MASS
.04311

TYPE 1
7233S
RHO
7719.24
C REAL
4970.00
AREA
-130699-02
C IMAG
.000000
ID
-000000
OD
-040794
C MULT
-000000
LENGTH
-010214
MASS
.10305

TYPE 1
7254S
RHO
7700.80
C REAL
4970.00
AREA
-790233-03
C IMAG
.000000
ID
-000000
OD
-031720
C MULT
-000000
LENGTH
-006679
MASS
.04066

TYPE 1
V2W1S
RHO
4416.90
C REAL
4820.00
AREA
-112776-01
C IMAG
.000000
ID
-000000
OD
-119829
C MULT
-000000
LENGTH
-011370
MASS
.56637

TYPE 1
V2W2S
RHO
4416.90
C REAL
4820.00
AREA
-112776-01
C IMAG
.000000
ID
-000000
OD
-119829
C MULT
-000000
LENGTH
-011370
MASS
.56637

TYPE 1
V2W3S
RHO
7788.48
C REAL
5116.00
AREA
-254984-02
C IMAG
.000000
ID
-000000
OD
-056979
C MULT
-000000
LENGTH
-002224
MASS
.04418

TYPE 1
RHO
ID
OD
LENGTH

Y221S
C REAL
5200.00

.346119-02
C IMAG
.000000

.000000
C MULT
.000000

.011370
MASS
.10698

TYPE 1
Y222S
C REAL
5200.00

.346119-02
C IMAG
.000000

.000000
C MULT
.000000

.011370
MASS
.10698

UNIT MATRIX
1.00

TYPE 4
Y223S

```

PRE 7      SCALE      MATRIX      NUMERATOR      DENOMINATOR      SYMMETRY
      FACTOR      FORM      ORDER      ORDER      FLAG
      .1000+01      3      3      1      -1
      CUEF. TO CHECK NEW TYPE 7 WITH OLD TYPE 7
      POLYNOMIAL COEFFICIENTS FOR Z(I,J)=(C0+C1*F+...)/(D0+D)*F+...

NUMERATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT( 1, 1)
      .0000000000
      -.8588996000+09
      .0000000000
      .7711482900+05
      .0000000000
      -.9040960000+01
      .0000000000
      .1627919980-02

DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT( 1, 1)
      .0000000000
      .0000000000
      .1000000000+01

NUMERATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT( 1, 2)
      .0000000000
      .8683080000+09
      .0000000000
      -.7620410000+05
      .0500000000
      .1246709980+02
      .0000000000
      -.1530115930-02

DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT( 1, 2)
      .0000000000
      .0000000000
      .1000000000+01

NUMERATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT( 2, 2)
      .0000000000
      .8691160000+09
      .0000000000
      -.7743060000+05
      .0000000000
      -.2671390000+00
      .0000000000
      -.1807459960-02

DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT( 2, 2)
      .0000000000
      .0000000000
      .1000000000+01

```

```

F2S UNIT MATRIX
D2S UNIT MATRIX
S2S UNIT MATRIX

```

..... F = 3500.000000

```

TYPE 1
Y2A1S
  RHO      7832.48
  C REAL   5216.00
  AREA     .217225-01
  C IMAG   .000000
  ID       .000000
  OD       .166307
  LENGTH   .038125
  MASS     6.48658

```

REPLACE

```

TYPE 1
Y2Z3S
  RHO      2702.81
  C REAL   5200.00
  AREA     .245000-02
  C IMAG   .000000
  ID       .000000
  OD       .035852
  LENGTH   .035354
  MASS     .23411

```

```

TYPE 11
C30S
  RHO      7538.21
  C REAL   3743.27
  AREA     .490000-02
  C IMAG   .312617-01
  ID       .000000
  OD       .078987
  LENGTH   .013625
  N PIECES 2
  MASS     1.01324

```

```

      REAL      IMAG      MULT
E33T  .1411666000+004  -.3416019970+001  .2419250000-002
G33   .2452070000-001  .4595841239-005  -.1874270000-003
S330  .9404950000-011  -.1570899394-013  .1670290000-002

```

K33 .6664539643+000 -.6940269089-004

TOTAL LENGTH = .061285 FOR SECTIONS VW EE CD

```

TYPE 1
P201S
  RHO      7702.80
  C REAL   4975.00
  AREA     .571140-03
  C IMAG   .000000
  ID       .000000
  OD       .026967
  LENGTH   .053199
  MASS     .23404

