



COMPUTERIZED SONAR TRANSDUCER ANALYSIS AND DESIGN BASED ON MULTIPOINT NETWORK INTERCONNECTION TECHNIQUES

by

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SUMMARY

PROBLEM

Develop a computer program to provide the capability for analysis and design of any conceivable electromechanical vibrator by implementing a generalized method based on multiport network interconnection techniques.

RESULTS

The computer program SEADUCER has been developed and applied successfully to several problems involving steady-state analysis and design of various longitudinal vibrators for Navy sonar systems. Calculations from mathematical models of transducer flexing heads have been curve-fit and then used in the program when vibrational modes other than plane wave have been known to exist. Applications other than longitudinal vibrator analysis have also been made successfully using the multiport interconnection techniques available in the program.

SEADUCER has been written so that it can easily be installed on most medium- to large-scale digital computers. The program is being used at other installations and is available to government and private organizations.

RECOMMENDATIONS

Develop a more general technique to solve for selected individual port variables. Also, implement hybrid interconnections to provide a more powerful tool. Additional mathematical models for element types should be added as the need arises. Applications to other fields such as electronics should be explored.

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INTRODUCTION

The purpose of this document is to provide a working guide to using the SEADUCER computer program. SEADUCER is an acronym for Steadystate Evaluation and Analysis of TransDUCERs. The techniques used by SEADUCER to combine sub-assemblies of transducers are applicable to math models for a wide variety of transducers. However, in this document SEADUCER is applied primarily to math models for longitudinal electromechanical vibrators. To a large extent, SEADUCER represents the state of the art both in the math models and in their computer implementation for analysis and design of this type of transducer. These computerized techniques have been developed and implemented by the Transducer and Array Systems Division, Code 601, of the Naval Undersea Center. SEADUCER, originally called MOD 8, is the latest in a long series of transducer analysis and design computer programs developed by NUC Code 601 and is significantly different in two respects:

(1) the mathematical method for combining the elements of the transducer is more flexible, and (2) the program implementation can be easily adapted for use on most medium- to large-scale digital computers.

For transducer analysis, SEADUCER has as its fundamental building blocks the mathematical models of transducer subassemblies. While some of these models have existed for years, their first combination into a transducer analysis computer program (MOD 1) was begun in 1961 by Dr. Gordon Martin of Code 601. Since that time several individuals have made a number of improvements in math models for sub-assemblies and in their use in transducer analysis programs.

The development of SEADUCER began early in 1968 when it became apparent that the existing MOD 7 program was not capable of handling several transducer configurations of importance. To overcome this problem, H. Ding and J. Ward of Code 601 described the method which forms the basis for combining elements in SEADUCER. This multiport interconnection technique is used primarily for transducer analysis and design; however, it can be used within the SEADUCER program for solution of other problems in electronics, mechanics, thermal flow, etc.

With the generalized multiport concepts available, L. McCleary began the computer implementation after appropriate computer input notation for the network interconnections was selected. The programming has proceeded continuously since that time.

The basic purpose of this report, as stated above, is to provide the potential user with enough information, including examples, to enable him to prepare typical transducer application computer runs. The mathematical equations used as a basis for the programs are given; but, in general, no derivation or detailed discussion of them is included, particularly if either is readily available in other literature.

The report consists of three major sections in addition to the Introduction. The first, Definitions and Conventions, presents the terms, definitions, and conventions used throughout the report. The second, Theoretical Description of Multiport Interconnection Technique, contains a mathematical description of the multiport interconnection technique. The third, General Description of Computer Program, presents the basic features of the SEADUCER Program for both programmers and non-programmers. There are six appendices, A through F. Appendix A is programmer oriented in that it provides a description of each subroutine in the program; the primary common storage blocks are also described. Appendix B defines the types of networks implemented, giving the input data required, sign conventions, and mathematical equations. Appendices C, D, and E present discussions and specific examples of computer runs for various applications involving longitudinal electromechanical vibrators. Appendix F, which is an active band-pass filter analysis, illustrates an application in a field other than transducer analysis. A complete computer program listing is too large to include in this report; however, copies of the program will be released in a form suitable for a particular installation on receipt by NUC Code 601 of an official request.

In order to make effective use of rapidly advancing technology, the SEADUCER program and documentation must be frequently updated. In order to accomplish this easily and efficiently, Appendix A had been completely computerized using a type-setting program so that future changes, deletions, and insertions can be made quickly and inexpensively. Such information will be supplied either as updates to this report or as follow-on reports when appropriate.

DEFINITIONS AND CONVENTIONS

The following definitions and explanatory notes are stated to aid clarity. Figure 1 illustrates many of the definitions given here. "Voltage" and "current" are used here but the same principles can be applied to a variety of problems, e.g., mechanical, in which case the preceding terms would be replaced by "force" and "velocity" respectively.

A *port* is defined as a terminal-pair wherein the current at one terminal must at every instant be equal and opposite to the current at the other terminal of the pair. An *accessible port* is a terminal-pair of a connected array of networks, whereas a *network port* is a terminal-pair of a single network.

A *multiport network* is defined as a set of linear equations relating current and voltage (or other analogous variables) at each of the one or more ports.

A *connection* must join together two or more network ports with a single accessible port. These ports are said to be *involved* in the connection.

A *series connection* is a connection wherein all involved ports have a common current; i.e., a *common-current loop* is formed by the connection.

A *parallel connection* is a connection wherein all involved ports have a common voltage; i.e., a *common-voltage node pair* is formed by the connection.

A connection involving no more than two network ports can be treated either as a series or parallel connection, depending on the type of accessible port involved.

A *series port* is a port involved in a series connection.

A *parallel port* is a port involved in a parallel connection.

An *interconnection* is defined as a connected array of a number of multiport networks containing at least one connection. An interconnection has one or more accessible ports and is itself a multiport network which relates current and voltage (or other analogous variables) at each of the one or more accessible ports.

A *series interconnection* is composed exclusively of series connections and is called Type S.

A *parallel interconnection* is composed exclusively of parallel connections and is called Type P.

A *hybrid or mixed interconnection* may contain both series and parallel connections.

Compaction is the process of removing undesired ports having trivial boundary conditions from an interconnection, leaving only those accessible ports desired in the final relationship. This is accomplished by placing the proper short- or open-circuit boundary condition on each undesired port. *Decompaction*, on the other hand, is the process of determining the voltages and currents at each port of every multiport network in the interconnection, subject to the necessary and sufficient boundary conditions applied to the accessible ports of the interconnection.

Several different matrix forms are used in describing multiport networks. The Z-form relates voltage to current, i.e.,

$$[E] = [Z][I]$$

where $[E]$ is the voltage vector, $[Z]$ is impedance matrix, and $[I]$ is the current vector. The Y-form relates current to voltage, or

$$[I] = [Y][E],$$

where $[I]$ and $[E]$ are vectors as before, and $[Y]$ is the admittance matrix. Another useful form which is defined for even-order networks only is the A-form, which maps output port variables into the input port variables, i.e., for a two-port network,

$$\begin{bmatrix} E_i \\ I_i \end{bmatrix} = [A] \begin{bmatrix} E_o \\ I_o \end{bmatrix}.$$

The naming convention adopted for network ports is

$$\pm i X_n Y_k$$

where

i is the port number (arbitrarily numbered from 1, ..., n for each network),

X and Y are any pair of letters used to uniquely name the network or interconnection,

n is the number of ports possessed by network $X_n Y$, and

k is the piece number (used only for certain types of networks which allow automatic cascading of pieces with the same name – normally 2×2 matrices in the A-form).

Note: A *section* is either an input network which has no piece numbers or a network which is composed of cascaded pieces.

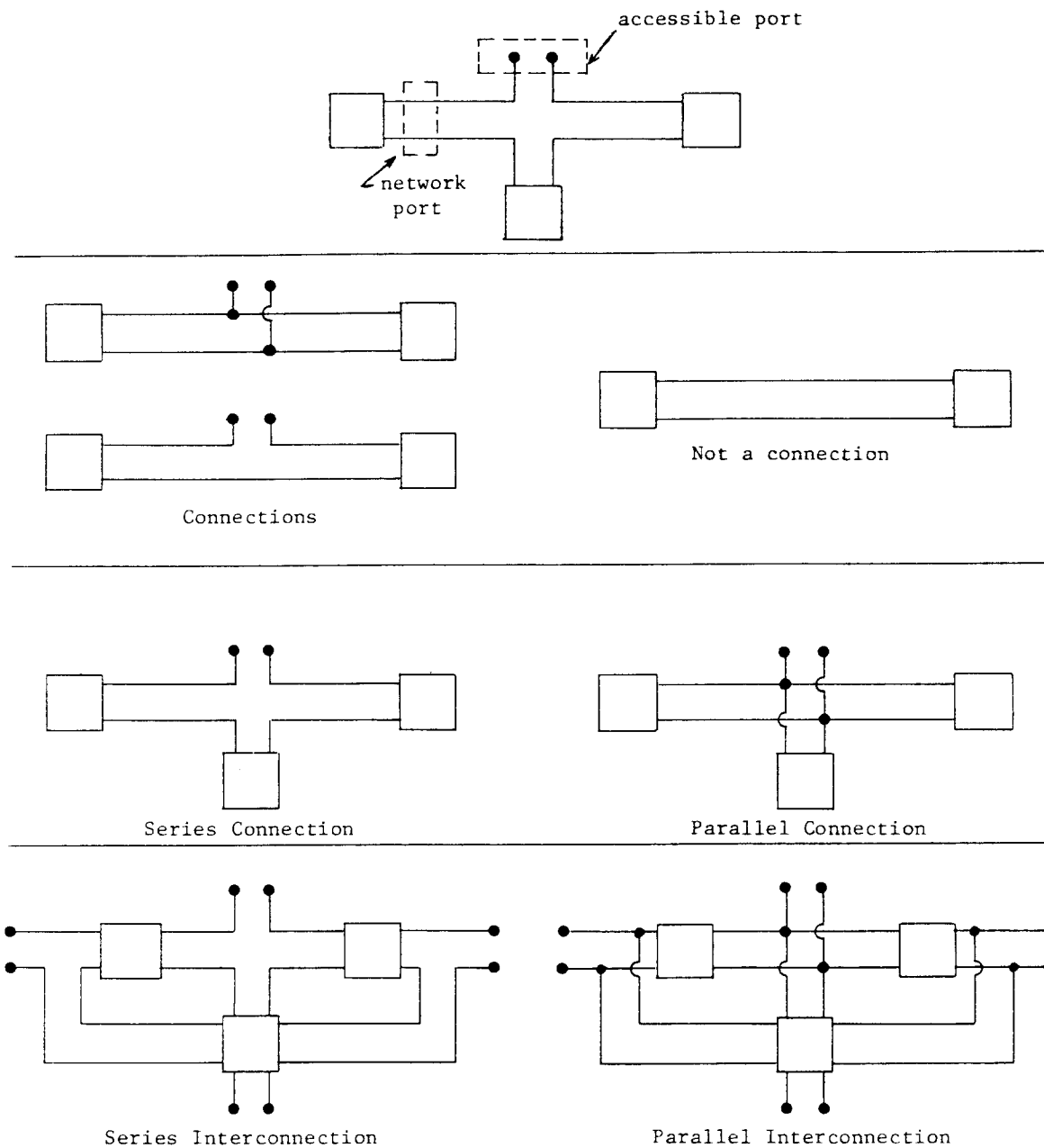


Figure 1. Illustration of Definitions. In many cases an accessible port is introduced artificially in order to satisfy the definition of a connection and then is later terminated with a trivial boundary condition (opened or shorted).

The signs preceding the name are used to define the sign convention prescribed by the user and represent the sign of the dependent variable (or force, for series) and independent variable (or velocity, for series), respectively. For example, consider the network, A2B, shown in figure 2. The first accessible port is 1A2B, and the second is 2A2B. The connection joins two pieces, A2B1 and A2B2.

Several different network sign conventions may be used simultaneously with an interconnection provided that the sign convention ascribed to a given network is consistent with the given network equations.

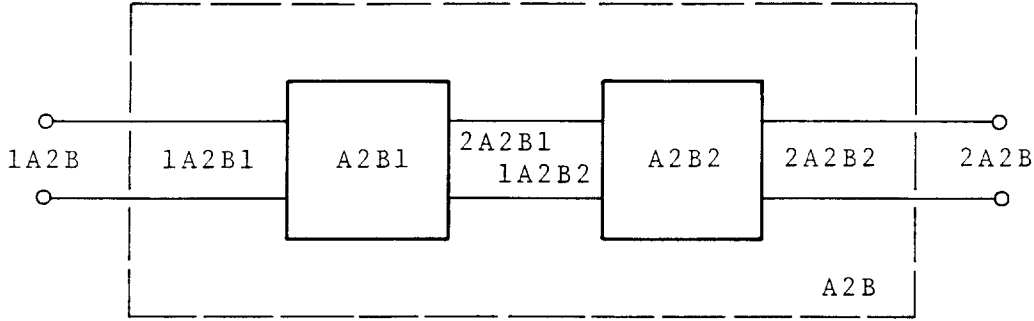


Figure 2. Network Illustrating Naming Convention.

THEORETICAL DESCRIPTION OF MULTI-PORT INTERCONNECTION TECHNIQUE

The technique described in this section is simply a transformation of variables process. The voltages and currents at each network port (old variables) are transformed into the voltages and currents at each accessible port (new variables) by means of two transformation matrices determined by the interconnection topology and by Kirchoff's laws. The determination of these two transformation matrices and subsequent operations are much simpler if the appropriate connection definition (series or parallel) is used wherever there is a choice.

The following development assumes a hybrid or mixed form of interconnection for generality. Consider the b^{th} interconnection of N multiport networks where each network has p_n ports ($n=1,2,\dots,r,\dots,N$). Each network may be written in the following form relating *network port* variables:

$$[W_i^r] = [K_{ij}^r] [U_j^r] \quad (i,j=1,2,3,\dots,p_r),$$

where $[W_i^r]$ and $[U_j^r]$ are column vectors of p_r components, $[K_{ij}^r]$ is a square matrix of $p_r \times p_r$ components, and W_a^r and U_a^r are the two port variables at the a^{th} port of the r^{th} network.

Proper formulation of $[W_i^r]$ and $[U_j^r]$ implies the following conditions for the r^{th} network:

if 'a' is a series network port, $W_a^r = E_a^r$ and $U_a^r = I_a^r$;

if 'a' is a parallel network port, $W_a^r = I_a^r$ and $U_a^r = E_a^r$.

where E denotes port voltage and I denotes port current.

These "proper formulation" rules are required to allow an automatic application of short- and open-circuit boundary conditions to undesired accessible ports during the *compaction* process.

Since each network matrix equation is independent of the interconnection, the entire set of interconnected multiport networks may be arrayed in a single matrix equation, once the individual network equations are in proper form.

$$\begin{bmatrix} (W_i^1) \\ (W_i^2) \\ \vdots \\ (W_i^N) \end{bmatrix} = \begin{bmatrix} (K_{ij}^1) & (0) & \dots & (0) \\ (0) & (K_{ij}^2) & \dots & (0) \\ \vdots & \vdots & \ddots & \vdots \\ (0) & (0) & \dots & (K_{ij}^N) \end{bmatrix} \begin{bmatrix} (U_j^1) \\ (U_j^2) \\ \vdots \\ (U_j^N) \end{bmatrix} \quad (i,j=1,2,\dots,p_n),$$

or, expressed simply, $[W_i^n] = [K_{ij}^n] [U_j^n]$ ($n=1,2,\dots,N$) ($i,j=1,2,\dots,p_n$), where $[W_i^n]$ and $[U_j^n]$ are column vectors of $\sum_{n=1}^N p_n$ components (each a voltage or current) and $[K_{ij}^n]$ is a square matrix of $\sum_{n=1}^N p_n \times \sum_{n=1}^N p_n$ components.

Consider the relationship of *accessible port* variables for the b^{th} interconnection (p_b in number):

$$[W_k^b] = [K_{k\ell}^b] [U_\ell^b] \quad (k,\ell=1,2,\dots,p_b),$$

where $[W_k^b]$ and $[U_\ell^b]$ are column vectors of p_b components, each a voltage or current, and $[K_{k\ell}^b]$ is a $p_b \times p_b$ square matrix.

From previous definitions and conventions, the p_b accessible ports include, at a minimum, a series accessible port in every series connection, a parallel accessible port in every parallel connection, and an unaffected accessible port for every unaffected network port (which may be specified as either series or parallel connection). If additional accessible ports are introduced, they will lead, at best, to formation of hybrid connections necessitating further work.

Again, proper formulation of $[W_k^b]$ and $[U_\ell^b]$ implies that

if a is a series port, $W_a^b = E_a^b$ and $U_a^b = I_a^b$;

if a is a parallel port, $W_a^b = I_a^b$ and $U_a^b = E_a^b$,

where E denotes port voltage and I denotes port current.

In general (for the hybrid or mixed interconnection), the W and U matrices contain both E and I elements mixed according to the occurrence of series and parallel connections and unaffected ports in the hybrid interconnection. If all connections are series or all connections are parallel, the W and U matrices will not be mixed.

The transformation matrices are defined as follows:

$$[W_k^b] \stackrel{D}{=} [C^b] [W_i^n] \quad (\text{subscripts as before})$$

$$[U_j^n] \stackrel{D}{=} [D^b] [U_\ell^b]$$

$$[W_k^b] = [C^b] [W_i^n] = [C^b] [K_{ij}^n] [U_j^n] = [C^b] [K_{ij}^n] [D^b] [U_\ell^b]$$

which implies

$$[K_{k\ell}^b] = [C^b] [K_{ij}^n] [D^b].$$

The $[C^b]$ and $[D^b]$ *connection* or *transformation* matrices are determined by applying Kirchoff's laws to the interconnection topology and will contain only integer elements equal to zero or ± 1 . $[C^b]$ has p_b rows and $\sum_{n=1}^N p_n$ columns, and $[D^b]$ has $\sum_{n=1}^N p_n$ rows and p_b columns.

If there exists a connection between two or more network ports without at least one involved accessible port (contrary to definition), a row or column of the $[C^b]$ and $[D^b]$ matrices will contain all zeros and will cause an invalid variable transformation.

Consider the matrix equation for all accessible ports for the b^{th} interconnection following transformation of variables:

$$[W_k^b] = [K_{k\ell}^b] [U_\ell^b] \quad (k, \ell = 1, 2, \dots, p_b).$$

Many of the accessible ports present during transformation of variables may have trivial boundary conditions (i.e., open- or short-circuit) and this may not be desired in the final relationship. *Compaction* of the interconnection is accomplished as follows:

Let

α = number of desired accessible ports,

β = number of undesired accessible ports (to be shorted if series and opened if parallel in form).

Therefore,

$$p_b = \alpha + \beta.$$

The matrix equation after transformation of variables must be partitioned (by the method described later in this section). The rearranged and partitioned equation may be written as (dropping the interconnection-naming superscript, "b")

$$\begin{bmatrix} [W_a] \\ [W_b] \end{bmatrix} = \begin{bmatrix} [K_{ac}] & [K_{ad}] \\ [K_{bc}] & [K_{bd}] \end{bmatrix} \begin{bmatrix} [U_c] \\ [U_d] \end{bmatrix} \quad \begin{matrix} (a,c=1,2,\dots,\alpha) \\ (b,d=1,2,\dots,\beta) \end{matrix}$$

The undesired ports may be removed by setting $[W_b] = [0]$. This effectively shorts a series port ($E \rightarrow 0$) and opens a parallel port ($I \rightarrow 0$) which generally represents the trivial boundary conditions. Therefore, setting $[W_b] = [0]$ and rearranging terms, we find that

$$[U_d] = -[K_{bd}]^{-1} [K_{bc}] [U_c].$$

So

$$[W_a] = \left[[K_{ac}] - [K_{ad}] [K_{bd}]^{-1} [K_{bc}] \right] [U_c],$$

or

$$[W_a] = [H_{ac}] [U_c],$$

where

$$[H_{ac}] = [K_{ac}] - [K_{ad}] [K_{bd}]^{-1} [K_{bc}].$$

This is the generalized compacted interconnection equation relating voltages and currents (or analogous quantities) at the α desired accessible ports of the N interconnected multi-port networks.

To illustrate the decompaction process, consider the generalized *compacted* interconnection equation for the b^{th} interconnection:

$$[W_a^b] = [H_{ac}^b] [U_c^b] \quad (a,c=1,2,\dots,\alpha).$$

The applied boundary conditions are such that $[U_c]$ can be evaluated as a function of the known terminating impedances, voltages, and currents, i.e.,

(It is necessary and sufficient that α independent boundary conditions be specified.)

$$[U_c^b] = f(W, W/U, U), \quad .$$

where W , W/U , and U are the necessary boundary conditions at the accessible ports of the compacted interconnection. From the previous development of the compacted interconnection equation, $[U_d]$ may be computed:

$$[U_d^b] = -[K_{bd}^b]^{-1} [K_{bc}^b] [U_c^b] \quad \begin{array}{l} (a,c=1,2,\dots,\alpha) \\ (b,d=1,2,\dots,\beta). \end{array}$$

So, $[U_\ell^b]$ may be computed:

$$[U_\ell^b] = \begin{bmatrix} U_c^b \\ U_d^b \end{bmatrix} \quad (\ell=1,2,\dots,p_b).$$

Also, $[U_j^n]$ may be computed:

$$[U_j^n] = [D^b] [U_\ell^b].$$

Decomposition allows computation of all network port variables, subject to boundary conditions, as follows:

$$[U_j^n] = [D^b] \begin{bmatrix} [U_c^b] \\ [-[K_{bd}^b]^{-1} [K_{bc}^b] [U_c^b]] \end{bmatrix} \quad (\text{Subscripts as before})$$

$$[W_j^n] = [K_{ij}^n] [U_j^n].$$

PARTITIONING METHOD

A *partitioning method* for rearrangement of variables can be used to convert any network equation into a more desirable form than might occur as a matter of course. Consider the following:

$$[W_\alpha^b] = [K_{\alpha\gamma}^b] [U_\gamma^b] \quad (\alpha,\gamma=1,2,\dots,p_b),$$

or simply,

$$[W] = [K] [U].$$

Where certain elements of $[W]$ are voltages (at series ports) and others are currents (at parallel ports). Rearrangement and partitioning yields

$$\begin{bmatrix} [W_s] \\ [W_p] \end{bmatrix} = \begin{bmatrix} [H_1] & [H_2] \\ [H_3] & [H_4] \end{bmatrix} \begin{bmatrix} [U_s] \\ [U_p] \end{bmatrix},$$

where

$[W_s]$ and $[U_s]$ exist at series ports

and

$[U_p]$ and $[W_p]$ exist at parallel ports.

i.e., the series port variables and parallel port variables have been grouped in each of the vectors. Although similar manipulation will produce various forms of this matrix equation, the relationship in the Z-form,

$$\begin{bmatrix} [W_s] \\ [U_p] \end{bmatrix} = \begin{bmatrix} [Z_1] & [Z_2] \\ [Z_3] & [Z_4] \end{bmatrix} \begin{bmatrix} [U_s] \\ [W_p] \end{bmatrix},$$

or

$$[E] = [Z][I],$$

is found by solving

$$[W_s] = [H_1] [U_s] + [H_2] [U_p]$$

$$[W_p] = [H_3] [U_s] + [H_4] [U_p]$$

for

$$[U_p] = [H_4]^{-1} [W_p] - [H_4]^{-1} [H_3] [U_s].$$

We find that

$$[W_s] = [H_2] [H_4]^{-1} [W_p] + \left[[H_1] - [H_2] [H_4]^{-1} [H_3] \right] [U_s].$$

Therefore,

$$[Z] = \begin{bmatrix} [H_1] - [H_2] [H_4]^{-1} [H_3] & [H_2] [H_4]^{-1} \\ -[H_4]^{-1} [H_3] & [H_4]^{-1} \end{bmatrix}.$$

The resultant Z-form relates the voltages at the network ports to the currents at the network ports.

In general, this partitioning method is used in converting individual multiport equations into required form, and is used in compaction. Also, if it is necessary to short a parallel port ($E \rightarrow 0$) or open a series port ($I \rightarrow 0$), this method can be used prior to compaction to arrange the elements of $[W]$ appropriately. Finally, in setting boundary conditions, this method is used to solve for $[U_c]$ from the actual boundary conditions applied to the desired accessible ports.

The current computer program will not handle hybrid interconnections (i.e., mixtures of series and parallel interconnections); therefore, only two types of interconnections will be discussed.

Type S

This interconnection is composed exclusively of series connections. Type S requires the use of a Z-form description of the individual networks, which is a common form for network description. This type occurs most frequently in transducer models. Figure 3 shows an example of a series interconnection of three multiport networks having two desired accessible ports where loop 4 involves only two network ports and, therefore, may be treated as either a parallel or series connection. Figure 4 shows the interconnection with all four accessible ports, one being the unaffected network port and one involved in each of the three series connections.

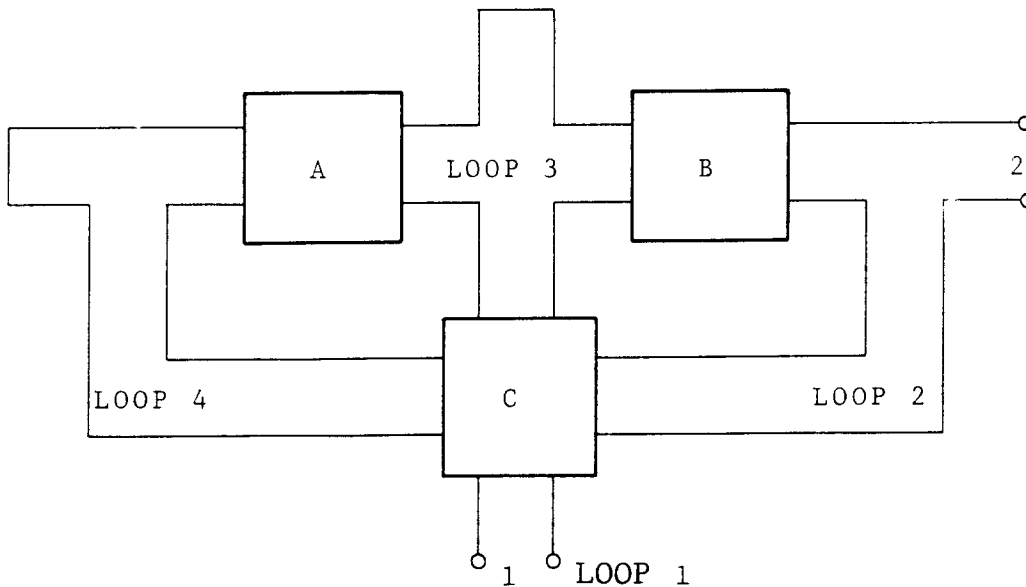


Figure 3. Series Interconnection.

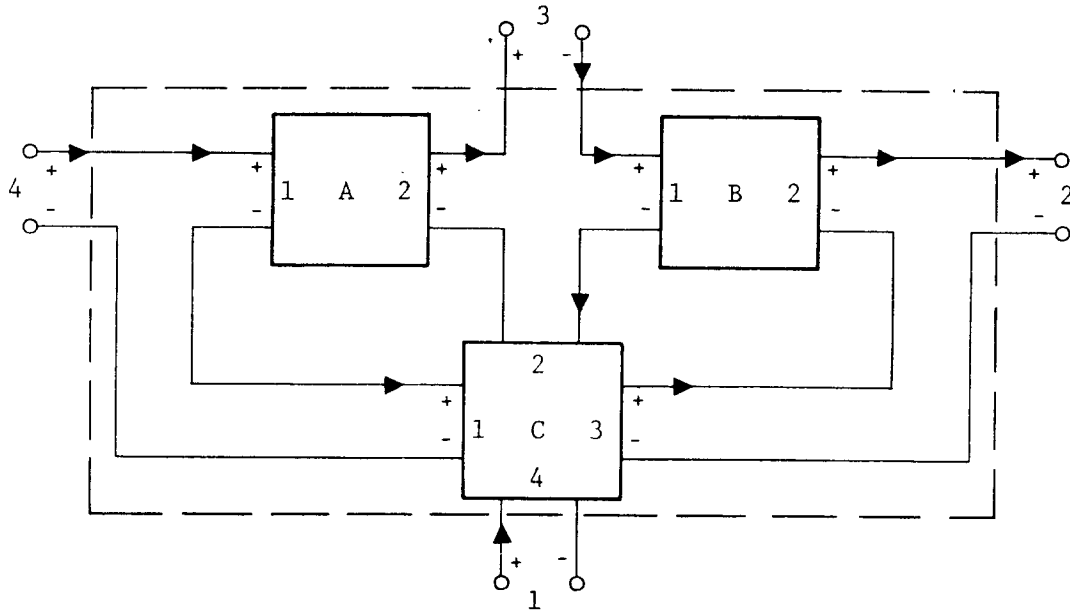


Figure 4. Series Interconnection With Sign Convention.

The following equations describe each of the networks shown in the figure:

$$\begin{bmatrix} E_1^A \\ E_2^A \end{bmatrix} = \begin{bmatrix} Z_{11}^A & Z_{12}^A \\ Z_{21}^A & Z_{22}^A \end{bmatrix} \begin{bmatrix} I_1^A \\ I_2^A \end{bmatrix},$$

$$\begin{bmatrix} E_1^B \\ E_2^B \end{bmatrix} = \begin{bmatrix} Z_{11}^B & Z_{12}^B \\ Z_{21}^B & Z_{22}^B \end{bmatrix} \begin{bmatrix} I_1^B \\ I_2^B \end{bmatrix},$$

$$\begin{bmatrix} E_1^C \\ E_2^C \\ E_3^C \\ E_4^C \end{bmatrix} = \begin{bmatrix} Z_{11}^C & Z_{12}^C & Z_{13}^C & Z_{14}^C \\ Z_{21}^C & Z_{22}^C & Z_{23}^C & Z_{24}^C \\ Z_{31}^C & Z_{32}^C & Z_{33}^C & Z_{34}^C \\ Z_{41}^C & Z_{42}^C & Z_{43}^C & Z_{44}^C \end{bmatrix} \begin{bmatrix} I_1^C \\ I_2^C \\ I_3^C \\ I_4^C \end{bmatrix}$$

The Z-form was chosen since every port involved in the connection is a series port and the description of the ports should therefore use current as the independent variable, i.e.,

$$[W_i^n] = [E_i^n],$$

$$[U_j^n] = [I_j^n].$$

The entire set of network equations can be written

$$[W_i^n] = [K_{ij}^n] [U_j^n] \quad (n=A,B,C).$$

or

$$[E_i^n] = [Z_{ij}^n] [I_j^n] \quad (\text{for series ports}).$$

Thus,

$$\begin{bmatrix} E_1^A \\ E_2^A \\ E_1^B \\ E_2^B \\ E_1^C \\ E_2^C \\ E_3^C \\ E_4^C \end{bmatrix} = \begin{bmatrix} Z_{11}^A & Z_{12}^A & 0 & 0 & 0 & 0 & 0 & 0 \\ Z_{21}^A & Z_{22}^A & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & Z_{11}^B & Z_{12}^B & 0 & 0 & 0 & 0 \\ 0 & 0 & Z_{21}^B & Z_{22}^B & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & Z_{11}^C & Z_{12}^C & Z_{13}^C & Z_{14}^C \\ 0 & 0 & 0 & 0 & Z_{21}^C & Z_{22}^C & Z_{23}^C & Z_{24}^C \\ 0 & 0 & 0 & 0 & Z_{31}^C & Z_{32}^C & Z_{33}^C & Z_{34}^C \\ 0 & 0 & 0 & 0 & Z_{41}^C & Z_{42}^C & Z_{43}^C & Z_{44}^C \end{bmatrix} \begin{bmatrix} I_1^A \\ I_2^A \\ I_1^B \\ I_2^B \\ I_1^C \\ I_2^C \\ I_3^C \\ I_4^C \end{bmatrix}.$$

Next, we write the relationships between voltages and currents at the four accessible ports of the interconnection (naming it "D"):

$$[W_k^D] = [K_{k\ell}^D] [U_\ell^D] \quad (k, \ell = 1, 2, 3, 4).$$

Since all four accessible ports are series ports,

$$[W_k^D] = [E_k^D],$$

$$[U_\ell^D] = [I_\ell^D],$$

and

$$\begin{bmatrix} E_1^D \\ E_2^D \\ E_3^D \\ E_4^D \end{bmatrix} = [Z_{k\ell}^D] \begin{bmatrix} I_1^D \\ I_2^D \\ I_3^D \\ I_4^D \end{bmatrix}.$$

The transformation of variables is accomplished by means of the $[C^D]$ and $[D^D]$ matrices, which can be determined by inspection of figure 4 (for sign conventions, etc.) and by referral to Kirchoff's laws.

$$\begin{bmatrix} E_1^D \\ E_2^D \\ E_3^D \\ E_4^D \end{bmatrix} = [C^D] \begin{bmatrix} E_1^A \\ E_2^A \\ E_1^B \\ E_2^B \\ E_1^C \\ E_2^C \\ E_3^C \\ E_4^C \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & -1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} E_1^A \\ E_2^A \\ E_1^B \\ E_2^B \\ E_1^C \\ E_2^C \\ E_3^C \\ E_4^C \end{bmatrix},$$

or

$$\begin{aligned} E_1^D &= E_4^C \\ E_2^D &= E_2^B + E_3^C \\ E_3^D &= E_2^A + E_2^C - E_1^B \\ E_4^D &= E_1^A + E_1^C \end{aligned}$$

$$\begin{bmatrix} I_1^A \\ I_2^A \\ I_1^B \\ I_2^B \\ I_1^C \\ I_2^C \\ I_3^C \\ I_4^C \end{bmatrix} = [D^D] \begin{bmatrix} I_1^D \\ I_2^D \\ I_3^D \\ I_4^D \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_1^D \\ I_2^D \\ I_3^D \\ I_4^D \end{bmatrix}$$

or

$$I_1^D = I_4^C$$

$$I_2^D = I_2^B = I_3^C$$

$$I_3^D = I_2^A = I_1^B = I_2^C$$

$$I_4^D = I_1^A = I_1^C$$

Finally, using the expression from the general description

$$[K_{k\ell}^D] = [C^D] [K_{ij}^n] [D^D],$$

we find that

$$[K_{k\ell}^D] = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & -1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} z_{11}^A & z_{12}^A & 0 & 0 & 0 & 0 & 0 & 0 \\ z_{21}^A & z_{22}^A & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & z_{11}^B & z_{12}^B & 0 & 0 & 0 & 0 \\ 0 & 0 & z_{21}^B & z_{22}^B & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & z_{11}^C & z_{12}^C & z_{13}^C & z_{14}^C \\ 0 & 0 & 0 & 0 & z_{21}^C & z_{22}^C & z_{23}^C & z_{24}^C \\ 0 & 0 & 0 & 0 & z_{31}^C & z_{32}^C & z_{33}^C & z_{34}^C \\ 0 & 0 & 0 & 0 & z_{41}^C & z_{42}^C & z_{43}^C & z_{44}^C \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

or

$$[K_{k\ell}^D] = \begin{bmatrix} z_{44}^C & z_{43}^C & z_{42}^C & z_{41}^C \\ z_{34}^C & (z_{33}^C + z_{22}^B) & (z_{32}^C + z_{21}^B) & z_{31}^C \\ z_{24}^C & (z_{23}^C - z_{12}^B) & (z_{22}^C + z_{22}^A - z_{11}^B) & (z_{21}^C + z_{21}^A) \\ z_{14}^C & z_{13}^C & (z_{12}^C + z_{12}^A) & (z_{11}^C + z_{11}^A) \end{bmatrix}$$

Since the boundary conditions at accessible ports 3 and 4 are trivial short circuits, the matrix may be compacted. This compaction will not be done in detail but will be sketched as follows (no rearrangement is necessary in this instance):

$$\begin{bmatrix} E_1^D \\ E_2^D \\ E_3^D \\ E_4^D \end{bmatrix} = \begin{bmatrix} z_{44}^C & z_{43}^C & | & z_{42}^C & z_{41}^C \\ z_{34}^C & (z_{33}^C + z_{22}^B) & | & (z_{32}^C + z_{21}^B) & z_{31}^C \\ z_{24}^C & (z_{23}^C - z_{12}^B) & | & (z_{22}^C + z_{22}^A - z_{11}^B) & (z_{21}^C + z_{21}^A) \\ z_{14}^C & z_{13}^C & | & (z_{12}^C + z_{12}^A) & (z_{11}^C + z_{11}^A) \end{bmatrix} \begin{bmatrix} I_1^D \\ I_2^D \\ I_3^D \\ I_4^D \end{bmatrix} = \begin{bmatrix} E_a^D \\ E_b^D \end{bmatrix}$$

Recall that if

$$\begin{bmatrix} [W_a] \\ [W_b] \end{bmatrix} = \begin{bmatrix} [K_{ac}] & [K_{ad}] \\ [K_{bc}] & [K_{bd}] \end{bmatrix} \begin{bmatrix} [U_c] \\ [U_d] \end{bmatrix} \quad \begin{array}{l} \text{a.c} \Rightarrow \text{desired} \\ \text{b.d} \Rightarrow \text{undesired.} \end{array}$$

and

$$[W_b] = 0$$

then

$$[W_a] = [K_{ac}] - [K_{ad}][K_{bd}]^{-1}[K_{bc}] \quad [U_c] = [H^D][U_c].$$

Therefore,

$$\begin{bmatrix} H_{11}^D & H_{12}^D \\ H_{21}^D & H_{22}^D \end{bmatrix} = \begin{bmatrix} (Z_{44}^C) & (Z_{43}^C) \\ (Z_{34}^C) & (Z_{33}^C + Z_{22}^B) \end{bmatrix} - \begin{bmatrix} (Z_{42}^C) & (Z_{41}^C) \\ (Z_{32}^C + Z_{21}^B) & (Z_{31}^C) \end{bmatrix} \\ \times \begin{bmatrix} (Z_{22}^C + Z_{22}^A - Z_{11}^B) & (Z_{21}^C + Z_{21}^A) \\ (Z_{12}^C + Z_{12}^A) & (Z_{11}^C + Z_{11}^A) \end{bmatrix}^{-1} \times \begin{bmatrix} Z_{24}^C & (Z_{23}^C - Z_{12}^B) \\ Z_{14}^C & Z_{13}^C \end{bmatrix},$$

which will yield through simple matrix multiplication and addition a final result in the form

$$\begin{bmatrix} E_1^D \\ E_2^D \end{bmatrix} = \begin{bmatrix} H_{11}^D & H_{12}^D \\ H_{21}^D & H_{22}^D \end{bmatrix} \begin{bmatrix} I_1^D \\ I_2^D \end{bmatrix},$$

where the elements of the H-matrix are known in terms of the elements of the Z-matrices for the three networks which were given originally.

Type P

This interconnection is composed exclusively of parallel connections. The example is included here to illustrate that connections involving only two network ports may be treated either as series or parallel. Consider the same three networks used in the Type S example, but connected in parallel as shown in figure 5. Node-pair 4 is introduced instead of Loop 4 as before, and is treated as a parallel connection here. The Y-form will be used for this interconnection, since every port involved is a parallel port. In view of the requirements of proper formulation discussed previously, voltage must be the independent variable. Thus,

$$[W_i^n] = [I_i^n]$$

$$[U_j^n] = [E_j^n] \quad (\text{for parallel ports}).$$

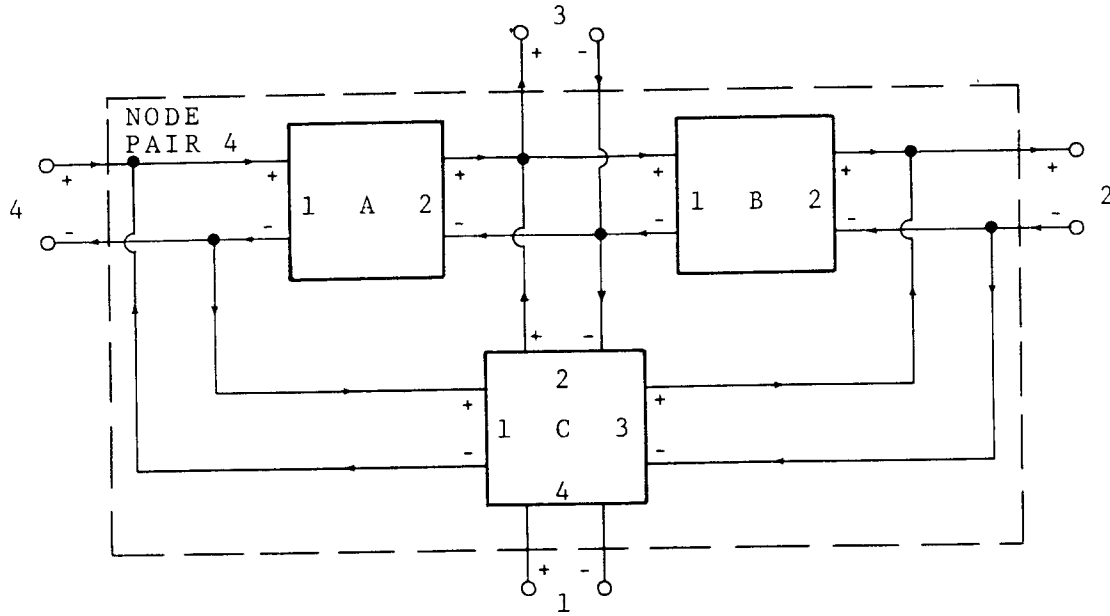


Figure 5. Parallel Interconnection.

If the Z-form is known for each network, the following conversion from the Z-form to the Y-form is required:

We know that $[E] = [Z] [I]$,

$$[I] = [Z]^{-1} [E],$$

and

$$[I] = [Y] [E].$$

Therefore,

$$[Y] = [Z]^{-1}.$$

In particular, for A, B, and C,

$$[I^A] = [Y^A] [E^A], \text{ where } [Y^A] = [Z^A]^{-1};$$

$$[I^B] = [Y^B] [E^B], \text{ where } [Y^B] = [Z^B]^{-1};$$

and

$$[I^C] = [Y^C] [E^C], \text{ where } [Y^C] = [Z^C]^{-1}.$$

It should be noted that the unaffected port can also be considered as a series port, as is done for Type S interconnection, in which case the matrix equation for network C would take the following hybrid K-form (not yet implemented in the computer program package):

$$\begin{bmatrix} I_1^C \\ I_2^C \\ I_3^C \\ E_4^C \end{bmatrix} = \begin{bmatrix} K_{11}^C & K_{12}^C & K_{13}^C & K_{14}^C \\ K_{21}^C & K_{22}^C & K_{23}^C & K_{24}^C \\ K_{31}^C & K_{32}^C & K_{33}^C & K_{34}^C \\ K_{41}^C & K_{42}^C & K_{43}^C & K_{44}^C \end{bmatrix} \begin{bmatrix} E_1^C \\ E_2^C \\ E_3^C \\ I_4^C \end{bmatrix},$$

where $[K^C]$ is determined from $[Z^C]$ by means of the partitioning method discussed previously. However, this unaffected network port is treated as a parallel port in this example to simplify the problem and to allow the use of the simpler Y-form notation.

The entire set of network equations can be written as

$$\begin{bmatrix} I_1^A \\ I_2^A \\ I_1^B \\ I_2^B \\ I_1^C \\ I_2^C \\ I_3^C \\ I_4^C \end{bmatrix} = \begin{bmatrix} Y_{11}^A & Y_{12}^A & 0 & 0 & 0 & 0 & 0 & 0 \\ Y_{21}^A & Y_{22}^A & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & Y_{11}^B & Y_{12}^B & 0 & 0 & 0 & 0 \\ 0 & 0 & Y_{21}^B & Y_{22}^B & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & Y_{11}^C & Y_{12}^C & Y_{13}^C & Y_{14}^C \\ 0 & 0 & 0 & 0 & Y_{21}^C & Y_{22}^C & Y_{23}^C & Y_{24}^C \\ 0 & 0 & 0 & 0 & Y_{31}^C & Y_{32}^C & Y_{33}^C & Y_{34}^C \\ 0 & 0 & 0 & 0 & Y_{41}^C & Y_{42}^C & Y_{43}^C & Y_{44}^C \end{bmatrix} \begin{bmatrix} E_1^A \\ E_2^A \\ E_1^B \\ E_2^B \\ E_1^C \\ E_2^C \\ E_3^C \\ E_4^C \end{bmatrix}.$$

Again, if we name the interconnection "Network #D", the relationship between the voltages and currents at the four accessible ports is described by the following equations:

$$[W_k^D] = [K_{k\ell}^D] [U_\ell^D] \quad (k, \ell = 1, 2, 3, 4),$$

where

$$[W_k^D] = [I_k^D],$$

$$[U_\ell^D] = [E_\ell^D],$$

and $[K_{k\ell}^D] = [Y_{k\ell}^D].$

Thus, $[I_k^D] = [Y_{k\ell}^D] [E_\ell^D].$

The transformation of variables is again accomplished by means of the $[C^D]$ and $[D^D]$ matrices, which are determined from the diagram and Kirchoff's laws.

$$[I_k^D] = [C^D] [I_1^n]; [E_j^n] = [D^D] [E_\ell^D]$$

$$[C^D] = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & -1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{bmatrix} \quad \begin{aligned} I_1^D &= I_4^C \\ I_2^D &= I_2^B + I_3^C \\ I_3^D &= I_2^A + I_2^C - I_1^B \\ I_4^D &= I_1^A - I_1^C \end{aligned}$$

$$[D^D] = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \quad \begin{aligned} E_1^D &= E_4^C \\ E_2^D &= E_2^B = E_3^C \\ E_3^D &= E_2^A = E_1^B = E_2^C \\ E_4^D &= E_1^A = -E_1^C \end{aligned}$$

Finally,

$$[Y_{k\ell}^D] = [C^D][Y_{ij}^n][D^D];$$

$$[Y_{k\ell}^D] = \begin{bmatrix} Y_{44}^C & Y_{43}^C & Y_{42}^C & -Y_{41}^C \\ Y_{34}^C & (Y_{33}^C + Y_{22}^B) & (Y_{32}^C + Y_{21}^B) & -Y_{31}^C \\ Y_{24}^C & (Y_{23}^C - Y_{12}^B) & (Y_{22}^C + Y_{22}^A - Y_{11}^B) & (Y_{21}^A - Y_{21}^C) \\ -Y_{14}^C & -Y_{13}^C & (-Y_{12}^C + Y_{12}^A) & (Y_{11}^A + Y_{11}^C) \end{bmatrix}.$$

Since ports 3 and 4 are trivially open circuited, the matrix equation can again be compacted to yield this expression:

$$\begin{bmatrix} I_1^D \\ I_2^D \end{bmatrix} = [H^D] \begin{bmatrix} E_1^D \\ E_2^D \end{bmatrix},$$

where $[H^D]$ is now in the Y-form.

The fact that only series and parallel interconnections are considered here should not be construed by the reader to mean that the theoretical methods presented are restricted to these types of connections. The theory is general and valid for hybrid interconnections; however, the computer program will, at present, handle only series interconnections or parallel interconnections.

GENERAL DESCRIPTION OF COMPUTER PROGRAM

The purpose of this section is to provide insight into the basic features of the computer program for both programmers and non-programmers. The description is organized into the following sections:

- (1) SEADUCER Computer Programming Considerations,
- (2) Network Types,
- (3) Interconnection Table,
- (4) Catalog,
- (5) Boundary Condition Specification,
- (6) Control Program,
- (7) Program Conversion from Double Precision to Single Precision, and
- (8) Summary.

SEADUCER COMPUTER PROGRAMMING CONSIDERATIONS

Basic design goals for the programming of SEADUCER are as follows:

1. Provide for computerized analysis and design of transducers based on multiport network interconnection techniques.
2. Produce the program in a form as near standard as possible so that it can easily be implemented on most medium- to large-scale digital computers.
3. Provide for automatic run-by-run allocation of the core storage required for storing all input data as well as computed variables and matrices for any transducer configuration.
4. Provide an extremely straightforward method for converting the program from double precision to single precision.
5. Allow for complete program flexibility by requiring for each application the preparation of a main routine, written in the programming language, which explicitly controls the flow of input, computation, and output.
6. Provide for output options to be controlled independently of computations performed. These options are for printout as well as output via tape or cards to be processed with a separate plotting package.

In order to implement these basic goals, the following measures have been taken:

1. Even though the multiport technique has been implemented primarily for transducer applications, a great deal of care has been taken to allow the implementation of other applications.
2. ASA FORTRAN has been followed as faithfully as possible throughout the body of the program. The primary exception is the use of the FLD function, which must be provided for bit handling.
3. By setting Blank Common to an appropriate size within the main routine, the user is able to set aside only as much core storage as is required for a particular run. This is especially advantageous when using computer systems which charge for the amount of core used. It also eliminates the problem of dimensioning large areas of core that are not used in all applications.
4. The primary mode of the program is double precision. However, a consistent convention has been used throughout the program making it simple to create a single precision version. This allows an installation to maintain both single and double precision versions, if necessary. Where 20 to 23 bits of precision are available in single precision, many applications will require double; while for 48 bits in single precision, it is unlikely that double would be required. Further analysis of the various precisions available will need to be performed for particular applications.

5. Since no package of application-oriented subroutines can ever contain every conceivable option and variation required in a fast-moving research and development environment, SEADUCER requires that for each application a FORTRAN main routine be written (referred to as the Control Routine). For the typical transducer application such as that described in Appendix C, the Control Routine involves several subroutine calls to load the network configuration, several subroutine calls to load the input data, and several calls for the desired logic and output. Only in cases where a large volume of repetitive data is required are actual data cards read in for input parameters. In general, it is desirable to have the input data loaded within the main routine since only in this way can values be directly computed as they are loaded into the program. This method also allows complete flexibility with respect to the order and number of input combinations without having to settle for options preset within the program.

The success of this approach depends upon having a method for the particular computer system which allows the storage (preferably in source and relocatable code) of the entire program on magnetic tape (or disk, drum, etc.). This storage must be in a form such that for a particular run, the user need only keypunch the Control Routine and system control cards required for automatically compiling the Control Routine as well as loading and executing the desired portion of the program. Here is where sophisticated computer system loaders are highly desirable, since they can be used to load only the sections of SEADUCER needed for a particular run. Presently, the entire program cannot be loaded into a 32K word machine at one time, although with proper selective loading techniques, the same computer can be used for many of the runs of interest. When this limit has been reached in a particular computer, the only solution is to have a system for dynamic program segmentation (i.e., where sections of logic are automatically rolled into and out of core during the course of the runs). Also of significant benefit to the user is a computer operating system which offers the capabilities just mentioned as well as the ability to selectively modify and recompile any routine previously stored away, and to use the newly compiled version in the same run.

6. In order to inhibit vast amounts of unnecessary printout, most SEADUCER subroutines have a print option in a common block which can be set. Since SEADUCER is so large and since plotting hardware and software are so non-standard among computer installations, the information which needs to be plotted from SEADUCER is output on cards or magnetic tape in a form convenient for loading into a separate plotting program.

NETWORK TYPES (GENERAL DESCRIPTION)

All networks input by the user must have a special type number associated with them. The routine associated with this particular type number is preprogrammed to compute the elements of a specific form of the matrix (generally Z-form) as a function of specified independent variables (frequency in all applications of transducer analysis and

design). The computations are in general a function of (1) the independent variable, (2) the sign convention assumed for the network, (3) the number of ports, and (4) the port numbering originally specified.

A library of the network types encountered in transducer analysis presently exists. It should be noted that this library is continually expanding as different networks are used, and may be expanded to include other matrix forms or other physical problems. Specific types already implemented are described in Appendix B.

The user can specify types of networks other than those available in the existing library with the following specifications:

- (1) network equations (matrix form; element equations),
- (2) port sign conventions and numbering, and
- (3) definitions of the input constants needed to compute the network matrix elements.

If the network under consideration is actually composed of a number of two-port networks cascaded together, the user may take advantage of a short-cut technique used widely for transducer problems. Each piece is simply considered as a network having the same name as the composite except for an additional number of the right side of the name which designates piece number. The program automatically cascades the A-form matrices representing each piece of the same name together to acquire the matrix for the composite network, called a section.

INTERCONNECTION TABLE

All interconnections of linear networks may be considered to be single networks themselves having similar properties, i.e., sign conventions, port numbering, boundary conditions, and names. The *accessible ports* are the ports of the interconnection, and *network ports* are the ports of the component networks. All connections involve *just* one accessible port and *at least* one network port. The interconnection table is a description of the interconnection for the computer program and contains sufficient information to allow complete non-ambiguous reconstruction of the interconnection.

Basically, for each connection, the following information is required to describe the interconnection:

- (1) connection type (i.e., series or parallel),
- (2) sign convention at the connection,
- (3) accessible port name, and
- (4) names of all involved network ports.

For example, consider the interconnection shown in figure 6.

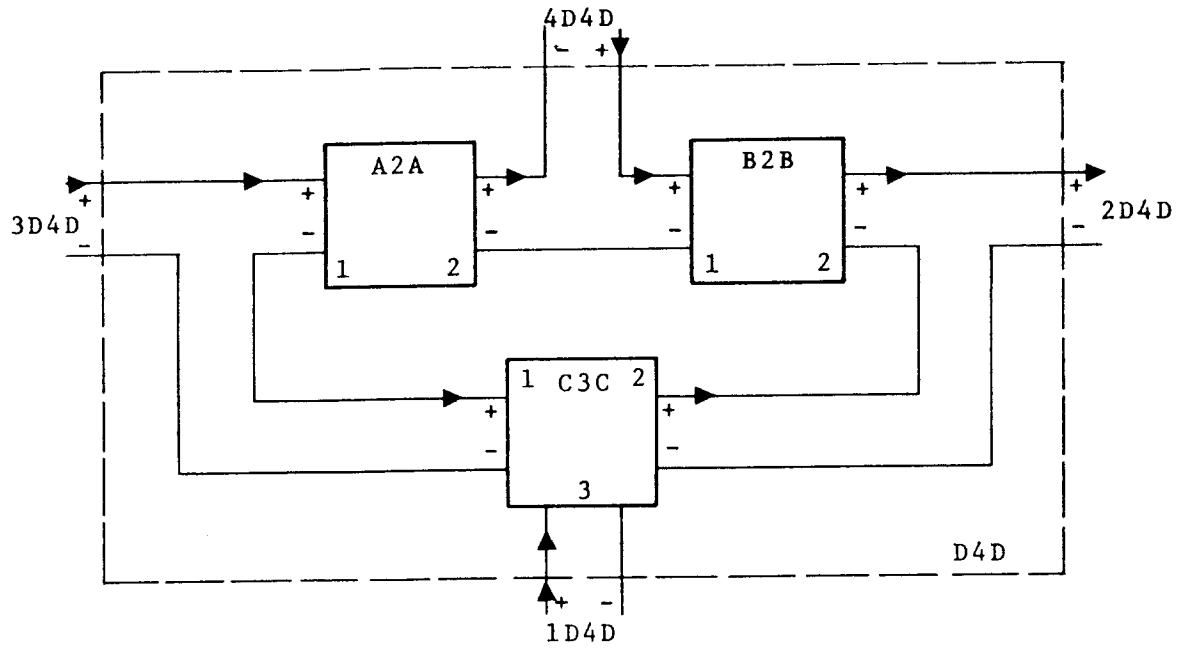


Figure 6. Example of Interconnected Array of Networks.

