A Fortran Program For Calculating
The Equivalent Source Strength For The
Class I and II Flextensional Underwater
Acoustic Transducer Designs

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ABSTRACT

A Fortran program is presented which computes a normalized equivalent source strength for the Class I and approximates the Class II Flexntentional Underwater Acoustic Transducer Shells. The program utilization, the input data and the output data formats are described in detail.

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INTRODUCTION

This report describes a Fortran program of an equivalent source strength model for the Class I and II (Reference 1) Flextensional Underwater Acoustic Transducer Shells. Pictures of these two shell configurations are shown in Figures 1 and 2.

An approximate analytical model for the Class I type of shell design has been developed (References 2 and 3. The math model described in References 2 and 3 utilizes a numerical model in order to obtain the near- and far-field acoustic pressures for a specified displacement on the shell and associated frequency of radiation. This model is sufficient for engineering applications up through the fundamental mode of vibration provided that a so-called forbidden frequency is not encountered (Reference 4).

It is not uncommon for the effective ka of a flextensional shell to be less than one thus yielding a relatively omni-directional far-field radiation pattern. If for such design situations an equivalent source strength model was available, an approximation to the far-field pressures at a defined frequency and shell displacement would be possible. In addition, the equivalent source strength model would be more economical to utilize, computer cost, etc., and would yield important preliminary design information.
For a given transducer having the general configuration depicted in Figure 3, all geometric quantities pertinent to the solution of the free vibration eigenvalue problem and the computation of the source strength may be determined by specifying any one of several dimensionless parameters and the opening angle, \( \theta_0 \). The parameters \( L/D \) and \( \theta_0 \) are the independent variables in the accompanying FORTRAN program; \( L/D \) being selected since it is also relevant with respect to the size of the piezoelectric stack required to drive the transducer.

The solution of the approximate dynamic model involves computing the first eigenvalue and eigenvector of a \( 2 \times NP - 2 \) square matrix, where \( NP \) is the number of control points input for generation of the discrete system equations of motion. It is suggested that, for best numerical results, \( NP \) should lie in the range \( 10 \leq NP \leq 15 \).

The units used are immaterial since all input - output quantities are dimensionless ratios with the exception of the opening angle which is in degrees.
Figure 3 - Transducer Configuration
INPUT DATA

On the first data card enter NN, the number of cases to be run consecutively. NN is input in FORMAT (12).

On each following card enter the quantities IVC, NP, IAL, IAU, INC, RK, and RATIO in FORMAT (11, 12, 313, 2F4.1).

IVC controls the printout of the components of the eigenvector normal to the surface of the transducer and the normalized radiating areas. These vectors are printed out only if IVC is entered as a non zero positive quantity.

NP is the number of control points to be defined on one half of a typical transducer element for the discrete system dynamic model.

IAL, IAU, and INC correspond to the first opening angle, the last opening angle, and the opening angle increment, respectively, desired in the output for a given RATIO. These quantities have units of degrees.

RK is the ratio of the radius of curvature of a typical transducer element to the radius of gyration of a typical element section as measured at the guided end. The dynamic model is insensitive to this parameter for RK < 20. RK is normally input as any large positive number for thin transducer elements. RATIO = L/D.

PRINT-OUT DATA

The input quantities RATIO and NP appear as header information for each case. The output quantities THETA, RADIUS/LENGTH, HEIGHT/LENGTH, DISP., RATIO, WIDTH RATIO, WIDTH FACTOR, COEFFICIENT AND NORM. SOURCE STR. are printed out for each opening angle where:

THETA = \theta
RADIUS/LENGTH = R/L
HEIGHT/LENGTH = H/L

(9)
DISPL. RATIO is the ratio of the displacement measured at the center of the circular arc formed by a typical transducer element to the corresponding horizontal displacement of the guided end.

WIDTH RATIO is the ratio of the width of a typical element as measured at the center of the circular arc to the width of the element as measured at the guided end.