```

Z SELF

MAS

.0000000000

ANG DEG

.0000000000

REAL

.0000000000

IMAG

.0000000000

L	T241	A	C30	L	C30	TOT	MASS	TOT	LENGTH	REACTOR	GAMMA	IC	GAM	EC	MIN
.3812-01	.4900-02	.1738+00	.1910+02	.3242+00	.4270-01	.1106+08	.1037+03								
		N = 12													
.3812-01	.6500-02	.2086+00	.2315+02	.3590+00	.1997-01	.1231+08	.1373+03								
		N = 16													
.3812-01	.7520-02	.2259+00	.2538+02	.3764+00	.1774-01	.1263+08	.1578+03								
		N = 16													
.3812-01	.8100-02	.2345+00	.2747+02	.3850+00	.1313-01	.1271+08	.1693+03								
		N = 18													
.3812-01	.1290-01	.2827+00	.4116+02	.4331+00	.6547-02	.1210+08	.2626+03								
		N = 20													
.7625-01	.4900-02	.1291+00	.2372+02	.3176+00	.4755-01	.9667+07	.8358+02								
		N = 10													
.7625-01	.6500-02	.1614+00	.2710+02	.3499+00	.2907-01	.1171+08	.1153+03								
		N = 12													
.7625-01	.7520-02	.1782+00	.2944+02	.3668+00	.1945-01	.1249+08	.1355+03								
		N = 14													
.7625-01	.8100-02	.1863+00	.3031+02	.3754+00	.1842-01	.1279+08	.1470+03								
		N = 14													
.7625-01	.1290-01	.2387+00	.4315+02	.4273+00	.7201-02	.1291+08	.2434+03								
		N = 18													
.1144+00	.4900-02	.1095+00	.2939+02	.3362+00	.6387-01	.8577+07	.7236+02								
		N = 3													
.1144+00	.6500-02	.1385+00	.3236+02	.3552+00	.3691-01	.1077+08	.1007+03								
		N = 10													
.1144+00	.7520-02	.1537+00	.3442+02	.3804+00	.2364-01	.1176+08	.1189+03								
		N = 12													
.1144+00	.8100-02	.1615+00	.3563+02	.3882+00	.2252-01	.1219+08	.1293+03								
		N = 12													
.1144+00	.1290-01	.2096+00	.4666+02	.4363+00	.8462-02	.1328+08	.2202+03								
		N = 16													
.1525+00	.4900-02	.9843-01	.3542+02	.3633+00	.5775-01	.7851+07	.6559+02								
		N = 6													
.1525+00	.6500-02	.1252+00	.3613+02	.3901+00	.3383-01	.1002+08	.9124+02								

.1525+00	.7520-02	N = 10	.1391+00	.4000+02	.4039+00	.3140-01	.1105+08	.1076+03
			N = 12					
.1525+00	.8100-02		.1461+00	.4111+02	.4110+00	.3002-01	.1154+08	.1171+03
			N = 10					
.1525+00	.1290-01		.1697+00	.5112+02	.4545+00	.1045-01	.1329+08	.1998+03
			N = 14					
.1906+00	.4900-02		.9114-01	.4161+02	.3941+00	.9532-01	.7333+07	.6097+02
			N = 6					
.1906+00	.6500-02		.1183+00	.4414+02	.4192+00	.4949-01	.9430+07	.8459+02
			N = 8					
.1906+00	.7520-02		.1292+00	.4538+02	.4321+00	.2951-01	.1047+08	.9955+02
			N = 10					
.1906+00	.8100-02		.1357+00	.4690+02	.4386+00	.2827-01	.1096+08	.1081+03
			N = 10					
.1906+00	.1290-01		.1753+00	.5612+02	.4782+00	.1359-01	.1311+08	.1831+03
			N = 12					

A Y2Z4

1	1	.9383815355+00	.0000000000
2	1	.0000000000	.5132157777-05
1	2	.0000000000	.5614587184+05
2	2	.7595939197+00	.0000000000

Z Y2Z4

1	1	.0000000000	-.1828434698+06
2	1	.0000000000	-.1946498163+06
1	2	.0000000000	.1946498163+06
2	2	.0000000000	.1478118859+06

COMMON PRT TBL

N	NET SP	I	SIGN	J	PORT	N	NET NAM	NUM APO	NUM NPO	N	AHEAD	N	BACK	LC J ROW
1	S	1	1	1	1	7	BD	1	-1	4	0	1	0	858
2	S	-1	1	1	1	1	YA	1	1	3	0	380	2	380
3	S	-1	1	1	1	2	RA	1	2	7	1	1	1	341
4	S	1	1	1	1	7	BD	2	-2	6	7	3	4	341
5	S	1	1	1	1	2	EE	2	4	13	8	3	3	381
6	S	1	1	1	1	7	BD	3	-3	5	6	4	4	419
7	S	1	1	1	1	2	RA	3	3	10	13	5	5	652
8	S	1	1	1	1	7	BD	4	-4	18	15	6	6	342
9	S	1	1	1	1	2	PZ	4	6	12	18	11	11	566
10	S	1	1	1	1	7	BD	5	-5	14	20	18	18	651
11	S	1	1	1	1	2	YZ	5	9	16	12	12	12	7
12	S	1	1	1	1	7	BD	6	-6	19	15	19	19	862
13	S	-1	1	1	1	2	EE	6	5	20	16	14	14	420
14	S	1	1	1	1	7	VW	6	10	22	17	17	17	567
15	S	1	1	1	1	2	YZ	6	8	28	25	16	16	197
16	S	1	1	1	1	7	BD	7	-7	24	28	25	25	1024
17	S	-1	1	1	1	1	TB	7	12	32	20	20	20	198
18	S	1	1	1	1	2	RZ	7	7	27	34	34	34	870
19	S	1	1	1	1	7	VW	7	11	21	22	22	22	199
20	S	1	1	1	1	6	AD	1	-1	31	29	29	29	1023
21	S	1	1	1	1	3	CD	1	3	26	28	28	28	867
22	S	1	1	1	1	6	AD	2	-2	30	24	24	24	200
23	S	1	1	1	1	5	BD	2	8	26	21	21	21	966
24	S	1	1	1	1	6	AD	3	-3	25	27	27	27	1022
25	S	-1	1	1	1	3	CD	3	2	33	25	25	25	201
26	S	1	1	1	1	5	BD	3	5	34	26	26	26	868
27	S	1	1	1	1	6	AD	4	-4	35	34	34	34	1091
28	S	-1	1	1	1	5	BD	4	4	0	35	35	35	202
29	S	1	1	1	1	3	CD	4	1	23	0	23	23	869
30	S	1	1	1	1	6	AD	5	-5	23	27	27	27	
31	S	-1	1	1	1	5	BD	5	6	30	26	26	26	
32	S	1	1	1	1	2	RD	5	9	31	30	30	30	
33	S	1	1	1	1	6	AD	6	-6	23	31	31	31	
34	S	-1	1	1	1	5	BD	6	7	23	31	31	31	