The following equations relate the voltage and currents at the accessible ports to the voltages and currents at the network ports:

$$\begin{aligned}
 (1) \quad E_1^D &= E_3^C, \quad I_1^D = I_3^C \\
 (2) \quad E_2^D &= E_2^B + E_2^C, \quad I_2^D = I_2^B = I_2^C \\
 (3) \quad E_3^D &= E_1^A + E_1^C, \quad I_3^D = I_1^A = I_1^C \\
 (4) \quad E_4^D &= E_1^B - E_2^A, \quad I_4^D = I_1^B = I_1^A
 \end{aligned}$$

The information contained in these equations can then be transferred into an interconnection table as follows:

S ++1D4D, ++3C3C
 S ++2D4D, ++2B2B, ++2C3C
 S ++3D4D, ++1A2A, ++1C3C
 S ++4D4D, -+2A2A, ++1B2B

where S denotes series connection, and signs are for voltage and current (or force and velocity, etc.), respectively.

The interconnection table (or *port table*) is a basic input into the computer program. Each interconnection must be described via its own interconnection table. This information is stored and defines the system of linear equations that is to be solved for the program.

A powerful feature of Seaducer is its provision for nesting of interconnection tables. Therefore, by judiciously choosing interconnection tables, the user can substructure his problem so that portions of the entire network which involve changes in the physical characteristics of components can be studied in depth without recomputing the entire network. (See Appendices C and D.)

CATALOG

The program utilizes a master storage area to retain all input data as well as computed variables and matrices for the individual and combined networks. As each new network is encountered, this area is dynamically allocated in the sense that pointers (subscripts) are set and stored away in the catalog. The catalog stores the following:

- (1) network name,
- (2) matrix size,
- (3) piece number (for cascaded pieces),
- (4) total number of pieces (for a section composed of cascaded pieces),
- (5) network type,
- (6) total amount of storage reserved for basic input values and permanently stored computed quantities, and
- (7) location in master storage area for network with above properties.

For example, the catalog for the network shown in figure 6 might be

	Name	Matrix size	Piece no.	Total number of pieces	Network type	Data storage	Location in master storage
1	DD	4	0	0	0	0	1
2	AA	2	0	1	0	0	65
3	AA	2	1	1	1	7	81
4	BB	2	0	1	0	0	104
5	BB	2	1	1	1	7	120
6	CC	3	1	0	11	34	143

It should be pointed out that for each network port, twice the amount of storage needed is allocated to allow the user storage for different forms (Z-form, A-form, etc.) of the matrix other than that provided by the calculation of the "*network type*" subprogram. In summary, the catalog is used to handle the tedious bookkeeping task involved in the storage of the data and matrices of each network involved in the interconnection.

BOUNDARY CONDITION SPECIFICATION

Boundary conditions must be specified when the process of compaction, or decompaction, is to be carried out. Recall that compaction, as described under Theoretical Description of Multiport Interconnection Technique, is the process of removing undesired ports from the interconnection through application of *trivial* boundary conditions (open circuit or short circuit). The compaction, as done automatically by the program, always assumes zero left-hand side in the equations relating variables at the undesired ports. This effectively shorts a series port and opens a parallel port. Compaction is called automatically for interconnections of the same name which have fewer ports in a succeeding interconnection table. For example, if an interconnection table exists for A6B, and the name A4B appeared in a later interconnection table, then A6B would automatically be reduced to A4B *assuming ports 5 and 6 to be the undesired ports*.

The *decompaction* process is the means of determining voltages and currents at each port of every multiport network in the interconnection subject to sufficient boundary conditions specified by the user. The generalized decompaction process is currently not available, although the force and velocity at the edge of each piece of a 3-3 mode ceramic stack can be found, and decompaction can be done for all cascaded two-port networks.

CONTROL PROGRAM

The program is run by a user-supplied control routine that contains the problem specification. This control routine defines the interconnection tables, defines the network type for each network name appearing in an interconnection table, and specifies the calculations and output to be performed. The control program is a FORTRAN routine supplied by the user which allows added generality for the solution of the user's specific problems. Essentially, a library of subroutines is provided to perform various operations pertinent to the solution of any problem which can be represented by an interconnection of multiport networks. Examples of the control routines used in the solution of several different types of problems are presented in the appendices. Also included in Appendix A are write-ups of all subroutines available with the present program.

The first step to be taken in every control routine is to define the interconnection topology, or port table. This is done by calling a subroutine, LDPORT, once for each accessible port, by specifying the names of the network ports involved in the connection, and by specifying the connection's sign conventions and whether it is series or parallel.

Next, each network port is specified by calling the appropriate (corresponding to network type) routine that stores in the master storage area information that will allow the computation of the impedance (or similar form) matrix for the network. The calculation of the impedance matrix actually takes place in a separate routine if the matrix is a function of an independent variable (e.g., frequency). In other words, every network type has a routine associated with it that stores in the master storage area pertinent data about the network, and calculates the impedance matrix if the matrix is not a function of another independent variable. However, if the impedance matrix is a function of an independent variable, the calculation of the matrix takes place within another routine that is called during the cycling of the independent variable.

The impedance matrix for the entire network is found by effectively pre- and post-multiplying by the [C] and [D] matrices as described under Theoretical Description of Multiport Interconnection Technique. This operation is performed in subroutine BLDKKL. *Actual storage and matrix-multiplication is not required due to the nature of the [C] and [D] matrices.*

The steps described above are the basic steps that are performed in almost all control routines. As mentioned previously, the user can perform any calculations that are necessary and supply all print options.

PROGRAM CONVERSION FROM DOUBLE PRECISION TO SINGLE PRECISION

A consistent programming convention has been used throughout the computer program in order to facilitate the straightforward conversion from double precision to single precision. The following two types of changes are required:

1. Cards to be deleted for the single precision version contain the name of the routine starting in Column 73.
2. Cards to be changed contain the name of the routine starting in Column 73, immediately followed by an *.

Example

Double Precision

```
SUBROUTINE DCACSH (DINR, DINI, DOUTR, DOUTI)
DOUBLE PRECISION DINR, DINI, DOUTR, DOUTI, DTOUTR, DTOUTI  DCACSH
DOUBLE PRECISION DCANG1, DSQRT, DLOG                        DCACSH
.
.
.
DOUTR = DLOG (DSQRT(DTOUTR*DTOUTR+DTOUTI*DTOUTI))          DCACSH*
```

Single Precision

```
SUBROUTINE DCACSH (DINR, DINI, DOUTR, DOUTI)
delete
delete
.
.
.
DOUTR = ALOG(SQRT(DTOUTR*DTOUTR+DTOUTI*DTOUTI))
```

SUMMARY

This section has attempted to provide a description of the computer program in terms that are useful for non-programmers as well as programmers. Due to the general nature of the program package, a clear-cut description of its use is not possible without first defining a problem. For this reason, several examples are included in the appendices to show the user how to construct a control routine for the solution of a particular problem. *The use of a FORTRAN control routine for each different data set allows the user the full generality of the programming system for physical simulation of his specific problem.*

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APPENDIX A

Program Description

Introduction

Presented in this appendix are write-ups describing the primary common storage blocks and all subroutines in the computer program. The primary common blocks are given in order to provide easy reference, and to avoid having to describe a common block several times. The subroutine write-ups describe the basic functions of the routines, and define the variables in the parameter lists.

Packed and Unpacked Network Names

Network names appear throughout the program in two forms, referred to as packed and unpacked. A network name in the packed form is one that has not been decoded by subroutine UNPACK. The name still contains port number, total number of ports for the network, and the piece number if applicable, as well as a terminating \$. An unpacked name is simply the two letter network designation assigned by the user.

Description of the Primary Common Blocks

COMMON / / DATA(size=MXDATA)

Blank common is used exclusively as the master storage area discussed in Section 4.4.

COMMON / DTA TOT / MX DATA

MX DATA - total storage dimensioned for master storage area

COMMON / DTA SUB / I DTA SB

I DTA SB - counter for the number of data cells which have been allocated in the master storage area

COMMON / CPT WRD / N BYT P W, N B P BYT

N BYT P W - number of bytes (1 byte=1 Hollerith character) per word for the particular machine being used

N B P BYT - number of bits per byte

COMMON / PRT OFF / NO PRT

NO PRT - print flag
= 0 indicates print
≠ 1 suppresses print

COMMON / BASIC 8 / D F, D OMEGA, D PI

D F - frequency

D OMEGA - 2π *frequency

D PI - 3.141592653589

COMMON / CATALOG / NAME(100), MTR SIZ(100), I PC(100),
N PC TOT(100), I TYPE(100), N DT STR(100), LOC(100), I CLG SB

This area is used for the master storage area catalog.

NAME	- network name(unpacked)
MTR SIZ	- matrix size
I PC	- piece number (0 if not applicable)
N PC TOT	- total number of pieces with this network name(0 if not applicable)
I TYPE	- network type(0 if not applicable)
N DT STR	- amount of data storage required for this network in addition to the matrix storage
LOC	- index into master storage where information pertinent to this particular network is located
I CLG SB	- total number of entries that have been made into the catalog.

COMMON / PRT TBL / NET SP(100), I SIGN C(100), I SIGN D(100),
 J PORT(100), N PORTS(100), NET NAM(100),
 NUM APO(100), NUM NPO(100), N AHEAD(100),
 N BACK(100), LC J ROW(100), N PRT SB

This area is used for the interconnection (or port) table.

NET SP - flag denoting either series or parallel connection

I SIGN C - sign associated with voltage(or force)

I SIGN D - sign associated with current (or velocity)

J PORT - the network port number

N PORTS - total number of ports associated with this particular network

NET NAM - network name(unpacked)

NUM APO - accessible port order number. Accessible ports are ordered (NUM APO = J PORT), however, for network ports this is the accessible port number to which the network port is connected

NUM NPO - network port order number(negative for accessible ports)

N AHEAD - a subscript that is a pointer to the entry in the table which has the next higher network port order for network ports, and next higher accessible port order for accessible ports

N BACK - subscript that is a pointer to the entry that has next lower network port order for network ports, and next lower accessible port order for accessible ports

LC J ROW - starting location in master storage for port information

N PRT SB - number of entries currently in the port table.

COMMON/ CA 2BY2 /IA11R,IA21R,IA12R,IA22R, IA11I,IA21I,IA12I,IA22I

Indices for referencing complex quantities of a 2 by 2 A-form matrix

COMMON/ CZ 2BY2 /IZ11R,IZ21R,IZ12R,IZ22R, IZ11I,IZ21I,IZ12I,IZ22I

Indices for referencing complex quantities of a 2 by 2 Z-form matrix

COMMON/ CY 2BY2 /IY11R,IY21R,IY12R,IY22R, IY11I,IY21I,IY12I,IY22I

Indices for referencing complex quantities of a 2 by 2 Y-form matrix

COMMON / CZ 3BY3 /

IZ11R, IZ21R, IZ31R, IZ12R, IZ22R, IZ32R, IZ13R, IZ23R, IZ33R,
IZ11I, IZ21I, IZ31I, IZ12I, IZ22I, IZ32I, IZ13I, IZ23I, IZ33I

Indices for referencing complex quantities of a 3 by 3 Z-form matrix

COMMON / CY 3BY3 /

IY11R, IY21R, IY31R, IY12R, IY22R, IY32R, IY13R, IY23R, IY33R,
IY11I, IY21I, IY31I, IY12I, IY22I, IY32I, IY13I, IY23I, IY33I

Indices for referencing complex quantities of a 3 by 3 Y-form matrix

Subroutine Descriptions

Subroutine descriptions have been grouped according to the functions performed, and are preceded by an alphabetical index to allow easy access if the routine name is known. The subroutines have also been classified to aid the user in determining priorities in studying the write-ups. The classifications are as follows:

- * - routines for which the purpose should be understood by the user for operation of the program,
- ** - routines which do not require detailed understanding by the user,
- *** - routines that are used internally in the program, and will probably not be directly needed by the user.

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LDPORT *

LDPORT loads into the interconnection table the description of the network ports comprising a particular accessible port. For calls to this routine, the accessible ports should be defined in consecutive and ascending order.

calling sequence:

CALL LDPORT(IH SP, IPORT)

input:

IH SP - flag denoting series (S) or parallel (P)
 interconnection (left justified Hollerith word).

IPORT - a string of characters (terminated by \$) which
 describes the accessible port by name, and each
 network port involved in the connection.

example:

CALL LDPORT('S', '8K8D,-+2D3A,1B2E,\$')

The eighth accessible port of K8D is series connected to the second port of D3A and the first port of B2E.

printout:

Each call to LDPORT prints the information being loaded.

BLDMTR *

BLDMTR constructs the matrix relating variables at the accessible ports of a network for which an interconnection table has already been loaded. This is performed by automatically chaining successive calls to BLDKKL and RDCPRT. This matrix may be of size less than or equal to that size as loaded in the port table.

calling sequence:

CALL BLDMTR(LH ANA)

input:

LH ANA - packed name terminated by \$ (two computer words), of the interconnected network.

BLDKKL **

BLDKKL initiates the computation of the individual network matrices (through CASCDE), and using these matrices computes the matrix relating variables at the accessible ports by pre- and post-multiplying by the C and D matrices which are determined by Kirchoff's laws (without actual storage of C and D).

calling sequence:

CALL BLDKKL(LH ANA)

input:

LH ANA - packed name terminated by \$ (two computer words), of the interconnection network.

RDCPRT **

RDCPRT reduces a network by the compaction process described in Section 3.

Note: after reducing AnA to AmA do not reduce AkA to AmA for k greater than m .

calling sequence:

CALL RDCPRT(LH ANA, LH AMA)

input:

- LH ANA - packed name terminated by \$ (two computer words), of the original network.
- LH AMA - packed name terminated by \$ (two computer words), of the new smaller network.

LDREQ *

LDREQ loads the frequency into a common area named BASIC8, as well as the corresponding value of omega ($2. \times \pi \times \text{frequency}$).

calling sequence:

CALL LDREQ(DDF)

input:

DDF - frequency

printout:

Value of frequency (controlled by COMMON / PRT OFF / NO PRT)

UPPTBL ***

UPPTBL updates the interconnection table with network port order numbers, and forward and backward pointers to network ports.

calling sequence:

CALL UPPTBL

FNDLCJ ***

FNDLCJ obtains the location in master storage for all matrices needed for a particular network, and allocates storage for all networks for which storage has not been set aside. Additional storage is also set aside for networks that will automatically be reduced in size.

calling sequence:

CALL FNDLCJ(N FIRST, N LAST)

input:

N FIRST - entry in interconnection table to begin processing.
N LAST - entry in interconnection table to end processing.

ALOCAT **

ALOCAT allocates storage in the master storage area by inserting a new entry into the catalog.

calling sequence:

CALL ALOCAT(NAM MTR, M NEW, NMT TOT)

input:

NAM MTR - unpacked name of network to be added to catalog.

M NEW - size of matrix.

NMT TOT - total number of storage locations required.

CHKSTR **

CHKSTR checks to insure that the current total master storage area has not exceeded the allowable storage limit, MXDATA.

calling sequence:

CALL CHK STR(I DTA CH)

input:

I DTA CH - counter which is compared to total allowable storage limit, MX DATA.

FNDNET **

FNDNET searches the interconnection table for a particular interconnection denoted by input name, and returns the first and last entries in the port table for that name.

calling sequence:

CALL FND NET(LH ANA, N FIRST, N LAST)

input:

LH ANA - packed name terminated by \$ (two computer words), of the interconnection network.

output:

N FIRST - first entry for this interconnection.

N LAST - last entry for this interconnection.

LOCMTR **

LOCMTR returns the location in master storage of the network specified through input name and matrix size.

calling sequence:

I = LOCMTR(I NAME, I MTR SZ)

input:

I NAME - network name (unpacked).

I MTR SZ - matrix size.

output:

I - master storage location (0 if not found).

LOCNAM **

LOCNAM returns the location in master storage of the first network specified by input name. No check is made on matrix size.

calling sequence:

I = LOCNAM(INAME)

input:

I NAME - network name (unpacked).

output:

I - master storage location (0 if not found).

FNDMTR **

FNDMTR returns to the calling program the entry number in the master storage area catalog that agrees with the input name and matrix size.

calling sequence:

CALL FNDMTR(I NAME, I MTR SZ, I SUB)

input:

I NAME - network name (unpacked).

I MTR SZ - matrix size.

output:

I SUB - subscript in master storage area catalog (0 if not found).

FNDNAM **

FNDNAM searches the catalog for the first occurrence of an input name and returns the entry number in the catalog. Note that no check is made on matrix size.

calling sequence:

CALL FNDNAM(I NAME, I SUB)

input:

I NAME - network name (unpacked).

output:

I SUB - subscript in master storage area catalog (0 if not found).

CASCDE **

CASCDE computes the individual (typed) network matrices through a routine called TYPICAL, and cascades (or multiplies) all 2 by 2 matrices that are flagged appropriately and stores the product matrix into the primary storage area for that section.

calling sequence:

CALL CASCDE(ISUB)

input:

I SUB - entry in master storage catalog for the product matrix.

note: An additional input parameter is supplied via COMMON/C FLG AZ/N ZAY

N ZAY - flag indicating form of cascaded matrix desired.
0 indicates convert A to Z form for primary area
1 indicates leave in A form
2 indicates convert A to Y form for primary area

TYPICAL ***

TYPICAL checks the network type of the entry in the catalog specified by input, and branches to the proper routine to calculate the matrix describing the network.

calling sequence:

CALL TYPICAL(IC SUB)

input:

IC SUB - catalog entry number of the network for which matrix computations are to be performed.

LDDT1 *

LDDT1 loads data for a type 1 network which represents a straight piece.

calling sequence:

CALL LDDT1(LH ANAI, RHO, AREA, AID, AOD, PIECL, CR, CI, CM)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
RHO - density.
AREA - cross-sectional area.
AID - inner diameter.
AOD - outer diameter.
PIECL - length of single piece.
CR - real part of velocity of sound in medium.
CI - imaginary part of velocity of sound.
CM - multiplier for complex velocity of sound.

note: If CI or CM is non zero, then the missing parameter will be computed from $CM = CI/CR$.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE1 ***

TYPE1 computes the matrix for a type 1 network as a function of frequency.

calling sequence:

CALL TYPE1(NAMTR, NNDTA)

input:

NAMTR - master storage location for matrix.
NNDTA - master storage location for data.

LDDT2 *

LDDT2 loads data for a type 2 network which represents a conical piece.

calling sequence:

CALL LDDT2(LH ANAI,RHO, A1,AID1,AOD1, A2,AID2,AOD2, PIECL, CR,CI,CM)

input:

LH ANAI	- piece name (packed) terminated by \$ (two words).
RHO	- density.
A1	- cross-sectional area of end 1.
AID1	- inner diameter of end 1.
AOD1	- outer diameter of end 1.
A2	- cross-sectional area of end 2.
AID2	- inner diameter of end 2.
AOD2	- outer diameter of end 2.
PIECL	- length of single piece.
CR	- real part of velocity of sound in medium.
CI	- imaginary part of velocity of sound.
CM	- multiplier for complex velocity of sound.

note: If CI or CM is non zero, then the missing parameter will be computed from $CM = CI/CR$.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE2 ***

TYPE2 computes the matrix for a type 2 network as a function of frequency.

calling sequence:

CALL TYPE2(NAMIR, NNDTA)

input:

NAMIR - master storage location for matrix.

NNDTA - master storage location for data.

LDDT4 *

LDDT4 loads data for a type 4 network which represents an ideal transformer.

calling sequence:

CALL LDDT4(LH ANAI, SEC TRN)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).

SEC TRN - secondary to primary turns ratio.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

LDDT5 *

LDDT5 loads data for a type 5 network which is an arbitrary matrix.

calling sequence:

CALL LDDT5(LH ANAI, ZR, ZI)

input:

LH ANAI - section name(packed) terminated by \$ (two words).

ZR - real part of Zij array.

ZI - imag part of Zij array.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

LDDT7 *

LDDT7 loads data for a type 7 network which is a rational polynomial fit to an impedance or mobility matrix.

calling sequence:

CALL LDDT7(LH ANAI, FACTOR, IFORM)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
FACTOR - scale factor for all coefficients.
IFORM - flag to determine matrix form,
= 0 Z form (impedance)
= 1 Y form (admittance) = inverse of Z form.

data card input for polynomial fit coefficients:

Card 1 (FORMAT(3I5, 16A4))

N ORD N - order of numerator polynomial.
N ORD D - order of denominator polynomial.
N SYM FG - symmetry flag for loading matrix coefficients.
= -1 indicates negative symmetry across diagonal.
= 0 indicates no symmetry.
= +1 indicates symmetry across diagonal.

note: if symmetry exists then only coefficients for elements in upper triangle are needed and should be ordered by columns as (1,1), (1,2), (2,2), (1,3), ..., (N,N). However, if no symmetry exists then the order should be (1,1), (2,1), ..., (N,1), (1,2), (2,2), ...

IHEAD - 16 word alphanumeric heading to identify coefficients.

Cards 2 - NORDN+1 (FORMAT(E17.10, 1X, E17.10))

DCR - real part of numerator coefficient in ascending powers of the independent variable.
DCI - imaginary part of numerator coefficient in ascending powers of the independent variable.

Cards NORDN+2 - NORDN+NORDD+1 (FORMAT(E17.10, 1X, E17.10))

DCR - real part of denominator coefficient in ascending
 powers of the independent variable.

DCI - imaginary part of denominator coefficient in
 ascending powers of the independent variable.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE7 ***

TYPE7 computes the matrix for a type 7 network as a function of frequency.

calling sequence:

CALL TYPE7(NAMTR, NNDTA)

input:

NAMTR - master storage location for matrix.

NNDTA - master storage location for data.

LDDT8 *

LDDT8 loads data for a type 8 network which is a voltage to voltage converter.

calling sequence:

CALL LDDT8(LH ANAI, ZIR, ZII, ZGR, ZGI, ALPR, ALPI)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
ZIR - real part of amplifier input impedance (ohms).
ZII - imag part of amplifier input impedance (ohms).
ZGR - real part of amplifier output impedance (ohms).
ZGI - imag part of amplifier output impedance (ohms).
ALPR - real part of amplification factor.
ALPI - imag part of amplification factor.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

LDDT9 *

LDDT9 loads data for a type 9 network which is a voltage to current converter.

calling sequence:

CALL LDDT9(LH ANAI, ZIR, ZII, ZOR, ZOI, BETAR, BETAI)

input:

LH ANAI	- piece name (packed) terminated by \$ (two words).
ZIR	- real part of amplifier input impedance (ohms).
ZII	- imag part of amplifier input impedance (ohms).
ZOR	- real part of amplifier output impedance (ohms).
ZOI	- imag part of amplifier output impedance (ohms).
BETAR	- real part of voltage to current gain (mhos).
BETAI	- imag part of voltage to current gain (mhos).

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

LDDT11 *

LDDT11 loads data for a type 11 network which is a 3-3 mode ceramic stack.

calling sequence:

CALL LDDT11(LH ANAI, NPCS, RHO, AREA, AID, AOD, PIECL,
DE33TR,DE33TI,DE33TM, DG33R,DG33I,DG33M, DS33DR,DS33DI,DS33DM)

input:

LH ANAI	- section name(packed) terminated by \$ (two words).
NPCS	- total number of pieces for this ceramic section.
RHO	- density.
AREA	- cross-sectional area.
AID	- inner diameter.
AOD	- outer diameter.
PIECL	- length of single piece.
DE33TR	- real part of E33T (always double precision).
DE33TI	- imag part of E33T (always double precision).
DE33TM	- E33T multiplier (always double precision).
DG33R	- real part of G33R (always double precision).
DG33I	- imag part of G33I (always double precision).
DG33M	- G33 multiplier (always double precision).
DS33DR	- real part of S33D (always double precision).
DS33DI	- imag part of S33D (always double precision).
DS33DM	- S33D multiplier (always double precision).

note: For ceramic parameters if either I or M is zero, the missing parameter will be computed by $M = -I/R$.

printout:

Values of input data (controlled by COMMON/PRT OFF/NO PRT).

TYPE11 ***

TYPE11 computes the matrix for a type 11 network as a function of frequency.

calling sequence:

CALL TYPE11(NAMTR, NNDTA)

input:

NAMTR - master storage location for matrix.

NNDTA - master storage location for data.

T11SER ***

T11SER performs operations required by type 11, and stores into common areas used in type 11 calculations.

calling sequence:

CALL T11SER

LDDT14 *

LDDT14 loads data for a type 14 network which is a 3-1 mode ceramic bar.

calling sequence:

```
CALL LDDT14(LH ANAI, RHO, THICK, FOIL W, PIEC L,  
DE33TR,DE33TI,DE33TM, DG31R,DG31I,DG31M, DS11ER,DS11EI,DS11EM)
```

input:

LH ANAI	- section name(packed) terminated by \$ (two words).
RHO	- density.
THICK	- thickness.
FOIL W	- foil width.
PIECL	- length of single piece.
DE33TR	- real part of E33T (always double precision).
DE33TI	- imag part of E33T (always double precision).
DE33TM	- E33T multiplier (always double precision).
DG31R	- real part of G31R (always double precision).
DG31I	- imag part of G31I (always double precision).
DG31M	- G31 multiplier (always double precision).
DS11ER	- real part of S11E (always double precision).
DS11EI	- imag part of S11E (always double precision).
DS11EM	- S11E multiplier (always double precision).

note: For ceramic parameters if either I or M is zero, the missing parameter will be computed by $M = -I/R$.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE14 ***

TYPE14 computes the matrix for a type 14 network as a function of frequency.

calling sequence:

CALL TYPE14(NZMTR, NNDTA)

input:

NZMTR - master storage location for matrix.
NNDTA - master storage location for data.

LDDT15 *

LDDT15 loads data for a type 15 network which is a 3-1 mode ceramic tube.

calling sequence:

CALL LDDT15(LH ANAI, RHO, R IN D, R OUT D, PIEC L,
DE33TR,DE33TI,DE33TM, DG31R,DG31I,DG31M, DS11ER,DS11EI,DS11EM)

input:

LH ANAI - section name(packed) terminated by \$ (two words).
RHO - density.
R IN D - inner diameter.
R OUT D - outer diameter.
PIECL - length of single piece.
DE33TR - real part of E33T (always double precision).
DE33TI - imag part of E33T (always double precision).
DE33TM - E33T multiplier (always double precision).
DG31R - real part of G31R (always double precision).
DG31I - imag part of G31I (always double precision).
DG31M - G31 multiplier (always double precision).
DS11ER - real part of S11E (always double precision).
DS11EI - imag part of S11E (always double precision).
DS11EM - S11E multiplier (always double precision).

note: For ceramic parameters if either I or M is zero, the missing parameter will be computed by $M = -I/R$.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE15 ***

TYPE15 computes the matrix for a type 15 network as a function of frequency.

calling sequence:

CALL TYPE15(NZMTR, NNDTA)

input:

NZMTR - master storage location for matrix.

NNDTA - master storage location for data.

T1415S ***

T1415S performs operations required by type 14 and type 15, and stores into common areas used in type 14 and type 15 calculations.

calling sequence:

CALL T1415S

TP1415 ***

TP1415 performs operations required by type 14 and type 15 networks.

calling sequence:

CALL TP1415

LDDT20 *

LDDT20 loads data for a type 20 network which is a linear transformer.

calling sequence:

CALL LDDT20(LH ANAI, RP, HLP, RO, HLO, RS, HLS, PHI)

input:

LH ANAI	- piece name (packed) terminated by \$ (two words).
RP	- copper loss in primary.
HLP	- winding inductance in primary.
RO	- core loss.
HLO	- magnetizing inductance.
RS	- copper loss in secondary.
HLS	- winding inductance in secondary.
PHI	- secondary to primary turns ratio.

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE20 ***

TYPE20 computes the matrix for a type 20 network as a function of frequency.

calling sequence:

CALL TYPE20(NAMTR, NNDTA)

input:

NAMTR - master storage location for matrix.

NNDTA - master storage location for data.

LDDT21 *

LDDT21 loads data for a type 21 network which is a series impedance.

calling sequence:

CALL LDDT21(LH ANAI, RS, HLS, CS)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
RS - resistance (Ohms).
HLS - inductance (Hy).
CS - capacitance (Fy).

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE21 ***

TYPE21 computes the matrix for a type 21 network as a function of frequency.

calling sequence:

CALL TYPE21(NAMTR, NNDTA)

input:

NAMTR - master storage location for matrix.

NNDTA - master storage location for data.

LDDT22 *

LDDT22 loads data for a type 22 network which is a parallel impedance.

calling sequence:

CALL LDDT22(LH ANAI, RS, HLS, CS)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
RS - resistance (Ohms).
HLS - inductance (Hy).
CS - capacitance (Fy).

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE22 ***

TYPE22 computes the matrix for a type 22 network as a function of frequency.

calling sequence:

CALL TYPE22(N MTR, N DTA)

input:

N MTR - master storage location for matrix.

N DTA - master storage location for data.

LDDT24 *

LDDT24 loads data for a type 24 network which is a series admittance.

calling sequence:

CALL LDDT24(LH ANAI, RP, HLP, CP)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
RP - resistance (Ohms).
HLP - inductance (Hy).
CP - capacitance (Fd).

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE24 ***

TYPE24 computes the matrix for a type 24 network as a function of frequency.

calling sequence:

CALL TYPE24(NAMTR, NNDTA)

input:

NAMTR - master storage location for matrix.

NNDTA - master storage location for data.

LDDT25 *

LDDT25 loads data for a type 25 network which is a parallel admittance.

calling sequence:

CALL LDDT25(LH ANAI, RP, HLP, CP)

input:

LH ANAI - piece name (packed) terminated by \$ (two words).
RP - resistance (Ohms).
HLP - inductance (Hy).
CP - capacitance (Fd).

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE25 ***

TYPE25 computes the matrix for a type 25 network as a function of frequency.

calling sequence:

CALL TYPE25(N MIR, N DTA)

input:

N MIR - master storage location for matrix.

N DTA - master storage location for data.

LDDT26 *

LDDT26 loads data for a type 26 network which is a differential input operational amplifier.

calling sequence:

```
CALL LDDT26(LH ANAI, R1,C1, R2,C2, RD,CD, R3,HL3,  
OMEGA1, OMEGA2, OMEGA3)
```

input:

LH ANAI	- section name(packed) terminated by \$ (two words).
R1	- input resistance (Ohms).
C1	- input capacitance (farads).
R2	- input resistance (Ohms).
C2	- input capacitance (farads).
RD	- differential input resistance (Ohms).
CD	- differential input capacitance (farads).
R3	- output resistance (Ohms).
C3	- output capacitance (farads).
HL3	- output inductance (henries).
A0	- dc open loop gain.
OMEGA1	- first pole frequency of open loop transfer function (1/sec).
OMEGA2	- second pole frequency of open loop transfer function (1/sec).
OMEGA3	- third pole frequency of open loop transfer function (1/sec).

printout:

Values of input data (controlled by COMMON / PRT OFF / NO PRT).

TYPE26 ***

TYPE26 computes the matrix for a type 26 network as a function of frequency.

calling sequence:

CALL TYPE26(N MIR, N DTA)

input:

N MIR - master storage location for matrix.

N DTA - master storage location for data.

AIDOD **

AIDOD calculates either inner diameter, outer diameter, or area given the proper combination of the other two.

calling sequence:

CALL AIDOD(A, AID, AOD)

input/output (see tables below):

A - area
AID - inner diameter
AOD - outer diameter

The following table shows the input quantities and output quantities for every combination of input.

input			output		
Area	ID	OD	Area	ID	OD
X	O	O	X	O	O
O	X	O	(insufficient data)		
O	O	X	C	O	X
X	X	O	X	X	C
X	O	X	X	C	X
O	X	X	C	X	X
X	X	X	X	X	X
O	O	O	(insufficient data)		

where X - non-zero input
C - calculated

caution: a zero input should be passed through a variable name, and not as a literal in the subroutine call since the value may be changed in the subroutine.

The following relationships are used in the computation and are valid for types 1, 2, and 11.

$$\begin{aligned}A &= (\pi/4)(OD^{**2} - ID^{**2}) \\ID &= \text{SQRT}(OD^{**2} - 4A/\pi) \\OD &= \text{SQRT}(4A/\pi + ID^{**2})\end{aligned}$$

LA2BY2 **

LA2BY2 loads indices for master storage for the A-form of a 2 port network (2x2 matrix) into common area CA2BY2.

calling sequence:

CALL LA2BY2

input:

N MTR - master storage location for matrix

LZ2BY2 **

LZ2BY2 loads indices for master storage for the Z-form of a 2 port network (2x2 matrix) into common area CZ2BY2.

calling sequence:

CALL LZ2BY2

input:

N MTR - master storage location for matrix

LZ3BY3 **

LZ3BY3 loads indices for master storage for the Z-form of a 3 port network (3x3 matrix) into common area CZ3BY3.

calling sequence:

CALL LZ3BY3

input:

N MIR - master storage location for matrix

LY2BY2 **

LY2BY2 loads indices for master storage for the Y-form of a 2 port network (2x2 matrix) into common area CY2BY2.

calling sequence:

CALL LY2BY2

input:

N MTR - master storage location for matrix

LY3BY3 **

LY3BY3 loads indices for master storage for the Y-form of a 3 port network (3x3 matrix) into common area CY3BY3.

calling sequence:

CALL LY3BY3

input:

N MTR - master storage location for matrix

LDDRIM ***

LDDRIM loads into the master storage area the real, imaginary, and multiplier supplied on input. Note that only the real(R) and either the imaginary(I) or multiplier(M) or both need be supplied and the missing parameter(input as zero) will be computed by $M = -I/R$. The parameters are stored in sequence using the present value of IDTASB which is the total number of storage cells used in master storage.

calling sequence:

CALL LDDRIM(DR, DI, DM)

input:

DR - real part.

DI - imaginary part.

input/output:

DM - multiplier ($DM = -DI/DR$).

LDSB11 ***

LDSB11 sets up a group of indices that enables easy referencing of network type 11 (3-3 mode ceramic stack) data. These indices are stored in common block COMN11.

calling sequence:

CALL LDSB11(NDTA)

input:

NDTA - master storage location where data starts.

LS1415 ***

LS1415 sets up a group of indices that enables easy referencing of network type 14(3-1 mode ceramic bar) and type 15(3-1 mode ceramic tube) data. These indices are stored into common block CM1415.

calling sequence:

CALL LS1415(NDTA)

input:

NDTA - master storage location where data starts.

FNDTMS **

FNDTMS determines the total mass of all type 1, type2, and typell networks.

calling sequence:

CALL FNDTMS

printout:

mass in MKS and English units (controlled by COMMON / PRT OFF / NO PRT).

FNDTL **

FNDTL determines the total length of all networks specified by input name for types 1, 2, 11, 14, and 15.

calling sequence:

CALL FNDTL(L NAMES, N NAMES)

input:

L NAMES - an array containing the names(unpacked) of sections to be used in total length computation.

N NAMES - number of names in the array L NAMES.

printout:

value of length (controlled by COMMON / PRT OFF / NO PRT).

MTRMOV **

MTRMOV moves a matrix of given size from one area in master storage to another area in master storage.

calling sequence:

CALL MTRMOV(NNEW, NOLD, MTRSIZ)

input:

NNEW	- master storage location where matrix is to be moved.
NOLD	- master storage location where matrix is stored.
MTRSIZ	- matrix size.

MTRMUL **

MTRMUL multiplies two matrices stored in master storage.

calling sequence:

CALL MTRMUL(LCNEW, LCOLDA, LCOLDB, MA, NA, MB, NB)

where (matrix NEW) = (matrix A) x (matrix B)

input:

LCNEW	- master storage location where product is to be stored.
LCOLDA	- master storage location where matrix A is stored.
LCOLDB	- master storage location where matrix B is stored.
MA	- number of rows of matrix A.
NA	- number of columns of matrix A.
MB	- number of rows of matrix B.
NB	- number of columns of matrix B.

note: LCNEW cannot coincide with either LCOLDA or LCOLDB, and NA must equal MB.

DLETRC **

DLETRC deletes specified rows and/or columns from a matrix and performs a scalar multiplication on the matrix.

calling sequence:

CALL DLETRC(NN OLD R, NN OLD I, M OLD, N OLD, I OUT, J OUT,
NI OUT, NJ OUT, N NEW R, N NEW I, SCALAR)

input:

NN OLD R - master storage location of real part of input matrix.

NN OLD I - master storage location of imaginary part of input matrix.

M OLD - number of rows in input matrix.

N OLD - number of columns in input matrix.

I OUT - array containing indices of rows to be deleted.

J OUT - array containing indices of columns to be deleted.

NI OUT - number of rows to be deleted.

NJ OUT - number of columns to be deleted.

N NEW R - master storage location of real part of output matrix.

N NEW I - master storage location of imaginary part of output matrix.

SCALAR - scale factor for output matrix.

LDIMTR **

LDIMTR loads an identity matrix of specified size into the desired master storage area.

calling sequence:

CALL LDIMTR(ISUB, MSIZ)

input:

ISUB - master storage location for unit matrix.

MSIZ - matrix size.

DECOM8 **

DECOM8 solves the system of equations $AX = B$ for the vector X (INVFG = 0) or computes the inverse of the matrix A (INVFG = 1).

calling sequence:

CALL DECOM8(DA,NA, DAI,NAI, DAINV,NAINV, DAINVI,NAINVI,
 NSIZE, MDFA, INVFG)

input:

DA - array containing the real part of matrix A.
NA - starting subscript in DA.
DAI - array containing imaginary part of matrix A.
NAI - starting subscript in DAI.

output:

DAINV - array for storing the real part of A inverse.

input:

NAINV - subscript in DAINV to begin storing.

output:

DAINVI - array for storing imaginary part of A inverse.

input:

NAINVI - subscript into DAINVI to begin storing.
NSIZE - size of matrix A.
MDFA - matrix decomposition flag,
 = 0, decompose matrix.
 = 1, matrix has already been decomposed.
INVFG - either solve for vector X (INVFG = 0), or compute
 inverse of A (INVFG = 1).

ATOZ **

ATOZ converts a 2x2 matrix in the A-form to the Z-form.

calling sequence:

CALL ATOZ(N AMIR, N ZMIR)

input:

N AMIR - master storage location for A-form.

N ZMIR - master storage location for Z-form.

transformation:

$$Z_{11} = A_{11} / A_{21}$$

$$Z_{12} = A_{12} - A_{11} A_{22} / A_{21}$$

$$Z_{21} = 1 / A_{21}$$

$$Z_{22} = -A_{22} / A_{21}$$

ZTOA **

ZTOA converts a 2x2 matrix in the Z-form to the A-form.

calling sequence:

CALL ZTOA(N ZMTR, N AMTR)

input:

N ZMTR - master storage location for Z-form.

N AMTR - master storage location for A-form.

transformation:

$$A_{11} = Z_{11} / Z_{21}$$

$$A_{12} = Z_{12} - Z_{11} Z_{22} / Z_{21}$$

$$A_{21} = 1 / Z_{21}$$

$$A_{22} = -Z_{22} / Z_{21}$$

ATOY **

ATOY converts a 2x2 matrix in the A-form to the Y-form.

calling sequence:

CALL ATOY(N AMTR, N YMTR)

input:

N AMTR - master storage location for A-form.

N YMTR - master storage location for Y-form.

transformation:

$$Y_{11} = A_{22} / A_{12}$$

$$Y_{12} = (A_{12} A_{21} - A_{11} A_{22}) / A_{12}$$

$$Y_{21} = 1 / A_{12}$$

$$Y_{22} = -A_{11} / A_{12}$$

YTOA **

YTOA converts a 2x2 matrix in the Y-form to the A-form.

calling sequence:

CALL YTOA(N YMTR, N AMTR)

input:

N YMTR - master storage location for Y-form.

N AMTR - master storage location for A-form.

transformation:

$$A_{11} = -Y_{22} / Y_{21}$$

$$A_{12} = 1 / Y_{21}$$

$$A_{21} = (Y_{12} Y_{21} - Y_{11} Y_{12}) / Y_{21}$$

$$A_{22} = Y_{11} / Y_{21}$$

DACMUL **

DACMUL performs a complex accumulative multiplication.

calling sequence:

CALL DACMUL(DA, DB, DC, DD, DE, DF)

input:

DA	- real part of first input number.
DB	- imag part of first input number.
DC	- real part of second input number.
DD	- imag part of second input number.

input/output:

DE	- real part of resultant.
DF	- imag part of resultant.

the following steps are performed:

$$DE = DE + DA * DC - DB * DD$$

$$DF = DF + DA * DD + DB * DC$$

note: resultant variables may occupy the same locations as either input.

DCMMUL **

DCMMUL performs a complex multiplication.

calling sequence:

CALL DCMMUL(DA, DB, DC, DD, DE, DF)

input:

DA	- real part of multiplicand.
DB	- imag part of multiplicand.
DC	- real part of multiplier.
DD	- imag part of multiplier.

output:

DE	- real part of product.
DF	- imag part of product.

note: the result may occupy the same locations as either input.

DCMDIV **

DCMDIV performs a complex division.

calling sequence:

CALL DCMDIV(DA, DB, DC, DD, DE, DF)

input:

DA	- real part of dividend.
DB	- imag part of dividend.
DC	- real part of divisor.
DD	- imag part of divisor.

output:

DE	- real part of quotient.
DF	- imag part of quotient.

note: the result may occupy the same locations as either input.

DCRCIP **

DCRCIP computes the reciprocal of a complex number.

calling sequence:

CALL DCRCIP(DINR, DINI, DOUTR, DOUTI)

input:

DINR - real part of input.

DINI - imag part of input.

output:

DOUTR - real part of output.

DOUTI - imag part of output.

note: the result may occupy the same locations as either input.

DCSQRT **

DCSQRT computes the square root of a complex argument.

calling sequence:

CALL DCSQRT(DINR, DINI, DCSQTR, DCSQTI)

input:

DINR - real part of argument.

DINI - imag part of argument.

output:

DCSQTR - real part of square root.

DCSQTI - imag part of square root.

note: the result may occupy the same locations as the input.

DCANG1 **

DCANG1 returns the phase (in radians) of a complex number adjusted so that the result appears between $-\pi$ and π .

calling sequence:

ANG = DCANG1(DX, DY)

where: ANG = ARC TAN(DY/DX).

DCACSH **

DCACSH calculates the complex inverse hyperbolic cosine, $Y = \text{ARC COSH}(Z)$.

where: $\text{real } Y = \ln(|Z + \text{SQRT}(Z^2 - 1)|)$

$\text{imag } Y = \text{ang}(Z + \text{SQRT}(Z^2 - 1))$

CALLING SEQUENCE:

CALL DCACSH(DINR, DINI, DOUTR, DOUTI)

input:

DINR - real part of input, Z.

DINI - imag part of input, Z.

output:

DOUTR - real part of output, Y.

DOUTI - imag part of output, Y.

note: the result may occupy the same locations as the input.

DSHCH **

DSHCH computes the hyperbolic sine and hyperbolic cosine of an argument.

calling sequence:

CALL DSHCH(DARG, DSINH, DCOSH)

input:

DARG - input argument.

output:

DSINH - hyperbolic sine of DARG.

DCOSH - hyperbolic cosine of DARG.

DCSNCS **

DCSNCS computes the sine and cosine of a complex argument.

calling sequence:

CALL DCSNCS(DARGR,DARGI, DSINR,DSINI, DCOSR,DCOSI)

input:

DARGR - real part of input argument.

DARGI - imag part of input argument.

output:

DSINR - real part of sine.

DSINI - imag part of sine.

DCOSR - real part of cosine.

DCOSI - imag part of cosine.

note: either result may occupy the same locations as the input.

DCSHCH **

DCSHCH computes the hyperbolic sine and cosine of a complex argument.

calling sequence:

CALL DCSHCH(DARGR,DARGI, DSINHR,DSINHI, DCOSHR,DCOSHI)

input:

DARGR - real part of input argument.

DARGI - imag part of input argument.

output:

DSINHR - real part of hyperbolic sine.

DSINHI - imag part of hyperbolic sine.

DCOSHR - real part of hyperbolic cosine.

DCOSHI - imag part of hyperbolic cosine.

note: either result may occupy the same locations as the input.

PRTMTR **

PRTMTR prints a square matrix that is in master storage.

calling sequence:

CALL PRTMTR(N MTR, MTR SIZ)

input:

N MTR - master storage location of matrix.

MTR SIZ - matrix size.

printout:

see above.

PRTMBN **

PRTMBN prints an M by N matrix that is in master storage.

calling sequence:

CALL PRTMBN(N MTR, MTR M, MTR N)

input:

N MTR	- master storage location of matrix.
MTR M	- number of rows in matrix.
MTR N	- number of columns in matrix.

printout:

see above.

PRMARI **

PRMARI prints the magnitude, angle (either in degrees or radians), real, and imaginary parts of a complex number.

calling sequence:

CALL PRMARI(IHEAD, IANGLE, DREAL, DIMAG)

input:

IHEAD	- flag that determines whether a heading should be printed (=0, no heading).
IAngle	- flag that specifies either degrees (=3hdeg) or radians.
DREAL	- real part of input number.
DIMAG	- imag part of input number.

printout:

see above.

HEAD24 **

HEAD24 prints a given string of 24 Hollerith characters. The first character need not be blank as the output format skips the first print position.

calling sequence:

CALL HEAD24(I HEAD)

input:

I HEAD - an array containing the character string to be printed.

printout:

see above.

PAGE **

PAGE initiates a page eject on the output form.

calling sequence:

CALL PAGE

printout:

see above.

STRLIN **

STRLIN prints a line consisting of 80 asterisks on the output form.

calling sequence:

CALL STRLIN

printout:

see above.

SKPLIN **

SKPLIN causes a desired number of lines to be skipped on the output form.

calling sequence:

CALL SKPLIN(NUMLIN)

INPUT:

NUMLIN - number of lines to be skipped.

printout:

see above.

PRPTBL **

PRPTBL prints the interconnection (or port) table.

calling sequence:

CALL PRPTBL

printout:

see above.

PRCTLG **

PRCTLG prints the master storage area catalog.

calling sequence:

CALL PRCTLG

printout:

see above.

UNPACK ***

UNPACK decodes the input string of Hollerith characters (until it reaches a \$) to determine such items as sign conventions, accessible port number, network name, number of ports, and piece number if applicable.

calling sequence:

```
CALL UNPACK(IPORT, NIPORT, MCOUNT, N, ISIGNC, ISIGND,  
            JPORT, NPORTS, NETNAM, IPC, NCHAR)
```

INPUT:

IPORT - array containing string of Hollerith characters.
NIPORT - maximum number of words in array IPORT.

input/output:

MCOUNT - counter for actual number of words used in IPORT.
N - counter for number of bytes in IPORT(I).

output:

ISIGNC - sign of C-matrix entry (dependent variable).
ISIGND - sign of D-matrix entry (independent variable).
JPORT - accessible port number.
NPORTS - network port number.
NETNAM - network name.
IPC - piece number if applicable.
NCHAR - counter for number of characters in NETNAM.

note: this routine calls the FLD function available in FORTRAN V on the Univac 1106 and 1108. For other systems it will need to be provided. Although more general on the Univac systems, the FLD function is used here only to extract the left most byte from a word.

calling sequence:

```
ICHR(IF, IL, IWORD)
```

input:

A - 100

- IF - bit in IWORD to begin extracting (=0 for this case).
- IL - bit in IWORD to end extracting (=number of bits per byte for this case).
- IWORD - word from which bits are to be extracted.

BLKDTA *

BLKDTA is a BLOCK DATA routine used only for initializing certain quantities in COMMON.

Note: COMMON / CPT WRD / N BYT P W, N B P BYT must be set properly here for each particular computer.

(See Page A-2)

TIME **

TIME uses the subroutine LKCLKS (not provided in this package) to determine the present clock time and prints the elapsed time from the last call to TIME, as well as the total time since CALL LKCLKS (another routine not provided which initializes time in LKCLKS to 0).

calling sequence:

CALL TIME

note: LKCLKS returns the current clock time in seconds.

calling sequence:

CALL LKCLKS(T)

INPUT:

T - clock time (seconds)

printout:

see above.

Z1TOZ2 *

Z1TOZ2 finds the impedance (Z2) seen at output port given the A-form of the network matrix and the impedance (Z1) at input.

calling sequence:

CALL Z1TOZ2(NAME, NPC Z, DZ1R,DZ1I, DZ2R,DZ2I)

INPUT:

NAME - network name(unpacked).
NPCZ - piece number (0 for entire section).
DZ1R - real part of input impedance.
DZ1I - imag part of input impedance.

output:

DZ2R - real part of output impedance.
DZ2I - imag part of output impedance.

where:

$$Z2 = (A22*Z1-A12)/(-A21*Z1+A11)$$

DCPCT2 **

DCPCT2 computes the force and velocity on the left of a piece (F1,V1) given the force and velocity on the right (Fr,Vr) and the 2x2 A matrix.

calling sequence:

```
CALL DCPCT2(NAME, N PC FV, DFRR,DFRI, DVRR,DVRI,  
            DFLR,DFLI, DFLR,DVLI)
```

INPUT:

NAME - network name(unpacked).
N PC FV - piece number (0 for entire section).
DFRR - real part of Fr.
DFRI - imag part of Fr.
DVRR - real part of Vr.
DVRI - imag part of Vr.

output:

DFLR - real part of F1.
DFLI - imag part of F1.
DVLR - real part of V1.
DVLI - imag part of V1.

where:

$$F1 = A11*Fr + A12*Vr$$

$$V1 = A21*Fr + A22*Vr$$

FNDKRC **

FNDKRC computes the right handed decompaction matrix for a 3-3 mode ceramic stack (network type 11). (See Appendix D.)

calling sequence:

CALL FNDKRC(IZ C3S, IN ZC3, IKR3C)

input:

- IZ C3S - master storage location for C3S matrix.
- IN ZC3 - master storage location for single piece matrix.
- IKR3C - master storage location for storing right handed decompaction matrix.

SRCHBC **

SRCHBC performs the Search process as described in Appendix D.

calling sequence:

CALL SRCHBC(IA5S, IB4C, IC3S, IR3C, IM2S, IS2S)

input:

IA5S	- master storage location for matrix A5S.
IB4C	- master storage location for matrix B4C.
IC3S	- master storage location for matrix C3S.
IR3C	- master storage location for matrix R3C.
IM2S	- master storage location for matrix M2S.
IS2S	- master storage location for matrix S2S.

MINCHK ***

MINCHK compares two input numbers to find the minimum. If a new minimum is found, then a new identification subscript is stored, and a flag is set.

calling sequence:

CALL MINCHK(DNEW, DMIN, INEW, IMIN, MINFND)

INPUT:

DNEW - new value.

input/output:

DMIN - minimum.

input:

INEW - identification subscript corresponding to DNEW.

input/output:

IMIN - identification subscript corresponding to DMIN.

output:

MINFND - flag to indicate that new minimum was found.

logic:

If (DNEW .LT. DMIN) then DMIN=DNEW, IMIN=INEW, MINFND=1

otherwise MINFND = 0

MAXCHK ***

MAXCHK compares two input numbers to find the maximum. If a new maximum is found, then a new identification subscript is stored, and a flag is set.

calling sequence:

CALL MAXCHK(DNEW, DMAX, INEW, IMAX, MAXFND)

input:

DNEW - new value.

input/output:

DMAX - maximum.

input:

INEW - identification subscript corresponding to DNEW.

input/output:

IMAX - identification subscript corresponding to DMAX.

output:

MAXFND - flag to indicate that new maximum was found.

logic:

If (DNEW .GT. DMAX) then DMAX=DNEW, IMAX=INEW, MAXFND=1

otherwise MAXFND = 0

CMPZS **

CMPZS is used in conjunction with the SEARCH procedure (Appendix D) to compute and store the self impedance. This routine should be modified by the user when a non-zero self impedance is required.

calling sequence:

CALL CMPZS

printout:

As written this routine prints ZSELF=0 only once in a run.

PREPZV *

PREPZV reads from cards or card images on magnetic tape a heading card followed by an array of radiation impedances. The array is scaled by desired scale factors and written onto an auxiliary storage unit for use later in the calculations.

calling sequence:

CALL PREPZV(NARRAY, IFARRAY, INZVUN, IOUTUN, FSCALE,ZSCALE,VSCALE)

input:

NARRAY - array number.

IFARRAY - frequency at which the radiation impedances were generated.

INZVUN - logical input unit number.

IOUTUN - logical output unit number (not equal to INZVUN).

FSCALE - scale factor for IFARRAY.

ZSCALE - scale factor for radiation impedances.

VSCALE - scale factor for velocities associated with the impedances.

heading card input format:

FORMAT(A4,A2, I4, I5, 16A4)

columns 2- 6 contain ARRAY (Hollerith string)

columns 7-10 contain array number

columns 11-15 contain number of impedances to read in

columns 16-79 contain heading information

data card input format:

FORMAT(2I3, I5, 3I3, 2E15.8, 2E15.8)

SEE LDZRVR for arguments

printout:

prints the input card information.

FNDFZV ***

FNDFZV reads the array of radiation impedances that has previously been read in by PREPZV for the purpose of checking for proper array number and frequency.

calling sequence:

CALL FNDFZV(IF SWP)

input:

IF SWP - not presently used by the routine. However it is the value of the frequency (from the Search process frequency sweep) in the event that the user wants to change the array of radiation impedances as a function of frequency.

