(2)

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

NUMERICAL MODELING
OF A
FREE-FLOODED
PIEZOELECTRIC RING SONAR TRANSDUCER

by

Tiong Beng Tay

March, 1993

Thesis Co-Advisors: Steven R. Baker
Ron J. Pieper
Oscar B. Wilson

Unclassified

Security Classification of this page

REPORT DOCUMENTATION PAGE

1a Report Security Classification: Unclassified	1b Restrictive Markings
2a Security Classification Authority	3 Distribution/Availability of Report Approved for public release: distribution is unlimited.
2b Declassification/Downgrading Schedule	
4 Performing Organization Report Number(s)	5 Monitoring Organization Report Number(s)
6a Name of Performing Organization Naval Postgraduate School	6b Office Symbol *(if applicable)* 33
7a Name of Monitoring Organization Naval Postgraduate School	
6c Address *(city, state, and ZIP code)* Monterey CA 93943-5000	7b Address *(city, state, and ZIP code)* Monterey CA 93943-5000
8a Name of Funding/Sponsoring Organization	8b Office Symbol *(if applicable)*
9 Procurement Instrument Identification Number	
Address *(city, state, and ZIP code)*	10 Source of Funding Numbers

Program Element No	Project No	Task No	Work Unit Accession No

11 Title *(include security classification)* NUMERICAL MODELING OF A FREE-FLOODED PIEZOELECTRIC SONAR RING TRANSDUCER

12 Personal Author(s) Tiong Beng Tay

13a Type of Report	13b Time Covered	14 Date of Report *(year, month, day)*	15 Page Count
Master's Thesis	From To	March 1993	114

16 Supplementary Notation The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17 Cosati Codes			18 Subject Terms *(continue on reverse if necessary and identify by block number)*
Field	Group	Subgroup	Numerical Modeling, Pizoelectric, Ring Transducer, Free-Flooded.

19 Abstract *(continue on reverse if necessary and identify by block number)*

A two-dimensional finite element model of a low frequency, free-flooded piezoelectric thin ring sonar transducer was developed for use with the ATILA code.

Effective material properties for the ring were determined from in-air modal analyses using ATILA. These were adjusted to obtain the closest agreement between the calculated ring resonance frequency and coupling coefficient and measured data supplied by the manufacturer. In addition, equations for the electrical admittance for this transducer in air were developed based on an analytical approach published by Hong-zhang Wang (J. Acoust. Soc. Am. 79, 164-176 (1986)). A MATLAB program was written to implement these equations and to calculate various electromechanical network parameters. The calculated values agreed with measured values to within 5 percent.

An in-water harmonic analysis, in which the transmitting voltage response and the directivity pattern are computed, was performed using the ATILA code. In general, results obtained using the finite element model and manufacturer's measured values agree within 10 percent. The effects of changes in material properties on acoustic performance of the transducer were investigated; the results are discussed.

20 Distribution/Availability of Abstract x unclassified/unlimited __ same as report __ DTIC users	21 Abstract Security Classification Unclassified

22a Name of Responsible Individual	22b Telephone *(include Area Code)*	22c Office Symbol
Steven R. Baker	408-656 2729	Code PH/Ba

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted — security classification of this page

All other editions are obsolete — Unclassified

Numerical Modeling of a Free-Flooded Piezoelectric Ring Sonar Transducer

by
Tiong Beng Tay
Major, Republic of Singapore Navy
B. Eng (Hons), National University of Singapore, 1985

Submitted in partial fulfillment
of the requirements for the degrees of
MASTER OF SCIENCE IN ENGINEERING ACOUSTICS
and
MASTER OF SCIENCE IN ELECTRICAL ENGINEERING
from the

NAVAL POSTGRADUATE SCHOOL
March 1993

Author: ______________________
Tiong Beng Tay

Approved by: ______________________
Steven R. Baker, Thesis Co-Advisor

____
Ron J. Pieper, Thesis Co-Advisor

____
Oscar B. Wilson, Thesis Co-Advisor

____
Anthony A. Atchley, Chairman, Engineering Acoustics Academic Committee

____
Michael A. Morgan, Chairman, Department of Electrical and Computer Engineering

ABSTRACT

A two-dimensional finite element model of a low frequency, free-flooded piezoelectric thin ring sonar transducer was developed for use with the ATILA code.

Effective material properties for the ring were determined from in-air modal analyses using ATILA. These were adjusted to obtain the closest agreement between the calculated ring resonance frequency and coupling coefficient and measured data supplied by the manufacturer. In addition, equations for the electrical admittance for this transducer in air were developed based on an analytical approach published by Hong-zhang Wang (J. Acoust. Soc. Am. 79, 164-176 (1986)). A Matlab program was written to implement these equations and to calculate various electromechanical network parameters. The calculated values agreed with measured values to within 5 percent.

An in-water harmonic analysis, in which the transmitting voltage response and the directivity pattern are computed, was performed using the ATILA code. In general, results obtained using the finite element model and manufacturer's measured values agree within 10 percent. The effects of changes in material properties on acoustic performance of the transducer were investigated; the results are discussed.

TABLE OF CONTENTS

I. INTRODUCTION

Free-flooded piezoelectric ring transducers have found increasing use in deep ocean sonar applications. Though simple in concept, the ability to reliably predict the performance of such devices is complicated by the nature of their construction. In particular, the acoustic performance of such transducers depends upon the physical properties of the encapsulant materials used, making their performance difficult to model.

Standard multiport network analysis techniques, long used to model the electromechanical behavior of piezoelectric transducers, are usually restricted to one-dimensional motion. Newer types of transducer structures, such as the free-flooded ring, that have more than one important degree of freedom, do not lend themselves to this technique. Consequently, finite element analysis (FEA) techniques, which provide the capability to analyze engineering problems of many degrees of freedom, are frequently employed.

The objectives of this research were (1) to numerically model a free-flooded piezoelectric ring sonar transducer and (2) using the developed model, predict the changes in acoustic performance due to changes in the elastic properties of the encapsulants used.

The electroacoustic properties of this free-flooded piezoelectric ring sonar transducer were numerically modeled using the finite-element code "ATILA", developed by the Institut Supérieur d'Electronique du Nord (Lille, France) [Ref. 1]. Since the ring is constructed of ceramic staves cemented together, the effective material properties for the ring were determined from in-air modal analyses using ATILA. The material property values were adjusted to obtain the closest agreement between the calculated ring assembly resonance frequency and coupling coefficient and measured data supplied by the manufacturer.

In addition to the finite element analysis, equations for the electrical admittance of the thin ring transducer when unloaded were developed based on an analytical approach published by Hong-zhang Wang [Ref. 2]. A MATLAB program was written to implement and compute various electromechanical network parameters. The results obtained from the analytical method were compared with the measured values and those obtained by the finite element code.

The finite element model built was further used to predict the changes in acoustical properties due to a change in the type of encapsulant materials used in manufacturing.

The remainder of this thesis is divided into seven chapters. Chapter II describes the transducer under study.

Chapter III gives a general description of the finite element analysis and the standard network analysis of piezoelectric ring transducers. Chapter IV describes the development of the 2-dimensional finite element model of the transducer for use with the ATILA code. Chapter V presents and discusses the results of the in-air modal analyses and in-water harmonic analyses using ATILA, as well as the results of the analytical model. Chapter VI presents the conclusions. Chapter VII provides suggestions for future work. Appendix A contains a copy of the input data file for the finite element mesh used in the in-water harmonic analyses. The MATLAB program written to implement the analytical model for the transducer in air is attached as Appendix B. Appendix C provides a list of the typical values of material constants used in the modeling. Appendix D is a sample calculation of the effective elastic constants of a homogeneous ceramic ring incorporating the fiberglass wrap.

II. TRANSDUCER DESCRIPTION

Figure 1 shows a schematic diagram of a free-flooded piezoelectric ring sonar transducer. When immersed in water and vibrating radially, such a transducer exhibits two fundamental resonant modes that can radiate acoustically into the water. They are the radial resonance of the ring and the cavity resonance of the enclosed water column. Radial motion of the cylinder walls will excite the symmetrical cavity modes in the enclosed water column. The radial resonance is the more important resonance.

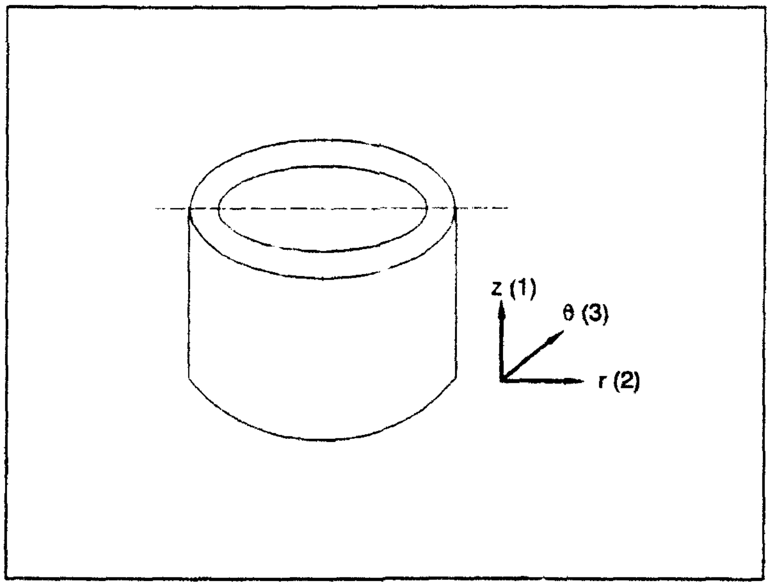

Figure 1: The Free Flooded Ring Transducer

The motor element (piezoelectric ring) of the transducer under study consists of a set of 72 tangentially polarized lead zirconate titanate, PZT, Navy Type II ceramic staves as shown in Figure 2.

PZT is an isotropic polycrystaline ceramic which exhibits piezoelectric properties after poling [Ref. 4]. It exhibits a high degree of symmetry in the plane transverse to the poling. These materials are usually treated as member of the 6 mm hexagonal class [Ref. 4].

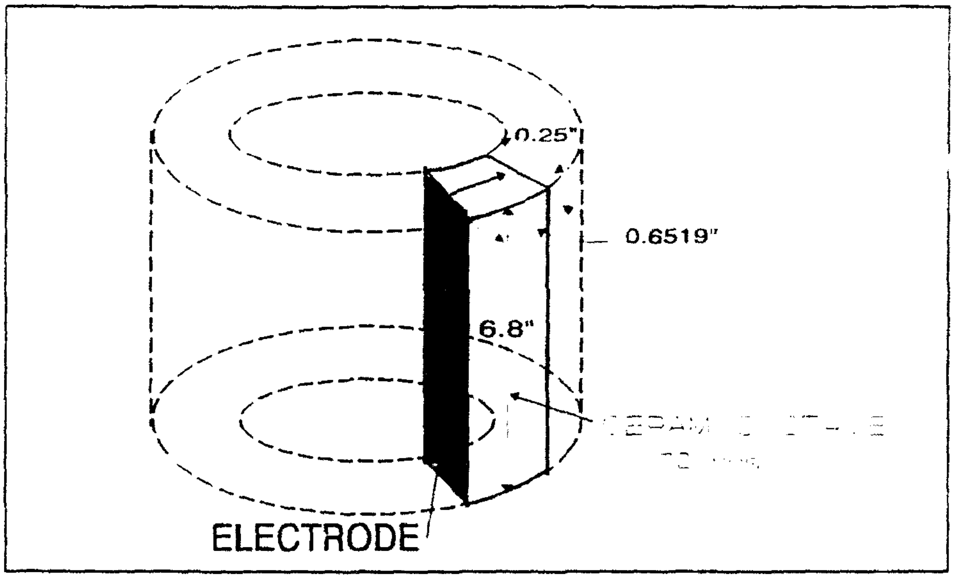

Figure 2: The Ceramic Staves

Each stave has dimensions (w x l x h) 0.25 x 0.6519 x 6.8 in. (0.635 x 1.656 x 17.272 cm). They are cemented together using epoxy resin to form a ring of 14.44 inches (0.3668 m) outside diameter, as shown in Figure 3.

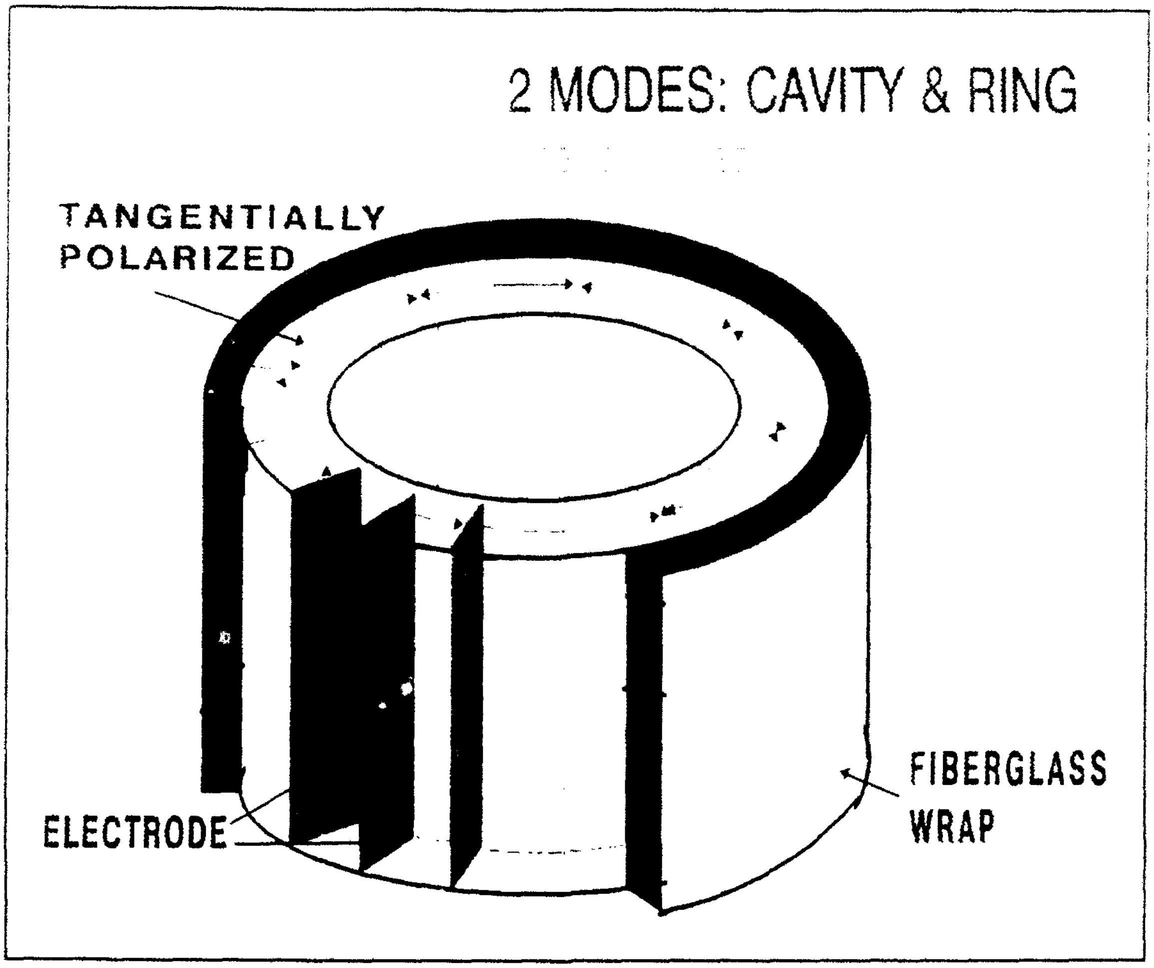

Figure 3: The Ring Transducer

The ceramic plates are poled tangentially and electrically wired in parallel. Thus, it is apparent that, during operation, the electric field will either simultaneouly be parallel or antiparallel to the poling direction shown in Figure 3. The ring is wrapped on the outside by epoxy-impregnated fiberglass of 0.03 in (0.762 mm) thickness, which provides a compressive stress bias.

A cutaway view is as shown in Figure 4.

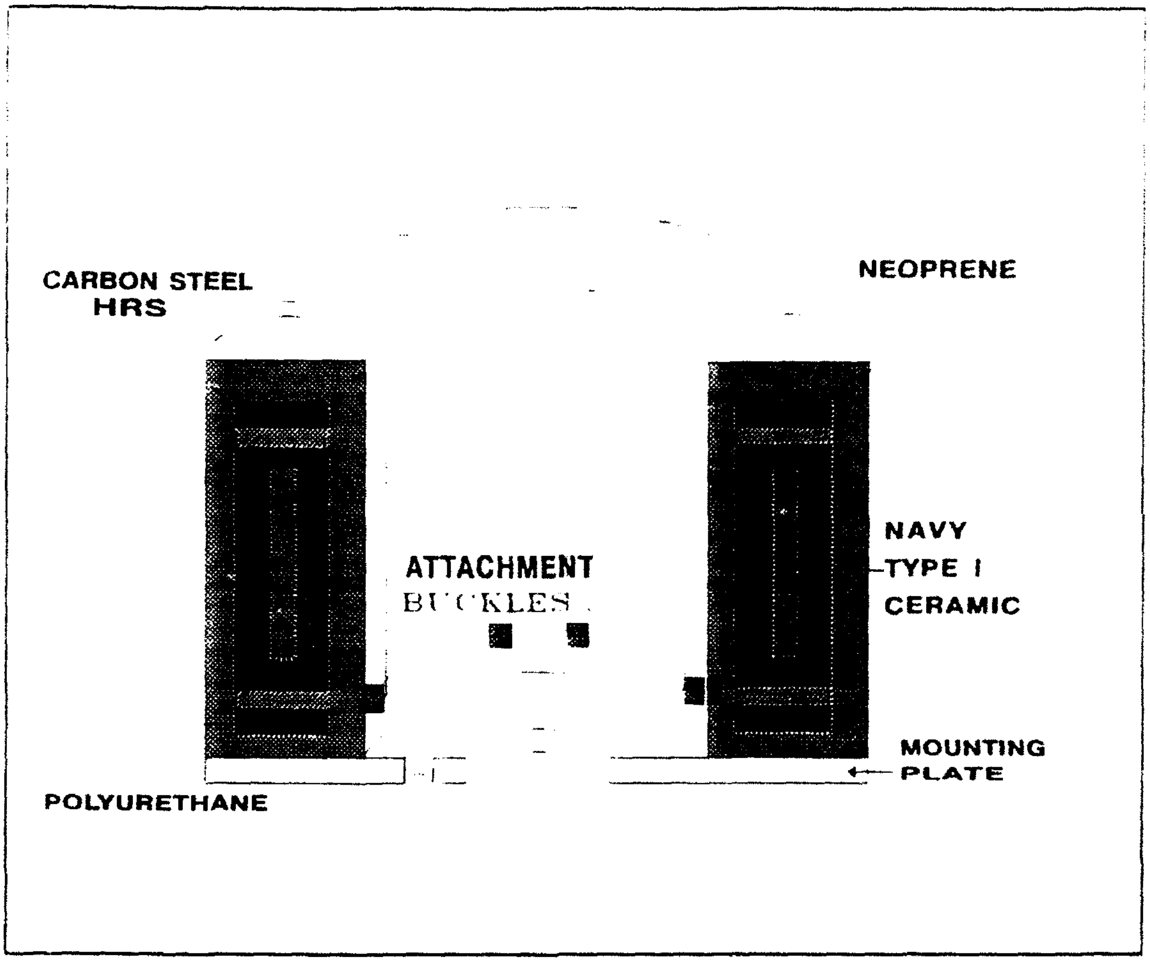

Figure 4: Cutaway View of Ring Transducer

The piezoelectric ring and fiberglass wrap is enclosed by two encapsulant materials: the inner one is a polyurethane and the other is a neoprene. Of particular importance is the annular mounting plate at the bottom, which has an inner radius less than half the radius of the transducer. Because of the narrow size of the center hole of the mounting plate, it is expected that the mounting plate will influence the acoustic cavity mode of the enclosed water column in the middle of the transducer.

Appendix C lists the physical dimensions and constants for the materials of the transducer.

The main operational characteristics of the transducer as provided by the manufacturer are:

a. Resonance frequencies are 1.0 kHz (cavity) and 2.5 kHz (ring);

b. Source Pressure Level, which corresponds to the effective pressure on the acoustic axis, at ring resonance is 132 dB ref 1 μPa/V at 1 meter;

c. Operational Depth, which corresponds to the maximum depth where the performance of the transducer is not compromised - unlimited.

The measured admittance circles of the ceramic ring assembly without and with fiberglass wrapping in air are as shown in Figures 5 and 6, respectively.

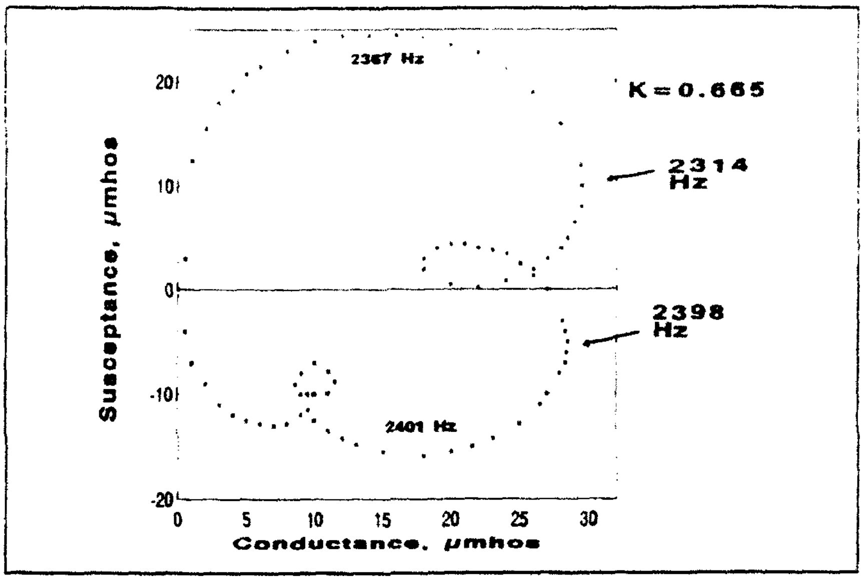

Figure 5: Measured Admittance Circle of the Unwrapped Ceramic Ring Assembly, In Air

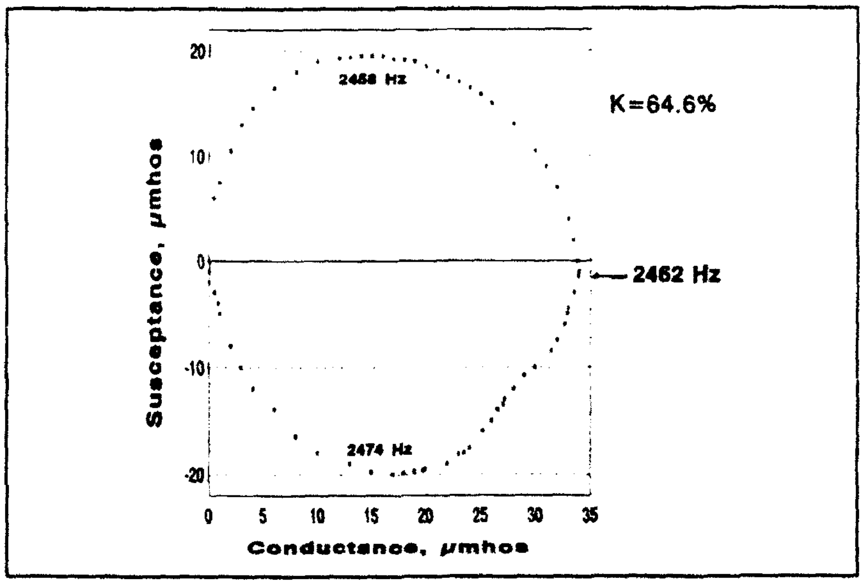

Figure 6: Measured Admittance Circle of the Ring Assembly with Fiberglass Wrap, In Air

The measured transmitting voltage response (TVR) with 1 V drive and the vertical directivity pattern at 2 kHz are as shown in Figures 7 and 8, respectively.

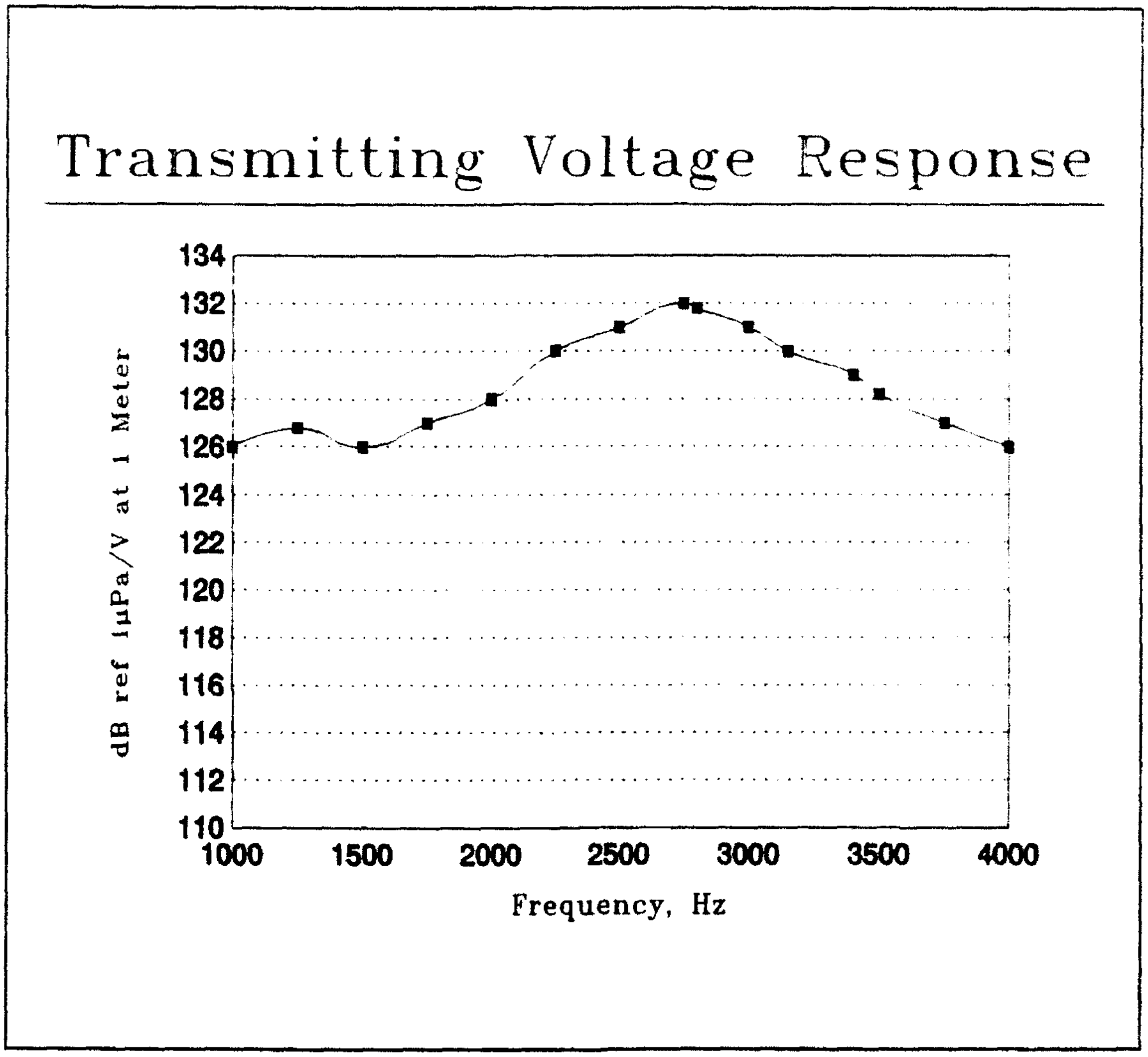

Figure 7: Measured Transmitting Voltage Response

At the ring resonance frequency of 2750 Hz, the TVR is 132 dB; it is 127 dB at the cavity resonance frequency of 1250 Hz.

The beam pattern is omni-directional in the equitorial plane and toroidal in a plane passing through the axis of symmetry, which in Figure 8 below is the 90° and 270° line. The mounting plate is at 270°. The narrow lobe at 270° is probably due to the mounting plate.

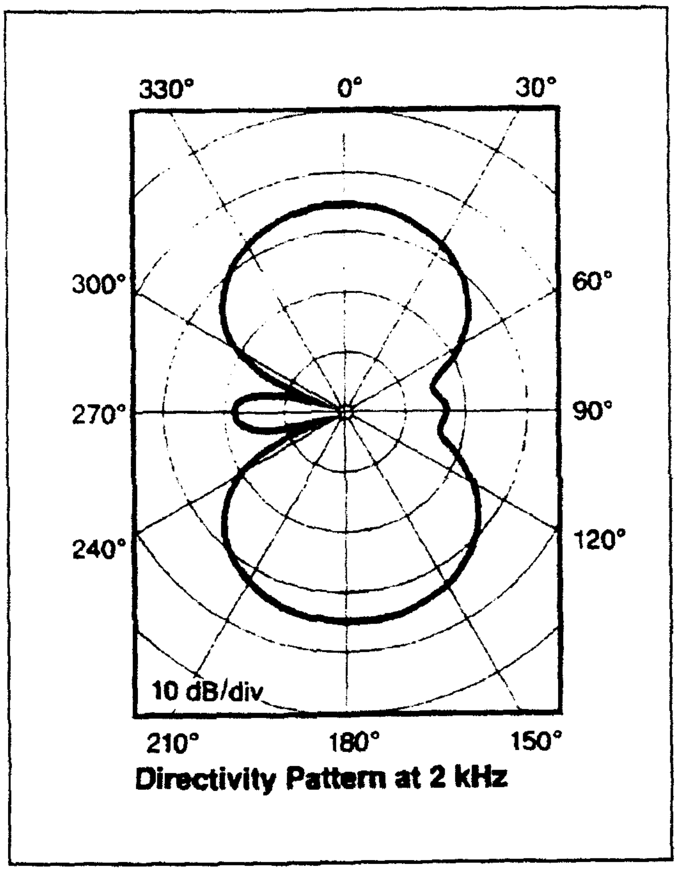

Figure 8: Vertical Directivity Pattern at 2 kHz

III. METHODS OF ANALYSIS

A. INTRODUCTION

This chapter presents the simple approximate expressions for the ring and cavity mode frequencies from G.W. McMahon [Ref. 3] and discusses the theoretical background behind the finite element code, ATILA, as well as the analytical approach, suggested by Hong-zhang Wang [Ref. 2], to obtain the approximate electrical admittance equations for the tangentially polarized piezoelectric thin circular cylindrical tube in the unloaded case.

B. RING AND CAVITY MODE FREQUENCIES [Ref. 3]

The behavior of the cavity and ring resonance in small length-to-radius ratio open tubes of lead zirconate titanate ceramic immersed in water was studied by G.W. McMahon.

When the tube is short i.e., $h/a \ll \pi$, G.W. McMahon gives the following formulas:

$$\omega_r = \left(\frac{Y_{33}}{\rho a^2}\right)^{\frac{1}{2}} \qquad (1)$$

$$\omega_c = \frac{\pi c_0}{(h + 2\alpha a)} \qquad (2)$$

where ω_r is the ring mode angular frequency, ω_c is the angular frequency of the first cavity mode, a is the inside radius, h is the height of the ring, B is the bulk modulus of water, t is the wall thickness of ring and c is the speed of sound in water. c_0 is the velocity of sound in the water column given by Equation 5 below and α, an end correction, is given by the empirical formula:

$$\alpha = 0.633 - 0.106\,\Omega \tag{3}$$

The dimensionless frequency parameter, $\Omega = \omega_c a/c_0$, is given by

$$\Omega\left(\frac{h}{2a} + 0.633\right) - 0.106\,\Omega^2 = \frac{\pi}{2} \tag{4}$$

The value of Ω is between 0.33 and 3.3. The velocity of sound within the tube, c_0, is effectively less than the velocity of sound c in open water because of the finite stiffness of the tube wall. It is given by

$$c_0 = c\left[1 + \frac{2Ba}{Y_{33}t}\right]^{-\frac{1}{2}} \tag{5}$$

The calculated value of the cavity mode frequency for the transducer is presented in Chapter V, Section C.

C. FINITE ELEMENT ANALYSIS, THE ATILA CODE

The application of finite element analysis (FEA) to solve boundary value problems consists of the transformation of the governing differential or integral equation(s) into a multi-nodal matrix equation, the solution of which represents the discretized solution of the problem. There are many techniques to obtain a finite element formulation [Ref. 5,6,7,8].

ATILA is a finite element code developed at l'Institut Supérieur d'Electronique du Nord (ISEN) in France for the analysis of underwater transducers. It utilizes the variational formulation of the finite element problem [Ref. 9,10,11,12,13].

ATILA uses quadratic isoparametric elements. Isoparametric means the same polynomial (quadratic in this case) is used to interpolate both the geometry and the field variation. ATILA has 46 different types of elements, including shell, plate, transition, spring, trilaminar, and two- and three-dimensional solid elements of various types. With ATILA, it is possible to model lossy elastic, piezoelectric, magnetostrictive, magnetic and composite materials, fluid, solid-fluid interfaces, dampers, and radiation conditions.

ATILA can perform: (1) static analyses, (2) modal analyses, which correspond to a free vibration problem, where the eigenfrequencies and eigenmodes are computed, and (3) harmonic analyses of radiation or scattering problems, which correspond to a forced vibration problem, the excitation being the voltage applied across the electrical terminals of the transducer or external forces applied to the nodes.

1. Harmonic Analysis of a Radiating Piezoelectric Transducer

This problem is governed by the equation of motion in the elastic and piezoelectric structures, by Poisson's equation in the piezoelectric structures, and by Helmholtz's equation in the fluid. Appropriate boundary conditions are defined, both on the solid-fluid interface and on the external fluid boundary, which must simulate the appropriate radiation condition.