35 5 1 1 2 2 RD 6 10 0 32 1392

***** COMMON CATALOG *****

I	NAME	MTR SIZ	I	PC	N	PC	TOT	I	TYPE	N	DT	STR	LOC
1	BD	7	0	0	0	0	0	0	0	0	0	0	1
2	AD	6	0	0	0	0	0	0	0	0	0	0	197
3	EE	-	0	0	0	0	0	0	0	0	0	0	341
4	EE	2	1	1	1	1	1	1	1	1	1	1	357
5	RA	2	0	0	0	0	0	0	0	0	0	0	360
6	RA	2	1	1	1	1	1	1	1	1	1	1	396
7	RZ	2	0	0	0	0	0	0	0	0	0	0	419
8	RZ	2	1	1	1	1	1	1	1	1	1	1	435
9	TB	2	0	0	0	0	0	0	0	0	0	0	458
10	TB	2	1	1	1	1	1	1	1	1	1	1	474
11	TB	2	2	2	2	2	2	2	2	2	2	2	497
12	TB	2	3	3	3	3	3	3	3	3	3	3	520
13	TB	2	4	4	4	4	4	4	4	4	4	4	543
14	VW	2	0	0	0	0	0	0	0	0	0	0	566
15	VW	2	1	1	1	1	1	1	1	1	1	1	582
16	VW	2	2	2	2	2	2	2	2	2	2	2	605
17	VW	2	3	3	3	3	3	3	3	3	3	3	628
18	YZ	2	0	0	0	0	0	0	0	0	0	0	651
19	YZ	2	1	1	1	1	1	1	1	1	1	1	667
20	YZ	2	2	2	2	2	2	2	2	2	2	2	690
21	YZ	2	3	3	3	3	3	3	3	3	3	3	713
22	YZ	2	4	4	4	4	4	4	4	4	4	4	737
23	FS	2	0	0	0	0	0	0	0	0	0	0	795
24	DS	2	0	0	0	0	0	0	0	0	0	0	803
25	SS	2	0	0	0	0	0	0	0	0	0	0	811
26	TA	2	0	0	0	0	0	0	0	0	0	0	819
27	TA	2	1	1	1	1	1	1	1	1	1	1	835
28	TA	1	0	0	0	0	0	0	0	0	0	0	858
29	TB	1	0	0	0	0	0	0	0	0	0	0	862
30	BD	5	0	0	0	0	0	0	0	0	0	0	866
31	BD	0	0	0	0	0	0	0	0	0	0	0	966
32	BD	0	0	0	0	0	0	0	0	0	0	0	982
33	CO	3	0	0	0	0	0	11	11	33	33	33	1022
34	RD	2	0	0	0	0	0	0	0	0	0	0	1091
35	RD	2	1	1	1	1	1	1	1	1	1	1	1107
36	RD	2	0	0	0	0	0	0	0	0	0	0	1130

37	AD	0	0	0	0	0	1146
38	AD	0	0	0	0	0	1210
39	ES	2	0	0	0	0	1242
40	MS	2	0	0	0	0	1250
41	GS	2	0	0	0	0	1258
42	HS	2	0	0	0	0	1266

TOTAL DATA CELLS USED IN MASTER STORAGE 1273

 SEADUCER RUN 80001 (LIKE MOD 7 RUN 70294) SEPT 26, 1970
 WARDS DUCER FOR MOD 8 DEVELOPMENT (K8D NETWORK)

 MOD 8 NETWORK TABLE

S 1K8D, 1825, S
 S 2K8D, 2828, S
 S 3K8D, 3034, S
 S 4K8D, 1828, 182C, -+282E, S
 S 5K8D, 1810, -+282C, -+282R, S
 S 6K8D, 182F, 182R, -+282G, S
 S 7K8D, 103A, -+282F, S
 S 8K8D, -+203A, 182E, S

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
8281s	7815.00	-139380-02	.000000	.042214	.121570	1.32972
	C REAL	C IMAG	C MULT			
	5116.00	.000000	.000000			

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
8282s	7815.00	-810000-02	.000000	.101554	.102400	6.48207
	C REAL	C IMAG	C MULT			
	5116.00	.000000	.000000			

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
8283s	7815.00	-134200-02	.000000	.041336	.067854	.71163
	C REAL	C IMAG	C MULT			
	5116.00	.000000	.000000			

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
82C1s	7558.40	-101971-02	.000000	.036032	.003175	.02447
	C REAL	C IMAG	C MULT			
	5116.00	.000000	.000000			

TYPE 4
 82C2s UNIT MATRIX
 1.00

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TYPE 1
B201S
RHO 7746.00
C REAL
4970.00
AREA .760378-03
C IMAG
.000000
ID .000000
OD .031115
LENGTH .009601
MASS .05655

TYPE 2
B202S
RHO 7743.74
C REAL
4970.00
A1 .760378-03
A2 .455310-03
C IMAG
.000000
ID1 .000000
ID2 .0024077
OD .031115
LENGTH .002540
MASS .01183