LDZRVR ***

LDZRVR reads a card image containing radiation impedance information used in the Search process.

calling sequence:

CALL LDZRVR

modified card image format:

FORMAT(2I4,I5,3I3, 2(E14.7,E13.7))

IL	- row number of element.
JL	- column number of element.
IF	- frequency for radiation impedance.
ICODE	- identification code supplied by user.
IBETAS	- azimuth
IGAMAS	- depression elevation.
ZR	- real part of radiation impedance.
ZI	- imag part of radiation impedance.
VR	- real part of velocity.
VI	- imag part of velocity.

SRMIDB *

SRMIDB performs the single reactor midband logic as described in the Search process of Appendix D.

calling sequence:

CALL SRMIDB(DFP, L MX MN, L EC IC, L FLG SP, DLRM, DLQM)

input:

- DFP - frequency
- L MX MN - flag specifying either to maximize or minimize.
 = 3HMAX to maximize
 ≠ 3HMAX to minimize
- L EC IC - specifies whether |Zec| or |Zic| is to be
 extremized.
 = 2HEC to extremize |Zec|
 ≠ 2HEC to extremize |Zic|
- L FLG SP - specifies either series or parallel reactor.
 = 1HS for series
 ≠ 1HS for parallel
- DLRM - series resistance of the reactor
- DLQM - reactor quality factor

printout:

values of input and output (controlled by COMMON / PRT OFF / NO PRT).

LDAM2S **

LDAM2S computes and stores the A-form of the M2S network(matching network) used in the Search procedure (Appendix D).

calling sequence:

CALL LDAM2S

printout:

A M2S matrix (controlled by COMMON / PRT OFF / NO PRT).

CMPGAM **

CMPGAM is used in the Search procedure discussed in Appendix D to compute (1) voltage-velocity control impedance, Z_{ec} , (2) current-velocity control impedance, Z_{ic} , (3) $GAMMA_{ec} = Z_{self} + Z_{ic}$, (4) $GAMMA_{ic} = Z_{self} + Z_{ic}$ where Z_{self} is the self impedance of the element.

calling sequence:

CALL CPMGAM(IN A APS)

input:

IN A APS - master storage location of the A-form matrix for the APS network.

printout:

A SPR matrix and GAMMA ec, GAMMA ic (controlled by COMMON / PRT OFF / NO PRT).

FSRCH *

FSRCH searches out performance variables for a transducer over a specified frequency range with an input array of radiation impedances. The method used is discussed in Appendix D.

calling sequence:

```
CALL FSRCH(IF FRST, IF LAST, IF DELT,  
           I OUT OP, I UNIT T, IHLBL1, IHLBL2)
```

input:

IF FRST - initial frequency.
IF LAST - maximum frequency.
IF DELT - frequency increment.
I OUT OP - output options as discussed in Appendix D.
I UNIT T - logical unit number for output to be saved (=0 if not desired).
IHLBL1 - first word of a label for output.
IHLBL2 - second word of a label for output.

printout:

a page for each frequency and its associated performance variables.

RLIMMG **

RLIMMG provides the functional relationship of the dependent variable used primarily by subroutine FMFN. The routine should be changed for different functional relationships. As programmed the routine finds the admittance Y_c of the DD network for Run 80006 in Appendix E.

calling sequence:

CALL RLIMMG(DX, DRL, DIM, DMG)

input:

DX - independent variable.

output:

DRL - real part of dependent variable.

DIM - imag part of dependent variable.

DMG - magnitude of dependent variable.

printout:

above values (controlled by COMMON / C FMN PR / I FMN PR

where I FMN PR = 0 for no print).

FMFN *

FMFN computes the maximum and/or minimum of a function (evaluated RLIMG) given an initial guess. The routine utilizes a pole-zero technique which is further refined by a parabolic fit.

calling sequence:

CALL FMFN(DFMGES, DXM, DYMM, DXN, DYNM)

input:

DFMGES - initial guess for independent variable, DXM.

output:

DXM - value of independent variable at maximum of dependent variable.

DYMM - relative maximum of dependent variable in region DFMGES.

DXN - value of independent variable at minimum of dependent variable.

DYNM - relative minimum of dependent variable in region DFMGES.

additional input options can be set via

COMMON / CMN FMN / MIN SKP, MAX SKP, N1 POL 0

MIN SKP - flag
= 1 will not find minimum of the function.
≠ 1 will find minimum of the function.

MAX SKP - flag
= 1 will not find maximum of the function.
≠ 1 will find maximum of the function.

N1 POL 0 - flag controlling pole-zero technique.
= 1 apply pole-zero once
≠ 1 apply pole zero twice

note: all three flags are set to 0 as a default condition in BLK DTA.

POLEO ***

POLEO is used to find the frequency at which a relative maximum and a relative minimum of the complex admittance function occurs given three frequencies for the function to be evaluated. This routine has been designed to apply particularly to piezoelectric electromechanical systems. The admittance, Y_c , of such systems with widely separated resonant behavior can be approximated at frequencies well below the second resonance by $Y(f) = f(f-b)/(f-c)$. (note: for magnetostrictive systems a similar type of treatment will apply, but Y must denote complex impedance instead of complex admittance.)

calling sequence:

CALL PCLEO(DX1, DX2, DX3, DXM, DXN)

input:

DX1 - first value of the independent variable.
DX2 - second value of the independent variable.
DX3 - third value of the independent variable.

output:

DXM - value of the independent variable at which the
 dependent variable is a maximum.
DXN - value of the independent variable at which the
 dependent variable is a minimum.

method:

The technique was developed from the idea that the frequency poles and zeros determine the admittance as a function of frequency.

$$Y(f) = (A(f-a_1)(f-a_2)(f-a_3)\dots)/((f-b_1)(f-b_2)(f-b_3)\dots)$$

where $a_1, a_2, a_3, \dots, b_1, b_2, \dots$ are complex constants.

For this case $Y(f)=0$ if $f=0$. Therefore, a_1 is set to 0. It may also be assumed that only a small portion of the complex frequency affects the function so that only one pole and one zero need be considered, i.e.

$$Y(f) = f(f-b)/(B(f-c))$$

or

$$Y(f)/f = B + B(c-b)/(f-c)$$

$$Y(f)/f = B + D/(f-c).$$

Given the value of the admittance function, $Y(f)$, at three frequencies (f_1, f_2, f_3) allows a solution for the constants B , D , and c . The solutions are

$$B = -D/(f_1 - c) + Y_1$$

$$D = (Y_1 - Y_2) / (1/(f_1 - c) - 1/(f_2 - c))$$

$$c = (f_1(f_2 - f_3)Y_1 + f_2(f_3 - f_1)Y_2 + f_3(f_1 - f_2)Y_3) / ((f_2 - f_3)Y_1 + (f_3 - f_1)Y_2 + (f_1 - f_2)Y_3)$$

$$b = c - D/B$$

Therefore, the value of b gives the frequency at which a minimum occurs, and c gives the frequency at which the maximum occurs.

PRBFIT ***

PRBFIT performs a parabolic fit to the dependent variable at the input value of the independent variable to determine either a maximum or minimum point. The dependent variable functional relationship is described through RLDMG.

calling sequence:

CALL PRBFIT(DX, DYMG)

input/output:

DX - independent variable input value which will be modified to give a value closer to the actual maximum or minimum.

output:

DYMG - maximum or minimum value of the dependent variable corresponding to DX.

method:

Assume that a parabolic fit to the function $y = f(x)$ is desired at the point x_m . Define

$eps = x_m * 1.E-4$

$x_1 = x_m - eps$

$x_2 = x_m$

$x_3 = x_m + eps$

and determine $f(x_1)$, $f(x_2)$, $f(x_3)$.

Calculate

$$eps\ prime = \frac{(eps/2)(|f(x_1)| - |f(x_3)|)}{(|f(x_1)| - 2|f(x_2)| + |f(x_3)|)}$$

and

$x_m = x_2 + eps\ prime$

If $|f(x_m)| - |f(x_2)| / |f(x_m)|$ is less than the error tolerance, then stop. Otherwise do the following replacements and cycle again:

$\text{eps} = \text{eps prime}$

$x_1 = x_2$

$x_2 = x_m$

$x_3 = x_m + \text{eps}.$

FNDPRM *

FNDPRM iterates on the given ceramic parameters until agreement with experimental results(i.e.,FM, FN, YM, YN, CLO, CLOM) is obtained within a certain tolerance. (See Appendix E.)

calling sequence:

CALL FNDPRM(C NAME, FM, FN, YM, YN, CLO, CLOM, FLO, MAX)

input:

C NAME	- name of the ceramic section.
FM	- frequency where admittance is a maximum.
FN	- frequency where admittance is a minimum.
YM	- maximum admittance.
YN	- minimum admittance.
CLO	- the electrical input parallel capacitance at the frequency FLO.
CLOM	- the dissipation factor at frequency FLO.
FLO	- frequency which is below FM and near the lower frequency limit of the actual transducer operating frequency.
MAX	- max number of iterations.

printout:

see writeup for subroutine PRTPRM.

FNDFDP ***

FNDFDP computes the values to compare with experimental data in the Find Parameters procedure described in Appendix E.

calling sequence:

CALL FNDFDP

LDBCOL ***

LDBCOL loads a column of the Find Parameters matrix. (See Appendix E.)

calling sequence:

CALL LDBCOL(J COL, N CAP)

input:

J COL - column number to be loaded.
N CAP - total number of rows in matrix.

PRTPRM ***

PRTPRM prints the output from the Find Parameters procedure. (see Appendix E.)

calling sequence:

CALL PRTPRM

printout:

prints at each iteration the experimental values, the new values using the newly computed parameters, and the relative errors.

APPENDIX B
IMPLEMENTED NETWORK TYPES

Table 1 summarizes the networks presently implemented in the program. For each network the input data, sign conventions, and equations programmed are included in the descriptions which follow:

TABLE 1. Summary of Network Types.

(* indicates frequency dependence)

<u>Type</u>	<u>Description</u>	<u>Input Data</u>
1	* Straight Piece	NAME,RHO,A,ID,OD,L,Cr,Ci,Cm
2	* Conical Piece	NAME,RHO,A1,ID1,OD1,A2,ID2, OD2,L,Cr,Ci,Cm
4	Ideal Transformer	NAME,TURNS RATIO
5	Arbitrary n by n Matrix	NAME,ZIJr,ZIJi
7	* Rational Polynomial in Frequency	NAME,FACTOR,IFORM,NSYMF, coefficients
8	Voltage to Voltage Converter	NAME,ZI,ZO,ALPHA
9	Voltage to Current Converter	NAME,ZI,ZO,BETA
11	* 3-3 Mode Ceramic Stack	NAME,N,RHO,A,ID,OD,L, E33Tr,E33Ti,E33Tm, G33r,G33i,G33m, S33Dr,S33Di,S33Dm
14	* 3-1 Mode Ceramic Thin Bar	NAME,RHO,T,W,L, E33Tr,E33Ti,E33Tm, G31r,G31i,G31m, S11Er,S11Ei,S11Em
15	* 3-1 Mode Ceramic Tube	NAME,RHO,ID,OD,L, E33Tr,E33Ti,E33Tm, G31r,G31i,G31m, S11Er,S11Ei,S11Em

20	* Linear Transformer	NAME,RP,LP,RO,LO,RS,LS,PHI
21	* Series Impedance	NAME,RS,LS,CS
22	* Parallel Impedance	NAME,RS,LS,CS
24	* Series Admittance	NAME,RP,LP,CP
25	* Parallel Admittance	NAME,RP,LP,CP
26	* Linear Model of a Differential Input Operational Amplifier	NAME,R1,C1,R2,C2,RD,CD,R3,L3, AO, OMEGA1,OMEGA2,OMEGA3

TYPE 1: STRAIGHT PIECE (non-ceramic)

Input Parameters:

$$A = \text{Area (m}^2\text{)}$$

$$L = \text{Length (m)}$$

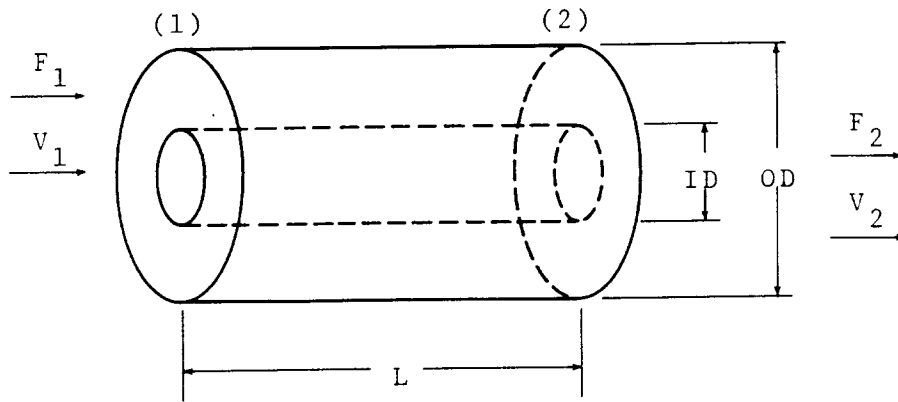
$$c = \text{Sound Velocity} = c_r (1 + jc_m) \text{ (m/sec)}$$

$$\rho = \text{Density (kg/m}^3\text{)}$$

$$\left. \begin{array}{l} \text{OD} = \text{Outer Diameter (m)} \\ \text{ID} = \text{Inner Diameter (m)} \end{array} \right\} \text{when applicable}$$

$$f = \text{Frequency (Hz)}$$

$$\omega = 2\pi f$$



Computed Parameters:

$$k = \omega/c$$

$$A_{11} = A_{22} = \cos(kL)$$

$$Z_{11} = -j\rho c A \cot(kL)$$

$$A_{12} = j\rho c A \sin(kL)$$

$$Z_{12} = -Z_{21} = j\rho c A \csc(kL)$$

$$A_{21} = j(\sin(kL))/(\rho c A)$$

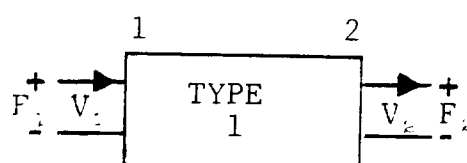
$$Z_{22} = j\rho c A \cot(kL)$$

Note that

$$\begin{bmatrix} F_1 \\ F_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \quad |A| = 1 \quad ,$$

and

$$\begin{bmatrix} F_1 \\ V_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} F_2 \\ V_2 \end{bmatrix} \quad .$$



TYPE 2: CONICAL PIECE (non-ceramic)

Input Parameters:

$$A_1 = \text{Area at (1) (m}^2\text{)}$$

$$A_2 = \text{Area at (2) (m}^2\text{)}$$

$$L = \text{Length (m)}$$

$$c = \text{Sound Velocity} = c_T (1 + j\eta) \text{ (m/sec)}$$

$$\rho = \text{Density (kg/m}^3\text{)}$$

$$OD_1 = \text{Outer Diameter at (1) (m)}$$

$$OD_2 = \text{Outer Diameter at (2) (m)}$$

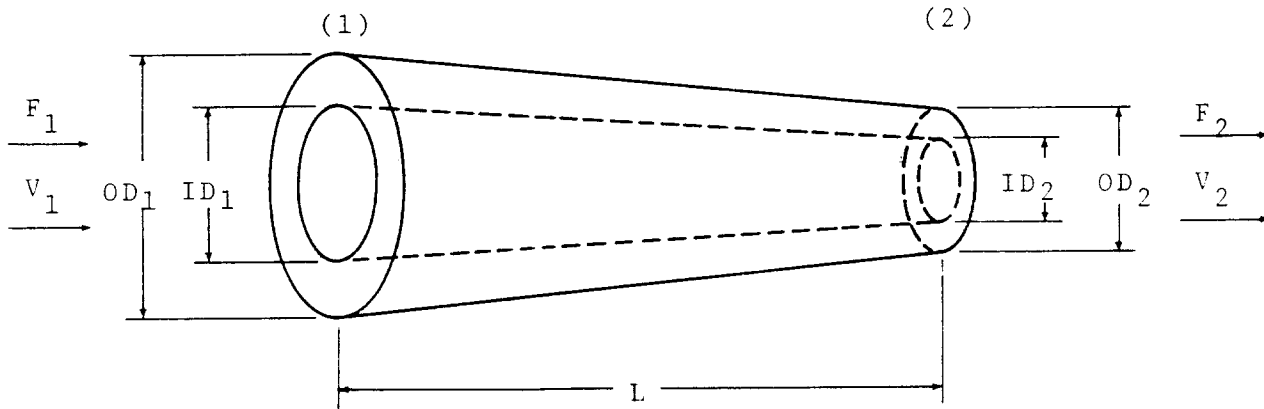
$$ID_1 = \text{Inner Diameter at (1) (m)}$$

$$ID_2 = \text{Inner Diameter at (2) (m)}$$

} when applicable

$$f = \text{Frequency (Hz)}$$

$$\omega = 2\pi f$$



Computed Parameters:

$$k = \omega/c$$

$$A_{11} = \sqrt{A_1/A_2} [\cos(kL) - \sin(kL)/(kL)] + \sin(kL)/kL$$

$$A_{12} = j\rho c [1/(kL) (\sin(kL)/(kL) + \cos(kL)) (\sqrt{A_1} - \sqrt{A_2})^2 + \sqrt{A_1 A_2} \sin(kL)]$$

$$A_{21} = j \sin(kL)/(\rho c \sqrt{A_1 A_2})$$

$$A_{22} = \sqrt{A_2/A_1} [\cos(kL) - \sin(kL)/(kL)] + \sin(kL)/(kL)$$

$$Z_{11} = -j\rho c A_1 [\cot(kL) - 1/(kL)] - j\rho c \sqrt{A_1 A_2} [1/(kL)]$$

$$Z_{12} = -Z_{21} = j\rho c \sqrt{A_1 A_2} \csc(kL)$$

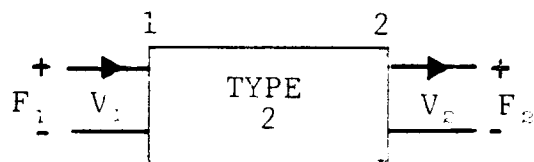
$$Z_{22} = j\rho c A_2 [\cot(kL) - 1/(kL)] + j\rho c \sqrt{A_1 A_2} [1/(kL)]$$

Note that

$$\begin{bmatrix} F_1 \\ F_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

and

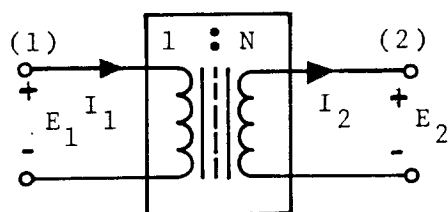
$$\begin{bmatrix} F_1 \\ V_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} F_2 \\ V_2 \end{bmatrix} \quad |A| = 1$$



TYPE 4: IDEAL TRANSFORMER

Input Parameters:

N = Secondary/Primary Turns Ratio



Computed Parameters:

$$A_{11} = 1/N$$

$$A_{12} = 0$$

$$A_{21} = 0$$

$$A_{22} = N$$

NOTE: THE Z-FORM DOES NOT EXIST
THE Y-FORM DOES NOT EXIST.

If $N=1$, $[A]$ = Unit Matrix,

where

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix}$$

TYPE 5: Arbitrary n by n Matrix

Input Parameters: List of complex numbers for elements of an n by n matrix.

TYPE 7: RATIONAL POLYNOMIAL IN FREQUENCY

Input Parameters:

FACTOR = scale factor for input coefficients

IFORM = flag for form of input matrix

NSYMFG = flag for symmetry of input matrix

C_{nij} = complex coefficients for numerator polynomial ($n=0, \dots, N$)

d_{mij} = complex coefficients for denominator polynomial ($m=0, 1, \dots, M$)

N = order of numerator polynomial

M = order of denominator polynomial

f = frequency (Hz)

where:

$i, j = 1, 2, \dots, K$

K = the number of network ports

Computed Parameters:

$$Z_{ij} = \frac{\sum_{n=0}^N C_{nij} * f^n}{\sum_{m=0}^M d_{mij} * f^m}$$

Note: For definitions of IFORM and NSYMFG, see Appendix A subroutine writeup for LD DT 7.

TYPE 8: VOLTAGE TO VOLTAGE CONVERTER (can be used as Amplifier model)

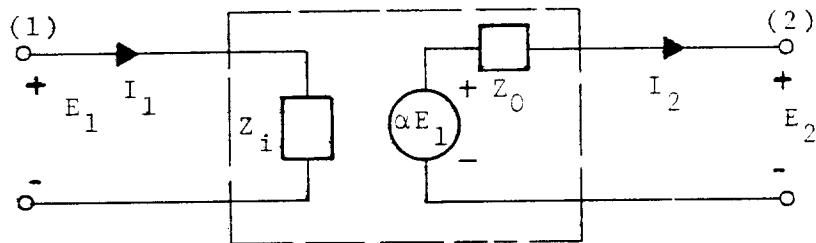
Input Parameters:

Z_i = Input impedance of amplifier (ohms)

Z_O = Output impedance (ohms)

α = Voltage gain

Note: All three parameters are complex and a function of frequency.



Computed Parameters:

$$A_{11} = 1/\alpha$$

$$A_{12} = Z_O/\alpha$$

$$A_{21} = 1/(\alpha Z_i)$$

$$A_{22} = Z_O/(\alpha Z_i)$$

$$Z_{11} = Z_i$$

$$Z_{12} = 0$$

$$Z_{21} = \alpha Z_i$$

$$Z_{22} = -Z_O$$

Note that

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix}, \quad |A| \neq 1$$

and

$$\begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$Y = Z^{-1}$$

TYPE 9: VOLTAGE TO CURRENT CONVERTER
(can be used as Norton Amplifier Model)

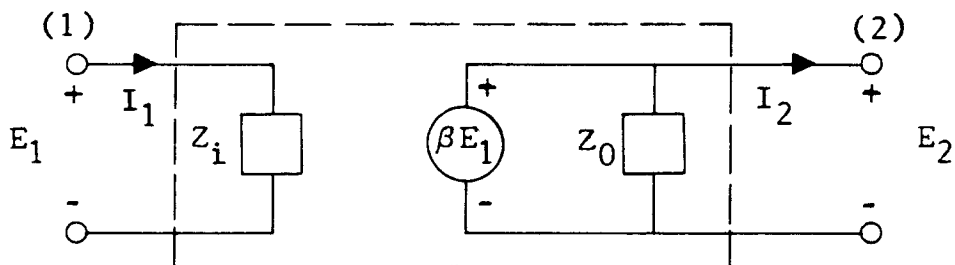
Input Parameters:

Z_i = Input impedance of amplifier (ohms)

Z_O = Output impedance (ohms)

β = Voltage to current gain (transconductance, Mhos)

All three parameters are complex and a function of frequency.



Computed Parameters:

$$A_{11} = 1/(\beta Z_O)$$

$$Z_{11} = Z_i$$

$$A_{12} = 1/\beta$$

$$Z_{12} = 0$$

$$A_{21} = 1/(\beta Z_i Z_O)$$

$$Z_{21} = \beta Z_i Z_O$$

$$A_{22} = 1/(\beta Z_i)$$

$$Z_{22} = -Z_O$$

Note that

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix}, \quad |A| \neq 1$$

and

$$\begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$Y = Z^{-1}$$

TYPE 11: 3-3 MODE CERAMIC STACK

Input Parameters:

$$\rho = \text{Density (kg/m}^3\text{)}$$

$$A = \text{Area of poled surface (m}^2\text{)}$$

$$L = \text{Piece length (m)}$$

$$N = \text{Number of pieces}$$

$$OD = \text{Outer diameter}$$

$$ID = \text{Inner diameter}$$

} when applicable

$$E_{33}^T = E33TR (1 - jE33TM)$$

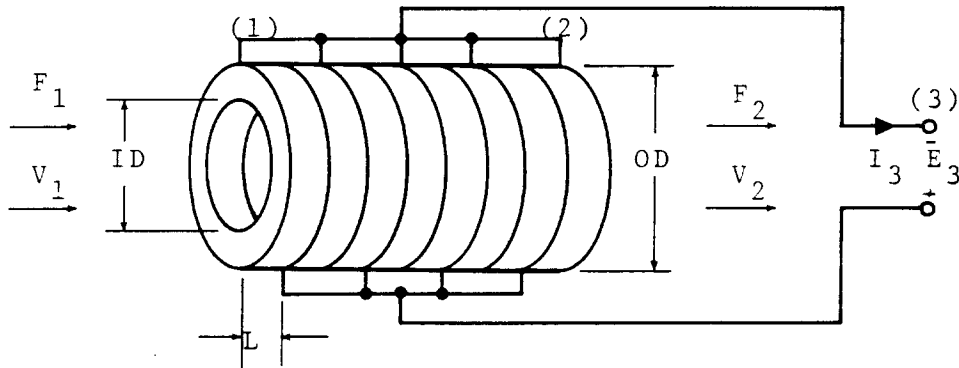
$$g_{33} = G33R (1 - jG33M)$$

$$s_{33}^D = S33DR (1 - jS33DM)$$

} Ceramic stack parameters
in RMKSAA Units

$$f = \text{Frequency (Hz)}$$

$$\omega = 2\pi f$$



Computed Parameters:

$$c = \sqrt{1/(\rho s_{33}^D)}$$

$$k = \omega/c$$

$$\epsilon_O = \text{Permittivity of vacuum (8.8542} \times 10^{-12}\text{)}$$

$$\beta_{33}^{LC} = (g_{33})^2/s_{33}^D + 1/(\epsilon_O E_{33}^T)$$

$$C_O = A/(L\beta_{33}^{LC})$$

$$\Phi = g_{33}C_O/s_{33}^D$$

$$z_O = \Phi / (j\omega C_O)$$

$$z_O^C = z_O / N$$

$$Z_{22}^S = j\rho c A \cot(kL) + \Phi z_O = -Z_{11}^S$$

$$Z_{12}^S = j\rho c A \csc(kL) + \Phi z_O = -Z_{21}^S$$

$$\alpha = \cosh^{-1}(Z_{22}^S / Z_{12}^S)$$

$$Z_O = -Z_{12}^S \sinh(\alpha)$$

$$K_{33} = g_{33} \sqrt{\frac{1}{\beta_{33}^{LC} s_{33}^D}}$$

$$Z_{11} = Z_O \coth(N\alpha) + \Phi z_O^C$$

$$Z_{12} = -Z_O \operatorname{csch}(N\alpha) - \Phi z_O^C$$

$$Z_{13} = z_O^C$$

$$Z_{21} = -Z_{12}$$

$$Z_{22} = -Z_{11}$$

$$Z_{23} = Z_{13}$$

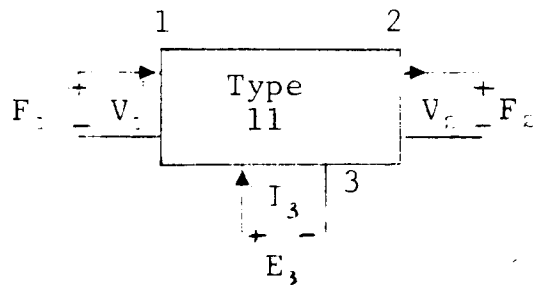
$$Z_{31} = Z_{13}$$

$$Z_{32} = -Z_{13}$$

$$Z_{33} = z_O^C / \Phi$$

Note that

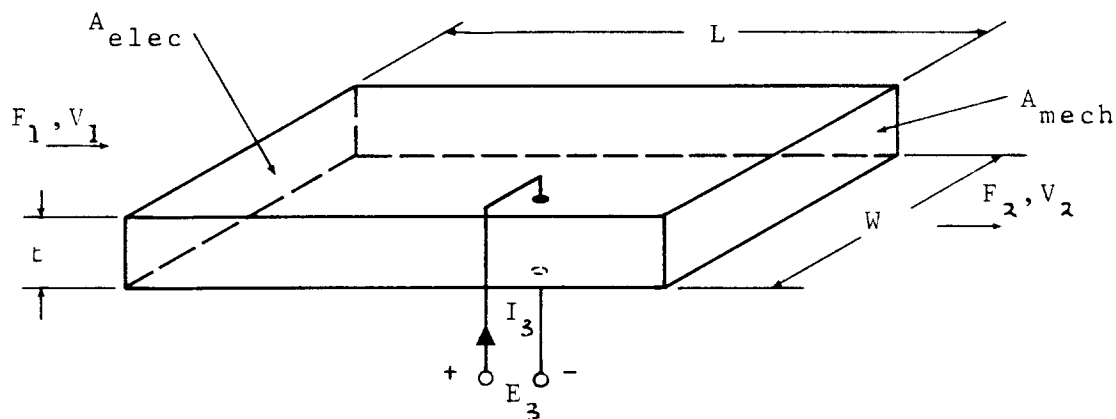
$$\begin{bmatrix} F_1 \\ F_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ I_3 \end{bmatrix}$$



TYPE 14: 3-1 MODE CERAMIC THIN BAR

Input Parameters:

$$\begin{aligned}\rho &= \text{density (kg/m}^3\text{)} \\ t &= \text{thickness (m)} \\ w &= \text{foil width (m)} \\ L &= \text{length (m)} \\ E_{33}^T &= E33TR (1 - jE33TM) \\ g_{31} &= G31R (1 - jG31M) \\ s_{11}^E &= S11ER (1 - jS11EM) \\ f &= \text{frequency (Hz)} \\ \omega &= 2\pi f\end{aligned}$$



COMPUTED PARAMETERS:

$$\begin{aligned}c &= \frac{1}{\sqrt{\rho s_{11}^E}} \\ k &= \omega/c \\ \epsilon_0 &= 8.8542 \times 10^{-12} \\ D_{31} &= E_{33}^T \times \epsilon_0 \times g_{31} \\ (k_{31})^2 &= g_{31} \times D_{31}/s_{11}^E \\ A_{mech} &= t \times w \\ A_{elec} &= L \times w\end{aligned}$$

$$\text{mass} = \rho \times A_{\text{mech}} \times L$$

$$C_O = \left(\frac{A_{\text{elec}}}{t} \right) \times \epsilon_O \times E_{33}^T \times (1 - K_{31}^2)$$

$$\Phi = A_{\text{elec}} \times D_{31} / (s_{11}^E \times L)$$

$$Z_{33} = 1 / (j\omega C_O)$$

$$z_O = \Phi \times Z_{33}$$

$$Z_{11}^S = -j\rho C \times A_{\text{mech}} / \tan(k \times L) = -Z_{22}^S$$

$$Z_{12}^S = j\rho C \times A_{\text{mech}} / \sin(k \times L) = -Z_{21}^S$$

$$Z_{11} = Z_{11}^S + \Phi z_O = -Z_{22}$$

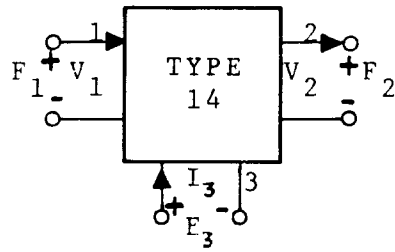
$$Z_{12} = Z_{12}^S - \Phi z_O = -Z_{21}$$

$$Z_{13} = z_O = Z_{31} = Z_{23}$$

$$Z_{32} = -Z_{13}$$

Note that

$$\begin{bmatrix} F_1 \\ F_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ I_3 \end{bmatrix}$$



TYPE 15: 3-1 MODE CERAMIC TUBE

Input Parameters:

$$\rho = \text{density (kg/m}^3\text{)}$$

$$\text{ID} = \text{inner diameter (m)}$$

$$\text{OD} = \text{outer diameter (m)}$$

$$L = \text{length (m) (all foiled)}$$

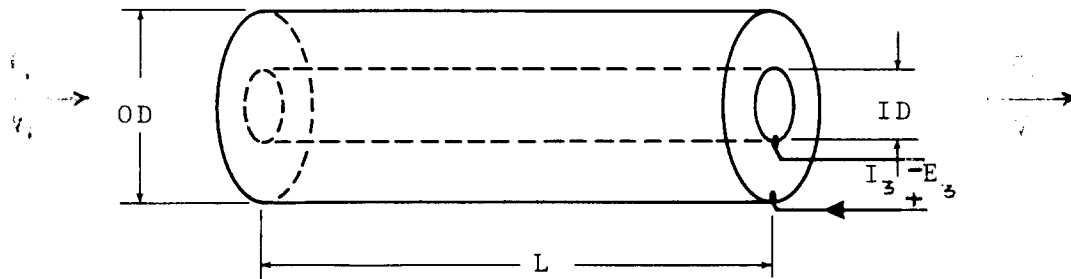
$$E_{33}^T = E33\text{TR (1 - jE33TM)}$$

$$g_{31} = G31\text{R (1 - jG31M)}$$

$$s_{11}^E = S11\text{ER (1 - jS11EM)}$$

$$f = \text{frequency}$$

$$\omega = 2\pi f$$



COMPUTED PARAMETERS:

$$c = \frac{1}{\rho \times s_{11}^E}$$

$$k = \omega/c$$

$$\epsilon_0 = 8.8542 \times 10^{-12}$$

$$D_{31} = E_{33}^T \times \epsilon_0 \times g_{31}$$

$$(K_{31})^2 = g_{31} \times D_{31} / s_{11}^E$$

$$A_{\text{mech}} = (\text{OD} + \text{ID}) (\text{OD} - \text{ID}) \times \pi/4$$

$$A_{\text{elec}} = (\text{OD} + \text{ID}) \times L \times \pi/2$$

$$\text{mass} = \rho \times A_{\text{mech}} \times L$$

$$C_O = 2\pi L / \ln(OD/ID) \times \epsilon_O \times E_{33}^T \times (1 - K_{31}^2)$$

$$\Phi = A_{\text{elec}} \times D_{31} / (s_{11}^E \times L)$$

$$Z_{33} = 1 / j\omega C_O$$

$$z_O = \Phi \times Z_{33}$$

$$Z_{11}^S = j\rho c \times A_{\text{mech}} / \tan(k \times L) = -Z_{22}^S$$

$$Z_{12}^S = j\rho c \times A_{\text{mech}} / \sin(k \times L) = -Z_{21}^S$$

$$Z_{11} = Z_{11}^S + \Phi z_O = -Z_{22}$$

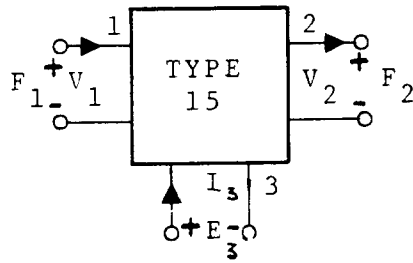
$$Z_{12} = Z_{12}^S - \Phi z_O = -Z_{21}$$

$$Z_{13} = z_O = Z_{31} = Z_{23}$$

$$Z_{32} = -Z_{13}$$

Note that

$$\begin{bmatrix} F_1 \\ F_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ I_3 \end{bmatrix}$$



TYPE 20: LINEAR TRANSFORMER

Input Parameters:

Φ = Turns ratio; secondary/primary

R_P, R_S = Copper losses in primary and secondary (ohms)

R_O = Core loss (ohms)

L_P, L_S = Winding inductances in primary and secondary (H)

L_O = Magnetizing inductance (H)

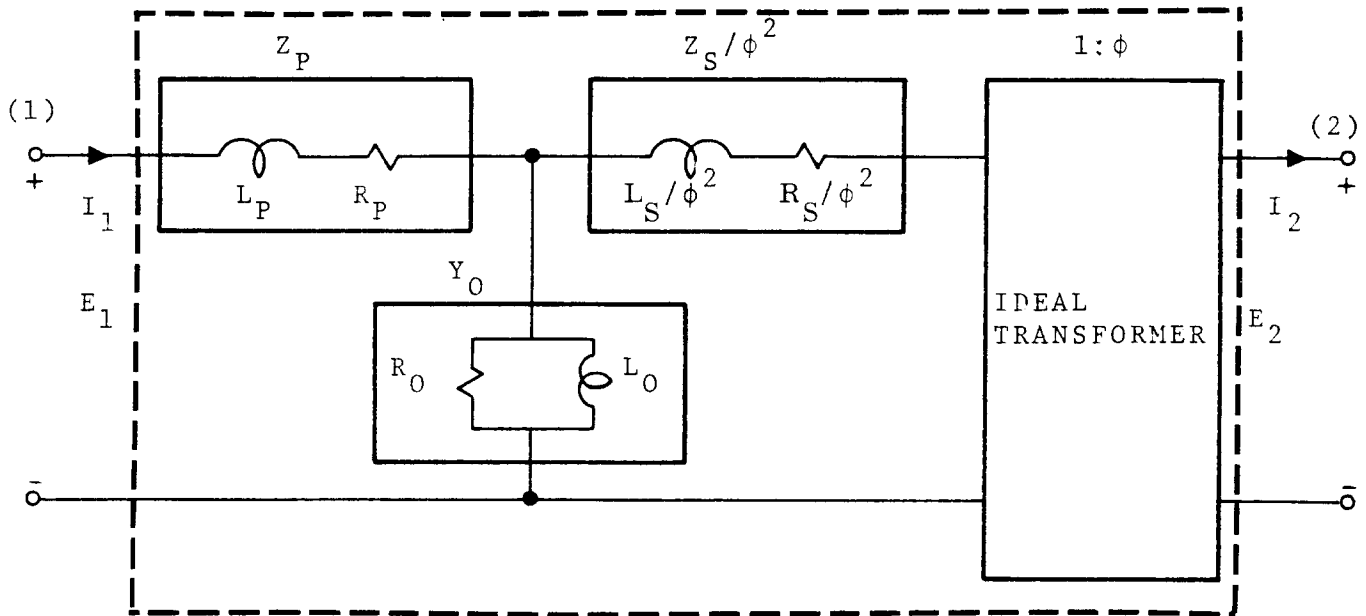
Z_P = Primary impedance = $R_P + j\omega L_P$ (ohms)

Y_O = Shunt Admittance = $\frac{1}{R_O} + \frac{1}{j\omega L_O}$ (mhos)

Z_S = Secondary impedance = $R_S + j\omega L_S$ (ohms)

f = Frequency (Hz)

$\omega = 2\pi f$



Computed Parameters:

$$Z_P = R_P + j\omega L_P$$

$$Z_O = 1/Y_O$$

$$Z_S = R_S + j\omega L_S$$

$$Z_{11} = Z_P + Z_O$$

$$Z_{12} = -\Phi Z_O$$

$$Z_{21} = -Z_{12}$$

$$Z_{22} = -[\Phi^2 Z_O + Z_S]$$

$$Z_{SAP} = Z_S/\Phi^2$$

$$A_{11} = [1 + Z_P Y_O]/\Phi$$

$$A_{12} = \Phi[Z_{SAP} + Z_P + Z_{SAP} Z_P Y_O]$$

$$A_{21} = Y_O/\Phi$$

$$A_{22} = \Phi[1 + Z_{SAP} Y_O]$$

Note that

$$\begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} ,$$

and

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix} . \quad |A| = 1$$

TYPE 21: SERIES IMPEDANCE

Input Parameters:

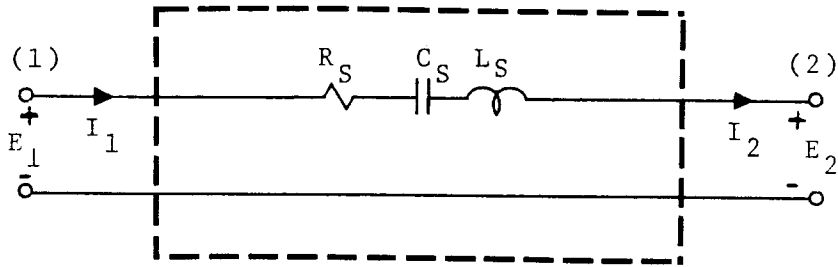
R_S = Resistance (ohms)

L_S = Inductance (H)

C_S = Capacitance (F)

f = Frequency (Hz)

$\omega = 2\pi f$



Computed Parameters:

$$Z_S = R_S + j\left(\omega L_S - \frac{1}{\omega C_S}\right)$$

Let

$C_S = 10^{30}$ for no capacitor,

$L_S = 0$ for no inductor,

and

$R_S = 0$ for no resistor.

Then

$$A_{11} = 1,$$

$$A_{12} = Z_S,$$

$$A_{21} = 0,$$

and

$$A_{22} = 1,$$

where

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix} \quad |A| = 1$$

NOTE: THE Z-FORM DOES NOT EXIST

TYPE 22: PARALLEL IMPEDANCE

Input Parameters:

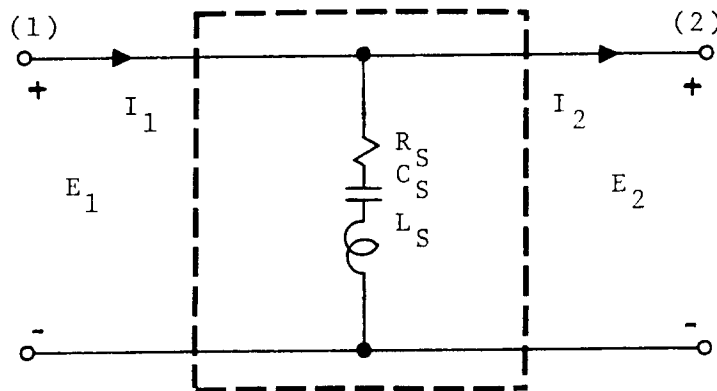
R_S = Resistance (ohms)

L_S = Inductance (H)

C_S = Capacitance (F)

f = Frequency (Hz)

$\omega = 2\pi f$



Computed Parameters:

$$Z_S = R_S + j\left(\omega L_S - \frac{1}{\omega C_S}\right)$$

Let

$C_S = 10^{30}$ for no capacitor,

$L_S = 0$ for no inductor,

and

$R_S = 0$ for no resistor.

Then

$$\begin{array}{lll} A_{11} = 1, & Z_{11} = Z_S, & \\ A_{12} = 0, & Z_{12} = -Z_S, & |A| = 1 \\ A_{21} = 1/Z_S, & Z_{21} = Z_S, & \\ A_{22} = 1, & Z_{22} = -Z_S, & |Z| = 0 \end{array}$$

where

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix},$$

and

$$\begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

NOTE: THE Y-FORM DOES NOT EXIST

TYPE 24: SERIES ADMITTANCE

Input Parameters:

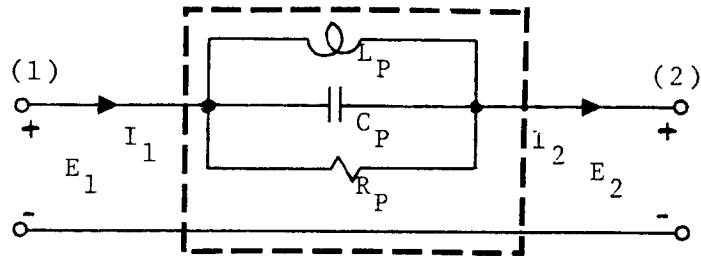
R_P = Resistance (ohms)

L_P = Inductance (H)

C_P = Capacitance (F)

f = Frequency (Hz)

$\omega = 2\pi f$



Computed Parameters:

$$Y_P = \frac{1}{R_P} + j\left(\omega C_P - \frac{1}{\omega L_P}\right)$$

Let

$R_P = 10^{30}$ for no resistor,

$L_P = 10^{30}$ for no inductor,

and

$C_P = 0$ for no capacitor.

Then,

$$A_{11} = 1$$

$$A_{12} = \frac{1}{Y_P}$$

$$A_{21} = 0$$

and

$$A_{22} = 1$$

Note that

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix} \quad |A| = 1$$

NOTE: Z-FORM DOES NOT EXIST

TYPE 25: PARALLEL ADMITTANCE

Input Parameters:

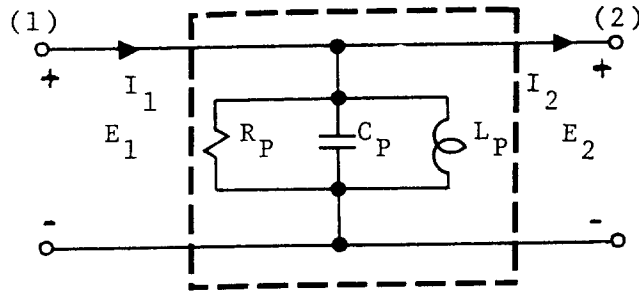
R_P = Resistance (ohms)

L_P = Inductance (H)

C_P = Capacitance (F)

f = frequency (Hz)

$\omega = 2\pi f$



Computed Parameters:

$$Y_P = \frac{1}{R_P} + j\left(\omega C_P - \frac{1}{\omega L_P}\right)$$

Let

$R_P = 10^{30}$ for no resistor,

$L_P = 10^{30}$ for no inductor,

and

$C_P = 0$ for no capacitor.

Then,

$$A_{11} = 1,$$

$$A_{12} = 0,$$

$$A_{21} = Y_P,$$

and

$$A_{22} = 1,$$

where

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix} \quad |A| = 1$$

NOTE: Y-FORM DOES NOT EXIST

TYPE 26: LINEAR MODEL OF A DIFFERENTIAL INPUT OPERATIONAL AMPLIFIER

Input Parameters:

R_1 = Input resistance (ohms)

C_1 = Input capacitance (F)

R_2 = Input resistance (ohms)

C_2 = Input capacitance (F)

R_D = Differential input resistance (ohms)

C_D = Differential input capacitance (F)

R_3 = Output resistance (ohms)

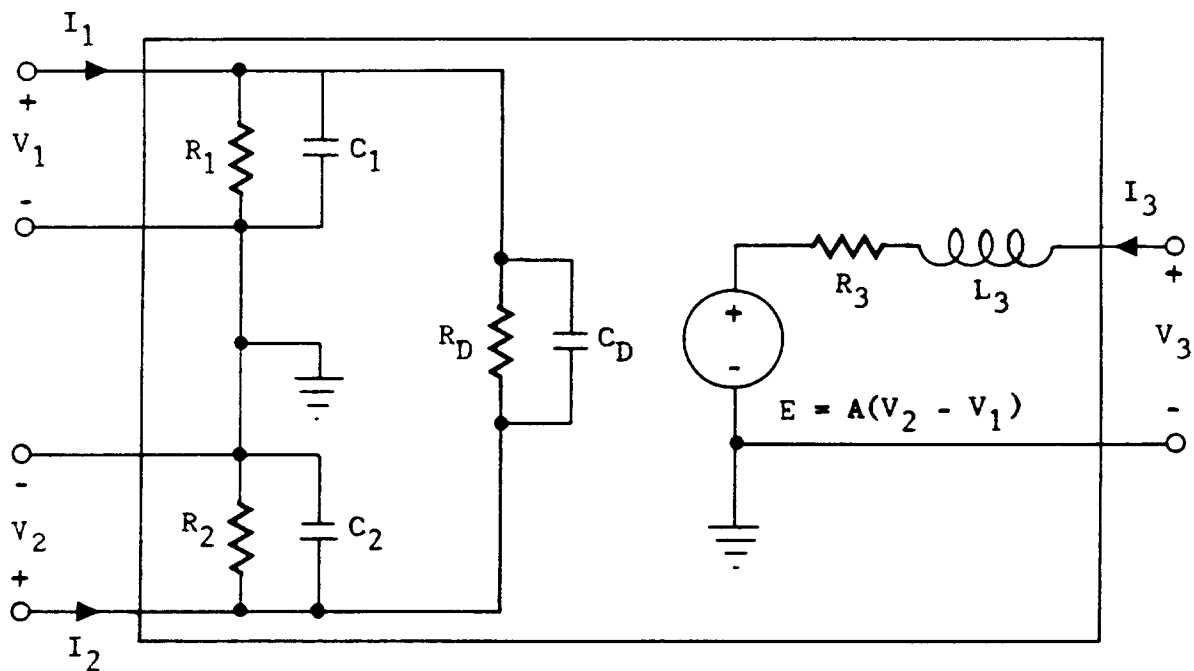
L_3 = Output inductance (H)

A_0 = dc open loop gain

$\omega_1, \omega_2, \omega_3$ = First three pole frequencies of the open loop transfer function (radians/sec)

f = frequency (Hz)

$\omega = 2\pi f$



Computed Parameters:

$$Y_1 = 1/R_1 + j\omega C_1$$

$$Y_2 = 1/R_2 + j\omega C_2$$

$$Y_3 = 1/(R_3 + j\omega L_3)$$

$$Y_D = 1/R_D + j\omega C_D$$

$$A = A_0/((1 + j\omega/\omega_1)(1 + j\omega/\omega_2)(1 + j\omega/\omega_3))$$

$$Y_{11} = Y_1 + Y_D$$

$$Y_{12} = -Y_D$$

$$Y_{13} = 0$$

$$Y_{21} = -Y_D$$

$$Y_{22} = Y_2 + Y_D$$

$$Y_{23} = 0$$

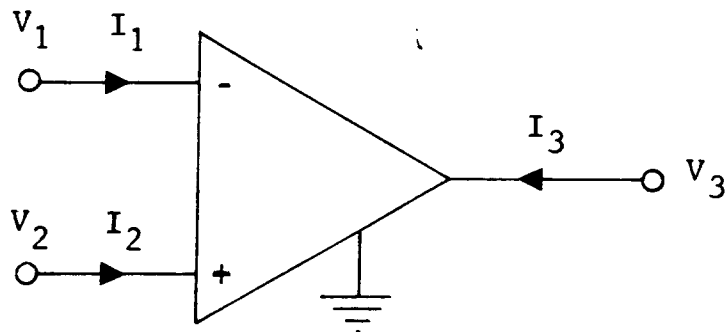
$$Y_{31} = AY_3$$

$$Y_{32} = -AY_3$$

$$Y_{33} = Y_3$$

Note that

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$



APPENDIX C

THE CONTROL ROUTINE USING A TRANSDUCER DESIGN EXAMPLE

This appendix presents a discussion of the operations that are written for a particular transducer design control routine. In this case, the specific problem dictates part of the routine; however, certain operations must be included in all control routines.

The first step in writing a control routine is to define the amount of storage to be used in the master storage area or blank common. The common block, DTA TOT, contains the variable, MX DATA, which is to be set by the user to the maximum number of storage cells to be used in blank common (i.e., the dimension size of the blank common array, DATA).

Secondly, the user must supply the port table description. The port table describes to the program the actual interconnection topology, series or parallel connection, and sign conventions. This operation is accomplished through subroutine LD PORT, which is called once for each accessible port of the network (Note: It is possible to define several networks at this time for use later in the program).

Following the description of the port table, each basic network that is referred to in the table must be described through a network description routine. A library of network description routines is available to include various types of networks, and may be easily expanded to handle any special types desired by the user. The purpose of these routines is to supply the data required to calculate the impedance matrix for the network (e.g., length, area, velocity of sound, etc.).

The control routine's major function is to perform the necessary calculations (or, as in most cases, the necessary calls to subroutines that perform the calculations) for the solution of the user's specific problem. Since the specific problems vary widely, a general structure for this portion cannot be provided. This approach offers the user maximum generality and flexibility for the solution of his problems.

The user must control through the routine the printed output of the problem. Several print flags can be turned on by the routine to provide some printed output; however, the user will have to supply some code to output the desired information.

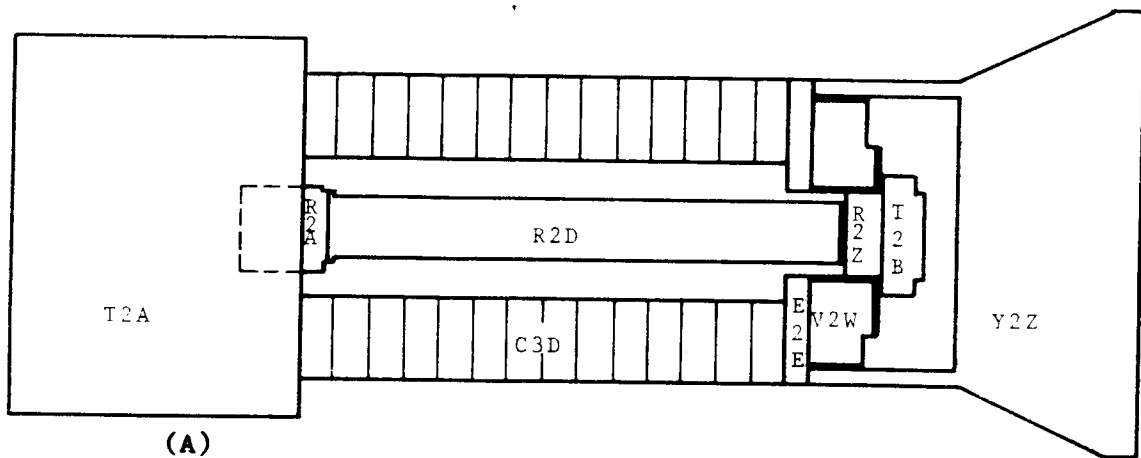
The control routine's basic functions are illustrated by a routine written to investigate the changes in transducer performance caused by varying the transducer's tail length and ceramic area. Figure C.1 shows a diagram of the transducer. Figure C.2 shows the listing and associated printed output for the control routine. The problem in this case is to minimize $|Z_{ec}|$, the voltage-velocity control impedance of the radiating face (or, equivalently, $\gamma_{ec} = Z_{ec} + Z_{self}$, where $Z_{self} = \text{constant}$), as a function of both the number of ceramic pieces and the length of each ceramic piece. Lines 8-22 of figure C.2 are the common blocks needed for this run. Line 17 is a common block used only for this type of design procedure and is used primarily for transfer of information to RLIMMG, a subroutine that determines the real and imaginary parts as well as the magnitude of a complex function evaluated at a particular point. In this case, the function to be minimized is programmed into the subroutine.

Lines 27-33 contain pertinent data such as the names of networks to be involved in total length calculations, ceramic areas, and tail lengths.