The solid equation of motion is given by [Ref. 12]:

$$\rho \frac{\partial^2 u_i}{\partial t^2} = \frac{\partial \sigma_{ij}}{\partial x_j} \qquad (6)$$

where ρ is the solid material density, **u** is the displacement vector, t is time, σ is the stress tensor, and x_j is a coordinate direction. Here i and j can be 1, 2 and 3, and the Einstein notation is used, where summation is implied over repeated indices in the same term.

Poisson's equation is given by [Ref. 12]:

$$\frac{\partial D_i}{\partial x_i} = 0 \qquad (7)$$

where D is the electric displacement vector and x_i is a coordinate direction; i can be 1, 2 and 3.

The linearized, lossless Helmholtz Equation for the propagation of sound in fluids is given by [Ref. 14]:

$$\nabla^2 p - \frac{1}{c^2} \frac{\partial^2 p}{\partial t^2} = 0 \qquad (8)$$

where ∇^2 is the three-dimensional Laplacian operator, p is the acoustic pressure, and t is time.

In piezoelectric materials the stress tensor and the electric displacement vector can be related to the strain tensor and electric field vector via material properties by the following constitutive equations, which neglect magnetic and pyroelectric effects [Ref. 12]:

$$T_{ij} = c^E_{ijkl} S_{kl} - e_{ijk} E_k \qquad (9)$$

$$D_i = e_{ikl} S_{kl} + \epsilon^S_{ij} E_j \qquad (10)$$

where $[T]$ is the stress tensor, $[S]$ is the strain tensor, E is the electric field vector, D is the electric displacement vector, $[c^E]$ is the constant electric field elastic stiffness tensor, $[e]$ is the piezoelectric tensor, and $[\epsilon^S]$ is the constant strain dielectric tensor; i, j, k and l can be equal to 1, 2 and 3.

Ultimately the solution must be expressed in terms of displacements and electric potentials. To this end the following two equations from elasticity and electricity, respectively, are used [Ref. 12]:

$$S_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) \qquad (11)$$

$$E_i = -\frac{\partial \Phi}{\partial x_i} \qquad (12)$$

where $[S]$ is the strain tensor, u is the displacement vector, x_i is a coordinate direction, E is the electric field vector and Φ is the electrical potential; i and j can be equal to 1, 2 and 3. It must be noted that the quasi-static approximation [Ref. 4] is used in writing Equation 12 for the low (acoustic) frequencies involved here.

The boundary conditions and prescribed excitations at each node can be defined either by a displacement or an applied force, an electrical potential or an electrical charge, or an acoustic pressure.

In ATILA, the previous seven equations are transformed into the following matrix equation [Ref. 1]:

$$\begin{bmatrix} [K_{uu}] - \omega^2 [M] & [K_{u\Phi}] & -[L] \\ [K_{u\Phi}]^T & [K_{\Phi\Phi}] & [0] \\ -\rho^2 c^2 \omega^2 [L]^T & [0]^T & [H] - \omega^2 [M_1] \end{bmatrix} \begin{bmatrix} U \\ \Phi \\ P \end{bmatrix} = \begin{bmatrix} F \\ -q \\ \rho^2 c^2 \psi \end{bmatrix} \qquad (13)$$

where:

U: vector of the nodal values of the components of the displacement field,

Φ: vector of the nodal values of the electrical potential,

P: vector of the nodal values of the pressure field,

F: vector of the nodal values of the externally applied forces,

q: vector of the nodal values of the externally applied electrical charges,

ψ: vector of the nodal values of the integrated normal derivative of the externally applied pressure on the surface boundary S,

$[K_{uu}]$: Finite Element stiffness matrix,

$[K_{u\Phi}]$: Finite Element pieozoelectric matrix,

$[K_{\Phi\Phi}]$: Finite Element dielectric matrix,

$[M]$: Finite Element consistent mass matrix,

$[H]$: Finite Element fluid pseudo- stiffness matrix,

$[M_1]$: Finite Element consistent fluid pseudo- mass matrix,

$[L]$: Finite Element coupling matrix at the fluid structure interface,

$[0]$: zero matrix,

ω: angular frequency,

ρ: fluid density,

c: fluid sound speed.

T: means transposed.

The results of this analysis for each input frequency are the complex displacement, rotation, and electrical potential fields at each transducer node, the complex pressure field at each fluid node, and the complex electrical impedance and admittance.

2. Modal Analysis of a Piezoelectric Transducer

This problem is governed by the equations of motion in the elastic and piezoelectric structures, and by Poisson's equation in the piezoelectric structures. The matrix equation governing this problem is easily obtained from that described in the previous section. In a modal analysis there is no fluid and there are no external forces applied (the natural boundary conditions), so the third row and column of Equation 13 become irrelevant, and F is replaced by **0**, resulting in

$$\begin{bmatrix} [K_{uu}] - \omega^2 [M] & [K_{u\Phi}] \\ [K_{u\Phi}]^T & [K_{\Phi\Phi}] \end{bmatrix} \begin{bmatrix} U \\ \Phi \end{bmatrix} = \begin{bmatrix} 0 \\ -q \end{bmatrix} \qquad (14)$$

where the elements are defined by Equation 13.

In this equation the resonance condition, which corresponds to the electrical short-circuit condition, is obtained by setting Φ=**0**. The anti-resonance condition, which corresponds to the electrical open-circuit condition, is obtained by setting q=**0** [Ref 15].

The results of this analysis are the eigenfrequencies and eigenmodes. The maximum number of modes, which must be specified by the user, is 100.

D. STANDARD NETWORK ANALYSIS [Ref. 2]

The state equations for piezoceramics as stated in Equation 9 and 10 can generally be expressed as follows:

$$S_i = s^E_{ij} T_j + d_{ki} E_k \tag{15}$$

$$D_k = d_{kj} T_j + \epsilon^T_{kl} E_l \tag{16}$$

where $[T]$ is the stress tensor, $[S]$ is the strain tensor, $\mathbf{E}$ is the electric field vector, $\mathbf{D}$ is the electric displacement vector, $[s^E]$ is the constant electric field elastic compliance tensor, $[d]$ is the transposed piezoelectric stress tensor, and $[\epsilon^T]$ is the constant stress permittivity tensor; i, j, k and l can be equal to 1, 2 and 3. The matrix notation has been used [Ref. 16].

If it is assumed that the ceramic is isotropic in the plane transverse to the poling, the piezoelectric equations in the cylindrical coordinate system may be written as

$$
\begin{aligned}
S_{rr} &= s^E_{11} T_{rr} + s^E_{13} T_{\theta\theta} + s^E_{12} T_{zz} + d_{31} E_\theta \\
S_{\theta\theta} &= s^E_{13} T_{rr} + s^E_{33} T_{\theta\theta} + s^E_{13} T_{zz} + d_{33} E_\theta \\
S_{zz} &= s^E_{12} T_{rr} + s^E_{13} T_{\theta\theta} + s^E_{11} T_{zz} + d_{31} E_\theta \\
S_{r\theta} &= s^E_{44} T_{r\theta} + d_{15} E_r \\
S_{z\theta} &= s^E_{44} T_{z\theta} + d_{15} E_z \\
S_{rz} &= s^E_{66} T_{rz} \\
D_r &= d_{15} T_{r\theta} + \epsilon^T_{11} E_r \\
D_\theta &= d_{31} T_{rr} + d_{33} T_{\theta\theta} + d_{31} T_{zz} + \epsilon^T_{33} E_\theta \\
D_z &= d_{15} T_{z\theta} + \epsilon^T_{11} E_z
\end{aligned}
\tag{17}
$$

where $s_{11} \approx s_{33}$, $s_{12} \approx s_{13}$. If we let the displacement be expressed as $u = (u_r, u_\theta, u_z)$, then the strain components are

$$
\begin{aligned}
S_{rr} &= \frac{\partial u_r}{\partial r} \\
S_{r\theta} &= \frac{\partial u_\theta}{\partial r} - \frac{u_\theta}{r} + \frac{1}{r}\frac{\partial u_r}{\partial \theta} \\
S_{\theta\theta} &= \frac{1}{r}\frac{\partial u_\theta}{\partial \theta} + \frac{u_r}{r} \\
S_{z\theta} &= \frac{\partial u_\theta}{\partial z} + \frac{1}{r}\frac{\partial u_z}{\partial \theta} \\
S_{zz} &= \frac{\partial u_z}{\partial z} \\
S_{rz} &= \frac{\partial u_z}{\partial r} + \frac{\partial u_r}{\partial z}
\end{aligned}
\tag{18}
$$

respectively.

The equations of motion of the elastic medium in the cylindrical coordinate system are

$$\rho \ddot{u}_r = \frac{\partial T_{rr}}{\partial r} + \frac{1}{r}\frac{\partial T_{r\theta}}{\partial \theta} + \frac{\partial T_{rz}}{\partial z} + \frac{T_{rr} - T_{\theta\theta}}{r}$$
$$\rho \ddot{u}_\theta = \frac{\partial T_{r\theta}}{\partial r} + \frac{1}{r}\frac{\partial T_{\theta\theta}}{\partial \theta} + \frac{\partial T_{\theta z}}{\partial z} + \frac{2T_{r\theta}}{r} \qquad (19)$$
$$\rho \ddot{u}_z = \frac{\partial T_{rz}}{\partial r} + \frac{1}{r}\frac{\partial T_{\theta z}}{\partial \theta} + \frac{\partial T_{zz}}{\partial z} + \frac{T_{rz}}{r}$$

1. Vibration of Unloaded Tube

For the tangentially polarized ring, the following assumptions were made:

a. the electric field, E is approximated as $(0, E_\theta, 0)$

b. the unloaded thin-wall tube vibrates with axial symmetry

c. the stress components, T_{rz}, T_{zr}, T_{rr}, $T_{r\theta}$, and $T_{\theta r}$ on the outer, inner surfaces and in the whole body of the tube are neglected.

d. $T_{zz} = 0$ at $z = \pm 1/2$

e. $u_\theta = 0$;

f. $\partial T_{r\theta}/\partial\theta = \partial T_{\theta\theta}/\partial\theta = \partial T_{z\theta}/\partial\theta = 0$

With the assumptions mentioned, the piezoelectric equations may be simplified as

$$\begin{aligned}
T_{rr} &= 0 \\
T_{\theta\theta} &= \left[Y^E / (1-\sigma^2) \right] \left(S_{\theta\theta} - \sigma S_{zz} - (d_{33} - \sigma d_{31}) E_\theta \right) \\
T_{zz} &= \left[Y^E / (1-\sigma^2) \right] \left(\sigma S_{\theta\theta} - S_{zz} - (d_{31} - \sigma d_{33}) E_\theta \right) \\
D_\theta &= d_{33} T_{\theta\theta} - d_{31} T_{zz} - \epsilon_{33}{}^T E_\theta
\end{aligned} \tag{20}$$

where $Y^E = 1/s_{11}{}^E$ is the Young's modulus and $\sigma = -s_{12}{}^E/s_{11}{}^E$ is the Poisson ratio.

The vibration equations of the thin-walled piezoceramic cylindrical tube can also be simplified as

$$\begin{aligned}
\rho \ddot{u}_r &= -\frac{T_{\theta\theta}}{r} \\
\rho \ddot{u}_\theta &= 0 \\
\rho \ddot{u}_z &= \frac{\partial T_{zz}}{\partial z}
\end{aligned} \tag{21}$$

By combining the piezoelectric equations and the equation of motion, the following acoustic wave equation may be obtained:

$$\frac{\partial^2 u_z}{\partial z^2} + K_a{}^2 u_z = 0 \tag{22}$$

where

$$K_a{}^2 = \left(\frac{\omega}{C_c} \right)^2 \frac{f_a(\omega)}{\left[(\omega/\omega_r)^2 - 1 \right]} \quad , \tag{23}$$

$$f_a(\omega) = (1-\sigma^2)\left(\frac{\omega}{\omega_r}\right)^2 - 1 \quad , \tag{24}$$

and $\omega_r = c_a/a$. c_a is the acoustic wave speed in the ceramic given by:

$$c_a = \left[\frac{Y^E}{\rho}\right]^{\frac{1}{2}} \tag{25}$$

Applying the boundary conditions, we obtain the following:

$$u_z = A_0 \sin(K_a z) \tag{26}$$

$$A_0 = J_a E_\theta \tag{27}$$

$$J_a = \frac{\sigma(d_{33}+\sigma d_{31}) + f_a(\omega)(d_{31}+\sigma d_{33})}{K_a[f_a(\omega)+\sigma^2]\cos\left(\frac{1}{2}K_a l\right)} \tag{28}$$

If a and b are the inside and outside radii of the ring and N is the number of silvered electrodes, the total electric charge on the electrodes is given by

$$Q = NQ_1 = N\int_{-l/2}^{l/2}\int_a^b D_\theta \; dr dz \tag{29}$$

The electric potential between the two near electrodes is V_0 and from Maxwell's equation, it follows that

$$E_r = \left(\frac{1}{r}\right)\left(\frac{NV_0}{2\pi}\right) \tag{30}$$

Combining the aforementioned relations, the admittance equation are obtained as

$$Y=\frac{j\omega C_0 k_{31}^2}{f_d(\omega)}\left[\frac{\left(f_d(\omega)\,(1+\sigma\tau)-\sigma(\sigma+\tau)\right)^2}{(1-\sigma^2)^2[(\omega/\omega_a)^2-1]}\left(\frac{\tan(\frac{1}{2}K_d l)}{\frac{1}{2}K_d l}\right)-\frac{(\sigma+\tau)^2}{1-\sigma^2}\right]-j\omega C \tag{31}$$

where

$$\begin{aligned} k_{31}^2 &= \frac{Y^E d_{31}^2}{\epsilon_{33}^T} \\ C_s &= C_0[1-(k_{31}^2/(1-\sigma^2))(1+2\sigma\tau+\tau^2)] \\ C_0 &= N^2\left(\frac{\epsilon_{33}^T l}{2\pi}\right)\ln(b/a) \\ \tau &= (d_{33}/d_{31}) \end{aligned} \tag{32}$$

These equations are applied in obtaining the results in Chapter V, Section E.

IV. TWO-DIMENSIONAL FINITE-ELEMENT MODEL

A. INTRODUCTION

In order to efficiently model the free flooded ring, as shown in Figure 1, the structure may be considered to be an axisymmetric body. Appropriate modifications to the material properties must be made to model the structure as axisymmetric. A continuing problem in the analysis of these piezoelectric devices is the determination of these material properties.

A two-dimensional finite element model was developed using 8-node isoparametric quadrilateral elements for the piezoelectric ceramic, the elastic encapsulant materials, the mounting plate, supporting structures, and the fluid. The fluid domain extends to 1m from the acoustic center. 6-node isoparametric linear elements were used for the solid-fluid interface and 3-node linear elements were used for the dipolar radiating damper. These were used to terminate the fluid mesh.

B. CHARACTERISTICS OF THE MODEL

1. Material Properties

a. *Unwrapped Piezoelectric ceramic Ring*

As described before, the transducer has 72 tangentially poled lead zirconate titanate ceramic staves, glued together with epoxy resin, and arranged in a 0.3668 m diameter ring.

In order to simplify the finite element model, an equivalent homogeneous piezoelectric ceramic ring with material properties determined by a combination of the piezoelectric ceramic and epoxy resin properties was used. Because the appropriate combination of properties is not known, "smeared" material properties for the homogeneous ring were obtained by adjusting the circumferential compliance so that the resonance frequencies obtained using the ATILA code tolerably matched the in-air experimental measurements of the resonance frequencies for the unwrapped ring.

A limitation of an axisymmetric ATILA model is that the tangential poling of the segmented ring cannot be modeled directly. It has to be modeled as a radially-poled ring as illustrated in Figure 9.

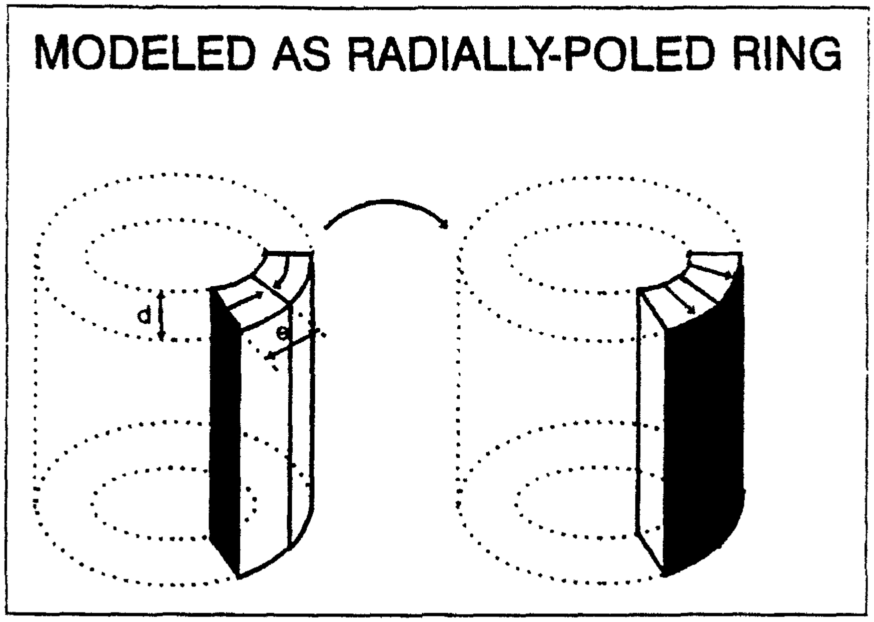

Figure 9: Modeled as a Radially-Poled Ring

The transformation from the tangentially to radial polarization is accomplished by a suitable exchange of the elastic, piezoelectric, and dielectric tensors as described in the ATILA manual [Ref. 1]. Since the potential degree of freedom is a scalar, the change in polarization direction is simply a geometrical transformation. Thus, to model the applied potential of the tangentially poled ring using the radially poled ring, the radial potential has to be corrected by a factor equal to the ratio of the radial thickness to the stave thickness, *d/e* in Figure 9. Similarly, the results computed in a harmonic analysis for the radially-poled axisymmetric model have to be modified as follows: (1) the displacement and pressure magnitudes must be divided by the ratio of the circumferential length of a "smeared" piezoelectric element, which is equal to 1/72 of the ring circumferential length, to its thickness, and (2) multiply the electrical impedance by the square of the same ratio. This ratio is 2.602 for the transducer under study.

b. Wrapped Piezoelectric Ceramic Ring

Normally, the fiberglass belt wrapped around the ceramic ring (Figure 3) is modeled as thin shell element. However, to simplify the model and to reduce the number of degrees of freedom, the 0.762 mm thick fiberglass belt in our case was not modeled as a separate element. Instead, the material properties of the equivalent homogeneous ceramic ring were modified. A sample calculation of the approximate new material constants is given in Appendix D. These approximate values were then used for a modal analysis using ATILA and were fine tuned by adjusting first the circumferential compliance so that the resonance frequency obtained tolerably matched the measured values provided by the manufacturer. Then the other compliances were adjusted to obtain a close match of the coupling coefficient to the measured value. This scheme is considered sufficient for the model even though a scheme implemented by McMahon and Armstrong [Ref. 17], which fits the resonance and antiresonance frequencies and the electrical capacitance taking into consideration the compression bias effect of the fiberglass wrapping, might give a more accurate result.

c. *Encapsulant Materials and Mounting Plate*

The encapsulant materials, namely the polyurethane and the neoprene, the reflector ring (high carbon steel), and the mounting plate, a fiberglass-epoxy composite, were modeled individually as 8-node quadrilateral elastic elements. The material properties were provided by the manufacturer.

2. Types of Elements

The quadratic isoparametric elements listed in Table 1, which are described in the ATILA User's Manual [Ref. 1], were used:

Table 1: TYPES OF ELEMENTS USED

Region	Element	Geometry
Piezoelectric ring	QUAD08P	8-node quadrilateral
Encapsulant (Boots, Spacer, Reflector Ring) & Mounting Plate	QUAD08E	8-node quadrilateral
Interface solid-fluid	LINE06I	6-node isoparametric
Fluid	QUAD08F	8-node quadrilateral
Radiation surface	LINE03R	3-node linear

3. Constraints on Mesh Design [Ref. 1]

Design of the mesh was guided by the following constraints:

a. Aspect ratio

The aspect ratio of each element should not be greater than 3, although 4 is considered an acceptable, though less conservative, value.

b. Internal angles

The angles between adjacent sides of quadrilaterals should be between 45 and 135 degrees, although 30 degrees and 150 degrees are considered, respectively, acceptable, though less conservative, values.

c. Element size

As ATILA utilizes quadratic interpolation functions, the size of each element must not be greater than one-fourth wavelength at the highest frequency of interest.

d. Interelement compatibility

The mesh should be built in such a way that adjacent elements have adjoining sides with collocated nodes to ensure accurate interpolation at their interfaces.

e. Radiation boundary elements

For in-water harmonic analyses (radiation problems) the fluid mesh outer limit must be spherical. This is required by the radiation damping elements available in the ATILA code. ATILA offers damper elements that are attached to the external surface of the surrounding fluid domain and are designed to absorb various components of the radiated multipolar acoustic field to overcome the problem of modeling an infinite fluid domain. The ATILA offers the monopole and dipole radiation damping elements. The latter includes not only the monopole term of the radiated field multipolar expansion, but also the dipole term. Dipolar damping elements were selected to terminate the fluid mesh because, in addition to providing a more accurate solution, a smaller mesh can be employed, resulting in a lower computational cost.

A fluid mesh outer limit radius greater than the far-field distance is desirable to compute the acoustic source pressure level and to compare computed and measured acoustic pressure data. The far field criteria for a baffled rigid piston-like source is given by [Ref. 15]:

$$R_{ff} > \frac{D^2}{\lambda} \qquad (33)$$

and

$$R_{ff} > D \qquad (34)$$

where D is the diameter of the ring which is 0.3795 m.

The minimum wavelength, λ, corresponding to the maximum frequency of interest is given by:

$$\lambda = \frac{c}{f} = 0.375m \qquad (35)$$

where c is the speed of sound in water, 1500 m/s, and f is the highest frequency of interest, 4000 Hz, giving $R_{ff} > 0.384$ m.

The boundary was placed at a radius R equal to 1 m from the transducer's acoustical center, which is more than 2.5 times the far-field limit of the equivalent piston-like source at the resonance frequency [Ref. 18].

f. Boundary Conditions

Boundary condition data entries enable the user to force, for example, clamped, hinged, or simply-supported conditions, or to set the master degrees-of-freedom. These conditions are generally associated with symmetry planes or axes, electroded or pressure release surfaces.

In a harmonic analysis of a piezoelectric structure, the degree-of-freedom, D, for all the nodes associated with the applied potential, V, to the plane or line, P, containing the node N has to be a master degree of freedom and identical. This is realised by using the following line in our data file:

-N -D -P V

for example,

-1 -4 -2 1

where the degree of freedom 4 indicates electrical potential on a plane 2 (normal to the OY axis) passing through the node number 1 with an excitation voltage of 1 V. The negative sign in front of the 2 indicates that the electrical potential degree of freedom of all nodes on that plane are identical, i.e., 1 V.

Since our model is a 2-D model, the degree-of-freedom in the plane normal to the OZ axis are all deleted using the following data line:

-N D P

where D is 3 which corresponds to the displacement in the z-direction and P is 3 which corresponds to the plane normal to the OZ axis.

4. Final Mesh Designs

With the above considerations, an in-air axisymmetrical mesh about the OX axis was designed for fitting the material properties. Only half of the ring cross-section needs to be modeled. The bare ceramic staves without the fiberglass wrap were divided into five elements to meet the aspect ratio requirement of the ATILA code. The in-air model is as shown in Figure 10.

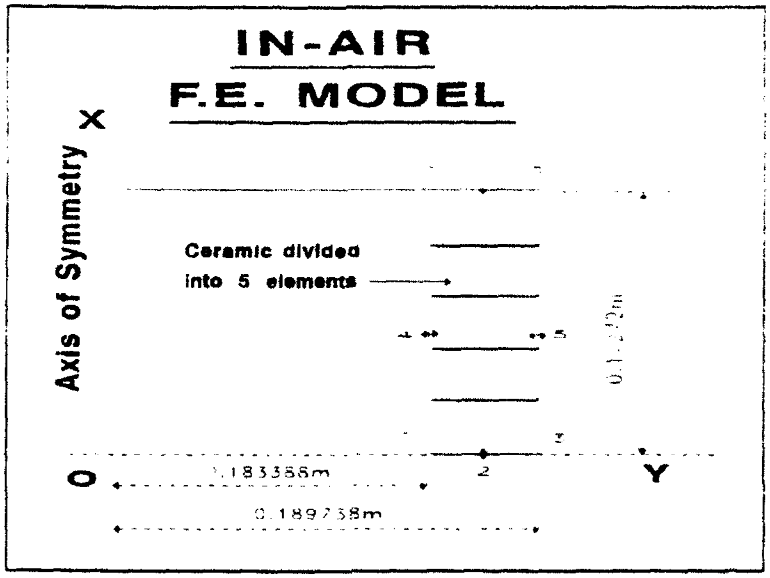

Figure 10: In-Air Model

Using the pre-processor mesh generator MOSAIQUE [Ref. 1], the in-water mesh without the mounting plate as shown in Figure 11 was generated. The transducer mesh consists of 40 solid elements, 21 interface elements, 166 fluid elements, and 15 radiating elements, totaling 2884 DOF. This mesh was also used to investigate effects of encapsulant material changes.

The final mesh to be developed was the in-water model with the mounting plate. The total mesh is shown in Figure 12 and an enlarged view of the solid mesh with the mounting plate is as shown in Figure 13. There were a total of 87 solid elements, 48 interface elements, 406 fluid elements and 35 radiating elements with a total of 6600 DOF. The input data file of this final mesh is given in Appendix A.

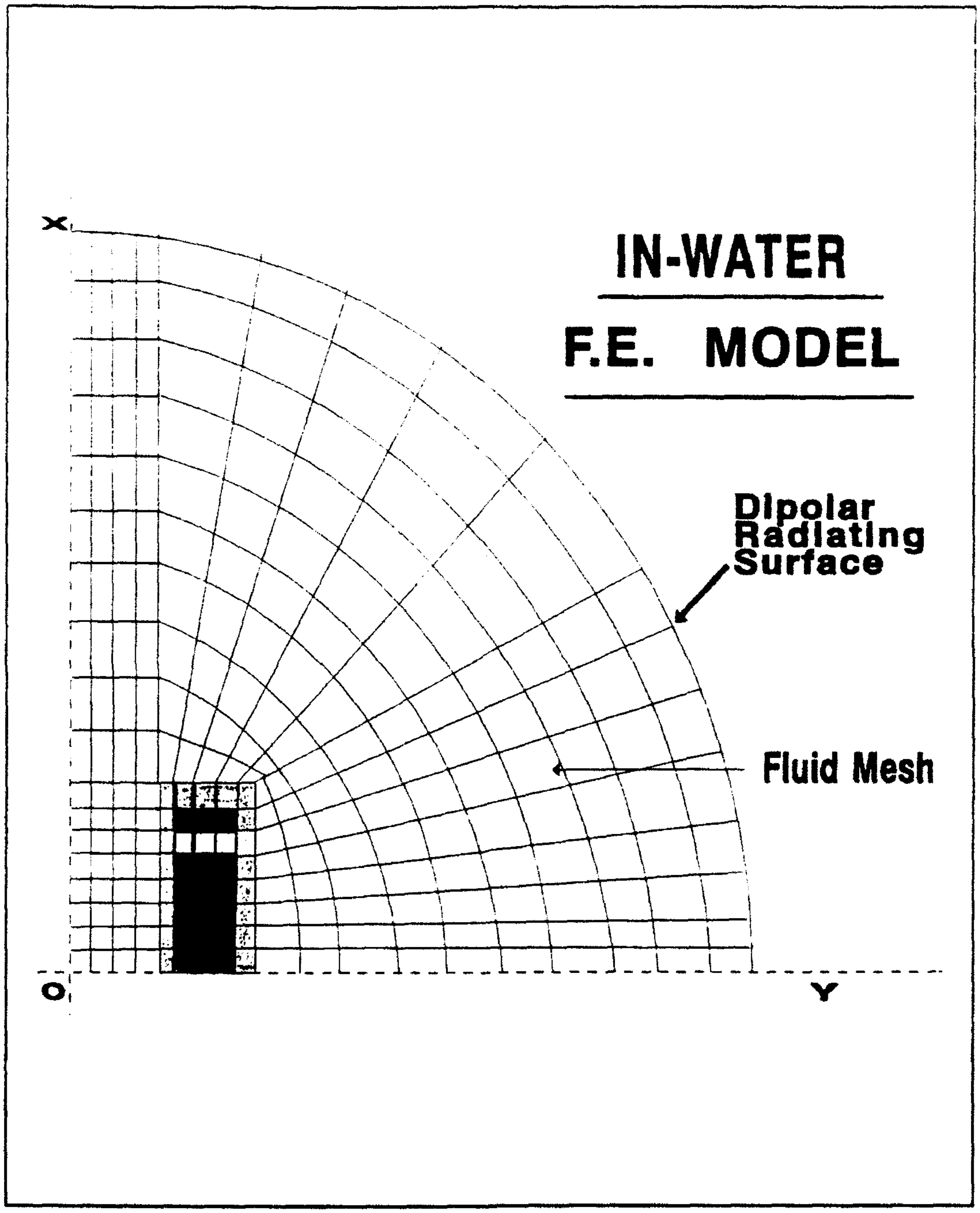

Figure 11: In-Water F.E. Model Without Mounting Plate

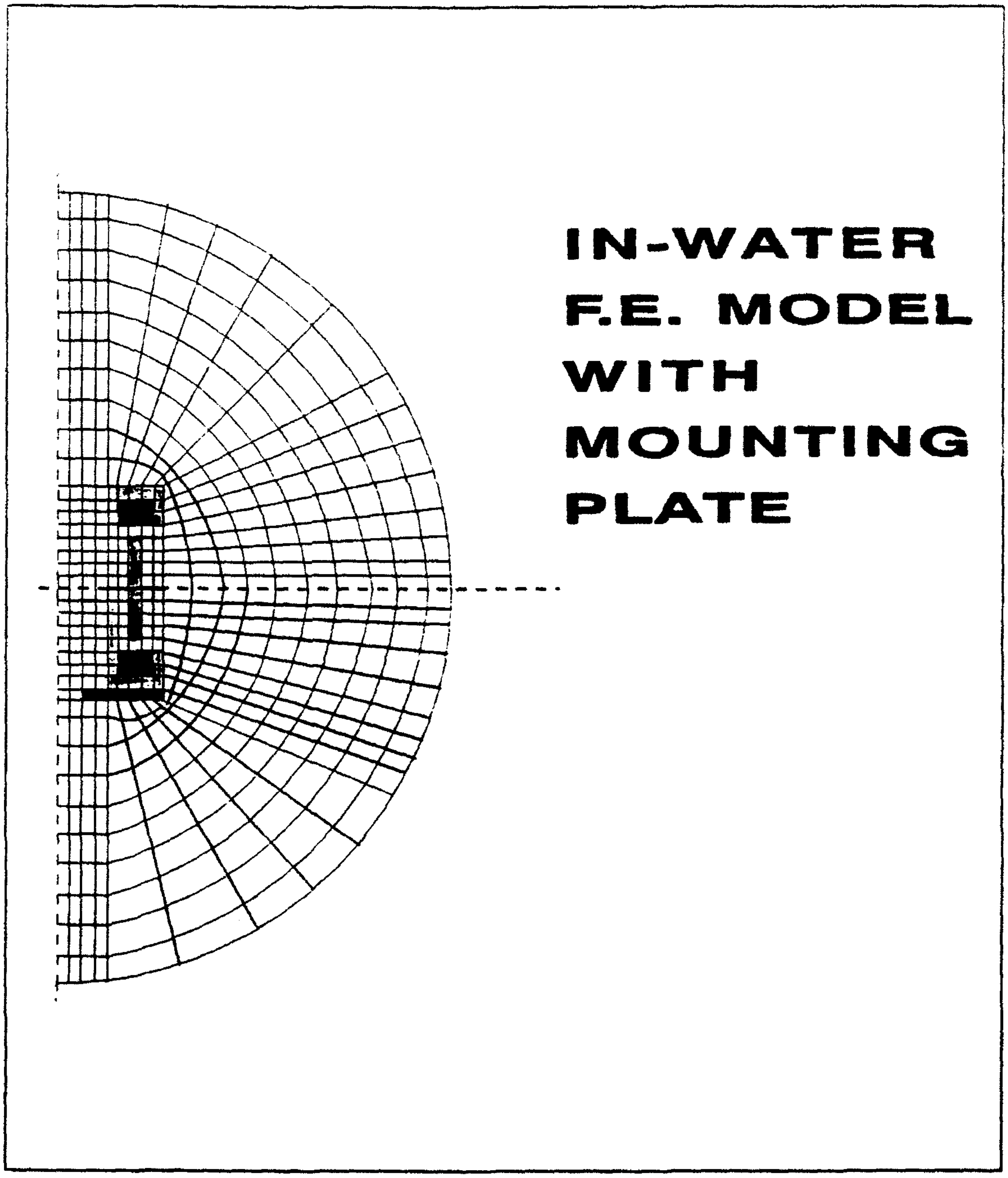

Figure 12: In-Water Model With Mounting Plate

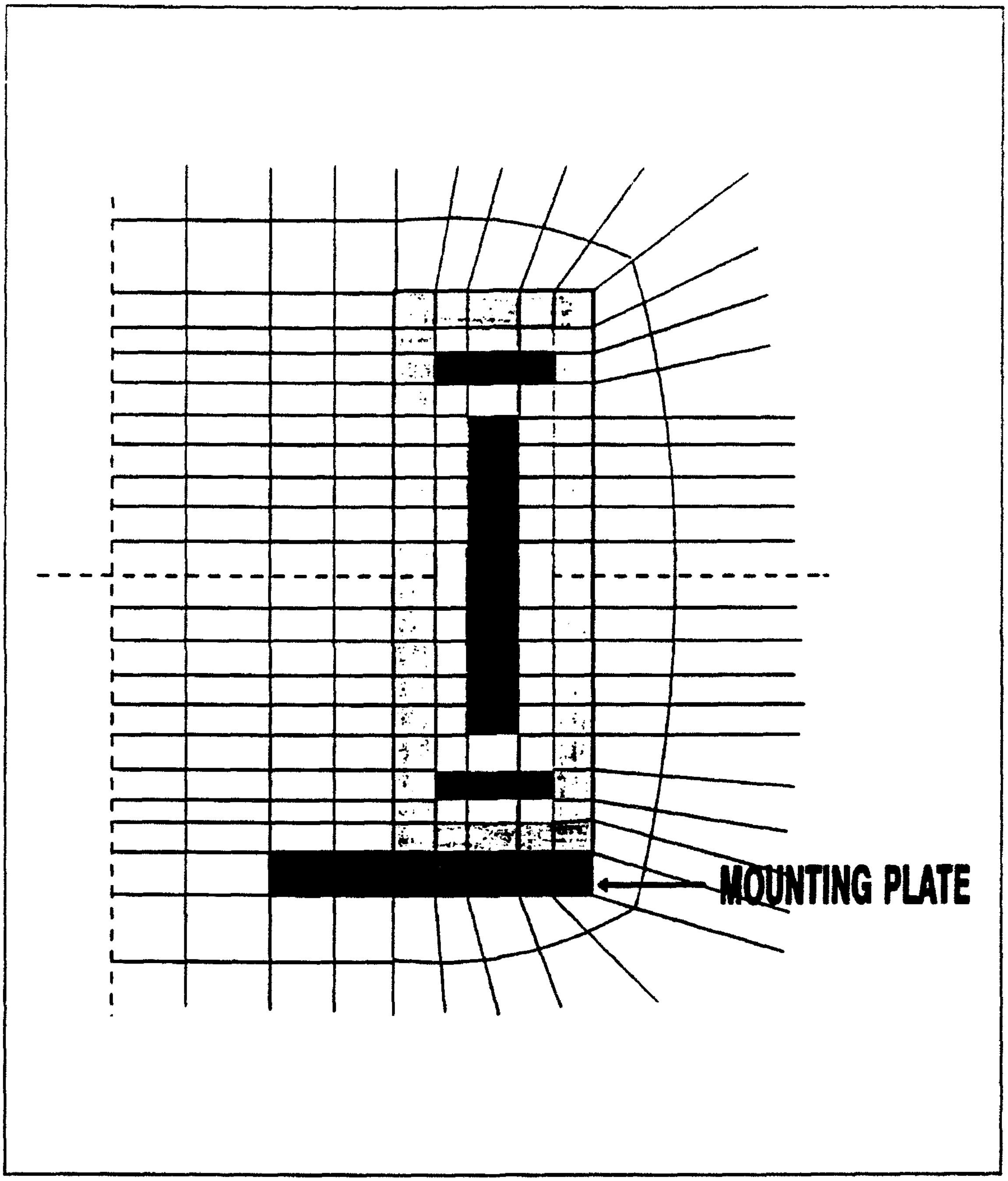

Figure 13: The Enlarged View

V. RESULTS

A. MATERIAL PROPERTIES OF EQUIVALENT HOMOGENEOUS RING

The material properties of the equivalent homogeneous piezoelectric ceramic ring, unwrapped and wrapped, were determined by modal analysis using ATILA. This analysis corresponds to a free vibration problem in which the eigenfrequencies and eigenmodes are computed.