WIDTH FACTOR = element width at center of arc/(1/2 arc length of element * sin (PI/N)), where N is the number of transducer elements.

COEFFICIENT is the frequency coefficient i.e. that number which, when multiplied by SQRT (E*I/m)/(L*L), yields the natural frequency in rad./sec. where E is the modulus of elasticity, I and m are the area moment of inertia and mass per unit length of a typical element as measured at the guided end, and L is as shown in Figure 3.

NORM. SOURCE STR is the source strength of the transducer normalized with respect to ((PI*D)**2)*F* DELTA where F is the frequency of excitation in cycles/sec., DELTA is the displacement amplitude of the guided end, and D is as in Figure 3. Negative values of this quantity indicate that the net volume displacement is negative when the ends of the transducer are displaced in such a manner that the transducer is elongated.

If IVC > 0, the vectors NORMAL VECTOR and NORMALIZED AREAS are also printed out. NORMAL VECTOR is the vector of eigenvector components normal to the transducer surface normalized with respect to the eigenvector component at the guided end. NORMALIZED AREAS is the vector of radiating areas associated with the discrete system control points normalized with respect to the area of the circular end section.
The model presented in this report is an approximate model since several simplifying assumptions were necessary. A list of the most important assumptions made and where deemed appropriate the anticipated results of having to make such assumptions are as follows:

a) It is assumed that the external geometry of the shells can be approximated by cylindrical end sections (actual length is not considered since it is assumed that knoll and circular curved beams exhibiting a varying taper characteristic.

b) The cylindrical end sections do not radiate except on the ends. If the radial thickness of the cylindrical end sections is small compared to the thickness of the curved beams then most likely these end sections will contribute significantly to the overall radiation field.

c) Radiation through the slits between the curved beams is assumed to be insignificant.

d) It is assumed that the boundary condition for the curved beams is clamped-guided. Most Class II shells will approximate this boundary condition as will relatively thick Class I1 shell designs.

e) The present program does not allow the option of specifying the actual curved beam end mass. If the end masses become large as compared to the total mass of the curved beams, as is quite possible for the Class I1 shell, then the eigenvector associated with the shells fundamental frequency of vibration approaches the quasi-static solution. This would result in a reduction in the predicted far-field pressures of approximately 25%.

The program described here in has been checked by comparing the predicted and measured far-field pressures for a transducer of known performance. The predicted pressures were approximately 41.5 db above the measured data. In
light of the intended use for the model described herein the above variation is acceptable. In addition, since it is entirely possible to design a flexensional transducer (for ka ') with Q = 0, this program should be utilized early in the design process in order to eliminate this type of design error.
REFERENCES

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tensional Underwater Acoustic Transducers. Paper presented at the 
Seventy-Seventh Meeting of the Acoustical Society of America, Philadelphia, 
Pennsylvania, April, 1969.

2) Royster, L. H. The Flextentional Underwater Acoustic Transducer. J. 

3) Royster, L. H. Investigation of the Design Principles of the Flextentional 
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4) Hess, J. L. Calculation of Acoustic Fields About Arbitrary Three-Dimensional 
Bodies by a Method of Surface Source Distributions Based on Certain Wave 
APPENDIX A
listing of the Fortran Program