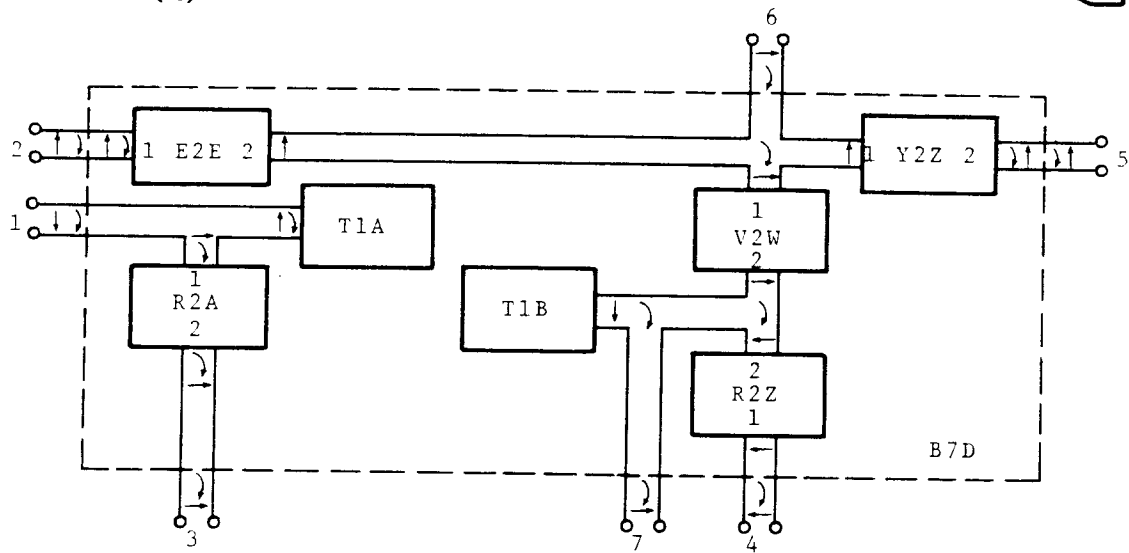
Lines 46-59 define to the routine the interconnection table and sign conventions utilized by the user. Each of the basic networks that appears in the interconnection table is then described through particular network type calculations in lines 61-81.

Three major loops begin on lines 108 (tail lengths), 114 (ceramic areas), and 126 (number of ceramic pieces). The computations that are a function of these variables must be defined within these loops. The problem is to determine the number of pieces required to minimize $|\gamma_{ec}|$ and, using that number of ceramic pieces, to refine the estimate of the minimum by varying the ceramic piece length. The refined estimate is computed by both a pole-zero technique and a parabolic fit.

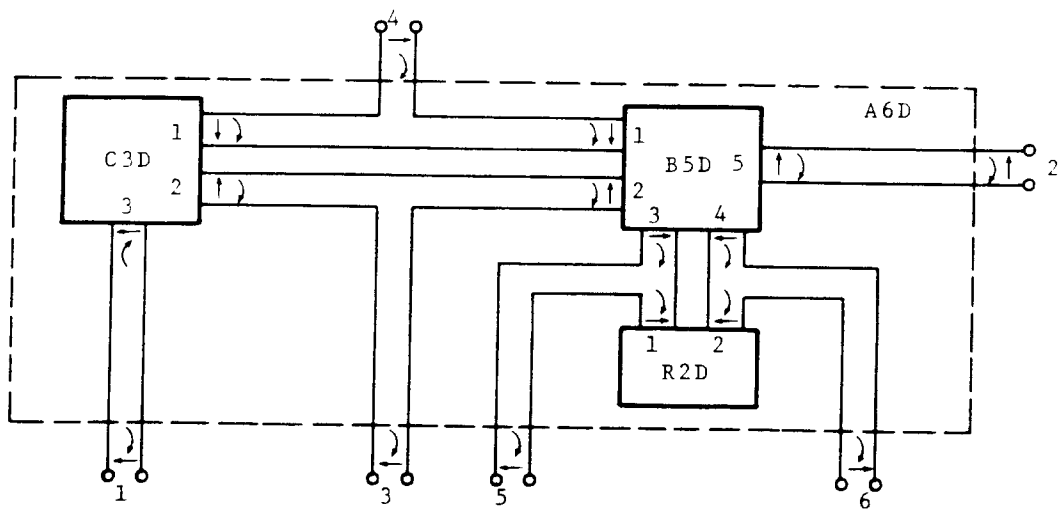
The subroutine RLIMMG is presented on pages 8, 9 and 10 of the computer print-out. Computer routine loading information appears on pages 11 through 22, while pages 23 through 30 are given to computer run output.



(A)



(B)



(C)

Figure C.1. Transducer Diagram and Interconnection Schematics. The figure includes (A) the transducer diagram, (B) the interconnection schematic for B7D, and (C) the interconnection schematic for A6D.

Figure C.2.

Listing and Output for Sample Control Routine for
Transducer Design. This routine investigates the effects
on the performance of a transducer element of varying
the tail length and ceramic area.

[illegible]

• SEALUCER VERSION 1 (DOUBLE PRECISION)

C-6

SEARCHER RUN 60033 FOR TP-228 APPL LIA C
CUPIN R., TFFS.
FURPUR 023A-10/19-19:4J
112 SYM 112 REL

DATE 101972

PAGE 1

WFILE B.

Figure C.2. (Continued).

FOR IS CONTROL CONTROL
FOR 0010-10/19/72-19:44:16 (10)

MAIN PROGRAM

STORAGE USED: CODE(1) 001206; DATA(0) 000605; BLANK COMMON(2) 000050

COMMON BLOCKS:

0003	CATALOG	001275
0004	BASIC	000006
0005	JTATOL	000001
0006	TOTL	000002
0007	TOTMAS	000002
0010	PTIOFF	000001
0011	CFMNR	000001
0012	DESIGN	000005
0013	SMERIC	000020
0014	CRMCT	000006
0015	CSMTN	000001
0016	FLSRH	000004
0017	CMFNN	000003

EXTERNAL REFERENCES (BLOCK NAME)

0020	USQRT
0021	SEICLK
0022	PAGE
0023	STRLIN
0024	LDPORT
0025	LDDI1
0026	LDDI4
0027	LDDI7
0030	ALOCAT
0031	LOCNAM
0032	SKPLIN
0033	LDIMTR
0034	HEAD24
0035	LDREQ
0036	BLDKKL
0037	RDCPT
0040	LDDI11
0041	FNDIL
0042	LOCMTN
0043	ZTOA
0044	PRMTN
0045	LDAM25
0046	CMPGAM
0047	FMFN
0050	FNDTMS
0051	SRMIDB
0052	TIME
0053	FNDNAM
0054	PRPTBL
0055	PRCTLG
0056	NINTRS

Figure C.2. (Continued).

0057	NPRTS
0060	NIO2\$
0061	NWDC\$
0062	NSTOPS

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)																		
0001	000722	100L	0001	000724	101L	0000	000424	149F	0001	001057	160L	0000	000443	165F				
0001	000453	2516	0001	000500	2606	0001	000542	274G	0000	000113	5F	0001	000660	9AL				
0001	000715	99L	0000	R	000021	C3PAR	0002	D	000000	DATA	0004	D	000000	DFRAMP				
0013	000802	DGELCI	0000	J	000004	DGECMG	0000	D	000002	DGECMN	0013	D	000000	DGICR				
0013	000004	DGICR	0000	D	000006	DLC3D	0000	D	000010	DLMIN	0000	D	000002	DOWEGA				
0004	000004	DPI	0014	D	000002	DWM	0014	D	000004	DREACT	0014	D	000000	DSQRT				
0006	000000	DTL	0007	D	000000	DTMASS	0013	D	000012	DZECI	0013	D	000010	DZECR				
0013	000014	DZICR	0000	R	000056	FACTOR	0000	I	000077	IAA2D	0000	I	000111	IAY224				
0000	000062	102S	0016	000001	IECIC	0016	I	000003	IFLGLC	0016	I	000002	IFL6SP	0011	I	000000	IFMNPRT	
0000	000057	IFORW	0000	I	000061	IE2S	0016	000000	IXEN	0003	000310	IPC	0000	I	000060	IPUNCH		
0000	000063	IS2S	0003	000620	ITYPE	0000	I	000076	IZA2D	0000	I	000112	IZY224	0000	I	000051	L	
0000	000026	LNAME\$	0003	I	001130	LOC	0042	I	000000	LOCMT	0031	I	000000	LOCNAM	0000	I	000032	LR2D1
0000	000064	LTOP	0000	I	000110	LYZ	0000	I	000052	M	0017	I	000001	MAXSKP	0000	I	000070	MINCNT
0017	000000	MINSKP	0000	I	000066	MTOP	0015	I	000000	MTRGVN	0003	000144	MTR512	0005	I	000000	MXDATA	
0000	000073	N	0003	000000	NAME	0000	I	000044	NC	0003	000764	MTR51R	0010	I	000000	NOPRRT		
0003	000454	NPLCOT	0012	I	000003	NPGEMN	0000	I	000072	NPH1	0000	I	000071	NPLQ	0000	I	000037	NT
0000	000053	NHUG	0017	I	000002	NIPOL0	0012	R	000002	RAC3D	0012	R	000004	RAR2D1	0000	P	000067	RAY223
0000	000107	RGECMN	0000	R	000103	RGICMG	0000	R	000074	RLC3D	0000	R	000100	RLGEMN	0012	R	000000	RLR2A1
0000	000075	RLR2U1	0012	R	000001	RLR221	0000	R	000065	RLT2A1	0000	R	000055	RLY224	0000	R	000054	RMV224
0000	000105	RPGEMN	0000	R	000104	RREACT	0000	R	000102	RTL	0000	R	000106	RTLCSU	0000	R	000101	RTMASS
0000	000014	T2A1L																

00101	1*	DOUBLE PRECISION	D F, D OMEGA, D PI	CONTROL
00103	2*	DOUBLE PRECISION	DATA	CONTROL
00104	3*	DOUBLE PRECISION	DT L, DT MASS	CONTROL
00105	4*	DOUBLE PRECISION	DGECR, DGECI, DGICR, DGICI, DZLCP, DZECI, DZICR, D7ICIC	CONTROL
00106	5*	DOUBLE PRECISION	DRM, DQM, DREACT	CONTROL
00107	6*	DOUBLE PRECISION	DFBAND, DRECMH, DRECMG, DLC3D, DLMIN, DNONE	CONTROL
00110	7*	DOUBLE PRECISION	DSORT	CONTROL
00111	8*	COMMON	CATALOG / NAME(100), MTP SIZE(100), I PC(100),	
00111	9*	COMMON	N PC TOT(100), I TYPE(100), N DI STR(100), LOC(100), I CLG 5R	
00112	10*	COMMON	BASIC 8 / D F, D OMEGA, D PI	
00113	11*	COMMON	DATA TOT / MX DATA	
00114	12*	COMMON	TOT L / DT L	
00115	13*	COMMON	TOT L / DT L	
00116	14*	COMMON	TOT L / DT L	
00117	15*	COMMON	PILOT OFF / NO PRT	
00120	16*	COMMON	C FMN PR / I FMN PR	
00121	17*	COMMON	C FLSGN / RL R2A1, RA C3D, RP GE MN, RA R2D1	
00122	18*	COMMON	GM EC IC / DGECR, DGLCI, DGICR, DGICI, DZLCP, DZECI, DZICR, D7ICIC	
00123	19*	COMMON	C RA HCT / DRM, DQM, DREACT	
00124	20*	COMMON	C SRMTR / MTR GVN	
00125	21*	COMMON	FLG SRH / I MX MH, I EC IC, I FLG 3P, I LG LC	
00126	22*	COMMON	C FMN / MIN SKP, MAX SKP, NI POL 0	
00127	23*	COMMON	T2A1 L(5), C3D AR(5)	
00130	24*	COMMON	L NAMES(4)	

Figure C.2. (Continued).


```

00222 82*
00222 83*      1PUNCH = 1
00223 84*      1PUNCH = 0
00224 85*      MAX SKP = 1
00225 86*      N1 POL 0 = 1
00226 87*
00226 88*      CALL ALOCAT('FS', 2, A)
00227 89*      IF25 = LOC NAM('FS')
00230 90*      CALL ALOCAT('DS', 2, 8)
00231 91*      AD25 = LOC NAM('DS')
00232 92*      CALL ALOCAT('SS', 2, 8)
00233 93*      AS25 = LOC NAM('SS')
00234 94*      CALL SKP LIN(1)
00235 95*      CALL LD 1 MTR(IF25, 2)
00236 96*      CALL HEAD 24(' F25 UNIT MATRIX ' )
00237 97*      CALL LD 1 MTR(ID25, 2)
00240 98*      CALL HEAD 24(' D25 UNIT MATRIX ' )
00241 99*      CALL LD 1 MTR(IS25, 2)
00242 100*      CALL HEAD 24(' S25 UNIT MATRIX ' )
00243 101*
00243 102*      CALL PAGE
00244 103*      UF = 3500.00
00245 104*      CALL LD FREQ( UF )
00246 105*
00246 106*      L TOP = 1
00247 107*      L TOP = 5
00250 108*      UO 300 L = 1, L TOP
00253 109*      RL T2A1 = T2A1 L(L)
00254 110*      CALL LD DT1('T2A1$', 7832.48, 2.17225E-2, 0.0, 0., RL T2A1, 5116.0, 0.0.)
00255 111*
00255 112*      M TOP = 1
00256 113*      M TOP = 5
00257 114*      UO 200 M = 1, M TOP
00262 115*      KA C30 = C30 AR(M)
00263 116*      RAY223 = RAYC30 * 0.5
00264 117*      CALL LD DT1('Y223$', 2702.61, RAY223, 0.0, 0.0, 0.353544, 5200.0, 0.0.)
00265 118*      CALL BLD KKL('B70$', )
00266 119*      CALL RDC PRT('B 70$', 'R50$', )
00267 120*
00267 121*      UGEC*H = 1.030
00270 122*      MIN CNT = 0
00271 123*      NP LO = 2
00272 124*      NP HI = 26
00273 125*
00273 126*      UO 100 N = NP LO, NP HI, 2
00276 127*      KL C30 = .0136253
00277 128*      CALL LD DT 11('C30$', N, 7586.21, 9A C30, 0.0, 0.0, 0., KL C30,
00277 129*      E .141166634, 0.00, .2419A5J-2,
00277 130*      G .2452070-1, 0.00, -.1674270-3,
00277 131*      S .9404950-11, 0.00, .1670290-2 )
00277 132*      CALL FND T L ( L R201, 3 )
00277 133*      KA R201 = JT L - RL R2A1 - RL P271
00300 134*      CALL LD DT1('R201$', 7702.60, KA R201, 0.0, 0., PL R201, 4970.0, 0.0.)
00301 135*      IF ( NO PRT .EQ. 0 ) CALL PAGE
00302 136*      NO PRT = 0
00303 137*      NO PRT = 1
00306 138*
00307 139*

```

Figure C.2. (Continued).

SEADUCER RUN 80030 FOR TP-228 APPENDIX C

```

00405 190* 1 RT(L), NC(M), RL T2A1, RA C3D, RTL C3D, MPGE/MN,
00405 197* 2 RTMASS, RTL, RREACT, RGICMG, RGECHN
00422 198* IF ( IPUNCH .NE. 0 ) PUNCH 165,
00422 199* 1 RT(L), NC(M), RL T2A1, RA C3D, RTL C3D, MPGE/MN,
00422 200* 2 RTMASS, RTL, RREACT, RGICMG, RGECHN
00440 201* 165 FORMAT( 1X, A242, 2X, 3E8, 6, 13, F8.4, F8.5, 3E10.4 )
00441 202*
00441 203* 200 CONTINUE
00441 204* C 200 EXIT C3D AREA LOOP
00443 205*
00443 206* CALL SKP LIN(1)
00444 207* 300 CONTINUE
00444 208* C 300 EXIT T2L LENGTH LOOP
00446 209*
00446 210* CALL TIME
00447 211* CALL END NAN(1YZ,1YZ)
00450 212* 1AY2Z4 = LOC(LYZ+4)
00451 213* 1ZY2Z4 = 1AY2Z4 + 8
00452 214* CALL SKPLIN(2)
00453 215* CALL HEAD 24(1, A Y2Z4
00454 216* CALL PRT MTR(1A Y2Z4,2)
00455 217* CALL SKPLIN(2)
00456 218* CALL HEAD 24(1, 2 Y2Z4
00457 219* CALL PRT MTR(1Z Y2Z4,2)
00460 220*
00460 221* CALL PAGE
00461 222* CALL PR PTBL
00462 223* CALL PAGE
00463 224* CALL PR CTG
00464 225* CALL PAGE
00465 226* CALL TIME
00466 227* STOP
00467 228* END

```

END OF COMPILATION: NO DIAGNOSTICS.

Figure C.2. (Continued).

WFOR,IS RLIMMG,RL1-IMG
FOR 0010-10/19/72-19:44:28 (,0)

SUBROUTINE RL1IMG ENTRY POINT 000167

STORAGE USED: CODE(1) 000205; DATA(0) 000102; BLANK COMMON(2) 000310

COMMON BLOCKS:

0003 CEMNPR 000001
0004 PRTOFF 000001
0005 JOIL 000002
0006 GMECIC 000020
0007 LDESIGN 000005

EXTERNAL REFERENCES (BLOCK, NAME)

0010 USORT
0011 PAGE
0012 LDT11
0013 FNDIL
0014 LDT1
0015 BALDKL
0016 RDCPT
0017 LOCMT
0020 ZTOA
0021 HEAD24
0022 PRMTR
0023 LDAM2S
0024 CMPGAM
0025 PRMARI
0026 NERR35

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

0001	000121	9L	0002	0	000000	DATA	0006	D	000002	DGECI	0006	D	000006	DGICI	
0006	D	000004	DGICH	0010	0	000000	DSORT	0005	D	000000	DZECI	0006	D	000010	DZFCP
0006	D	000016	DZICI	0006	0	000014	DZICR	0000	I	000013	IAA2D	0000	I	000071	INJPS
0000	I	000012	IZACU	0000	I	000005	L	0017	I	000000	LOCATR	0000	I	000007	N
0000	I	000006	NOPR3V	0004	I	000000	NOPRT	0007	I	000003	NPCEMN	0007	R	000004	RAR201
0000	R	000010	RLC3D	0007	R	000000	RLR2A1	0000	R	000011	RLR2D1	0007	R	000001	RLR2Z1

00101	1*	SUBROUTINE RL1M MG(0X, 0RL, 0IM, 01G)	RLIMMG
00103	2*	DOUBLE PRECISION DX, 0RL, 0IM, 01G	RLIMMG
00104	3*	DOUBLE PRECISION DATA	RLIMMG
00105	4*	DOUBLE PRECISION DSORT	RLIMMG
00106	5*	DOUBLE PRECISION DT	RLIMMG
00107	6*	DOUBLE PRECISION DGECR, DGECI, DZICR, DZICI, DZICR, DZICI	RLIMMG
00110	7*	COMMON / DATA(100)	
00111	8*	COMMON / C FM, PR / I FMN PR	