1. Unwrapped Equivalent Homogeneous Ring

First, a simple transducer model of only the bare ceramic ring without the fiberglass wrap, as shown in Figure 10, was designed. A modal analysis of this model was conducted using book values for the piezoelectric properties. Table 2 lists the calculated resonance and antiresonance frequencies and the coupling coefficient for the first ten modes of vibration. The coupling coefficient is calculated using the relationship [Ref. 19]:

$$k^2 = 1 - \left[\frac{f_r}{f_a}\right]^2 \tag{36}$$

where k is the coupling coefficient, f_r is the resonance frequency and f_a is the antiresonance frequency.

TABLE 2: RESULTS OF THE MODAL ANALYSIS OF UNWRAPPED PIEZOELECTRIC RING USING BOOK VALUES FOR THE MATERIAL PROPERTIES

No.	RESONANCE (HZ)	ANTIRESONANCE (HZ)	COUPLING COEFF., k
1.	1.06e-3	0.86e-3	≈ 0
2.	2491	3287	0.652
3.	2499	2499	0
4.	2611	2611	0
5.	3287	3488	0.335
6.	4889	4889	0
7.	7393	7393	0
8.	10402	10446	0.092
9.	10728	10728	0
10.	14900	14900	0

The ring mode of vibration(mode 2) is the most important in operation and is shown in Figure 14. The dashed lines in Figure 14 correspond to the rest position, and the deformed shape is in solid lines.

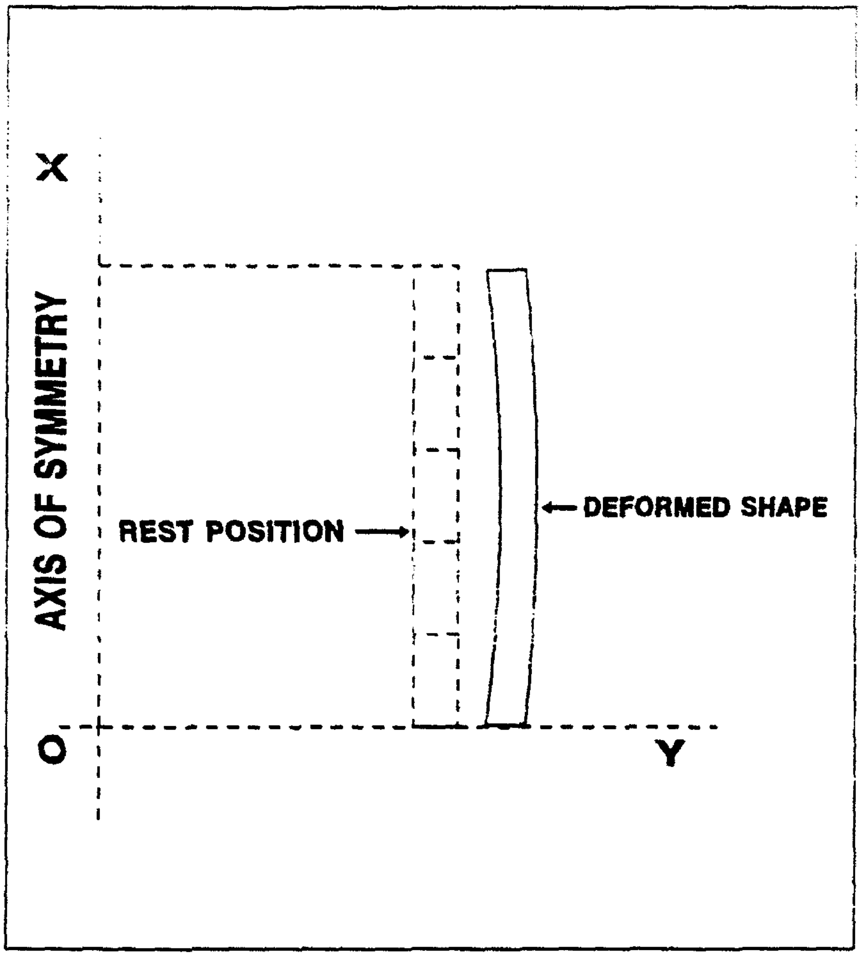

Figure 14: The Ring Mode of Vibration

To obtain the smeared properties of the unwrapped ring assembly, the circumferential compliance s_{33} was adjusted so that the ring mode resonance frequency obtained for the unwrapped ceramic ring in air using the ATILA model matched the manufacturer's measured values.

Table 3 compares the results obtained using typical elastic constant values provided in handbooks and the adjusted values.

TABLE 3: RESULTS FOR RING MODE OF UNWRAPPED CERAMIC RING USING BOOK VALUES AND ADJUSTED VALUES

	MEASURED	USING BOOK VALUES	ADJUSTED VALUES
Resonance	2356 Hz	2491 Hz (5.7%)	2356 Hz (0.0%)
Antiresonance	4224 Hz	3287 Hz	3177 Hz
Coupling Coefficient, *k*	0.665	0.652	0.671 (0.9%)

Note: The number in brackets are the percentage error.

A comparison of the value for the ring mode frequency for the ATILA 2-D in-air model for the unwrapped ceramic using the adjusted values for elastic constants and the in-air experimental results provided by the manufacturer shows the expected match of resonance frequency. The computed coupling coefficient, however, was 0.9% higher than the measured value. The difference is due to the fact that only the elastic constant s_{33} was adjusted. (Several ATILA modal analysis runs were made with adjustments made to the elastic constants s_{11} and s_{12} just to see the effect on the ring resonance frequency and coupling coefficient. The resonance frequency changed only very slightly and the change to the coupling coefficient was also very small.) It was felt that a 0.9% difference is acceptable for our purposes. For our results, the value of s_{33} was increased by 12 percent (i.e., more compliance) from the book value of 0.1539E-10 to 0.1724E-10. This is consistent with our expectation that a ring made of glued segments is more compliant than a solid piezoelectric ceramic ring. This value of s_{33} was used for calculating the first-guess smeared material properties for the fiberglass wrapped ceramic ring as described below.

2. Wrapped Equivalent Homogeneous Ring

Smeared material properties for the homogeneous equivalent wrapped ceramic ring assembly were obtained by a four-step process. First, the coarse values for the elastic constants were calculated. A sample calculation is given in Appendix D. The circumferential compliance s_{33} is then adjusted so that the calculated ring resonance frequency matched the measured frequency. The other elastic constants were then adjusted by a common factor such that the computed coupling coefficient matched that of the measured value. The results for the ring resonance frequency and coupling coefficient are given in Table 4:

TABLE 4: RESULTS OF THE WRAPPED EQUIVALENT CERAMIC RING

	MEASURED	USING VALUES OBTAINED EARLIER	ADJUSTED VALUES
RESONANCE FREQUENCY	2462 Hz	2442 Hz (0.8%)	2465 Hz (0.1%)
COUPLING COEFFICIENT	0.646	0.65 (0.62%)	0.644 (0.3%)

Note: The number in brackets are the percentage error.

Table 5 lists the values of the elastic constants calculated as described in Appendix D, and the final adjusted values. These latter values were then used for in-water harmonic analyses:

TABLE 5: ELASTIC CONSTANTS USED FOR IN-WATER HARMONIC ANALYSES

COMPLIANCE CONSTANTS	COMPUTED AS IN APPENDIX D (m^2/N)	ADJUSTED (m^2/N)
$s_{11}=s_{22}$	1.142e-11	1.342e-11
$s_{12}=s_{21}$	-4.9e-12	-4.05e-12
$s_{13}=s_{31}$	-5.3e-12	-4.43e-12
$s_{23}=s_{32}$	-5.3e-12	-4.43e-12
s_{33}	1.722e-11	1.702e-11
$s_{44}=s_{55}$	3.9e-11	3.9e-11
s_{66}	3.25e-11	3.58e-11

The other material constants, such as the dielectric constants and the piezoelectric constants, were not adjusted. The effective density of the homogeneous ring incorporating the fiberglass wrap was obtained by dividing the total mass of the ceramic and fiberglass by the volume of the homogeneous ceramic ring.

B. IN-WATER HARMONIC ANALYSES

A harmonic analysis corresponds to a forced vibration problem, the excitation being the voltage applied across the electrical terminals of the transducer. The applied voltage in our case is 1 Vrms. Internal material losses for the encapsulant materials were included in this model (but not for the ceramic ring assembly). These were obtained from the loss tangents for the respective materials. Values of 0.4 and 0.7 were used for the loss tangent for polyurethane and neoprene, respectively [Ref. 20].

1. Mounting Plate Not Included

Using the material property values obtained from in-air modal analyses, described earlier, an in-water model without the mounting plate was first nalyzed. The mesh is shown in Figure 11.

The plot in Figure 15 depicts the transmitting voltage response curve obtained by ATILA for this model along with the corresponding manufacturer's data for the actual transducer (with the mounting plate).

The computed transmitting voltage response was generally of the same form except for the lower frequency region between 1000 to 1750 Hz. The discrepancy in this region is probably due to not including the mounting plate in this model. The mounting plate is expected to change the transmitting voltage response at the cavity resonance as well as the cavity resonance frequency itself. The TVR at the ring resonance frequency was calculated to be about 2 dB lower than that measured at the same frequency.

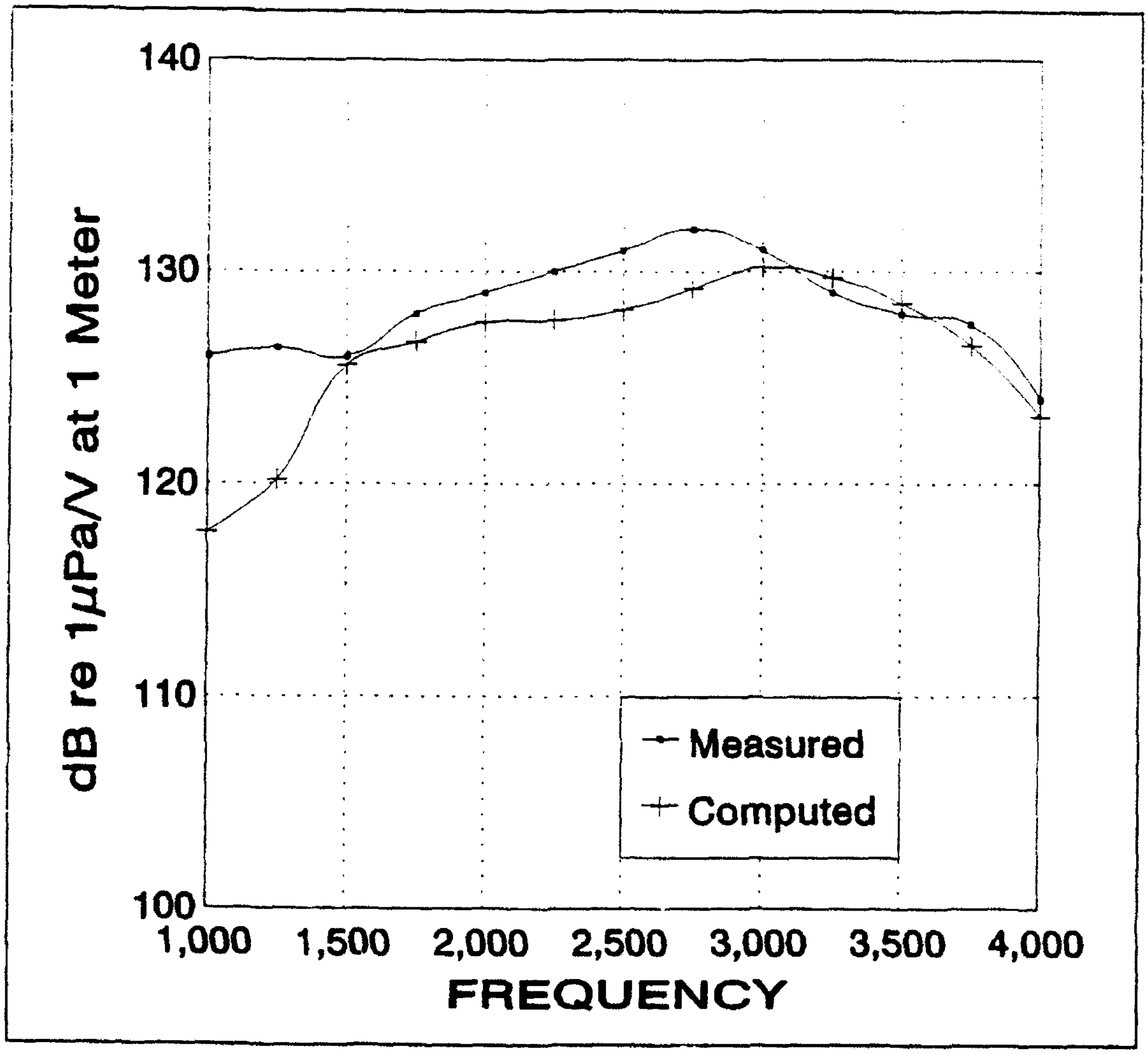

Figure 15: Comparison Of The Measured Transmitting Voltage Response With That Computed For In-water Model without Mounting Plate

2. Mounting Plate Included

An in-water ATILA model including the mounting plate was then developed. The mesh are shown in Figures 12 and 13. A comparison of the calculated transmitting voltage response with the measured response is shown in Figure 16 below:

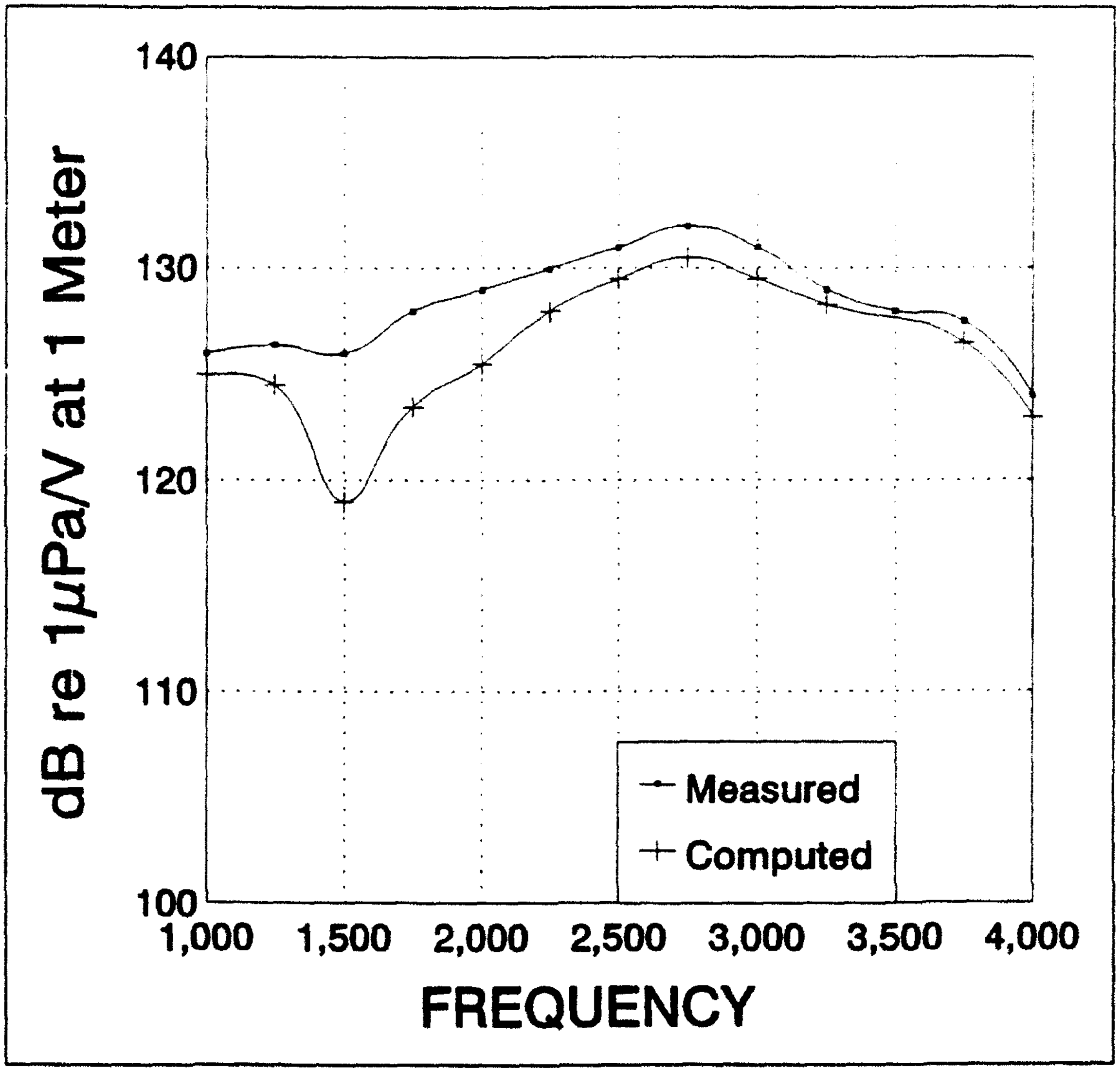

Figure 16: Comparison Of Measured TVR With That Calculated For In-water Model with Mounting Plate

The agreement between the calculated and measured TVR is about the same as the previous model. It is greatly improved in the cavity mode region and the ring resonance frequency calculated is exactly the same as the measured values. However, there is a deep dip at 1500 Hz. If this dip can be made shallower, then the overall agreement would be excellent. It is hoped that the results will be better when accurate material property values are available for the polyurethane and neoprene encapsulants. The variation in TVR with encapsulant material properties is explored in the Section D.

C. COMPARISON OF CAVITY MODE FREQUENCY [Ref. 3]

The results of the previous section for the cavity mode frequency can be compared with the approximate analytical formulae given by G.W. McMahon and present previously in Chapter III.

Using relationships given by G.W. McMahon, the first cavity mode can be calculated from Equation 2. The speed of sound in the water column, c_0 is first computed using Equation 5 presented in Chapter III. With B equal to 2.18×10^9 N/m^2 and Y_{33} to 5.875×10^{10} N/m^2, c_0 is found to be 846.06 m/s. Ω is found to be 1.075 and α is 0.519. With these values, the cavity resonance frequency, ω_c, is 7320.7 rad/s or f_c is 1165 Hz. The relative error between this value and the value obtained from the modeling (1250 Hz) is 7%.

D. EFFECT OF ENCAPSULANT MATERIAL PROPERTIES CHANGE

The ATILA model, without the mounting plate, was used to explore the effect of changing the material properties of the encapsulant materials, namely the polyurethane around the ceramic and the neoprene boots.

Figures 17 and 18 show the results of the TVR computed for different values of the Young's modulus for neoprene and polyurethane, respectively. The curves are plotted over the range of values of Young's modulus quoted in the manufacturer's literature.

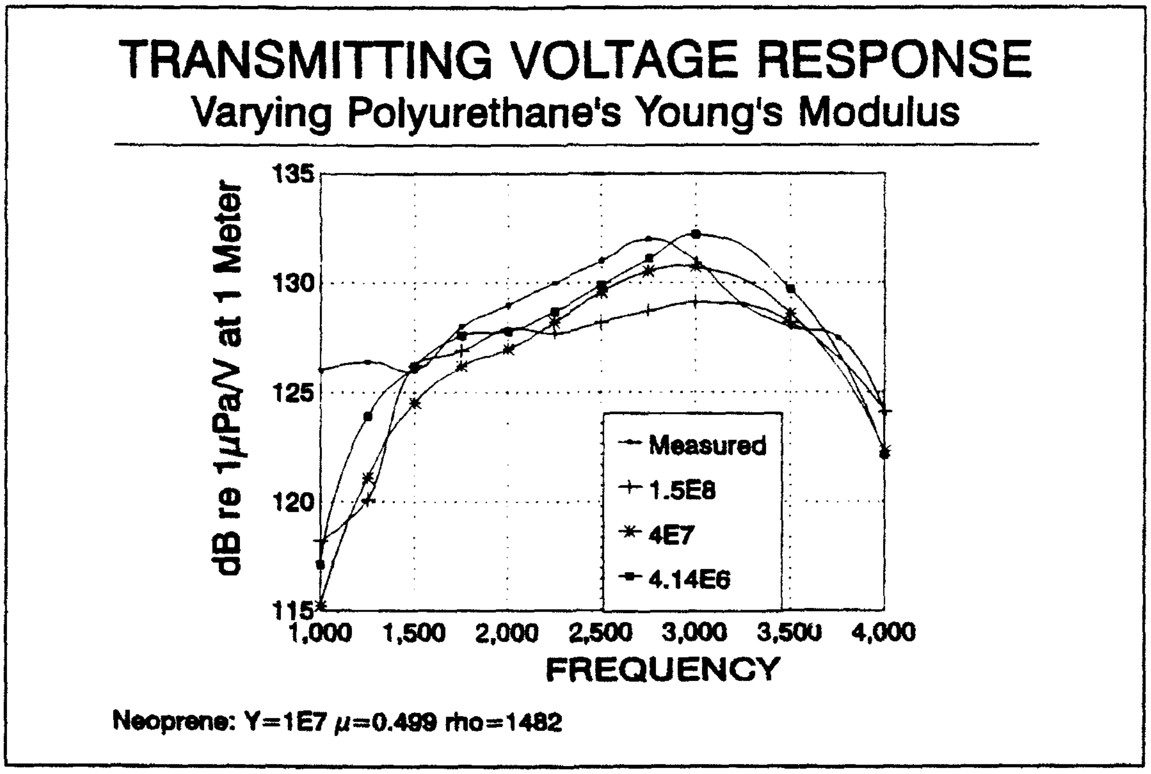

Figure 17: Effects of Varying Properties of Polyurethane

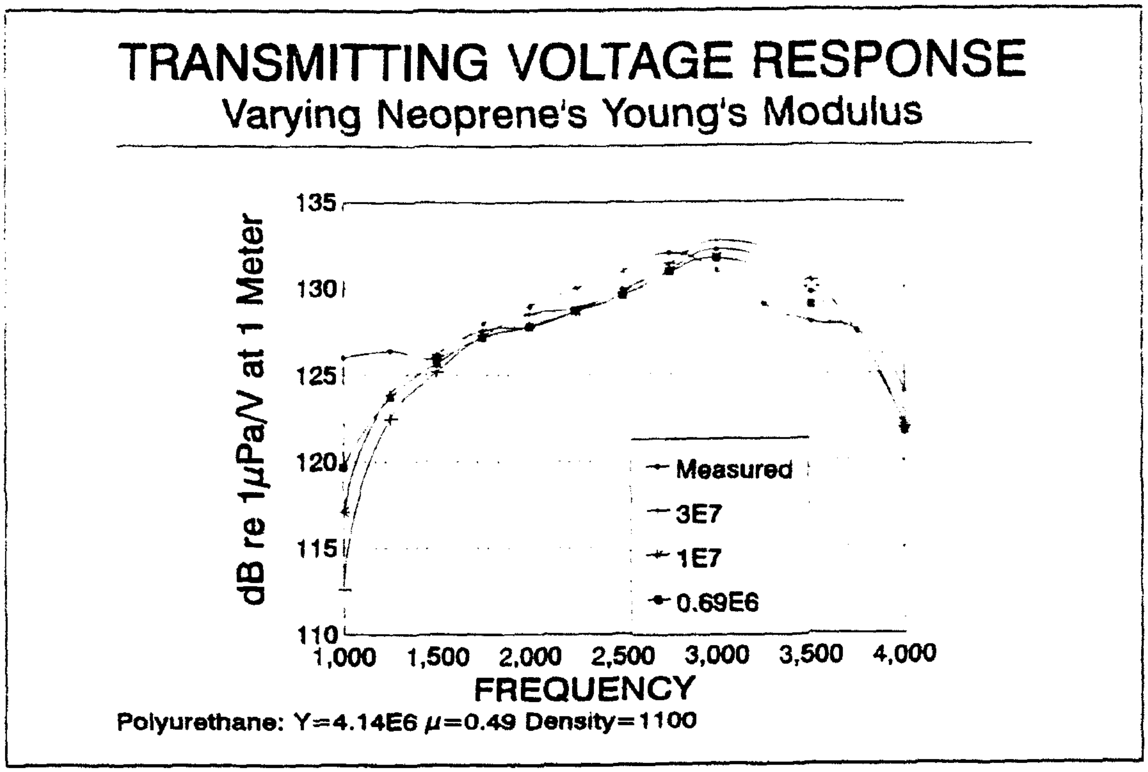

Figure 18: Effect of Varying Properties of Neoprene

From Figure 17, it can be seen that the best agreement with the measured result is for the curve with $Y = 4.14 \times 10^6$ N/m^2 and in Figure 18, it was the curve with $Y = 1 \times 10^7$ N/m^2. These two values were used for the finite element in-water harmonic analyses presented in the previous sections.

It is observed from the two figures that the value of Young's modulus for polyurethane has much greater influence on the TVR than that for neoprene. No noticeable change in ring resonance frequency was observed in any case. The transmitting voltage response was found to increase with a decrease in the

Young's modulus of polyurethane. It was, however, the reverse in the case of the neoprene.

E. THE ANALYTICAL MODEL

1. The Unloaded Case

The expressions developed based on work by Hong-zhang Wang [Ref. 2] were implemented using the MATLAB program. The program listing is provided in Appendix B. The effective elastic constant values obtained for the unencapsulated, fiberglass wrapped ceramic ring assembly of the finite element model were used for the analytical model. The admittance circle of the unencapsulated fiberglass wrapped ring is graphically compared to the measured values in Figure 19.

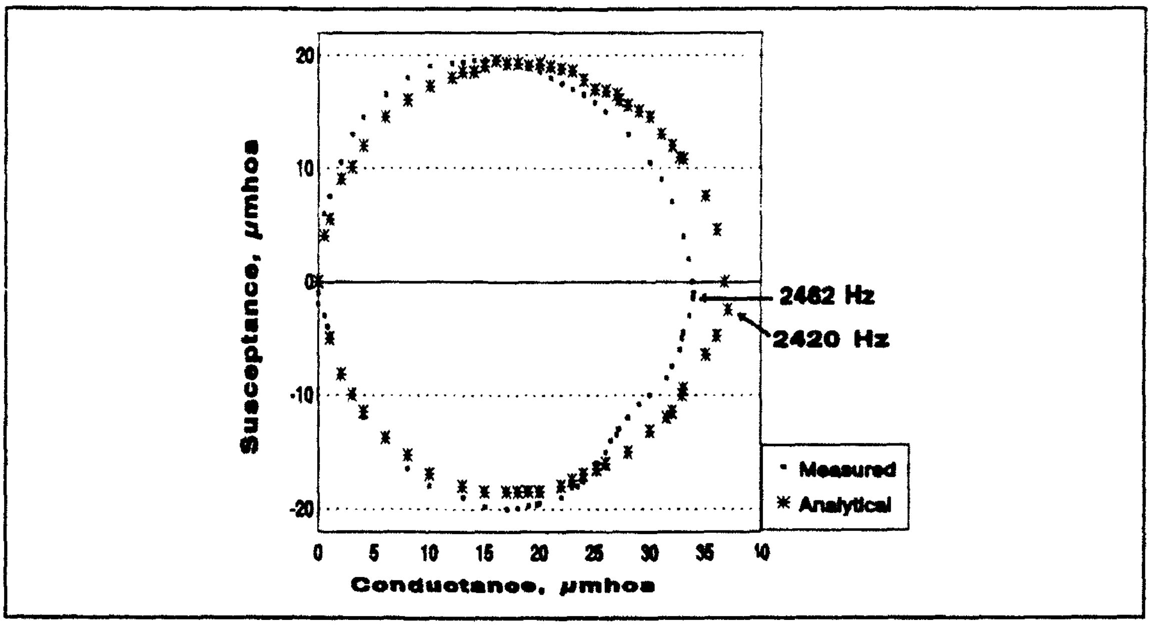

Figure 19: Comparison of Analytical with Measured Results of Wrapped Ring In Air

The resonance frequency obtained using the analytical method (2420 Hz) was approximately 2 percent lower than the measured (2462 Hz) and the value obtained using the finite element code (2465 Hz).

Wang's approach is quicker and easier to use compared to finite element modeling as only the circumferential compliance s_{33} and the Poisson ratio are required for the modeling. It is especially useful when only measured admittance circle and handbook material property values are available. The expressions developed, however, do not take into consideration the encapsulant materials.

Also, Wang's approach could not be applied to the piezoelectric thin ring transducer in water, as it was not possible to obtain expressions for the radiation impedances presented to the inner and outer surfaces of the ring transducer.

VI. CONCLUSIONS

A successful two-dimensional finite element model of a free-flooded, tangentially polarized piezoelectric ring sonar transducer was built. The model includes internal losses of the encapsulant materials. Although the model includes many necessary simplifications to handle the problem in the available MICROVAX VMS system, they were designed in such a way that the transmitting voltage response results obtained from the in-water harmonic analyses differs by only 2 dB from the measured value at the ring resonance frequency. In the region of the cavity mode, the model including the mounting plates has better agreement except for a dip at 1500 Hz. It was able to accurately predict the ring resonance frequency.

The model built (without the mounting plate) was used to investigate the effect on the acoustical properties of the transducer due to a change in the properties of the encapsulant materials used in manufacturing. It was observed that the Young's modulus of the polyurethane has a significant influence on the computed transmitting voltage response.

For the analytical model, only the case of the transducer in air was developed. The resonance frequency was found to be only 2 percent lower than the measured value.

VII. SUGGESTIONS FOR FUTURE WORK

Suggestions for future work include:

1. Obtain samples of the actual encapsulant materials used for testing to determine the actual material properties. With these values, the model can then be refined. A harmonic analysis should then be performed and the transmitting voltage response results obtained compared with measured values.

2. With known values of the material properties, the effects of changes in encapsulant materials should again be investigated using the in-water model with mounting plate.

3. Finally, it would be very helpful and interesting to obtain an analytical expression for the radiation impedance of a free-flooded ring transducer. With this and the results of Hong-zhang Wang [Ref. 2], a more complete analytical model for the transducer in water can be produced. The results obtained with this model should then be compared to those obtained using ATILA and the measured values.

4. Study of array element interaction effects should be made using these models to develop techniques for array performance modeling.