TYPE 1
B203S
RHO 7743.45
C REAL
4970.00
AREA .455310-03
C IMAG
.000000
ID .000000
OD .024077
LENGTH .003302
MASS .01164

TYPE 1
B204S
RHO 7737.80
C REAL
4970.00
AREA .240258-03
C IMAG
.000000
ID .000000
OD .017490
LENGTH .003600
MASS .00669

TYPE 1
B2R1S
RHO 7738.00
C REAL
4970.00
AREA .240258-03
C IMAG
.000000
ID .000000
OD .017490
LENGTH .010500
MASS .01952

TYPE 1
B2R2S
RHO 7738.00
C REAL
4970.00
AREA .285023-03
C IMAG
.000000
ID .000000
OD .019050
LENGTH .035250
MASS .07774

TYPE 1
B2R3S
RHO 7738.00
C REAL
4970.00
AREA .197933-03
C IMAG
.000000
ID .000000
OD .015875
LENGTH .474537
MASS .72680

TYPE 1
B2P4S
RHO 7738.00
C REAL
4970.00
AREA .285023-03
C IMAG
.000000
ID .000000
OD .019050
LENGTH .337290
MASS .08224

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TYPE 1
 82R5S
 RHO 7738.00
 C REAL 4970.00
 AREA .240258-03
 C IMAG .000000
 ID .000000
 OD .017490
 LENGTH .009246
 MASS .01533

TYPE 4
 82E1S
 UNIT MATRIX
 1.00

TYPE 1
 82E2S
 RHO 7814.88
 C REAL 5116.00
 AREA .426383-02
 C IMAG .000000
 ID .000000
 OD .073681
 LENGTH .031750
 MASS 1.05795

TYPE 1
 82F1S
 RHO 7802.15
 C REAL 5116.00
 AREA .456037-02
 C IMAG .000000
 ID .000000
 OD .076200
 LENGTH .031750
 MASS 1.12969

TYPE 1
 82G1S
 RHO 7815.00
 C REAL 5116.00
 AREA .260000-02
 C IMAG .000000
 ID .000000
 OD .057536
 LENGTH .010520
 MASS .21376

TYPE 1
 82G2S
 RHO 7815.00
 C REAL 5116.00
 AREA .215000-02
 C IMAG .000000
 ID .000000
 OD .052321
 LENGTH .021340
 MASS .35856

TYPE 11
 D3AS
 RHO 7440.00
 C REAL 3479.30
 AREA .253354-02
 C IMAG .482230+01
 ID .000000
 OD .056796
 LENGTH .019198
 N PIECES 26
 MASS 9.40871

REAL
 E33T .128089000+004
 533 .2378780000-001
 30 .1110300000-010
 IMAG
 .1771470870+001
 -.1207944484-004
 -.3077751600-013
 MULT
 .1383000000-002
 .5076000000-003
 .7720000000-002

W33 .6052162040+000
 .7160454577-004

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REPLACE

UNIT MATRIX
TYPE 4
82E2S
1.00

REPLACE

TYPE 1
82E1S
RHO 7814.88
C REAL 5116.00
AREA .426383-02
C IMAG .000000
ID .000000
OD .073681
LENGTH .031750
MASS 1.05795

REPLACE

TYPE 2
82D2S
RHO 7743.74
C REAL 4970.00
A1 .760378-03
A2 .455310-03
C IMAG .000000
ID1 .000000
ID2 .002
OD1 .031115
OD2 .024077
C MULT .000000
LENGTH .002540
MASS .01183

REPLACE

TYPE 1
82D4S
RHO 7737.80
C REAL 4970.00
AREA .240258-03
C IMAG .000000
ID .000000
OD .017490
C MULT .000000
LENGTH .003600
MASS .00669

REPLACE

TYPE 1
82E1S
RHO 7815.00
C REAL 5116.00
AREA .139960-02
C IMAG .000000
ID .000000
OD .042214
C MULT .000000
LENGTH .121570
MASS 1.32972

REPLACE

TYPE 11
82E1S
RHO 7440.00
C REAL 7470.70
AREA .253354-02
C IMAG .000000
ID .000000
OD .056795
C MULT .000000
LENGTH .019198
MASS 0.00071

	REAL	IMAG	MULT
E33T	-1280890000+004	-.1771470870+001	.1383000000-002
G33	-2378720000-001	-.1207944484-004	.5078000000-003
S33D	.1110300000-010	-.3077751600-013	.2772000000-002
K33	.6052162044+000	.7160454537-004	

TOTAL MASS = 21.72491 KG. 47.89518 LBS.

TOTAL LENGTH = .886332 FOR SECTIONS BG BF DA BE BB

..... F = 2500.000000

FINAL K30 MATRIX

1	1	.8246889136+03	-.9647054664+05
2	1	-.8518089926+03	.1639490892+06
3	1	.5459747958+02	-.1129571571+05
1	2	.8516089926+03	-.1639490892+06
2	2	-.1464582941+04	.9957370445+05
3	2	.5914333365+02	-.1980934506+04
1	3	.5459747958+02	-.1129571571+05
2	3	-.5914333365+02	.1980934506+04
3	3	.5935133270+01	-.2570213422+04

Z K20 MATRIX

1	1	.4594277801+03	-.4682782852+05
2	1	-.5899045679+03	.1552435546+06
1	2	.5899045679+03	-.1552435546+06
2	2	-.1376936933+04	.8804802498+05