Figure C.2. (Continued).

```

00112 9* COMMON / PRT OFF / NO PRT
00113 10* COMMON / TOT L / UT L
00114 11* COMMON / GN EC IC / DGEGR,DGEIC,DGICR,DGICI,DZECR,DZICI
00115 12* COMMON / CLESN / RL R2A1, RL R2I, RA C3D, NP GE MN, RA R2D1
00116 13* DIMENSION L R2D1(5)
00117 14* DATA (L R2D1 (L), L=1,3) / 'VW','EE','CD' /
00121 15* C * * * * * PROGRAMMED BY L. E. MCCLEARY NUC CODE 601 * * * * *
00121 16* C * * * * * SUBROUTINE USED FOR EVALUATING A MOD B FUNCTION AT DX
00121 17* C * * * * * TO RETURN THE REAL, IMAG, AND MAGNITUDE OF A COMPLEX NUMBER
00121 18* C * * * * * CHANGE THESE STATEMENTS TO LOAD THE INDEP. VARIABLE (DX)
00121 19* NO PR SV = NO PRT
00121 20* NO PRT = 1 - 1 FMN PR
00121 21* IF ( NO PRT .EQ. 0 ) CALL PAGE
00121 22* N = NP GE MN
00121 23* RL C3D = 0X
00121 24* CALL LD UT 11,'C3D5',0,7588.21, RA C3D ,0,0,0,0, RL C3D,
00121 25* E ,14116660, 0,00, ,2419850-2,
00121 26* G ,2452070-1, 0,00, ,1874270-3,
00121 27* S ,9409950-11, 0,00, ,1670290-2 )
00121 28* CALL FND T L ( L R2D1, 3 )
00121 29* RL R2D1 = UT L - RL R2A1 - RL R2I
00121 30* CALL LD UT 1('R2D15',7702.80,RA R2D1,0,0,0,RL R2D1,4970,0,0,0.)
00121 31* NO PRT = NO PR SV
00121 32* C * * * * * CHANGE THESE STATEMENTS TO COMPUTE THE FUNCTION (DRL, DIM)
00121 33* C
00121 34* THIS EXAMPLE IS FOR DESIGN RUNS 80038, 50047, 80050,
00121 35* CALL RLD K,L('A6D5')
00121 36* CALL RDC PRT('A6D5', 'A2D5' )
00121 37* IZAD0 = LOC MTR('AD', 2)
00121 38* IAA2D = IZAD0+8
00121 39* CALL Z TO A(IZAD0, IAA2D)
00121 40* IF ( NO PRT .NE. 0 ) GO TO 9
00121 41* CALL HEAD 24(' A A2D
00121 42* CALL PRT MTR(IAA2D, 2)
00121 43* 9 CONTINUE
00121 44* CALL LD A 25
00121 45* CALL CMP GMM(IAA2D)
00121 46* DRL = DGECP
00121 47* DIM = DGEIC
00121 48* C * * * * * COMPUTE DMG
00121 49* DMG = USOR1(DRL*2+JIM*2)
00121 50* C * * * * * FUNCTION PRINTOUTS
00121 51* IF ( 1 FMN, PR .EQ. 0 ) RETURN
00121 52* CALL HEAD 24(' GAMMA EC
00121 53* CALL PR MTR(1, 'DEG', DRL, DIV)
00121 54* RETURN
00121 55*
00121 56*
00121 57*
00121 58*
00121 59*
00121 60*
00121 61*
00121 62*
00121 63*
00121 64*
00121 65*
00121 66*
00121 67*
00121 68*
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00121 90*
00121 91*
00121 92*
00121 93*
00121 94*
00121 95*
00121 96*
00121 97*
00121 98*
00121 99*
00121 100*

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RLIMMG*

Figure C.2. (Continued).

LD0T4	RELOCATABLE	28 MAR 72	23:17:32	44	2	13	5	0	1	2390
LD0T5	FOR SYMB	28 MAR 72	23:17:33	45		17				2405
LD0T6	RELOCATABLE	28 MAR 72	23:17:34	46	2	11	5	0	1	2422
LD0T7	FOR SYMB	28 MAR 72	23:17:36	47		51				2435
LD0T7	RELOCATABLE	28 MAR 72	23:17:38	48	2	30	5	0	1	2446
TYPE7	FOR SYMB	28 MAR 72	23:17:39	49		28				2518
LD0T8	RELOCATABLE	28 MAR 72	23:17:42	50	1	23	5	0	1	2546
LD0T8	FOR SYMB	28 MAR 72	23:17:42	51		22				2570
LD0T9	RELOCATABLE	28 MAR 72	23:17:44	52	3	20	5	0	1	2592
LD0T9	FOR SYMB	28 MAR 72	23:17:46	53		22				2615
LD0T11	RELOCATABLE	28 MAR 72	23:17:48	54	3	20	5	0	1	2637
LD0T11	FOR SYMB	28 MAR 72	23:17:49	55		26				2660
TYPE11	RELOCATABLE	28 MAR 72	23:17:51	56	3	19	5	0	1	2686
TYPE11	FOR SYMB	28 MAR 72	23:17:52	57		31				2708
T11SBR	RELOCATABLE	28 MAR 72	23:17:55	58	2	29	5	0	1	2739
T11SBR	FOR SYMB	28 MAR 72	23:17:55	59		11				2770
LD0T14	RELOCATABLE	28 MAR 72	23:17:57	60	2	11	5	0	1	2781
LD0T14	FOR SYMB	28 MAR 72	23:17:58	61		25				2794
TYPE14	RELOCATABLE	28 MAR 72	23:18:00	62	3	19	5	0	1	2819
TYPE14	FOR SYMB	28 MAR 72	23:18:01	63		3				2841
LD0T15	RELOCATABLE	28 MAR 72	23:18:03	64	1	2	5	0	1	2844
LD0T15	FOR SYMB	28 MAR 72	23:18:04	65		26				2847
TYPE15	RELOCATABLE	28 MAR 72	23:18:05	66	3	21	5	0	1	2873
TYPE15	FOR SYMB	28 MAR 72	23:18:06	67		3				2897
T1415S	RELOCATABLE	28 MAR 72	23:18:07	68	1	2	5	0	1	2900
T1415S	FOR SYMB	28 MAR 72	23:18:08	69		9				2903
TP1415	RELOCATABLE	28 MAR 72	23:18:09	70	2	10	5	0	1	2912
TP1415	FOR SYMB	28 MAR 72	23:18:09	71		19				2924
LD0I20	RELOCATABLE	28 MAR 72	23:18:11	72	2	20	5	0	1	2943
LD0I20	FOR SYMB	28 MAR 72	23:18:12	73		19				2965
TYPE20	RELOCATABLE	28 MAR 72	23:18:13	74	2	14	5	0	1	2984
TYPE20	FOR SYMB	28 MAR 72	23:18:14	75		13				3000
LD0I21	RELOCATABLE	28 MAR 72	23:18:15	76	2	10	5	0	1	3013
LD0I21	FOR SYMB	28 MAR 72	23:18:16	77		17				3025
TYPE21	RELOCATABLE	28 MAR 72	23:18:18	78	2	12	5	0	1	3042
TYPE21	FOR SYMB	28 MAR 72	23:18:19	79		5				3056
LD0I22	RELOCATABLE	28 MAR 72	23:18:19	80	1	3	5	0	1	3061
LD0I22	FOR SYMB	28 MAR 72	23:18:21	81		17				3065
TYPE22	RELOCATABLE	28 MAR 72	23:18:22	82	2	12	5	0	1	3082
TYPE22	FOR SYMB	28 MAR 72	23:18:22	83		5				3096
LD0I24	RELOCATABLE	28 MAR 72	23:18:24	84	1	4	5	0	1	3101
LD0I24	FOR SYMB	28 MAR 72	23:18:25	85		17				3106
LD0T24	RELOCATABLE	28 MAR 72	23:18:26	86	2	12	5	0	1	3123
LD0T24	FOR SYMB	28 MAR 72	23:18:27	87		5				3137
TYPE24	RELOCATABLE	28 MAR 72	23:18:28	88	1	4	5	0	1	3142
LD0I25	RELOCATABLE	28 MAR 72	23:18:29	89		17				3147
LD0I25	FOR SYMB	28 MAR 72	23:18:30	90	2	12	5	0	1	3164
TYPE25	RELOCATABLE	28 MAR 72	23:18:31	91		5				3178
TYPE25	FOR SYMB	28 MAR 72	23:18:32	92	1	4	5	0	1	3183
LD0I26	RELOCATABLE	28 MAR 72	23:18:33	93		19				3188
LD0I26	FOR SYMB	28 MAR 72	23:18:34	94	2	14	5	0	1	3207
TYPE26	RELOCATABLE	28 MAR 72	23:18:35	95		14				3223
TYPE26	FOR SYMB	28 MAR 72	23:18:37	96	2	13	5	0	1	3237
AID00	RELOCATABLE	28 MAR 72	23:18:37	97		12				3252
AID00	FOR SYMB	28 MAR 72	23:18:39	98	1	8	5	0	1	3264
LA2BY2	RELOCATABLE	28 MAR 72	23:18:39	99		4				3273
LA2BY2	FOR SYMB	28 MAR 72	23:18:40	100	1	2	5	0	1	3277

Figure C.2. (Continued).

LZ2B Y2	FOR SYMB	28 MAR 72	23:18:40	101		4	5	0	1	3280
LZ2B Y2	RELOCATABLE	28 MAR 72	23:18:42	102	1	2				3284
LZ3B Y3	FOR SYMB	28 MAR 72	23:18:42	103		5	0	1		3287
LZ3B Y3	RELOCATABLE	28 MAR 72	23:18:43	104	1	2				3291
LY2B Y2	FOR SYMB	28 MAR 72	23:18:44	105		5	0	1		3294
LY2B Y2	RELOCATABLE	28 MAR 72	23:18:45	106	1	2				3298
LY3B Y3	FOR SYMB	28 MAR 72	23:18:46	107		5	0	1		3301
LY3B Y3	RELOCATABLE	28 MAR 72	23:18:47	108	1	2				3305
LDORIM	FOR SYMB	28 MAR 72	23:18:48	109		5	0	1		3308
LDORIM	RELOCATABLE	28 MAR 72	23:18:49	110	1	4				3313
LD5B11	FOR SYMB	28 MAR 72	23:18:49	111		7	5	0	1	3318
LD5B11	RELOCATABLE	28 MAR 72	23:18:51	112	1	3				3325
LS1415	FOR SYMB	28 MAR 72	23:18:51	113		5	0	1		3329
LS1415	RELOCATABLE	28 MAR 72	23:18:52	114	1	3				3335
FNDTMS	FOR SYMB	28 MAR 72	23:18:53	115		5	0	1		3339
FNDTMS	RELOCATABLE	28 MAR 72	23:18:54	116	2	5				3348
FNDTL	FOR SYMB	28 MAR 72	23:18:55	117		13	5	0	1	3355
FNDTL	RELOCATABLE	28 MAR 72	23:18:56	118	2	9				3368
MTRMOV	FOR SYMB	28 MAR 72	23:18:57	119		5	0	1		3379
MTRMOV	RELOCATABLE	28 MAR 72	23:18:58	120	1	3				3383
MTRMUL	FOR SYMB	28 MAR 72	23:18:59	121		12	5	0	1	3387
MTRMUL	RELOCATABLE	28 MAR 72	23:19:00	122	1	11				3399
DLETRC	FOR SYMB	28 MAR 72	23:19:01	123		11	5	0	1	3411
DLETRC	RELOCATABLE	28 MAR 72	23:19:03	124	1	7				3422
LD1MTR	FOR SYMB	28 MAR 72	23:19:03	125		4	5	0	1	3430
LD1MTR	RELOCATABLE	28 MAR 72	23:19:04	126	1	4				3434
DECOM8	FOR SYMB	28 MAR 72	23:19:06	127		45	5	0	1	3439
DECOM8	RELOCATABLE	28 MAR 72	23:19:10	128	2	55				3484
AIOZ	FOR SYMB	28 MAR 72	23:19:10	129		10	5	0	1	3541
AIOZ	RELOCATABLE	28 MAR 72	23:19:12	130	2	9				3551
ZTOA	FOR SYMB	28 MAR 72	23:19:13	131		10	5	0	1	3562
ZTOA	RELOCATABLE	28 MAR 72	23:19:15	132	2	9				3572
ATOY	FOR SYMB	28 MAR 72	23:19:16	133		9	5	0	1	3583
ATOY	RELOCATABLE	28 MAR 72	23:19:17	134	2	11				3592
YTOA	FOR SYMB	28 MAR 72	23:19:18	135		9	5	0	1	3605
YTOA	RELOCATABLE	28 MAR 72	23:19:19	136	2	11				3614
DACNUL	FOR SYMB	28 MAR 72	23:19:20	137		3	5	0	1	3627
DACNUL	RELOCATABLE	28 MAR 72	23:19:21	138	1	2				3630
DCMNUL	FOR SYMB	28 MAR 72	23:19:22	139		3	5	0	1	3633
DCMNUL	RELOCATABLE	28 MAR 72	23:19:23	140	1	2				3636
DCMDIV	FOR SYMB	28 MAR 72	23:19:24	141		3	5	0	1	3639
DCMDIV	RELOCATABLE	28 MAR 72	23:19:25	142	1	3				3642
DCRCIP	FOR SYMB	28 MAR 72	23:19:25	143		3	5	0	1	3646
DCRCIP	RELOCATABLE	28 MAR 72	23:19:27	144	1	2				3649
DCSORT	FOR SYMB	28 MAR 72	23:19:28	145		10	5	0	1	3652
DCSORT	RELOCATABLE	28 MAR 72	23:19:29	146	1	9				3662
DCANG1	FOR SYMB	28 MAR 72	23:19:30	147		8	5	0	1	3672
DCANG1	RELOCATABLE	28 MAR 72	23:19:31	148	1	6				3680
UCACSCH	FOR SYMB	28 MAR 72	23:19:32	149		5	5	0	1	3687
UCACSCH	RELOCATABLE	28 MAR 72	23:19:33	150	1	4				3692
USHCH	FOR SYMB	28 MAR 72	23:19:34	151		4	5	0	1	3697
USHCH	RELOCATABLE	28 MAR 72	23:19:35	152	1	3				3701
UCSNCS	FOR SYMB	28 MAR 72	23:19:36	153		5	5	0	1	3710
UCSNCS	RELOCATABLE	28 MAR 72	23:19:37	154	1	3				3714
UCSNCH	FOR SYMB	28 MAR 72	23:19:37	155		5	5	0	1	3719
UCSNCH	RELOCATABLE	28 MAR 72	23:19:39	156	1	3				3723
PRINTR	FOR SYMB	28 MAR 72	23:19:40	157		5	5	0	1	3729

Figure C.2. (Continued).

PRTR	RELOCATABLE	28 MAR 72	23:19:41	158	1	5	5	0	1	3728
PRTRN	FOR SYMB	28 MAR 72	23:19:42	159	1	5	5	0	1	3734
PRTRN	RELOCATABLE	28 MAR 72	23:19:43	160	1	5	5	0	1	3739
PRMARI	FOR SYMB	28 MAR 72	23:19:43	161	8	6	5	0	1	3745
PRMARI	RELOCATABLE	28 MAR 72	23:19:45	162	2	6	5	0	1	3753
HEAD24	FOR SYMB	28 MAR 72	23:19:45	163	6	6	5	0	1	3761
HEAD24	RELOCATABLE	28 MAR 72	23:19:47	164	1	6	5	0	1	3767
PAGE	FOR SYMB	28 MAR 72	23:19:48	165	1	1	5	0	1	3774
PAGE	RELOCATABLE	28 MAR 72	23:19:49	166	1	2	5	0	1	3775
STRLIN	FOR SYMB	28 MAR 72	23:19:49	167	2	2	5	0	1	3778
STRLIN	RELOCATABLE	28 MAR 72	23:19:51	168	1	2	5	0	1	3780
SKPLIN	FOR SYMB	28 MAR 72	23:19:51	169	2	2	5	0	1	3783
SKPLIN	RELOCATABLE	28 MAR 72	23:19:52	170	1	2	5	0	1	3785
PRPTBL	FOR SYMB	28 MAR 72	23:19:53	171	7	5	5	0	1	3788
PRPTBL	RELOCATABLE	28 MAR 72	23:19:54	172	1	5	5	0	1	3795
PRCTLG	FOR SYMB	28 MAR 72	23:19:55	173	6	6	5	0	1	3801
PRCTLG	RELOCATABLE	28 MAR 72	23:19:55	174	2	5	5	0	1	3807
UNPACK	FOR SYMB	28 MAR 72	23:19:57	175	26	5	5	0	1	3814
UNPACK	RELOCATABLE	28 MAR 72	23:19:59	176	1	22	5	0	1	3840
BLKDTA	FOR SYMB	28 MAR 72	23:20:00	177	15	5	5	0	1	3863
BLKDTA	RELOCATABLE	28 MAR 72	23:20:00	178	4	3	5	0	1	3878
TIME	FOR SYMB	28 MAR 72	23:20:01	179	5	5	5	0	1	3885
TIME	RELOCATABLE	28 MAR 72	23:20:02	180	1	3	5	0	1	3890
Z11022	FOR SYMB	28 MAR 72	23:20:03	181	8	5	5	0	1	3894
Z11022	RELOCATABLE	28 MAR 72	23:20:04	182	1	6	5	0	1	3902
DCPCT2	FOR SYMB	28 MAR 72	23:20:05	183	9	5	5	0	1	3909
DCPCT2	RELOCATABLE	28 MAR 72	23:20:06	184	1	7	5	0	1	3918
FNDKRC	FOR SYMB	28 MAR 72	23:20:07	185	26	5	5	0	1	3926
FNDKRC	RELOCATABLE	28 MAR 72	23:20:09	186	2	20	5	0	1	3952
SRCHBC	FOR SYMB	28 MAR 72	23:20:12	187	101	5	5	0	1	3974
SRCHBC	RELOCATABLE	28 MAR 72	23:20:16	188	4	76	5	0	1	4075
MINCHK	FOR SYMB	28 MAR 72	23:20:16	189	3	5	5	0	1	4155
MINCHK	RELOCATABLE	28 MAR 72	23:20:18	190	1	2	5	0	1	4158
XAXCHK	FOR SYMB	28 MAR 72	23:20:18	191	3	3	5	0	1	4161
XAXCHK	RELOCATABLE	28 MAR 72	23:20:19	192	1	2	5	0	1	4164
CMPZ5	FOR SYMB	28 MAR 72	23:20:19	193	5	5	5	0	1	4167
CMPZ5	RELOCATABLE	28 MAR 72	23:20:21	194	2	3	5	0	1	4172
PREPZV	FOR SYMB	28 MAR 72	23:20:22	195	16	5	5	0	1	4177
PREPZV	RELOCATABLE	28 MAR 72	23:20:23	196	2	18	5	0	1	4193
FNDZV	FOR SYMB	28 MAR 72	23:20:24	197	7	5	5	0	1	4213
FNDZV	RELOCATABLE	28 MAR 72	23:20:25	198	2	5	5	0	1	4220
LDZVR	FOR SYMB	28 MAR 72	23:20:25	199	5	5	5	0	1	4227
LDZVR	RELOCATABLE	28 MAR 72	23:20:27	200	2	3	5	0	1	4232
SRMIDB	FOR SYMB	28 MAR 72	23:20:29	201	57	5	5	0	1	4237
SRMIDB	RELOCATABLE	28 MAR 72	23:20:32	202	4	50	5	0	1	4294
LDAM2S	FOR SYMB	28 MAR 72	23:20:33	203	19	5	5	0	1	4348
LDAM2S	RELOCATABLE	28 MAR 72	23:20:34	204	3	15	5	0	1	4367
CMPGAM	FOR SYMB	28 MAR 72	23:20:36	205	16	5	5	0	1	4385
CMPGAM	RELOCATABLE	28 MAR 72	23:20:37	206	2	14	5	0	1	4401
FSRCH	FOR SYMB	28 MAR 72	23:20:41	207	142	5	5	0	1	4417
FSRCH	RELOCATABLE	28 MAR 72	23:20:48	208	5	123	5	0	1	4559
* RLIMMG	FOR SYMB	28 MAR 72	23:20:48	209	17	5	5	0	1	4687
* RLIMMG	RELOCATABLE	28 MAR 72	23:20:49	210	2	6	5	0	1	4697
EMEN	FOR SYMB	28 MAR 72	23:20:50	211	6	5	5	0	1	4705
FMFN	RELOCATABLE	28 MAR 72	23:20:51	212	2	5	5	0	1	4711
POLEN	FOR SYMB	28 MAR 72	23:20:52	213	14	5	5	0	1	4718
POLEN	RELOCATABLE	28 MAR 72	23:20:54	214	13	5	5	0	1	4732

Figure C.2. (Continued).

PRBEIT	FOR SYMB	28 MAR 72	23:20:54	215'	9	5	0	1	4746
PRBEIT	RELOCATABLE	28 MAR 72	23:20:55	216	1				4755
FNDPRM	FOR SYMB	28 MAR 72	23:20:57	217	40	5	0	1	4763
FNDPRM	RELOCATABLE	28 MAR 72	23:21:00	218	29				4803
FNDPDP	FOR SYMB	28 MAR 72	23:21:00	219	8	5	0	1	4836
FNDPDP	RELOCATABLE	28 MAR 72	23:21:01	220	3				4844
LD8COL	FOR SYMB	28 MAR 72	23:21:02	221	6	5	0	1	4849
LD8COL	RELOCATABLE	28 MAR 72	23:21:03	222	4				4855
PRIPRM	FOR SYMB	28 MAR 72	23:21:04	223	14	5	0	1	4861
PRIPRM	RELOCATABLE	28 MAR 72	23:21:05	224	9				4875
CONTRL	FOR SYMB	19 OCT 72	19:44:24	225	56	5	0	1	4886
CONTRL	RELOCATABLE	19 OCT 72	19:44:28	226	58				4942
RLIMMG	FOR SYMB	19 OCT 72	19:44:28	227	17	5	0	1	5006
RLIMMG	RELOCATABLE	19 OCT 72	19:44:30	228	11				5023
NEXT AVAILABLE LOCATION:-									
ASSEMBLER PROCEDURE TABLE EMPTY									
COBOL PROCEDURE TABLE EMPTY									
FORTRAN PROCEDURE TABLE EMPTY									

ENTRY POINT TABLE

D NAME	LINK	D NAME	LINK	D NAME	LINK	D NAME	LINK	D NAME	LINK	D NAME	LINK
AIDDD	98	ALOCAT	18	AIOT	134	AIOT	134	BLDKKL	130	BLDKKL	130
BLOMTR	6	CASCOE	32	CHKSTR	20	CMPGAM	20	CMPTZ	206	CMPTZ	194
DACNUL	138	DCACSH	150	DCANG1	148	DCMDIV	148	DCMDUL	142	DCMDUL	140
DCPCT2	184	DCRCIP	144	DCSCH	156	DCSNC	156	DCSORT	154	DCSORT	146
DECOMB	128	DETRC	124	DSCH	152	FREN	152	FNDPDP	212	FNDPDP	220
FNDPZV	198	FNDKRC	186	FNDLCJ	16	FNDMTR	16	FNDNAM	28	FNDNAM	30
FNDNET	22	FNDPRM	218	FNDTL	118	FNDTMS	118	FORMAINS	226	FORMAINS	226
FSRCH	208	HEAD24	164	LA2BY2	100	LUAM25	100	LORCOL	204	LORCOL	222
LDDRM	110	LDOT1	36	LDOT11	56	LDOT14	56	LDOT15	62	LDOT15	66
LDOT2	40	LDOT20	74	LDOT21	78	LDOT22	78	LDOT24	82	LDOT24	86
LDOT25	90	LDOT26	94	LDOT4	44	LDOT5	44	LDOT7	46	LDOT7	48
LDOT8	52	LDOT9	54	LDOTREQ	12	LOIMTR	12	LOPORT	126	LOPORT	4
LDSP11	112	LDZVR	200	LOCMTR	24	LOCNAM	24	LS1415	26	LS1415	114
LY2BY2	106	LY3BY3	108	LZ2BY2	102	LZ3BY3	102	MAXCHK	104	MAXCHK	192
MINCHK	190	MTRMOV	120	MTRMUL	122	PAGE	122	POLFO	166	POLFO	214
PRBEIT	216	PRCTLG	174	PREP7V	196	PRMARI	196	PRPTRL	162	PRPTRL	172
PRIMBN	160	PRIMTR	158	PRTPRM	224	RUCPRT	224	RLIMMG	10	RLIMMG	228
SKPLIN	170	SRCHBC	188	SRWIOB	202	STRLIN	202	TIME	168	TIME	180
TP1415	72	TYPCAL	34	TYPE1	38	TYPE11	38	TYPE14	58	TYPE14	64
TYPE15	68	TYPE2	42	TYPE20	76	TYPE21	76	TYPE22	80	TYPE22	84
TYPE24	68	TYPE25	92	TYPE26	96	TYPE7	96	TYPE7	50	TYPE7	60
TI1415	70	UNPACK	176	UPPTAL	14	YIOA	14	YIOA	136	YIOA	132
Z11022	162										

Figure C.2. (Continued).

MAP, X14 SY:RIM/ARS(01)
MAP 0022-10/19-10:44 - (10)

1. IN CONTRL
2. IN FLKUTA

ADDRESS LIMITS	001000 040112	041000 064762
STARTING ADDRESS	036705	
WORDS DECIMAL	15947 INANK	10227 ORANK
SEGMENT MAIN		
ISWTCs/FOR	1 001000 001021	041000 064762
IRBLKs/FOR-NUC	1 001000 001047	
IRWIDs/FOR50-NUC	1 001000 001127	2 041000 041011
IRWFS/FOR55	1 001100 001322	2 041012 041014
IRFCHs/FOR57	1 001300 001622	2 041032 041067
IRCLSSs/FOR57	1 001600 001761	2 041070 041114
IRBLKs/FOR57-NUC	1 001700 002104	
IRBSdLs/FOR	1 002100 002142	
IRUPJAS/FOR	1 002140 002176	
IRBF00s/FOR	1 002177 002332	2 041115 043316
IRBDCs/FOR57	1 002330 002355	2 043317 043356
IRFTVs/FOR	1 002350 002610	
IRCNVTs/FOR57	1 002611 003034	2 043357 043446
IRNINs/FOR55	1 003035 003714	2 043447 043470
IRNPTs/FOR57	1 003715 004516	2 043471 043513
IRFCHs/FOR57	1 004517 004635	2 043514 043655
IRIULRs/FOR57	1 004636 005605	4 043656 043727
IROUTs/FOR57-IN1V	1 005606 005612	2 043730 044032
IRFMTs/FOR57	1 005613 005612	2 044033 044063
IRTAGs/FOR	1 005613 005612	2 044064 044102
IRKUS/57	1 005613 005612	2 044103 044141
IREXPs/FOR54	1 005613 005612	2 044142 044175
IRLUGs/FOR54	1 005613 005612	2 044176 044302
IR51NCOs/FOR57	1 007003 007144	2 044303 044361
IRLATHs/FOR54	1 007145 007273	2 044362 044444
IRLUG10s/FOR54	1 007274 007304	2 044445 044450
IRSGRTs/FOR55	1 007305 007344	2 044451 044462
IREXP1s/FOR54	1 007345 007400	0 044463 044463
IRIBUFs/FOR54	1 007401 007442	
IRERRs/FOR57-NUC	1 007443 010004	2 044464 044640
IRSTOPs/NUC	1 010005 010030	2 044641 044647

Figure C.2. (Continued).

NIEK\$/FOR52	1	010031	010113	2	044650	044777
NOSYMS\$/FOR5/	1	010114	010346	2	045000	045005
HINTRS\$/NUC	1	010347	010403	2	045003	045025
DATE-TIME/NUC-PACK	1	010404	010433	0	045026	045063
USGATS\$/FOR57	1	010434	010503	2	045064	045102
II4155	1	010504	010746	0	045103	045126
	3	CS1415		2	BLANK\$COMMON	
DSHCH	1	010747	011005	4	CM1415	
LY3BY3	1	011006	011035	2	045127	045143
	3	CY3BY3		2	BLANK\$COMMON	
CS1415 (COMMON BLOCK)	3			2	045144	045154
JP1415	1	011036	011602	2	BLANK\$COMMON	
	3	CS1415		0	045155	045160
	5	CM1415		2	045161	045245
				4	BLANK\$COMMON	
				6	BASIC8	
CM1415 (COMMON BLOCK)	1	011603	011651	2	CZ3BY3	
LS1415	3	CM1415		0	045246	045277
	1	011652	011731	2	045300	045312
DCSHCH	1	011732	012023	4	BLANK\$COMMON	
DCACSH	1	011732	012023	0	CEGSEF	
	1	012024	012053	0	045313	045331
LZ3BY3	3	CZ3BY3		2	BLANK\$COMMON	
DCSNCS	1	012054	012136	0	045332	045354
	1	012137	012166	2	BLANK\$COMMON	
LY2BY2	3	CY2BY2		0	045355	045365
RLIMG	1	012167	012373	2	BLANK\$COMMON	
	3	CFMNP8		2	045366	045404
	5	TOTL		2	BLANK\$COMMON	
	7	CDEGN		0	045405	045415
DCANG1	1	012374	012532	2	BLANK\$COMMON	
	1	012533	012761	2	045520	045542
DCSGRT	1	012533	012761	0	BLANK\$COMMON	
	1	012762	013327	0	045543	045577
COMN26 (COMMON BLOCK)	3	BASIC8		2	BLANK\$COMMON	
CY3BY3 (COMMON BLOCK)	5	COMN26		0	045600	045613
TYPE26	1	013330	013411	2	045614	045635
	3	PAS1C8		0	045636	045677
TYPE25	1	013412	013511	2	BLANK\$COMMON	
TYPE24	3	BASIC8		2	045700	045717
	1	013512	013610	2	BLANK\$COMMON	
TYPE22	3	BASIC8		0	045740	045757
	1	013611	013671	2	BLANK\$COMMON	
TYPE21	3	PAS1C8		2	045760	045777
	1	013672	014125	2	BLANK\$COMMON	
TYPE20	3	BASIC8		0	046000	046065
	1	014126	014152	2	BLANK\$COMMON	
CMN15C (COMMON BLOCK)	1	014126	014152	4	CA2RY2	
TYPE15	1	014126	014152	0	046066	046067
				0	046070	046074

Figure C.2. (Continued).

SEADUCER RUN 80038 FOR TP-22R APPENDIX C

TYPE14	3	CMN15C	2	BLANK\$COMMON
	1	014153 014177	0	046075 046101
CZ3BY3 (COMMON BLOCK)			2	BLANK\$COMMON
TYPE11	1	014200 015214	0	046102 046123
	3	BASIC8	2	046124 046214
	5	CZ3BY3	4	BLANK\$COMMON
TYPE7	1	015215 016047	0	CMN11
	3	BASIC8	2	046215 046307
TYPE2	1	016050 016405	2	BLANK\$COMMON
	3	BASIC6	0	BLANK\$COMMON
			2	046310 046430
TYPE1	1	016406 016622	4	BLANK\$COMMON
	3	BASIC6	0	CA2BY2
			0	046431 046522
CY2BY2 (COMMON BLOCK)			2	BLANK\$COMMON
AT0Y	1	016623 017130	4	046523 046532
	3	CA2BY2	0	046533 046562
			2	BLANK\$COMMON
AT0Z	1	017131 017355	4	CY2RY2
	3	CA2BY2	0	046563 046621
			2	BLANK\$COMMON
DACMUL	1	017356 017416	4	CZ2BY2
			0	046622 046630
			2	BLANK\$COMMON
BLDMTR	1	017417 017675	0	046631 046662
	3	PRTFUL	2	BLANK\$COMMON
	5	CPRTIN	4	CATALG
	7	CMAG1C	6	CNMRDC
			8	CBLD
CMFZS	1	017676 017730	0	046663 046702
	3	BASIC6	2	BLANK\$COMMON
			4	CMNZS
PRBFIT	1	017731 020073	0	046703 046746
	3	CPRBFT	2	BLANK\$COMMON
POLE0	1	020074 020436	0	046747 047101
			2	BLANK\$COMMON
PRMARI	1	020437 020544	0	047102 047141
	3	BASIC8	2	BLANK\$COMMON
MTRMOV	1	020545 020613	0	047142 047157
			2	BLANK\$COMMON
LZ2BY2	1	020614 020643	0	047160 047170
	3	CZ2BY2	2	BLANK\$COMMON
LA2BY2	1	020644 020673	0	047171 047201
	3	CA2BY2	2	BLANK\$COMMON
T115BR	1	020674 021170	0	047202 047236
	3	CMN11	2	BLANK\$COMMON
LDURIM	1	021171 021253	0	047237 047247
	3	DTASUB	2	BLANK\$COMMON
CEGSFP (COMMON BLOCK)			0	047250 047255
LD5B11	1	021254 021322	0	047256 047270
	3	CMN11	2	BLANK\$COMMON
MTRMUL	1	021323 021573	4	CEGSFP
			0	047271 047366
			2	BLANK\$COMMON
DCMSOL (COMMON BLOCK)			0	047367 050004
DECOND (COMMON BLOCK)			0	050005 050006
VALDET (COMMON BLOCK)			0	050007 050012

Figure C.2. (Continued).

SEAUUCER RUN 80038 FOR TP-22R APPENDIX C

UECOMB	1	021574	023535	0	050013	050237
	3	VALJET		2	BLANK\$COMMON	
UCRCIP	5	DCMSOL		4	DECOND	
	1	023536	023570	0	050240	050246
UCMMUL	1	023571	023625	2	BLANK\$COMMON	
	2			2	BLANK\$COMMON	
DCMDIV	1	023626	023673	0	050256	050270
	2			2	BLANK\$COMMON	
FNDRTR	1	023674	023751	0	050271	050301
	3	CATALG		2	BLANK\$COMMON	
TYPCAL	1	023752	024254	0	050302	050326
	3	CATALG		2	BLANK\$COMMON	
CASCODE	1	024255	024507	0	050327	050351
	3	CATALG		2	BLANK\$COMMON	
FNDLCU	1	024510	025007	4	CFLGAZ	
	3	PRITLL		0	050352	050400
	4			2	BLANK\$COMMON	
FNDRRT	1	025010	025160	4	CATALG	
	3	PRITBL		0	050401	050423
CHKSTR	1	025161	025211	2	BLANK\$COMMON	
	3	DTATUT		0	050424	050441
ALDOD	1	025212	025403	2	BLANK\$COMMON	
	0			0	050442	050464
UPPTBL	1	025404	025575	2	BLANK\$COMMON	
	3	PRITLL		0	050465	050507
UNPACK	1	025576	026361	2	BLANK\$COMMON	
	3	CPIWMD		4	CUPTBL	
PRCTLG	1	026362	026436	2	050510	050615
	3	CATALG		0	BLANK\$COMMON	
PRPTBL	1	026437	026515	2	BLANK\$COMMON	
	3	PRITLL		0	050674	050752
FNQUAM	1	026516	026561	2	BLANK\$COMMON	
	3	CATALG		0	050753	050763
TIME	1	026562	026610	2	BLANK\$COMMON	
	3			0	050764	051010
SRMIDB	1	026611	030154	2	BLANK\$COMMON	
	3	CATALG		0	051011	051365
	2	SRMCT		2	BLANK\$COMMON	
	7	SRCHSB		4	BASICB	
	9	CSRATR		6	CMNZS	
	11	CFLG62		8	FLGSRH	
FNUTMS	1	030155	030264	10	PRTOFF	
	3	CATALG		0	051366	051415
	5	PRTOFF		2	BLANK\$COMMON	
FNFTI	1	030265	030405	4	TOTMAS	
	3	CFMTRK		0	051416	051435
				2	BLANK\$COMMON	
CMNZS (COMMON BLOCK)				4	CMNFMN	
CMPSAM	1	030406	030560	0	051436	051441
	3	CMNZS		0	051442	051537
	5	GMERIC		2	BLANK\$COMMON	
	7	PRTOFF		4	SPCHSB	
SRCHSB (COMMON BLOCK)				0	PRGMTR	
				0	051540	051547

Figure C.2. (Continued).

SEADUCER RUN 8003R FOR TP-22R APPENDIX C

LOAM25	1	030661	031206	0	051550	051633
	3	CATALG		2	BLANK\$COMMON	
	5	CRMCT		4	BASIC8	
	7	FLGSHH		6	SRCHS9	
	9	CFLGAZ		8	PRTOFF	
PRINTR	1	031207	031313	0	051634	051661
				2	BLANK\$COMMON	
CZ2BY2 (COMMON BLOCK)					051662	051671
CA2BY2 (COMMON BLOCK)	1	031314	031540	0	051672	051701
ZIOA	3	CA2BY2		2	051702	051740
				2	BLANK\$COMMON	
				4	CZ2BY2	
LOCATR	1	031541	031615	0	051741	051752
	3	CATALG		2	PLANK\$COMMON	
FN0TL	1	031616	032022	0	051753	052014
	3	CATALG		2	PLANK\$COMMON	
	5	PRTOFF		4	TOTL	
COMN11 (COMMON BLOCK)					052015	052055
LODT11	1	032023	032460	0	052056	052236
	3	CATALG		2	BLANK\$COMMON	
	5	COM111		4	DTASUB	
HDCPRT	1	032461	033477	0	052237	052360
	3	CATALG		2	BLANK\$COMMON	
				4	CNRDC	
BLDKKL	1	033500	034111	0	052361	052445
	3	PRTRIL		2	BLANK\$COMMON	
	5	CNRDC		4	CATALG	
	7	CMAGIC		6	CPTIN	
				8	CFLGAZ	
LODFEG	1	034112	034142	0	052446	052461
	3	BASIC8		2	BLANK\$COMMON	
				4	PRTOFF	
HEAD24	1	034143	034265	0	052462	052503
	3	CPTWRD		2	BLANK\$COMMON	
LODMTR	1	034266	034356	0	052504	052527
				2	BLANK\$COMMON	
SKPLIN	1	034357	034411	0	052530	052537
				2	BLANK\$COMMON	
LOCHAM	1	034412	034454	0	052540	052551
	3	CATALG		2	BLANK\$COMMON	
ALUCAT	1	034455	034536	0	052552	052576
	3	CATALG		2	BLANK\$COMMON	
				4	DTASUB	
LODT7	1	034537	035437	0	052577	053036
	3	CATALG		2	BLANK\$COMMON	
	5	PRTOFF		4	DTASUB	
LODT4	1	035440	035732	0	053037	053127
	3	CATALG		2	BLANK\$COMMON	
	5	PRTOFF		4	DTASUB	
LODT1	1	035733	036327	0	053130	053247
	3	CATALG		2	BLANK\$COMMON	
LOPORT	1	036330	036652	0	053250	053337
	3	PRTRIL		2	BLANK\$COMMON	
				4	CPTWRD	
SHRLIN	1	036653	036667	0	053340	053363

Figure C.2. (Continued).

PAGE	1	036670 036704	
FLGSRH (COMMON BLOCK)			2
CRMRCT (COMMON BLOCK)			0
GMELIC (COMMON BLOCK)			2
CDESGN (COMMON BLOCK)			
TOTIAS (COMMON BLOCK)			
TOTL (COMMON BLOCK)			
CSRUBC (COMMON BLOCK)			
CMNFMN (COMMON BLOCK)			
CFMIPR (COMMON BLOCK)			
PRGSTR (COMMON BLOCK)			
CSRSTR (COMMON BLOCK)			
CUPTHL (COMMON BLOCK)			
CPRBFT (COMMON BLOCK)			
CSTACK (COMMON BLOCK)			
CNMRDC (COMMON BLOCK)			
CPH11N (COMMON BLOCK)			
CMAGIC (COMMON BLOCK)			
CBLU (COMMON BLOCK)			
CFLGAZ (COMMON BLOCK)			
CPTWRD (COMMON BLOCK)			
UASICB (COMMON BLOCK)			
PRTOFF (COMMON BLOCK)			
DTATOT (COMMON BLOCK)			
UTASUB (COMMON BLOCK)			
CATALG (COMMON BLOCK)			
PRTHL (COMMON BLOCK)			
BLANK\$COMMON (COMMON BLOCK)			
CONTRL	1	036705 040112	0
	3	CATALG	2
	5	DTATOT	4
	7	TOTIAS	6
	9	CMNFMN	8
	11	GMELIC	10
	13	CSRMRCT	12
	15	CMNFMN	14
	17	PRTHL	16
	19	DTATOT	18
	21	CPH11N	20
	23	CPTWRD	22
	25	CFLGAZ	
	27	CMRDC	
	29	CPH11N	
	31	PRTHL	
	33	CMNFMN	
	35	CMRDC	
	37	CPH11N	
	39	PRTHL	
	41	CMNFMN	
	43	CMRDC	
	45	CPH11N	
	47	PRTHL	
	49	CMNFMN	
	51	CMRDC	
	53	CPH11N	
	55	PRTHL	
	57	CMNFMN	
	59	CMRDC	
	61	CPH11N	
	63	PRTHL	
	65	CMNFMN	
	67	CMRDC	
	69	CPH11N	
	71	PRTHL	
	73	CMNFMN	
	75	CMRDC	
	77	CPH11N	
	79	PRTHL	
	81	CMNFMN	
	83	CMRDC	
	85	CPH11N	
	87	PRTHL	
	89	CMNFMN	
	91	CMRDC	
	93	CPH11N	
	95	PRTHL	
	97	CMNFMN	
	99	CMRDC	
	101	CPH11N	
	103	PRTHL	
	105	CMNFMN	
	107	CMRDC	
	109	CPH11N	
	111	PRTHL	
	113	CMNFMN	
	115	CMRDC	
	117	CPH11N	
	119	PRTHL	
	121	CMNFMN	
	123	CMRDC	
	125	CPH11N	
	127	PRTHL	
	129	CMNFMN	
	131	CMRDC	
	133	CPH11N	
	135	PRTHL	
	137	CMNFMN	
	139	CMRDC	
	141	CPH11N	
	143	PRTHL	
	145	CMNFMN	
	147	CMRDC	
	149	CPH11N	
	151	PRTHL	
	153	CMNFMN	
	155	CMRDC	
	157	CPH11N	
	159	PRTHL	
	161	CMNFMN	
	163	CMRDC	
	165	CPH11N	
	167	PRTHL	
	169	CMNFMN	
	171	CMRDC	
	173	CPH11N	
	175	PRTHL	
	177	CMNFMN	
	179	CMRDC	
	181	CPH11N	
	183	PRTHL	
	185	CMNFMN	
	187	CMRDC	
	189	CPH11N	
	191	PRTHL	
	193	CMNFMN	
	195	CMRDC	
	197	CPH11N	
	199	PRTHL	
	201	CMNFMN	
	203	CMRDC	
	205	CPH11N	
	207	PRTHL	
	209	CMNFMN	
	211	CMRDC	
	213	CPH11N	
	215	PRTHL	
	217	CMNFMN	
	219	CMRDC	
	221	CPH11N	
	223	PRTHL	
	225	CMNFMN	
	227	CMRDC	
	229	CPH11N	
	231	PRTHL	
	233	CMNFMN	
	235	CMRDC	
	237	CPH11N	
	239	PRTHL	
	241	CMNFMN	
	243	CMRDC	
	245	CPH11N	
	247	PRTHL	
	249	CMNFMN	
	251	CMRDC	
	253	CPH11N	
	255	PRTHL	
	257	CMNFMN	
	259	CMRDC	
	261	CPH11N	
	263	PRTHL	
	265	CMNFMN	
	267	CMRDC	
	269	CPH11N	
	271	PRTHL	
	273	CMNFMN	
	275	CMRDC	
	277	CPH11N	
	279	PRTHL	
	281	CMNFMN	
	283	CMRDC	
	285	CPH11N	
	287	PRTHL	
	289	CMNFMN	
	291	CMRDC	
	293	CPH11N	
	295	PRTHL	
	297	CMNFMN	
	299	CMRDC	
	301	CPH11N	
	303	PRTHL	
	305	CMNFMN	
	307	CMRDC	
	309	CPH11N	
	311	PRTHL	
	313	CMNFMN	
	315	CMRDC	
	317	CPH11N	
	319	PRTHL	
	321	CMNFMN	
	323	CMRDC	
	325	CPH11N	
	327	PRTHL	
	329	CMNFMN	
	331	CMRDC	
	333	CPH11N	
	335	PRTHL	
	337	CMNFMN	
	339	CMRDC	
	341	CPH11N	
	343	PRTHL	
	345	CMNFMN	
	347	CMRDC	
	349	CPH11N	
	351	PRTHL	
	353	CMNFMN	
	355	CMRDC	
	357	CPH11N	
	359	PRTHL	
	361	CMNFMN	
	363	CMRDC	
	365	CPH11N	
	367	PRTHL	
	369	CMNFMN	
	371	CMRDC	
	373	CPH11N	
	375	PRTHL	
	377	CMNFMN	
	379	CMRDC	
	381	CPH11N	
	383	PRTHL	
	385	CMNFMN	
	387	CMRDC	
	389	CPH11N	
	391	PRTHL	
	393	CMNFMN	
	395	CMRDC	
	397	CPH11N	
	399	PRTHL	
	401	CMNFMN	
	403	CMRDC	
	405	CPH11N	
	407	PRTHL	
	409	CMNFMN	
	411	CMRDC	
	413	CPH11N	
	415	PRTHL	
	417	CMNFMN	
	419	CMRDC	
	421	CPH11N	
	423	PRTHL	
	425	CMNFMN	
	427	CMRDC	
	429	CPH11N	
	431	PRTHL	
	433	CMNFMN	
	435	CMRDC	
	437	CPH11N	
	439	PRTHL	
	441	CMNFMN	
	443	CMRDC	
	445	CPH11N	
	447	PRTHL	
	449	CMNFMN	
	451	CMRDC	
	453	CPH11N	
	455	PRTHL	
	457	CMNFMN	
	459	CMRDC	
	461	CPH11N	
	463	PRTHL	
	465	CMNFMN	
	467	CMRDC	
	469	CPH11N	
	471	PRTHL	
	473	CMNFMN	
	475	CMRDC	
	477	CPH11N	
	479	PRTHL	
	481	CMNFMN	
	483	CMRDC	
	485	CPH11N	
	487	PRTHL	
	489	CMNFMN	
	491	CMRDC	
	493	CPH11N	
	495	PRTHL	
	497	CMNFMN	
	499	CMRDC	
	501	CPH11N	
	503	PRTHL	
	505	CMNFMN	
	507	CMRDC	
	509	CPH11N	
	511	PRTHL	
	513	CMNFMN	
	515	CMRDC	
	517	CPH11N	
	519	PRTHL	
	521	CMNFMN	
	523	CMRDC	
	525	CPH11N	
	527	PRTHL	
	529	CMNFMN	
	531	CMRDC	
	533	CPH11N	
	535	PRTHL	
	537	CMNFMN	
	539	CMRDC	
	541	CPH11N	
	543	PRTHL	
	545	CMNFMN	
	547	CMRDC	
	549	CPH11N	
	551	PRTHL	
	553	CMNFMN	
	555	CMRDC	
	557	CPH11N	
	559	PRTHL	
	561	CMNFMN	
	563	CMRDC	
	565	CPH11N	
	567	PRTHL	
	569	CMNFMN	
	571	CMRDC	
	573	CPH11N	
	575	PRTHL	
	577	CMNFMN	
	579	CMRDC	
	581	CPH11N	
	583	PRTHL	
	585	CMNFMN	
	587	CMRDC	
	589	CPH11N	
	591	PRTHL	
	593	CMNFMN	
	595	CMRDC	
	597	CPH11N	
	599	PRTHL	
	601	CMNFMN	
	603	CMRDC	
	605	CPH11N	
	607	PRTHL	
	609	CMNFMN	
	611	CMRDC	
	613	CPH11N	
	615	PRTHL	
	617	CMNFMN	
	619	CMRDC	
	621	CPH11N	
	623	PRTHL	
	625	CMNFMN	
	627	CMRDC	
	629	CPH11N	
	631	PRTHL	
	633	CMNFMN	
	635	CMRDC	
	637	CPH11N	
	639	PRTHL	
	641	CMNFMN	
	643	CMRDC	
	645	CPH11N	
	647	PRTHL	
	649	CMNFMN	
	651	CMRDC	
	653	CPH11N	
	655	PRTHL	
	657	CMNFMN	
	659	CMRDC	
	661	CPH11N	
	663	PRTHL	
	665	CMNFMN	
	667	CMRDC	
	669	CPH11N	
	671	PRTHL	
	673	CMNFMN	
	675	CMRDC	
	677	CPH11N	
	679	PRTHL	
	681	CMNFMN	
	683	CMRDC	
	685	CPH11N	
	687	PRTHL	
	689	CMNFMN	
	691	CMRDC	
	693	CPH11N	
	695	PRTHL	
	697	CMNFMN	
	699	CMRDC	
	701	CPH11N	
	703	PRTHL	
	705	CMNFMN	
	707	CMRDC	
	709	CPH11N	
	711	PRTHL	
	713	CMNFMN	
	715	CMRDC	
	717	CPH11N	
	719	PRTHL	
	721	CMNFMN	
	723	CMRDC	
	725	CPH11N	
	727	PRTHL	
	729	CMNFMN	
	731	CMRDC	
	733	CPH11N	
	735	PRTHL	
	737	CMNFMN	
	739	CMRDC	
	741	CPH11N	

SEADUCEE RUN 80038 FOR TP-22A APPLICIA C
NEXT ABSRUH

Figure C.2. (Continued).

 SEADUCER RUN 80038 APR 23, 1970S LIKE MOD 7 RUN 70335
 DESIGN RUN S
 LINES OF CONSTANT TAIL LENGTHS
 CHARGE TO 16054501 BASELINE

B7 c-29

***** HQ 7 NETWORK TABLE

S 1B7D: -+111A: -+1R2A:\$
 S 2B7D: 1E2E:\$
 S 3B7D: 2R2A:\$
 S 4B7D: 1R2Z:\$
 S 5B7D: 2Y2Z:\$
 S 6B7D: -+2E2E: 1V2W: 1Y2Z:\$
 S 7B7D: -+111B: 2H2Z: 2V2W:\$

***** AD 6 NETWORK TABLE

S 1A6D: 3C3D:\$
 S 2A6D: 5B5D:\$
 S 3A6D: -+2C3D: 2B5D:\$
 S 4A6D: -+1B5D: 1C3D:\$
 S 5A6D: -+3B5D: 1R2D:\$
 S 6A6D: -+4B5D: 2R2D:\$

TYPE 1	RHO	AREA	ID	OD	LENGTH
E2E1\$	4416.90	.148261-01	.000000	.000000	.009070
	C REAL	C IMAG	C MULT		MASS
	4820.90	.000000	.000000		.59334

TYPE 1	RHO	AREA	ID	OD	LENGTH
R2A1\$	7702.80	.790233-03	.000000	.000000	.007248
	C REAL	C IMAG	C MULT		MASS
	4970.00	.000000	.000000		.04412

TYPE 1	RHO	AREA	ID	OD	LENGTH
B2Z1\$	7702.80	.790233-03	.000000	.000000	.000838
	C REAL	C IMAG	C MULT		MASS
	4970.00	.000000	.000000		.00510

TYPE 1	RHO	AREA	ID	OD	LENGTH
T2B1\$	7730.00	.228639-02	.000000	.000000	.003357
	C REAL	C IMAG	C MULT		MASS
	4970.00	.000000	.000000		.05933

TYPE 1	RHO	AREA	ID	OD	LENGTH
T2B2\$	7724.87	.168402-02	.000000	.000000	.003314
	C REAL	C IMAG	C MULT		MASS
	4970.00	.000000	.000000		.04311

TYPE 1	RHO	AREA	ID	OD	LENGTH

Figure C.2. (Continued).

SEAUUCER RUL. 80038 FOR TP-229 APPENDIX C

TYPE 1 Y2L3s	RHO 4416.90 C REAL 4970.00	AREA .130699-02 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .010215 C MULTI .000000	MASS .10305
TYPE 1 Y2U4s	RHO 7702.80 C REAL 4970.00	AREA .790233-03 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .006679 C MULTI .000000	MASS .04066
TYPE 1 Y2M1s	RHO 4416.90 C REAL 4920.00	AREA .112776-01 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .011370 C MULTI .000000	MASS .56637
TYPE 1 Y2M2s	RHO 4416.90 C REAL 4920.00	AREA .112776-01 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .011370 C MULTI .000000	MASS .56637
TYPE 1 Y2M3s	RHO 7708.46 C REAL 5116.00	AREA .254984-02 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .002224 C MULTI .000000	MASS .04418
TYPE 1 Y2Z1s	RHO 2702.81 C REAL 5200.00	AREA .348119-02 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .011370 C MULTI .000000	MASS .10698
TYPE 1 Y2Z2s	RHO 2702.81 C REAL 5200.00	AREA .348119-02 C IMAG .000000	ID .000000 C MULTI .000000	OD .000000 C MULTI .000000	LENGTH .011370 C MULTI .000000	MASS .10698
TYPE 4 Y2Z3s	UNIT MATRIX 1.00					

Figure C.2. (Continued).

TYPE 7	SCALE FACTOR	MATRIX FORM	NUMERATOR ORDER	DENOMINATOR ORDER	SYMMETRY FLAG
Y224s	.1000+01	0	3	1	-1
COEF. TO CHECK NEW TYPE 7					
POLYNOMIAL COEFFICIENTS FOR Z(1,1)E(CD+CI*E+...)/(100+DI*E+...)					
NUMERATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(1, 1)					
	.0000000000		-.8668996000+09		
	.0000000000		.7711489900+05		
	.0000000000		-.9040960000+01		
	.0000000000		.1627919980-02		
DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(1, 1)					
	.0000000000		.0000000000		
	.1000000000+01		.0000000000		
NUMERATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(1, 2)					
	.0000000000		.8663080000+09		
	.0000000000		-.7690410000+05		
	.0000000000		.1246709880+02		
	.0000000000		-.1530116980-02		
DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(1, 2)					
	.0000000000		.0000000000		
	.1000000000+01		.0000000000		
NUMERATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(2, 2)					
	.0000000000		.8691160000+09		
	.0000000000		-.7743060000+05		
	.0000000000		-.2671390000+00		
	.0000000000		-.1807459880-02		
DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(2, 2)					
	.0000000000		.0000000000		
	.1000000000+01		.0000000000		

F2S UNIT MATRIX
 D2S UNIT MATRIX
 S2S UNIT MATRIX

Figure C.2. (Continued).

***** F = 3500.00000 *****

TYPE 1	RHO	AREA	ID	OD	LENGTH	
T2A1\$	7932.40	.217225-01	.000000	.000000	.038125	
	C REAL	C IMAG	C MULT			MASS