C THIS PROGRAM COMPUTES THE SOURCE STRENGTH, FREQUENCY COEFFICIENT,
C AND A NUMBER OF GEOMETRIC PARAMETERS FOR A CLASS OF FLEXIONAL
C ACOUSTIC TRANSDUCERS COMPOSED OF AN ARRAY OF TAPERED CURVED BEAMS
C (CIRCULAR ARCS) FORMING A SURFACE OF REVOLUTION AND EXHIBITING
C SHORT CYLINDRICAL END SECTIONS
C
C USAGE: THE FOLLOWING PARAMETERS MUST APPEAR ON THE DATA CARD
C FOR EACH CASE- IVC, NP, IAL, IAU, INC, RK, RATIO
C
C DESCRIPTION OF INPUT PARAMETERS
C
C NN=NUMBERS OF DATA SETS
C IVC=1 IF A PRINTOUT OF THE NORMALIZED AREAS AND NORMALIZED NORMAL
C VECTORS IS DESIRED (THE TANGENTIAL COMPONENTS OF THE EIGENVECTOR ARE
C DESTROYED IN THE NORMALIZATION), IVC=0 OTHERWISE
C NP=THE NUMBER OF CONTROL POINTS IN HALF OF THE BEAM
C IAL=FIRST OPENING ANGLE DESIRED IN THE OUTPUT
C IAU=LAST OPENING ANGLE DESIRED IN THE OUTPUT
C INC=OPENING ANGLE INCREMENT
C RK=BEAM RADIUS/RADIUS OF GYRATION OF A TYPICAL ELEMENT EVALUATED
C AT THE GUIDED END
C RATIO=CHORD SUBTENDED BY THE OPENING ANGLE/DIAMETER OF CYLINDRICAL
C END SECTION AT THE GUIDED END
C
C DESCRIPTION OF OUTPUT PARAMETERS
C
C THETA=OPENING ANGLE SUBTENDED BY A TYPICAL ELEMENT OF THE ARRAY
C RADIUS/LENGTH=BEAM RADIUS/CHORD LENGTH
C HEIGHT/LENGTH=TRANSDUCER HEIGHT/CHORD LENGTH
C DISPL. RATIO=RATIO OF NORMAL DISPLACEMENT AT THE BEAM CENTER TO THE
C DISPLACEMENT OF THE GUIDED END
C WIDTH RATIO=RATIO OF BEAM WIDTH AT THE CENTER OF THE BEAM TO THE
C BEAM WIDTH AT THE GUIDED END
C WIDTH FACTOR=MAXIMUM BEAM WIDTH/(ARC LENGTH OF HALF BEAM*S IN(P/I
C IN)), N=NUMBER OF BEAMS IN THE ARRAY
C COEFFICIENT=FREQUENCY COEFFICIENT
C NORM. SOURCE STR.=SOURCE STRENGTH/((((PI*D)**2)*F*DEL TA), D=END
C DIAMETER, F=FREQUENCY IN CI./SEC., DELTA=DISPLACEMENT OF GUIDED END
C NORMAL VECTOR=NORMAL EIGENVECTOR COMPONENTS NORMALIZED ON THE
C DISPLACEMENT OF THE GUIDED END
C NORMALIZED AREAS=RADIATING AREAS ASSOCIATED WITH EACH DISCRETE CONTROL
C POINT NORMALIZED WITH RESPECT TO THE AREA OF THE CYLINDRICAL END

(14)
MAIN (continued)

DIMENSION A(60,60),W(60),RN(60),RT(30),RM(30),RS(30)
COMMON N,M,MODE,A,*
PT=3.1415927
N=1
MODE=1
READ(1,100)N
102 FORMAT(IJ)
DC 1 K=1,IN