APPENDIX A

INPUT DATA FILE FOR HARMONIC FINITE ELEMENT MODEL

```
*      In-Water Harmonic Analysis of a free-flooded piezoelectric ring
*      sonar transducer
*      Prepared By MAJ Tiong Beng Tay, 14 Feb 1993
*
*==================================================================*
*      Navy Type I ceramic                                         *
*      Encapsulant Material: Polyurethane & Neoprene               *
*      Tangentially Polarized  but modeled as radially-poled       *
*      Radius of dipolar damper = 1 m                              *
*==================================================================*
*
RADIATION DIPOLAR
ANALYSIS HARMONIC
SKYLINE COMPLEX
PRECISION DOUBLE
CLASS  AXISYMME
LCPDDC = 7
NLOAD  = 40               * The number of loading cases must be less than or equal
                          * to 100. The minimum is the number of frequencies
                          * multiplied by 2 because we are analyzing a radiating
                          * transducer
FREQUENCY
      0.225E+04  0.250E+04  0.275E+04  0.300E+04  0.325E+04 0.35E4 &
      0.375E4  0.4E4
GEOMETRY  POLARIZA  CARTESIA
      1
0.900E+02  0.000E+00  0.180E+03

GEOMETRY
      2
0.762E-03  0.000E+00
      3
 0.100E+01

MATERIAL
PZT4TA
 0.000E+00  0.000E+00  0.700E+04  0.000E+00  0.000E+00  0.000E+00 &
 0.134E-10 -0.443E-11 -0.405E-11  0.000E+00  0.000E+00  0.000E+00 &
-0.443E-11  0.170E-10 -0.443E-11  0.000E+00  0.000E+00  0.000E+00 &
-0.405E-11 -0.443E-11  0.134E-10  0.000E+00  0.000E+00  0.000E+00 &
 0.000E+00  0.000E+00  0.000E+00  0.390E-10  0.000E+00  0.000E+00 &
 0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.357E-10  0.000E+00 &
 0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.390E-10 &
 0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.525E-09  0.000E+00 &
 0.000E+00  0.000E+00  0.000E+00  0.525E-09  0.000E+00  0.000E+00 &
-0.135E-09  0.300E-09 -0.135E-09  0.000E+00  0.000E+00  0.000E+00 &
 0.624E-08  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00 &
 0.000E+00  0.624E-08  0.000E+00  0.000E+00  0.000E+00  0.000E+00 &
 0.000E+00  0.000E+00  0.570E-08  0.000E+00  0.000E+00  0.000E+00

FGLR
 0.587E+11  0.280E+00  0.254E+04
P1590
 0.100E+09  0.490E+00  0.110E+04  0.000E+00  0.000E+00  0.400E+08
```

```
NEOPRENE
 0.100E+08  0.499E+00  0.148E+04  0.000E+00  0.000E+00  0.700E+07
HRS
 0.195E+12  0.333E+00  0.770E+04
ENTRAN
 0.138E+08  0.330E+00  0.170E+04

NODES
*    1 * -0.86360E-01  0.18339E+00  0.00000E+00
*    2 * -0.86360E-01  0.18656E+00  0.00000E+00
*    3 * -0.86360E-01  0.18974E+00  0.00000E+00
*    4 * -0.75565E-01  0.18339E+00  0.00000E+00
*    5 * -0.75565E-01  0.18974E+00  0.00000E+00
*    6 * -0.64770E-01  0.18339E+00  0.00000E+00
*    7 * -0.64770E-01  0.18656E+00  0.00000E+00
*    8 * -0.64770E-01  0.18974E+00  0.00000E+00
*    9 * -0.53975E-01  0.18339E+00  0.00000E+00
*   10 * -0.53975E-01  0.18974E+00  0.00000E+00
*   11 * -0.43180E-01  0.18339E+00  0.00000E+00
*   12 * -0.43180E-01  0.18656E+00  0.00000E+00
*   13 * -0.43180E-01  0.18974E+00  0.00000E+00
*   14 * -0.32385E-01  0.18339E+00  0.00000E+00
*   15 * -0.32385E-01  0.18974E+00  0.00000E+00
*   16 * -0.21590E-01  0.18339E+00  0.00000E+00
*   17 * -0.21590E-01  0.18656E+00  0.00000E+00
*   18 * -0.21590E-01  0.18974E+00  0.00000E+00
*   19 * -0.10795E-01  0.18339E+00  0.00000E+00
*   20 * -0.10795E-01  0.18974E+00  0.00000E+00
*   21 *  0.00000E+00  0.18339E+00  0.00000E+00
*   22 *  0.00000E+00  0.18656E+00  0.00000E+00
*   23 *  0.00000E+00  0.18974E+00  0.00000E+00
*   24 *  0.10795E-01  0.18339E+00  0.00000E+00
*   25 *  0.10795E-01  0.18974E+00  0.00000E+00
*   26 *  0.21590E-01  0.18339E+00  0.00000E+00
*   27 *  0.21590E-01  0.18656E+00  0.00000E+00
*   28 *  0.21590E-01  0.18974E+00  0.00000E+00
*   29 *  0.32385E-01  0.18339E+00  0.00000E+00
*   30 *  0.32385E-01  0.18974E+00  0.00000E+00
*   31 *  0.43180E-01  0.18339E+00  0.00000E+00
*   32 *  0.43180E-01  0.18656E+00  0.00000E+00
*   33 *  0.43180E-01  0.18974E+00  0.00000E+00
*   34 *  0.53975E-01  0.18339E+00  0.00000E+00
*   35 *  0.53975E-01  0.18974E+00  0.00000E+00
*   36 *  0.64770E-01  0.18339E+00  0.00000E+00
*   37 *  0.64770E-01  0.18656E+00  0.00000E+00
*   38 *  0.64770E-01  0.18974E+00  0.00000E+00
*   39 *  0.75565E-01  0.18339E+00  0.00000E+00
*   40 *  0.75565E-01  0.18974E+00  0.00000E+00
*   41 *  0.86360E-01  0.18339E+00  0.00000E+00
*   42 *  0.86360E-01  0.18656E+00  0.00000E+00
*   43 *  0.86360E-01  0.18974E+00  0.00000E+00
*   44 * -0.15875E+00  0.16510E+00  0.00000E+00
*   45 * -0.15875E+00  0.16942E+00  0.00000E+00
*   46 * -0.15875E+00  0.17374E+00  0.00000E+00
*   47 * -0.15240E+00  0.16510E+00  0.00000E+00
*   48 * -0.15240E+00  0.17374E+00  0.00000E+00
*   49 * -0.14605E+00  0.16510E+00  0.00000E+00
*   50 * -0.14605E+00  0.16942E+00  0.00000E+00
*   51 * -0.14605E+00  0.17374E+00  0.00000E+00
*   52 * -0.13350E+00  0.16510E+00  0.00000E+00
*   53 * -0.13350E+00  0.17374E+00  0.00000E+00
```

*	54	*	-0.12065E+00	0.16510E+00	0.00000E+00
*	55	*	-0.12065E+00	0.16942E+00	0.00000E+00
*	56	*	-0.12065E+00	0.17374E+00	0.00000E+00
*	57	*	-0.11430E+00	0.16510E+00	0.00000E+00
*	58	*	-0.11430E+00	0.17374E+00	0.00000E+00
*	59	*	-0.10795E+00	0.16510E+00	0.00000E+00
*	60	*	-0.10795E+00	0.16942E+00	0.00000E+00
*	61	*	-0.10795E+00	0.17374E+00	0.00000E+00
*	62	*	-0.10160E+00	0.16510E+00	0.00000E+00
*	63	*	-0.10160E+00	0.17374E+00	0.00000E+00
*	64	*	-0.95250E-01	0.16510E+00	0.00000E+00
*	65	*	-0.95250E-01	0.16942E+00	0.00000E+00
*	66	*	-0.95250E-01	0.17374E+00	0.00000E+00
*	67	*	-0.90805E-01	0.16510E+00	0.00000E+00
*	68	*	-0.90805E-01	0.17374E+00	0.00000E+00
*	69	*	-0.86360E-01	0.16510E+00	0.00000E+00
*	70	*	-0.86360E-01	0.16942E+00	0.00000E+00
*	71	*	-0.86360E-01	0.17374E+00	0.00000E+00
*	72	*	-0.75565E-01	0.16510E+00	0.00000E+00
*	73	*	-0.75565E-01	0.17374E+00	0.00000E+00
*	74	*	-0.64770E-01	0.16510E+00	0.00000E+00
*	75	*	-0.64770E-01	0.16942E+00	0.00000E+00
*	76	*	-0.64770E-01	0.17374E+00	0.00000E+00
*	77	*	-0.53975E-01	0.16510E+00	0.00000E+00
*	78	*	-0.53975E-01	0.17374E+00	0.00000E+00
*	79	*	-0.43180E-01	0.16510E+00	0.00000E+00
*	80	*	-0.43180E-01	0.16942E+00	0.00000E+00
*	81	*	-0.43180E-01	0.17374E+00	0.00000E+00
*	82	*	-0.32385E-01	0.16510E+00	0.00000E+00
*	83	*	-0.32385E-01	0.17374E+00	0.00000E+00
*	84	*	-0.21590E-01	0.16510E+00	0.00000E+00
*	85	*	-0.21590E-01	0.16942E+00	0.00000E+00
*	86	*	-0.21590E-01	0.17374E+00	0.00000E+00
*	87	*	-0.10795E-01	0.16510E+00	0.00000E+00
*	88	*	-0.10795E-01	0.17374E+00	0.00000E+00
*	89	*	0.00000E+00	0.16510E+00	0.00000E+00
*	90	*	0.00000E+00	0.16942E+00	0.00000E+00
*	91	*	0.00000E+00	0.17374E+00	0.00000E+00
*	92	*	0.10795E-01	0.16510E+00	0.00000E+00
*	93	*	0.10795E-01	0.17374E+00	0.00000E+00
*	94	*	0.21590E-01	0.16510E+00	0.00000E+00
*	95	*	0.21590E-01	0.16942E+00	0.00000E+00
*	96	*	0.21590E-01	0.17374E+00	0.00000E+00
*	97	*	0.32385E-01	0.16510E+00	0.00000E+00
*	98	*	0.32385E-01	0.17374E+00	0.00000E+00
*	99	*	0.43180E-01	0.16510E+00	0.00000E+00
*	100	*	0.43180E-01	0.16942E+00	0.00000E+00
*	101	*	0.43180E-01	0.17374E+00	0.00000E+00
*	102	*	0.53975E-01	0.16510E+00	0.00000E+00
*	103	*	0.53975E-01	0.17374E+00	0.00000E+00
*	104	*	0.64770E-01	0.16510E+00	0.00000E+00
*	105	*	0.64770E-01	0.16942E+00	0.00000E+00
*	106	*	0.64770E-01	0.17374E+00	0.00000E+00
*	107	*	0.75565E-01	0.16510E+00	0.00000E+00
*	108	*	0.75565E-01	0.17374E+00	0.00000E+00
*	109	*	0.86360E-01	0.16510E+00	0.00000E+00
*	110	*	0.86360E-01	0.16942E+00	0.00000E+00
*	111	*	0.86360E-01	0.17374E+00	0.00000E+00
*	112	*	0.90805E-01	0.16510E+00	0.00000E+00
*	113	*	0.90805E-01	0.17374E+00	0.00000E+00
*	114	*	0.95250E-01	0.16510E+00	0.00000E+00
*	115	*	0.95250E-01	0.16942E+00	0.00000E+00

*	116	*	0.95250E-01	0.17374E+00	0.00000E+00
*	117	*	0.10160E+00	0.16510E+00	0.00000E+00
*	118	*	0.10160E+00	0.17374E+00	0.00000E+00
*	119	*	0.10795E+00	0.16510E+00	0.00000E+00
*	120	*	0.10795E+00	0.16942E+00	0.00000E+00
*	121	*	0.10795E+00	0.17374E+00	0.00000E+00
*	122	*	0.11430E+00	0.16510E+00	0.00000E+00
*	123	*	0.11430E+00	0.17374E+00	0.00000E+00
*	124	*	0.12065E+00	0.16510E+00	0.00000E+00
*	125	*	0.12065E+00	0.16942E+00	0.00000E+00
*	126	*	0.12065E+00	0.17374E+00	0.00000E+00
*	127	*	0.13350E+00	0.16510E+00	0.00000E+00
*	128	*	0.13350E+00	0.17374E+00	0.00000E+00
*	129	*	0.14605E+00	0.16510E+00	0.00000E+00
*	130	*	0.14605E+00	0.16942E+00	0.00000E+00
*	131	*	0.14605E+00	0.17374E+00	0.00000E+00
*	132	*	-0.15875E+00	0.17856E+00	0.00000E+00
*	133	*	-0.15875E+00	0.18339E+00	0.00000E+00
*	134	*	-0.15240E+00	0.18339E+00	0.00000E+00
*	135	*	-0.14605E+00	0.17856E+00	0.00000E+00
*	136	*	-0.14605E+00	0.18339E+00	0.00000E+00
*	137	*	-0.13350E+00	0.18339E+00	0.00000E+00
*	138	*	-0.12065E+00	0.17856E+00	0.00000E+00
*	139	*	-0.12065E+00	0.18339E+00	0.00000E+00
*	140	*	-0.11430E+00	0.18339E+00	0.00000E+00
*	141	*	-0.10795E+00	0.17856E+00	0.00000E+00
*	142	*	-0.10795E+00	0.18339E+00	0.00000E+00
*	143	*	-0.10160E+00	0.18339E+00	0.00000E+00
*	144	*	-0.95250E-01	0.17856E+00	0.00000E+00
*	145	*	-0.95250E-01	0.18339E+00	0.00000E+00
*	146	*	-0.90805E-01	0.18339E+00	0.00000E+00
*	147	*	-0.86360E-01	0.17856E+00	0.00000E+00
*	148	*	-0.64770E-01	0.17856E+00	0.00000E+00
*	149	*	-0.43180E-01	0.17856E+00	0.00000E+00
*	150	*	-0.21590E-01	0.17856E+00	0.00000E+00
*	151	*	0.00000E+00	0.17856E+00	0.00000E+00
*	152	*	0.21590E-01	0.17856E+00	0.00000E+00
*	153	*	0.43180E-01	0.17856E+00	0.00000E+00
*	154	*	0.64770E-01	0.17856E+00	0.00000E+00
*	155	*	0.86360E-01	0.17856E+00	0.00000E+00
*	156	*	0.90805E-01	0.18339E+00	0.00000E+00
*	157	*	0.95250E-01	0.17856E+00	0.00000E+00
*	158	*	0.95250E-01	0.18339E+00	0.00000E+00
*	159	*	0.10160E+00	0.18339E+00	0.00000E+00
*	160	*	0.10795E+00	0.17856E+00	0.00000E+00
*	161	*	0.10795E+00	0.18339E+00	0.00000E+00
*	162	*	0.11430E+00	0.18339E+00	0.00000E+00
*	163	*	0.12065E+00	0.17856E+00	0.00000E+00
*	164	*	0.12065E+00	0.18339E+00	0.00000E+00
*	165	*	0.13350E+00	0.18339E+00	0.00000E+00
*	166	*	0.14605E+00	0.17856E+00	0.00000E+00
*	167	*	0.14605E+00	0.18339E+00	0.00000E+00
*	168	*	-0.15875E+00	0.18656E+00	0.00000E+00
*	169	*	-0.15875E+00	0.18974E+00	0.00000E+00
*	170	*	-0.15240E+00	0.18974E+00	0.00000E+00
*	171	*	-0.14605E+00	0.18656E+00	0.00000E+00
*	172	*	-0.14605E+00	0.18974E+00	0.00000E+00
*	173	*	-0.13350E+00	0.18974E+00	0.00000E+00
*	174	*	-0.12065E+00	0.18656E+00	0.00000E+00
*	175	*	-0.12065E+00	0.18974E+00	0.00000E+00
*	176	*	-0.11430E+00	0.18974E+00	0.00000E+00
*	177	*	-0.10795E+00	0.18656E+00	0.00000E+00

*	178	*	-0.10795E+00	0.18974E+00	0.00000E+00
*	179	*	-0.10160E+00	0.18974E+00	0.00000E+00
*	180	*	-0.95250E-01	0.18656E+00	0.00000E+00
*	181	*	-0.95250E-01	0.18974E+00	0.00000E+00
*	182	*	-0.90805E-01	0.18974E+00	0.00000E+00
*	183	*	0.90805E-01	0.18974E+00	0.00000E+00
*	184	*	0.95250E-01	0.18656E+00	0.00000E+00
*	185	*	0.95250E-01	0.18974E+00	0.00000E+00
*	186	*	0.10160E+00	0.18974E+00	0.00000E+00
*	187	*	0.10795E+00	0.18656E+00	0.00000E+00
*	188	*	0.10795E+00	0.18974E+00	0.00000E+00
*	189	*	0.11430E+00	0.18974E+00	0.00000E+00
*	190	*	0.12065E+00	0.18656E+00	0.00000E+00
*	191	*	0.12065E+00	0.18974E+00	0.00000E+00
*	192	*	0.13350E+00	0.18974E+00	0.00000E+00
*	193	*	0.14605E+00	0.18656E+00	0.00000E+00
*	194	*	0.14605E+00	0.18974E+00	0.00000E+00
*	195	*	-0.15875E+00	0.19202E+00	0.00000E+00
*	196	*	-0.15875E+00	0.19430E+00	0.00000E+00
*	197	*	-0.15240E+00	0.19430E+00	0.00000E+00
*	198	*	-0.14605E+00	0.19202E+00	0.00000E+00
*	199	*	-0.14605E+00	0.19430E+00	0.00000E+00
*	200	*	-0.13350E+00	0.19430E+00	0.00000E+00
*	201	*	-0.12065E+00	0.19202E+00	0.00000E+00
*	202	*	-0.12065E+00	0.19430E+00	0.00000E+00
*	203	*	-0.11430E+00	0.19430E+00	0.00000E+00
*	204	*	-0.10795E+00	0.19202E+00	0.00000E+00
*	205	*	-0.10795E+00	0.19430E+00	0.00000E+00
*	206	*	-0.10160E+00	0.19430E+00	0.00000E+00
*	207	*	-0.95250E-01	0.19202E+00	0.00000E+00
*	208	*	-0.95250E-01	0.19430E+00	0.00000E+00
*	209	*	-0.90805E-01	0.19430E+00	0.00000E+00
*	210	*	-0.86360E-01	0.19202E+00	0.00000E+00
*	211	*	-0.86360E-01	0.19430E+00	0.00000E+00
*	212	*	-0.75565E-01	0.19430E+00	0.00000E+00
*	213	*	-0.64770E-01	0.19202E+00	0.00000E+00
*	214	*	-0.64770E-01	0.19430E+00	0.00000E+00
*	215	*	-0.53975E-01	0.19430E+00	0.00000E+00
*	216	*	-0.43180E-01	0.19202E+00	0.00000E+00
*	217	*	-0.43180E-01	0.19430E+00	0.00000E+00
*	218	*	-0.32385E-01	0.19430E+00	0.00000E+00
*	219	*	-0.21590E-01	0.19202E+00	0.00000E+00
*	220	*	-0.21590E-01	0.19430E+00	0.00000E+00
*	221	*	-0.10795E-01	0.19430E+00	0.00000E+00
*	222	*	0.00000E+00	0.19202E+00	0.00000E+00
*	223	*	0.00000E+00	0.19430E+00	0.00000E+00
*	224	*	0.10795E-01	0.19430E+00	0.00000E+00
*	225	*	0.21590E-01	0.19202E+00	0.00000E+00
*	226	*	0.21590E-01	0.19430E+00	0.00000E+00
*	227	*	0.32385E-01	0.19430E+00	0.00000E+00
*	228	*	0.43180E-01	0.19202E+00	0.00000E+00
*	229	*	0.43180E-01	0.19430E+00	0.00000E+00
*	230	*	0.53975E-01	0.19430E+00	0.00000E+00
*	231	*	0.64770E-01	0.19202E+00	0.00000E+00
*	232	*	0.64770E-01	0.19430E+00	0.00000E+00
*	233	*	0.75565E-01	0.19430E+00	0.00000E+00
*	234	*	0.86360E-01	0.19202E+00	0.00000E+00
*	235	*	0.86360E-01	0.19430E+00	0.00000E+00
*	236	*	0.90805E-01	0.19430E+00	0.00000E+00
*	237	*	0.95250E-01	0.19202E+00	0.00000E+00
*	238	*	0.95250E-01	0.19430E+00	0.00000E+00
*	239	*	0.10160E+00	0.19430E+00	0.00000E+00

*	240	*	0.10795E+00	0.19202E+00	0.00000E+00
*	241	*	0.10795E+00	0.19430E+00	0.00000E+00
*	242	*	0.11430E+00	0.19430E+00	0.00000E+00
*	243	*	0.12065E+00	0.19202E+00	0.00000E+00
*	244	*	0.12065E+00	0.19430E+00	0.00000E+00
*	245	*	0.13350E+00	0.19430E+00	0.00000E+00
*	246	*	0.14605E+00	0.19202E+00	0.00000E+00
*	247	*	0.14605E+00	0.19430E+00	0.00000E+00
*	248	*	-0.15875E+00	0.19951E+00	0.00000E+00
*	249	*	-0.15875E+00	0.20472E+00	0.00000E+00
*	250	*	-0.15240E+00	0.20472E+00	0.00000E+00
*	251	*	-0.14605E+00	0.19951E+00	0.00000E+00
*	252	*	-0.14605E+00	0.20472E+00	0.00000E+00
*	253	*	-0.13350E+00	0.20472E+00	0.00000E+00
*	254	*	-0.12065E+00	0.19951E+00	0.00000E+00
*	255	*	-0.12065E+00	0.20472E+00	0.00000E+00
*	256	*	-0.11430E+00	0.20472E+00	0.00000E+00
*	257	*	-0.10795E+00	0.19951E+00	0.00000E+00
*	258	*	-0.10795E+00	0.20472E+00	0.00000E+00
*	259	*	-0.10160E+00	0.20472E+00	0.00000E+00
*	260	*	-0.95250E-01	0.19951E+00	0.00000E+00
*	261	*	-0.95250E-01	0.20472E+00	0.00000E+00
*	262	*	-0.90805E-01	0.20472E+00	0.00000E+00
*	263	*	-0.86360E-01	0.19951E+00	0.00000E+00
*	264	*	-0.86360E-01	0.20472E+00	0.00000E+00
*	265	*	-0.75565E-01	0.20472E+00	0.00000E+00
*	266	*	-0.64770E-01	0.19951E+00	0.00000E+00
*	267	*	-0.64770E-01	0.20472E+00	0.00000E+00
*	268	*	-0.53975E-01	0.20472E+00	0.00000E+00
*	269	*	-0.43180E-01	0.19951E+00	0.00000E+00
*	270	*	-0.43180E-01	0.20472E+00	0.00000E+00
*	271	*	-0.32385E-01	0.20472E+00	0.00000E+00
*	272	*	-0.21590E-01	0.19951E+00	0.00000E+00
*	273	*	-0.21590E-01	0.20472E+00	0.00000E+00
*	274	*	-0.10795E-01	0.20472E+00	0.00000E+00
*	275	*	0.00000E+00	0.19951E+00	0.00000E+00
*	276	*	0.00000E+00	0.20472E+00	0.00000E+00
*	277	*	0.10795E-01	0.20472E+00	0.00000E+00
*	278	*	0.21590E-01	0.19951E+00	0.00000E+00
*	279	*	0.21590E-01	0.20472E+00	0.00000E+00
*	280	*	0.32385E-01	0.20472E+00	0.00000E+00
*	281	*	0.43180E-01	0.19951E+00	0.00000E+00
*	282	*	0.43180E-01	0.20472E+00	0.00000E+00
*	283	*	0.53975E-01	0.20472E+00	0.00000E+00
*	284	*	0.64770E-01	0.19951E+00	0.00000E+00
*	285	*	0.64770E-01	0.20472E+00	0.00000E+00
*	286	*	0.75565E-01	0.20472E+00	0.00000E+00
*	287	*	0.86360E-01	0.19951E+00	0.00000E+00
*	288	*	0.86360E-01	0.20472E+00	0.00000E+00
*	289	*	0.90805E-01	0.20472E+00	0.00000E+00
*	290	*	0.95250E-01	0.19951E+00	0.00000E+00
*	291	*	0.95250E-01	0.20472E+00	0.00000E+00
*	292	*	0.10160E+00	0.20472E+00	0.00000E+00
*	293	*	0.10795E+00	0.19951E+00	0.00000E+00
*	294	*	0.10795E+00	0.20472E+00	0.00000E+00
*	295	*	0.11430E+00	0.20472E+00	0.00000E+00
*	296	*	0.12065E+00	0.19951E+00	0.00000E+00
*	297	*	0.12065E+00	0.20472E+00	0.00000E+00
*	298	*	0.13350E+00	0.20472E+00	0.00000E+00
*	299	*	0.14605E+00	0.19951E+00	0.00000E+00
*	300	*	0.14605E+00	0.20472E+00	0.00000E+00
*	301	*	-0.15875E+00	0.98290E-01	0.00000E+00

*	302	*	-0.15875E+00	0.11500E+00	0.00000E+00
*	303	*	-0.15875E+00	0.13170E+00	0.00000E+00
*	304	*	-0.15875E+00	0.14840E+00	0.00000E+00
*	305	*	-0.15240E+00	0.98290E-01	0.00000E+00
*	306	*	-0.15240E+00	0.13170E+00	0.00000E+00
*	307	*	-0.14605E+00	0.98290E-01	0.00000E+00
*	308	*	-0.14605E+00	0.11500E+00	0.00000E+00
*	309	*	-0.14605E+00	0.13170E+00	0.00000E+00
*	310	*	-0.14605E+00	0.14840E+00	0.00000E+00
*	311	*	0.00000E+00	0.00000E+00	0.00000E+00
*	312	*	0.10795E-01	0.00000E+00	0.00000E+00
*	313	*	-0.10795E-01	0.00000E+00	0.00000E+00
*	314	*	0.21590E-01	0.00000E+00	0.00000E+00
*	315	*	-0.21590E-01	0.00000E+00	0.00000E+00
*	316	*	0.00000E+00	0.24576E-01	0.00000E+00
*	317	*	0.32385E-01	0.00000E+00	0.00000E+00
*	318	*	-0.32385E-01	0.00000E+00	0.00000E+00
*	319	*	0.21590E-01	0.24576E-01	0.00000E+00
*	320	*	-0.21590E-01	0.24576E-01	0.00000E+00
*	321	*	0.43180E-01	0.00000E+00	0.00000E+00
*	322	*	-0.43180E-01	0.00000E+00	0.00000E+00
*	323	*	0.00000E+00	0.49150E-01	0.00000E+00
*	324	*	0.43180E-01	0.24576E-01	0.00000E+00
*	325	*	-0.43180E-01	0.24576E-01	0.00000E+00
*	326	*	0.10795E-01	0.49150E-01	0.00000E+00
*	327	*	-0.10795E-01	0.49150E-01	0.00000E+00
*	328	*	0.21590E-01	0.49150E-01	0.00000E+00
*	329	*	-0.21590E-01	0.49150E-01	0.00000E+00
*	330	*	0.53975E-01	0.00000E+00	0.00000E+00
*	331	*	-0.53975E-01	0.00000E+00	0.00000E+00
*	332	*	0.32385E-01	0.49150E-01	0.00000E+00
*	333	*	-0.32385E-01	0.49150E-01	0.00000E+00
*	334	*	0.64770E-01	0.00000E+00	0.00000E+00
*	335	*	-0.64770E-01	0.00000E+00	0.00000E+00
*	336	*	0.43180E-01	0.49150E-01	0.00000E+00
*	337	*	-0.43180E-01	0.49150E-01	0.00000E+00
*	338	*	0.64770E-01	0.24576E-01	0.00000E+00
*	339	*	-0.64770E-01	0.24576E-01	0.00000E+00
*	340	*	0.53975E-01	0.49150E-01	0.00000E+00
*	341	*	-0.53975E-01	0.49150E-01	0.00000E+00
*	342	*	0.00000E+00	0.73721E-01	0.00000E+00
*	343	*	0.75565E-01	0.00000E+00	0.00000E+00
*	344	*	-0.75565E-01	0.00000E+00	0.00000E+00
*	345	*	0.21590E-01	0.73721E-01	0.00000E+00
*	346	*	-0.21590E-01	0.73721E-01	0.00000E+00
*	347	*	0.64770E-01	0.49150E-01	0.00000E+00
*	348	*	-0.64770E-01	0.49150E-01	0.00000E+00
*	349	*	0.43180E-01	0.73721E-01	0.00000E+00
*	350	*	-0.43180E-01	0.73721E-01	0.00000E+00
*	351	*	-0.86360E-01	0.00000E+00	0.00000E+00
*	352	*	0.86360E-01	0.00000E+00	0.00000E+00
*	353	*	-0.86360E-01	0.24576E-01	0.00000E+00
*	354	*	0.86360E-01	0.24576E-01	0.00000E+00
*	355	*	0.75565E-01	0.49150E-01	0.00000E+00
*	356	*	-0.75565E-01	0.49150E-01	0.00000E+00
*	357	*	-0.90805E-01	0.00000E+00	0.00000E+00
*	358	*	0.90805E-01	0.00000E+00	0.00000E+00
*	359	*	-0.95250E-01	0.00000E+00	0.00000E+00
*	360	*	0.95250E-01	0.00000E+00	0.00000E+00
*	361	*	0.64770E-01	0.73721E-01	0.00000E+00
*	362	*	-0.64770E-01	0.73721E-01	0.00000E+00
*	363	*	0.00000E+00	0.98290E-01	0.00000E+00

*	364	*	-0.95250E-01	0.24576E-01	0.00000E+00
*	365	*	0.95250E-01	0.24576E-01	0.00000E+00
*	366	*	0.10795E-01	0.98290E-01	0.00000E+00
*	367	*	-0.10795E-01	0.98290E-01	0.00000E+00
*	368	*	-0.86360E-01	0.49150E-01	0.00000E+00
*	369	*	0.86360E-01	0.49150E-01	0.00000E+00
*	370	*	0.21590E-01	0.98290E-01	0.00000E+00
*	371	*	-0.21590E-01	0.98290E-01	0.00000E+00
*	372	*	-0.10160E+00	0.00000E+00	0.00000E+00
*	373	*	0.10160E+00	0.00000E+00	0.00000E+00
*	374	*	-0.90805E-01	0.49150E-01	0.00000E+00
*	375	*	0.90805E-01	0.49150E-01	0.00000E+00
*	376	*	0.32385E-01	0.98290E-01	0.00000E+00
*	377	*	-0.32385E-01	0.98290E-01	0.00000E+00
*	378	*	-0.95250E-01	0.49150E-01	0.00000E+00
*	379	*	0.95250E-01	0.49150E-01	0.00000E+00
*	380	*	0.43180E-01	0.98290E-01	0.00000E+00
*	381	*	-0.43180E-01	0.98290E-01	0.00000E+00
*	382	*	-0.10795E+00	0.00000E+00	0.00000E+00
*	383	*	0.10795E+00	0.00000E+00	0.00000E+00
*	384	*	-0.10795E+00	0.24576E-01	0.00000E+00
*	385	*	0.10795E+00	0.24576E-01	0.00000E+00
*	386	*	0.53975E-01	0.98290E-01	0.00000E+00
*	387	*	-0.53975E-01	0.98290E-01	0.00000E+00
*	388	*	-0.10160E+00	0.49150E-01	0.00000E+00
*	389	*	0.10160E+00	0.49150E-01	0.00000E+00
*	390	*	-0.86360E-01	0.73721E-01	0.00000E+00
*	391	*	0.86360E-01	0.73721E-01	0.00000E+00
*	392	*	-0.11430E+00	0.00000E+00	0.00000E+00
*	393	*	0.11430E+00	0.00000E+00	0.00000E+00
*	394	*	0.00000E+00	0.11500E+00	0.00000E+00
*	395	*	0.21590E-01	0.11500E+00	0.00000E+00
*	396	*	-0.21590E-01	0.11500E+00	0.00000E+00
*	397	*	0.64770E-01	0.98290E-01	0.00000E+00
*	398	*	-0.64770E-01	0.98290E-01	0.00000E+00
*	399	*	-0.10795E+00	0.49150E-01	0.00000E+00
*	400	*	0.10795E+00	0.49150E-01	0.00000E+00
*	401	*	-0.95250E-01	0.73721E-01	0.00000E+00
*	402	*	0.95250E-01	0.73721E-01	0.00000E+00
*	403	*	-0.12065E+00	0.00000E+00	0.00000E+00
*	404	*	0.12065E+00	0.00000E+00	0.00000E+00
*	405	*	0.43180E-01	0.11500E+00	0.00000E+00
*	406	*	-0.43180E-01	0.11500E+00	0.00000E+00
*	407	*	-0.12065E+00	0.24576E-01	0.00000E+00
*	408	*	0.12065E+00	0.24576E-01	0.00000E+00
*	409	*	0.75565E-01	0.98290E-01	0.00000E+00
*	410	*	-0.75565E-01	0.98290E-01	0.00000E+00
*	411	*	-0.11430E+00	0.49150E-01	0.00000E+00
*	412	*	0.11430E+00	0.49150E-01	0.00000E+00
*	413	*	-0.12065E+00	0.49150E-01	0.00000E+00
*	414	*	0.12065E+00	0.49150E-01	0.00000E+00
*	415	*	-0.10795E+00	0.73721E-01	0.00000E+00
*	416	*	0.10795E+00	0.73721E-01	0.00000E+00
*	417	*	-0.86360E-01	0.98290E-01	0.00000E+00
*	418	*	0.86360E-01	0.98290E-01	0.00000E+00
*	419	*	0.00000E+00	0.13170E+00	0.00000E+00
*	420	*	0.64770E-01	0.11500E+00	0.00000E+00
*	421	*	-0.64770E-01	0.11500E+00	0.00000E+00
*	422	*	0.10795E-01	0.13170E+00	0.00000E+00
*	423	*	-0.10795E-01	0.13170E+00	0.00000E+00
*	424	*	0.21590E-01	0.13170E+00	0.00000E+00
*	425	*	-0.21590E-01	0.13170E+00	0.00000E+00