***** COMMON PRT TRL *****

N	NET SP	I	SIGN	J	PORT	N	NET NAM	NUM APO	NUM NPO	N AHEAD	N BACK	LC J ROW
1	S	1	1	1	1	8	KD	1	-1	3	0	1
2	S	1	1	1	1	2	SG	1	1	18	0	17
3	S	1	1	2	2	6	KD	2	-2	5	1	2
4	S	1	1	2	2	2	BB	2	4	20	6	258
5	S	1	1	3	3	2	KD	3	-3	7	3	3
6	S	1	1	3	3	3	DA	3	7	9	23	811
7	S	1	1	4	4	8	KD	4	-4	11	5	4
8	S	1	1	1	1	2	BB	4	3	4	18	257
9	S	1	1	1	1	2	BC	4	8	13	6	342
10	S	-1	1	2	2	2	BE	4	11	12	24	646
11	S	1	1	5	5	8	KD	5	-5	15	7	5
12	S	1	1	1	1	1	BD	5	12	17	10	878
13	S	-1	1	2	2	2	BC	5	9	24	9	343
14	S	-1	1	2	2	8	BR	5	14	16	17	515
15	S	1	1	6	6	8	KD	6	-6	19	11	6
16	S	1	1	1	1	2	BF	6	15	21	14	708
17	S	1	1	1	1	2	BR	6	13	14	12	514
18	S	-1	1	2	2	2	SG	6	2	8	2	748
19	S	1	1	7	7	8	KD	7	-7	22	15	7
20	S	1	1	1	1	3	DA	7	5	23	4	809
21	S	-1	1	2	2	2	BF	7	16	6	16	709
22	S	-1	1	8	8	8	KD	8	-8	0	19	8
23	S	-1	1	2	2	3	DA	8	6	6	20	810
24	S	1	1	1	1	2	BE	8	10	10	13	645

***** COMMON CATALOG *****

I	NAME	MTR	I	PC	N	PC	I	N	DT	LOC
		SIZ			TOT	TYPE		STR		
1	KD	8		0	0	0		0		1
2	BB	2		0	3	0		0		257
3	BB	2		1	3	1		7		273
4	BB	2		2	3	1		7		296
5	BB	2		3	3	1		7		319
6	BC	2		0	2	0		0		342
7	BC	2		1	2	1		7		356
8	BC	2		2	2	4		8		381
9	BD	2		0	4	0		0		405
10	BD	2		1	4	1		7		421
11	BD	2		2	4	2		8		444
12	BD	2		3	4	1		7		468
13	BD	2		4	4	1		7		491
14	BR	2		0	5	0		0		514
15	BR	2		1	5	1		7		530
16	BR	2		2	5	1		7		553
17	BR	2		3	5	1		7		576
18	BR	2		4	5	1		7		599
19	BR	2		5	5	1		7		622
20	BE	2		0	2	0		0		645
21	BE	2		1	2	1		7		661
22	BE	2		2	2	4		8		685
23	BF	2		0	1	0		0		708
24	BF	2		1	1	0		7		724
25	BG	2		0	2	0		0		747
26	BG	2		1	2	1		7		763
27	BG	2		2	2	1		7		786
28	DA	3		0	0	1		33		809
29	DB	1		0	0	0		0		878
30	KD	3		0	0	0		0		882
31	KD	0		0	0	0		0		918
32	KD	0		0	0	0		0		1018
33	KD	2		0	0	0		0		1078
34	KD	0		0	0	0		0		1094
35	KD	0		0	0	0		0		1098

TOTAL DATA CELLS USED IN MASTER STORAGE 1105

Radian Corporation

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Appendix B

Scattering from Translucent Baffles

Scattering from Translucent Baffles

The purpose of this discussion is to outline an approach for treating the combined effects of transmission and edge diffraction for plane wave scattering from a planar baffle. The scope of the discussion includes a brief description of an integral formulation of the problem and some of the difficulties inherent in an approximate approach.

A rigorous formulation of the problem of interest differs from that of an opaque baffle in the requirement of characterizing the response of the baffle material to a distribution of forces on its surfaces. In effect, this requirement is equivalent to the determination of a Green's function or "influence" function for the baffle material.*

Knowing the influence function for the baffle material, one can write an integral relationship between the force distribution on the baffle surfaces and the velocity field on the baffle surface. Since the baffle is immersed in a fluid which is assumed inviscid, the force at a given point on the baffle is normal to the surface. Consequently, the normal velocity $V_n(\vec{r})$ at a point $\vec{r}$ on the baffle surface depends on the normal force per unit area, i.e., the pressure, p , according to the relation:

$$V_n(\vec{r}) = \int_{S_b} K(\vec{r}|\vec{r}') p(\vec{r}') dS' , \quad (B-1)$$

* See Sec. IV of Ref. [B-1] for an analogous approach to transducer dome interaction.

where $K(\vec{r}|\vec{r}')$ is the n-n component of the influence dyadic [B-1] for the baffle material. The integral in Equation (B-1) is taken over both sides of the baffle.

It is important to note that the kernel, $K(\vec{r}|\vec{r}')$, depends only on the geometrical and physical properties of the baffle, i.e., it is independent of the conditions existing at any point of the fluid in which the baffle is immersed. Also we note that Equation (B-1) is a generalized impedance relationship; more correctly $K(\vec{r}|\vec{r}')$ has the units of an admittance per unit area. As such, Equation (B-1) is a mathematical formulation of the transmissive properties of the baffle material. Furthermore, any baffle material having linear constitutive equations gives rise to an impedance relationship of the form given in Equation (B-1)*, i.e., the form of Equation (B-1) does not depend on any assumptions regarding baffle geometry.