READ(1,103)TVC,RP,IAI,IAU,INC,RK,RATIO
103 FORMAT(I1,12,213.2F4.1)
N=2*NP+2
WRITE(3,100)RATIO,NP
100 FORMAT('1///47X,'LENTH/END DIA.-'F7.4/47X,'NO. OF CONTROL PTS
1. IN HAFE BEAM,'12///8X,'THETA',3X,'RADIUS/LENGTH',3X,'HEIGHT/LEN
2TH',3X,'DISPL. RATIO',3X,'WIDTH RATIO',3X,'WIDTH FACTOR',3X,'COEF
3ICIENT',3X,'NORM. SOURCE STR.')
DO 1 LA=1A,IAU,INC
OA=LA*PT/180.
RR=STN(OA/2.)/RATIO
CALL COEFF(N,NP,OA,RR,SI,PHI,RM,RT,SN,RS)
CALL STUFF(N,NP,RP,SI,PHI,A,RR,RT,SN)
CALL GIVEXS
VU(1)=SQRT(VU(1))*COS(PHI/2.)*(S IN(OA/2.)**2)/(S IN(PHI/2.)**2)
DO 1 T=1,N
A(I,1)=A(I,1)/SQRT(RM(I))
2 CONTINUE
QSN=A(I,1)/ABS(A(I,1))
DO 3 I=2,N,2
K=I/2+1
QSN=QSN+A(1,1)*RS(K)/ABS(A(I,1))
3 CONTINUE
TF(A(I,1))=TF(A(I,1)4.4.5
4 QSN=-QSN
5 RL=1./(2.*SIN(OA/2.))
THL=(RR+1.-COS(OA/2.))/SIN(OA/2.)
DR=A(N,1)/A(I,1)
WR=RT(NP)
MR=4.*(1.-COS(OA/2.)*SIN(OA/2.)/RATIO)/OA
OA=QA*1.80./PT
WRITE(3,101)OA,RL,THL,DR,WR,MR,VU(1),QSN
101 FORMAT('1///F13.1,2E16.6,E15.5,E14.5,E15.5,E14.5,E18.6)
TF(TVC)1,1.6
6 TF(A(I,1))=7.7.8
7 A(I,1)=A(I,1)
DO 9 I=2,N,2
A(I,1)=A(I,1)
9 CONTINUE

(15)
9 CONTINUE
8 DO 10 I=2,N,2
   K=I/2+1
   A(K,1)=A(I,1)/A(1,1)
10 CONTINUE
   A(1,1)=1.
   WRITE(3,104)
104 FORMAT(//34X,'NORMAL VECTOR',34X,'NORMALIZED AREAS'//)
   WRITE(3,105)(A(I,1),RS(I),I=1,NP)
105 FORMAT(35X,E12.5,36X,E12.5)
1 CONTINUE
   END

(16)
SUBROUTINE COEFF(N,NP,OA,RR,SI,PHI,RM,RI,RN,RS)
DIMENSION RM(60),RI(30),RN(30),RS(30)
PI=3.1415927
SI=(PI-OA)/2.
PHI=OA/(2.*((NP-1.))
OA2=OA/2.
PHI2=PHI/2.
D=COS(OA/2.)/RR
RI(1)=1.
RN(1)=1. RS(1)=1
DO 1 J=2,NP
RI(J)=(COS(OA2-(J-1.)*PHI)-D)/RR
RN(J)=2.*RI(J)*RI(J-1)/((RI(J)+RI(J-1)))
RS(J)=2.*(2.*SIN(PHI2)*COS(OA2-(J-1.)*PHI)-D*PHI)/(RR*RR)
1 CONTINUE
RS(2)=2.*((2.*SIN(3.*PHI/4.)*COS(OA/2.-3.*PHI/4.)-D*3.*PHI/2.))/(RR*RR)
RS(NP)=2.*((SIN(PHI2)-D*PHI2)/(RR*RR)
RM(1)=1.
RM(N)=RI(NP)/2.
M=N-2
DO 2 J=2,M,2
RM(J)=RI(J/2+1)
RM(J+1)=RM(J)
2 CONTINUE
RETURN
END
SUBROUTINE STIFF(N,NP,RK,SL,PHI,A,RM,RI,RN)
DIMENSION A(N,NP),RK,SL,PHI,A,RM,RI,RN
C=SIN(PHI/2.)/COS(PHI/2.)
C2=SIN(SL)/COS(SL)
P=-(2.*RI+SIN(PHI/2.))/2
DO 1 I=1,N
DO 1 J=1,N
A(1,1)=0.0
1 CONTINUE:
A(1,1)=((C*G+C2-1.)*P-J + (2. + RI (2))*C2)*C2*RI
A(2,2)=C2*RI
A(3,3)=C2*C2
A(4,4)=RI
A(5,5)=RI
A(6,6)=RI
A(7,7)=RI
K1=N-4
K2=N-3
K3=N-2
K4=N-1
J1=N-3
J2=N-2
J3=N-1
A(K1,K1)=(RN(J2)+RN(J3))*P+RI(J1)+4*R1(J2)+RI(J3)
A(K1,K2)=C*R(N(J2)-RN(J3))*P-RI(J1)+RI(J3)
A(K1,K3)=RN(J3)*P+2. +RI(J2)
A(K1,K4)=RI
A(K2,K1)=RI
A(K2,K2)=(RN(J2)+RN(J3))*P+RI(J1)+RI(J3)
A(K2,K3)=C*R(N(J3))*P+2. +RI(J2)
A(K2,K4)=RI
A(K3,K1)=RN(J3)*P+2. +RI(J2)
A(K3,K2)=RI
A(K3,K3)=(RN(J3)+RN(NP))*P*RI(J2)+2.*RI(NP)
A(K3,K4)=C2*(RN(J3)-RN(NP))*P-RI(J2)+2.*RI(NP)
A(K4,K1)=RI
A(K4,K2)=RI
A(K4,K3)=RI
A(K4,K4)=C2*(RN(NP))*P+2.*RI(NP)
A(K5,K5)=RI
A(K6,K6)=RI
IF(I-J),2,2}
STIFF (continued)