*	426	*	-0.13350E+00	0.00000E+00	0.00000E+00
*	427	*	0.13350E+00	0.00000E+00	0.00000E+00
*	428	*	-0.90805E-01	0.98290E-01	0.00000E+00
*	429	*	0.90805E-01	0.98290E-01	0.00000E+00
*	430	*	0.32385E-01	0.13170E+00	0.00000E+00
*	431	*	-0.32385E-01	0.13170E+00	0.00000E+00
*	432	*	-0.95250E-01	0.98290E-01	0.00000E+00
*	433	*	0.95250E-01	0.98290E-01	0.00000E+00
*	434	*	0.43180E-01	0.13170E+00	0.00000E+00
*	435	*	-0.43180E-01	0.13170E+00	0.00000E+00
*	436	*	-0.10160E+00	0.98290E-01	0.00000E+00
*	437	*	0.10160E+00	0.98290E-01	0.00000E+00
*	438	*	-0.12065E+00	0.73721E-01	0.00000E+00
*	439	*	0.12065E+00	0.73721E-01	0.00000E+00
*	440	*	-0.13350E+00	0.49150E-01	0.00000E+00
*	441	*	0.13350E+00	0.49150E-01	0.00000E+00
*	442	*	0.53975E-01	0.13170E+00	0.00000E+00
*	443	*	-0.53975E-01	0.13170E+00	0.00000E+00
*	444	*	0.86360E-01	0.11500E+00	0.00000E+00
*	445	*	-0.86360E-01	0.11500E+00	0.00000E+00
*	446	*	-0.10795E+00	0.98290E-01	0.00000E+00
*	447	*	0.10795E+00	0.98290E-01	0.00000E+00
*	448	*	0.14605E+00	0.00000E+00	0.00000E+00
*	449	*	-0.14605E+00	0.00000E+00	0.00000E+00
*	450	*	0.64770E-01	0.13170E+00	0.00000E+00
*	451	*	-0.64770E-01	0.13170E+00	0.00000E+00
*	452	*	0.14605E+00	0.24576E-01	0.00000E+00
*	453	*	-0.14605E+00	0.24576E-01	0.00000E+00
*	454	*	0.00000E+00	0.14840E+00	0.00000E+00
*	455	*	0.95250E-01	0.11500E+00	0.00000E+00
*	456	*	-0.95250E-01	0.11500E+00	0.00000E+00
*	457	*	0.21590E-01	0.14840E+00	0.00000E+00
*	458	*	-0.21590E-01	0.14840E+00	0.00000E+00
*	459	*	-0.11430E+00	0.98290E-01	0.00000E+00
*	460	*	0.11430E+00	0.98290E-01	0.00000E+00
*	461	*	0.75565E-01	0.13170E+00	0.00000E+00
*	462	*	-0.75565E-01	0.13170E+00	0.00000E+00
*	463	*	-0.15240E+00	0.00000E+00	0.00000E+00
*	464	*	0.14605E+00	0.49150E-01	0.00000E+00
*	465	*	-0.14605E+00	0.49150E-01	0.00000E+00
*	466	*	0.43180E-01	0.14840E+00	0.00000E+00
*	467	*	-0.43180E-01	0.14840E+00	0.00000E+00
*	468	*	-0.12065E+00	0.98290E-01	0.00000E+00
*	469	*	0.12065E+00	0.98290E-01	0.00000E+00
*	470	*	0.86360E-01	0.13170E+00	0.00000E+00
*	471	*	-0.86360E-01	0.13170E+00	0.00000E+00
*	472	*	0.10795E+00	0.11500E+00	0.00000E+00
*	473	*	-0.10795E+00	0.11500E+00	0.00000E+00
*	474	*	-0.15875E+00	0.00000E+00	0.00000E+00
*	475	*	0.90805E-01	0.13170E+00	0.00000E+00
*	476	*	-0.90805E-01	0.13170E+00	0.00000E+00
*	477	*	-0.15240E+00	0.49150E-01	0.00000E+00
*	478	*	-0.15875E+00	0.24576E-01	0.00000E+00
*	479	*	0.64770E-01	0.14840E+00	0.00000E+00
*	480	*	-0.64770E-01	0.14840E+00	0.00000E+00
*	481	*	0.95250E-01	0.13170E+00	0.00000E+00
*	482	*	-0.95250E-01	0.13170E+00	0.00000E+00
*	483	*	0.14605E+00	0.73721E-01	0.00000E+00
*	484	*	-0.14605E+00	0.73721E-01	0.00000E+00
*	485	*	0.00000E+00	0.16510E+00	0.00000E+00
*	486	*	0.10795E-01	0.16510E+00	0.00000E+00
*	487	*	-0.10795E-01	0.16510E+00	0.00000E+00

*	488	*	-0.13350E+00	0.98290E-01	0.00000E+00
*	489	*	0.13350E+00	0.98290E-01	0.00000E+00
*	490	*	-0.15875E+00	0.49150E-01	0.00000E+00
*	491	*	0.10160E+00	0.13170E+00	0.00000E+00
*	492	*	-0.10160E+00	0.13170E+00	0.00000E+00
*	493	*	0.21590E-01	0.16510E+00	0.00000E+00
*	494	*	-0.21590E-01	0.16510E+00	0.00000E+00
*	495	*	0.12065E+00	0.11500E+00	0.00000E+00
*	496	*	-0.12065E+00	0.11500E+00	0.00000E+00
*	497	*	0.32385E-01	0.16510E+00	0.00000E+00
*	498	*	-0.32385E-01	0.16510E+00	0.00000E+00
*	499	*	0.10795E+00	0.13170E+00	0.00000E+00
*	500	*	-0.10795E+00	0.13170E+00	0.00000E+00
*	501	*	0.43180E-01	0.16510E+00	0.00000E+00
*	502	*	-0.43180E-01	0.16510E+00	0.00000E+00
*	503	*	0.86360E-01	0.14840E+00	0.00000E+00
*	504	*	-0.86360E-01	0.14840E+00	0.00000E+00
*	505	*	0.53975E-01	0.16510E+00	0.00000E+00
*	506	*	-0.53975E-01	0.16510E+00	0.00000E+00
*	507	*	0.11430E+00	0.13170E+00	0.00000E+00
*	508	*	-0.11430E+00	0.13170E+00	0.00000E+00
*	509	*	-0.15875E+00	0.73721E-01	0.00000E+00
*	510	*	0.14605E+00	0.98290E-01	0.00000E+00
*	511	*	-0.14605E+00	0.98290E-01	0.00000E+00
*	512	*	0.95250E-01	0.14840E+00	0.00000E+00
*	513	*	-0.95250E-01	0.14840E+00	0.00000E+00
*	514	*	0.64770E-01	0.16510E+00	0.00000E+00
*	515	*	-0.64770E-01	0.16510E+00	0.00000E+00
*	516	*	0.12065E+00	0.13170E+00	0.00000E+00
*	517	*	-0.12065E+00	0.13170E+00	0.00000E+00
*	518	*	-0.15240E+00	0.98290E-01	0.00000E+00
*	519	*	0.75565E-01	0.16510E+00	0.00000E+00
*	520	*	-0.75565E-01	0.16510E+00	0.00000E+00
*	521	*	0.10795E+00	0.14840E+00	0.00000E+00
*	522	*	-0.10795E+00	0.14840E+00	0.00000E+00
*	523	*	0.14605E+00	0.11500E+00	0.00000E+00
*	524	*	-0.14605E+00	0.11500E+00	0.00000E+00
*	525	*	0.86360E-01	0.16510E+00	0.00000E+00
*	526	*	-0.86360E-01	0.16510E+00	0.00000E+00
*	527	*	-0.15875E+00	0.98290E-01	0.00000E+00
*	528	*	0.13350E+00	0.13170E+00	0.00000E+00
*	529	*	-0.13350E+00	0.13170E+00	0.00000E+00
*	530	*	0.90805E-01	0.16510E+00	0.00000E+00
*	531	*	-0.90805E-01	0.16510E+00	0.00000E+00
*	532	*	0.18875E+00	0.00000E+00	0.00000E+00
*	533	*	0.95250E-01	0.16510E+00	0.00000E+00
*	534	*	-0.95250E-01	0.16510E+00	0.00000E+00
*	535	*	0.12065E+00	0.14840E+00	0.00000E+00
*	536	*	-0.12065E+00	0.14840E+00	0.00000E+00
*	537	*	0.10160E+00	0.16510E+00	0.00000E+00
*	538	*	-0.10160E+00	0.16510E+00	0.00000E+00
*	539	*	0.18869E+00	0.49150E-01	0.00000E+00
*	540	*	-0.15875E+00	0.11500E+00	0.00000E+00
*	541	*	0.14605E+00	0.13170E+00	0.00000E+00
*	542	*	-0.14605E+00	0.13170E+00	0.00000E+00
*	543	*	0.10795E+00	0.16510E+00	0.00000E+00
*	544	*	-0.10795E+00	0.16510E+00	0.00000E+00
*	545	*	0.11430E+00	0.16510E+00	0.00000E+00
*	546	*	-0.11430E+00	0.16510E+00	0.00000E+00
*	547	*	-0.20081E+00	0.00000E+00	0.00000E+00
*	548	*	0.12065E+00	0.16510E+00	0.00000E+00
*	549	*	-0.12065E+00	0.16510E+00	0.00000E+00

*	550	*	0.00000E+00	0.20472E+00	0.00000E+00
*	551	*	-0.10795E-01	0.20472E+00	0.00000E+00
*	552	*	0.10795E-01	0.20472E+00	0.00000E+00
*	553	*	-0.21590E-01	0.20472E+00	0.00000E+00
*	554	*	0.21590E-01	0.20472E+00	0.00000E+00
*	555	*	-0.15875E+00	0.13170E+00	0.00000E+00
*	556	*	-0.20075E+00	0.49150E-01	0.00000E+00
*	557	*	-0.32385E-01	0.20472E+00	0.00000E+00
*	558	*	0.32385E-01	0.20472E+00	0.00000E+00
*	559	*	0.14605E+00	0.14840E+00	0.00000E+00
*	560	*	-0.14605E+00	0.14840E+00	0.00000E+00
*	561	*	-0.43180E-01	0.20472E+00	0.00000E+00
*	562	*	0.43180E-01	0.20472E+00	0.00000E+00
*	563	*	-0.53975E-01	0.20472E+00	0.00000E+00
*	564	*	0.53975E-01	0.20472E+00	0.00000E+00
*	565	*	0.13350E+00	0.16510E+00	0.00000E+00
*	566	*	-0.13350E+00	0.16510E+00	0.00000E+00
*	567	*	0.18851E+00	0.98290E-01	0.00000E+00
*	568	*	-0.64770E-01	0.20472E+00	0.00000E+00
*	569	*	0.64770E-01	0.20472E+00	0.00000E+00
*	570	*	-0.15875E+00	0.14840E+00	0.00000E+00
*	571	*	-0.75565E-01	0.20472E+00	0.00000E+00
*	572	*	0.75565E-01	0.20472E+00	0.00000E+00
*	573	*	0.14605E+00	0.16510E+00	0.00000E+00
*	574	*	-0.14605E+00	0.16510E+00	0.00000E+00
*	575	*	-0.86360E-01	0.20472E+00	0.00000E+00
*	576	*	0.86360E-01	0.20472E+00	0.00000E+00
*	577	*	-0.20057E+00	0.98290E-01	0.00000E+00
*	578	*	0.14605E+00	0.16942E+00	0.00000E+00
*	579	*	-0.90805E-01	0.20472E+00	0.00000E+00
*	580	*	0.90805E-01	0.20472E+00	0.00000E+00
*	581	*	-0.95250E-01	0.20472E+00	0.00000E+00
*	582	*	0.95250E-01	0.20472E+00	0.00000E+00
*	583	*	0.14605E+00	0.17374E+00	0.00000E+00
*	584	*	-0.10160E+00	0.20472E+00	0.00000E+00
*	585	*	0.10160E+00	0.20472E+00	0.00000E+00
*	586	*	-0.15875E+00	0.16510E+00	0.00000E+00
*	587	*	0.18831E+00	0.13170E+00	0.00000E+00
*	588	*	0.14605E+00	0.17856E+00	0.00000E+00
*	589	*	-0.10795E+00	0.20472E+00	0.00000E+00
*	590	*	0.10795E+00	0.20472E+00	0.00000E+00
*	591	*	0.23144E+00	0.00000E+00	0.00000E+00
*	592	*	-0.15875E+00	0.16942E+00	0.00000E+00
*	593	*	0.23141E+00	0.24576E-01	0.00000E+00
*	594	*	0.14605E+00	0.18339E+00	0.00000E+00
*	595	*	-0.11430E+00	0.20472E+00	0.00000E+00
*	596	*	0.11430E+00	0.20472E+00	0.00000E+00
*	597	*	-0.15875E+00	0.17374E+00	0.00000E+00
*	598	*	0.23132E+00	0.49150E-01	0.00000E+00
*	599	*	0.14605E+00	0.18656E+00	0.00000E+00
*	600	*	0.12065E+00	0.20472E+00	0.00000E+00
*	601	*	-0.12065E+00	0.20472E+00	0.00000E+00
*	602	*	-0.15875E+00	0.17856E+00	0.00000E+00
*	603	*	0.14605E+00	0.18974E+00	0.00000E+00
*	604	*	0.14605E+00	0.19202E+00	0.00000E+00
*	605	*	-0.15875E+00	0.18339E+00	0.00000E+00
*	606	*	0.23117E+00	0.73721E-01	0.00000E+00
*	607	*	-0.24288E+00	0.00000E+00	0.00000E+00
*	608	*	0.14605E+00	0.19430E+00	0.00000E+00
*	609	*	-0.24284E+00	0.24576E-01	0.00000E+00
*	610	*	-0.13350E+00	0.20472E+00	0.00000E+00
*	611	*	0.13350E+00	0.20472E+00	0.00000E+00

*	612	*	0.00000E+00	0.24449E+00	0.00000E+00
*	613	*	-0.15875E+00	0.18656E+00	0.00000E+00
*	614	*	0.22142E-01	0.24446E+00	0.00000E+00
*	615	*	-0.22142E-01	0.24446E+00	0.00000E+00
*	616	*	0.14605E+00	0.19951E+00	0.00000E+00
*	617	*	-0.15875E+00	0.18974E+00	0.00000E+00
*	618	*	-0.24275E+00	0.49150E-01	0.00000E+00
*	619	*	0.44285E-01	0.24438E+00	0.00000E+00
*	620	*	-0.44285E-01	0.24438E+00	0.00000E+00
*	621	*	-0.15875E+00	0.19202E+00	0.00000E+00
*	622	*	0.18806E+00	0.16510E+00	0.00000E+00
*	623	*	-0.15875E+00	0.19430E+00	0.00000E+00
*	624	*	0.23096E+00	0.98290E-01	0.00000E+00
*	625	*	0.14605E+00	0.20472E+00	0.00000E+00
*	626	*	-0.14605E+00	0.20472E+00	0.00000E+00
*	627	*	0.66427E-01	0.24425E+00	0.00000E+00
*	628	*	-0.66427E-01	0.24425E+00	0.00000E+00
*	629	*	-0.24260E+00	0.73721E-01	0.00000E+00
*	630	*	-0.15875E+00	0.19951E+00	0.00000E+00
*	631	*	-0.15240E+00	0.20472E+00	0.00000E+00
*	632	*	0.23078E+00	0.11500E+00	0.00000E+00
*	633	*	0.18704E+00	0.17799E+00	0.00000E+00
*	634	*	-0.15875E+00	0.20472E+00	0.00000E+00
*	635	*	-0.20013E+00	0.16510E+00	0.00000E+00
*	636	*	0.88569E-01	0.24406E+00	0.00000E+00
*	637	*	-0.88569E-01	0.24406E+00	0.00000E+00
*	638	*	-0.24239E+00	0.98290E-01	0.00000E+00
*	639	*	-0.10088E+00	0.24340E+00	0.00000E+00
*	640	*	0.10301E+00	0.24290E+00	0.00000E+00
*	641	*	0.23057E+00	0.13170E+00	0.00000E+00
*	642	*	-0.19911E+00	0.17799E+00	0.00000E+00
*	643	*	0.18406E+00	0.19535E+00	0.00000E+00
*	644	*	-0.11549E+00	0.24278E+00	0.00000E+00
*	645	*	0.12088E+00	0.24101E+00	0.00000E+00
*	646	*	0.23034E+00	0.14840E+00	0.00000E+00
*	647	*	0.27414E+00	0.00000E+00	0.00000E+00
*	648	*	-0.13294E+00	0.24101E+00	0.00000E+00
*	649	*	-0.24200E+00	0.13170E+00	0.00000E+00
*	650	*	0.17971E+00	0.20893E+00	0.00000E+00
*	651	*	0.13848E+00	0.23843E+00	0.00000E+00
*	652	*	-0.19613E+00	0.19535E+00	0.00000E+00
*	653	*	0.27396E+00	0.49150E-01	0.00000E+00
*	654	*	0.17410E+00	0.21994E+00	0.00000E+00
*	655	*	0.23007E+00	0.16510E+00	0.00000E+00
*	656	*	-0.19177E+00	0.20893E+00	0.00000E+00
*	657	*	0.00000E+00	0.28425E+00	0.00000E+00
*	658	*	0.11347E-01	0.28424E+00	0.00000E+00
*	659	*	-0.11347E-01	0.28424E+00	0.00000E+00
*	660	*	-0.28494E+00	0.00000E+00	0.00000E+00
*	661	*	0.22695E-01	0.28420E+00	0.00000E+00
*	662	*	-0.22695E-01	0.28420E+00	0.00000E+00
*	663	*	0.34042E-01	0.28413E+00	0.00000E+00
*	664	*	-0.34042E-01	0.28413E+00	0.00000E+00
*	665	*	0.22917E+00	0.17370E+00	0.00000E+00
*	666	*	0.45389E-01	0.28404E+00	0.00000E+00
*	667	*	-0.45389E-01	0.28404E+00	0.00000E+00
*	668	*	-0.18617E+00	0.21994E+00	0.00000E+00
*	669	*	-0.16261E+00	0.23843E+00	0.00000E+00
*	670	*	0.16778E+00	0.23519E+00	0.00000E+00
*	671	*	-0.28476E+00	0.49149E-01	0.00000E+00
*	672	*	0.56737E-01	0.28392E+00	0.00000E+00
*	673	*	-0.56737E-01	0.28392E+00	0.00000E+00

*	674	*	0.27342E+00	0.98290E-01	0.00000E+00
*	675	*	0.68084E-01	0.28377E+00	0.00000E+00
*	676	*	-0.68084E-01	0.28377E+00	0.00000E+00
*	677	*	0.22804E+00	0.18225E+00	0.00000E+00
*	678	*	-0.24151E+00	0.16510E+00	0.00000E+00
*	679	*	0.79431E-01	0.28360E+00	0.00000E+00
*	680	*	-0.79431E-01	0.28360E+00	0.00000E+00
*	681	*	-0.17985E+00	0.23519E+00	0.00000E+00
*	682	*	-0.24060E+00	0.17370E+00	0.00000E+00
*	683	*	0.90779E-01	0.28340E+00	0.00000E+00
*	684	*	-0.90779E-01	0.28340E+00	0.00000E+00
*	685	*	0.22542E+00	0.19491E+00	0.00000E+00
*	686	*	-0.98660E-01	0.28281E+00	0.00000E+00
*	687	*	0.10081E+00	0.28241E+00	0.00000E+00
*	688	*	-0.28421E+00	0.98290E-01	0.00000E+00
*	689	*	-0.23947E+00	0.18225E+00	0.00000E+00
*	690	*	-0.10651E+00	0.28207E+00	0.00000E+00
*	691	*	0.11076E+00	0.28107E+00	0.00000E+00
*	692	*	0.27284E+00	0.13171E+00	0.00000E+00
*	693	*	0.22208E+00	0.20731E+00	0.00000E+00
*	694	*	-0.11478E+00	0.28149E+00	0.00000E+00
*	695	*	0.12234E+00	0.27936E+00	0.00000E+00
*	696	*	-0.12304E+00	0.28084E+00	0.00000E+00
*	697	*	-0.23685E+00	0.19491E+00	0.00000E+00
*	698	*	0.13380E+00	0.27729E+00	0.00000E+00
*	699	*	0.21805E+00	0.21791E+00	0.00000E+00
*	700	*	-0.13419E+00	0.27922E+00	0.00000E+00
*	701	*	0.14513E+00	0.27488E+00	0.00000E+00
*	702	*	-0.23350E+00	0.20731E+00	0.00000E+00
*	703	*	0.21336E+00	0.22812E+00	0.00000E+00
*	704	*	-0.14524E+00	0.27729E+00	0.00000E+00
*	705	*	0.15630E+00	0.27213E+00	0.00000E+00
*	706	*	0.20805E+00	0.23710E+00	0.00000E+00
*	707	*	-0.22948E+00	0.21791E+00	0.00000E+00
*	708	*	0.31684E+00	0.00000E+00	0.00000E+00
*	709	*	0.31678E+00	0.24576E-01	0.00000E+00
*	710	*	0.20216E+00	0.24558E+00	0.00000E+00
*	711	*	0.27209E+00	0.16510E+00	0.00000E+00
*	712	*	-0.16241E+00	0.27488E+00	0.00000E+00
*	713	*	0.17314E+00	0.26906E+00	0.00000E+00
*	714	*	-0.22479E+00	0.22812E+00	0.00000E+00
*	715	*	0.31660E+00	0.49150E-01	0.00000E+00
*	716	*	0.19606E+00	0.25588E+00	0.00000E+00
*	717	*	-0.21948E+00	0.23710E+00	0.00000E+00
*	718	*	0.00000E+00	0.32402E+00	0.00000E+00
*	719	*	0.23247E-01	0.32394E+00	0.00000E+00
*	720	*	-0.23247E-01	0.32394E+00	0.00000E+00
*	721	*	0.31630E+00	0.73721E-01	0.00000E+00
*	722	*	-0.21359E+00	0.24558E+00	0.00000E+00
*	723	*	-0.17916E+00	0.27213E+00	0.00000E+00
*	724	*	0.18951E+00	0.26566E+00	0.00000E+00
*	725	*	-0.32700E+00	0.00000E+00	0.00000E+00
*	726	*	0.46494E-01	0.32369E+00	0.00000E+00
*	727	*	-0.46494E-01	0.32369E+00	0.00000E+00
*	728	*	0.26903E+00	0.18650E+00	0.00000E+00
*	729	*	-0.28288E+00	0.16510E+00	0.00000E+00
*	730	*	-0.32694E+00	0.24576E-01	0.00000E+00
*	731	*	-0.20749E+00	0.25588E+00	0.00000E+00
*	732	*	-0.19015E+00	0.26906E+00	0.00000E+00
*	733	*	-0.32676E+00	0.49149E-01	0.00000E+00
*	734	*	0.69741E-01	0.32329E+00	0.00000E+00
*	735	*	-0.69741E-01	0.32329E+00	0.00000E+00

*	736	*	0.31587E+00	0.98290E-01	0.00000E+00
*	737	*	-0.20094E+00	0.26566E+00	0.00000E+00
*	738	*	-0.32646E+00	0.73720E-01	0.00000E+00
*	739	*	0.31551E+00	0.11500E+00	0.00000E+00
*	740	*	0.92988E-01	0.32273E+00	0.00000E+00
*	741	*	-0.92988E-01	0.32273E+00	0.00000E+00
*	742	*	-0.27983E+00	0.18650E+00	0.00000E+00
*	743	*	-0.11215E+00	0.32074E+00	0.00000E+00
*	744	*	0.26009E+00	0.21927E+00	0.00000E+00
*	745	*	-0.32603E+00	0.98290E-01	0.00000E+00
*	746	*	0.11852E+00	0.31924E+00	0.00000E+00
*	747	*	0.31510E+00	0.13171E+00	0.00000E+00
*	748	*	-0.13058E+00	0.31890E+00	0.00000E+00
*	749	*	0.14673E+00	0.31358E+00	0.00000E+00
*	750	*	0.31463E+00	0.14841E+00	0.00000E+00
*	751	*	-0.27088E+00	0.21927E+00	0.00000E+00
*	752	*	0.24701E+00	0.24731E+00	0.00000E+00
*	753	*	-0.32526E+00	0.13171E+00	0.00000E+00
*	754	*	-0.15753E+00	0.31358E+00	0.00000E+00
*	755	*	0.17413E+00	0.30584E+00	0.00000E+00
*	756	*	0.31410E+00	0.16510E+00	0.00000E+00
*	757	*	0.23021E+00	0.27122E+00	0.00000E+00
*	758	*	-0.25781E+00	0.24731E+00	0.00000E+00
*	759	*	0.31229E+00	0.17798E+00	0.00000E+00
*	760	*	0.35954E+00	0.00000E+00	0.00000E+00
*	761	*	0.35923E+00	0.49150E-01	0.00000E+00
*	762	*	-0.24100E+00	0.27122E+00	0.00000E+00
*	763	*	-0.19572E+00	0.30584E+00	0.00000E+00
*	764	*	0.21125E+00	0.29613E+00	0.00000E+00
*	765	*	0.00000E+00	0.36378E+00	0.00000E+00
*	766	*	-0.32426E+00	0.16510E+00	0.00000E+00
*	767	*	0.11900E-01	0.36375E+00	0.00000E+00
*	768	*	-0.11900E-01	0.36375E+00	0.00000E+00
*	769	*	0.31003E+00	0.19076E+00	0.00000E+00
*	770	*	0.23799E-01	0.36367E+00	0.00000E+00
*	771	*	-0.23799E-01	0.36367E+00	0.00000E+00
*	772	*	0.35699E-01	0.36354E+00	0.00000E+00
*	773	*	-0.35699E-01	0.36354E+00	0.00000E+00
*	774	*	0.47599E-01	0.36335E+00	0.00000E+00
*	775	*	-0.47599E-01	0.36335E+00	0.00000E+00
*	776	*	0.59498E-01	0.36311E+00	0.00000E+00
*	777	*	-0.59498E-01	0.36311E+00	0.00000E+00
*	778	*	-0.32245E+00	0.17798E+00	0.00000E+00
*	779	*	-0.36906E+00	0.00000E+00	0.00000E+00
*	780	*	0.71398E-01	0.36282E+00	0.00000E+00
*	781	*	-0.71398E-01	0.36282E+00	0.00000E+00
*	782	*	-0.22204E+00	0.29613E+00	0.00000E+00
*	783	*	0.30478E+00	0.21125E+00	0.00000E+00
*	784	*	0.35833E+00	0.98290E-01	0.00000E+00
*	785	*	0.83298E-01	0.36247E+00	0.00000E+00
*	786	*	-0.83298E-01	0.36247E+00	0.00000E+00
*	787	*	-0.36876E+00	0.49149E-01	0.00000E+00
*	788	*	-0.32019E+00	0.19076E+00	0.00000E+00
*	789	*	0.95197E-01	0.36207E+00	0.00000E+00
*	790	*	-0.95197E-01	0.36207E+00	0.00000E+00
*	791	*	-0.10652E+00	0.36089E+00	0.00000E+00
*	792	*	0.11081E+00	0.36011E+00	0.00000E+00
*	793	*	0.29810E+00	0.23123E+00	0.00000E+00
*	794	*	-0.11778E+00	0.35941E+00	0.00000E+00
*	795	*	0.12628E+00	0.35741E+00	0.00000E+00
*	796	*	-0.31494E+00	0.21126E+00	0.00000E+00
*	797	*	-0.12797E+00	0.35826E+00	0.00000E+00

*	798	*	-0.36785E+00	0.98290E-01	0.00000E+00
*	799	*	0.35736E+00	0.13171E+00	0.00000E+00
*	800	*	0.14308E+00	0.35399E+00	0.00000E+00
*	801	*	0.29004E+00	0.24925E+00	0.00000E+00
*	802	*	-0.13812E+00	0.35697E+00	0.00000E+00
*	803	*	0.15966E+00	0.34986E+00	0.00000E+00
*	804	*	-0.30826E+00	0.23123E+00	0.00000E+00
*	805	*	-0.15407E+00	0.35372E+00	0.00000E+00
*	806	*	0.28067E+00	0.26651E+00	0.00000E+00
*	807	*	0.17596E+00	0.34504E+00	0.00000E+00
*	808	*	-0.16982E+00	0.34986E+00	0.00000E+00
*	809	*	0.19195E+00	0.33954E+00	0.00000E+00
*	810	*	-0.30020E+00	0.24925E+00	0.00000E+00
*	811	*	0.27004E+00	0.28218E+00	0.00000E+00
*	812	*	0.35611E+00	0.16510E+00	0.00000E+00
*	813	*	0.25826E+00	0.29686E+00	0.00000E+00
*	814	*	-0.29083E+00	0.26651E+00	0.00000E+00
*	815	*	-0.19132E+00	0.34504E+00	0.00000E+00
*	816	*	0.21278E+00	0.33339E+00	0.00000E+00
*	817	*	0.24607E+00	0.31226E+00	0.00000E+00
*	818	*	-0.28020E+00	0.28218E+00	0.00000E+00
*	819	*	-0.26842E+00	0.29686E+00	0.00000E+00
*	820	*	-0.21227E+00	0.33954E+00	0.00000E+00
*	821	*	-0.36564E+00	0.16510E+00	0.00000E+00
*	822	*	0.23298E+00	0.32660E+00	0.00000E+00
*	823	*	0.35102E+00	0.19501E+00	0.00000E+00
*	824	*	0.40224E+00	0.00000E+00	0.00000E+00
*	825	*	0.40214E+00	0.24576E-01	0.00000E+00
*	826	*	0.00000E+00	0.40354E+00	0.00000E+00
*	827	*	-0.22790E+00	0.33339E+00	0.00000E+00
*	828	*	-0.25622E+00	0.31226E+00	0.00000E+00
*	829	*	0.24352E-01	0.40341E+00	0.00000E+00
*	830	*	-0.24352E-01	0.40341E+00	0.00000E+00
*	831	*	0.40187E+00	0.49150E-01	0.00000E+00
*	832	*	0.48703E-01	0.40301E+00	0.00000E+00
*	833	*	-0.48703E-01	0.40301E+00	0.00000E+00
*	834	*	-0.24314E+00	0.32660E+00	0.00000E+00
*	835	*	0.40142E+00	0.73721E-01	0.00000E+00
*	836	*	0.73055E-01	0.40234E+00	0.00000E+00
*	837	*	-0.73055E-01	0.40234E+00	0.00000E+00
*	838	*	-0.36055E+00	0.19501E+00	0.00000E+00
*	839	*	-0.41113E+00	0.00000E+00	0.00000E+00
*	840	*	-0.41103E+00	0.24575E-01	0.00000E+00
*	841	*	0.40078E+00	0.98290E-01	0.00000E+00
*	842	*	0.97406E-01	0.40140E+00	0.00000E+00
*	843	*	-0.97406E-01	0.40140E+00	0.00000E+00
*	844	*	-0.41076E+00	0.49149E-01	0.00000E+00
*	845	*	0.33612E+00	0.24319E+00	0.00000E+00
*	846	*	0.40024E+00	0.11501E+00	0.00000E+00
*	847	*	-0.12341E+00	0.39808E+00	0.00000E+00
*	848	*	-0.41031E+00	0.73720E-01	0.00000E+00
*	849	*	0.13403E+00	0.39558E+00	0.00000E+00
*	850	*	0.39962E+00	0.13171E+00	0.00000E+00
*	851	*	-0.14567E+00	0.39503E+00	0.00000E+00
*	852	*	-0.40967E+00	0.98290E-01	0.00000E+00
*	853	*	-0.34564E+00	0.24319E+00	0.00000E+00
*	854	*	0.17259E+00	0.38615E+00	0.00000E+00
*	855	*	0.31433E+00	0.28570E+00	0.00000E+00
*	856	*	0.39891E+00	0.14841E+00	0.00000E+00
*	857	*	-0.18211E+00	0.38615E+00	0.00000E+00
*	858	*	0.20978E+00	0.37325E+00	0.00000E+00
*	859	*	-0.40851E+00	0.13171E+00	0.00000E+00

*	860	*	0.39812E+00	0.16510E+00	0.00000E+00
*	861	*	0.28632E+00	0.32250E+00	0.00000E+00
*	862	*	-0.32385E+00	0.28570E+00	0.00000E+00
*	863	*	0.39540E+00	0.18225E+00	0.00000E+00
*	864	*	-0.29584E+00	0.32250E+00	0.00000E+00
*	865	*	-0.22883E+00	0.37325E+00	0.00000E+00
*	866	*	0.25471E+00	0.35707E+00	0.00000E+00
*	867	*	-0.40702E+00	0.16510E+00	0.00000E+00
*	868	*	0.39201E+00	0.19926E+00	0.00000E+00
*	869	*	0.00000E+00	0.44331E+00	0.00000E+00
*	870	*	0.12452E-01	0.44327E+00	0.00000E+00
*	871	*	-0.12452E-01	0.44327E+00	0.00000E+00
*	872	*	-0.40429E+00	0.18225E+00	0.00000E+00
*	873	*	0.24904E-01	0.44315E+00	0.00000E+00
*	874	*	-0.24904E-01	0.44315E+00	0.00000E+00
*	875	*	-0.26424E+00	0.35707E+00	0.00000E+00
*	876	*	0.37356E-01	0.44295E+00	0.00000E+00
*	877	*	-0.37356E-01	0.44295E+00	0.00000E+00
*	878	*	0.44493E+00	0.00000E+00	0.00000E+00
*	879	*	0.49808E-01	0.44266E+00	0.00000E+00
*	880	*	-0.49808E-01	0.44266E+00	0.00000E+00
*	881	*	0.38415E+00	0.22760E+00	0.00000E+00
*	882	*	0.62260E-01	0.44230E+00	0.00000E+00
*	883	*	-0.62260E-01	0.44230E+00	0.00000E+00
*	884	*	0.44451E+00	0.49150E-01	0.00000E+00
*	885	*	-0.40090E+00	0.19926E+00	0.00000E+00
*	886	*	0.74711E-01	0.44186E+00	0.00000E+00
*	887	*	-0.74711E-01	0.44186E+00	0.00000E+00
*	888	*	0.87163E-01	0.44134E+00	0.00000E+00
*	889	*	-0.87163E-01	0.44134E+00	0.00000E+00
*	890	*	0.99615E-01	0.44074E+00	0.00000E+00
*	891	*	-0.99615E-01	0.44074E+00	0.00000E+00
*	892	*	0.37413E+00	0.25515E+00	0.00000E+00
*	893	*	-0.45319E+00	0.00000E+00	0.00000E+00
*	894	*	-0.11437E+00	0.43897E+00	0.00000E+00
*	895	*	0.44324E+00	0.98290E-01	0.00000E+00
*	896	*	0.12081E+00	0.43780E+00	0.00000E+00
*	897	*	-0.39304E+00	0.22760E+00	0.00000E+00
*	898	*	-0.12904E+00	0.43675E+00	0.00000E+00
*	899	*	-0.45276E+00	0.49148E-01	0.00000E+00
*	900	*	0.14179E+00	0.43375E+00	0.00000E+00
*	901	*	-0.14115E+00	0.43503E+00	0.00000E+00
*	902	*	0.36204E+00	0.28059E+00	0.00000E+00
*	903	*	0.16383E+00	0.42862E+00	0.00000E+00
*	904	*	-0.15321E+00	0.43309E+00	0.00000E+00
*	905	*	-0.38302E+00	0.25515E+00	0.00000E+00
*	906	*	0.44188E+00	0.13172E+00	0.00000E+00
*	907	*	0.18551E+00	0.42243E+00	0.00000E+00
*	908	*	-0.45149E+00	0.98290E-01	0.00000E+00
*	909	*	-0.17396E+00	0.42822E+00	0.00000E+00
*	910	*	0.34798E+00	0.30489E+00	0.00000E+00
*	911	*	0.20680E+00	0.41520E+00	0.00000E+00
*	912	*	-0.19440E+00	0.42243E+00	0.00000E+00
*	913	*	-0.37093E+00	0.28059E+00	0.00000E+00
*	914	*	0.33204E+00	0.32725E+00	0.00000E+00
*	915	*	0.22760E+00	0.40695E+00	0.00000E+00
*	916	*	0.31437E+00	0.34814E+00	0.00000E+00
*	917	*	-0.35687E+00	0.30489E+00	0.00000E+00
*	918	*	-0.22024E+00	0.41520E+00	0.00000E+00
*	919	*	0.44014E+00	0.16510E+00	0.00000E+00
*	920	*	0.25243E+00	0.39772E+00	0.00000E+00
*	921	*	-0.34093E+00	0.32725E+00	0.00000E+00