	5116.00	.000000	.000000			6.48658
REPLACE						
TYPE 1	RHO	AREA	ID	OD	LENGTH	
Y2Z3\$	2702.81	.245000-02	.000000	.000000	.035354	
	C REAL	C IMAG	C MULT			MASS
	5200.00	.000000	.000000			.23411
TYPE 11	RHO	AREA	ID	OD	LENGTH	
C30\$	7588.21	.490000-02	.000000	.000000	.013625	
	C REAL	C IMAG	C MULT		PIECES	MASS
	3743.27	.312617+01	.835144-03		2	1.01324
		REAL	IMAG		MULT	
	E43I	.1411606000+04	-.3416019970+01		.2419850000-02	
	G33	.2452070000-01	.4595841239-05		-.1474270000-03	
	S33D	.9404950000-11	-.1570899394-13		.1670290000-02	
	K33	.6604539643+00	-.6940268089-04			
TOTAL LENGTH = .061205 FOR SECTIONS VW EE CD						
TYPE 1	RHO	AREA	ID	OD	LENGTH	
R201\$	7702.80	.571140-03	.000000	.000000	.053199	
	C REAL	C IMAG	C MULT			MASS
	4970.00	.000000	.000000			.23404

Figure C.2. (Continued).

SEAUUCER RUN 80038 FOR TP-22A APPENDIX C

Z	SELF	MAG	ANG DEG	REAL	IMAG	REACTOR	GAMMA	IC	GA	EC	MIN
L	I241	A	C3D	T	L	C3D	NP	I	MASS	T	LENGTH
T1C1	.038125	.004900	.173784	12	19.0963	.32423	.4270-01	.1106+08	.1037+03		
T1C2	.038125	.006500	.208582	16	23.1521	.35903	.1997-01	.1231+08	.1373+03		
T1C3	.038125	.007520	.225941	16	25.8822	.37639	.1774-01	.1263+08	.1578+03		
T1C4	.038125	.008100	.234529	18	27.4699	.38498	.1313-01	.1271+08	.1693+03		
T1C5	.038125	.012898	.282654	20	41.1598	.43310	.6547-02	.1210+08	.2826+03		
T2C1	.076249	.004900	.129069	10	23.7235	.31764	.4755-01	.9667+07	.6358+02		
T2C2	.076249	.006500	.161370	12	27.1023	.34994	.2907-01	.1171+08	.1153+03		
T2C3	.076249	.007520	.176211	14	29.4351	.36678	.1945-01	.1249+08	.1355+03		
T2C4	.076249	.008100	.186784	14	30.8118	.37536	.1842-01	.1279+08	.1470+03		
T2C5	.076249	.012898	.238733	18	43.1544	.42731	.7201-02	.1291+08	.2434+03		
T3C1	.114374	.004900	.109460	8	29.3947	.33616	.6387-01	.8577+07	.7236+02		
T3C2	.114374	.006500	.138534	10	32.3620	.36523	.3691-01	.1077+08	.1007+03		
T3C3	.114374	.007520	.153708	12	34.4156	.38041	.2364-01	.1176+08	.1189+03		
T3C4	.114374	.008100	.161460	12	35.6304	.38816	.2252-01	.1219+08	.1293+03		
T3C5	.114374	.012898	.209580	16	46.6595	.43628	.8462-02	.1328+08	.2202+03		
T4C1	.152499	.004900	.098433	8	35.4228	.36326	.5775-01	.7851+07	.6559+02		
T4C2	.152499	.006500	.125234	10	38.1342	.39006	.3383-01	.1002+08	.9124+02		
T4C3	.152499	.007520	.139094	10	40.0041	.40392	.3100-01	.1105+08	.1076+03		
T4C4	.152499	.008100	.146145	10	41.1083	.41097	.3002-01	.1154+08	.1171+03		
T4C5	.152499	.012898	.189725	14	51.1155	.45455	.1045-01	.1329+08	.1998+03		
T5C1	.190623	.004900	.091135	6	41.6058	.39408	.9532-01	.7333+07	.6097+02		
T5C2	.190623	.006500	.116295	8	44.1404	.41924	.4949-01	.9430+07	.8459+02		
T5C3	.190623	.007520	.129159	10	45.8799	.43211	.2951-01	.1047+08	.9955+02		
T5C4	.190623	.008100	.135663	10	46.9044	.43861	.2827-01	.1096+08	.1081+03		
T5C5	.190623	.012898	.175267	12	56.1233	.47821	.1359-01	.1311+08	.1831+03		
LAST TIME INTERVAL = 21.635 SEC TOTAL RUN TIME = 21.635 SEC											
A Y2Z4											
1	1	.9383815355+00	.0000000000	.513215777-05							
2	1	.0000000000									
1	2	.0000000000	.5614587184+05								
2	2	.7585939197+00	.0000000000								
Z Y2Z4											
1	1	.0000000000	-.1828434698+06								
2	1	.0000000000	-.1948498163+06								
1	2	.0000000000	.1948498163+06								
2	2	.0000000000	.1478118859+06								

Figure C.2. (Continued).

***** COMMON PRT TBL *****											
N	NET	1	SIGN	J	N	NET	NUM	NUM	N	J	LC J
SP	C	D	PORT	PORTS	NUM	NUM	NUM	NUM	AHEAD	PACK	ROW
1	5	1	1	1	7	BU	1	-1	4	0	1
2	5	-1	1	1	1	TA	1	1	3	0	658
3	5	-1	1	1	2	RA	1	2	7	2	580
4	5	1	1	2	7	BU	2	-2	6	1	2
5	5	1	1	1	2	EE	2	4	13	7	341
6	5	1	1	3	7	BU	3	-3	6	4	3
7	5	1	1	2	2	RA	3	3	5	3	341
8	5	1	1	4	7	BU	4	-4	10	6	4
9	5	1	1	1	2	RZ	4	6	18	13	419
10	5	1	1	3	7	BU	5	-5	12	8	5
11	5	1	1	2	2	YZ	5	9	14	15	652
12	5	1	1	0	7	BU	6	-6	16	10	6
13	5	-1	1	2	2	EE	6	5	9	5	342
14	5	1	1	1	2	VW	6	10	19	11	566
15	5	1	1	1	2	YZ	6	8	11	14	651
16	5	1	1	7	7	BU	7	-7	20	12	7
17	5	-1	1	1	1	IB	7	12	11	19	462
18	5	1	1	2	2	RZ	7	7	15	9	420
19	5	1	1	2	2	VW	7	11	17	14	567
20	5	1	1	1	6	AU	1	-1	22	16	197
21	5	1	1	3	3	CU	1	3	28	25	1024
22	5	1	1	2	6	AD	2	-2	24	20	198
23	5	1	1	5	5	BU	2	8	32	34	670
24	5	1	1	3	6	AJ	3	-3	27	22	199
25	5	-1	1	2	3	CU	3	2	21	24	1023
26	5	1	1	2	5	BU	3	5	31	24	667
27	5	1	1	4	6	AD	4	-4	30	24	200
28	5	-1	1	1	5	BU	4	4	26	21	666
29	5	1	1	1	3	CU	4	1	25	0	1022
30	5	1	1	3	6	AD	5	-5	33	27	201
31	5	-1	1	3	5	BU	5	6	34	26	666
32	5	1	1	1	2	RJ	5	9	35	23	1001
33	5	1	1	0	6	AU	6	-6	0	30	202
34	5	-1	1	4	5	BU	6	7	23	31	669
35	5	1	1	2	2	RJ	6	10	0	32	1092

Figure C.2. (Continued).

***** COMMON CATALOG *****									
I	NAME	WTK	I	PC	H	PC	I	I	LOC
		SIZ			LOI	I	TYPE	SIR	
1	UD	7	0	0	0	0	0	0	1
2	AD	6	0	0	0	0	0	0	197
3	EE	2	0	1	0	0	0	0	341
4	EE	2	1	1	1	1	7	7	357
5	RA	2	0	1	1	0	0	0	380
6	RA	2	1	1	1	1	7	7	396
7	HZ	2	0	1	1	0	0	0	419
8	HZ	2	1	1	1	1	7	7	435
9	TB	2	0	4	4	0	0	0	458
10	TB	2	1	4	4	1	7	7	474
11	TB	2	2	4	4	1	7	7	497
12	TB	2	3	4	4	1	7	7	520
13	TB	2	4	4	4	1	7	7	543
14	VM	2	0	3	3	0	0	0	560
15	VM	2	1	3	3	1	7	7	582
16	VM	2	2	3	3	1	7	7	605
17	VM	2	3	3	3	1	7	7	628
18	YZ	2	0	4	4	0	0	0	651
19	YZ	2	1	4	4	1	7	7	667
20	YZ	2	2	4	4	1	7	7	690
21	YZ	2	3	4	4	1	7	7	713
22	YZ	2	4	4	4	7	42	0	737
23	FS	2	0	0	0	0	0	0	795
24	LS	2	0	0	0	0	0	0	803
25	SS	2	0	0	0	0	0	0	811
26	TA	2	0	1	1	0	0	0	819
27	TA	2	1	1	1	1	7	7	835
28	TA	1	0	0	0	0	0	0	858
29	TR	1	0	0	0	0	0	0	862
30	AD	5	0	0	0	0	0	0	866
31	HD	0	0	0	0	0	0	0	966
32	HD	0	0	0	0	0	0	0	982
33	CD	3	0	0	0	11	33	0	1022
34	HD	2	0	1	1	0	0	0	1091
35	HD	2	1	1	1	1	7	7	1107
36	AD	2	0	0	0	0	0	0	1130
37	AD	0	0	0	0	0	0	0	1146
38	AD	0	0	0	0	0	0	0	1210
39	ES	2	0	0	0	0	0	0	1242
40	MS	2	0	0	0	0	0	0	1250
41	GS	2	0	0	0	0	0	0	1258
42	MS	2	0	0	0	0	0	0	1266
TOTAL DATA CELLS USED IN MASTER STORAGE									1273

Figure C.2. (Continued).

LAST TIME INTERVAL = .516 SEC TOTAL RUN TIME = 22.151 SEC

QBKPT PRINTS

RUNID: MERNR ACCOUNT: IEC17FFIUCCL PROJECT: LMEUFT14E22

LOAD 9F 9/F PROFILE -1 MLCU3P

MEMPSMSG: SC-2072

PREHEAT IN THIS RUN

LOAD 279 9/E R -1 MLCU3P

PREHEAT IN THIS RUN

TIME: 00:00:22.901 IN: 334 OUT: L PAGES: 39

WDS XFCCE2: 5753 I/O REFS: 1928 CORE SEC: 181.9

INITIATION TIME: 19:00:21-OCT 19,1972 VERSION: 28.3.1EP 10

TERMINATION TIME: 19:05:42-OCT 19,1972

Figure C.2. (Continued).

APPENDIX D

SEARCH ROUTINE

INTRODUCTION

This appendix presents a description of the search procedure employed by the program for longitudinal vibrators. A detailed summary of naming conventions, equations, and user conventions presently existent in the search package is presented as well as a sample run. The procedure includes a decompaction process for a 3-3 mode ceramic stack.

The first step of this search procedure is the optional computation of a velocity control reactor with specified properties which maximizes the velocity control of the transducer element at a specified frequency. Following the loading of this reactor, the transducer element performance is computed at a number of frequencies over a band centered about a specified center frequency, f_0 .

At each frequency within the frequency sweep, element performance is computed for each of a number of radiation boundary conditions by means of a boundary condition loop. Each performance variable is checked and only the maximum and minimum of each is stored. Several computed quantities are summed over the boundary condition loop, providing totals and averages. Following completion of the boundary condition loop, several quantities are computed for use later in computing two new quantities as a function of bandwidth about the center frequency. Also, selected performance variables are output at this point by printer, and either card punch or magnetic tape.

The process is then repeated at a new frequency until the entire frequency sweep is complete. Following completion of the frequency sweep, the two "FBAND" variables are computed as a function of bandwidth and output by specified means.

MECHANICAL NETWORK CONVENTIONS

All longitudinal resonator transducers using 3-3 mode ceramic may be compacted into three networks, as shown in figure D.1. The double arrow ($\Rightarrow$) defines the direction of positive power flow, and the current (velocity) is always in the clockw ise direction. The following are descriptions of the basic networks and their ports:

Network A5S is defined as the compacted interconnection of networks B4S, C3S, and T1S. The standard interconnection table is

1	S	1A5S, 3C3S
2	S	2A5S, 3B4S
3	S	3A5S, 4B4S, 1T1S
4	S	4A5S, 1B4S, -+1C3S
5	S	5A5S, 2B4S, -+2C3S .

Network C3S is defined as the compacted (type 11) 3-3 mode ceramic stack, where, by convention,

1C3S is the ceramic mechanical port at the tail end,

2C3S is the ceramic mechanical port at the head end,

and 3C3S is the ceramic electrical port.

Network B4S is defined as the compacted and reduced interconnection of the remainder of the transducer, where, by convention,

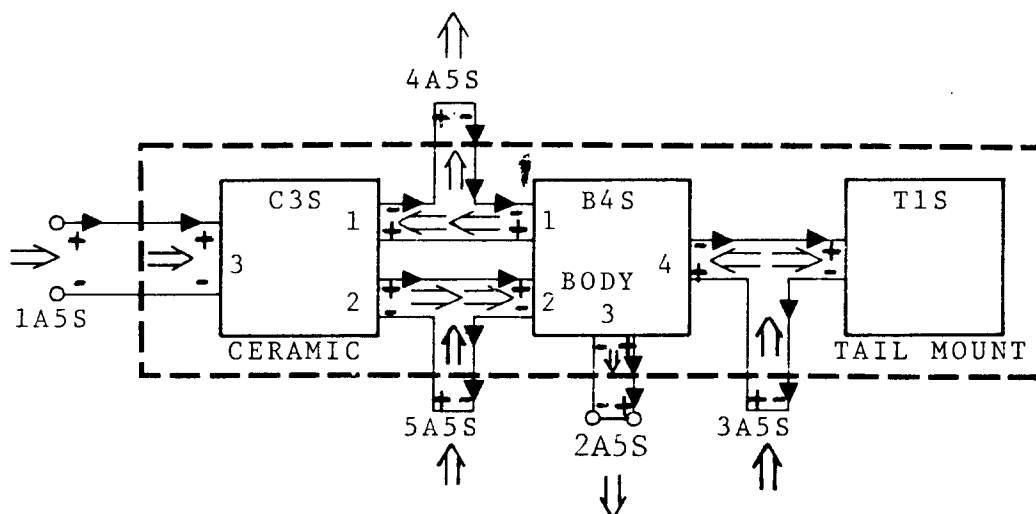


Figure D.1. Three Basic Networks for All Longitudinal Resonator Transducers.

1B4S is the mechanical port at the tail end of C3S,
2B4S is the mechanical port at the head end of C3S,
3B4S is the mechanical port at the radiating face,
and 4B4S is the mechanical port at the tail mount.

Network T1S is defined as the compacted and reduced interconnection of the tail mount assembly and is of the form of a complex passive tail impedance, Z_T .

ELECTRICAL NETWORK CONVENTIONS

The electrical network naming and sign conventions assumed by the procedure are presented in Figure D.2. Also shown are particular voltages (or forces) and currents (or velocities). The electrical networks are described as

Network S2S, the power amplifier;

Network A2S, the transducer element;

Network E2S, the velocity control network;

Network D2S and F2S, the matching networks;

Network G2S, $[A^{G2S}] \triangleq [A^{S2S}] * [A^{D2S}]$;

Network H2S, $[A^{H2S}] \triangleq [A^{F2S}] * [A^{A2S}]$;

and Network M2S, $[A^{M2S}] \triangleq [A^{D2S}] * [A^{E2S}] * [A^{F2S}]$;

where $[A^X]$ represents the A-form for a two-port network named X, and

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A \\ 1 \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix} .$$

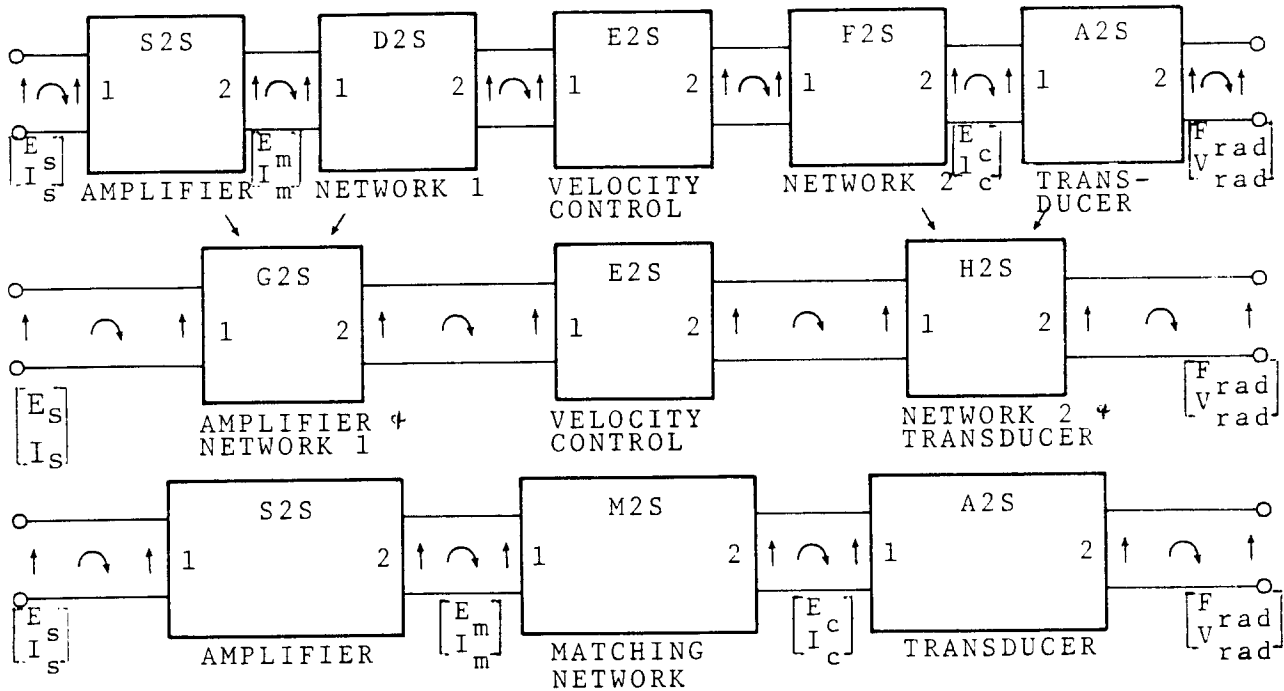


Figure D.2. Electrical Networks Assumed in the Search Procedure.

Similarly, the Z-form for a two-port network is defined by

$$\begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} Z \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} .$$

PORT VARIABLE DEFINITIONS

The following symbol definitions and relationships for port variables are made:

1. f_{li}, v_{li} = force and velocity at the left (tail) end of ceramic piece #i.
2. f_{ri}, v_{ri} = force and velocity at the right (head) end of ceramic piece #i.
3. E_C, i_{Ci} = voltage and current at the electrical port of ceramic piece #i.
4. F_L, V_L = force and velocity at Port #1C3S and Port #1B4S.
5. F_R, V_R = force and velocity at Port #2C3S and Port #2B4S.
6. E_C, I_C = voltage and current at Port #3C3S and Port #1A5S.
7. F_T, V_T = force and velocity at Port #4B4S.
8. $-F_T, V_T$ = force and velocity at Port #1T1S.
9. F_{rad}, V_{rad} = force and velocity at Port #3B4S and Port #2A5S.
10. $Z_{rad} \triangleq F_{rad}/V_{rad}$ = radiation impedance connected at 2A5S.
11. $Z_T \triangleq -F_T/V_T$ = tail impedance = Z^{T1S} ; ($Z_T = 0$ for air termination).
12. E_S, I_S = voltage and current into power amplifier at 1S2S.
13. E_M, I_M = voltage and current into matched transducer at 1M2S.
14.
$$\begin{bmatrix} E_S \\ I_S \end{bmatrix} \triangleq \begin{bmatrix} A^{S2S} \end{bmatrix} \begin{bmatrix} E_M \\ I_M \end{bmatrix}$$
15.
$$\begin{bmatrix} E_M \\ I_M \end{bmatrix} \triangleq \begin{bmatrix} A^{M2S} \end{bmatrix} \begin{bmatrix} E_C \\ I_C \end{bmatrix}$$
16.
$$\begin{bmatrix} E_C \\ I_C \end{bmatrix} \triangleq \begin{bmatrix} A^{A2S} \end{bmatrix} \begin{bmatrix} F_{rad} \\ V_{rad} \end{bmatrix}$$
17. $[A^{M2R}] \triangleq [A^{M2S}] * [A^{A2S}]$
18. $[A^{S2C}] \triangleq [A^{S2S}] * [A^{M2S}]$
19. $[A^{S2R}] \triangleq [A^{S2S}] * [A^{M2S}] * [A^{A2S}]$

$$20. \begin{bmatrix} f_{\ell i} \\ f_{ri} \\ E_c \end{bmatrix} \stackrel{d}{=} \begin{bmatrix} Z^C \end{bmatrix} \begin{bmatrix} V_{\ell i} \\ V_{ri} \\ i_{ci} \end{bmatrix}$$

$$21. Z_{ec} \stackrel{d}{=} A_{12}^{S2R} / A_{11}^{S2R}$$

$$Z_{ic} \stackrel{d}{=} A_{22}^{S2R} / A_{21}^{S2R}$$

$$22. F_{ec} \stackrel{d}{=} 1/A_{11}^{S2R} * (\text{a given voltage})$$

$$F_{ic} \stackrel{d}{=} 1/A_{21}^{S2R} * (\text{a given current})$$

$$23. \begin{bmatrix} F_L \\ F_R \\ E_C \end{bmatrix} \stackrel{d}{=} \begin{bmatrix} Z^{C3S} \end{bmatrix} \begin{bmatrix} V_L \\ V_R \\ I_C \end{bmatrix}$$

$$24. \begin{bmatrix} F_L \\ F_R \\ F_{rad} \\ F_T \end{bmatrix} \stackrel{d}{=} \begin{bmatrix} Z^{B4S} \end{bmatrix} \begin{bmatrix} V_L \\ V_R \\ V_{rad} \\ V_T \end{bmatrix}$$

PERFORMANCE VARIABLE DEFINITIONS

The performance variables are denoted by the following:

1. T_{33}^i = stress in the i^{th} ceramic piece at distance (χ) from the left (tail) end of the piece.
2. S_{33}^i = strain in the i^{th} ceramic piece at distance (χ) from the left (tail) end of the piece.
3. P_{LC}^i = power loss in the i^{th} ceramic piece (numbering from left (tail) to right (head)).
4. η_C^i = efficiency of the i^{th} ceramic piece.
5. E = electric field on the ceramic.
6. P_{LC} = total power loss in the ceramic stack.
7. η_C = total ceramic stack efficiency.
8. P_{LD} = total power loss in the electromechanical portion of the transducer.
9. η_D = total transducer electromechanical efficiency.
10. P_{LT} = total power loss excluding only the amplifier (including P_{TL}).
11. η_T = total efficiency excluding only the amplifier (including P_{TL}).
12. P_M = power into the tuned transducer (amplifier output).
13. P_C = power into the electromechanical portion of the transducer (into the ceramic).
14. P_{TL} = power output from the tail into the tail impedance.
15. P_{rad} = power output from the head into the medium (water).
16. Z_{ec} = voltage-velocity control impedance seen looking into the radiating face with port 1S2S short-circuited.

17. Z_{ic} = current-velocity control impedance seen looking into the radiating face with port 1S2S open-circuited.
18. Z_C = impedance seen looking into the ceramic port (Port 3C3S).
19. Z_M = impedance seen looking into the matching network (Port 1M2S).
20. Y_C = admittance equivalent to Z_C .
21. Y_M = admittance equivalent to Z_M .
22. P_{Arad} = total array output power.
23. P_{MA} = total array input power.
24. η_{TA} = total array efficiency excluding only the amplifiers.
25. x_i^T = the location of maximum stress magnitude in the i^{th} ceramic piece expressed as a distance from the left end.
26. x_i^S = the location of maximum strain magnitude in the i^{th} ceramic piece expressed as a distance from the left end.
27. Q_M = reactive power output by the amplifier.
28. P_{LM} = power loss in the electrical matching network, M2S.
29. η_M = efficiency of network M2S.

30. $|S_M|$ = complex power magnitude at port 1M2S (out of amplifier).
 $S_M = E_M \times I_M^* = \text{Re}(E_M \times I_M^*) + j\text{Im}(E_M \times I_M^*) = P_M + jQ_M$
31. Z^M = reactor inserted to extremize $|\gamma_{ec}|$ or $|\gamma_{ic}|$ in midband logic.

USER INSTRUCTIONS

1. Specify interconnection table defining the BnS network which will be reduced to the B4S network.
2. Specify interconnection table defining the TmS network which will be reduced to the T1S network.
3. Specify all network parameters and types, including those for the Type 11 C3S network.
4. Specify $[A^{F2S}]$, $[A^{D2S}]$, $[A^{S2S}]$ and Z_{self} .
5. Specify the midband logic parameters to be used in computing velocity control network matrix, $[A^{E2S}]$ (optional).
6. Specify the array of radiation impedance and velocity boundary conditions to be searched at each frequency.
7. Specify frequency range and frequency increment to be investigated.
8. Specify print, punch, and tape output options.

SEARCH PROCEDURE

The following paragraphs provide the basic equations and conventions found in the search procedure. The five basic operations are summarized below.

(Set frequency of maximum velocity control)

Midband logic procedure (optional)

(Enter frequency sweep)

Compaction

(Enter boundary condition loop)

Port variable computation

Performance variable computation

(Exit boundary condition loop – output results)

(Exit frequency sweep)

FBAND ZM

Midband Logic Procedure (Optional)

Single-reactor midband logic computes the series or parallel reactor Z^M , where $Q^M \triangleq \text{Imag}(Z^M)/\text{Real}(Z^M)$ and $R^M \triangleq \text{Real}(Z^M)$, required to extremize $|\gamma_{ec}|$ or $|\gamma_{ic}|$ at a specified frequency. If this subroutine is not called, $[A^{E2S}]$ is automatically set to a unit matrix and the following procedure is ignored.

1. Compute $[A^{G2S}]$ and $[A^{H2S}]$ from available information.

2. If $|Z_{ec}|$ is extremized, let $i=1, j=1$.

If $|Z_{ic}|$ is extremized, let $i=2, j=2$.

If Z^M = parallel reactor, let $k=2, \ell=1$.

If Z^M = series reactor, let $k=1, \ell=2$, and compute the following constants:

$$K_{11} = A_{i1}^{G2S} * A_{11}^{H2S} + A_{j2}^{G2S} * A_{21}^{H2S}$$

$$K_{12} = A_{i1}^{G2S} * A_{12}^{H2S} + A_{j2}^{G2S} * A_{22}^{H2S}$$

$$K_{21} = A_{ik}^{G2S} * A_{\ell 1}^{H2S}$$

$$K_{22} = A_{ik}^{G2S} * A_{\ell 2}^{H2S}$$

$$N_O = K_{k1} Z_{\text{SELF}} + K_{k2}$$

$$N_1 = K_{\ell 1} Z_{\text{SELF}} + K_{\ell 2}$$

$$D_O = K_{k1}$$

$$D_1 = K_{\ell 1}$$

3. Compute reactor constants (caution: Q^M is always series).

$$M_0 = N_0 + R^M N_1$$

$$M_1 = jN_1 + N_1/Q^M$$

$$C_0 = D_0 + R^M D_1$$

$$C_1 = jD_1 + D_1/Q^M$$

$$\alpha_0 = |M_0|^2$$

$$\alpha_1 = 2 (M_{0r} M_{1r} + M_{0i} M_{1i})$$

$$\alpha_2 = |M_1|^2$$

$$\beta_0 = |C_0|^2$$

$$\beta_1 = 2 (C_{0r} C_{1r} + C_{0i} C_{1i})$$

$$\beta_2 = |C_1|^2$$

$$\delta_0 = (\alpha_1 \beta_0 - \alpha_0 \beta_1)$$

$$\delta_1 = 2 (\alpha_2 \beta_0 - \alpha_0 \beta_2)$$

$$\delta_2 = (\alpha_2 \beta_1 - \alpha_1 \beta_2)$$

$$\epsilon_0 = (\beta_0 \delta_1 - 2 \beta_1 \delta_0)$$

$$\epsilon_1 = (2 \beta_0 \delta_2 - \beta_1 \delta_1 - 4 \beta_2 \delta_0)$$

$$\epsilon_2 = (-3 \beta_2 \delta_1)$$

$$\epsilon_3 = (-2 \beta_2 \delta_2)$$

4. Compute reactor variables:

$$X^{\pm} = \frac{1}{2\delta_2} \left[-\delta_1 \pm \left(\delta_1^2 - 4\delta_2 \delta_0 \right)^{1/2} \right]$$

$$D^{\pm} = \frac{\epsilon_0 + \epsilon_1 X^{\pm} + \epsilon_2 (X^{\pm})^2 + \epsilon_3 (X^{\pm})^3}{\beta_0 + \beta_1 X^{\pm} + \beta_2 (X^{\pm})^2}$$

If $D^{\pm} < 0$, $X^{\pm}$ maximizes.

If $D^{\pm} > 0$, $X^{\pm}$ minimizes.

5. Select $x = x^{\pm}$ to maximize (or minimize).

If $x \geq 0$ set REACTOR FLAG = L ,

and REACTOR = x/ω .

If $x < 0$ set REACTOR FLAG = C ,

and REACTOR = $-\frac{1}{\omega x}$.

6. Load A^{E2S} from following equations:

$$A_{11}^{E2S} = A_{22}^{E2S} = 1 + j 0$$

$$\text{If REACTOR FLAG} = C, \text{ then } Z^M = R^M + \frac{1}{j\omega \text{ REACTOR}} \left(1 + \frac{j}{Q_M} \right) .$$

$$\text{If REACTOR FLAG} = L, \text{ then } Z^M = R^M + j\omega \text{ REACTOR} \left(1 - \frac{j}{Q_M} \right) .$$

If parallel reactor, then

$$A_{21}^{E2S} = 1/Z^M ,$$

and $A_{12}^{E2S} = 0 .$

If series reactor, then

$$A_{12}^{E2S} = Z^M .$$

and

$$A_{21}^{E2S} = 0 .$$

Compaction

The following procedure is performed once at each new frequency within the frequency sweep.

1. Compute $[Z^{C3S}]$, $[Z^{B4S}]$, and $[Z^{T1S}]$.
2. Compute $[Z^{A5S}]$, $[Z^{A2S}]$, and $[A^{A2S}]$.
3. Compute left boundary condition matrix, $[K^{BCL}]$, where

$$[K^{BCL}] \triangleq - \begin{bmatrix} Z_{21}^{A5S} & Z_{23}^{A5S} & Z_{24}^{A5S} & Z_{25}^{A5S} \\ Z_{31}^{A5S} & Z_{33}^{A5S} & Z_{34}^{A5S} & Z_{35}^{A5S} \\ Z_{41}^{A5S} & Z_{43}^{A5S} & Z_{44}^{A5S} & Z_{45}^{A5S} \\ Z_{51}^{A5S} & Z_{53}^{A5S} & Z_{54}^{A5S} & Z_{55}^{A5S} \end{bmatrix}.$$

4. Compute the piece matrix, $[Z^C]$, where

$$Z_{11}^C = -Z_{22}^C = -j\rho cA \cot(k\ell),$$

$$Z_{12}^C = -Z_{21}^C = j\rho cA \csc(k\ell),$$

$$Z_{13}^C = Z_{31}^C = Z_{23}^C = -Z_{32}^C = -j \left(\frac{\rho c}{k} \right) g_{33},$$

and
$$Z_{33}^C = -j \frac{\rho c \ell}{kA} \left[g_{33} + S_{33}^D / \epsilon_{33}^T \right].$$

Note: These equations are valid only for type 11 ceramic.

5. Compute right-handed decompaction matrix, $[K^{RC}]$, where

$$D \triangleq \left(Z_{13}^C \right)^2 + Z_{12}^C Z_{33}^C ,$$

$$K_{11}^{RC} = K_{22}^{RC} = \left[\left(Z_{13}^C \right)^2 - Z_{11}^C Z_{33}^C \right] / D ,$$

$$K_{12}^{RC} = - \left(Z_{11}^C + Z_{12}^C \right) \left[Z_{33}^C \left(Z_{12}^C - Z_{11}^C \right) + 2 \left(Z_{13}^C \right)^2 \right] / D ,$$

$$K_{13}^{RC} = -K_{32}^{RC} = Z_{13}^C \left(Z_{11}^C + Z_{12}^C \right) / D ,$$

$$K_{21}^{RC} = Z_{33}^C / D ,$$

$$K_{23}^{RC} = -K_{31}^{RC} = -Z_{13}^C / D ,$$

and $K_{33}^{RC} = Z_{12}^C / D .$

6. Compute $[A^{S2S}]$, $[A^{D2S}]$, $[A^{F2S}]$, $[A^{E2S}]$, and $[A^{M2S}]$.

7. Compute Z_{ec} and Z_{ic} from definitions. Then,

$$\gamma_{ec} = Z_{SELF} + Z_{ec} ,$$

$$\gamma_{ic} = Z_{SELF} + Z_{ic} ,$$

where Z_{SELF} is self impedance.

Port Variable Computation

The following procedure is used in computing the port variables for every network involved in the interconnection (decompaction) and is performed for a single radiation boundary condition within the boundary condition loop.

1. Compute $[K^{BCR}]$, the right boundary condition vector, where

$$[K^{BCR}] \triangleq \begin{bmatrix} Z_{22}^{A5S} - Z_{rad} \\ Z_{32}^{A5S} \\ Z_{42}^{A5S} \\ Z_{52}^{A5S} \end{bmatrix} * V_{rad}.$$

2. Solve

$$[K^{BCL}] \begin{bmatrix} I_C \\ V_T \\ V_L \\ V_R \end{bmatrix} = [K^{BCR}] \text{ for } \begin{bmatrix} I_C \\ V_T \\ V_L \\ V_R \end{bmatrix}.$$

3. Compute

$$\begin{bmatrix} F_L \\ F_R \\ E_C \end{bmatrix} = [Z^{C3S}] \begin{bmatrix} V_L \\ V_R \\ I_C \end{bmatrix}.$$

4. Compute $F_T = -Z^{T1S} V_T$.

5. Compute $\begin{bmatrix} E_M \\ I_M \end{bmatrix} = [A^{M2S}] \begin{bmatrix} E_C \\ I_C \end{bmatrix}$.

6. Compute $\begin{bmatrix} E_S \\ I_S \end{bmatrix} = [A^S S^S] \begin{bmatrix} E_M \\ I_M \end{bmatrix}$.

7. For each ceramic piece in the stack, compute

$$\begin{bmatrix} f_{ri} \\ v_{ri} \\ i_{ci} \end{bmatrix} = [K^{RC}] \begin{bmatrix} f_{\ell i} \\ v_{\ell i} \\ E_C \end{bmatrix} \text{ for the } i^{th} \text{ ceramic piece.}$$

where

$$\begin{bmatrix} f_{ri} \\ v_{ri} \end{bmatrix} \triangleq \begin{bmatrix} f_{\ell, i+1} \\ v_{\ell, i+1} \end{bmatrix}$$

$$\begin{bmatrix} f_{\ell 1} \\ v_{\ell 1} \end{bmatrix} = \begin{bmatrix} F_L \\ V_L \end{bmatrix}.$$

Performance Variable Computation

The following procedure is used to compute the performance variables from a single set of port variables.

All performance variables are searched for both maxima and minima over the specified boundary conditions at each frequency except for the cumulative array performance variables of Step 12.

1. Compute

$$\begin{bmatrix} F_L \\ F_R \end{bmatrix} = \begin{bmatrix} f_{\ell 1} \\ f_{\ell N} \end{bmatrix}$$

$$\begin{bmatrix} V_L \\ V_R \end{bmatrix} = \begin{bmatrix} v_{\ell 1} \\ v_{\ell N} \end{bmatrix}$$

where N is total number of ceramic pieces.

$$2. \quad |T_{33}^i|_{\max} = \text{MAX} \left[|T_{33}^i|_{X=0}, |T_{33}^i|_{X=\ell}, |T_{33}^i|_{X=\chi_{pi}^T} \right]$$

χ_i^T = location of $|T_{33}^i|_{\max}$.

$$3. \quad |S_{33}^i|_{\max} = \text{MAX} \left[|S_{33}^i|_{X=0}, |S_{33}^i|_{X=\ell}, |S_{33}^i|_{X=\chi_{pi}^S} \right]$$

χ_i^S = location of $|S_{33}^i|_{\max}$.

$$4. \quad \text{Re} \left(E_C i_{ci}^* \right) = \text{Re} (E_C) * \text{Re} (i_{ci}) + \text{Im} (E_C) * \text{Im} (i_{ci})$$

$$5. \quad P_{\ell c}^i = \text{Re} \left(E_C i_{ci}^* + f_{\ell i} v_{\ell i}^* - f_{\ell i+1} v_{\ell i+1}^* \right)$$

$$6. \quad \eta_C^i = 100\pi * \left[1 - \frac{P_{\ell c}^i}{\text{Re} \left(E_C i_{ci}^* \right)} \right]$$

7. Search over all ceramic pieces for these ceramic variables.

$$T^M = \text{MAX} \left[|T_{33}^i|_{\text{max}}, i=1, \dots, N \right]$$

$$S^M = \text{MAX} \left[|S_{33}^i|_{\text{max}}, i=1, \dots, N \right]$$

$$P_{\ell c}^M = \text{MAX} \left[p_{\ell c}^i, i=1, \dots, N \right]$$

$$\eta_C^N = \text{MIN} \left[\eta_C^i, i=1, \dots, N \right]$$

and $i_C^M = \text{MAX} [i_{ci}, i=1, \dots, N] .$

8. Compute exterior ceramic stack performance variables.

$$P_{LC} = \text{Re} \left(F_L V_L^* + E_C I_C^* - F_R V_R^* \right)$$

$$P_C = \text{Re} \left(E_C I_C^* \right)$$

$$E = E_C / \ell ; \ell = \text{ceramic piece length}$$

$$Z_C = E_C / I_C$$

$$Y_C = I_C / E_C$$

9. Compute exterior electromechanical performance variables.

$$P_{TL} = -\text{Re} \left(Z_T V_T V_T^* \right)$$

$$P_{rad} = \text{Re} (Z_{rad} V_{rad} V_{rad}^*)$$

10. Compute amplifier boundary condition performance variables.

$$P_M = \text{Re} \left(E_M I_M^* \right)$$

$$Q_M = \text{Im} \left(E_M I_M^* \right)$$

$$|S_M| = \left(P_M^2 + Q_M^2 \right)^{1/2}$$

$$Z_M = E_M / I_M$$

$$Y_M = I_M / E_M$$

11. Compute transducer performance variables.

$$P_{LT} = \text{Re} \left(E_M I_M^* \right) - \text{Re} \left(Z_{rad} V_{rad} V_{rad}^* \right) = P_M - P_{rad}$$

$$\eta_T = 100\% * (1 - P_{LT}/P_M)$$

$$V/E_s = V_{rad}/E_s \quad P_{rad}/|E_s|^2$$

$$V/I_s = V_{rad}/I_s \quad P_{rad}/|I_s|^2$$

12. Cumulative array performance variables are these:

$$P_{MA} = \sum P_M ,$$

$$P_{Arad} = \sum P_{rad} .$$

and $\eta_{TA} = 100\% * (P_{Arad}/P_{MA}) .$

FBAND ZM

Following completion of the frequency sweep, the ratio of ZM MAX/MIN is computed (magnitude and angle) as a function of bandwidth (in Hz) centered about a specified center frequency. The following procedure is used.

1. FBAND $|Z_M|$

This performance parameter is defined in the following manner:

Given: f_0 = center frequency of the operating band.

$f_0 + f_1, f_0 - f_1$ = edge frequencies of band BW_1 .

$|Z_M|_{\max_1}$ = max mag ZM in band BW_1 .

$|Z_M|_{\min_1}$ = min mag ZM in band BW_1 .

Thus, FBAND MAG ZM $\doteq \frac{|Z_M|_{\max_1}}{|Z_M|_{\min_1}}$ at BW = $BW_1 = 2f_1$.

Similarly for BW_i between $f_0 + f_i$ and $f_0 - f_i$, FBAND MAG ZM_i is computed. f_i is stepped from zero to one-half of operating band.

FBAND MAG ZM is to be plotted against BW and not FREQ.

2. FBAND $\angle Z_M$

This performance parameter is defined in similar manner to the foregoing:

Given: $f_0, f_0 + f_1, f_0 - f_1, BW, (\angle Z_M)_{\max_1}, (\angle Z_M)_{\min_1}$ as before.

Thus, FBAND ANG ZM = $(\angle Z_M)_{\max_1} - (\angle Z_M)_{\min_1}$ at BW = BW_1 .

FBAND ANG ZM is plotted against BW also; but the units are "degrees" instead of "unitless ratio" as was the case above.

Ceramic Stress And Strain

The following development provides a detailed documentation of the methods required in D.6.5, steps 2 and 3 to compute stress and strain existent at the interior of a ceramic piece. The symbols used here are defined in Appendix B.

1. The stress in the i^{th} ceramic piece at a distance χ from the left edge of the piece is given by this expression:

$$T_{33}^i = K'_1 + K'_2 \cos k\chi + K'_3 \sin k\chi ,$$

where

$$K'_1 = j \frac{g_{33} i_{ci}}{\omega A s_{33}} ,$$

$$K'_2 = -j\rho c [V_{\ell,i+1} \csc k\ell - V_{\ell i} \cot k\ell] ,$$

$$K'_3 = j\rho c V_{\ell i} ,$$

and $k = \omega/C .$

Assuming that higher order terms may be neglected (i.e., small angle approximation), then

$$T_{33}^i \approx K_0^T + K_1^T \chi + K_2^T \chi^2 ,$$

where

$$K_0^T = K'_1 + K'_2 = K_{0r}^T + j K_{0i}^T ,$$

$$K_1^T = k K'_3 = K_{1r}^T + j K_{1i}^T ,$$

and $K_2^T = -1/2 k^2 K_2' = K_{2r}^T + j K_{2i}^T$.

Differentiating $|T_{33}^i|^2$, equating to zero, and solving for χ we find that

$$\chi = \chi_p^T = -1/2 \frac{M_1^T}{M_2^T},$$

where

$$M_0^T = |K_0^T|^2,$$

$$M_1^T = 2 \left(K_{0r}^T K_{1r}^T + K_{0i}^T K_{1i}^T \right),$$

and $M_2^T = |K_1^T|^2 + 2 \left(K_{0r}^T K_{2r}^T + K_{0i}^T K_{2i}^T \right).$

2. The strain in the i^{th} ceramic piece at distance χ from the left edge of the piece is given by

$$S_{33}^i = (K_2' \cos k\chi + K_3' \sin k\chi) \begin{pmatrix} D \\ s_{33} \end{pmatrix}.$$

By again making the small angle approximation, differentiating $|S_{33}|^2$, and equating to zero, one finds

$$\chi = \chi_p^S = -1/2 \frac{M_1^S}{M_2^S},$$

where

$$M_0^S = |K_0^S|^2,$$

$$M_1^S = 2 \left(K_{0r}^S K_{1r}^S + K_{0i}^S K_{1i}^S \right),$$

$$M_2^S = |K_1^S|^2 + 2 \left(K_{0r}^S K_{2r}^S + K_{0i}^S K_{2i}^S \right),$$

$$K_0^S = K_2' s_{33}^D = K_{0r}^S + j K_{0i}^S,$$

$$K_1^S = K_1^T s_{33}^D = K_{1r}^S + j K_{1i}^S,$$

and $K_2^S = K_2^T s_{33}^D = K_{2r}^S + j K_{2i}^S.$

3. Search procedure for maximum and minimum values of $|T_{33}|$ and $|S_{33}|$. If χ_p^S or χ_p^T falls outside of $[0, \ell]$ inclusive, then discard that particular value. Otherwise, compute

$$|T_{33}|_{X=0} = \left(M_0^T \right)^{1/2}$$

$$|S_{33}|_{X=0} = \left(M_0^S \right)^{1/2}$$

$$|T_{33}|_{X=\ell} = |K_1' + (K_2' \cos k\ell + K_3' \sin k\ell)|$$

$$|S_{33}|_{X=\ell} = |s_{33}^D (K_2' \cos k\ell + K_3' \sin k\ell)|$$

$$|T_{33}|_{X=\chi_p^T} = |K_1' + K_2' \cos \left(k \chi_p^T \right) + K_3' \sin \left(k \chi_p^T \right)| \text{ if } 0 \leq \chi_p^T \leq \ell$$

$$|S_{33}|_{X=\chi_p^T} = |s_{33}^D * \left(K_2' \cos \left(k \chi_p^S \right) + K_3' \sin \left(k \chi_p^S \right) \right)| \text{ if } 0 \leq \chi_p^S \leq \ell.$$

SUMMARY

To summarize the requirements of the search procedure, the user must specify

- (1) the interconnection table that defines the BnS network, which will be reduced to the B4S network,
- (2) the interconnection table that defines TmS network, which will be reduced to the T1S network.
- (3) $[A^{F2S}]$, $[A^{D2S}]$, and $[A^{S2S}]$, which can be done either through interconnection tables or constants, and
- (4) the frequency range and frequency increment to be investigated.

He must also input an array of radiation impedances.

SAMPLE SEARCH ROUTINE

Figure D.3 shows a diagram of the transducer element used in the search example; a listing of the control program and associated printed output is shown in figure D.4. Computer-generated plots from the search procedure are shown in figure D.5.

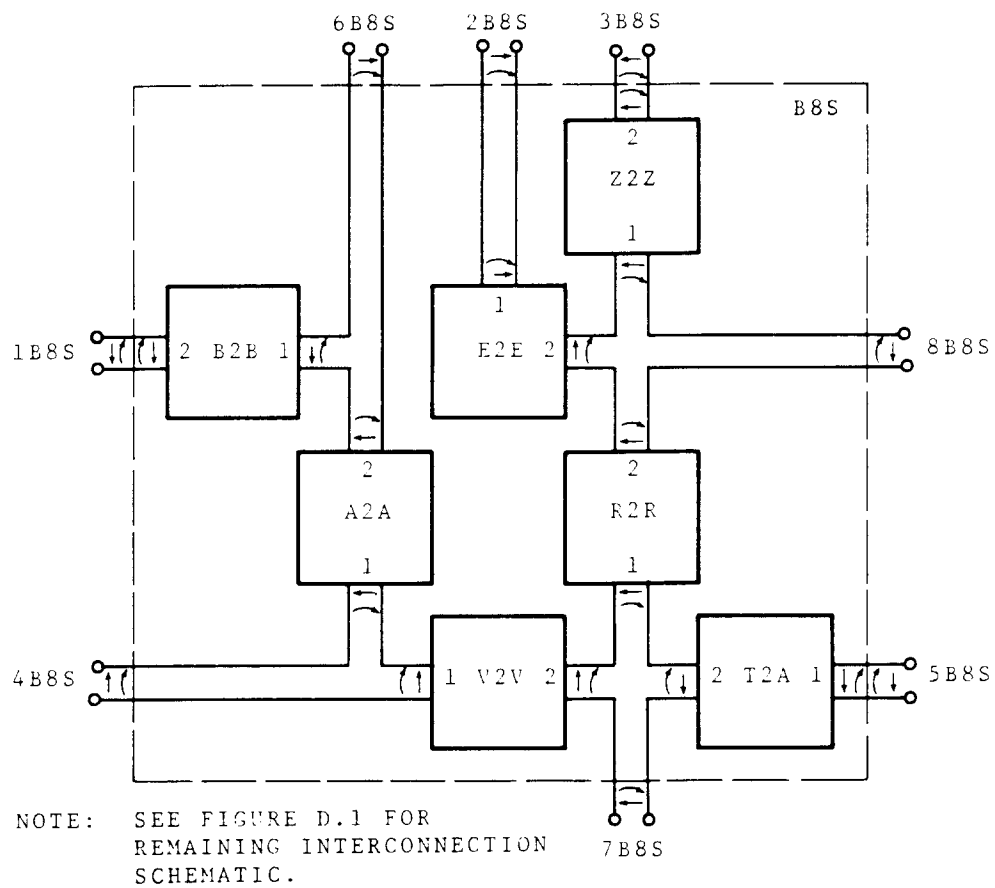
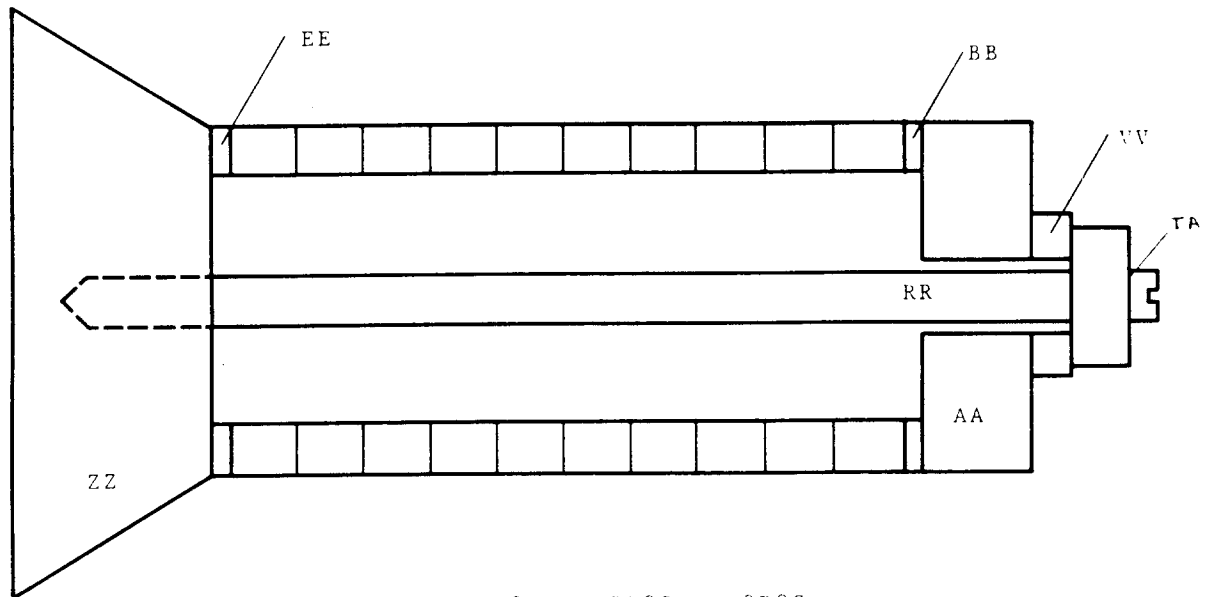


Figure D.3. Transducer Diagram And Interconnection Schematic.

Figure D.4.
Listing and Output of the Control Routine Used
in a Search Procedure

SEADUCER R014 00002 FOR T1-22P APP2 LIA D

WCOPIIN B.,TPEs.
FURPUR 023A-10/20-10:21
112 SYN 112 REL

OFFICE B.

WASG,T 14,T,PROUD2

DATE 102072

PAGE 1

Figure D.4. (Continued).

SEADUCER RUN 80002 FOR TP-22A APPLICATION D
 WFOR,IS COMPL,COMJRL
 FOR 0010-10/20/72-10/23:45 (00)
 MAIN PROGRAM
 STORAGE USED: CODE(1) 000563; DATA(0) 000374; BLANK COMMON(2) 004704

COMMON BLOCKS:

0003 BASIC8 000006
 0004 DATA1 000001

EXTERNAL REFERENCES (BLOCK, NAME)

0005 SETCLY
 0006 PAGE
 0007 STIRLH
 0010 LDPOR
 0011 LD011
 0012 LD012
 0013 LD015
 0014 LD011
 0015 ENDIMS
 0016 ALOCAT
 0017 LOCNAM
 0020 SKPLIN
 0021 LDINTR
 0022 HEAD24
 0023 PREPZV
 0024 SRMIDR
 0025 TIME
 0026 FSRCH
 0027 PRP1BL
 0030 PCTILG
 0031 NINIR\$
 0032 NPRT\$
 0033 NI02\$
 0034 NWDUS\$
 0035 HSTOP\$

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

0000	000023	5F	0002 D 000000 DATA	0003 D 000000 DF	0003 D 000002 DOWEGA
0003	D	000004	DPI	0000 D 000002 DRM	0000 I 000016 IFARAY
0000	I	000006	IF2S	0000 I 000017 INZVUN	0000 I 000010 IS2S
0000	I	000022	IUN1IT	0017 I 000000 LOCNAM	0000 R 000011 RHOCA
0000	R	000012	SCF	0000 R 000014 SCV	
				0000 I 000015 NARRAY	
				0000 D 000000 DFBAND	
				0000 I 000007 IS2S	
				0000 I 000020 IOUTUN	
				0000 I 000013 SCZ	

CONTROL
 CONTROL
 CONTROL

00101	1*	DOUBLE PRECISION DATA
00103	2*	DOUBLE PRECISION DF, DOWEGA, DPI
00104	3*	DOUBLE PRECISION DFBAND, DRM, DOW
00105	4*	COMMON / BASIC 8 / U F, D OMEGA, D PI

Figure D.4. (Continued).