To complete the specification of the scattering of a plane wave

$$p_i(\vec{r}) = e^{i\vec{k} \cdot \vec{r}} \quad (B-2)$$

by the baffle, we use the Helmholtz representation of the total field:

$$p(\vec{r}) = p_i(\vec{r}) + \int_{S_b} \left[p(\vec{r}') \frac{\partial g}{\partial n'}(\vec{r}|\vec{r}') - \frac{\partial p}{\partial n'}(\vec{r}') g(\vec{r}|\vec{r}') \right] dS' \quad , \quad (B-3)$$

* For cases of locally reacting surfaces, the kernel is proportional to a (surface) "delta function".

where $p(\vec{r})$ is the total pressure field at the point $\vec{r}$ in the fluid, and g is the free space Green's function for the fluid medium.^{B-1}

The above relationships, in conjunction with the definition

$$V_n(\vec{r}) = \left. \frac{1}{ik\rho c} \frac{\partial p}{\partial n}(\vec{r}) \right]_{S_b}, \quad (B-4)$$

where k is the wave number and ρc is the fluid, acoustical impedance, serve to define a solution to the problem. In particular, Equation (B-1), and the limiting form of Equation (B-3) as the field point $\vec{r}$ approaches the baffle surface, give rise to a pair or coupled integral equations which, by virtue of Equation (B-4), relate the unknown pressure and velocity fields on the baffle surface, p and V_n , respectively, to the incident pressure field p_i . A simultaneous solution of these integral equations defines the terms appearing in the integral of Equation (B-3), hence Equation (B-3) defines the pressure field at every point in the fluid.

While the above approach is conceptually applicable to general baffle shapes in either two or three dimensions, the practical aspects of implementing the formalism is limited first of all to baffles for which the influence function can be evaluated analytically and secondly by computational difficulties of obtaining an approximate solution to the coupled integral equations.*

In view of the difficulties mentioned, it would be desirable to have an alternative, approximate approach to represent the essential features of the pressure field. In order to

* Additionally the formalism would need to be modified for treating "resonance" wave numbers associated with the baffle.

derive such an approximation it is necessary to limit the discussion to specialized geometrical configurations. In particular, we limit the subsequent discussion to the case of a planar baffle.

As a first approximation, we assume that the pressure and velocity fields on the baffle surfaces are not influenced appreciably by the presence of the edge. This assumption corresponds in some sense to the Kirchhoff approximation used previously for analysis of opaque baffles. Furthermore, the assumption enables one to write

$$p(\vec{r}') \Big|_{S_b} = \begin{cases} e^{i\vec{k} \cdot \vec{r}} + R(\vec{k})e^{i\vec{k}_1 \cdot \vec{r}} & \text{on } S_i \\ T(\vec{k})e^{i\vec{k} \cdot \vec{r}} & \text{on } S_s \end{cases} \quad (B-5)$$

where $R(\vec{k})$, $T(\vec{k})$ denote, respectively, the (amplitude) reflection and transmission coefficients for a layer of the baffle material which incorporate the physical properties of the baffle*, $\vec{k}_1$ denotes the propagation vector of the reflected wave, S_i denotes the illuminated baffle surface, and S_s denotes the shadow baffle surface. In writing the above relationship, we have implicitly assumed the baffle thickness is negligible relative to the acoustical fluid wavelength. This assumption simplifies the discussion and can easily be removed.

* See Reference B-2 for the definition of the transmission and reflection coefficients for a composite layer.

If, in addition to Equation (B-5), we assume an analogous equality for the normal derivative on the baffle surface, then the resulting approximate pressure field takes the form:

$$p(\vec{r}) = e^{i\vec{k} \cdot \vec{r}} + [1 - T(\vec{k})]U(\vec{r}|\vec{k}) + R(\vec{k})U(\vec{r}|\vec{k}_1) \quad (B-6)$$

where

$$U(\vec{r}|\vec{k}) = \int_{S_s} \left[g(\vec{r}|\vec{r}') \frac{\partial}{\partial n'} e^{i\vec{k} \cdot \vec{r}'} - e^{i\vec{k} \cdot \vec{r}'} \frac{\partial g(\vec{r}|\vec{r}')}{\partial n'} \right] dS' \quad (B-7)$$

The above relationships result from substituting Equations (B-2), (B-5) into Equation (B-3) and using the fact that the integral over S_i is the negative of the integral over S_s because of the assumption of negligible thickness of the baffle.

As in the case for opaque baffles, the approximation scheme described above gives rise to an approximate Green's function which violates the reciprocity principle. It has been noted previously (B-4) that the problem of plane wave scattering corresponds to a limiting process on the Green's function in which the source point moves to infinity. Furthermore physical considerations have indicated that for an opaque baffle, a more accurate approximation for plane wave scattering can be obtained from a Kirchhoff approximation to the Green's function by interchanging field and source coordinates before taking the limit. Whether this holds true for the present approximation remains to be investigated, but the assumption that it does gives rise to an approximation which replaces Equation (B-6) by an integral representation which involves reflection and transmission coefficients

integrated over all angles. This form arises by using the plane wave integral representation for the Green's function given in Reference B-2. Presumably, the latter approximation accounts partially for the fact that the presence of the edge modifies the source strengths appearing in Equation (B-3) from the zero order approximation given by Equation (B-5). This point requires more investigation. In the final analysis it may be required to check any approximation with the pair of coupled integral equations for justification of the assumptions.

The above relationships represent approximate expressions for the pressure field which are applicable to either plates or strips. In the former case g denotes the three-dimensional free space Green's function and the integral is taken over the shadowed surface of the plate.* In the latter case, the integral can be considered as one-dimensional with g denoting the two-dimensional Green's function:

$$g(\vec{r}|\vec{r}') = \frac{i}{4} H_0(k|\vec{r}-\vec{r}'|) \quad (B-8)$$

with H_0 denoting the zero order Hankel function of the first kind.