*	922	*	0.29607E+00	0.36863E+00	0.00000E+00
*	923	*	-0.32326E+00	0.34814E+00	0.00000E+00
*	924	*	-0.24538E+00	0.40695E+00	0.00000E+00
*	925	*	0.27645E+00	0.38754E+00	0.00000E+00
*	926	*	-0.44839E+00	0.16510E+00	0.00000E+00
*	927	*	-0.26566E+00	0.39772E+00	0.00000E+00
*	928	*	-0.30496E+00	0.36863E+00	0.00000E+00
*	929	*	0.43301E+00	0.20352E+00	0.00000E+00
*	930	*	-0.28534E+00	0.38754E+00	0.00000E+00
*	931	*	0.00000E+00	0.48307E+00	0.00000E+00
*	932	*	0.25456E-01	0.48288E+00	0.00000E+00
*	933	*	-0.25456E-01	0.48288E+00	0.00000E+00
*	934	*	0.50912E-01	0.48232E+00	0.00000E+00
*	935	*	-0.50912E-01	0.48232E+00	0.00000E+00
*	936	*	-0.44126E+00	0.20352E+00	0.00000E+00
*	937	*	0.76368E-01	0.48139E+00	0.00000E+00
*	938	*	-0.76368E-01	0.48139E+00	0.00000E+00
*	939	*	0.48763E+00	0.00000E+00	0.00000E+00
*	940	*	0.48751E+00	0.24576E-01	0.00000E+00
*	941	*	0.48715E+00	0.49150E-01	0.00000E+00
*	942	*	0.10182E+00	0.48007E+00	0.00000E+00
*	943	*	-0.10182E+00	0.48007E+00	0.00000E+00
*	944	*	0.41214E+00	0.26711E+00	0.00000E+00
*	945	*	0.48654E+00	0.73721E-01	0.00000E+00
*	946	*	-0.13468E+00	0.47542E+00	0.00000E+00
*	947	*	0.14955E+00	0.47192E+00	0.00000E+00
*	948	*	-0.49525E+00	0.00000E+00	0.00000E+00
*	949	*	0.48569E+00	0.98290E-01	0.00000E+00
*	950	*	-0.49513E+00	0.24575E-01	0.00000E+00
*	951	*	-0.49477E+00	0.49148E-01	0.00000E+00
*	952	*	-0.16075E+00	0.47115E+00	0.00000E+00
*	953	*	-0.42039E+00	0.26711E+00	0.00000E+00
*	954	*	0.48497E+00	0.11501E+00	0.00000E+00
*	955	*	-0.49416E+00	0.73720E-01	0.00000E+00
*	956	*	0.19844E+00	0.45872E+00	0.00000E+00
*	957	*	0.38164E+00	0.32408E+00	0.00000E+00
*	958	*	0.48414E+00	0.13172E+00	0.00000E+00
*	959	*	-0.49331E+00	0.98290E-01	0.00000E+00
*	960	*	-0.20670E+00	0.45872E+00	0.00000E+00
*	961	*	0.24543E+00	0.44066E+00	0.00000E+00
*	962	*	0.48320E+00	0.14841E+00	0.00000E+00
*	963	*	0.34242E+00	0.37378E+00	0.00000E+00
*	964	*	-0.38989E+00	0.32408E+00	0.00000E+00
*	965	*	-0.49176E+00	0.13172E+00	0.00000E+00
*	966	*	0.48215E+00	0.16510E+00	0.00000E+00
*	967	*	-0.35067E+00	0.37378E+00	0.00000E+00
*	968	*	-0.26194E+00	0.44066E+00	0.00000E+00
*	969	*	0.29818E+00	0.41801E+00	0.00000E+00
*	970	*	0.47852E+00	0.18653E+00	0.00000E+00
*	971	*	-0.48977E+00	0.16510E+00	0.00000E+00
*	972	*	0.47400E+00	0.20777E+00	0.00000E+00
*	973	*	-0.30643E+00	0.41801E+00	0.00000E+00
*	974	*	-0.48614E+00	0.18653E+00	0.00000E+00
*	975	*	0.00000E+00	0.52283E+00	0.00000E+00
*	976	*	0.13004E-01	0.52278E+00	0.00000E+00
*	977	*	-0.13004E-01	0.52278E+00	0.00000E+00
*	978	*	0.26008E-01	0.52262E+00	0.00000E+00
*	979	*	-0.26008E-01	0.52262E+00	0.00000E+00
*	980	*	0.46351E+00	0.24394E+00	0.00000E+00
*	981	*	0.39012E-01	0.52235E+00	0.00000E+00
*	982	*	-0.39012E-01	0.52235E+00	0.00000E+00
*	983	*	-0.48162E+00	0.20777E+00	0.00000E+00

*	984	*	0.52016E-01	0.52198E+00	0.00000E+00
*	985	*	-0.52016E-01	0.52198E+00	0.00000E+00
*	986	*	0.65021E-01	0.52150E+00	0.00000E+00
*	987	*	-0.65021E-01	0.52150E+00	0.00000E+00
*	988	*	0.78025E-01	0.52091E+00	0.00000E+00
*	989	*	-0.78025E-01	0.52091E+00	0.00000E+00
*	990	*	0.91029E-01	0.52021E+00	0.00000E+00
*	991	*	-0.91029E-01	0.52021E+00	0.00000E+00
*	992	*	0.45015E+00	0.27907E+00	0.00000E+00
*	993	*	0.10403E+00	0.51941E+00	0.00000E+00
*	994	*	-0.10403E+00	0.51941E+00	0.00000E+00
*	995	*	0.53033E+00	0.00000E+00	0.00000E+00
*	996	*	-0.47113E+00	0.24395E+00	0.00000E+00
*	997	*	-0.12223E+00	0.51706E+00	0.00000E+00
*	998	*	0.13081E+00	0.51549E+00	0.00000E+00
*	999	*	0.52978E+00	0.49150E-01	0.00000E+00
*	1000	*	-0.14031E+00	0.51409E+00	0.00000E+00
*	1001	*	0.15730E+00	0.51009E+00	0.00000E+00
*	1002	*	0.43403E+00	0.31194E+00	0.00000E+00
*	1003	*	-0.15434E+00	0.51179E+00	0.00000E+00
*	1004	*	0.18457E+00	0.50326E+00	0.00000E+00
*	1005	*	-0.45777E+00	0.27907E+00	0.00000E+00
*	1006	*	-0.16830E+00	0.50921E+00	0.00000E+00
*	1007	*	0.52815E+00	0.98290E-01	0.00000E+00
*	1008	*	-0.53731E+00	0.00000E+00	0.00000E+00
*	1009	*	0.21137E+00	0.49500E+00	0.00000E+00
*	1010	*	-0.19384E+00	0.50271E+00	0.00000E+00
*	1011	*	0.41529E+00	0.34328E+00	0.00000E+00
*	1012	*	-0.53677E+00	0.49148E-01	0.00000E+00
*	1013	*	0.23763E+00	0.48536E+00	0.00000E+00
*	1014	*	-0.44165E+00	0.31194E+00	0.00000E+00
*	1015	*	-0.21899E+00	0.49500E+00	0.00000E+00
*	1016	*	0.39403E+00	0.37233E+00	0.00000E+00
*	1017	*	0.26325E+00	0.47436E+00	0.00000E+00
*	1018	*	0.52641E+00	0.13172E+00	0.00000E+00
*	1019	*	-0.53513E+00	0.98290E-01	0.00000E+00
*	1020	*	-0.42291E+00	0.34327E+00	0.00000E+00
*	1021	*	0.37047E+00	0.39942E+00	0.00000E+00
*	1022	*	-0.24915E+00	0.48536E+00	0.00000E+00
*	1023	*	0.29207E+00	0.46205E+00	0.00000E+00
*	1024	*	-0.40165E+00	0.37233E+00	0.00000E+00
*	1025	*	0.34608E+00	0.42500E+00	0.00000E+00
*	1026	*	0.52416E+00	0.16510E+00	0.00000E+00
*	1027	*	-0.37809E+00	0.39942E+00	0.00000E+00
*	1028	*	-0.27849E+00	0.47436E+00	0.00000E+00
*	1029	*	0.31991E+00	0.44848E+00	0.00000E+00
*	1030	*	-0.30341E+00	0.46205E+00	0.00000E+00
*	1031	*	-0.35370E+00	0.42500E+00	0.00000E+00
*	1032	*	-0.32753E+00	0.44848E+00	0.00000E+00
*	1033	*	-0.53115E+00	0.16510E+00	0.00000E+00
*	1034	*	0.51500E+00	0.21203E+00	0.00000E+00
*	1035	*	0.00000E+00	0.56260E+00	0.00000E+00
*	1036	*	0.26560E-01	0.56236E+00	0.00000E+00
*	1037	*	-0.26560E-01	0.56236E+00	0.00000E+00
*	1038	*	-0.52198E+00	0.21203E+00	0.00000E+00
*	1039	*	0.53121E-01	0.56164E+00	0.00000E+00
*	1040	*	-0.53121E-01	0.56164E+00	0.00000E+00
*	1041	*	0.79681E-01	0.56043E+00	0.00000E+00
*	1042	*	-0.79681E-01	0.56043E+00	0.00000E+00
*	1043	*	0.48817E+00	0.29103E+00	0.00000E+00
*	1044	*	0.10624E+00	0.55875E+00	0.00000E+00
*	1045	*	-0.10624E+00	0.55875E+00	0.00000E+00

*	1046	*	-0.14594E+00	0.55277E+00	0.00000E+00
*	1047	*	0.16506E+00	0.54827E+00	0.00000E+00
*	1048	*	0.57302E+00	0.00000E+00	0.00000E+00
*	1049	*	0.57287E+00	0.24576E-01	0.00000E+00
*	1050	*	-0.49515E+00	0.29103E+00	0.00000E+00
*	1051	*	0.57242E+00	0.49150E-01	0.00000E+00
*	1052	*	-0.17584E+00	0.54727E+00	0.00000E+00
*	1053	*	0.57166E+00	0.73721E-01	0.00000E+00
*	1054	*	0.22430E+00	0.53129E+00	0.00000E+00
*	1055		0.44894E+00	0.36247E+00	0.00000E+00
*	1056	*	0.57060E+00	0.98290E-01	0.00000E+00
*	1057	*	-0.57938E+00	0.00000E+00	0.00000E+00
*	1058	*	-0.23128E+00	0.53129E+00	0.00000E+00
*	1059	*	-0.57922E+00	0.24574E-01	0.00000E+00
*	1060	*	0.28108E+00	0.50807E+00	0.00000E+00
*	1061	*	-0.57877E+00	0.49148E-01	0.00000E+00
*	1062	*	0.56971E+00	0.11501E+00	0.00000E+00
*	1063	*	-0.45593E+00	0.36247E+00	0.00000E+00
*	1064	*	0.39853E+00	0.42506E+00	0.00000E+00
*	1065	*	-0.57801E+00	0.73719E-01	0.00000E+00
*	1066	*	0.56867E+00	0.13172E+00	0.00000E+00
*	1067	*	-0.57696E+00	0.98290E-01	0.00000E+00
*	1068	*	0.56749E+00	0.14842E+00	0.00000E+00
*	1069	*	-0.40551E+00	0.42506E+00	0.00000E+00
*	1070	*	-0.29505E+00	0.50807E+00	0.00000E+00
*	1071	*	0.34164E+00	0.47895E+00	0.00000E+00
*	1072	*	0.56617E+00	0.16510E+00	0.00000E+00
*	1073	*	-0.57502E+00	0.13172E+00	0.00000E+00
*	1074	*	-0.34863E+00	0.47895E+00	0.00000E+00
*	1075	*	0.56164E+00	0.19081E+00	0.00000E+00
*	1076	*	-0.57253E+00	0.16510E+00	0.00000E+00
*	1077	*	0.55599E+00	0.21628E+00	0.00000E+00
*	1078	*	-0.56799E+00	0.19081E+00	0.00000E+00
*	1079	*	0.54288E+00	0.26029E+00	0.00000E+00
*	1080	*	0.00000E+00	0.60236E+00	0.00000E+00
*	1081	*	0.13556E-01	0.60230E+00	0.00000E+00
*	1082	*	-0.13556E-01	0.60230E+00	0.00000E+00
*	1083	*	-0.56234E+00	0.21628E+00	0.00000E+00
*	1084	*	0.27113E-01	0.60209E+00	0.00000E+00
*	1085	*	-0.27113E-01	0.60209E+00	0.00000E+00
*	1086	*	0.40669E-01	0.60176E+00	0.00000E+00
*	1087	*	-0.40669E-01	0.60176E+00	0.00000E+00
*	1088	*	0.54225E-01	0.60129E+00	0.00000E+00
*	1089	*	-0.54225E-01	0.60129E+00	0.00000E+00
*	1090	*	0.67781E-01	0.60069E+00	0.00000E+00
*	1091	*	-0.67781E-01	0.60069E+00	0.00000E+00
*	1092	*	0.81338E-01	0.59995E+00	0.00000E+00
*	1093	*	-0.81338E-01	0.59995E+00	0.00000E+00
*	1094	*	0.94894E-01	0.59909E+00	0.00000E+00
*	1095	*	-0.94894E-01	0.59909E+00	0.00000E+00
*	1096	*	0.52618E+00	0.30299E+00	0.00000E+00
*	1097	*	-0.54923E+00	0.26029E+00	0.00000E+00
*	1098	*	0.10845E+00	0.59808E+00	0.00000E+00
*	1099	*	-0.10845E+00	0.59808E+00	0.00000E+00
*	1100	*	-0.13008E+00	0.59514E+00	0.00000E+00
*	1101	*	0.14081E+00	0.59318E+00	0.00000E+00
*	1102	*	-0.15157E+00	0.59144E+00	0.00000E+00
*	1103	*	0.17281E+00	0.58644E+00	0.00000E+00
*	1104	*	0.50603E+00	0.34328E+00	0.00000E+00
*	1105	*	-0.16752E+00	0.58856E+00	0.00000E+00
*	1106	*	-0.53253E+00	0.30299E+00	0.00000E+00
*	1107	*	0.20531E+00	0.57789E+00	0.00000E+00

* 1108 *	-0.18338E+00	0.58533E+00	0.00000E+00
* 1109 *	0.23722E+00	0.56757E+00	0.00000E+00
* 1110 *	0.48260E+00	0.38166E+00	0.00000E+00
* 1111 *	-0.21373E+00	0.57721E+00	0.00000E+00
* 1112 *	0.61572E+00	0.00000E+00	0.00000E+00
* 1113 *	-0.51237E+00	0.34328E+00	0.00000E+00
* 1114 *	0.26846E+00	0.55552E+00	0.00000E+00
* 1115 *	0.61506E+00	0.49150E-01	0.00000E+00
* 1116 *	-0.24358E+00	0.56757E+00	0.00000E+00
* 1117 *	0.45603E+00	0.41741E+00	0.00000E+00
* 1118 *	0.29890E+00	0.54177E+00	0.00000E+00
* 1119 *	-0.48895E+00	0.38166E+00	0.00000E+00
* 1120 *	0.42658E+00	0.45070E+00	0.00000E+00
* 1121 *	0.61306E+00	0.98290E-01	0.00000E+00
* 1122 *	-0.27806E+00	0.55552E+00	0.00000E+00
* 1123 *	-0.62144E+00	0.00000E+00	0.00000E+00
* 1124 *	0.33171E+00	0.52639E+00	0.00000E+00
* 1125 *	-0.62077E+00	0.49147E-01	0.00000E+00
* 1126 *	-0.46238E+00	0.41741E+00	0.00000E+00
* 1127 *	0.39609E+00	0.48137E+00	0.00000E+00
* 1128 *	-0.43292E+00	0.45070E+00	0.00000E+00
* 1129 *	0.61093E+00	0.13172E+00	0.00000E+00
* 1130 *	-0.31161E+00	0.54177E+00	0.00000E+00
* 1131 *	0.36338E+00	0.50942E+00	0.00000E+00
* 1132 *	-0.61878E+00	0.98290E-01	0.00000E+00
* 1133 *	-0.34116E+00	0.52639E+00	0.00000E+00
* 1134 *	-0.40244E+00	0.48137E+00	0.00000E+00
* 1135 *	-0.36972E+00	0.50942E+00	0.00000E+00
* 1136 *	0.60819E+00	0.16510E+00	0.00000E+00
* 1137 *	-0.61390E+00	0.16510E+00	0.00000E+00
* 1138 *	0.59698E+00	0.22053E+00	0.00000E+00
* 1139 *	-0.60270E+00	0.22053E+00	0.00000E+00
* 1140 *	0.00000E+00	0.64213E+00	0.00000E+00
* 1141 *	0.27665E-01	0.64183E+00	0.00000E+00
* 1142 *	-0.27665E-01	0.64183E+00	0.00000E+00
* 1143 *	0.55329E-01	0.64095E+00	0.00000E+00
* 1144 *	-0.55329E-01	0.64095E+00	0.00000E+00
* 1145 *	0.82994E-01	0.63948E+00	0.00000E+00
* 1146 *	-0.82994E-01	0.63948E+00	0.00000E+00
* 1147 *	0.56419E+00	0.31495E+00	0.00000E+00
* 1148 *	0.11066E+00	0.63742E+00	0.00000E+00
* 1149 *	-0.11066E+00	0.63742E+00	0.00000E+00
* 1150 *	-0.15721E+00	0.63011E+00	0.00000E+00
* 1151 *	0.18057E+00	0.62461E+00	0.00000E+00
* 1152 *	-0.56990E+00	0.31495E+00	0.00000E+00
* 1153 *	-0.19093E+00	0.62339E+00	0.00000E+00
* 1154 *	0.51626E+00	0.40085E+00	0.00000E+00
* 1155 *	0.25015E+00	0.60386E+00	0.00000E+00
* 1156 *	-0.25587E+00	0.60386E+00	0.00000E+00
* 1157 *	0.31673E+00	0.57548E+00	0.00000E+00
* 1158 *	-0.52197E+00	0.40085E+00	0.00000E+00
* 1159 *	0.65842E+00	0.00000E+00	0.00000E+00
* 1160 *	0.45463E+00	0.47634E+00	0.00000E+00
* 1161 *	0.65824E+00	0.24576E-01	0.00000E+00
* 1162 *	0.65769E+00	0.49150E-01	0.00000E+00
* 1163 *	0.65679E+00	0.73721E-01	0.00000E+00
* 1164 *	-0.46034E+00	0.47634E+00	0.00000E+00
* 1165 *	-0.32816E+00	0.57548E+00	0.00000E+00
* 1166 *	0.65552E+00	0.98290E-01	0.00000E+00
* 1167 *	0.38511E+00	0.53989E+00	0.00000E+00
* 1168 *	-0.66350E+00	0.00000E+00	0.00000E+00
* 1169 *	-0.66332E+00	0.24574E-01	0.00000E+00

*	1170	*	0.65444E+00	0.1150[illegible]E+00	0.00000E+00
*	1171	*	-0.66277E+00	0.49147E-01	0.00000E+00
*	1172	*	-0.66187E+00	0.73719E-01	0.00000E+00
*	1173	*	0.65319E+00	0.13173E+00	0.00000E+00
*	1174	*	-0.39082E+00	0.53989E+00	0.00000E+00
*	1175	*	-0.66060E+00	0.98290E-01	0.00000E+00
*	1176	*	0.65178E+00	0.14842E+00	0.00000E+00
*	1177	*	0.65020E+00	0.16510E+00	0.00000E+00
*	1178	*	-0.65827E+00	0.13173E+00	0.00000E+00
*	1179	*	0.64476E+00	0.19509E+00	0.00000E+00
*	1180	*	-0.65528E+00	0.16510E+00	0.00000E+00
*	1181	*	0.63798E+00	0.22479E+00	0.00000E+00
*	1182	*	-0.64984E+00	0.19509E+00	0.00000E+00
*	1183	*	0.62224E+00	0.27664E+00	0.00000E+00
*	1184	*	-0.64306E+00	0.22479E+00	0.00000E+00
*	1185	*	0.00000E+00	0.68189E+00	0.00000E+00
*	1186	*	0.14108E-01	0.68181E+00	0.00000E+00
*	1187	*	-0.14108E-01	0.68181E+00	0.00000E+00
*	1188	*	0.28217E-01	0.68157E+00	0.00000E+00
*	1189	*	-0.28217E-01	0.68157E+00	0.00000E+00
*	1190	*	0.42325E-01	0.68117E+00	0.00000E+00
*	1191	*	-0.42325E-01	0.68117E+00	0.00000E+00
*	1192	*	0.56433E-01	0.68061E+00	0.00000E+00
*	1193	*	-0.56433E-01	0.68061E+00	0.00000E+00
*	1194	*	0.70542E-01	0.67988E+00	0.00000E+00
*	1195	*	-0.70542E-01	0.67988E+00	0.00000E+00
*	1196	*	0.84650E-01	0.67900E+00	0.00000E+00
*	1197	*	-0.84650E-01	0.67900E+00	0.00000E+00
*	1198	*	0.98758E-01	0.67796E+00	0.00000E+00
*	1199	*	-0.98758E-01	0.67796E+00	0.00000E+00
*	1200	*	0.60220E+00	0.32691E+00	0.00000E+00
*	1201	*	-0.62732E+00	0.27664E+00	0.00000E+00
*	1202	*	0.11287E+00	0.67675E+00	0.00000E+00
*	1203	*	-0.11287E+00	0.67675E+00	0.00000E+00
*	1204	*	-0.13793E+00	0.67323E+00	0.00000E+00
*	1205	*	0.15081E+00	0.67087E+00	0.00000E+00
*	1206	*	-0.16284E+00	0.66878E+00	0.00000E+00
*	1207	*	0.57802E+00	0.37462E+00	0.00000E+00
*	1208	*	0.18833E+00	0.66278E+00	0.00000E+00
*	1209	*	-0.18071E+00	0.66533E+00	0.00000E+00
*	1210	*	-0.60728E+00	0.32692E+00	0.00000E+00
*	1211	*	0.22605E+00	0.65253E+00	0.00000E+00
*	1212	*	-0.19847E+00	0.66145E+00	0.00000E+00
*	1213	*	0.54991E+00	0.42004E+00	0.00000E+00
*	1214	*	0.26308E+00	0.64014E+00	0.00000E+00
*	1215	*	-0.23362E+00	0.65171E+00	0.00000E+00
*	1216	*	-0.58310E+00	0.37463E+00	0.00000E+00
*	1217	*	0.29929E+00	0.62568E+00	0.00000E+00
*	1218	*	-0.26816E+00	0.64014E+00	0.00000E+00
*	1219	*	0.51802E+00	0.46249E+00	0.00000E+00
*	1220	*	0.33456E+00	0.60918E+00	0.00000E+00
*	1221	*	-0.55499E+00	0.42004E+00	0.00000E+00
*	1222	*	0.48268E+00	0.50198E+00	0.00000E+00
*	1223	*	-0.306[illegible]E+00	0.62568E+00	0.00000E+00
*	1224	*	0.371[illegible]5E+00	0.59072E+00	0.00000E+00
*	1225	*	-0.52310E+00	0.46249E+00	0.00000E+00
*	1226	*	0.44609E+00	0.53774E+00	0.00000E+00
*	1227	*	-0.48776E+00	0.50198E+00	0.00000E+00
*	1228	*	-0.34472E+00	0.60918E+00	0.00000E+00
*	1229	*	0.40684E+00	0.57036E+00	0.00000E+00
*	1230	*	0.70112E+00	0.00000E+00	0.00000E+00
*	1231	*	-0.37891E+00	0.59072E+00	0.00000E+00

*	1232	*	-0.45117E+00	0.53774E+00	0.00000E+00
*	1233	*	0.70033E+00	0.49150E-01	0.00000E+00
*	1234	*	-0.41192E+00	0.57036E+00	0.00000E+00
*	1235	*	0.69797E+00	0.98290E-01	0.00000E+00
*	1236	*	-0.70556E+00	0.00000E+00	0.00000E+00
*	1237	*	-0.70478E+00	0.49147E-01	0.00000E+00
*	1238	*	0.69545E+00	0.13173E+00	0.00000E+00
*	1239	*	-0.70242E+00	0.98290E-01	0.00000E+00
*	1240	*	0.69221E+00	0.16510E+00	0.00000E+00
*	1241	*	-0.69666E+00	0.16510E+00	0.00000E+00
*	1242	*	0.67897E+00	0.22904E+00	0.00000E+00
*	1243	*	-0.68342E+00	0.22904E+00	0.00000E+00
*	1244	*	0.00000E+00	0.72165E+00	0.00000E+00
*	1245	*	0.28769E-01	0.72131E+00	0.00000E+00
*	1246	*	-0.28769E-01	0.72131E+00	0.00000E+00
*	1247	*	0.57538E-01	0.72026E+00	0.00000E+00
*	1248	*	-0.57538E-01	0.72026E+00	0.00000E+00
*	1249	*	0.86306E-01	0.71852E+00	0.00000E+00
*	1250	*	-0.86306E-01	0.71852E+00	0.00000E+00
*	1251	*	0.64022E+00	0.33887E+00	0.00000E+00
*	1252	*	0.11508E+00	0.71609E+00	0.00000E+00
*	1253	*	-0.11508E+00	0.71609E+00	0.00000E+00
*	1254	*	-0.16847E+00	0.70745E+00	0.00000E+00
*	1255	*	0.19608E+00	0.70095E+00	0.00000E+00
*	1256	*	-0.64466E+00	0.33888E+00	0.00000E+00
*	1257	*	-0.20602E+00	0.69951E+00	0.00000E+00
*	1258	*	0.58356E+00	0.43924E+00	0.00000E+00
*	1259	*	0.27601E+00	0.67643E+00	0.00000E+00
*	1260	*	-0.28045E+00	0.67643E+00	0.00000E+00
*	1261	*	0.35238E+00	0.64289E+00	0.00000E+00
*	1262	*	-0.58801E+00	0.43924E+00	0.00000E+00
*	1263	*	0.51074E+00	0.52762E+00	0.00000E+00
*	1264	*	-0.51518E+00	0.52762E+00	0.00000E+00
*	1265	*	-0.36127E+00	0.64289E+00	0.00000E+00
*	1266	*	0.42857E+00	0.60083E+00	0.00000E+00
*	1267	*	-0.43302E+00	0.60083E+00	0.00000E+00
*	1268	*	0.74382E+00	0.00000E+00	0.00000E+00
*	1269	*	0.74360E+00	0.24576E-01	0.00000E+00
*	1270	*	0.74297E+00	0.49150E-01	0.00000E+00
*	1271	*	0.74191E+00	0.73721E-01	0.00000E+00
*	1272	*	0.74043E+00	0.98290E-01	0.00000E+00
*	1273	*	-0.74762E+00	0.00000E+00	0.00000E+00
*	1274	*	-0.74741E+00	0.24574E-01	0.00000E+00
*	1275	*	0.73917E+00	0.11502E+00	0.00000E+00
*	1276	*	-0.74678E+00	0.49146E-01	0.00000E+00
*	1277	*	-0.74572E+00	0.73719E-01	0.00000E+00
*	1278	*	0.73771E+00	0.13173E+00	0.00000E+00
*	1279	*	-0.74424E+00	0.98290E-01	0.00000E+00
*	1280	*	0.73607E+00	0.14842E+00	0.00000E+00
*	1281	*	0.73422E+00	0.16510E+00	0.00000E+00
*	1282	*	-0.74152E+00	0.13173E+00	0.00000E+00
*	1283	*	0.72788E+00	0.19937E+00	0.00000E+00
*	1284	*	-0.73804E+00	0.16510E+00	0.00000E+00
*	1285	*	0.71997E+00	0.23330E+00	0.00000E+00
*	1286	*	-0.73169E+00	0.19937E+00	0.00000E+00
*	1287	*	0.70161E+00	0.29298E+00	0.00000E+00
*	1288	*	-0.72378E+00	0.23330E+00	0.00000E+00
*	1289	*	0.00000E+00	0.76142E+00	0.00000E+00
*	1290	*	0.14660E-01	0.76132E+00	0.00000E+00
*	1291	*	-0.14660E-01	0.76132E+00	0.00000E+00
*	1292	*	0.29321E-01	0.76104E+00	0.00000E+00
*	1293	*	-0.29321E-01	0.76104E+00	0.00000E+00

*	1294	*	0.43981E-01	0.76057E+00	0.00000E+00
*	1295	*	-0.43981E-01	0.76057E+00	0.00000E+00
*	1296	*	0.58642E-01	0.75992E+00	0.00000E+00
*	1297	*	-0.58642E-01	0.75992E+00	0.00000E+00
*	1298	*	0.73302E-01	0.75908E+00	0.00000E+00
*	1299	*	-0.73302E-01	0.75908E+00	0.00000E+00
*	1300	*	0.87962E-01	0.75805E+00	0.00000E+00
*	1301	*	-0.87962E-01	0.75805E+00	0.00000E+00
*	1302	*	0.67823E+00	0.35083E+00	0.00000E+00
*	1303	*	0.10262E+00	0.75683E+00	0.00000E+00
*	1304	*	-0.10262E+00	0.75683E+00	0.00000E+00
*	1305	*	-0.70542E+00	0.29298E+00	0.00000E+00
*	1306	*	0.11728E+00	0.75543E+00	0.00000E+00
*	1307	*	-0.11728E+00	0.75543E+00	0.00000E+00
*	1308	*	-0.14579E+00	0.75131E+00	0.00000E+00
*	1309	*	0.16081E+00	0.74856E+00	0.00000E+00
*	1310	*	-0.17411E+00	0.74612E+00	0.00000E+00
*	1311	*	0.65002E+00	0.40597E+00	0.00000E+00
*	1312	*	0.20384E+00	0.73912E+00	0.00000E+00
*	1313	*	-0.68204E+00	0.35084E+00	0.00000E+00
*	1314	*	-0.19389E+00	0.74210E+00	0.00000E+00
*	1315	*	-0.21356E+00	0.73757E+00	0.00000E+00
*	1316	*	0.24679E+00	0.72716E+00	0.00000E+00
*	1317	*	0.61722E+00	0.45843E+00	0.00000E+00
*	1318	*	0.28893E+00	0.71271E+00	0.00000E+00
*	1319	*	-0.25350E+00	0.72621E+00	0.00000E+00
*	1320	*	-0.65382E+00	0.40597E+00	0.00000E+00
*	1321	*	0.33012E+00	0.69583E+00	0.00000E+00
*	1322	*	-0.29274E+00	0.71271E+00	0.00000E+00
*	1323	*	0.58002E+00	0.50757E+00	0.00000E+00
*	1324	*	0.37021E+00	0.67659E+00	0.00000E+00
*	1325	*	-0.62103E+00	0.45843E+00	0.00000E+00
*	1326	*	0.53879E+00	0.55326E+00	0.00000E+00
*	1327	*	-0.33588E+00	0.69583E+00	0.00000E+00
*	1328	*	0.41099E+00	0.65505E+00	0.00000E+00
*	1329	*	-0.58382E+00	0.50757E+00	0.00000E+00
*	1330	*	0.49610E+00	0.59411E+00	0.00000E+00
*	1331	*	-0.54259E+00	0.55326E+00	0.00000E+00
*	1332	*	-0.37783E+00	0.67659E+00	0.00000E+00
*	1333	*	0.45031E+00	0.63130E+00	0.00000E+00
*	1334	*	-0.41666E+00	0.65505E+00	0.00000E+00
*	1335	*	-0.49991E+00	0.59411E+00	0.00000E+00
*	1336	*	-0.45411E+00	0.63130E+00	0.00000E+00
*	1337	*	0.78651E+00	0.00000E+00	0.00000E+00
*	1338	*	0.78561E+00	0.49150E-01	0.00000E+00
*	1339	*	0.78288E+00	0.98290E-01	0.00000E+00
*	1340	*	-0.78969E+00	0.00000E+00	0.00000E+00
*	1341	*	-0.78878E+00	0.49146E-01	0.00000E+00
*	1342	*	0.77998E+00	0.13173E+00	0.00000E+00
*	1343	*	-0.78606E+00	0.98290E-01	0.00000E+00
*	1344	*	0.77624E+00	0.16510E+00	0.00000E+00
*	1345	*	-0.77941E+00	0.16510E+00	0.00000E+00
*	1346	*	0.76096E+00	0.23755E+00	0.00000E+00
*	1347	*	-0.76414E+00	0.23755E+00	0.00000E+00
*	1348	*	0.00000E+00	0.80118E+00	0.00000E+00
*	1349	*	0.29873E-01	0.80078E+00	0.00000E+00
*	1350	*	-0.29873E-01	0.80078E+00	0.00000E+00
*	1351	*	0.59746E-01	0.79958E+00	0.00000E+00
*	1352	*	-0.59746E-01	0.79958E+00	0.00000E+00
*	1353	*	0.89618E-01	0.79757E+00	0.00000E+00
*	1354	*	-0.89618E-01	0.79757E+00	0.00000E+00
*	1355	*	0.71624E+00	0.36279E+00	0.00000E+00