3 \[ K = I/2 + 1 \]
\[ A(I, J) = (RN(K) + RN(K+1)) \times P \times C \times C + RI(K-1) + 4 \times RI(K) + RI(K+1) \]
\[ A(I, J+1) = C \times ((RN(K) - RN(K+1)) \times P - RI(K-1) + RI(K+1)) \]
\[ A(I, J+2) = RN(K+1) \times P \times C \times C - 2 \times (RI(K) + RI(K+1)) \]
\[ A(I, J+3) = C \times (RN(K+1) \times P + 2 \times RI(K)) \]
\[ A(I, J+4) = RI(K+1) \]
\[ A(I, J+5) = -RI(K+1) \times C \]
\[ M = I+1 \]
\[ L = J+1 \]
\[ A(N, L) = (RN(K) + RN(K+1)) \times P + (RI(K-1) + RI(K+1)) \times C \times C \]
\[ A(N, L+1) = -C \times (RN(K+1) \times P + 2 \times RI(K+1)) \]
\[ A(N, L+2) = -RN(K+1) \times P \]
\[ A(N, L+3) = RI(K+1) \times C \]
\[ A(N, L+4) = -RI(K+1) \times C \times C \]

2 CONTINUE
1 DO 4 I = 1, N
2 DO 4 J = 1, N
3 A(J, 1) = A(I, J)
4 CONTINUE
5 CONTINUE
6 \[ A(I, J) = A(I, J) / SQR1(RN(I) \times RN(J)) \]
7 CONTINUE
8 RETURN
9 END

(19)
SUBROUTINE GIVENS
DIMENSION A(60,60), B(60,60), DIAG(60), VU(60), VL(60), SD(60),
LD(60), S(60), C(60), D(60), IND(60), U(60),
COMMON N,M,MODE,A, VU
EQUIVALENCE (P, PRODS), (TAU, BETA), (T, SMALLD), (II, MATCH), (VL(1), D(1)),
(0(1), S(1))
C CALCULATE NORM OF MATRIX
ANORM=0.
DO 1 I=1,N
SD(I)=0.
DO 1 J=1,N
1 ANORM=ANORM+ A(I,J)*A(I,J)
D = MIS = SQRT (ANORM)
C GENERATE IDENTITY MATRIX
1 IF(H) 1000, 11, 1000
1000 DO 7 J=1,N
DO 7 I=1,N
1 IF(I-J) 6, 1001, 6
1001 B(I,J)=1.
GO TO 7
6 B(I,J)=0.
7 CONTINUE
C PERFORM ROTATIONS TO REDUCE MATRIX TO JACOBI FORM
11 NN=N-2
1 IF(NN) 100, 21, 1003
1003 DO 15 I=1,NN
I=I+2
DO 15 J=1,N
T1=A(I,J+1)
T2=A(I,J)
1 IF(T2) 1004, 15, 1004
1004 CALL ROTATE(T1, T2, SIN, CSN)
DO 12 K=1,N
T2=CSN*A(K, I+1)+SN*A(K, J)
A(K,J)=CSN*A(K,J)+SN*A(K, I+1)
12 A(K, I+1)=T2
DO 13 K+1
T2=CSN*A(I+1,K)+SN*A(J,K)
A(J,K)=CSN*A(J,K)+SN*A(I+1,K)
13 A(I+1,K)=T2
1 IF(H) 1005, 15, 1005
1005 DO 14 K=1,N
T2=CSN*B(K, I+1)+SN*B(K, J)