* The functional form of the integral in Equation (B-7) is such that its value is determined strictly by the edge line of the plate.

The subsequent discussion is concerned with a specialization of Equations (B-6) and (B-7) for the case of a strip baffle.

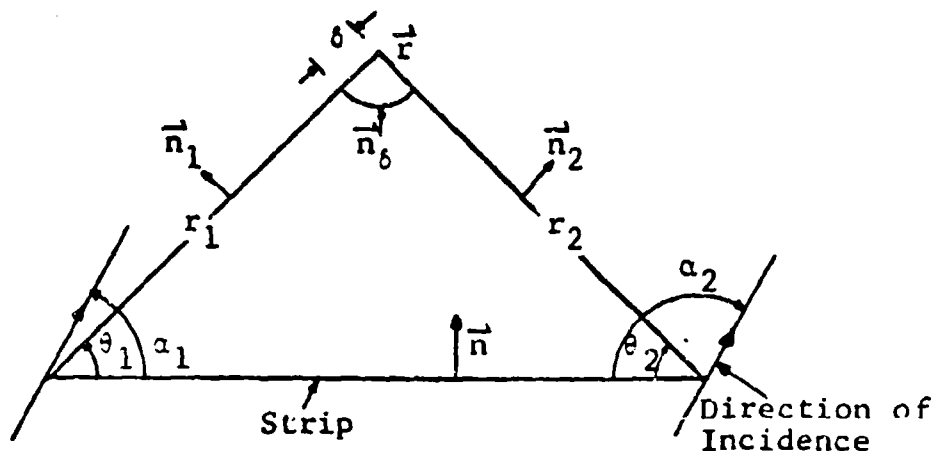


FIG. B-1 - GEOMETRY OF PLANE WAVE SCATTERING FROM A STRIP

Consider the geometrical situation depicted in Figure B-1. It is convenient to reference the arbitrary field point $\vec{r}$ relative to both edges in terms of two systems of cylindrical coordinates as indicated in Figure B-1.

To evaluate Equation (B-7), we make use of the fact that the line integral can be taken over any contour having its end points on the edges of the strip and lying on the same side of the field point as the strip. In particular, the contour can be taken to consist of S_1 : the straight line from the left edge to the point a small distance δ from the field point as indicated in Figure B-1; S_δ : the portion of a circle of radius δ centered at the field point and contained between rays from the field point passing through the edges of the strip; S_2 : the straight line joining the field point to the right-hand baffle edge taken from a distance δ away from the field point to the right-hand edge.

It is important to note that the contribution from S_δ does not vanish as the radius δ shrinks to zero. The simplest means of evaluating this limit is to recognize that it is equal to the limit for the integral taken over an entire circle multiplied by the ratio of the angle subtended by S_δ and 2π . Recognizing that the angle subtended at $\vec{r}$ by S_δ is $\pi - \theta_1 - \theta_2$, and that the limit over the entire circle is $-e^{-i\vec{k} \cdot \vec{r}}$ according to the Helmholtz integral formula, we obtain

$$U_\delta \xrightarrow{\delta \rightarrow 0^+} - \left[\frac{\pi - \theta_1 - \theta_2}{2\pi} \right] e^{i\vec{k} \cdot \vec{r}}.$$

Also by observing that on S_1 the normal derivative of G is identically zero we find in the limit as δ approaches zero that

$$U_1 \xrightarrow{\delta \rightarrow 0^+} \left[\frac{\sin(\theta_1 - \alpha_1)}{4} \int_0^{kr_1} dt H_0(t) e^{-it \cos(\theta_1 - \alpha_1)} \right] e^{i\vec{k} \cdot \vec{r}},$$

where we have used Equation (B-3) and the fact that $\vec{k}$ has an angular orientation α_1 relative to the left-hand edge.

A similar result is obtained for the right-hand edge except that the angles are referenced with the subscript 2. Combination of the results gives

$$U(\vec{r}|\vec{k}) = e^{i\vec{k} \cdot \vec{r}} \left[\frac{\theta_1 + \theta_2 - \pi}{2\pi} + \frac{\sin\psi_1}{4} \int_0^{kr} dt H_0(t) e^{-it \cos\psi_1} + \frac{\sin\psi_2}{4} \int_0^{kr_2} dt H_0(t) e^{-it \cos\psi_2} \right], \quad (B-9)$$

where

$$\psi_1 = \theta_1 - \alpha_1, \quad \psi_2 = \theta_2 - \alpha_2 \quad .$$

A method of evaluating the integrals in Equation (B-9) has already been discussed in the appendix of Reference B-3. An alternative means of evaluation will be discussed subsequently, but first it is convenient to consider the limiting case of Equation (B-9) as the right-hand edge moves to infinity keeping the field point $\vec{r}$ fixed. According to Figure B-1 this amounts to letting r_2 approach infinity and simultaneously allowing θ_2 to approach zero. Thus

$$\begin{aligned} \lim_{\substack{r_2 \rightarrow \infty \\ \theta_2 \rightarrow 0}} U(\vec{r}|\vec{k}) &= e^{i\vec{k} \cdot \vec{r}} \left[\frac{\theta_1 - \pi}{2\pi} + \frac{\sin \psi_1}{4} \int_0^{kr_1} dt H_0(t) e^{-it \cos \psi_1} \right. \\ &\quad \left. - \frac{\sin \alpha_2}{4} \int_0^\infty dt H_0(t) e^{-it \cos \alpha_2} \right] . \end{aligned}$$