```

SEADUCER RUN 80002 FOR TP-22R APPENDIX A D
00106 5* COMMON / JTA TOT / MX DATA
00107 6* COMMON / JTA TOT / MX DATA
00110 7* MX DATA = 1250
00111 8*
00111 9* CALL SETCLK
00112 10* CALL PAGE
00113 11*
00114 12* CALL STR LIN
00116 13* PRINT 5
00116 14* 5 FORMAT(' SEADUCER RUN 80002 MAY 13,1970 $ (LIKE MOD 7 RUN 70451)')
00116 15* / ' MODEL 451 $' /
00116 16* / ' SLARCH $' /
00116 17* / ' CHARGE TO 1605H501 TRANSMIT TECHNOLOGY.' )
00117 18*
00117 19* CALL LD PORT('S', '1A8S', 2R2B,$' )
00120 20* CALL LD PORT('S', '2R8S', 1E2E,$' )
00121 21* CALL LD PORT('S', '3B8S', 2Z2Z,$' )
00122 22* CALL LD PORT('S', '4R8S', 1A2A, 1V2V,$' )
00123 23* CALL LD PORT('S', '5B8S', 1T2A,$' )
00124 24* CALL LD PORT('S', '6B8S', 1R2B, -+2A2A,$' )
00125 25* CALL LD PORT('S', '7B8S', 1R2H, -+2V2V, -+2I2A,$' )
00126 26* CALL LD PORT('S', '8B8S', 1R2Z, -+2E2E, -+2M2R,$' )
00127 27*
00127 28* CALL LD PORT('S', '1T1S', 1Z1T,$' )
00130 29*
00130 30* CALL LD PORT('S', '1A5S', 3C3S,$' )
00131 31* CALL LD PORT('S', '2A5S', 3R4S,$' )
00132 32* CALL LD PORT('S', '3A5S', 4R4S, 1T1S,$' )
00133 33* CALL LD PORT('S', '4A5S', 1R4S, -+1C3S,$' )
00134 34* CALL LD PORT('S', '5A5S', 2R4S, -+2C3S,$' )
00135 35*
00135 36* CALL LD DT 1
00136 37* / ('A2A1S',7650,, .821425E-2,1.619E-2,0., 4.49072E-2, 5120.,0.,0.)
00136 38* CALL LD DT 1
00137 39* / ('B2B1S',7650,, .544568E-2,0.,10.16E-2, .4310E-2, 5120.,0.,0.)
00137 40* CALL LD DT 1
00137 41* / ('E2E1S',7650,, .544568E-2,0.,10.16E-2, .4310E-2, 5120.,0.,0.)
00140 42* CALL LD DT 1
00140 43* / ('V2V1S',7650,, .0617787E-2,1.618E-2,0., .404812E-2, 5120.,0.,0.)
00141 44* CALL LD DT 1
00141 45* / ('T2A1S',7650,, .0173586E-2,0.,0., 1.5113E-2, 5120.,0.,0.)
00142 46* CALL LD DT 1
00142 47* / ('T2A2S',7650,, .0601720E-2,0.,0., 1.61925E-2, 5120.,0.,0.)
00143 48*
00143 49* CALL LD DT 1
00143 50* / ('R2R1S',7650,, .0173586E-2,0.,0., .65E-2, 5120.,0.,0.)
00144 51* CALL LD DT 1
00144 52* / ('R2R2S',7650,, .0205929E-2,0.,0., 25.7334E-2, 5120.,0.,0.)
00145 53* CALL LD DT 1
00145 54* / ('R2R3S',7650,, .0173586E-2,0.,0., .65E-2, 5120.,0.,0.)
00146 55*
00146 56* CALL LD DT 1
00146 57* / ('Z2Z1S',2635,, .816851E-2,0.,0., .6477E-2, 4950.,0.,0.)
00147 58* CALL LD DT 1
00147 59* / ('Z2Z2S',2635,, .128476E-2,0.,0., 2.62197E-2,0.,0.,0.)
00147 60* / ('Z2Z3S',2635,, .5.8293E-2,4950.,0.,0.)
00150 61* CALL LD DT 1
00150 62* / ('Z2Z3S',2635,, .2.62197E-2,0.,0., .1.61925E-2,4950.,0.,0.)
00151 63*
00151 64* CALL LD DT 5('21T $', 0., 0. )
00151 65*

```

Figure D.4. (Continued).

END OF COMPILATION:

D-36

MPREP TPFs
 FURPUR 023A-10/20-10:25

MPRT, T TPFs.

LM6010314522*TPFs ELEMENT TABLE

U NAME	VERSION	TYPE	DATE	TIME	SEQ #	SIZE-PRG-TEXT	(CYCLE WORD)	PERMOUT	LOCATION
* CONTRL		FOR SYMB	28 MAR 72	23:16:43	1	1	5	0	1792
* CONTRL		RELOCATABLE	28 MAR 72	23:16:45	2	3	5	0	1818
LDPORT		FOR SYMB	28 MAR 72	23:16:45	3	20	5	0	1859
LDPORT		RELOCATABLE	28 MAR 72	23:16:47	4	2	15	0	1879
BLDMTR		FOR SYMB	28 MAR 72	23:16:48	5	19	5	0	1896
BLDMTR		RELOCATABLE	28 MAR 72	23:16:49	6	2	11	0	1915
BLDKKL		FOR SYMB	28 MAR 72	23:16:50	7	26	5	0	1928
BLDKKL		RELOCATABLE	28 MAR 72	23:16:52	8	3	16	0	1954
ROCPRI		FOR SYMB	28 MAR 72	23:16:53	9	39	5	0	1973
ROCPRI		RELOCATABLE	28 MAR 72	23:16:55	10	2	30	0	2012
LFREQ		FOR SYMB	28 MAR 72	23:16:56	11	4	5	0	2044
LFREQ		RELOCATABLE	28 MAR 72	23:16:57	12	2	3	0	2048
UPPTBL		FOR SYMB	28 MAR 72	23:16:58	13	11	5	0	2053
UPPTBL		RELOCATABLE	28 MAR 72	23:17:00	14	2	7	0	2064
ENDLCJ		FOR SYMB	28 MAR 72	23:17:00	15	17	5	0	2073
ENDLCJ		RELOCATABLE	28 MAR 72	23:17:02	16	2	11	0	2090
ALOCAT		FOR SYMB	28 MAR 72	23:17:03	17	8	5	0	2103
ALOCAT		RELOCATABLE	28 MAR 72	23:17:04	18	2	4	0	2111
CHKSTR		FOR SYMB	28 MAR 72	23:17:04	19	3	5	0	2117
CHKSTR		RELOCATABLE	28 MAR 72	23:17:06	20	2	3	0	2120
FINDNET		FOR SYMB	28 MAR 72	23:17:06	21	9	5	0	2125
FINDNET		RELOCATABLE	28 MAR 72	23:17:07	22	1	6	0	2134
ENDNET		FOR SYMB	28 MAR 72	23:17:08	23	4	5	0	2141
LOCMTN		RELOCATABLE	28 MAR 72	23:17:09	24	1	3	0	2145
LOCMTN		FOR SYMB	28 MAR 72	23:17:10	25	3	5	0	2149
LOCNAM		RELOCATABLE	28 MAR 72	23:17:11	26	1	3	0	2152
LOCNAM		FOR SYMB	28 MAR 72	23:17:12	27	4	5	0	2156
FINDMTR		RELOCATABLE	28 MAR 72	23:17:13	28	1	3	0	2160
FINDMTR		FOR SYMB	28 MAR 72	23:17:13	29	3	5	0	2164
FINDNAM		RELOCATABLE	28 MAR 72	23:17:15	30	1	3	0	2167
FINDNAM		FOR SYMB	28 MAR 72	23:17:15	31	3	5	0	2171
CASCDE		RELOCATABLE	28 MAR 72	23:17:17	32	2	6	0	2177
CASCDE		FOR SYMB	28 MAR 72	23:17:18	33	15	5	0	2198
TYPICAL		RELOCATABLE	28 MAR 72	23:17:19	34	2	12	0	2213
TYPICAL		FOR SYMB	28 MAR 72	23:17:20	35	23	5	0	2227
LODT1		RELOCATABLE	28 MAR 72	23:17:22	36	2	17	0	2250
LODT1		FOR SYMB	28 MAR 72	23:17:23	37	13	5	0	2269
TYPE1		RELOCATABLE	28 MAR 72	23:17:24	38	2	9	0	2282
TYPE1		FOR SYMB	28 MAR 72	23:17:25	39	25	5	0	2293
LODT2		RELOCATABLE	28 MAR 72	23:17:27	40	2	19	0	2318
LODT2		FOR SYMB	28 MAR 72	23:17:28	41	19	5	0	2339
TYPE2		RELOCATABLE	28 MAR 72	23:17:30	42	3	13	0	2356
TYPE2		FOR SYMB	28 MAR 72	23:17:30	43	10	5	0	2371

Figure D.4. (Continued).

L00T4	REL-CATABLE	28 MAR 72	23:17:32	44	2	13	5	0	1	2390
L00T5	FOR SYMB	28 MAR 72	23:17:33	45		17	5	0	1	2405
L00T5	REL-CATABLE	28 MAR 72	23:17:34	46	2	11	5	0	1	2422
L00T7	FOR SYMB	28 MAR 72	23:17:36	47		51	5	0	1	2435
L00T7	REL-CATABLE	28 MAR 72	23:17:38	48	2	30	5	0	1	2446
L00T7	FOR SYMB	28 MAR 72	23:17:39	49		29	5	0	1	2466
L00T7	REL-CATABLE	28 MAR 72	23:17:42	50	1	23	5	0	1	2510
L00T8	FOR SYMB	28 MAR 72	23:17:42	51		29	5	0	1	2546
L00T6	REL-CATABLE	28 MAR 72	23:17:44	52	3	20	5	0	1	2570
L00T9	FOR SYMB	28 MAR 72	23:17:46	53		22	5	0	1	2615
L00T9	REL-CATABLE	28 MAR 72	23:17:48	54	3	20	5	0	1	2637
L00T11	FOR SYMB	28 MAR 72	23:17:49	55		26	5	0	1	2660
L00T11	REL-CATABLE	28 MAR 72	23:17:51	56	3	19	5	0	1	2686
L00T11	FOR SYMB	28 MAR 72	23:17:52	57		31	5	0	1	2708
L00T11	REL-CATABLE	28 MAR 72	23:17:55	58	2	29	5	0	1	2739
L1158R	FOR SYMB	28 MAR 72	23:17:55	59		11	5	0	1	2770
L1158R	REL-CATABLE	28 MAR 72	23:17:57	60	2	11	5	0	1	2781
L00T14	FOR SYMB	28 MAR 72	23:17:58	61		25	5	0	1	2794
L00T14	REL-CATABLE	28 MAR 72	23:18:00	62	3	19	5	0	1	2819
L00T14	FOR SYMB	28 MAR 72	23:18:00	63		3	5	0	1	2841
L00T14	REL-CATABLE	28 MAR 72	23:18:01	64	1	2	5	0	1	2844
L00T15	FOR SYMB	28 MAR 72	23:18:03	65		26	5	0	1	2873
L00T15	REL-CATABLE	28 MAR 72	23:18:04	66	3	21	5	0	1	2897
L00T15	FOR SYMB	28 MAR 72	23:18:05	67		3	5	0	1	2900
L00T15	REL-CATABLE	28 MAR 72	23:18:06	68	1	2	5	0	1	2903
L1415S	FOR SYMB	28 MAR 72	23:18:07	69	2	9	5	0	1	2912
L1415S	REL-CATABLE	28 MAR 72	23:18:08	70		19	5	0	1	2924
T1415	FOR SYMB	28 MAR 72	23:18:09	71		20	5	0	1	2943
T1415	REL-CATABLE	28 MAR 72	23:18:11	72	2	19	5	0	1	2965
L00T20	FOR SYMB	28 MAR 72	23:18:12	73		14	5	0	1	2984
L00T20	REL-CATABLE	28 MAR 72	23:18:13	74	2	13	5	0	1	3000
L00T20	FOR SYMB	28 MAR 72	23:18:14	75		10	5	0	1	3013
L00T20	REL-CATABLE	28 MAR 72	23:18:15	76	2	17	5	0	1	3025
L00T21	FOR SYMB	28 MAR 72	23:18:16	77		12	5	0	1	3042
L00T21	REL-CATABLE	28 MAR 72	23:18:18	78	2	5	5	0	1	3056
L00T21	FOR SYMB	28 MAR 72	23:18:19	79		3	5	0	1	3061
L00T22	REL-CATABLE	28 MAR 72	23:18:21	80	1	17	5	0	1	3065
L00T22	FOR SYMB	28 MAR 72	23:18:22	81		12	5	0	1	3082
L00T22	REL-CATABLE	28 MAR 72	23:18:22	82	2	5	5	0	1	3096
L00T22	FOR SYMB	28 MAR 72	23:18:22	83		4	5	0	1	3101
L00T22	REL-CATABLE	28 MAR 72	23:18:24	84	1	17	5	0	1	3106
L00T24	FOR SYMB	28 MAR 72	23:18:25	85		12	5	0	1	3123
L00T24	REL-CATABLE	28 MAR 72	23:18:26	86	2	5	5	0	1	3137
L00T24	FOR SYMB	28 MAR 72	23:18:27	87		4	5	0	1	3142
L00T24	REL-CATABLE	28 MAR 72	23:18:28	88	1	17	5	0	1	3147
L00T25	FOR SYMB	28 MAR 72	23:18:29	89		12	5	0	1	3164
L00T25	REL-CATABLE	28 MAR 72	23:18:30	90	2	5	5	0	1	3178
L00T25	FOR SYMB	28 MAR 72	23:18:31	91		4	5	0	1	3183
L00T25	REL-CATABLE	28 MAR 72	23:18:32	92	1	19	5	0	1	3198
L00T26	FOR SYMB	28 MAR 72	23:18:33	93		14	5	0	1	3207
L00T26	REL-CATABLE	28 MAR 72	23:18:34	94	2	14	5	0	1	3223
L00T26	FOR SYMB	28 MAR 72	23:18:35	95		13	5	0	1	3237
L00T26	REL-CATABLE	28 MAR 72	23:18:37	96	2	12	5	0	1	3252
A1000	FOR SYMB	28 MAR 72	23:18:37	97		6	5	0	1	3264
L00T26	REL-CATABLE	28 MAR 72	23:18:39	98	1	4	5	0	1	3277
L00T26	FOR SYMB	28 MAR 72	23:18:39	99		2	5	0	1	3290
L00T26	REL-CATABLE	28 MAR 72	23:18:40	100	1	4	5	0	1	3290

Figure D.4. (Continued).

LZ2RY2	FOR SYMB	28 MAR 72	23:18:40	101	1	4	5	0	1	3280
LZ2RY2	RELOCATABLE	28 MAR 72	23:18:42	102	1	2	5	0	1	3284
LZ3RY3	FOR SYMB	28 MAR 72	23:18:42	103	1	4	5	0	1	3287
LZ3RY3	RELOCATABLE	28 MAR 72	23:18:43	104	1	2	5	0	1	3291
LY2RY2	FOR SYMB	28 MAR 72	23:18:44	105	1	4	5	0	1	3294
LY2RY2	RELOCATABLE	28 MAR 72	23:18:45	106	1	2	5	0	1	3298
LY3RY3	FOR SYMB	28 MAR 72	23:18:46	107	1	4	5	0	1	3301
LY3RY3	RELOCATABLE	28 MAR 72	23:18:47	108	1	2	5	0	1	3305
LDDRIM	FOR SYMB	28 MAR 72	23:18:47	109	1	5	5	0	1	3308
LDDRIM	RELOCATABLE	28 MAR 72	23:18:48	110	1	4	5	0	1	3313
LDS611	FOR SYMB	28 MAR 72	23:18:49	111	1	7	5	0	1	3318
LDS611	RELOCATABLE	28 MAR 72	23:18:49	112	1	3	5	0	1	3325
LS1415	FOR SYMB	28 MAR 72	23:18:51	113	1	6	5	0	1	3329
LS1415	RELOCATABLE	28 MAR 72	23:18:51	114	1	4	5	0	1	3335
FNDTMS	FOR SYMB	28 MAR 72	23:18:52	115	1	9	5	0	1	3339
FNDTMS	RELOCATABLE	28 MAR 72	23:18:53	116	2	5	5	0	1	3348
FNDTMS	RELOCATABLE	28 MAR 72	23:18:54	117	2	13	5	0	1	3355
FNDTMS	RELOCATABLE	28 MAR 72	23:18:55	118	2	9	5	0	1	3368
MTRMOV	FOR SYMB	28 MAR 72	23:18:56	119	1	4	5	0	1	3379
MTRMOV	RELOCATABLE	28 MAR 72	23:18:57	120	1	3	5	0	1	3383
MTRMOV	RELOCATABLE	28 MAR 72	23:18:58	121	1	12	5	0	1	3387
MTRMOV	RELOCATABLE	28 MAR 72	23:18:59	122	1	11	5	0	1	3399
OLETRC	FOR SYMB	28 MAR 72	23:19:00	123	1	11	5	0	1	3411
OLETRC	RELOCATABLE	28 MAR 72	23:19:01	124	1	7	5	0	1	3422
LDIMTR	FOR SYMB	28 MAR 72	23:19:03	125	1	4	5	0	1	3430
LDIMTR	RELOCATABLE	28 MAR 72	23:19:03	126	1	4	5	0	1	3434
DECOMB	FOR SYMB	28 MAR 72	23:19:04	127	1	4	5	0	1	3439
DECOMB	RELOCATABLE	28 MAR 72	23:19:06	128	2	55	5	0	1	3484
AT0Z	FOR SYMB	28 MAR 72	23:19:10	129	2	10	5	0	1	3541
AT0Z	RELOCATABLE	28 MAR 72	23:19:10	130	2	9	5	0	1	3551
ZTOA	FOR SYMB	28 MAR 72	23:19:12	131	2	10	5	0	1	3562
ZTOA	RELOCATABLE	28 MAR 72	23:19:13	132	2	9	5	0	1	3572
AT0Y	FOR SYMB	28 MAR 72	23:19:15	133	2	9	5	0	1	3583
AT0Y	RELOCATABLE	28 MAR 72	23:19:16	134	2	11	5	0	1	3592
YTOA	FOR SYMB	28 MAR 72	23:19:17	135	2	9	5	0	1	3605
YTOA	RELOCATABLE	28 MAR 72	23:19:18	136	2	11	5	0	1	3614
YTOA	RELOCATABLE	28 MAR 72	23:19:19	137	1	3	5	0	1	3627
DACMUL	FOR SYMB	28 MAR 72	23:19:20	138	1	2	5	0	1	3630
DACMUL	RELOCATABLE	28 MAR 72	23:19:21	139	1	2	5	0	1	3633
DACMUL	RELOCATABLE	28 MAR 72	23:19:22	140	1	2	5	0	1	3636
DACMUL	RELOCATABLE	28 MAR 72	23:19:23	141	1	3	5	0	1	3639
UCMDIV	FOR SYMB	28 MAR 72	23:19:24	142	1	3	5	0	1	3642
UCMDIV	RELOCATABLE	28 MAR 72	23:19:25	143	1	3	5	0	1	3646
DCRCIP	FOR SYMB	28 MAR 72	23:19:25	144	1	3	5	0	1	3649
DCRCIP	RELOCATABLE	28 MAR 72	23:19:27	145	1	2	5	0	1	3652
UCSORT	FOR SYMB	28 MAR 72	23:19:28	146	1	10	5	0	1	3662
UCSORT	RELOCATABLE	28 MAR 72	23:19:29	147	1	9	5	0	1	3672
UCANG1	FOR SYMB	28 MAR 72	23:19:30	148	1	6	5	0	1	3680
UCANG1	RELOCATABLE	28 MAR 72	23:19:31	149	1	5	5	0	1	3687
DCACSH	FOR SYMB	28 MAR 72	23:19:32	150	1	4	5	0	1	3692
DCACSH	RELOCATABLE	28 MAR 72	23:19:33	151	1	4	5	0	1	3697
DSHCH	FOR SYMB	28 MAR 72	23:19:34	152	1	3	5	0	1	3701
DSHCH	RELOCATABLE	28 MAR 72	23:19:35	153	1	5	5	0	1	3705
DCSNCS	FOR SYMB	28 MAR 72	23:19:36	154	1	3	5	0	1	3710
DCSNCS	RELOCATABLE	28 MAR 72	23:19:37	155	1	3	5	0	1	3714
DCSHCH	FOR SYMB	28 MAR 72	23:19:37	156	1	3	5	0	1	3719
DCSHCH	RELOCATABLE	28 MAR 72	23:19:39	157	1	5	5	0	1	3723
PRTMTR	FOR SYMB	28 MAR 72	23:19:40							

Figure D.4. (Continued).

SEAUCER RUN 80002 FOR TP-22A APPENDIX D

PRMTR	RELOCATABLE	28 MAR 72	23:19:41	158	1	5	5	0	1	3728
PRIMBN	FOR SYMB	28 MAR 72	23:19:42	159	1	5	5	0	1	3734
PRIMBN	RELOCATABLE	28 MAR 72	23:19:43	160	1	5	5	0	1	3739
PRMARI	FOR SYMB	28 MAR 72	23:19:43	161	2	6	6	0	1	3745
PRMARI	RELOCATABLE	28 MAR 72	23:19:45	162	2	6	6	0	1	3753
HEAD24	FOR SYMB	28 MAR 72	23:19:45	163	1	6	6	0	1	3761
HEAD24	RELOCATABLE	28 MAR 72	23:19:47	164	1	6	6	0	1	3767
PAGE	FOR SYMB	28 MAR 72	23:19:48	165	1	2	2	0	1	3774
PAGE	RELOCATABLE	28 MAR 72	23:19:49	166	1	2	2	0	1	3775
PAGE	FOR SYMB	28 MAR 72	23:19:49	167	2	2	2	0	1	3778
STRLIN	FOR SYMB	28 MAR 72	23:19:51	168	1	2	2	0	1	3780
STRLIN	RELOCATABLE	28 MAR 72	23:19:51	169	1	2	2	0	1	3783
SKPLIN	FOR SYMB	28 MAR 72	23:19:52	170	1	2	2	0	1	3785
SKPLIN	RELOCATABLE	28 MAR 72	23:19:53	171	1	7	7	0	1	3788
PRPTBL	FOR SYMB	28 MAR 72	23:19:54	172	1	5	5	0	1	3795
PRPTBL	RELOCATABLE	28 MAR 72	23:19:55	173	2	6	6	0	1	3801
PRCTLG	FOR SYMB	28 MAR 72	23:19:55	174	2	5	5	0	1	3807
PRCTLG	RELOCATABLE	28 MAR 72	23:19:57	175	1	22	22	0	1	3814
UNPACK	FOR SYMB	28 MAR 72	23:19:59	176	1	15	15	0	1	3840
UNPACK	RELOCATABLE	28 MAR 72	23:20:00	177	4	3	3	0	1	3863
BLKDTA	FOR SYMB	28 MAR 72	23:20:00	178	1	5	5	0	1	3878
BLKDTA	RELOCATABLE	28 MAR 72	23:20:01	179	1	3	3	0	1	3885
TIME	FOR SYMB	28 MAR 72	23:20:02	180	1	8	8	0	1	3890
TIME	RELOCATABLE	28 MAR 72	23:20:03	181	1	6	6	0	1	3894
Z110Z2	FOR SYMB	28 MAR 72	23:20:04	182	1	9	9	0	1	3902
Z110Z2	RELOCATABLE	28 MAR 72	23:20:05	183	1	7	7	0	1	3909
DCPCT2	FOR SYMB	28 MAR 72	23:20:06	184	1	26	26	0	1	3918
DCPCT2	RELOCATABLE	28 MAR 72	23:20:07	185	2	20	20	0	1	3926
ENDKRC	FOR SYMB	28 MAR 72	23:20:09	186	1	101	101	0	1	3952
ENDKRC	RELOCATABLE	28 MAR 72	23:20:12	187	4	76	76	0	1	3974
SRCHBC	FOR SYMB	28 MAR 72	23:20:16	188	1	3	3	0	1	4075
SRCHBC	RELOCATABLE	28 MAR 72	23:20:16	189	1	2	2	0	1	4155
MINCHK	FOR SYMB	28 MAR 72	23:20:18	190	1	3	3	0	1	4158
MINCHK	RELOCATABLE	28 MAR 72	23:20:18	191	1	2	2	0	1	4161
NAXCHK	FOR SYMB	28 MAR 72	23:20:19	192	1	5	5	0	1	4164
NAXCHK	RELOCATABLE	28 MAR 72	23:20:19	193	2	3	3	0	1	4167
CMPZ5	FOR SYMB	28 MAR 72	23:20:21	194	2	16	16	0	1	4172
CMPZ5	RELOCATABLE	28 MAR 72	23:20:22	195	2	18	18	0	1	4177
PREPZV	FOR SYMB	28 MAR 72	23:20:23	196	2	7	7	0	1	4193
PREPZV	RELOCATABLE	28 MAR 72	23:20:24	197	2	5	5	0	1	4213
FNDZV	FOR SYMB	28 MAR 72	23:20:25	198	2	5	5	0	1	4220
FNDZV	RELOCATABLE	28 MAR 72	23:20:25	199	2	5	5	0	1	4227
LDZVR	FOR SYMB	28 MAR 72	23:20:27	200	2	3	3	0	1	4232
LDZVR	RELOCATABLE	28 MAR 72	23:20:29	201	4	57	57	0	1	4237
SRM10B	FOR SYMB	28 MAR 72	23:20:32	202	4	50	50	0	1	4294
SRM10B	RELOCATABLE	28 MAR 72	23:20:33	203	3	14	14	0	1	4348
LDAM2S	FOR SYMB	28 MAR 72	23:20:34	204	3	15	15	0	1	4367
LDAM2S	RELOCATABLE	28 MAR 72	23:20:36	205	2	14	14	0	1	4385
CMPGAM	FOR SYMB	28 MAR 72	23:20:37	206	2	14	14	0	1	4401
CMPGAM	RELOCATABLE	28 MAR 72	23:20:41	207	5	142	142	0	1	4417
FSRCH	FOR SYMB	28 MAR 72	23:20:48	208	2	123	123	0	1	4559
FSRCH	RELOCATABLE	28 MAR 72	23:20:48	209	2	10	10	0	1	4687
RLIMM6	FOR SYMB	28 MAR 72	23:20:49	210	2	6	6	0	1	4697
RLIMM6	RELOCATABLE	28 MAR 72	23:20:50	211	2	5	5	0	1	4705
FMFN	FOR SYMB	28 MAR 72	23:20:51	212	2	14	14	0	1	4711
FMFN	RELOCATABLE	28 MAR 72	23:20:52	213	1	13	13	0	1	4716
POLE0	FOR SYMB	28 MAR 72	23:20:54	214	1	13	13	0	1	4732
POLE0	RELOCATABLE	28 MAR 72	23:20:54	214	1	13	13	0	1	4732

Figure D.4. (Continued).

PROFIT	FOR SYMB	28 MAR 72	23:20:54	215	0	5	0	1	4746
PROFIT	RELLOCATABLE	28 MAR 72	23:20:55	216	1				4755
FINDPRM	FOR SYMB	28 MAR 72	23:20:57	217	40	5	0	1	4763
FINDPRM	RELLOCATABLE	28 MAR 72	23:21:00	218	4	29			4803
FINDOPP	FOR SYMB	28 MAR 72	23:21:00	219	8	5	0	1	4836
ENDEDOP	RELLOCATABLE	28 MAR 72	23:21:01	220	2	3			4844
LDBCOL	FOR SYMB	28 MAR 72	23:21:02	221	6	5	0	1	4849
LDBCOL	RELLOCATABLE	28 MAR 72	23:21:03	222	2				4855
PRTPRM	FOR SYMB	28 MAR 72	23:21:04	223	14	5	0	1	4861
PRTPRM	RELLOCATABLE	28 MAR 72	23:21:05	224	2	9			4875
CONTRL	FOR SYMB	20 OCT 72	10:25:46	225	29	5	0	1	4886
CONTRL	RELLOCATABLE	20 OCT 72	10:25:52	226	3	36			4915
									4954

ASSEMBLER PROCEDURE TABLE EMPTY

COBOL PROCEDURE TABLE EMPTY

FORTRAN PROCEDURE TABLE EMPTY

COUNTRY POINT TABLE

[illegible]

Figure D.4. (Continued).

SEALUCER RUN 80002 FOR TP-228 APPENDIX D

MAP, X1B SYM, RUN, AB, RUN
MAP 0022-10/20-10:26 - (U)

1. IN CONTRL
2. IN RLKUTA

ADDRESS LIMITS	001000 046223	047000 075010
STARTING ADDRESS	045441	
WORDS DECIMAL	19092 IBANK	11273 DRANK
SEGMENT MAIN		
NSWIC\$/FOR	1 001000 001021	047000 075010
NWFS\$/FOR55	1 001022 001214	
NFCH\$/FOR57	1 001215 001514	2 047000 047017
NCLQ\$/FOR57	1 001515 001653	2 047020 047055
NBE0\$/FOR		2 047056 047102
NBUCV\$/FOR57	1 001654 002007	2 047103 051304
NFTV\$/FOR	1 002010 002032	2 051305 051344
NCNVT\$/FOR57	1 002033 002265	
NRBLK\$/FOR-NUC	1 002266 002313	2 051345 051434
NBSBL\$/FOR	1 002314 002351	
NUPDA\$/FOR	1 002352 002405	
NWBLK\$/FOR57-NUC	1 002406 002530	
NININ\$/FOR55	1 002531 002754	2 051435 051456
NINPT\$/FOR57	1 002755 003634	2 051457 051501
NOTLN\$/FOR55	1 003635 004162	2 051502 051512
NFCHK\$/FOR57	1 004163 004764	2 051513 051654
		4 051655 051726
NIOER\$/FOR57	1 004765 005103	2 051727 052031
NOUITS\$/FOR57-INITV	1 005104 006053	2 052032 052062
NEMTS\$/FOR57	1 006054 006760	2 052063 052101
NTAB\$/FOR		2 052102 052140
ERUS\$/57		
DLUG\$/FOR54	1 006761 007101	2 052141 052245
DEXP\$/FOR54	1 007102 007250	2 052246 052301
DLG10\$/FOR54	1 007251 007261	2 052302 052305
USITCOS\$/FOR57	1 007262 007423	2 052306 052364
NBKSP\$/FOR50	1 007424 010115	2 052365 052415
CATAN\$/FOR54	1 010116 010244	2 052416 052500
NEXP1\$/FOR54	1 010245 010300	0 052501 052501
DSGR1\$/FOR57	1 010301 010350	2 052502 052520
NKWNDS\$/FOR50-NUC	1 010351 010430	2 052521 052532
NIBUF\$/FOR52	1 010431 010472	

Figure D.4. (Continued).

SEAJUCEP RUH BU002 FOR TP-22R APPEALIA D									
SQRTS/FORS5	1	010473	010532	2	052533	052544			
IERKS/FORS7-NUC	1	010533	011074	2	052545	052721			
NSTOPS/NUC	1	011075	011120	2	052722	052730			
IORUFS/FORS1	1	011121	011160						
IERKS/FORS2	1	011161	011243	2	052731	053060			
HOSTMS/FORS7	1	011244	011476	2	053061	053066			
MINTR3/NUC	1	011477	011533	2	053067	053105			
DATE-TIME/NUC-PACK	1	011534	011563	0	053107	053144			
T14155	1	011564	012025	0	053145	053170			
	3	CS1415		2	BLANK3COMMON				
LY3BY3	1	012027	012056	4	CM1415				
CS1415 (COMMON BLOCK)	3	CY3BY3		0	053171	053201			
TP1415	1	012057	012623	2	BLANK3COMMON				
	3	CS1415		0	053202	053205			
	5	CM1415		0	053206	053272			
CM1415 (COMMON BLOCK)	1	012624	012672	2	FLANK3COMMON				
LS1415	3	CM1415		4	HASICH				
UCSHCH	1	012673	012752	6	CZ3BY3				
UCALSH	1	012753	013044	0	053273	053324			
LZ3BY3	1	013045	013074	0	053325	053337			
USMCH	3	CZ3BY3		2	BLANK3COMMON				
LY2LY2	1	013075	013153	4	CEGSFP				
COML26 (COMMON BLOCK)	1	013154	013163	0	053340	053356			
CY3BY3 (COMMON BLOCK)	3	CY2BY2		2	BLANK3COMMON				
TYPE25	1	013164	013531	0	053357	053401			
TYPE24	3	PASICO		0	FLANK3COMMON				
TYPE22	1	013532	013613	2	053402	053412			
TYPE21	3	HASICH		2	BLANK3COMMON				
TYPE20	1	013614	013713	0	053413	053427			
	3	PASICO		0	BLANK3COMMON				
CM15C (COMMON BLOCK)	1	013714	014012	0	053430	053440			
TYPE15	3	PASICO		2	BLANK3COMMON				
TYPE14	1	014013	014073	0	053441	053454			
CZ3BY3 (COMMON BLOCK)	1	014074	014327	0	053455	053476			
TYPE11	3	PASICO		2	053477	053540			
	1	014328		4	BLANK3COMMON				
	3	PASICO		0	CY3BY3				
	1	014354		2	053541	053560			
	3	CM1415		0	BLANK3COMMON				
	1	014355	014401	2	053561	053600			
	3	CM1415		0	BLANK3COMMON				
	1	014402	015416	2	053601	053620			
	3	PASICO		0	BLANK3COMMON				
	1	014403		0	053621	053640			
	3	PASICO		2	BLANK3COMMON				
	1	014404		0	053641	053726			
	3	PASICO		2	BLANK3COMMON				
	1	014405		4	CA2BY2				
	3	PASICO		0	053727	053730			
	1	014406		0	053731	053735			
	3	PASICO		2	BLANK3COMMON				
	1	014407		0	053736	053742			
	3	PASICO		2	FLANK3COMMON				
	1	014408		0	053743	053764			
	3	PASICO		0	053765	054055			
	1	014409		2	FLANK3COMMON				
	3	PASICO		4	CMN11				

Figure D.4. (Continued).

SEAUCLE RUN 80002 FOR TP-228 APPENDIX D

TYPE7	1	015417	016251	0	054056	054150
TYPE2	3	BASIC		2	BLANK\$COMMON	
	1	016252	016607	0	054151	054271
	3	BASIC		2	BLANK\$COMMON	
TYPE1	1	016610	017024	4	CA2BY2	
	3	BASIC		0	054272	054363
FNDLCJ	1	017025	017324	2	BLANK\$COMMON	
	3	PRITL		4	CA2BY2	
FNDJEL	1	017325	017475	0	054364	054412
	3	PRITL		2	BLANK\$COMMON	
DECOND (COMMON BLOCK)				4	CATALG	
VALDET (COMMON BLOCK)				0	054413	054435
DECO48	3	VALDET		2	BLANK\$COMMON	
	5	DCMSL		0	054436	054437
DLTRC	1	021490	021637	0	054440	054443
DCSNCS	1	021640	021722	2	054444	054670
CY2BY2 (COMMON BLOCK)				4	BLANK\$COMMON	
AIQY	1	021723	022230	0	RECORD	
	3	CA2BY2		0	054671	054730
AT02	1	022231	022455	2	BLANK\$COMMON	
	3	CA2BY2		0	054731	054747
MLRMOV	1	022456	022526	4	BLANK\$COMMON	
TYPCAL	1	022525	023027	0	054750	054757
LZ2BY2	3	CATALG		2	BLANK\$COMMON	
	1	023030	023057	0	054760	055007
LA2BY2	3	CZ2BY2		2	BLANK\$COMMON	
	1	023060	023107	0	CY2BY2	
RDCPRT	1	CA2BY2		4	055010	055046
	3	023110	024126	0	BLANK\$COMMON	
BLUKKL	1	024127	024540	2	CZ2BY2	
	3	PRITL		0	055047	055064
FNDXTR	1	024541	024616	2	BLANK\$COMMON	
	3	CATALG		0	055065	055111
PRMARI	1	024617	024724	2	BLANK\$COMMON	
	3	BASIC		0	055112	055122
DCMDIV	1	024725	024772	2	BLANK\$COMMON	
DC59RT	1	024773	025221	0	055123	055133
	3			2	BLANK\$COMMON	
DCRCIP	1	025222	025254	0	BLANK\$COMMON	
	3			2	055134	055255
MINCHK	1	025255	025313	2	BLANK\$COMMON	
	3			0	CMRDC	
	7	CMAGIC		4	055256	055342
				2	BLANK\$COMMON	
				4	CATALG	
				0	PRITL	
				6	RECORD	
				0	055343	055353
				2	BLANK\$COMMON	
				0	055354	055413
				2	BLANK\$COMMON	
				0	055414	055426
				2	BLANK\$COMMON	
				0	055427	055463
				2	BLANK\$COMMON	
				0	055464	055472
				2	BLANK\$COMMON	
				0	055473	055477
				2	BLANK\$COMMON	

Figure D.4. (Continued).

SEAUJER RUN 80002 FOR TH-228 APPENDIX D

MAXCHK	1	025314	025352	0	055500	055504
DCMSOL (COMMON BLOCK)				2	BLANK\$COMMON	
SRCHBC	1	025353	030056	0	055505	056122
	3	DCMSOL		0	056123	056456
	5	COMN11		2	BLANK\$COMMON	
	7	CERINT		4	BASICB	
	9	CMNAEP		6	COMZV	
	11	CZIVT		8	CEREXT	
	13	CSRHCC		10	CMNDUC	
LDZVR	1	030057	030127	12	CSTACK	
	3	LINGZY		0	056457	056476
				2	BLANK\$COMMON	
FNDKRC	1	030130	030664	4	CDTAZV	
	3	BASICB		0	056477	056555
				2	BLANK\$COMMON	
FNDZV	1	030665	030742	4	COMN11	
	3	LINGZY		0	056556	056604
				2	BLANK\$COMMON	
DCANG1	1	030743	031101	4	CDTAZV	
				0	056605	056627
CMPGM	1	031102	031354	2	BLANK\$COMMON	
	3	CMH25		0	056630	056725
	5	GMECIC		2	BLANK\$COMMON	
	7	PRTOFF		4	SRCHSB	
LDAM25	1	031355	031702	6	PRGMTR	
	3	CATALG		0	056726	057011
	5	CRMRCT		2	BLANK\$COMMON	
	7	FLGSRH		4	BASICB	
	9	CELGWZ		6	SRCHSB	
DACMUL	1	031703	031743	8	PRIOFF	
				0	057012	057020
DCMMUL	1	031744	032000	2	BLANK\$COMMON	
				0	057021	057027
MTRNUL	1	032001	032251	2	BLANK\$COMMON	
				0	057030	057125
CASCODE	1	032252	032504	2	BLANK\$COMMON	
	3	CATALG		0	057126	057150
				2	BLANK\$COMMON	
CZ2BY2 (COMMON BLOCK)				4	CFLGAZ	
CA2BY2 (COMMON BLOCK)	1	032505	032731	0	057151	057160
ZTOA	3	CA2BY2		0	057161	057170
				2	BLANK\$COMMON	
BLDMTR	1	032732	033210	4	CZ2BY2	
	3	PRTHL		0	057230	057261
	5	CPRIH		2	BLANK\$COMMON	
	7	CMAGIC		4	CATALG	
				9	CMNRDC	
CMPZS	1	033211	033243	8	CBLD	
	3	BASICB		0	057262	057301
				2	BLANK\$COMMON	
LOFREQ	1	033244	033274	4	CMH25	
	3	BASICB		0	057302	057315
				2	BLANK\$COMMON	
LUMTR	1	033275	033351	4	PRTOFF	
	3	CATALG		0	057316	057327
				2	BLANK\$COMMON	

Figure D.4. (Continued).

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SLAUGER RUN 80042 FOR T1-220 APPL 01A D
PRITBL (COMMON BLOCK)
BLANK$COMMON (COMMON BLOCK)
CONTRL          1 045441 046223
                3 BASICO
                5 PRITBL
                5 DTASLC
                7 PRITBL
                9 CPTMLO
                14 CBLU
                15 CPTMLO
                15 CSTACK
                17 CPTMLO
                19 PRG100
                21 CMWFLU
                22
                0 065374 067510
                2 067511 074414
                4 074415 075010
                4 BLANK$COMMON
                2 DTATOT
                2 BLANK$COMMON
                4 CATALG
                6 DTATOT
                8 NASICR
                10 CFLGAZ
                12 CMAGIC
                14 CMPOUC
                16 CPROFT
                18 CSOFT3
                20 CFMMP3
                22 CSRILC

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SYSTRIBS. LEVEL 57
END OF COLLECTION - TIME 5.520 SECONDS

Figure D.4. (Continued).

SEQUENCE RUN: 60002 FOR TP-228 APPEL JIA D
NEXT AHSRUN

Figure D.4. (Continued).

 SEADUCER RUN 80002 MAY 13, 1970 \$ (LIKE MOD 7 RUN 70451)
 MODEL 451 \$
 SEARCH \$
 CHARGE TO 16054501 TRANSMIT TECHNOLOGY

***** HS 8 NETWORK TABLE

S 1B8S, 2D2B, \$
 S 2B8S, 1E2E, \$
 S 3B8S, 2Z2Z, \$
 S 4B8S, 1A2A, 1V2V, \$
 S 5B8S, 1T2A, \$
 S 6B8S, 1B2B, -+2A2A, \$
 S 7B8S, 1K2R, -+2V2V, -+2I2A, \$
 S 8B8S, 1Z2Z, -+2E2E, -+2R2R, \$

***** IS 1 NETWORK TABLE

S 1I1S, 1Z1T, \$

***** AS 5 NETWORK TABLE

S 1A5S, 3C3S, \$
 S 2A5S, 3D4S, \$