(20)
B(K,J)=CSN*B(K,J)-SN*B(K,I+1)
14 B(K,I+1)=T2
15 CONTINUE

C MOVE JACOBI ELEMENTS AND INITIALIZE EIGENVALUE BOUNDS

21 DO 22 I=1,N
   DIAG(I)=A(I,I)
   VL(I)=ANORM
22 VL(I)=ANORM
   DO 23 I=2,N
      SD(I-1)=A(I-1,I)
23 Q(I-1)=SD(I-1)*SD(I-1)

C DETERMINE SIGNS OF PRINCIPAL MINORS

TAU=0.
I=1
35 MATCH=0
   T2=0.
   T1=1.
   DO 26 J=1,N
      P=DIAG(J)*TAU
      IF(T2)1007,27,1007
      1007 IF(T1)1008,28,1008
      1008 T=P*T-I-Q(J-1)*T2
      GO TO 29
   27 IF(T1)1009,30,30
   1009 T1=-1.
      T=-P
      GO TO 29
   30 T1=1.
      T=P
      GO TO 29
   28 IF(Q(J-1))1010,30,1010
   1010 IF(T2)31,1011,1011
   1011 T=-1.
      GO TO 29
   31 T=1.

C COUNT AGREEMENTS IN SIGN

29 IF(T1)32,1012,1012
1012 IF(T)34,33,33
32 IF(T)34,34,34
33 MATCH=MATCH+1
34 T2=T1/ABS(T1)
26 T1=T/ABS(T1)
GIVENS (continued)

C ESTABLISH TIGHTER BOUNDS ON EIGENVALUES

DO 41 K=1,MIDE
   IF(K-N+MATCH)1014,1014,42
1014 IF(VU(K)-TAU)41,41,1015
1015 VU(K)=TAU
   GO TO 41
42 IF(VL(K)-TAU)1018,41,41
1018 VL(K)=TAU
   CONTINUE
45 IF(VU(1)-VL(1)-5.E-6)43,43,1016
1016 IF(VU(1))1017,44,1017
1017 IF(ABS(VL(I)/VU(I)-1.)-5.E-6)43,43,44
   J=J+1
   IF(J-MODE)1019,1019,51
1019 GO TO 45
46 TAU=(VL(I)+VU(1))/2.
   GO TO 35
51 IF(M)100,100,1020
1020 IF(J-MODE)1021,1021,1022
1022 M=MODE
1021 DO 52 I=1,N
   DO 52 J=1,N
   52 A(I,J)=0.
   DO 53 I=1,N
      IF(I-1)1029,54,1029
1029 IF(VU(I)-VU(I-1)-5.E-6)55,55,1023
1023 IF(VU(I))1024,54,1024
1024 IF(ABS(VU(I-1)/VU(I)-1.)-5.E-6)55,55,54
   CSN=1.
   SN=0.
   DO 56 J=1,N
      IF(J-1)1025,57,1025
1025 CALL ROTATE(T1,T2,SN,CSN)
      S(J-1)=SN
      C(J-1)=CSN
      D(J-1)=T1*CSN+T2*SN
   57 T1=(DIAG(J)/VU(I))-CSN-BETA*SN
      T2=SD(J)
   56 BETA=SD(J)*CSN
      D(N)=T1
   DO 58 J=1,N
58 IN(0(J))=0
55 SMALLD=ANORM
   DO 60 J=1,N
      IF(IN(J))1026,60,60
1026 IF(ABS(SMALLD)-ABS(D(J)))60,60,1027
1027 SMALLD=D(J)