Using the integral representation of the Hankel function and rotating the contour in the t - plane by 90° it may be shown that

$$\frac{\sin \alpha}{4} \int_0^\infty dt H_0(t) e^{it \cos \alpha} = \frac{\alpha}{2\pi} \quad \text{for } -\pi \leq \alpha \leq \pi, \text{ and periodic outside this interval.}$$

(B-10)

This result in conjunction with the identity $\alpha_2 = \pi - \alpha_1$ evident from Figure B-1 gives:

$$\lim_{\substack{r_2 \rightarrow \infty \\ \theta_2 \rightarrow 0}} U(\vec{r}|\vec{k}) = u(kr_1, \psi_1) e^{-i\vec{k} \cdot \vec{r}}, \quad (B-11)$$

where

$$u(kr_1, \psi_1) = \frac{\psi_1 - \pi}{2\pi} + \frac{\sin \psi_1}{4} \int_0^{kr_1} dt H_0(t) e^{-it \cos \psi_1}, \quad (B-12)$$

the above relation being valid under the assumption that α_1 is less than π . A similar analysis shows

$$\lim_{\substack{r_1 \rightarrow \infty \\ \theta_1 \rightarrow 0}} U(\vec{r}|\vec{k}) = u(kr_2, \psi_2) e^{-i\vec{k} \cdot \vec{r}}. \quad (B-13)$$

The relation (B-12) is the same as Equation (3.23) derived by a different method in Reference B-5 if we recognize that Reference B-5 uses the complement of ψ_1 . It corresponds to the field diffracted by the edge of a black half-plane the geometric shadow occurring for $\psi_1 \leq 0$.

Furthermore we have according to Equations (B-9), (B-11), (B-12), and (B-13) that

$$U(\vec{r}|\vec{k}) = e^{-i\vec{k} \cdot \vec{r}} [1 + u(kr_1, \psi_1) + u(kr_2, \psi_2)],$$

which in conjunction with Equation (B-7) shows that the field is the superposition of the effects from the two edges.

Making use of Equation (B-10) it follows that Equation (B-12) can be written as

$$u(kr, \psi) = f(\psi) - \frac{\sin \psi}{4} \int_{kr}^{\infty} dt H_0(t) e^{-it \cos \psi}, \quad (B-14)$$

where

$$f(\psi) = \begin{cases} 0 & \psi > 0 \\ -1 & \psi < 0 \end{cases}.$$

A simple approximation to the integral in Equation (B-14) can be obtained by using the asymptotic form of the Hankel function to get

$$\begin{aligned} v(kr, \psi) &= \frac{\sin \psi}{4} \int_{kr}^{\infty} dt H_0(t) e^{-it \cos \psi} \\ &\approx \frac{\sin \psi}{4} \frac{2}{\pi} e^{-i(\pi/4)} \int_{kr}^{\infty} dt \frac{e^{i(1-\cos \psi)t}}{\sqrt{t}}. \end{aligned}$$

Or

$$v(kr, \psi) \approx \cos\left(\frac{\psi}{2}\right) \left[\frac{1-i}{2} \int_x^{\infty} dt e^{i(\pi/2)t^2} \right], \quad (B-15)$$

where

$$x = 2 \sqrt{\frac{kr}{\pi}} \sin \psi/2. \quad (B-16)$$

Equation (B-16) is valid only for $\psi \geq 0$ and we use the fact that the original expression is odd to determine the approximate representation in the shadow. Note that curves of constant x are parabolic.

While Equation (B-16) is strictly valid only for kr large relative to unity, in practice the approximation compares well with the previous representation given in Reference B-3 for distances greater than 2 or 3 wavelengths. Furthermore a slight modification of the previous analysis shows that applying the approximation in Equation (B-16) to the case of a black half-plane gives a pressure field in the shadow region that differs from the Sommerfeld function B^{-6} by the factor $\cos \psi/2$.

The above relationships provide an approximate representation for the scattering from a translucent strip baffle which is straightforward from a computational point of view. Furthermore it is not difficult to show that Equation (B-6) reduces to the solution for an infinite planar baffle as the edges of the strip move to infinity. This fact can be obtained most simply by recognizing that for this case the integral in Equation (B-7) can be evaluated in terms of the Helmholtz integral formula if one recognizes that the integral over a large semicircle drawn in the shadow region vanishes. Consequently we find

$$U(\vec{r}|\vec{k}) = \begin{cases} -e^{i\vec{k}\cdot\vec{r}} & \text{in the shadow} \\ 0 & \text{in the illuminated region} \end{cases}$$

$$U(\vec{r}|\vec{k}_1) = \begin{cases} 0 & \text{in the shadow} \\ e^{i\vec{k}_1\cdot\vec{r}} & \text{in the illuminated region.} \end{cases}$$

Substitution of these relations into Equation (B-6) gives the usual results for an infinite planar baffle.

Previous investigations (B-3), (B-4) concerning diffraction from opaque baffles have shown that the diffracted field computed according to the above approach gives good agreement with known exact results for strip baffles greater than or equal to four wavelengths.* Consequently one might expect similar criteria to apply also in the present case. On the other hand, it should be noted that the above approximation does not account for the additional structural modes of vibration resulting from the boundary conditions on the plate edges which are not present in an infinite plate. The extent to which these modes affect the pressure field in the vicinity of a finite plate remains to be investigated.

* Note that an opaque baffle can be characterized in terms of Equation (B-6) by setting the transmission coefficient to zero and the reflection coefficient to plus or minus unity.

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