*	1356	*	0.11949E+00	0.79476E+00	0.00000E+00
*	1357	*	-0.11949E+00	0.79476E+00	0.00000E+00
*	1358	*	-0.17974E+00	0.78479E+00	0.00000E+00
*	1359	*	0.21160E+00	0.77729E+00	0.00000E+00
*	1360	*	-0.71941E+00	0.36280E+00	0.00000E+00
*	1361	*	-0.22110E+00	0.77563E+00	0.00000E+00
*	1362	*	0.65087E+00	0.47762E+00	0.00000E+00
*	1363	*	0.30186E+00	0.74900E+00	0.00000E+00
*	1364	*	-0.30504E+00	0.74900E+00	0.00000E+00
*	1365	*	0.38803E+00	0.71030E+00	0.00000E+00
*	1366	*	-0.65405E+00	0.47762E+00	0.00000E+00
*	1367	*	0.56684E+00	0.57890E+00	0.00000E+00
*	1368	*	-0.57001E+00	0.57890E+00	0.00000E+00
*	1369	*	-0.39438E+00	0.71030E+00	0.00000E+00
*	1370	*	0.47204E+00	0.66177E+00	0.00000E+00
*	1371	*	-0.47521E+00	0.66177E+00	0.00000E+00
*	1372	*	0.82921E+00	0.00000E+00	0.00000E+00
*	1373	*	0.82897E+00	0.24576E-01	0.00000E+00
*	1374	*	0.82824E+00	0.49150E-01	0.00000E+00
*	1375	*	0.82703E+00	0.73721E-01	0.00000E+00
*	1376	*	0.82534E+00	0.98290E-01	0.00000E+00
*	1377	*	-0.83175E+00	0.00000E+00	0.00000E+00
*	1378	*	-0.83151E+00	0.24573E-01	0.00000E+00
*	1379	*	0.82390E+00	0.11502E+00	0.00000E+00
*	1380	*	-0.83078E+00	0.49146E-01	0.00000E+00
*	1381	*	0.82224E+00	0.13174E+00	0.00000E+00
*	1382	*	-0.82957E+00	0.73718E-01	0.00000E+00
*	1383	*	0.82035E+00	0.14843E+00	0.00000E+00
*	1384	*	-0.82788E+00	0.98290E-01	0.00000E+00
*	1385	*	0.81825E+00	0.16510E+00	0.00000E+00
*	1386	*	-0.82478E+00	0.13174E+00	0.00000E+00
*	1387	*	0.81099E+00	0.20364E+00	0.00000E+00
*	1388	*	-0.82079E+00	0.16510E+00	0.00000E+00
*	1389	*	0.80195E+00	0.24180E+00	0.00000E+00
*	1390	*	-0.81353E+00	0.20364E+00	0.00000E+00
*	1391	*	0.78097E+00	0.30933E+00	0.00000E+00
*	1392	*	-0.80449E+00	0.24180E+00	0.00000E+00
*	1393	*	0.00000E+00	0.84094E+00	0.00000E+00
*	1394	*	0.15212E-01	0.84084E+00	0.00000E+00
*	1395	*	-0.15212E-01	0.84084E+00	0.00000E+00
*	1396	*	0.30425E-01	0.84052E+00	0.00000E+00
*	1397	*	-0.30425E-01	0.84052E+00	0.00000E+00
*	1398	*	0.45637E-01	0.83998E+00	0.00000E+00
*	1399	*	-0.45637E-01	0.83998E+00	0.00000E+00
*	1400	*	0.60850E-01	0.83923E+00	0.00000E+00
*	1401	*	-0.60850E-01	0.83923E+00	0.00000E+00
*	1402	*	0.76062E-01	0.83827E+00	0.00000E+00
*	1403	*	-0.76062E-01	0.83827E+00	0.00000E+00
*	1404	*	0.91274E-01	0.83709E+00	0.00000E+00
*	1405	*	-0.91274E-01	0.83709E+00	0.00000E+00
*	1406	*	0.75425E+00	0.37476E+00	0.00000E+00
*	1407	*	-0.78351E+00	0.30933E+00	0.00000E+00
*	1408	*	0.10649E+00	0.83570E+00	0.00000E+00
*	1409	*	-0.10649E+00	0.83570E+00	0.00000E+00
*	1410	*	0.12170E+00	0.83410E+00	0.00000E+00
*	1411	*	-0.12170E+00	0.83410E+00	0.00000E+00
*	1412	*	-0.15364E+00	0.82939E+00	0.00000E+00
*	1413	*	0.17081E+00	0.82625E+00	0.00000E+00
*	1414	*	-0.18537E+00	0.82346E+00	0.00000E+00
*	1415	*	0.72201E+00	0.43731E+00	0.00000E+00
*	1416	*	0.21935E+00	0.81546E+00	0.00000E+00
*	1417	*	-0.75679E+00	0.37476E+00	0.00000E+00

*	1418	*	-0.20708E+00	0.81886E+00	0.00000E+00
*	1419	*	-0.22865E+00	0.81369E+00	0.00000E+00
*	1420	*	0.26754E+00	0.80179E+00	0.00000E+00
*	1421	*	0.68453E+00	0.49681E+00	0.00000E+00
*	1422	*	0.31479E+00	0.78528E+00	0.00000E+00
*	1423	*	-0.27339E+00	0.80070E+00	0.00000E+00
*	1424	*	-0.72455E+00	0.43731E+00	0.00000E+00
*	1425	*	0.36096E+00	0.76599E+00	0.00000E+00
*	1426	*	-0.31733E+00	0.78528E+00	0.00000E+00
*	1427	*	0.64201E+00	0.55264E+00	0.00000E+00
*	1428	*	0.40586E+00	0.74400E+00	0.00000E+00
*	1429	*	-0.68707E+00	0.49681E+00	0.00000E+00
*	1430	*	0.59489E+00	0.60454E+00	0.00000E+00
*	1431	*	-0.36480E+00	0.76599E+00	0.00000E+00
*	1432	*	0.45064E+00	0.71938E+00	0.00000E+00
*	1433	*	-0.64455E+00	0.55264E+00	0.00000E+00
*	1434	*	0.54611E+00	0.65049E+00	0.00000E+00
*	1435	*	-0.59743E+00	0.60454E+00	0.00000E+00
*	1436	*	-0.41094E+00	0.74400E+00	0.00000E+00
*	1437	*	0.49377E+00	0.69224E+00	0.00000E+00
*	1438	*	-0.45442E+00	0.71938E+00	0.00000E+00
*	1439	*	-0.54865E+00	0.65049E+00	0.00000E+00
*	1440	*	-0.49631E+00	0.69224E+00	0.00000E+00
*	1441	*	0.87191E+00	0.00000E+00	0.00000E+00
*	1442	*	0.87088E+00	0.49150E-01	0.00000E+00
*	1443	*	0.86779E+00	0.98290E-01	0.00000E+00
*	1444	*	-0.87381E+00	0.00000E+00	0.00000E+00
*	1445	*	-0.87278E+00	0.49146E-01	0.00000E+00
*	1446	*	0.86450E+00	0.13174E+00	0.00000E+00
*	1447	*	-0.86970E+00	0.98290E-01	0.00000E+00
*	1448	*	0.86026E+00	0.16510E+00	0.00000E+00
*	1449	*	-0.86217E+00	0.16510E+00	0.00000E+00
*	1450	*	0.84295E+00	0.24606E+00	0.00000E+00
*	1451	*	-0.84485E+00	0.24606E+00	0.00000E+00
*	1452	*	0.00000E+00	0.88071E+00	0.00000E+00
*	1453	*	0.30977E-01	0.88025E+00	0.00000E+00
*	1454	*	-0.30977E-01	0.88025E+00	0.00000E+00
*	1455	*	0.61954E-01	0.87889E+00	0.00000E+00
*	1456	*	-0.61954E-01	0.87889E+00	0.00000E+00
*	1457	*	0.92930E-01	0.87662E+00	0.00000E+00
*	1458	*	-0.92930E-01	0.87662E+00	0.00000E+00
*	1459	*	0.79227E+00	0.38672E+00	0.00000E+00
*	1460	*	0.12391E+00	0.87343E+00	0.00000E+00
*	1461	*	-0.12391E+00	0.87343E+00	0.00000E+00
*	1462	*	-0.19100E+00	0.86214E+00	0.00000E+00
*	1463	*	-0.79417E+00	0.38672E+00	0.00000E+00
*	1464	*	0.22711E+00	0.85364E+00	0.00000E+00
*	1465	*	-0.23619E+00	0.85175E+00	0.00000E+00
*	1466	*	0.71819E+00	0.51600E+00	0.00000E+00
*	1467	*	0.32772E+00	0.82157E+00	0.00000E+00
*	1468	*	-0.32962E+00	0.82157E+00	0.00000E+00
*	1469	*	0.42368E+00	0.77771E+00	0.00000E+00
*	1470	*	-0.72009E+00	0.51600E+00	0.00000E+00
*	1471	*	0.62295E+00	0.63018E+00	0.00000E+00
*	1472	*	-0.62485E+00	0.63018E+00	0.00000E+00
*	1473	*	-0.42749E+00	0.77771E+00	0.00000E+00
*	1474	*	0.51550E+00	0.72271E+00	0.00000E+00
*	1475	*	-0.51741E+00	0.72271E+00	0.00000E+00
*	1476	*	0.91460E+00	0.00000E+00	0.00000E+00
*	1477	*	0.91433E+00	0.24576E-01	0.00000E+00
*	1478	*	0.91352E+00	0.49150E-01	0.00000E+00
*	1479	*	0.91215E+00	0.73721E-01	0.00000E+00

*	1480	*	0.91025E+00	0.98290E-01	0.00000E+00
*	1481	*	-0.91588E+00	0.00000E+00	0.00000E+00
*	1482	*	0.90863E+00	0.11503E+00	0.00000E+00
*	1483	*	-0.91560E+00	0.24573E-01	0.00000E+00
*	1484	*	-0.91479E+00	0.49146E-01	0.00000E+00
*	1485	*	0.90676E+00	0.13174E+00	0.00000E+00
*	1486	*	-0.91342E+00	0.73718E-01	0.00000E+00
*	1487	*	0.90464E+00	0.14843E+00	0.00000E+00
*	1488	*	-0.91152E+00	0.98290E-01	0.00000E+00
*	1489	*	0.90227E+00	0.16510E+00	0.00000E+00
*	1490	*	-0.90803E+00	0.13174E+00	0.00000E+00
*	1491	*	0.89411E+00	0.20792E+00	0.00000E+00
*	1492	*	-0.90355E+00	0.16510E+00	0.00000E+00
*	1493	*	0.88394E+00	0.25031E+00	0.00000E+00
*	1494	*	-0.89538E+00	0.20792E+00	0.00000E+00
*	1495	*	0.86034E+00	0.32567E+00	0.00000E+00
*	1496	*	-0.88521E+00	0.25031E+00	0.00000E+00
*	1497	*	0.00000E+00	0.92047E+00	0.00000E+00
*	1498	*	0.15764E-01	0.92035E+00	0.00000E+00
*	1499	*	-0.15764E-01	0.92035E+00	0.00000E+00
*	1500	*	0.31529E-01	0.91999E+00	0.00000E+00
*	1501	*	-0.31529E-01	0.91999E+00	0.00000E+00
*	1502	*	0.47293E-01	0.91939E+00	0.00000E+00
*	1503	*	-0.47293E-01	0.91939E+00	0.00000E+00
*	1504	*	0.63057E-01	0.91855E+00	0.00000E+00
*	1505	*	-0.63057E-01	0.91855E+00	0.00000E+00
*	1506	*	0.78822E-01	0.91746E+00	0.00000E+00
*	1507	*	-0.78822E-01	0.91746E+00	0.00000E+00
*	1508	*	0.94586E-01	0.91614E+00	0.00000E+00
*	1509	*	-0.94586E-01	0.91614E+00	0.00000E+00
*	1510	*	0.83028E+00	0.39868E+00	0.00000E+00
*	1511	*	-0.86161E+00	0.32567E+00	0.00000E+00
*	1512	*	0.11035E+00	0.91457E+00	0.00000E+00
*	1513	*	-0.11035E+00	0.91457E+00	0.00000E+00
*	1514	*	0.12611E+00	0.91277E+00	0.00000E+00
*	1515	*	-0.12611E+00	0.91277E+00	0.00000E+00
*	1516	*	-0.16150E+00	0.90748E+00	0.00000E+00
*	1517	*	0.18081E+00	0.90394E+00	0.00000E+00
*	1518	*	0.79401E+00	0.46866E+00	0.00000E+00
*	1519	*	-0.19663E+00	0.90081E+00	0.00000E+00
*	1520	*	-0.83154E+00	0.39868E+00	0.00000E+00
*	1521	*	0.23487E+00	0.89181E+00	0.00000E+00
*	1522	*	-0.22026E+00	0.89563E+00	0.00000E+00
*	1523	*	-0.24373E+00	0.88981E+00	0.00000E+00
*	1524	*	0.28828E+00	0.87643E+00	0.00000E+00
*	1525	*	0.75184E+00	0.53520E+00	0.00000E+00
*	1526	*	0.34064E+00	0.85785E+00	0.00000E+00
*	1527	*	-0.29327E+00	0.87520E+00	0.00000E+00
*	1528	*	-0.79527E+00	0.46866E+00	0.00000E+00
*	1529	*	0.39179E+00	0.83615E+00	0.00000E+00
*	1530	*	-0.34191E+00	0.85785E+00	0.00000E+00
*	1531	*	0.70401E+00	0.59772E+00	0.00000E+00
*	1532	*	0.44151E+00	0.81141E+00	0.00000E+00
*	1533	*	-0.75311E+00	0.53520E+00	0.00000E+00
*	1534	*	0.65100E+00	0.65582E+00	0.00000E+00
*	1535	*	-0.39371E+00	0.83615E+00	0.00000E+00
*	1536	*	0.49028E+00	0.78372E+00	0.00000E+00
*	1537	*	-0.70527E+00	0.59772E+00	0.00000E+00
*	1538	*	0.59611E+00	0.70686E+00	0.00000E+00
*	1539	*	-0.65227E+00	0.65582E+00	0.00000E+00
*	1540	*	-0.44405E+00	0.81141E+00	0.00000E+00
*	1541	*	0.53723E+00	0.75318E+00	0.00000E+00

*	1542	*	-0.49217E+00	0.78372E+00	0.00000E+00
*	1543	*	-0.59738E+00	0.70686E+00	0.00000E+00
*	1544	*	-0.53850E+00	0.75318E+00	0.00000E+00
*	1545	*	0.95730E+00	0.00000E+00	0.00000E+00
*	1546	*	0.95615E+00	0.49150E-01	0.00000E+00
*	1547	*	0.95270E+00	0.98290E-01	0.00000E+00
*	1548	*	-0.95794E+00	0.00000E+00	0.00000E+00
*	1549	*	-0.95679E+00	0.49145E-01	0.00000E+00
*	1550	*	0.94902E+00	0.13174E+00	0.00000E+00
*	1551	*	-0.95334E+00	0.98290E-01	0.00000E+00
*	1552	*	0.94429E+00	0.16510E+00	0.00000E+00
*	1553	*	-0.94492E+00	0.16510E+00	0.00000E+00
*	1554	*	0.92494E+00	0.25457E+00	0.00000E+00
*	1555	*	-0.92557E+00	0.25457E+00	0.00000E+00
*	1556	*	0.00000E+00	0.96024E+00	0.00000E+00
*	1557	*	0.32081E-01	0.95973E+00	0.00000E+00
*	1558	*	-0.32081E-01	0.95973E+00	0.00000E+00
*	1559	*	0.64161E-01	0.95820E+00	0.00000E+00
*	1560	*	-0.64161E-01	0.95820E+00	0.00000E+00
*	1561	*	0.86829E+00	0.41064E+00	0.00000E+00
*	1562	*	0.96242E-01	0.95566E+00	0.00000E+00
*	1563	*	-0.96242E-01	0.95566E+00	0.00000E+00
*	1564	*	0.12832E+00	0.95210E+00	0.00000E+00
*	1565	*	-0.12832E+00	0.95210E+00	0.00000E+00
*	1566	*	-0.20227E+00	0.93948E+00	0.00000E+00
*	1567	*	-0.86892E+00	0.41064E+00	0.00000E+00
*	1568	*	0.24262E+00	0.92998E+00	0.00000E+00
*	1569	*	-0.25128E+00	0.92787E+00	0.00000E+00
*	1570	*	0.78549E+00	0.55439E+00	0.00000E+00
*	1571	*	0.35357E+00	0.89414E+00	0.00000E+00
*	1572	*	-0.35421E+00	0.89414E+00	0.00000E+00
*	1573	*	0.45933E+00	0.84512E+00	0.00000E+00
*	1574	*	-0.78613E+00	0.55439E+00	0.00000E+00
*	1575	*	0.67905E+00	0.68146E+00	0.00000E+00
*	1576	*	-0.67968E+00	0.68146E+00	0.00000E+00
*	1577	*	-0.46060E+00	0.84512E+00	0.00000E+00
*	1578	*	0.55897E+00	0.78365E+00	0.00000E+00
*	1579	*	-0.55960E+00	0.78365E+00	0.00000E+00
*	1580	*	0.00000E+00	0.10000E+01	0.00000E+00
*	1581	*	0.16316E-01	0.99987E+00	0.00000E+00
*	1582	*	-0.16316E-01	0.99987E+00	0.00000E+00
*	1583	*	0.32632E-01	0.99947E+00	0.00000E+00
*	1584	*	-0.32632E-01	0.99947E+00	0.00000E+00
*	1585	*	0.48949E-01	0.99880E+00	0.00000E+00
*	1586	*	-0.48949E-01	0.99880E+00	0.00000E+00
*	1587	*	0.65265E-01	0.99786E+00	0.00000E+00
*	1588	*	-0.65265E-01	0.99786E+00	0.00000E+00
*	1589	*	0.81581E-01	0.99666E+00	0.00000E+00
*	1590	*	-0.81581E-01	0.99666E+00	0.00000E+00
*	1591	*	0.97897E-01	0.99519E+00	0.00000E+00
*	1592	*	-0.97897E-01	0.99519E+00	0.00000E+00
*	1593	*	0.11421E+00	0.99345E+00	0.00000E+00
*	1594	*	-0.11421E+00	0.99345E+00	0.00000E+00
*	1595	*	0.13053E+00	0.99144E+00	0.00000E+00
*	1596	*	-0.13053E+00	0.99144E+00	0.00000E+00
*	1597	*	-0.16935E+00	0.98556E+00	0.00000E+00
*	1598	*	0.19081E+00	0.98163E+00	0.00000E+00
*	1599	*	-0.20790E+00	0.97815E+00	0.00000E+00
*	1600	*	-0.23345E+00	0.97240E+00	0.00000E+00
*	1601	*	0.25038E+00	0.96815E+00	0.00000E+00
*	1602	*	-0.25882E+00	0.96593E+00	0.00000E+00
*	1603	*	0.30902E+00	0.95106E+00	0.00000E+00

```
* 1604 * -0.31316E+00  0.94970E+00  0.00000E+00
* 1605 *  0.36650E+00  0.93042E+00  0.00000E+00
* 1606 * -0.36650E+00  0.93042E+00  0.00000E+00
* 1607 *  0.42262E+00  0.90631E+00  0.00000E+00
* 1608 * -0.42262E+00  0.90631E+00  0.00000E+00
* 1609 *  0.47716E+00  0.87882E+00  0.00000E+00
* 1610 * -0.47716E+00  0.87882E+00  0.00000E+00
* 1611 *  0.52992E+00  0.84805E+00  0.00000E+00
* 1612 * -0.52992E+00  0.84805E+00  0.00000E+00
* 1613 * -0.58070E+00  0.81412E+00  0.00000E+00
* 1614 *  0.58070E+00  0.81412E+00  0.00000E+00
* 1615 * -0.64612E+00  0.76323E+00  0.00000E+00
* 1616 *  0.64612E+00  0.76323E+00  0.00000E+00
* 1617 * -0.70710E+00  0.70710E+00  0.00000E+00
* 1618 *  0.70710E+00  0.70710E+00  0.00000E+00
* 1619 * -0.76600E+00  0.64280E+00  0.00000E+00
* 1620 *  0.76600E+00  0.64280E+00  0.00000E+00
* 1621 * -0.81915E+00  0.57358E+00  0.00000E+00
* 1622 *  0.81915E+00  0.57358E+00  0.00000E+00
* 1623 * -0.86600E+00  0.50000E+00  0.00000E+00
* 1624 *  0.86600E+00  0.50000E+00  0.00000E+00
* 1625 * -0.90630E+00  0.42260E+00  0.00000E+00
* 1626 *  0.90630E+00  0.42260E+00  0.00000E+00
* 1627 * -0.93970E+00  0.34202E+00  0.00000E+00
* 1628 *  0.93970E+00  0.34202E+00  0.00000E+00
* 1629 * -0.96593E+00  0.25882E+00  0.00000E+00
* 1630 *  0.96593E+00  0.25882E+00  0.00000E+00
* 1631 * -0.97723E+00  0.21220E+00  0.00000E+00
* 1632 *  0.97723E+00  0.21220E+00  0.00000E+00
* 1633 * -0.98630E+00  0.16510E+00  0.00000E+00
* 1634 *  0.98630E+00  0.16510E+00  0.00000E+00
* 1635 *  0.98893E+00  0.14843E+00  0.00000E+00
* 1636 * -0.99128E+00  0.13174E+00  0.00000E+00
* 1637 *  0.99128E+00  0.13174E+00  0.00000E+00
* 1638 *  0.99336E+00  0.11503E+00  0.00000E+00
* 1639 * -0.99516E+00  0.98290E-01  0.00000E+00
* 1640 *  0.99516E+00  0.98290E-01  0.00000E+00
* 1641 *  0.99728E+00  0.73721E-01  0.00000E+00
* 1642 * -0.99728E+00  0.73717E-01  0.00000E+00
* 1643 *  0.99879E+00  0.49150E-01  0.00000E+00
* 1644 * -0.99879E+00  0.49145E-01  0.00000E+00
* 1645 *  0.99970E+00  0.24576E-01  0.00000E+00
* 1646 * -0.99970E+00  0.24573E-01  0.00000E+00
* 1647 * -0.10000E+01  0.00000E+00  0.00000E+00
* 1648 *  0.10000E+01  0.00000E+00  0.00000E+00
* 1649 * -0.98893E+00  0.14843E+00  0.00000E+00
* 1650 * -0.99336E+00  0.11503E+00  0.00000E+00

ELEMENTS
 QUAD08P    PZT4TA       1
*   1*    1    3    6    8    2    4    5    7
*   2*    6    8   11   13    7    9   10   12
*   3*   11   13   16   18   12   14   15   17
*   4*   16   18   21   23   17   19   20   22
*   5*   21   23   26   28   22   24   25   27
*   6*   26   28   31   33   27   29   30   32
*   7*   31   33   36   38   32   34   35   37
*   8*   36   38   41   43   37   39   40   42

 QUAD08E    ENTRAN       1
*   9*   44   46   49   51   45   47   48   50
```

```
 QUAD08E    NEOPRENE    1
* 10*   49   51   54   56   50   52   53   55
* 11*   54   56   59   61   55   57   58   60
* 12*   59   61   64   66   60   62   63   65
* 13*   64   66   69   71   65   67   68   70
* 14*   69   71   74   76   70   72   73   75
* 15*   74   76   79   81   75   77   78   80
* 16*   79   81   84   86   80   82   83   85
* 17*   84   86   89   91   85   87   88   90
* 18*   89   91   94   96   90   92   93   95
* 19*   94   96   99  101   95   97   98  100
* 20*   99  101  104  106  100  102  103  105
* 21*  104  106  109  111  105  107  108  110
* 22*  109  111  114  116  110  112  113  115
* 23*  114  116  119  121  115  117  118  120
* 24*  119  121  124  126  120  122  123  125
* 25*  124  126  129  131  125  127  128  130

 QUAD08E    ENTRAN      1
* 26*   46  133   51  136  132   48  134  135

 QUAD08E    NEOPRENE    1
* 27*   51  136   56  139  135   53  137  138

 QUAD08E    P1590       1
* 28*   56  139   61  142  138   58  140  141

 QUAD08E    HRS         1
* 29*   61  142   66  145  141   63  143  144

 QUAD08E    P1590       1
* 30*   66  145   71    1  144   68  146  147
* 31*   71    1   76    6  147   73    4  148
* 32*   76    6   81   11  148   78    9  149
* 33*   81   11   86   16  149   83   14  150
* 34*   86   16   91   21  150   88   19  151
* 35*   91   21   96   26  151   93   24  152
* 36*   96   26  101   31  152   98   29  153
* 37*  101   31  106   36  153  103   34  154
* 38*  106   36  111   41  154  108   39  155
* 39*  111   41  116  158  155  113  156  157

 QUAD08E    HRS         1
* 40*  116  158  121  161  157  118  159  160

 QUAD08E    P1590       1
* 41*  121  161  126  164  160  123  162  163

 QUAD08E    NEOPRENE    1
* 42*  126  164  131  167  163  128  165  166

 QUAD08E    ENTRAN      1
* 43*  133  169  136  172  168  134  170  171

 QUAD08E    NEOPRENE    1
* 44*  136  172  139  175  171  137  173  174

 QUAD08E    P1590       1
* 45*  139  175  142  178  174  140  176  177

 QUAD08E    HRS         1
```

```
* 46*  142  178  145  181  177  143  179  180

 QUAD08E    P1590       1
* 47*  145  181    1    3  180  146  182    2
* 48*   41   43  158  185   42  156  183  184

 QUAD08E    HRS         1
* 49*  158  185  161  188  184  159  186  187

 QUAD08E    P1590       1
* 50*  161  188  164  191  187  162  189  190

 QUAD08E    NEOPRENE    1
* 51*  164  191  167  194  190  165  192  193

 QUAD08E    ENTRAN      1
* 52*  169  196  172  199  195  170  197  198

 QUAD08E    NEOPRENE    1
* 53*  172  199  175  202  198  173  200  201

 QUAD08E    P1590       1
* 54*  175  202  178  205  201  176  203  204

 QUAD08E    HRS         1
* 55*  178  205  181  208  204  179  206  207

 QUAD08E    P1590       1
* 56*  181  208    3  211  207  182  209  210
* 57*    3  211    8  214  210    5  212  213
* 58*    8  214   13  217  213   10  215  216
* 59*   13  217   18  220  216   15  218  219
* 60*   18  220   23  223  219   20  221  222
* 61*   23  223   28  226  222   25  224  225
* 62*   28  226   33  229  225   30  227  228
* 63*   33  229   38  232  228   35  230  231
* 64*   38  232   43  235  231   40  233  234
* 65*   43  235  185  238  234  183  236  237

 QUAD08E    HRS         1
* 66*  185  238  188  241  237  186  239  240

 QUAD08E    P1590       1
* 67*  188  241  191  244  240  189  242  243

 QUAD08E    NEOPRENE    1
* 68*  191  244  194  247  243  192  245  246

 QUAD08E    ENTRAN      1
* 69*  196  249  199  252  248  197  250  251


 QUAD08E    NEOPRENE    1
* 70*  199  252  202  255  251  200  253  254
* 71*  202  255  205  258  254  203  256  257
* 72*  205  258  208  261  257  206  259  260
* 73*  208  261  211  264  260  209  262  263
* 74*  211  264  214  267  263  212  265  266
* 75*  214  267  217  270  266  215  268  269
* 76*  217  270  220  273  269  218  271  272
* 77*  220  273  223  276  272  221  274  275
```

```
 * 78*   223   276   226   279   275   224   277   278
 * 79*   226   279   229   282   278   227   280   281
 * 80*   229   282   232   285   281   230   283   284
 * 81*   232   285   235   288   284   233   286   287
 * 82*   235   288   238   291   287   236   289   290
 * 83*   238   291   241   294   290   239   292   293
 * 84*   241   294   244   297   293   242   295   296
 * 85*   244   297   247   300   296   245   298   299

  QUAD08E    ENTRAN        1
 * 86*   301   303   307   309   302   305   306   308
 * 87*   303    44   309    49   304   306    47   310

  LINE06I                  0
 * 88*   511   527   307   301   518   305
 * 89*   542   511   309   307   524   308
 * 90*   574   542    49   309   560   310
 * 91*   549   574    54    49   566    52
 * 92*   544   549    59    54   546    57
 * 93*   534   544    64    59   538    62
 * 94*   526   534    69    64   531    67
 * 95*   515   526    74    69   520    72
 * 96*   502   515    79    74   506    77
 * 97*   494   502    84    79   498    82
 * 98*   485   494    89    84   487    87
 * 99*   493   485    94    89   486    92
 *100*   501   493    99    94   497    97
 *101*   514   501   104    99   505   102
 *102*   525   514   109   104   519   107
 *103*   533   525   114   109   530   112
 *104*   543   533   119   114   537   117
 *105*   548   543   124   119   545   122
 *106*   573   548   129   124   565   127
 *107*   583   573   131   129   578   130
 *108*   594   583   167   131   588   166
 *109*   603   594   194   167   599   193
 *110*   608   603   247   194   604   246
 *111*   625   608   300   247   616   299
 *112*   600   625   297   300   611   298
 *113*   590   600   294   297   596   295
 *114*   582   590   291   294   585   292
 *115*   576   582   288   291   580   289
 *116*   569   576   285   288   572   286
 *117*   562   569   282   285   564   283
 *118*   554   562   279   282   558   280
 *119*   550   554   276   279   552   277
 *120*   553   550   273   276   551   274
 *121*   561   553   270   273   557   271
 *122*   568   561   267   270   563   268
 *123*   575   568   264   267   571   265
 *124*   581   575   261   264   579   262
 *125*   589   581   258   261   584   259
 *126*   601   589   255   258   595   256
 *127*   626   601   252   255   610   253
 *128*   634   626   249   252   631   250
 *129*   623   634   196   249   630   248
 *130*   617   623   169   196   621   195
 *131*   605   617   133   169   613   168
 *132*   597   605    46   133   602   132
 *133*   586   597    44    46   592    45
 *134*   555   586   303    44   570   304
 *135*   527   555   301   303   540   302
```

QUAD08F FLUIDE 0

136	511	542	468	517	524	488	529	496
137	542	574	517	549	560	529	566	536
138	468	517	446	500	496	459	508	473
139	517	549	500	544	536	508	546	522
140	446	500	432	482	473	436	492	456
141	500	544	482	534	522	492	538	513
142	432	482	417	471	456	428	476	445
143	482	534	471	526	513	476	531	504
144	417	471	398	451	445	410	462	421
145	471	526	451	515	504	462	520	480
146	398	451	381	435	421	387	443	406
147	451	515	435	502	480	443	506	467
148	381	435	371	425	406	377	431	396
149	435	502	425	494	467	431	498	458
150	371	425	363	419	396	367	423	394
151	425	494	419	485	458	423	487	454
152	363	419	370	424	394	366	422	395
153	419	485	424	493	454	422	486	457
154	370	424	380	434	395	376	430	405
155	424	493	434	501	457	430	497	466
156	380	434	397	450	405	386	442	420
157	434	501	450	514	466	442	505	479
158	397	450	418	470	420	409	461	444
159	450	514	470	525	479	461	519	503
160	418	470	433	481	444	429	475	455
161	470	525	481	533	503	475	530	512
162	433	481	447	499	455	437	491	472
163	481	533	499	543	512	491	537	521
164	447	499	469	516	472	460	507	495
165	499	543	516	548	521	507	545	535
166	469	516	510	541	495	489	528	523
167	516	548	541	573	535	528	565	559
168	634	737	626	723	681	631	732	669
169	737	834	723	820	782	732	827	763
170	834	930	820	924	875	827	927	865
171	930	1032	924	1028	973	927	1030	968
172	1032	1135	1028	1130	1074	1030	1133	1070
173	1135	1234	1130	1228	1174	1133	1231	1165
174	1234	1336	1228	1332	1267	1231	1334	1265
175	1336	1440	1332	1436	1371	1334	1438	1369
176	1440	1544	1436	1540	1475	1438	1542	1473
177	1544	1613	1540	1610	1579	1542	1612	1577
178	626	723	601	704	669	610	712	648
179	723	820	704	808	763	712	815	754
180	820	924	808	912	865	815	918	857
181	924	1028	912	1015	968	918	1022	960
182	1028	1130	1015	1116	1070	1022	1122	1058
183	1130	1228	1116	1218	1165	1122	1223	1156
184	1228	1332	1218	1322	1265	1223	1327	1260
185	1332	1436	1322	1426	1369	1327	1431	1364
186	1436	1540	1426	1530	1473	1431	1535	1468
187	1540	1610	1530	1606	1577	1535	1608	1572
188	601	704	589	696	648	595	700	644
189	704	808	696	802	754	700	805	748
190	808	912	802	904	857	805	909	851
191	912	1015	904	1006	960	909	1010	952
192	1015	1116	1006	1108	1058	1010	1111	1052
193	1116	1218	1108	1212	1156	1111	1215	1153
194	1218	1322	1212	1315	1260	1215	1319	1257
195	1322	1426	1315	1419	1364	1319	1423	1361