(22)
GIVENS (continued)

NN=J
60 CONTINUE
1ND(JNN)=1
......
IF(NN+1)1028,53,1028
1028 DO 61 K=2,NN
11=NN+1-K
A(11+1,1)=C(11)*PRODS
61 PRODS=PRODS*S(11)
53 A(1,1)=PRODS

C FORM PRODUCT OF ROTATION MATRIX WITH JACOBI VECTOR MATRIX

DO 66 J=1,M
DO 67 K=1,N
67 U(K)=A(K,J)
DO 56 I=1,N
A(I,J)=0.
DO 65 K=1,N
66 A(I,J)=B(I,K)*U(K)+A(I,J)
100 RETURN
END

SUBROUTINE ROTATE(A,B,C,D)
E=SQR(A*A+B*B)
D=A/E
C=B/E
RETURN
END

(23)
APPENDIX B

Listing of a Typical Output Data Set

**TYPICAL OUTPUT**

**LENGTH/END DIA. = 1.2600**

**NO. OF CONTROL PTS. IN HALF BEAM = 15**

<table>
<thead>
<tr>
<th>( \theta )</th>
<th>RADIUS/LENGTH</th>
<th>HEIGHT/LENGTH</th>
<th>DISPL. RATIO</th>
<th>WIDTH RATIO</th>
<th>WIDTH FACTOR</th>
<th>COEFFICIENT</th>
<th>NORM. SOURCE STR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>102.0</td>
<td>0.643380E 00</td>
<td>0.127063E 01</td>
<td>-0.19610E 01</td>
<td>0.16010E 01</td>
<td>0.22187E 01</td>
<td>0.16698E 02</td>
<td>-0.234460E 01</td>
</tr>
</tbody>
</table>

**NORMAL VECTOR**

\[
\begin{align*}
0.10000E 01 \\
0.69187E 00 \\
0.53385E 00 \\
0.31990E 00 \\
0.65892E-01 \\
-0.21328E 00 \\
-0.50371E 00 \\
-0.79261E 00 \\
-0.10684E 01 \\
-0.13207E 01 \\
-0.15403E 01 \\
-0.17195E 01 \\
-0.18521E 01 \\
-0.19335E 01 \\
-0.19610E 01 \\
\end{align*}
\]

**NORMALIZED AREAS**

\[
\begin{align*}
0.10000E 01 \\
0.32734E 00 \\
0.23737E 00 \\
0.25156E 00 \\
0.26471E 00 \\
0.27677E 00 \\
0.28771E 00 \\
0.29746E 00 \\
0.30599E 00 \\
0.31327E 00 \\
0.31926E 00 \\
0.32395E 00 \\
0.32731E 00 \\
0.32934E 00 \\
0.16501E 00 \\
\end{align*}
\]

(24)
TYPICAL OUTPUT (continued)

108.0 0.618035E 00 0.130317E 01 -0.18372E 01 0.16420E 01 0.22373E 01 0.16727E 02 -0.212407E 01

<table>
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<th>NORMALIZED AREAS</th>
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<tr>
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<tr>
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<tr>
<td>-0.18372E 01</td>
<td>0.17213E 00</td>
</tr>
</tbody>
</table>

(25)
A Fortran program is presented which computes a normalized equivalent source strength for the Class I and approximates the Class II Flex-tensional Underwater Acoustic Transducer Shells. The program utilization, the input data and the output data formats are described in detail.
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