196	1426	1530	1419	1523	1468	1423	1527	1465
197	1530	1606	1523	1602	1572	1527	1604	1569
198	589	696	581	690	644	584	694	639
199	696	802	690	794	748	694	797	743
200	802	904	794	398	351	797	901	347
201	904	1006	898	1000	952	901	1003	946
202	1006	1108	1000	1102	1052	1003	1105	1046
203	1108	1212	1102	1206	1153	1105	1209	1150
204	1212	1315	1206	1310	1257	1209	1314	1254
205	1315	1419	1310	1414	1361	1314	1418	1358
206	1419	1523	1414	1519	1465	1418	1522	1462
207	1523	1602	1519	1599	1569	1522	1600	1566
208	581	690	575	684	639	579	686	637
209	690	794	684	790	743	686	791	741
210	794	898	790	891	847	791	894	843
211	898	1000	891	994	946	894	997	943
212	1000	1102	994	1099	1046	997	1100	1045
213	1102	1206	1099	1203	1150	1100	1204	1149
214	1206	1310	1203	1307	1254	1204	1308	1253
215	1310	1414	1307	1411	1358	1308	1412	1357
216	1414	1519	1411	1515	1462	1412	1516	1461
217	1519	1599	1515	1596	1566	1516	1597	1565
218	575	684	568	676	637	571	680	628
219	684	790	676	781	741	680	786	735
220	790	891	781	887	843	786	889	837
221	891	994	887	989	943	889	991	938
222	994	1099	989	1093	1045	991	1095	1042
223	1099	1203	1093	1197	1149	1095	1199	1146
224	1203	1307	1197	1301	1253	1199	1304	1250
225	1307	1411	1301	1405	1357	1304	1409	1354
226	1411	1515	1405	1509	1461	1409	1513	1458
227	1515	1596	1509	1592	1565	1513	1594	1563
228	568	676	561	667	628	563	673	620
229	676	781	667	775	735	673	777	727
230	781	887	775	880	837	777	883	833
231	887	989	880	985	938	883	987	935
232	989	1093	985	1089	1042	987	1091	1040
233	1093	1197	1089	1193	1146	1091	1195	1144
234	1197	1301	1193	1297	1250	1195	1299	1248
235	1301	1405	1297	1401	1354	1299	1403	1352
236	1405	1509	1401	1505	1458	1403	1507	1456
237	1509	1592	1505	1588	1563	1507	1590	1560
238	561	667	553	662	620	557	664	615
239	667	775	662	771	727	664	773	720
240	775	880	771	874	833	773	877	830
241	880	985	874	979	935	877	982	933
242	985	1089	979	1085	1040	982	1087	1037
243	1089	1193	1085	1189	1144	1087	1191	1142
244	1193	1297	1189	1293	1248	1191	1295	1246
245	1297	1401	1293	1397	1352	1295	1399	1350
246	1401	1505	1397	1501	1456	1399	1503	1454
247	1505	1588	1501	1584	1560	1503	1586	1558
248	553	662	550	657	615	551	659	612
249	662	771	657	765	720	659	768	718
250	771	874	765	869	830	768	871	826
251	874	979	869	975	933	871	977	931
252	979	1085	975	1080	1037	977	1082	1035
253	1085	1189	1080	1185	1142	1082	1187	1140
254	1189	1293	1185	1289	1246	1187	1291	1244
255	1293	1397	1289	1393	1350	1291	1395	1348
256	1397	1501	1393	1497	1454	1395	1499	1452
257	1501	1584	1497	1580	1558	1499	1582	1556

258	550	657	554	661	612	552	658	614
259	657	765	661	770	718	658	767	719
260	765	869	770	873	826	767	870	829
261	869	975	873	978	931	870	976	932
262	975	1080	978	1084	1035	976	1081	1036
263	1080	1185	1084	1188	1140	1081	1186	1141
264	1185	1289	1188	1292	1244	1186	1290	1245
265	1289	1393	1292	1396	1348	1290	1394	1349
266	1393	1497	1396	1500	1452	1394	1498	1453
267	1497	1580	1500	1583	1556	1498	1581	1557
268	554	661	562	666	614	558	663	619
269	661	770	666	774	719	663	772	726
270	770	873	774	879	829	772	876	832
271	873	978	879	984	932	876	981	934
272	978	1084	984	1088	1036	981	1086	1039
273	1084	1188	1088	1192	1141	1086	1190	1143
274	1188	1292	1192	1296	1245	1190	1294	1247
275	1292	1396	1296	1400	1349	1294	1398	1351
276	1396	1500	1400	1504	1453	1398	1502	1455
277	1500	1583	1504	1587	1557	1502	1585	1559
278	562	666	569	675	619	564	672	627
279	666	774	675	780	726	672	776	734
280	774	879	780	886	832	776	882	836
281	879	984	886	988	934	882	986	937
282	984	1088	988	1092	1039	986	1090	1041
283	1088	1192	1092	1196	1143	1090	1194	1145
284	1192	1296	1196	1300	1247	1194	1298	1249
285	1296	1400	1300	1404	1351	1298	1402	1353
286	1400	1504	1404	1508	1455	1402	1506	1457
287	1504	1587	1508	1591	1559	1506	1589	1562
288	569	675	576	683	627	572	679	636
289	675	780	683	789	734	679	785	740
290	780	886	789	890	836	785	888	842
291	886	988	890	993	937	888	990	942
292	988	1092	993	1098	1041	990	1094	1044
293	1092	1196	1098	1202	1145	1094	1198	1148
294	1196	1300	1202	1306	1249	1198	1303	1252
295	1300	1404	1306	1410	1353	1303	1408	1356
296	1404	1508	1410	1514	1457	1408	1512	1460
297	1508	1591	1514	1595	1562	1512	1593	1564
298	576	683	582	691	636	580	687	640
299	683	789	691	795	740	687	792	746
300	789	890	795	900	842	792	896	849
301	890	993	900	1001	942	896	998	947
302	993	1098	1001	1103	1044	998	1101	1047
303	1098	1202	1103	1208	1148	1101	1205	1151
304	1202	1306	1208	1312	1252	1205	1309	1255
305	1306	1410	1312	1416	1356	1309	1413	1359
306	1410	1514	1416	1521	1460	1413	1517	1464
307	1514	1595	1521	1601	1564	1517	1598	1568
308	582	691	590	698	640	585	695	645
309	691	795	698	803	746	695	800	749
310	795	900	803	907	849	800	903	854
311	900	1001	907	1009	947	903	1004	956
312	1001	1103	1009	1109	1047	1004	1107	1054
313	1103	1208	1109	1214	1151	1107	1211	1155
314	1208	1312	1214	1318	1255	1211	1316	1259
315	1312	1416	1318	1422	1359	1316	1420	1363
316	1416	1521	1422	1526	1464	1420	1524	1467
317	1521	1601	1526	1605	1568	1524	1603	1571
318	590	698	600	705	645	596	701	651
319	698	803	705	809	749	701	807	755

320	803	907	809	915	854	807	911	858
321	907	1009	915	1017	956	911	1013	961
322	1009	1109	1017	1118	1054	1013	1114	1060
323	1109	1214	1118	1220	1155	1114	1217	1157
324	1214	1318	1220	1324	1259	1217	1321	1261
325	1318	1422	1324	1428	1363	1321	1425	1365
326	1422	1526	1428	1532	1467	1425	1529	1469
327	1526	1605	1532	1609	1571	1529	1607	1573
328	600	705	625	724	651	611	713	670
329	705	809	724	822	755	713	816	764
330	809	915	822	925	858	816	920	866
331	915	1017	925	1029	961	920	1023	969
332	1017	1118	1029	1131	1060	1023	1124	1071
333	1118	1220	1131	1229	1157	1124	1224	1167
334	1220	1324	1229	1333	1261	1224	1328	1266
335	1324	1428	1333	1437	1365	1328	1432	1370
336	1428	1532	1437	1541	1469	1432	1536	1474
337	1532	1609	1541	1614	1573	1536	1611	1578
338	625	724	608	710	670	616	716	654
339	724	822	710	813	764	716	817	757
340	822	925	813	916	866	817	922	861
341	925	1029	916	1021	969	922	1025	963
342	1029	1131	1021	1120	1071	1025	1127	1064
343	1131	1229	1120	1222	1167	1127	1226	1160
344	1229	1333	1222	1326	1266	1226	1330	1263
345	1333	1437	1326	1430	1370	1330	1434	1367
346	1437	1541	1430	1534	1474	1434	1538	1471
347	1541	1614	1534	1618	1578	1538	1616	1575
348	608	710	603	703	654	604	706	650
349	710	813	703	806	757	706	811	752
350	813	916	806	910	861	811	914	855
351	916	1021	910	1011	963	914	1016	957
352	1021	1120	1011	1110	1064	1016	1117	1055
353	1120	1222	1110	1213	1160	1117	1219	1154
354	1222	1326	1213	1317	1263	1219	1323	1258
355	1326	1430	1317	1421	1367	1323	1427	1362
356	1430	1534	1421	1525	1471	1427	1531	1466
357	1534	1618	1525	1622	1575	1531	1620	1570
358	603	703	594	693	650	599	699	643
359	703	806	693	793	752	699	801	744
360	806	910	793	892	855	801	902	845
361	910	1011	892	992	957	902	1002	944
362	1011	1110	992	1096	1055	1002	1104	1043
363	1110	1213	1096	1200	1154	1104	1207	1147
364	1213	1317	1200	1302	1258	1207	1311	1251
365	1317	1421	1302	1406	1362	1311	1415	1355
366	1421	1525	1406	1510	1466	1415	1518	1459
367	1525	1622	1510	1626	1570	1518	1624	1561
368	594	693	583	677	643	588	685	633
369	693	793	677	769	744	685	783	728
370	793	892	769	868	845	783	881	823
371	892	992	868	972	944	881	980	929
372	992	1096	972	1077	1043	980	1079	1034
373	1096	1200	1077	1181	1147	1079	1183	1138
374	1200	1302	1181	1285	1251	1183	1287	1242
375	1302	1406	1285	1389	1355	1287	1391	1346
376	1406	1510	1389	1493	1459	1391	1495	1450
377	1510	1626	1493	1630	1561	1495	1628	1554
378	583	677	573	655	633	578	665	622
379	677	769	655	756	728	665	759	711
380	769	868	756	860	823	759	863	812
381	868	972	860	966	929	863	970	919

382	972	1077	966	1072	1034	970	1075	1026
383	1077	1181	1072	1177	1138	1075	1179	1136
384	1181	1285	1177	1281	1242	1179	1283	1240
385	1285	1389	1281	1385	1346	1283	1387	1344
386	1389	1493	1385	1489	1450	1387	1491	1448
387	1493	1630	1489	1634	1554	1491	1632	1552
388	573	655	541	641	622	559	646	587
389	655	756	641	747	711	646	750	692
390	756	860	747	850	812	750	856	799
391	860	966	850	958	919	856	962	906
392	966	1072	958	1066	1026	962	1068	1018
393	1072	1177	1066	1173	1136	1068	1176	1129
394	1177	1281	1173	1278	1240	1176	1280	1238
395	1281	1385	1278	1381	1344	1280	1383	1342
396	1385	1489	1381	1485	1448	1383	1487	1446
397	1489	1634	1485	1637	1552	1487	1635	1550
398	541	641	510	624	587	523	632	567
399	641	747	624	736	692	632	739	674
400	747	850	736	841	799	739	846	784
401	850	958	841	949	906	846	954	895
402	958	1066	949	1056	1018	954	1062	1007
403	1066	1173	1056	1166	1129	1062	1170	1121
404	1173	1278	1166	1272	1238	1170	1275	1235
405	1278	1381	1272	1376	1342	1275	1377	1339
406	1381	1485	1376	1480	1446	1379	1482	1443
407	1485	1637	1480	1640	1550	1482	1638	1547
408	510	624	464	598	567	483	606	539
409	624	736	598	715	674	606	721	653
410	736	841	715	831	784	721	835	761
411	841	949	831	941	895	835	945	884
412	949	1056	941	1051	1007	945	1053	999
413	1056	1166	1051	1162	1121	1053	1163	1115
414	1166	1272	1162	1270	1235	1163	1271	1233
415	1272	1376	1270	1374	1339	1271	1375	1338
416	1376	1480	1374	1478	1443	1375	1479	1442
417	1480	1640	1478	1643	1547	1479	1641	1546
418	464	598	448	591	539	452	593	532
419	598	715	591	708	653	593	709	647
420	715	831	708	824	761	709	825	760
421	831	941	824	939	884	825	940	878
422	941	1051	939	1048	999	940	1049	995
423	1051	1162	1048	1159	1115	1049	1161	1112
424	1162	1270	1159	1268	1233	1161	1269	1230
425	1270	1374	1268	1372	1338	1269	1373	1337
426	1374	1478	1372	1476	1442	1373	1477	1441
427	1478	1643	1476	1648	1546	1477	1645	1545
428	404	414	448	464	408	427	441	452
429	414	469	464	510	439	441	489	483
430	383	400	404	414	385	393	412	408
431	400	447	414	469	416	412	460	439
432	360	379	383	400	365	373	389	385
433	379	433	400	447	402	389	437	416
434	352	369	360	379	354	358	375	365
435	369	418	379	433	391	375	429	402
436	351	368	335	348	353	344	356	339
437	368	417	348	398	390	356	410	362
438	335	348	322	337	339	331	341	325
439	348	398	337	381	362	341	387	350
440	322	337	315	329	325	318	333	320
441	337	381	329	371	350	333	377	346
442	315	329	311	323	320	313	327	316
443	329	371	323	363	346	327	367	342

444	311	323	314	328	316	312	326	319
445	323	363	328	370	342	326	366	345
446	314	328	321	336	319	317	332	324
447	328	370	336	380	345	332	376	349
448	321	336	334	347	324	330	340	338
449	336	380	347	397	349	340	386	361
450	334	347	352	369	338	343	355	354
451	347	397	369	418	361	355	409	391
452	359	378	351	368	364	357	374	353
453	378	432	368	417	401	374	428	390
454	382	399	359	378	384	372	388	364
455	399	446	378	432	415	388	436	401
456	403	413	382	399	407	392	411	384
457	413	468	399	446	438	411	459	415
458	449	465	403	413	453	426	440	407
459	465	511	413	468	484	440	488	438
460	474	490	449	465	478	463	477	453
461	490	527	465	511	509	477	518	484
462	1613	1544	1617	1539	1579	1615	1543	1576
463*	1544	1440	1539	1435	1475	1543	1439	1472
464	1440	1336	1435	1331	1371	1439	1335	1368
465	1336	1234	1331	1227	1267	1335	1232	1264
466	1234	1135	1227	1128	1174	1232	1134	1164
467	1135	1032	1128	1027	1074	1134	1031	1069
468	1032	930	1027	923	973	1031	928	967
469	930	834	923	819	875	928	828	864
470	834	737	819	722	782	828	731	762
471	737	634	722	623	681	731	630	668
472	1617	1539	1621	1533	1576	1619	1537	1574
473	1539	1435	1533	1429	1472	1537	1433	1470
474	1435	1331	1429	1325	1368	1433	1329	1366
475	1331	1227	1325	1221	1264	1329	1225	1262
476	1227	1128	1221	1119	1164	1225	1126	1158
477	1128	1027	1119	1020	1069	1126	1024	1063
478	1027	923	1020	917	967	1024	921	964
479	923	819	917	814	864	921	818	862
480	819	722	814	714	762	818	717	758
481	722	623	714	617	668	717	621	656
482	1621	1533	1625	1520	1574	1623	1528	1567
483	1533	1429	1520	1417	1470	1528	1424	1463
484	1429	1325	1417	1313	1366	1424	1320	1360
485	1325	1221	1313	1210	1262	1320	1216	1256
486	1221	1119	1210	1106	1158	1216	1113	1152
487	1119	1020	1106	1005	1063	1113	1014	1050
488	1020	917	1005	905	964	1014	913	953
489	917	814	905	804	862	913	810	853
490	814	714	804	702	758	810	707	751
491	714	617	702	605	656	707	613	652
492	1625	1520	1629	1496	1567	1627	1511	1555
493	1520	1417	1496	1392	1463	1511	1407	1451
494	1417	1313	1392	1288	1360	1407	1305	1347
495	1313	1210	1288	1184	1256	1305	1201	1243
496	1210	1106	1184	1083	1152	1201	1097	1139
497	1106	1005	1083	983	1050	1097	996	1038
498	1005	905	983	885	953	996	897	936
499	905	804	885	788	853	897	796	838
500	804	702	788	689	751	796	697	742
501	702	605	689	597	652	697	602	642
502	1629	1496	1633	1492	1555	1631	1494	1553
503	1496	1392	1492	1388	1451	1494	1390	1449
504	1392	1288	1388	1284	1347	1390	1286	1345
505	1288	1184	1284	1180	1243	1286	1182	1241

506	1184	1083	1180	1076	1139	1182	1078	1137
507	1083	983	1076	971	1038	1078	974	1033
508	983	885	971	867	936	974	872	926
509	885	788	867	766	838	872	778	821
510	788	689	766	678	742	778	682	729
511	689	597	678	586	642	682	592	635
512	1633	1492	1639	1488	1553	1636	1490	1551
513	1492	1388	1488	1384	1449	1490	1386	1447
514	1388	1284	1384	1279	1345	1386	1282	1343
515	1284	1180	1279	1175	1241	1282	1178	1239
516	1180	1076	1175	1067	1137	1178	1073	1132
517	1076	971	1067	959	1033	1073	965	1019
518	971	867	959	852	926	965	859	908
519	867	766	852	745	821	859	753	798
520	766	678	745	638	729	753	649	688
521	678	586	638	527	635	649	555	577
522	1639	1488	1644	1484	1551	1642	1486	1549
523	1488	1384	1484	1380	1447	1486	1382	1445
524	1384	1279	1380	1276	1343	1382	1277	1341
525	1279	1175	1276	1171	1239	1277	1172	1237
526	1175	1067	1171	1061	1132	1172	1065	1125
527	1067	959	1061	951	1019	1065	955	1012
528	959	852	951	844	908	955	848	899
529	852	745	844	733	798	848	738	787
530	745	638	733	618	688	738	629	671
531	638	527	618	490	577	629	509	556
532	1644	1484	1647	1481	1549	1646	1483	1548
533	1484	1380	1481	1377	1445	1483	1378	1444
534	1380	1276	1377	1273	1341	1378	1274	1340
535	1276	1171	1273	1168	1237	1274	1169	1236
536	1171	1061	1168	1057	1125	1169	1059	1123
537	1061	951	1057	948	1012	1059	950	1008
538	951	844	948	839	899	950	840	893
539	844	733	839	725	787	840	730	779
540	733	618	725	607	671	730	609	660
541	618	490	607	474	556	609	478	547

LINE03R FLUIDE 3

542	1648	1643	1645
543	1643	1640	1641
544	1640	1637	1638
545	1637	1634	1635
546	1634	1630	1632
547	1630	1626	1628
548	1626	1622	1624
549	1622	1618	1620
550	1618	1614	1616
551	1614	1609	1611
552	1609	1605	1607
553	1605	1601	1603
554	1601	1595	1598
555	1595	1591	1593
556	1591	1587	1589
557	1587	1583	1585
558	1583	1580	1581
559	1580	1584	1582
560	1584	1588	1586
561	1588	1592	1590
562	1592	1596	1594
563	1596	1599	1597
564	1599	1602	1600
565	1602	1606	1604

```
*566* 1606 1610 1608
*567* 1610 1613 1612
*568* 1613 1617 1615
*569* 1617 1621 1619
*570* 1621 1625 1623
*571* 1625 1629 1627
*572* 1629 1633 1631
*573* 1633 1636 1649
*574* 1636 1639 1650
*575* 1639 1644 1642
*576* 1644 1647 1646

END
        -1    3    3          * Non existing degree of freedom (2-D)
        -1    4    2    S     * Electrode at 0 V
        -3   -4   -2    1     * Electrode at 1 V
```

APPENDIX B

MATLAB PROGRAM FOR ANALYTICAL MODEL OF UNLOADED TRANSDUCER

```
%
%   This MATLAB program was written by MAJ Tay Tiong Beng
%   on 1 Feb 1993 to implement the formula developed
%   by Hong-zhang Wang [Ref. 2] for unloaded tangentially
%   polarized ring transducer
%

%   Initialization

clear;
clg;
!del res
!del res1.met
!del res2.met
!del res3.met
diary res

%   Material Constants

j=sqrt(-1);
rhoc=7002;
s11=0.1702e-10*(1-0.015*j);  % Losses is 1.5% of the real part. The real part
                             % is the published value of the elastic constant
s12=-0.405e-11;
nu=-(s12)/(s11)              % Poisson Ratio
s66=2*(s11-s12)
e33=0.57e-8
d31=-0.135e-9
d33=0.3e-9
Yc=1/s11;
F=3000;                 % Frequency

%   Fluid Constants

cair=343;
cwater=1500;
ccer=sqrt(Yc/rhoc);

%   Dimensions

a=(14.44/2)*0.0254             % Inside radius
b=(14.94/2)*0.0254             % outside radius of ceramic stave
l=6.8*0.0254                   % height

%   Capacitance and Admittance

N=72;
Co=N^2*e33*l/(2*pi)*log(b/a)
k31s=Yc*(d31^2)/e33
t=(d33/d31)
Cs=Co*(1-(k31s/(1-nu^2))*(1+2*nu*t+t^2))
```

```
%  Admittance Circle

j=sqrt(-1);
wr=ccer/a                 % Radial Res
fr=wr/(2*pi)
n=0;
for f=1:5:F
    n=n+1;
    w=2*pi*f;
    ww=w/wr;
    WW(1,n)=ww;
    jwcs=j*w*Cs;
    fa=(1-nu^2)*(w/wr)^2 - 1;
    A=j*w*Co*k31s/fa;
    ka2=(w/ccer)^2*fa/((w/wr)^2-1);
    KA2(1,n)=ka2;
    ka=sqrt(ka2);
    KA(1,n)=ka;
    B=(fa*(1+nu*t)+nu*(nu+t))^2/((1-nu^2)^2*((w/wr)^2-1));
    D=(nu+t)^2/(1-nu^2);
    T=A*(B*(tan(0.5*ka*1)/(0.5*ka*1))-D)+jwcs;
    TT=T/(j*wr*Co);
    z=1/TT;
    Z(1,n)=z;
    Y(1,n)=T;
    YY(1,n)=TT;
end;

q=abs(Y)
G=real(Y)
S=imag(Y)
f=1:5:F;
axis('square');

plot(G,S);grid;
title('ADMITTANCE CIRCLE OF A TANGENTIALLY POLARIZED UNLOADED TRANSDUCER')
xlabel('Conductance, G  mhos');
ylabel('Susceptance, S  mhos');
meta res1;

plot(f',G); grid;
title('CONDUCTANCE AS A FUNCTION OF FREQUENCY');
xlabel('Frequency,  Hz'); ylabel('Conductance, G  mhos'); pause;
meta res2;

plot(f',S); grid;
title('SUSCEPTANCE AS A FUNCTION OF FREQUENCY');
xlabel('Frequency,  Hz'); ylabel('Susceptance, S  mhos'); pause;
meta res3;

diary off
end;
```

APPENDIX C

TYPICAL VALUES FOR MATERIALS CONSTANTS

TABLE 1: PHYSICAL DIMENSIONS AND MATERIAL CONSTANTS

The Transducer

Inside Radius	:	0.1651 m
Outside Radius	:	0.204724 m
Height	:	0.2921 m

Motor Element: Navy Type 1 Ceramic (Hexagonal Class 6mm)

Density	:	7550 kg/m^3
Inside Radius	:	0.183388 m
Outside Radius	:	0.189738 m

Elastic Constants (m^2/N)

s_{33}^E = 1.539E-11

s_{13}^E = -5.31E-12

s_{12}^E = -4.05E-12

s_{11}^E = 1.22E-11

s_{44}^E = 3.90E-11

s_{66}^E = 3.25E-11

Dielectric Constants

ϵ_{33}^T = 1.149E-8

ϵ_{11}^T = 1.2963E-8

ϵ_{33}^S = 0.57E-8

ϵ_{11}^S = 0.624E-8

Piezoelectric Constants

g tensor (m^2/c)

g_{33} = 26.1E-3

g_{31} = -11.7E-3

g_{15} = 40.5E-3

d tensor (m/v)

d_{33} = 300E-12

d_{31} = -135E-12

d_{15} = 525E-12

TABLE 1: CONTINUED

Fiberglass Wrap

Thickness	:	0.762 mm
Density	:	2540 kg/m^3
Longitudinal Modulus	:	8.5E6 psi (5.86E10 Pa)
Transverse Modulus	:	2.9E6 psi (2.00E10 Pa)
Poisson Ratio	:	0.28

Encapsulant Material

Polyurethane

Density :0.039 pci (≈1100 kg/m^3)
Young's Modulus : 600 psi (4.14 MPa)
Poisson Ratio : 0.49

Neoprene

Density : 0.045 pci (≈1250 kg/m^3)
Young's Modulus : 100-3000 psi
(0.69-20.69 MPA)
Poisson Ratio : 0.49

Reflector Ring: HRS Carbon Steel

Density : 7700 Kg/m^3
Young's Modulus : 19.5E10 Pa
Poisson Ratio : 0.28

Mounting Plate: Fiberglass-epoxy composite

Density : 1700 Kg/m^3
Young Modulus : 2000 psi (13.79 MPa)
Poisson Ratio : 0.34

APPENDIX D

SAMPLE CALCULATIONS FOR THE EFFECTIVE ELASTIC CONSTANTS OF THE FIBERGLASS WRAPPED CERAMIC RING

The effective elastic constants of the ring are estimated as follows. Consider a section of the fiberglass wrapped ring as two rectangular volume elements cemented together as shown in Figure 1 below. The purpose is to calculate the elastic constants of an equivalent ceramic material which will give the same elastic properties as the fiberglass wrapped ceramic ring. The equivalent ceramic material has the same length, l, and height, h, as the fiberglass and ceramic, and a width equal to the sum of the widths of the fiberglass and ceramic.

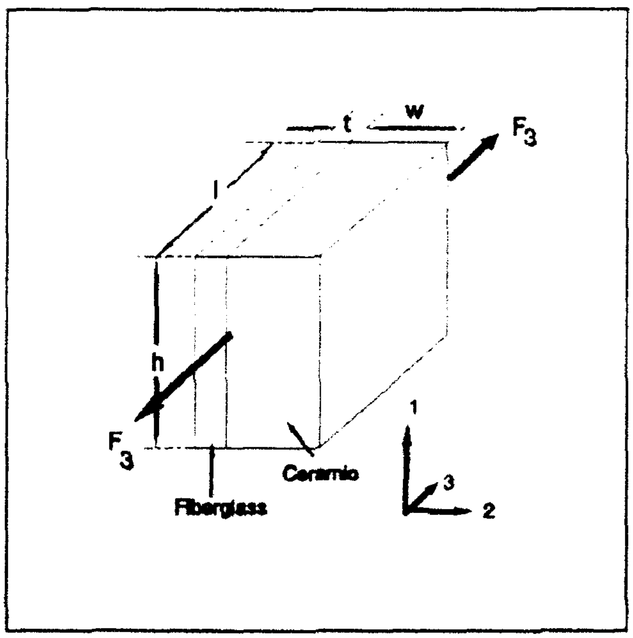

Figure 1

The thickness of the fiberglass is t and that of the ceramic is w, where t and w are 0.000762m and 0.0064m, respectively.

Consider first an applied force, F_3, in the circumferential direction only, as shown. Assuming that the resultant stress, T_3, is uniform then the strain, S_1, in each material is given by:

$$S_1 = \frac{\Delta h}{h} = s_{13} T_3 \tag{1}$$

For the ceramic,

$$(\Delta h)_c = h_c (s_{13})_c T_3 \tag{2}$$

And for the fiberglass,

$$(\Delta h)_g = h_g (s_{13})_g T_3 \tag{3}$$

There is no reason to assume $(\Delta h)_g$ equals to $(\Delta h)_c$. We therefore define $(\Delta h)_{eff}$ for the equivalent material as the average Δh across the composite material, neglecting boundary effects:

$$(\Delta h)_c w + (\Delta h)_g t = (\Delta h)_{eff} (w + t) \tag{4}$$

Then the effective strain in the axial direction, i.e., in the "1" direction is given by:

$$(S_1)_{eff} = \frac{(\Delta h)_{eff}}{h} = \frac{(s_{13})_c w + (s_{13})_g t}{w + t} T_3 \tag{5}$$

after taking $h_c = h_g = h$.

Thus the effective compliance, $(s_{13})_{eff}$, is given by:

$$(s_{13})_{eff} = \frac{(s_{13})_f w + (s_{13})_c t}{w + t} \qquad (6)$$

By considering forces in the other directions, in turn, the same result is obtained, with the appropriate identification of indices and element dimensions. For example, to compute s_{12} we will consider an applied force in the "2" direction, i.e., the radial direction, and calculate the strain in the "1", or axial, direction.

Using values listed in Appendix C for the fiberglass and ceramic, the following were obtained:

CONSTANTS	COMPUTED VALUES (m^2/N)
$s_{11} = s_{22}$	1.142×10^{-11}
$s_{12} = s_{21}$	-4.9×10^{-12}
$s_{13} = s_{31}$	-5.3×10^{-12}
$s_{23} = s_{32}$	-5.3×10^{-12}
s_{33}	1.702×10^{-11}
$s_{44} = s_{55}$	3.9×10^{-11}
s_{66}	3.58×10^{-11}

LIST OF REFERENCES

1. Institut Superieur d'Electronique du Nord, "ATILA Finite Element Code for Piezoelectric and Magnestostrictive Transducer Modeling Version 5.02," User's Manual, August 1991.

2. Hong-zhang Wang, "On the Tangentially and Radially Polarized Piezoceramic Thin Cylindrical Tube Transducers," Journal of Acoustical Society of America, Vol. 79(1), pp. 164-176, January 1986.

3. G. W. McMahon, "Performance of Open Ferroelectric Ceramic Cylinders In Underwater Transducers," Journal of Acoustical Society of America, Vol. 36, pp. 528-533, March 1964.

4. V.M. Ristic, "Principles of Acoustic Devices," John Wiley & Sons, 1983.

5. A. J. Davies, "The Finite Element Method: A First Approach," Clarendon Press - Oxford, 1980.

6. O. C. Zienkiewicz and R. L. Taylor, "The Finite Element Method," McGraw-Hill Book Company.

7. Roger T. Fenner, "Finite Element Methods for Engineers," The MacMillan Press Ltd - London, 1975.

8. H. R. Schwarz, "Finite Element Methods," Academic Press, 1988.

9. J. T. Hunt, M. R. Knittel, and D. Barach, "Finite Element Approach to Acoustic Radiation From Elastic Structures," Journal of Acoustical Society of America, vol. 55, pp. 269-280, 1974.

10. O. C. Zienkiewicz and R. F. Newton, "Coupled Vibrations of a Structure Submerged in a Compressible Fluid," Proceedings of the International Symposium on Finite Element Techniques, Stuttgart, 1969.

11. Decarpigny, J. N., "Application de la Methode des Elements Finis a L'Etude de Transducteurs Piezoelectriques," These de Doctorat d'Etat, Universite des Sciences et Techniques de Lille, 1974.

12. Anifrani, K., "Contribution a l'Etude de Structures Piezoelectriques a l'Aide de La Methode des Elements Finis," These de Doctorat en Sciences des Materiaux, Universite des Sciences et Techniques de Lille, 1988.

13. Bernard Hamonic, Jean Claude Debus, and Jean-Noel Decarpigny, "Analysis of a Radiating Thin-Shell Sonar Transducer Using the Finite-Element Method," Journal of Acoustical Society of America, vol. 86, pp. 1245, 1989.

14. Lawrence E. Kinsler, Austin R. Frey, Alan B. Coppens, and James V. Sanders, "Fundamental of Acoustics," 3rd Edition, John Wiley & Sons, 1982.

15. Jean N. Decarpigny, Bernard F. Hamonic, and Jean C. Debus, "Computation of the Equivalent Modal Impedance Matrix of a Multiple Degree of Freedom Electroelastic Structure Using Antiresonance Modes," Journal of Acoustical Society of America, vol. 90(6), pp. 2891-2894, December 1991.

16. J.F. Nye, "Physical Properties of Crystals," Oxford, 1975.

17. B. A. Armstrong and G. W. McMahon, "Modeling and Performance of Ring-Shell Projectors," IEE Proceedings, Vol. 131, Part F, No 3, June 1984.

18. Robert J. Bobber, "Underwater Electroacoustic Measurements," Peninsula Publishing, 1988.

19. O. B. Wilson, "Introduction to Theory and Design of Sonar Transducers," Peninsula Publishing, 1988.

20. Rodger N. Capps, "Elastomeric Materials for Acoustical Applications," Naval Research Laboratory, September 1989.

BIBLIOGRAPHY

Auld, B. A., "Acoustic Fields and Waves in Solids," John Wiley & Sons, 1973.

Beranek, Leo L., "Acoustics," McGraw-Hill, 1954.

Timoshenko, S., and Goodier, J. N., "Theory of Elasticity," McGraw-Hill, 1951.

INITIAL DISTRIBUTION LIST

1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 52 Naval Postgraduate School Monterey, California 93943-5000	2
3.	Chairman, Code EC Department of Electrical and Computer Engineering Naval Postgraduate School Monterey, California 93943-5000	1
4.	Professor Anthony A. Atchley, Code PH/Ay Department of Physics Naval Postgraduate School Monterey, California 93943-5000	1
5.	Professor Steven R. Baker, Code PH/Ba Department of Physics Naval Postgraduate School Monterey, California 93943-5000	2
6.	Professor Ron J. Pieper, Code EC/Pr Department of Electrical and Computer Engineering Naval Postgraduate School Monterey, California 93943-5000	1
7.	Professor Oscar B. Wilson, Code PH/Wl Department of Physics Naval Postgraduate School Monterey, California 93943-5000	1
8.	Dr. Roger Richards, Code 213 Naval Undersea Warfare Center New London, Connecticut 06320	1
9.	Dr. Robert Timme Naval Research Lab-USRD Orlando, Florida 32856	1

10. Dr. Bernard F. Hamonic 1
Institut Superieur d'Electronique du Nord
41 Blvd Vauban
59046 Lille, Cedex, France

11. HNL 1
Naval Logistics Department
HQ, Republic Of Singapore Navy
MINDEF Building
Gombak Drive
SINGAPORE 2366
Republic of Singapore

12. MAJ Tiong Beng Tay 1
Naval Logistics Department, HQ RSN
MINDEF Building
Gombak Drive
SINGAPORE 2366
Republic of Singapore