 S 3A5S, 4B4S, 1T1S, \$
 S 4A5S, 1M4S, -+1C3S, \$
 S 5A5S, 2B4S, -+2C3S, \$

TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
A2A1\$	7858.00	.821425-02	.016180	.100980	.044907	
	C REAL	C IMAG	C MULTI			
	5120.00	.000000	.000000			2.89865

TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
B2B1\$	7858.00	.544568-02	.058214	.101600	.004318	
	C REAL	C IMAG	C MULTI			
	5120.00	.000000	.000000			.18478

TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
E2E1\$	7858.00	.544568-02	.058214	.101600	.004318	
	C REAL	C IMAG	C MULTI			
	5120.00	.000000	.000000			.18478

TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
V2V1\$	7858.00	.617787-03	.016180	.022908	.004048	
	C REAL	C IMAG	C MULTI			
	5120.00	.000000	.000000			.01965

Figure D.4. (Continued).

TYPE 1	RHO	AREA	IO	OD	LENGTH	
T2A1\$	7858.00	.173586-03	.000000	.000000	.015113	MASS
	C REAL	C IMAG	C MULT			.02061
	5120.00	.000000				
TYPE 1	RHO	AREA	IO	OD	LENGTH	
T2A2\$	7858.00	.001728-03	.000000	.000000	.016193	MASS
	C REAL	C IMAG	C MULT			.07656
	5120.00	.000000				
TYPE 1	RHO	AREA	IO	OD	LENGTH	
R2R1\$	7858.00	.173586-03	.000000	.000000	.008500	MASS
	C REAL	C IMAG	C MULT			.01159
	5120.00	.000000				
TYPE 1	RHO	AREA	IO	OD	LENGTH	
R2R2\$	7858.00	.205929-03	.000000	.000000	.257334	MASS
	C REAL	C IMAG	C MULT			.41642
	5120.00	.000000				
TYPE 1	RHO	AREA	IO	OD	LENGTH	
R2R3\$	7858.00	.173586-03	.000000	.000000	.008500	MASS
	C REAL	C IMAG	C MULT			.01159
	5120.00	.000000				
TYPE 1	RHO	AREA	IO	OD	LENGTH	
Z2Z1\$	2635.00	.816851-02	.000000	.000000	.006477	MASS
	C REAL	C IMAG	C MULT			.13941
	4950.00	.000000				
TYPE 2	RHO	A1	IU1	OD1		
Z2Z2\$	2635.00	.128476-01	.000000	.000000		
		AP	ID2	OD2	LENGTH	
	C REAL	C IMAG	C MULT			.058293
	4950.00	.000000				MASS
						2.94000
TYPE 1	RHO	AREA	IO	OD	LENGTH	
Z2Z3\$	2635.00	.262197-01	.000000	.000000	.016193	MASS
	C REAL	C IMAG	C MULT			1.11872
	4950.00	.000000				
TYPE 5	REAL					
Z11 \$		IMAG				
1	1	.0000000000		.0000000000		
TYPE 11	RHO	AREA	IO	OD	LENGTH	
C55\$	7793.90	.260172-02	.083038	.101600	.021674	MASS
	C REAL	C IMAG	C MULT			4.54703
	3545.72	.430982+01	.121550-02		10	
	REAL		IMAG		MULT	

Figure D.4. (Continued).

*** F =	3400.00000	***	PLOT LABELS	LNLI	LNLI?
.294465+05	MAG(ZELC + ZSELF)				101
.501931+07	MAG(ZIC + ZSELF)				102
.895416+02	APG(ZELC + ZSELF)				103
.777489+02	APG(ZIC + ZSELF)				104
.417669+01	MAX/MIN OF MAG(VRAU/ES)				105
.101010+01	MAX/MIN OF MAG(VRAU/IS)				106
.282558+02	MAX-MIN OF ANG(VRAU/ES)				107
.615788+00	MAX-MIN OF ANG(VRAU/IS)				108
.578707+04	MIN MAG VRAU/ES	(ZR,VR)	3		109
.158174-03	MAX MAG VRAU/ES	(ZR,VR)	9		110
.262761+00	MIN MAG VRAU/IS	(ZR,VR)	4		111
.265414+00	MAX MAG VRAU/IS	(ZR,VR)	4		112
.425216+02	MIN ANG VRAU/ES	(ZR,VR)	8		113
.142658+02	MAX ANG VRAU/ES	(ZR,VR)	2		114
.126607+00	MIN ANG VRAU/IS	(ZR,VR)	6		115
.942396+00	MAX ANG VRAU/IS	(ZR,VR)	3		116
.125849-03	MIN POWER RAD / ES SW	(ZR,VR)	9		117
.490381-03	MAX POWER RAD / ES SW	(ZR,VR)	4		118
.131289+04	MIN POWER RAD / IS SW	(ZR,VR)	9		119
.661180+04	MAX POWER RAD / IS SW	(ZR,VR)	3		120
.375505+01	MAG(1./A11(S2R))				121
.493008-01	ANG(1./A11(S2R))				122
.132901+07	MAG(1./A21(S2R))				123
.776305+02	ANG(1./A21(S2R))				124
.196454+03	MAX MAG(E*I) AMPLIF OUT	(ZR,VR)	1		131
.98.4967	MIN EFF (TURNED DUCES)				132
.180168+03	MAX AMPLIF OUTPUT POWER	(ZR,VR)	1		133
.115797+03	AVG AMPLIF OUTPUT POWER				134
.109056+04	MAX MAG EM (AMPLIF OUT)	(ZR,VR)	3		135
.181151+00	MAX MAG IM (AMPLIF OUT)	(ZR,VR)	7		136
.167755+04	MIN MAG ZM (AMPLIF LOAD)	(ZR,VR)	9		137
.696511+04	MAX MAG ZM (AMPLIF LOAD)	(ZR,VR)	3		138
.151435+02	MIN ANG ZM (AMPLIF LOAD)	(ZR,VR)	2		139
.429544+02	MAX ANG ZM (AMPLIF LOAD)	(ZR,VR)	8		140
.115797+04	TOT ARRAY AMPLIF PWR OUT				141
.03.9074	TOT ARRAY EFF EX AMPLIF				142
.11607+03	MAX IMAG E*I AMPLIF OUT	(ZR,VR)	7		143
.605143+02	AVG IMAG E*I AMPLIF OUT				144
.127803+01	MAX CER FIELD VOLTS/IN	(ZR,VR)	3		161
.135452+01	MAX CERAM POWER LOSS	(ZR,VR)	7		162
.211436+00	MAX MAG IC (INTO CERAM)	(ZR,VR)	1		163
.109056+04	MAX MAG EC (INTO CERAM)	(ZR,VR)	3		164
.101512+01	AVG CERAM POWER LOSS				165
.624972-01	MAX MAG TAIL VELOCITY	(ZR,VR)	7		171
.144731+01	MAX/MIN MAG(TAIL VEL)				172
.000000	MAX TAIL OUTPUT POWER	(ZR,VR)	1		173
.000000	AVG TAIL OUTPUT POWER				174
.186821+03	MAX RADIATED POWER	(ZR,VR)	1		181
.114782+03	AVG RADIATED POWER				182
.114782+04	TOTAL ARRAY POWER RAD				183

Figure D.4. (Continued).

SEQUENCER RUN 80002 FOR TP-22R APPENDIX D				DATE 102072	PAGE 25
.315050+03	MAX CERAM STRESS (PSI)	(ZR+VR)	7	PIECE 7.65	201
.250260-04	MAX CERAM STRAIN	(ZR+VR)	7	PIECE 7.32	202
.155814+00	MAX CER PIECE PWR LOSS	(ZR+VR)	7	PIECE 7	203
.235870-01	MAX CERAM PIECE CURRENT	(ZR+VR)	1	PIECE 1	204
98.3575	MIN CERAM PIECE EFF	(ZR+VR)	6	PIECE 6	205
LAST TIME INTERVAL = 1.183 SEC			TOTAL RUN TIME = 2.241 SEC		

Figure D.4. (Continued).

SEAJUGER RUIN 60002 FOR TP-22R APPL LIA D

PLOT LABELS	LBL1	LBL2
* * * * F = 3420.00000 * * * *		
.314710+05 MAG(ZEL + ZSELF)		101
.229025+08 MAG(ZIC + ZSELF)		102
.895777+02 MAG(ZEL + ZSELF)		103
.254120+00 MAG(ZIC + ZSELF)		104
.398667+01 MAX/MIN OF MAG(VRAU/ES)		105
.100333+01 MAX/MIN OF MAG(VRAU/IS)		106
.281648+02 MAX-MIN OF MAG(VRAU/ES)		107
.970130-01 MAX-MIN OF MAG(VRAU/IS)		108
.374656-04 MIN MAG VRAU/ES	(ZK+VR)	109
.149363-03 MAX MAG VRAU/ES	(ZK+VR)	110
.266521+00 MIN MAG VRAU/IS	(ZK+VR)	111
.267410+00 MAX MAG VRAU/IS	(ZK+VR)	112
-.436594+02 MIN MAG VRAU/ES	(ZK+VR)	113
-.154946+02 MAX MAG VRAU/ES	(ZK+VR)	114
-.161912+00 MIN MAG VRAU/IS	(ZK+VR)	115
-.848966-01 MAX MAG VRAU/IS	(ZK+VR)	116
.121565-03 MIN POWER RAD / ES ES	(ZK+VR)	117
.443795-03 MAX POWER RAD / ES ES	(ZK+VR)	118
.133359+04 MIN POWER RAD / IS ES	(ZK+VR)	119
.675022+04 MAX POWER RAD / IS ES	(ZK+VR)	120
.373649+01 MAG(1./A11(S2R))		121
.463325-01 MAG(1./A11(S2R))		122
.612933+07 MAG(1./A21(S2R))		123
.127060+00 MAG(1./A21(S2R))		124
.196858+03 MAX MAG(E*I) AMPLIF CUI	(ZK+VR)	131
.98.4044 MIN EFF (TUNED DUCED)	(ZK+VR)	132
.108165+03 MAX AMPLIF OUTPUT POWER	(ZK+VR)	133
.115812+03 AVG AMPLIF OUTPUT POWER	(ZK+VR)	134
.110236+04 MAX MAG EM (AMPLIF OUT)	(ZK+VR)	135
.178724+00 MAX MAG IM (AMPLIF OUT)	(ZK+VR)	136
.179033+04 MIN MAG ZM AMPLIF LOAD	(ZK+VR)	137
.711375+04 MAX MAG ZM AMPLIF LOAD	(ZK+VR)	138
.153857+02 MIN MAG ZM AMPLIF LOAD	(ZK+VR)	139
.434816+02 MAX MAG ZM AMPLIF LOAD	(ZK+VR)	140
.115812+04 TOT ARRAY AMPLIF PWR CUI		141
.98.9751 TOT ARRAY EFF EX AMPLIF		142
.113341+03 MAX IMAG E*I AMPLIF CUI	(ZK+VR)	143
.625829+02 AVG IMAG E*I AMPLIF CUI		144
.129185+01 MAX CER FIELD VOLTS/IN	(ZK+VR)	161
.137841+01 MAX CERAM POWER LOSS	(ZK+VR)	162
.210046+00 MAX MAG IC (INTO CERAM)	(ZK+VR)	163
.110236+04 MAX MAG EC (INTO CERAM)	(ZK+VR)	164
.102929+01 AVG CERAM POWER LOSS		165
.623443-01 MAX MAG TAIL VELOCITY	(ZK+VR)	171
.144393+01 MAX/MIN (MAG(TAIL V.L.))	(ZK+VR)	172
.000000 MAX TAIL OUTPUT POWER	(ZK+VR)	173
.000000 AVG TAIL OUTPUT POWER	(ZK+VR)	174
.166821+03 MAX RADIATED POWER	(ZK+VR)	181
.114782+03 AVG RADIATED POWER		182
.114782+04 TOTAL ARRAY POWER RAD		183

Figure D.4. (Continued).

.316616+03	MAX CERAM STRESS (P.1)	(ZIR-VR)	7	PIECE 7.65	201
.248700-04	MAX CERAM STRAIN	(ZIR-VR)	7	PIECE 7.32	202
.158316+00	MAX CER PIECE PWR LOSS	(ZIR-VR)	7	PIECE 7	203
.236525-01	MAX CERAM PIECE CURRENT	(ZIR-VR)	1	PIECE 1	204
98.3450	MIN CERAM PIECE EFF	(ZIR-VR)	6	PIECE 6	205
LAST TIME INTERVAL = 1.123 SEC					
TOTAL RUN TIME = 3.364 SEC					

Figure D.4. (Continued).

SEAUCER RUN 80002 FOR TP-22R APPENDIX 2

PLOT LABELS			LBL1	LBL2
* * * * F = 3440.00000 * * * *				
.334666+05 MAG(ZEC + ZSELF)				101
.490865+07 MAG(ZIC + ZSELF)				102
.896088+02 ANG(ZEC + ZSELF)				103
-.771927+02 ANG(ZIC + ZSELF)				104
.380552+01 MAX/MIN OF MAG(VRAD/ES)				105
.100707+01 MAX/MIN OF MAG(VRAU/IS)				106
.280486+02 MAX-MIN OF ANG(VRAD/ES)				107
.898832+00 MAX-MIN OF ANG(VRAU/IS)				108
.370622-04 MIN MAG VRAD/ES	(ZR,VR)	3		109
.141041-03 MAX MAG VRAD/ES	(ZR,VR)	6		110
.269216+00 MIN MAG VRAD/IS	(ZR,VR)	2		111
.271121+00 MAX MAG VRAD/IS	(ZR,VR)	8		112
-.447403+02 MIN ANG VRAD/ES	(ZR,VR)	8		113
-.166917+02 MAX ANG VRAD/ES	(ZR,VR)	2		114
-.120744+01 MIN ANG VRAD/IS	(ZR,VR)	3		115
-.308510+00 MAX ANG VRAD/IS	(ZR,VR)	6		116
.117512-03 MIN POWER RAD / ES SG	(ZR,VR)	9		117
.400615-03 MAX POWER RAD / ES SG	(ZR,VR)	4		118
.135594+04 MIN POWER RAD / IS SG	(ZR,VR)	6		119
.689627+04 MAX POWER RAD / IS SG	(ZR,VR)	3		120
.371871+01 MAG(1./A11(S2R))				121
.473879-01 AUG(1./A11(S2R))				122
.132875+07 MAG(1./A21(S2R))				123
-.773287+02 ANG(1./A21(S2R))				124
.197215+03 MAX MAG(E*1) AMPLIF CUI	(ZR,VR)	1		131
98.4702 MIN EFF (TURNED DUCED)	(ZR,VR)	6		132
.188203+03 MAX AMPLIF OUTPUT POWER	(ZR,VR)	1		133
.115827+03 AVG AMPLIF OUTPUT POWER				134
.114533+04 MAX MAG EM (AMPLIF OUT)	(ZR,VR)	1		135
.176948+00 MAX MAG IM (AMPLIF OUT)	(ZR,VR)	1		136
.191194+04 MIN MAG ZM (AMPLIF LOAU)	(ZR,VR)	6		137
.726856+04 MAX MAG ZM (AMPLIF LOAU)	(ZR,VR)	3		138
.155772+02 MIN ANG ZM (AMPLIF LOAU)	(ZR,VR)	2		139
.439334+02 MAX ANG ZM (AMPLIF LOAU)	(ZR,VR)	8		140
.115827+04 TOT ARRAY AMPLIF PWR CUI				141
98.9618 TOT ARRAY EFF EX AMPLIF				142
.114802+03 MAX IMAG E*1 AMPLIF CUI	(ZR,VR)	7		143
.644746+02 AVG IMAG E*1 AMPLIF CUI				144
.130612+01 MAX CER FIELD VOLTS/MIL	(ZR,VR)	1		161
.140329+01 MAX CERAM POWER LOSS	(ZR,VR)	7		162
.208604+00 MAX MAG IC (INTO CERAM)	(ZR,VR)	1		163
.111453+04 MAX MAG EC (INTO CERAM)	(ZR,VR)	1		164
.104426+01 AVG CERAM POWER LOSS				165
.621922-01 MAX MAG TAIL VELOCITY	(ZR,VR)	7		171
.144058+01 MAX/MIN (MAG(TAIL VEL))				172
.000000 MAX TAIL OUTPUT POWER	(ZR,VR)	1		173
.000000 AVG TAIL OUTPUT POWER				174
.186621+03 MAX RADIAIED POWER	(ZR,VR)	1		181
.114762+03 AVG RADIAIED POWER				182
.114782+04 TOTAL ARRAY POWER RAD				183

Figure D.4. (Continued).

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SEQUENCER RUN 80012 FOR TP-22P APPENDIX D
.318177+03 MAX CERAM STRESS (PL1) (ZK,VR) 7 PIECE 7.65 201
.247160+04 MAX CERAM STRAIN (ZK,VR) 7 PIECE 7.32 202
.160918+00 MAX CER PIECE PWR LOSS (ZK,VR) 7 PIECE 7 203
.237358+01 MAX CERAM PIECE CUR LNI (ZK,VR) 1 PIECE 1 204
98.3506 MTH CERAM PIECE EFF (ZK,VR) 6 PIECE 6 205
LAST TIME INTERVAL = 1.000 SEC TOTAL RUN TIME = 4.368 SEC

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Figure D.4. (Continued).

* * * * F =	3460.00000	* * * *	PLOT LABELS	LBL1	LBL2
.354350+05 MAG(ZEC + ZSELF)					101
.246908+07 MAG(ZIC + ZSELF)					102
.896359+02 ANG(ZEC + ZSELF)					103
-.833680+02 ANG(ZIC + ZSELF)					104
.363539+01 MAX/MIN OF MAG(VRAD/ES)					105
.101327+01 MAX/MIN OF MAG(VRAD/IS)					106
.292923+02 MAX-MIN OF ANG(VRAD/ES)					107
.178603+01 MAX-MIN OF ANG(VRAD/IS)					108
.366611-04 MIN MAG VRAD/FS			(ZR+VR)	3	109
.133277-03 MAX MAG VRAD/ES			(ZR+VR)	3	110
.271896+00 MIN MAG VRAD/IS			(ZR+VR)	4	111
.275505+00 MAX MAG VRAD/IS			(ZR+VR)	4	112
-.471503+02 MIN ANG VRAD/FS			(ZR+VR)	6	113
-.178580+02 MAX ANG VRAD/ES			(ZR+VR)	2	114
-.231801+01 MIN ANG VRAD/IS			(ZR+VR)	3	115
-.531985+00 MAX ANG VRAD/IS			(ZR+VR)	3	116
.113623-03 MIN POWER RAD / ES SW			(ZR+VR)	9	117
.361356-03 MAX POWER RAD / ES SW			(ZR+VR)	9	118
.138064+04 MIN POWER RAD / IS SW			(ZR+VR)	4	119
.705013+04 MAX POWER RAD / IS SW			(ZR+VR)	6	120
.370166+01 MAG(1./A11(SPR))			(ZR+VR)	3	121
.484657-01 ANG(1./A11(S2R))					122
.676524+06 MAG(1./A21(S2R))					123
-.835132+02 ANG(1./A21(S2R))					124
.197519+03 MAX MAG(E*1) AMPLIF OUT			(ZR+VP)	1	131
.98.4541 MIN EFF (TUNED DUCEN)			(ZR+VR)	6	132
.188222+03 MAX AMPLIF OUTPUT POWER			(ZR+VR)	1	133
.115842+03 AVG AMPLIF OUTPUT POWER			(ZR+VR)	1	134
.112792+04 MAX MAG EM (AMPLIF OUT)			(ZR+VR)	1	135
.175289+00 MAX MAG IM (AMPLIF OUT)			(ZR+VR)	4	136
.204165+04 MIN MAG ZM AMPLIF LOAD			(ZR+VR)	6	137
.742959+04 MAX MAG ZM AMPLIF LOAD			(ZR+VR)	3	138
.157173+02 MIN ANG ZM AMPLIF LOAD			(ZR+VR)	2	139
.466163+02 MAX ANG ZM AMPLIF LOAD			(ZR+VR)	6	140
.115842+04 TOT ARRAY AMPLF PWR OUT					141
.98.9476 TOT ARRAY EFF EX AMPLIF					142
.115985+03 MAX IMAG E*1 AMPLIF OUT			(ZR+VR)	7	143
.661851+02 AVG IMAG E*1 AMPLIF OUT					144
.132101+01 MAX CER FIELD VOLTS/IN			(ZR+VR)	1	161
.142916+01 MAX CERAM POWER LOSS			(ZR+VR)	7	162
.207714+00 MAX MAG IC (INTO CERA)			(ZR+VR)	1	163
.112792+04 MAX MAG EC (INTO CERA)			(ZR+VR)	1	164
.106000+01 AVG CERAM POWER LOSS					165
.620416-01 MAX MAG TAIL VELOCITY			(ZR+VR)	7	171
.143727+01 MAX/MIN (MAG(TAIL V.L.))					172
.000000 MAX TAIL OUTPUT POWER			(ZR+VR)	1	173
.000000 AVG TAIL OUTPUT POWER			(ZR+VR)	1	174
.186821+03 MAX RADIATED POWER			(ZR+VR)	1	181
.114702+03 AVG RADIATED POWER					182
.114702+04 TOTAL ARRAY POWER RAD					183

Figure D.4. (Continued).

SEALUCER RUN 86002 FOR TP-22P APPLICIX D
 .319733+03 MAX CERAM STRESS (P01) (ZRVVR) 7 PIECE 7.64 201
 .245641-04 MAX CERAM STRAIN (ZRVVR) 7 PIECE 7.30 202
 .163619+00 MAX CER PIECE PWR LOSS (ZRVVR) 7 PIECE 7 203
 .230368-01 MAX CERAM PIECE CUR LMI (ZRVVR) 1 PIECE 1 204
 98.3117 MIN CERAM PIECE EFF (ZRVVR) 6 PIECE 7 205
 LAST TIME INTERVAL = 1.062 SEC
 TOTAL RUN TIME = 5.430 SEC

DATE 102072

PAGE

1

Figure D.4. (Continued).

* * * * F =	3450.00000	* * * *	PL01 LABELS	LRL1	LRL2
.573773*05	MAG(ZEC + ZSELF)				101
.163093*07	MAG(ZIC + ZSELF)				102
.896596*02	ANG(ZEC + ZSELF)				103
.854613*02	ANG(ZIC + ZSELF)				104
.348479*01	MAX/MIN OF MAG(VRAD/ES)				105
.102085*01	MAX/MIN OF MAG(VRAJ/IS)				106
.307498*02	MAX-MIN OF ANG(VRAD/ES)				107
.269472*01	MAX-MIN OF ANG(VRAJ/IS)				108
.562630*04	MTJ MAG VKAL/FS	(ZRVVR)	3		109
.126369*03	MAX MAG VKAD/ES	(ZRVVR)	4		110
.274439*00	MIN MAG VKAD/IS	(ZRVVR)	4		111
.200161*00	MAX MAG VKAD/IS	(ZRVVR)	8		112
.497440*02	MIN ANG VKAD/ES	(ZRVVR)	6		113
.189941*02	MAX ANG VKAD/ES	(ZRVVR)	2		114
.345449*01	MIN ANG VKAD/IS	(ZRVVR)	3		115
.753779*00	MAX ANG VKAD/IS	(ZRVVR)	6		116
.109910*03	MIN POWER RAD / ES SW	(ZRVVR)	9		117
.326116*03	MAX POWER RAD / ES SW	(ZRVVR)	4		118
.140761*04	MIN POWER RAD / IS SW	(ZRVVR)	6		119
.721199*04	MAX POWER RAD / IS SW	(ZRVVR)	3		120
.368531*01	MAG(1./A11(S2R))				121
.455650*01	ANG(1./A11(S2R))				122
.452656*06	MAG(1./A21(S2R))				123
.856161*02	ANG(1./A21(S2R))				124
.197768*03	MAX MAG(E*1) AMPLIF GUI	(ZRVVR)	1		131
.98.4361	MTJ EFF (TUNED DUCCL)	(ZRVVR)	6		132
.188241*03	MAX AMPLIF OUTPUT POWER	(ZRVVR)	1		133
.115859*03	AVG AMPLIF OUTPUT POWER				134
.114160*04	MAX MAG EM (AMPLIF OUT)	(ZRVVR)	1		135
.173664*00	MAX MAG IM (AMPLIF OUT)	(ZRVVR)	4		136
.217173*04	MIN MAG ZM AMPLIF LOAD	(ZRVVR)	4		137
.759689*04	MAX MAG ZM AMPLIF LOAD	(ZRVVR)	3		138
.158051*02	MIN ANG ZM AMPLIF LOAD	(ZRVVR)	2		139
.469842*02	MAX ANG ZM AMPLIF LOAD	(ZRVVR)	6		140
.115859*04	TOT ARRAY AMPLF PWK GUI				141
.98.9325	TOT ARRAY EFF EX AMPLIF				142
.116887*03	MAX IMAG E*1 AMPLIF GUI	(ZRVVR)	7		143
.677104*02	AVG IMAG E*1 AMPLIF GUI				144
.133784*01	MAX CER FIELD VOLTS/IN	(ZRVVR)	1		161
.145600*01	MAX CERAM POWER LOSS	(ZRVVR)	7		162
.206781*00	MAX MAG IC (INTO CERAM)	(ZRVVR)	1		163
.114160*04	MAX MAG EC (INTO CERAM)	(ZRVVR)	1		164
.107653*01	AVG CERAM POWER LOSS				165
.618905*01	MAX MAG TAIL VELOCITY	(ZRVVR)	7		171
.143399*01	MAX/MIN (MAG(TAIL VLL))				172
.000000	MAX TAIL OUTPUT POWER	(ZRVVR)	1		173
.000000	AVG TAIL OUTPUT POWER				174
.166821*03	MAX RADIATED POWER	(ZRVVR)	1		181
.114782*03	AVG RADIATED POWER				182
.114782*04	TOTAL ARRAY POWER RAD				183

Figure D.4. (Continued).

.321285+03	MAX CERAM STRESS (PSI)	(ZR,VR)	7	PIECE 7.64	201
.244143-04	MAX CERAM STRAIN	(ZR,VR)	7	PIECE 7.33	202
.166419+00	MAX CER PIECE PWR LOSS	(ZR,VR)	7	PIECE 7	203
.239555-01	MAX CERAM PIECE CURRENT	(ZR,VR)	1	PIECE 1	204
98.2906	MIN CERAM PIECE EFF	(ZR,VR)	6	PIECE 7	205
LAST TIME INTERVAL = .972 SEC					
TOTAL RUN TIME = 6.402 SEC					

Figure D.4. (Continued).

* * * * *	F =	3500.00000	* * * * *	PLOT LABELS	LBL1	LBL2
.392949+05	MAG(ZEL + ZSELF)					101
.120848+07	MAG(ZIC + ZSELF)					102
.896807+02	ANG(ZEL + ZSELF)					103
.865078+02	ANG(ZIC + ZSELF)					104
.334936+01	MAX/MIN OF MAG(VRAD/ES)					105
.102856+01	MAX/MIN OF MAG(VRAD/IS)					106
.319584+02	MAX-MIN OF ANG(VRAD/ES)					107
.362611+01	MAX-MIN OF ANG(VRAD/IS)					108
.358684+04	MIN MAG VKAD/ES		(ZR+VR)	3		109
.120136+03	MAX MAG VKAD/ES		(ZR+VR)	4		110
.277186+00	MIN MAG VKAL/IS		(ZR+VR)	5		111
.285103+00	MAX MAG VKAL/IS		(ZR+VR)	6		112
-.520593+02	MIN ANG VKAD/ES		(ZR+VR)	6		113
-.201008+02	MAX ANG VKAD/ES		(ZR+VR)	2		114
-.461856+01	MIN ANG VKAD/IS		(ZR+VR)	3		115
-.992451+00	MAX ANG VKAD/IS		(ZR+VR)	6		116
.106366+03	MIN POWER RAD / ES SG		(ZR+VR)	9		117
.294740+03	MAX POWER RAD / ES SG		(ZR+VR)	4		118
.143700+04	MIN POWER RAD / IS SG		(ZR+VR)	6		119
.738202+04	MAX POWER RAD / IS SG		(ZR+VR)	3		120
.366965+01	MAG(1./A11(S2R))					121
.446846+01	ANG(1./A11(S2R))					122
.340003+06	MAG(1./A21(S2R))					123
-.866724+02	ANG(1./A21(S2R))					124
.197958+03	MAX MAG(E*1) AMPLIF GUI		(ZR+VR)	1		131
.98.4161	MIN EFF (UNED DUCER)		(ZR+VR)	6		132
.162262+03	MAX AMPLIF OUTPUT POWER		(ZR+VR)	1		133
.115876+03	AVG AMPLIF OUTPUT POWER					134
.115555+04	MAX MAG E _m (AMPLIF OUT)		(ZR+VR)	1		135
.171943+00	MAX MAG I _m (AMPLIF OUT)		(ZR+VR)	4		136
.230726+04	MIN MAG Z _m (AMPLIF LOAD)		(ZR+VR)	4		137
.777048+04	MAX MAG Z _m (AMPLIF LOAD)		(ZR+VR)	3		138
.158398+02	MIN ANG Z _m (AMPLIF LOAD)		(ZR+VR)	2		139
.510668+02	MAX ANG Z _m (AMPLIF LOAD)		(ZR+VR)	6		140
.115676+04	TOT ARRAY AMPLIF PWR GUI					141
.98.9164	TOT ARRAY EFF EX AMPLIF					142
.117505+03	MAX IMAG E*1 AMPLIF GUI		(ZR+VR)	7		143
.690464+02	AVG IMAG E*1 AMPLIF GUI					144
.135419+01	MAX CER FIELD VOLTS/mIL		(ZR+VR)	1		161
.148382+01	MAX CERAM POWER LOSS		(ZR+VR)	7		162
.206009+00	MAX MAG IC (INTO CERAM)		(ZR+VR)	1		163
.115555+04	MAX MAG EC (INTO CERAM)		(ZR+VR)	1		164
.109382+01	AVG CERAM POWER LOSS					165
.617408+01	MAX MAG TAIL VELOCITY		(ZR+VR)	7		171
.143075+01	MAX/MIN (MAG(TAIL VLL))					172
.000000	MAX TAIL OUTPUT POWER		(ZR+VR)	1		173
.000000	AVG TAIL OUTPUT POWER					174
.186821+03	MAX RADIAIED POWER		(ZR+VR)	1		181
.114782+03	AVG RADIAIED POWER					182
.114782+04	TOTAL ARRAY POWER RAD					183

Figure D.4. (Continued).

SEADUCER RUN 80002 FOR TP-228 APPENDIX D			DATE 102072	PAGE 35	
.322831+03	MAX CERAM STRFSS (PSI)	(ZR,VR)	7	PIECE 7.64	201
.292665-04	MAX CERAM STRAIN	(ZR,VR)	7	PIECE 7.33	202
.169318+00	MAX CER PIECE PWR LOSS	(ZR,VR)	7	PIECE 7	203
.240919-01	MAX CERAM PIECE CURRENT	(ZR,VR)	1	PIECE 1	204
98.2677	MIN CERAM PIECE EFF	(ZR,VR)	6	PIECE 7	205
LAST TIME INTERVAL = 1.004 SEC			TOTAL RUN TIME = 7.406 SEC		

Figure D.4. (Continued).

SEAUUCER RUN 80002 FOR TP-220 APPELJIA 0

BAND WIDTH	MAG	ZM SPREAD	ANG	ZM SPREAD
.000000	.330167+01	.400000+02	.400000+02	.400000+02
.400000+02	.414784+01	.512526+02	.512526+02	.512526+02
.800000+02	.452555+01	.538467+02	.538467+02	.538467+02

LAST TIME INTERVAL = .030 SEC

TOTAL RUN TIME = 7.435 SEC

Figure D.4. (Continued)

***** COMMON PR1 TBL *****

N	NET	1	SIGN	J	II	NET	NUM	N	LC	J
SP	C	D	PORTL	PORTS	HA	APQ	APQ	BACK	ROW	ROW
1	S	1	1	1	1	8	BS	1	-1	3
2	S	1	1	1	2	8	BS	1	2	401
3	S	1	1	1	2	8	BS	2	-2	5
4	S	1	1	1	2	8	BS	2	3	21
5	S	1	1	1	2	8	BS	3	-3	3
6	S	1	1	1	2	2	ZZ	3	6	20
7	S	1	1	1	4	8	BS	4	-4	10
8	S	1	1	1	2	8	AA	4	7	14
9	S	1	1	1	2	8	VV	4	9	17
10	S	1	1	1	3	8	HS	5	-5	12
11	S	1	1	1	2	TA	5	11	18	17
12	S	1	1	1	0	8	BS	6	-6	15
13	S	1	1	1	2	8	BJ	6	1	2
14	S	1	1	1	2	8	AA	6	8	9
15	S	1	1	1	7	8	BS	7	-7	19
16	S	1	1	1	1	2	RR	7	13	22
17	S	1	1	1	2	2	VV	7	10	11
18	S	1	1	1	2	2	TA	7	12	16
19	S	1	1	1	0	8	BS	8	-8	23
20	S	1	1	1	1	2	ZZ	8	5	6
21	S	1	1	1	2	2	EE	8	4	20
22	S	1	1	1	2	2	RR	8	14	0
23	S	1	1	1	1	1	TS	1	-1	25
24	S	1	1	1	1	1	ZT	1	1	0
25	S	1	1	1	5	5	AS	1	-1	27
26	S	1	1	1	3	3	CS	1	3	33
27	S	1	1	1	2	5	AS	2	-2	29
28	S	1	1	1	3	4	BS	2	6	30
29	S	1	1	1	3	5	AS	3	-3	32
30	S	1	1	1	4	4	BS	3	7	31
31	S	1	1	1	1	1	TS	3	8	0
32	S	1	1	1	4	5	AS	4	-4	35
33	S	1	1	1	1	4	BS	4	4	36
34	S	1	1	1	1	3	CS	4	1	37
35	S	1	1	1	5	5	AS	5	-5	0
36	S	1	1	1	2	4	BS	5	5	28
37	S	1	1	1	2	3	CS	5	2	26

Figure D.4. (Continued).

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

I	NAME	MTR	I	PC	N	PC	I	UT	LOC
		SIZ			LOI	TYPE	SIR		
1	BS	8	0	0	0	0	0	1	
2	TS	1	0	0	0	0	0	257	
3	AS	5	0	0	0	0	0	261	
4	AA	2	0	1	1	0	0	361	
5	AA	2	1	1	1	1	7	377	
6	RR	2	0	1	1	0	0	400	
7	BB	2	1	1	1	1	7	416	
8	EE	2	0	1	1	0	0	439	
9	EE	2	1	1	1	1	7	455	
10	VV	2	0	1	1	0	0	478	
11	VV	2	1	1	1	1	7	494	
12	TA	2	0	2	0	0	0	517	
13	TA	2	1	2	1	1	7	533	
14	IA	2	2	2	1	1	7	556	
15	RR	2	0	3	0	0	0	579	
16	RR	2	1	3	1	1	7	595	
17	RR	2	2	3	1	1	7	618	
18	RR	2	3	3	1	1	7	641	
19	ZZ	2	0	3	0	0	0	664	
20	ZZ	2	1	3	1	1	7	680	
21	ZZ	2	2	3	2	2	8	703	
22	ZZ	2	3	3	1	1	7	727	
23	ZT	1	0	0	0	5	0	750	
24	CS	3	0	0	11	33	0	754	
25	FS	2	0	0	0	0	0	823	
26	DS	2	0	0	0	0	0	831	
27	SS	2	0	0	0	0	0	839	
28	GS	2	0	0	0	0	0	847	
29	ES	2	0	0	0	0	0	855	
30	HS	2	0	0	0	0	0	863	
31	MS	2	0	0	0	0	0	871	
32	BS	4	0	0	0	0	0	879	
33	BS	0	0	0	0	0	0	943	
34	BS	0	0	0	0	0	0	1007	
35	AS	2	0	0	0	0	0	1071	
36	AS	0	0	0	0	0	0	1087	
37	AS	0	0	0	0	0	0	1123	
38	BC	4	0	0	0	0	0	1147	
39	ZC	3	0	0	0	0	0	1211	
40	RC	3	0	0	0	0	0	1229	
TOTAL DATA CELLS USED IN MASTER STORAGE									1246

Figure D.4. (Continued).

LAST TIME INTERVAL = .412 SEC TOTAL RUN TIME = 7.046 SEC

BOOKPT PRINTS

RUNID: M80002 ACCOUNT: 1E0178010000 PROJECT: LME010314522

LOAD P80002 9/7 PROFILE -1 M80002

M80002*MS6: 50-2119

BREAKPOINT IN THIS RUN

*M80002 P80002=3738 P80002=525

LB#0-279 9/0 B -1 M80002

SERVICE 9/0

LOAD P80002 9/7 14 -1 M80002

TIME: 00:00:17.135 IN: 147 OUT: 0 PAGES: 47

WDS XFRDIE2: 5364 I/O REFS: 2147 CORE SEC: 957

INITIATION TIME: 10:20:27-OCT 20.1972 VERSION: 2E.70.150 10

TERMINATION TIME: 10:27:49-OCT 20.1972

BREAKPOINT IN THIS RUN

Figure D.4. (Continued)

Figure D.5.
Computer-generated Plots from Search Procedure.

SEADUCER RUN 80002 MAY 13, 1970
MODEL 451
SEARCH

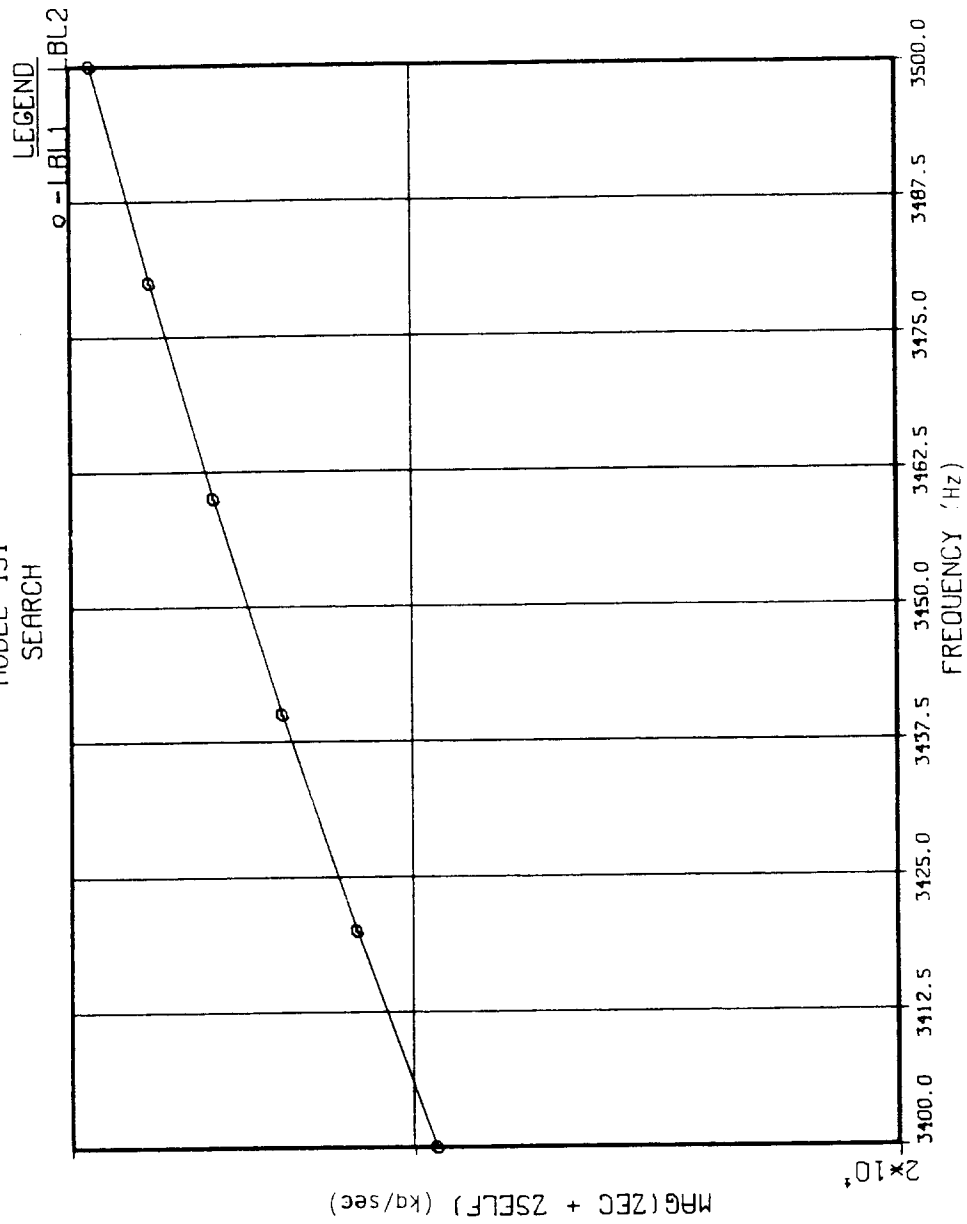


Figure D.5. (Continued).

SEADUCER RUN 80002 MAY 13, 1970
MODEL 451
SEARCH

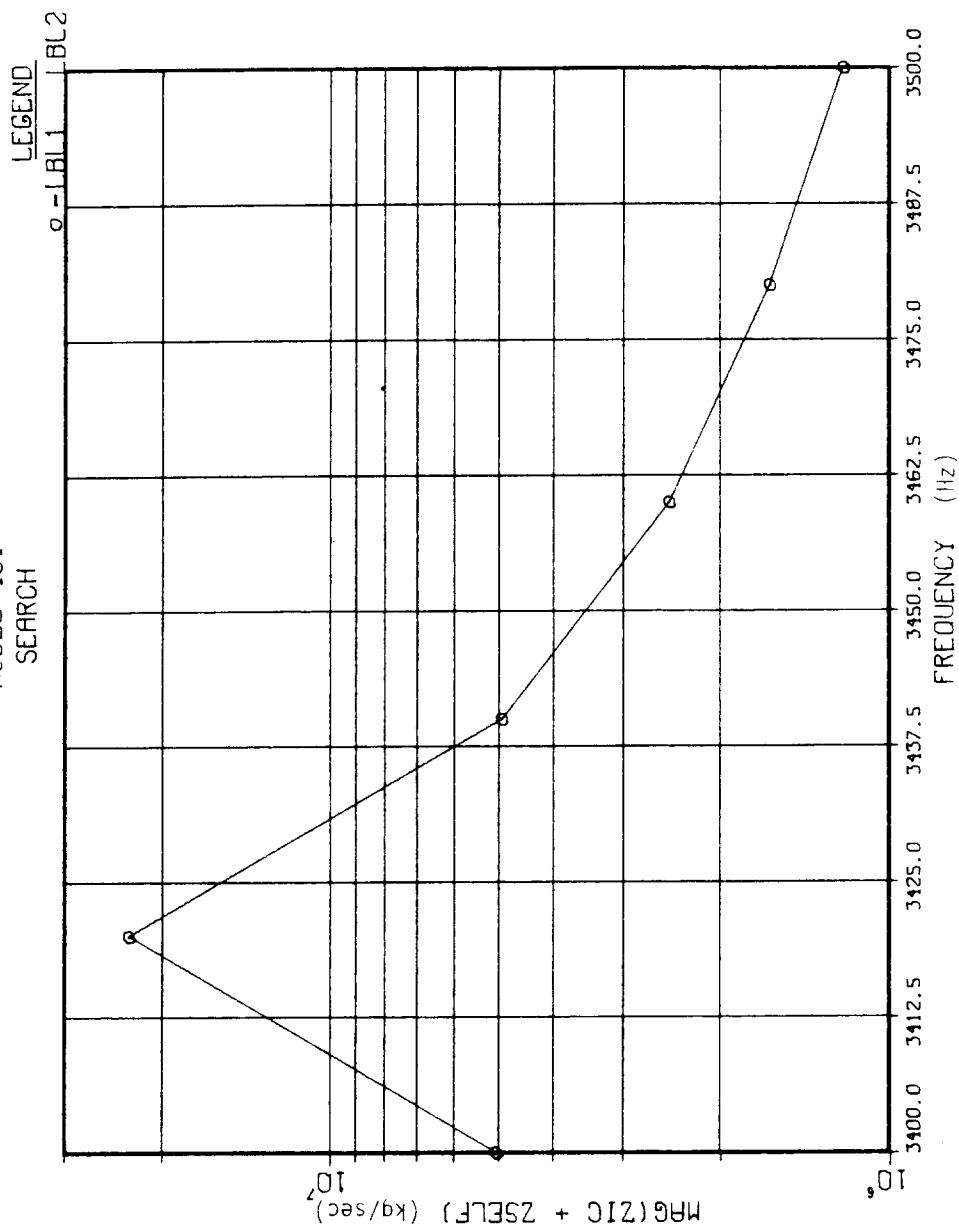


Figure D.5. (Continued).

TIME RUN 1116 PLOT NO 3 DATE 10/20/72 N. U. C. DISSEMINATION VERSION 1

SEAFINDER RUN 80000 PHY 13, 1970

MODE 451

SEARCH

LEGEND

o - LBL1 LBL2

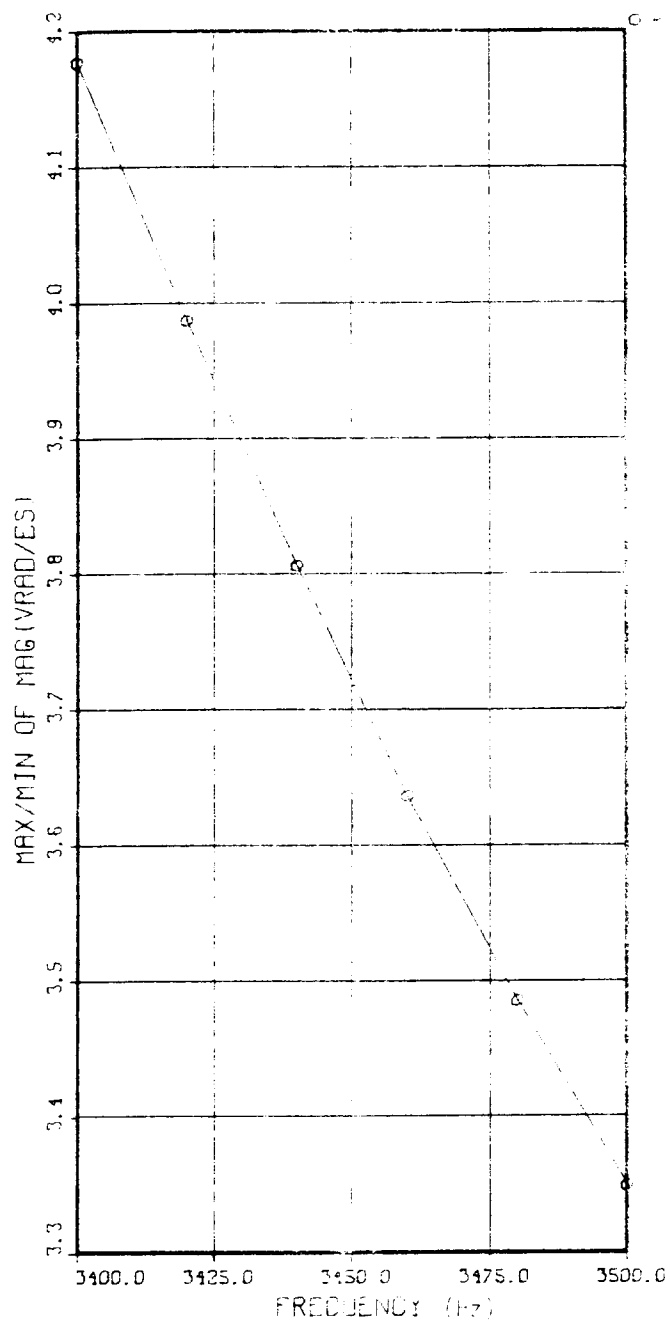


Figure D.5. (Continued).

TIME RUN 1416 PLOT NO 1 DATE 10/20/72 M.U.C. DISPLAY VERSION 1

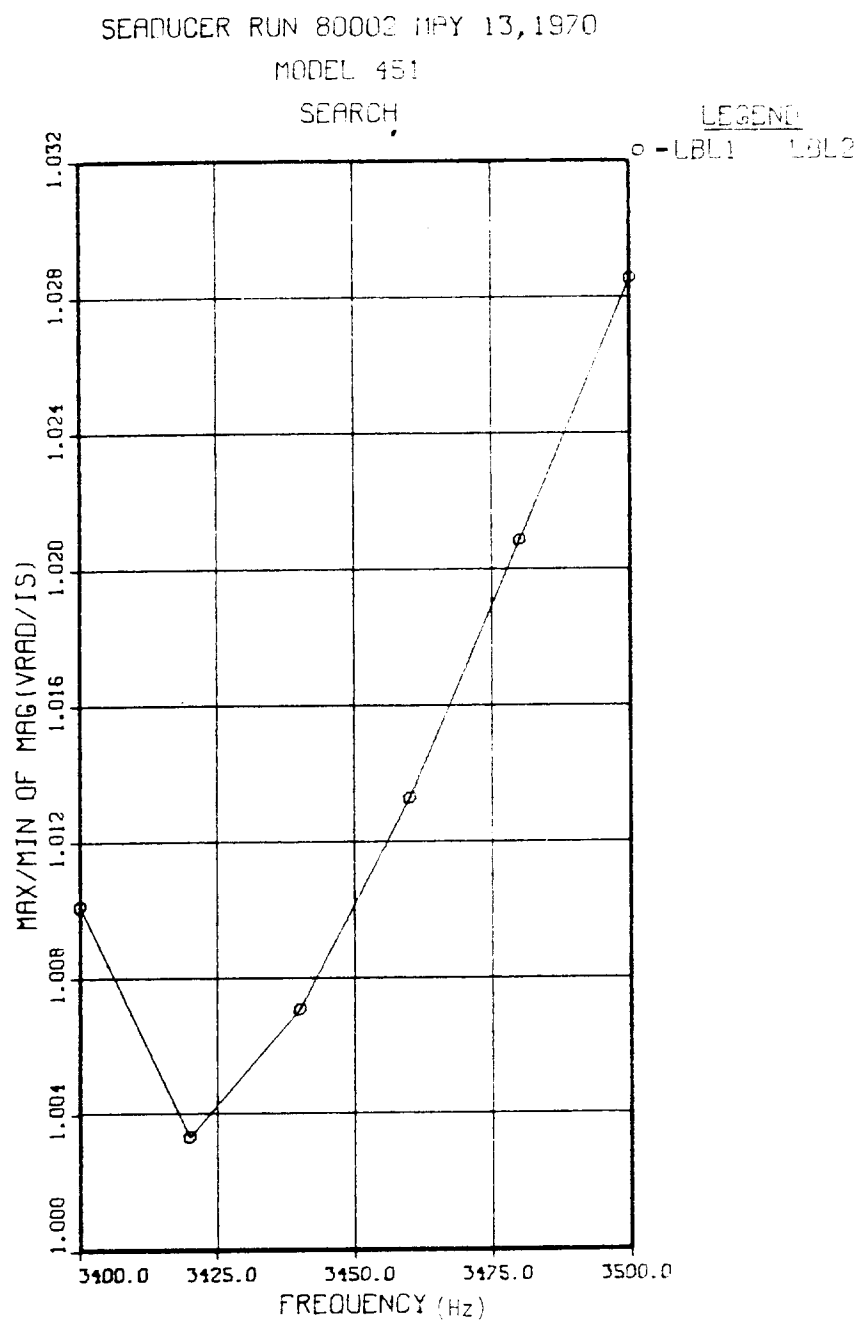


Figure D.5. (Continued).

TIME RUN 1416 PLOT NO 5 DATE 10/20/72 M.U.C. DISPLAY VERSION 1

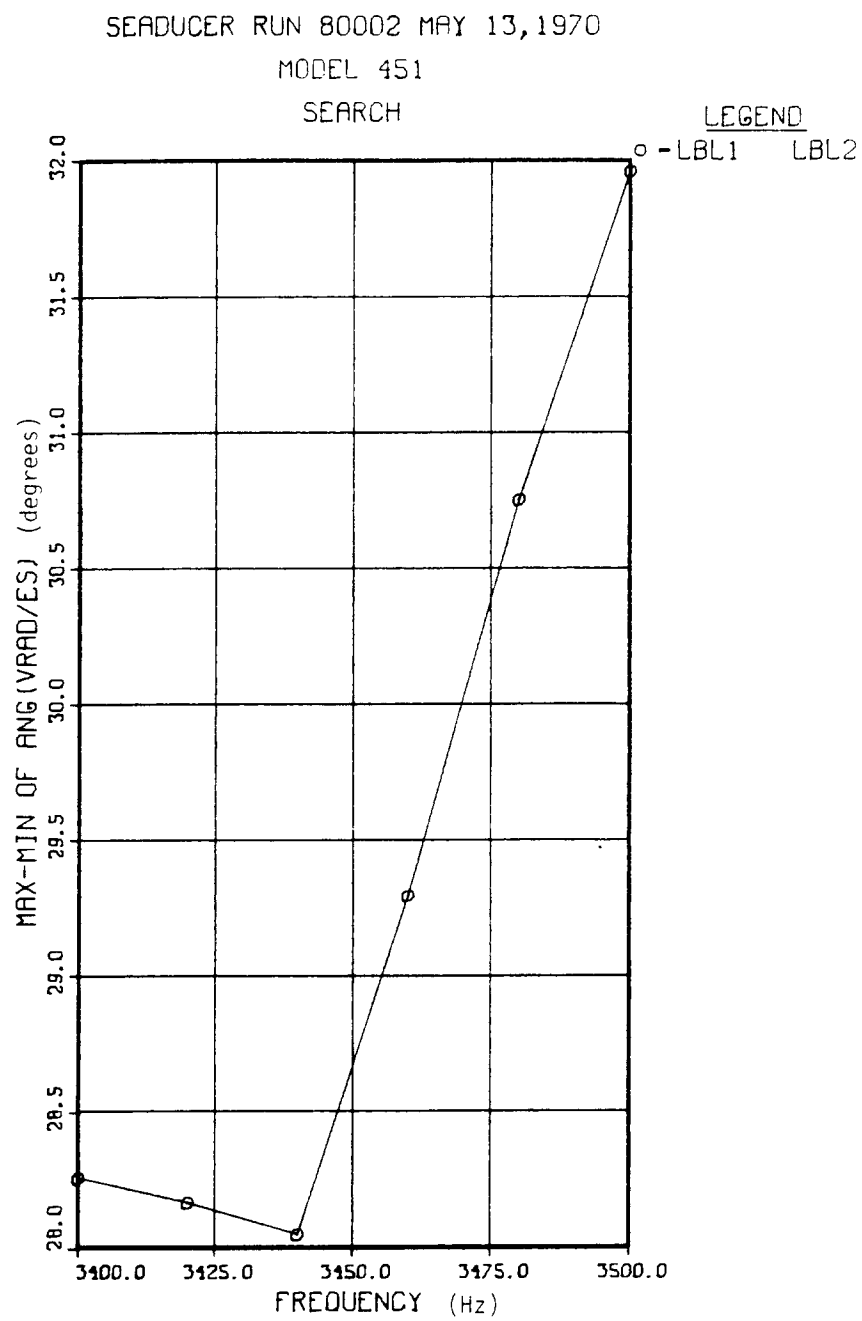


Figure D.5. (Continued).

TIME RUN 1317 PLOT NO 6 DATE 10/20/72 N.U.C. DISPLAY VERSION 1

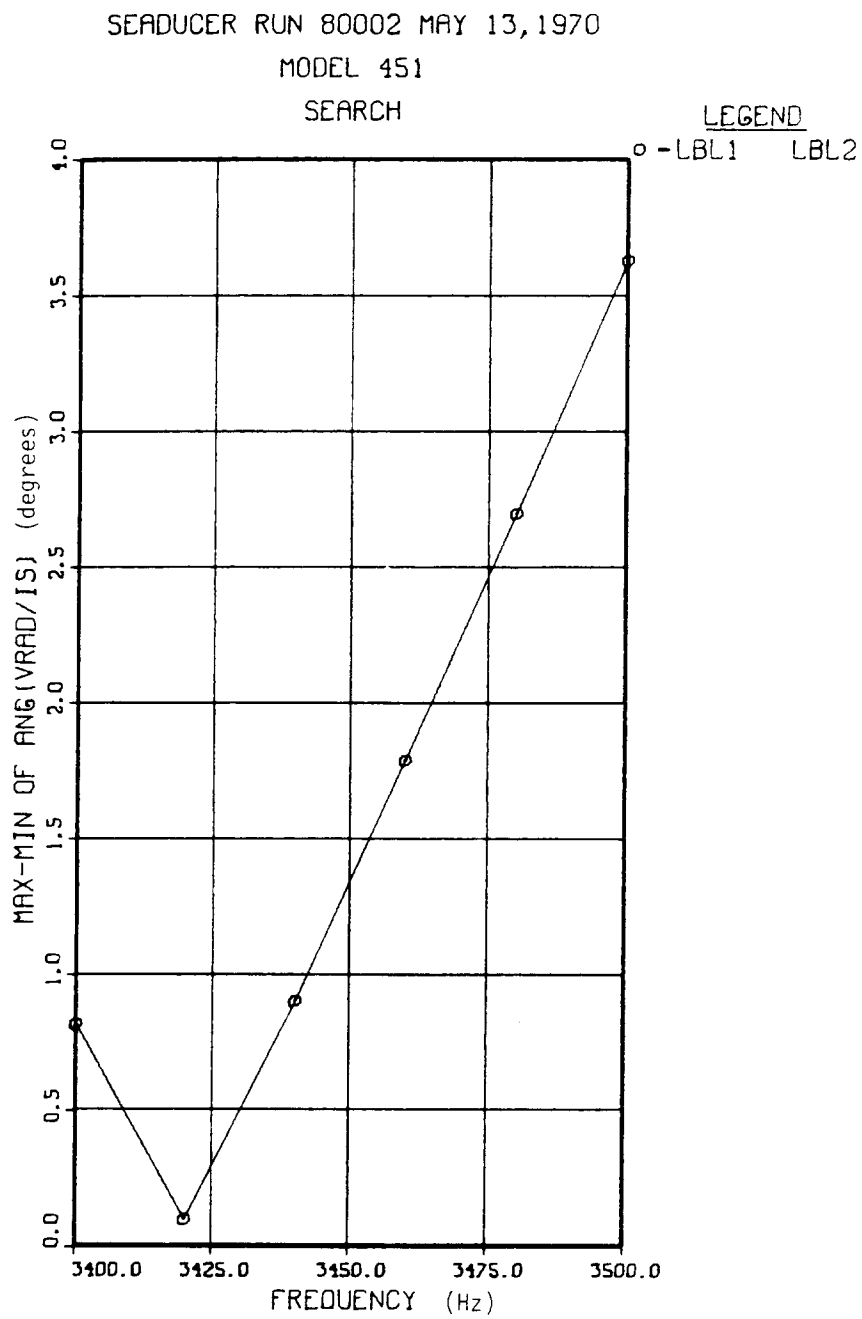


Figure D.5. (Continued).

TIME RUN 1417 PLOT NO. 7 DATE 10/20/73 M.U.C. DISPLAY VERSION 1

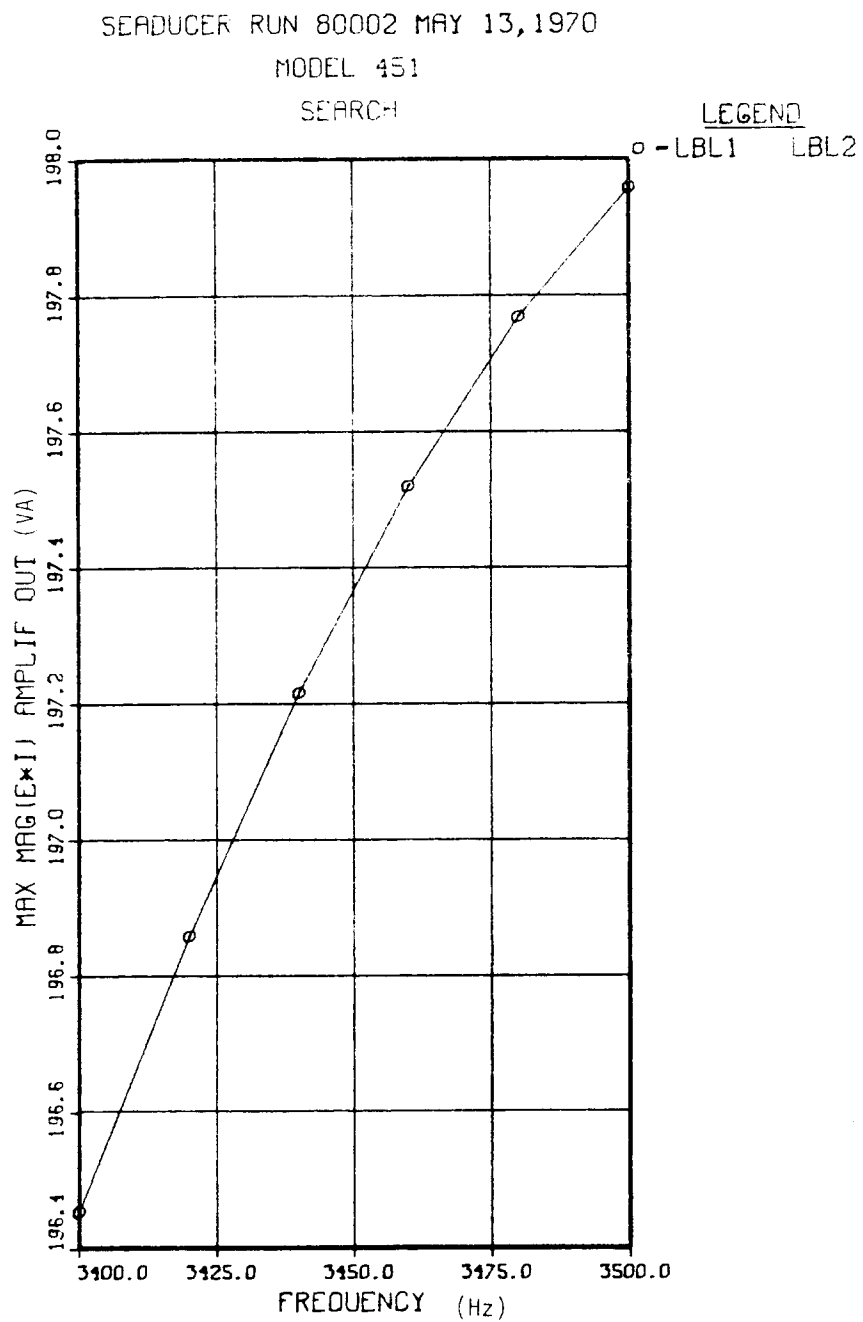


Figure D.5. (Continued).

TIME RUN 1417 PLOT NO 8 DATE 10/30/73 M.U.C. DISPLAY VERSION 1

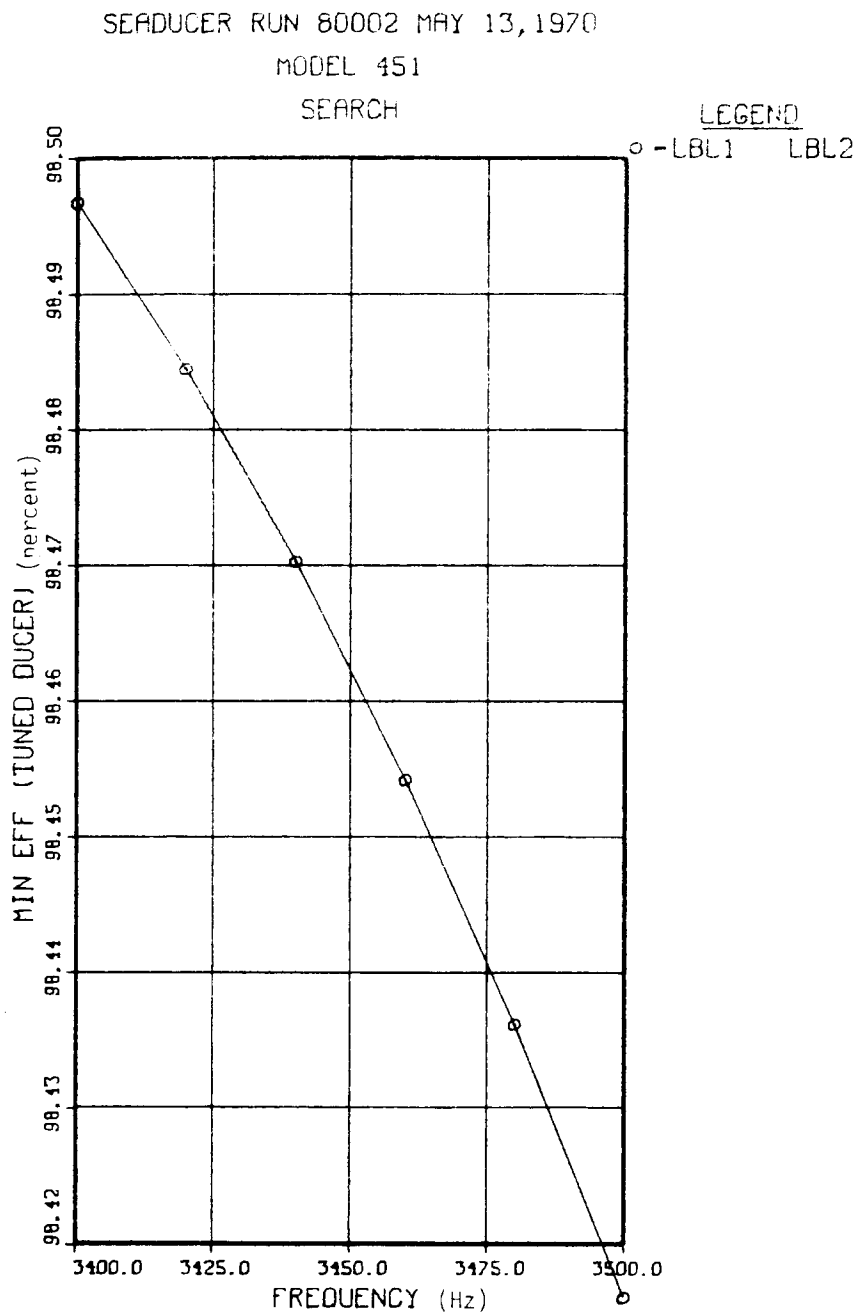


Figure D.5. (Continued).

TIME RUN 1417 PLOT NO 9 DATE 10/20/73 M.U.C. DISPLAY VERSION 1

SEADUCER RUN 80002 MAY 13, 1970

MODEL 451

SEARCH

LEGEND

○ - LBL1 LBL2

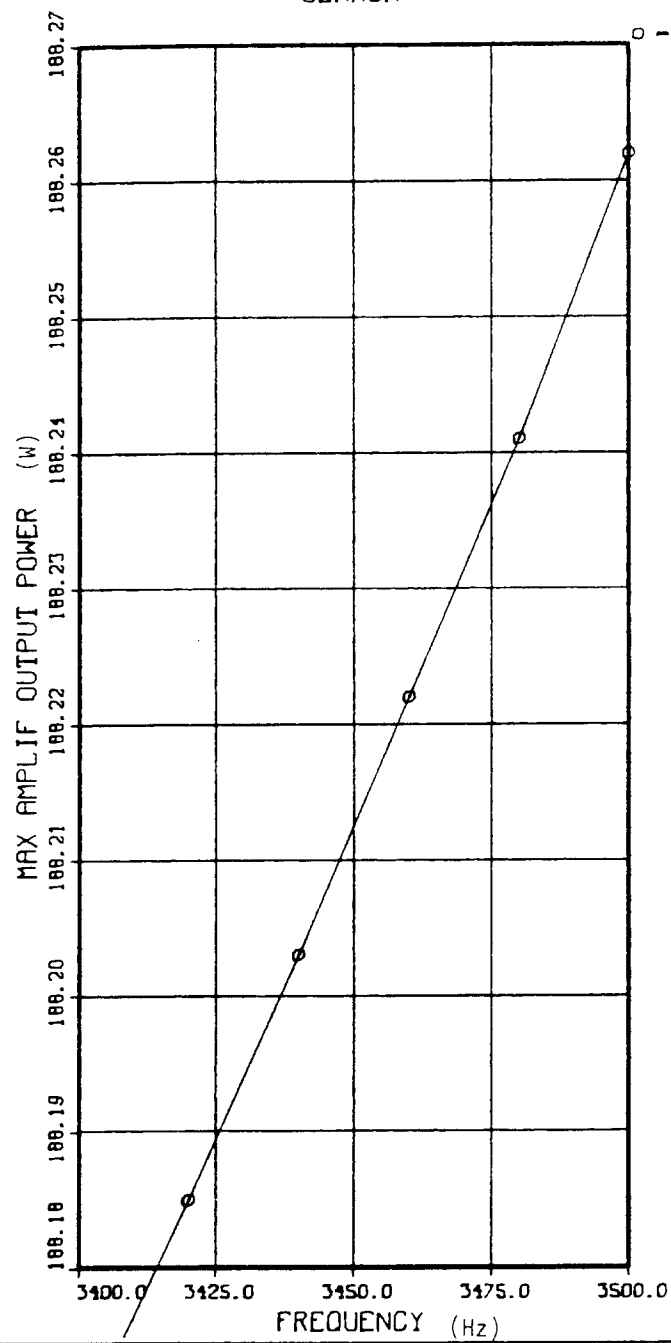


Figure D.5. (Continued).

TIME RUN 1417 PLOT NO 10 DATE 10/20/72 M.U.C. DISPLAY VERSION 1

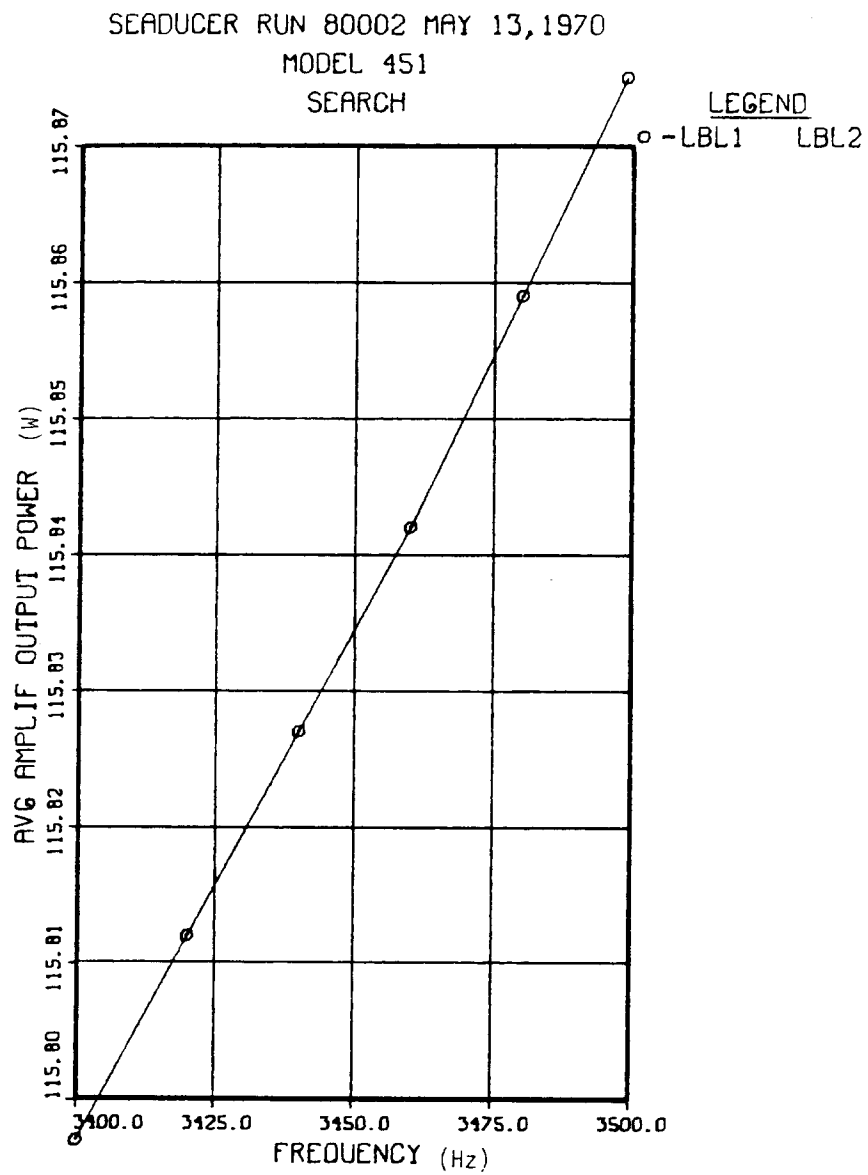


Figure D.5. (Continued).

TYPE RUN 1417 PLOT NO 11 DATE 10/20/73 M.U.C. DISPLAY VERSION 1

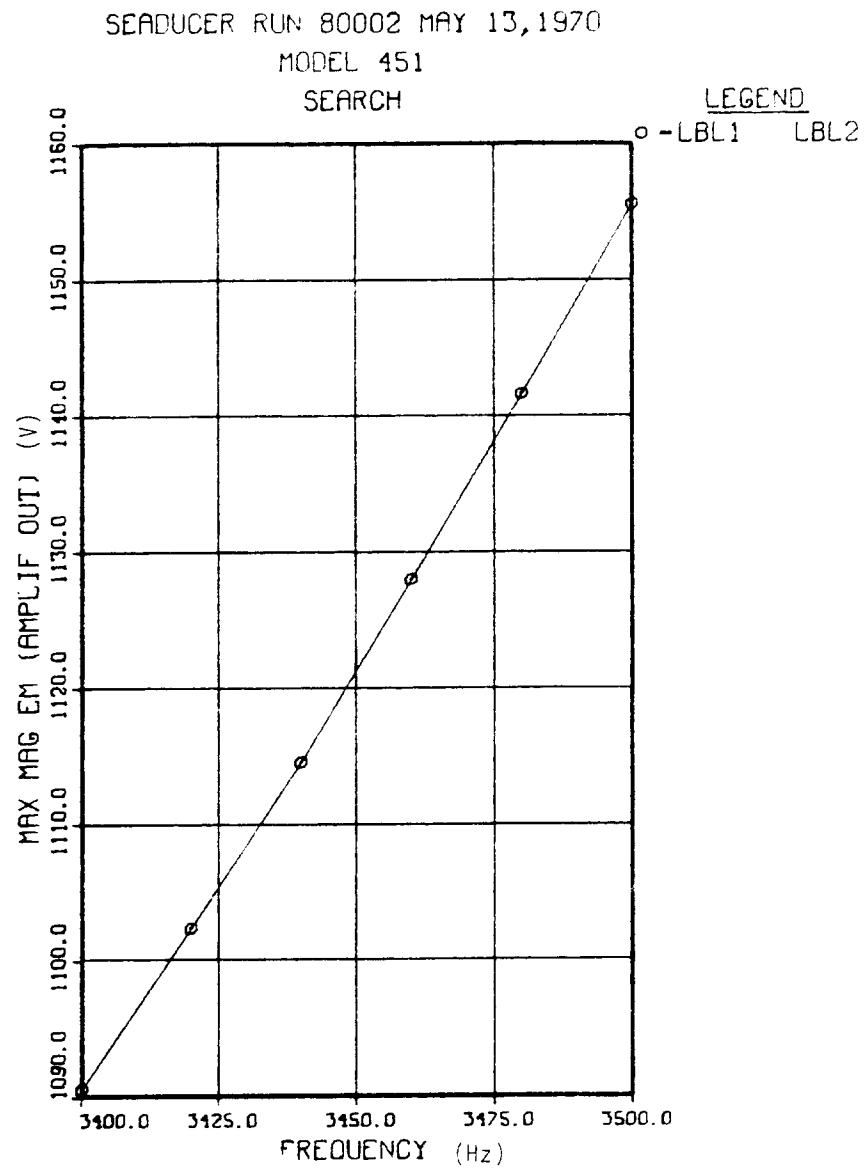


Figure D.5. (Continued).

TIME RUN 1417 PLOT NO 12 DATE 10/30/73 M.U.C. DISPLAY VERSION 1

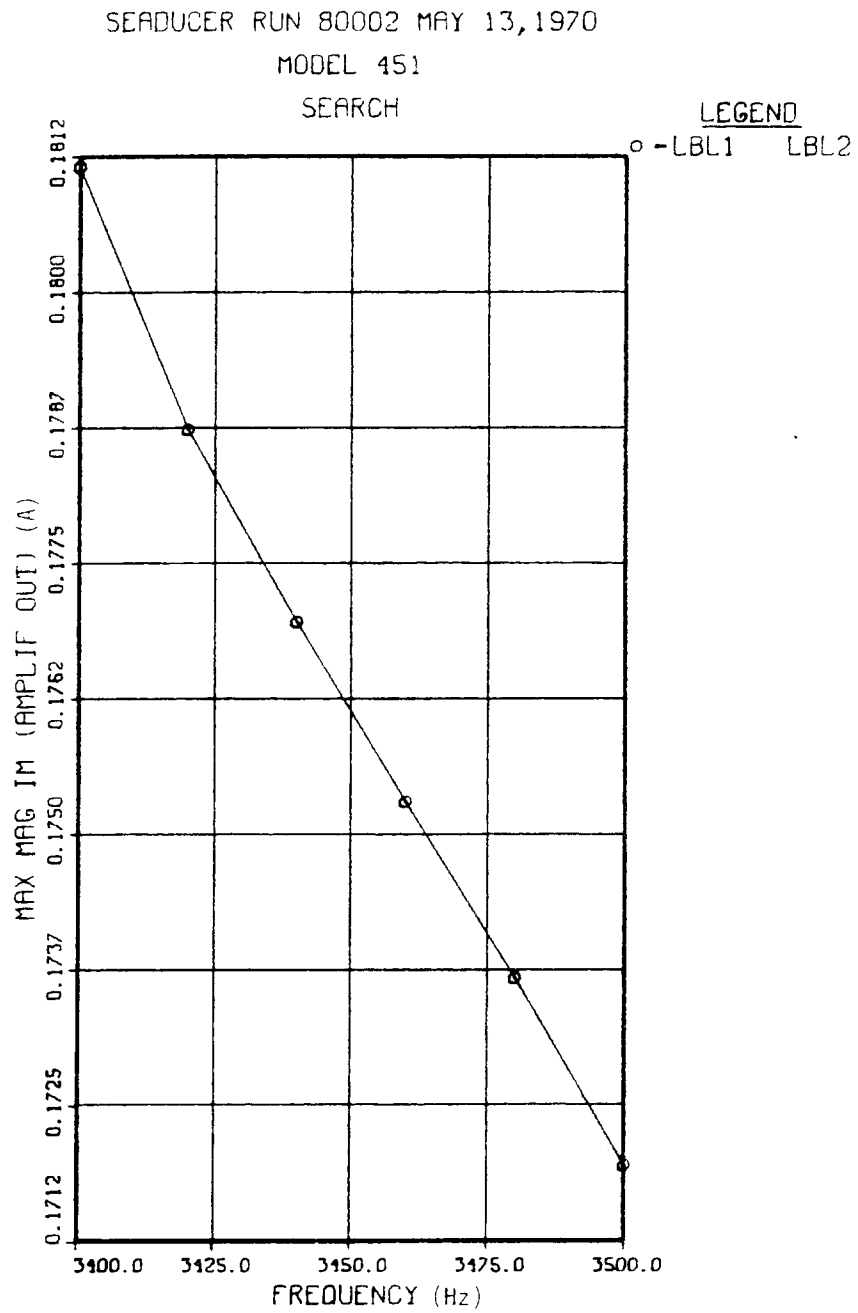


Figure D.5. (Continued).

SEADUCER RUN 80002 MAY 13, 1970
MODEL 451
SEARCH

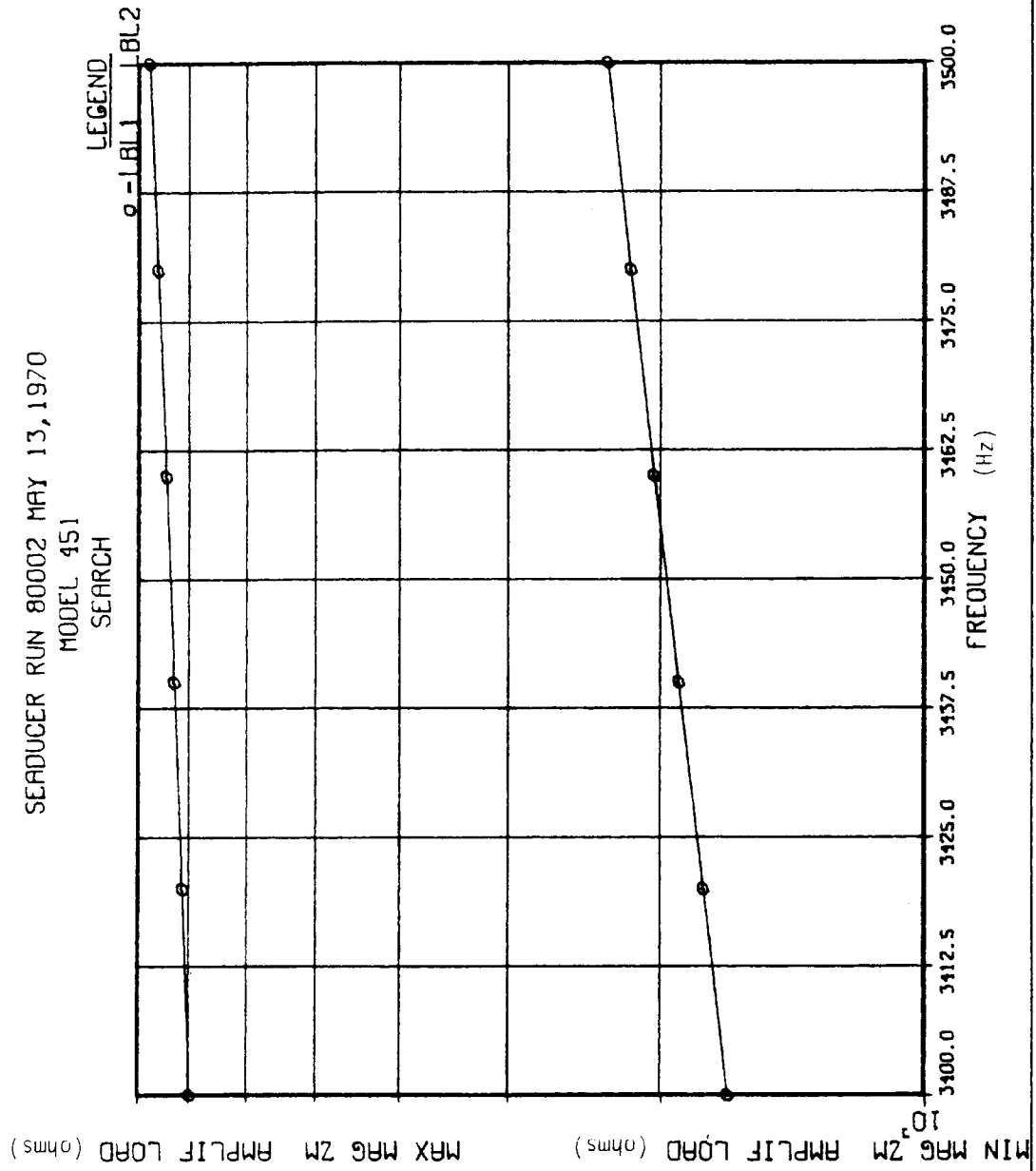


Figure D.5. (Continued).

TIME RUN 1117 PLOT NO 14 DATE 10/28/73 H.U.E. DISPLAY VERSION 1

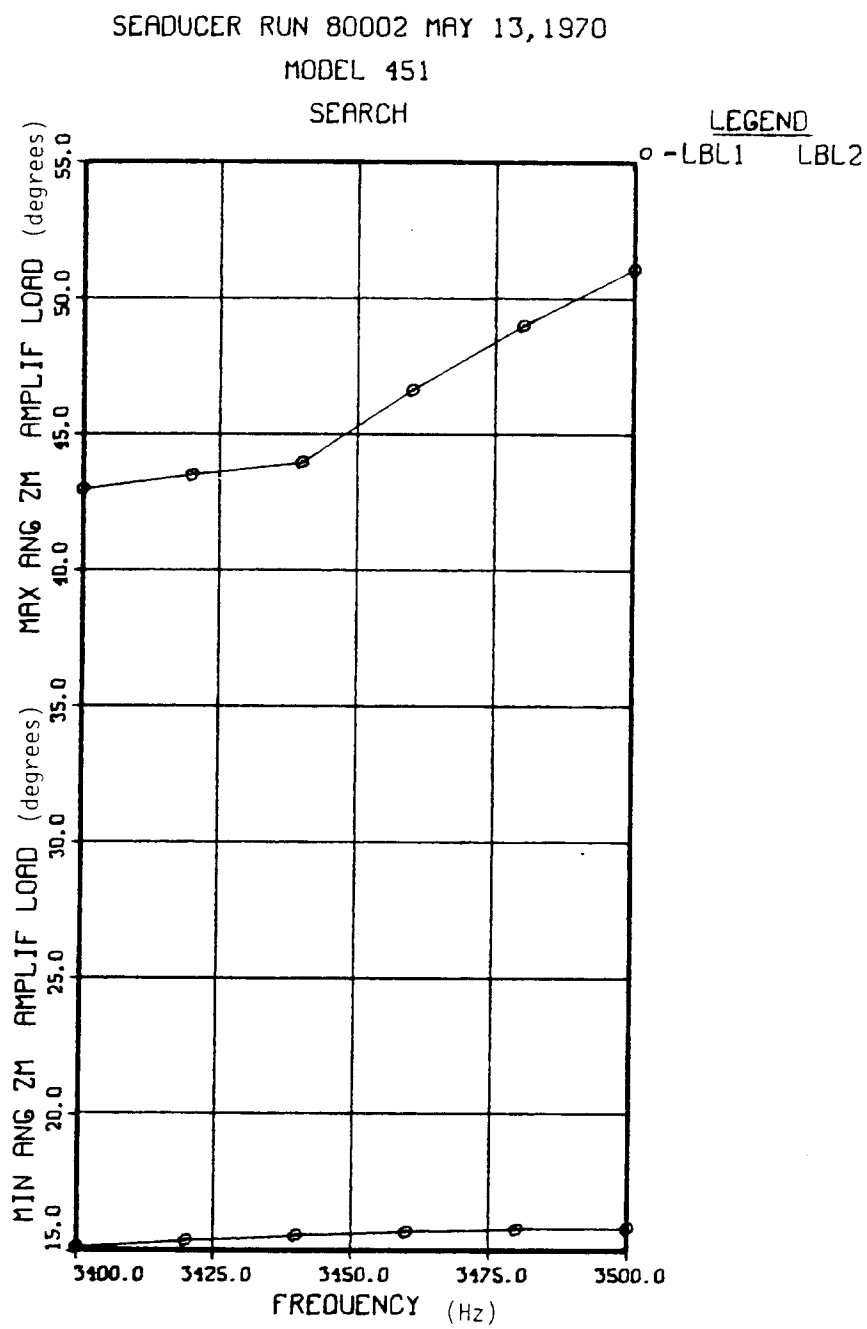


Figure D.5. (Continued).

SEADUCER RUN 80002 MAY 13, 1970

MODEL 451

SEARCH

LEGEND

o - LBL1 LBL2

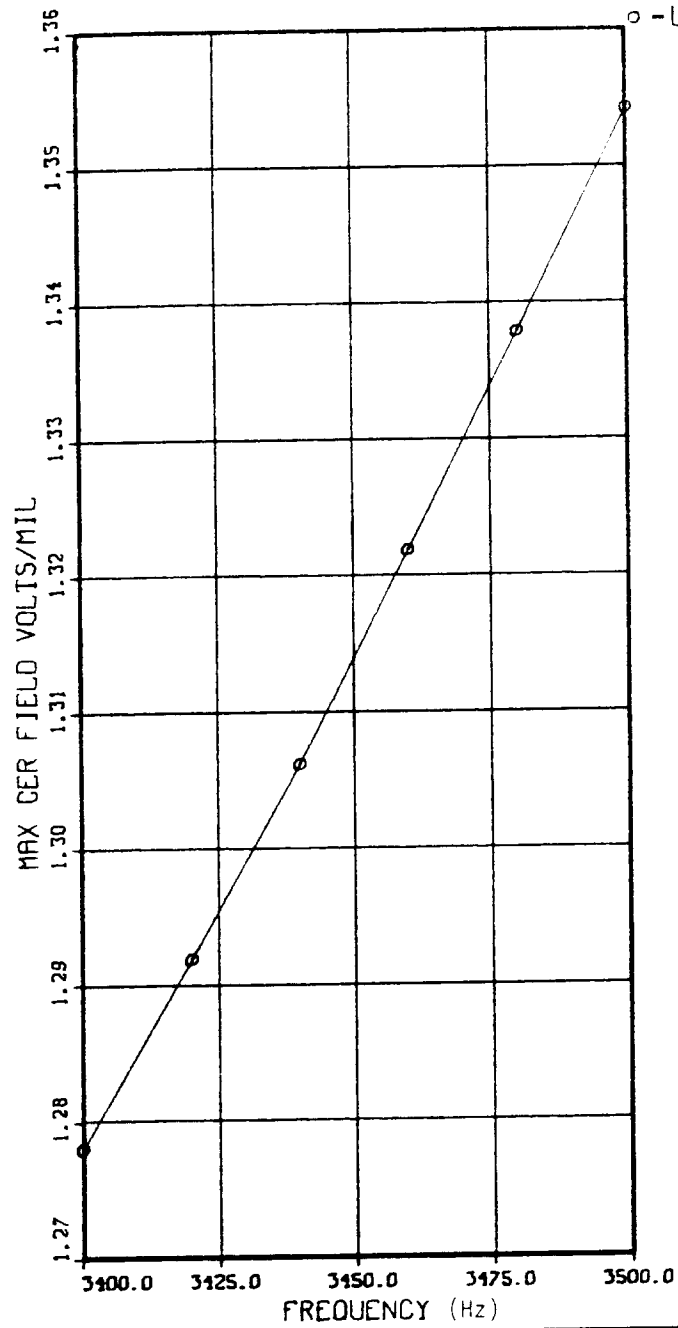


Figure D.5. (Continued).

TIME RUN 1318 PLOT NO 16 DATE 10/30/73 W.U.C. DISPLAY VERSION 1

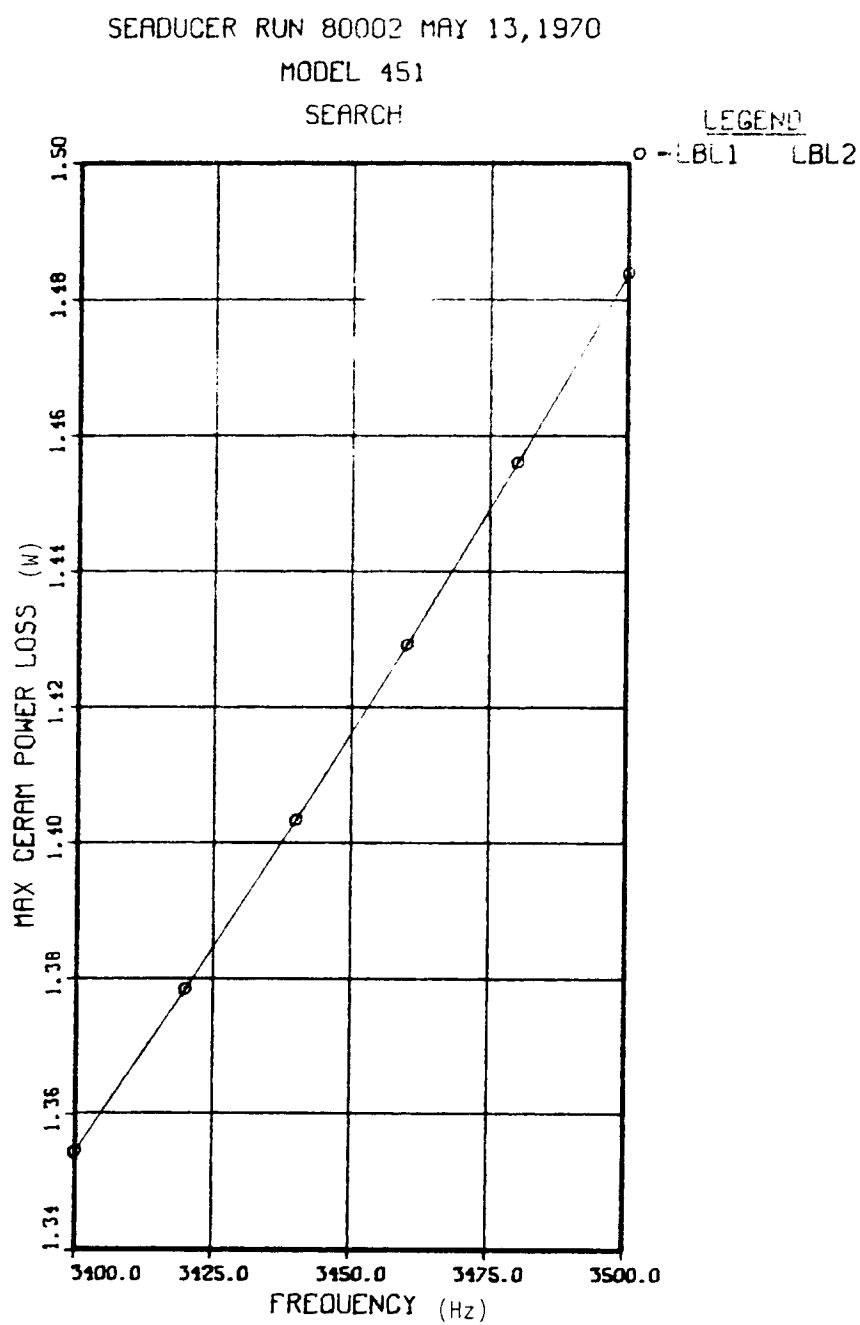


Figure D.5. (Continued).

SEADUCER RUN 80002 MAY 13, 1970
MODEL 451
SEARCH

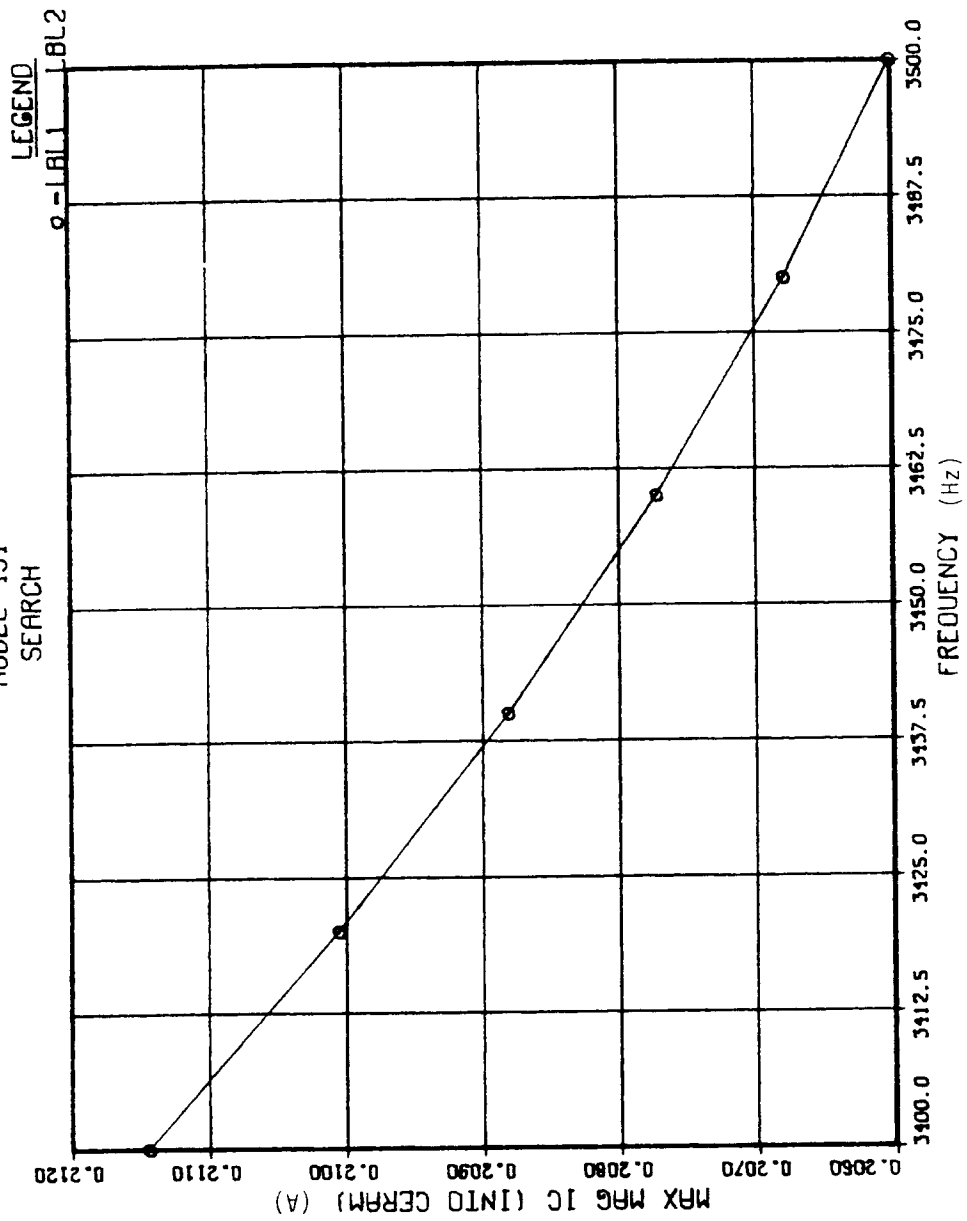


Figure D.5. (Continued).

TIME MAP 1110 PLAT 10110 DATE 10/20/72 M.U.C. DISPLAY VERSION 1

SEADUCER RUN 80002 MAY 13, 1970

MODEL 451

SEARCH

LEGEND

o - LBL1 LBL2

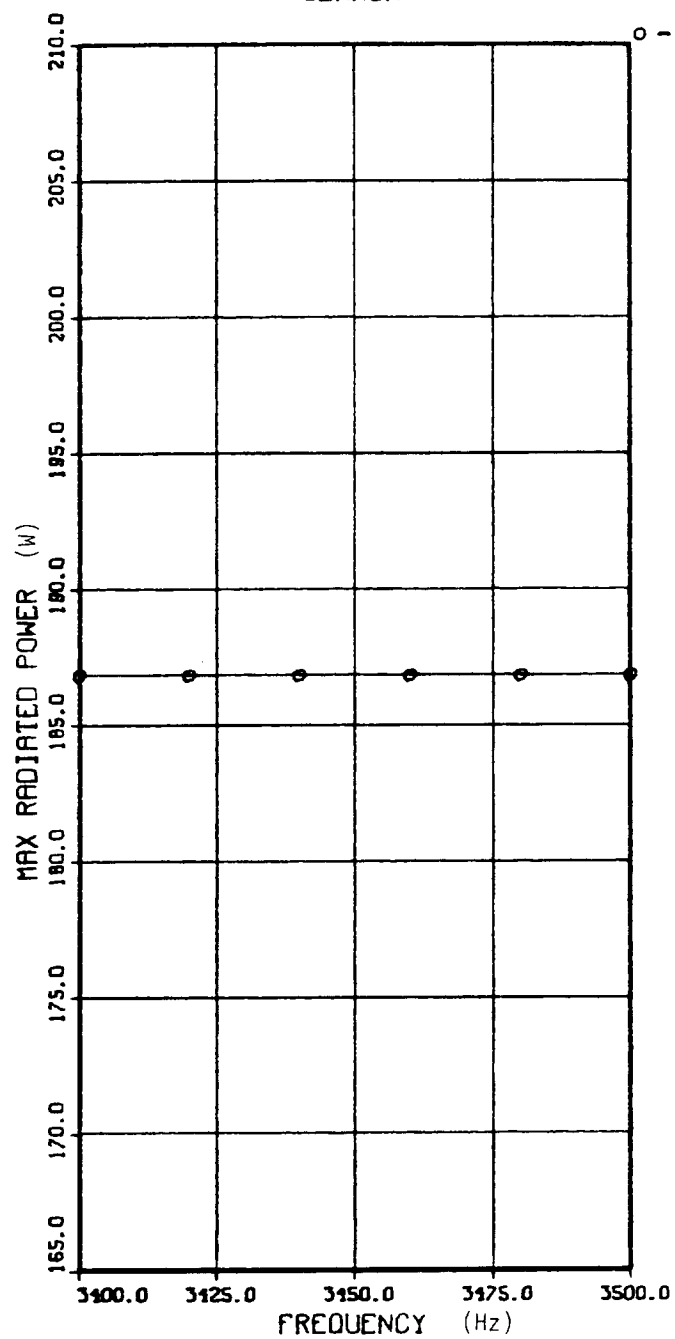


Figure D.5. (Continued).

SEADUCER RUN 80002 MAY 13, 1970

MODEL 451

SEARCH

LEGEND

o - LBL1 LBL2

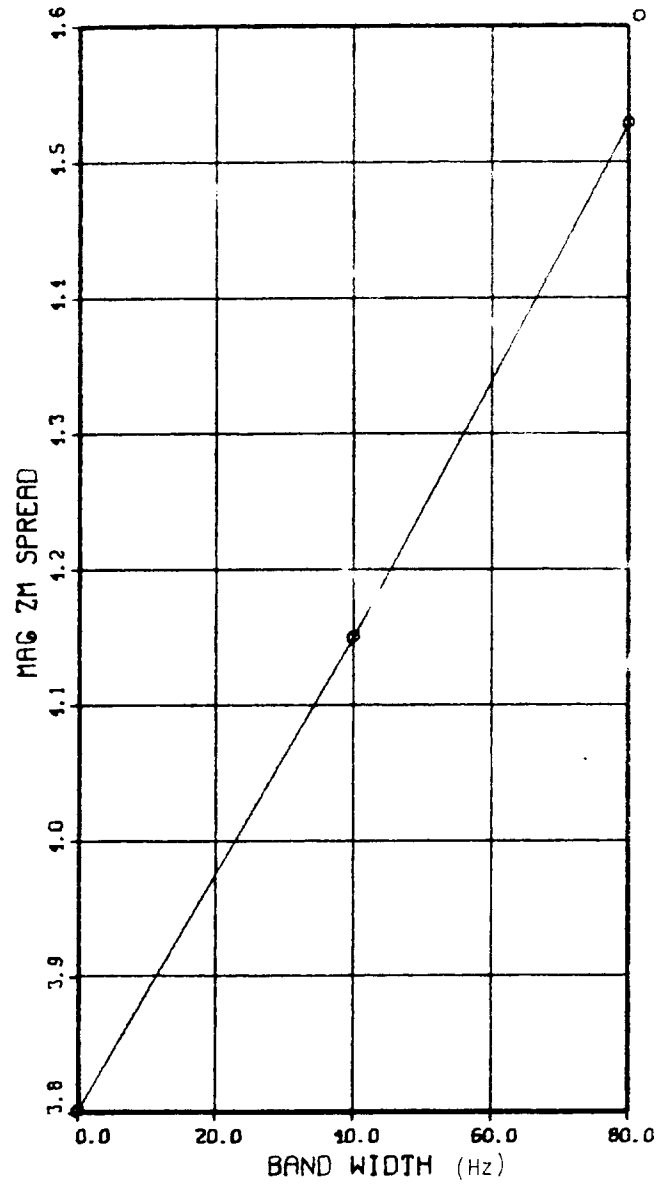


Figure D.5. (Continued).

SEADUCER RUN 80002 MAY 13, 1970
MODEL 451
SEARCH

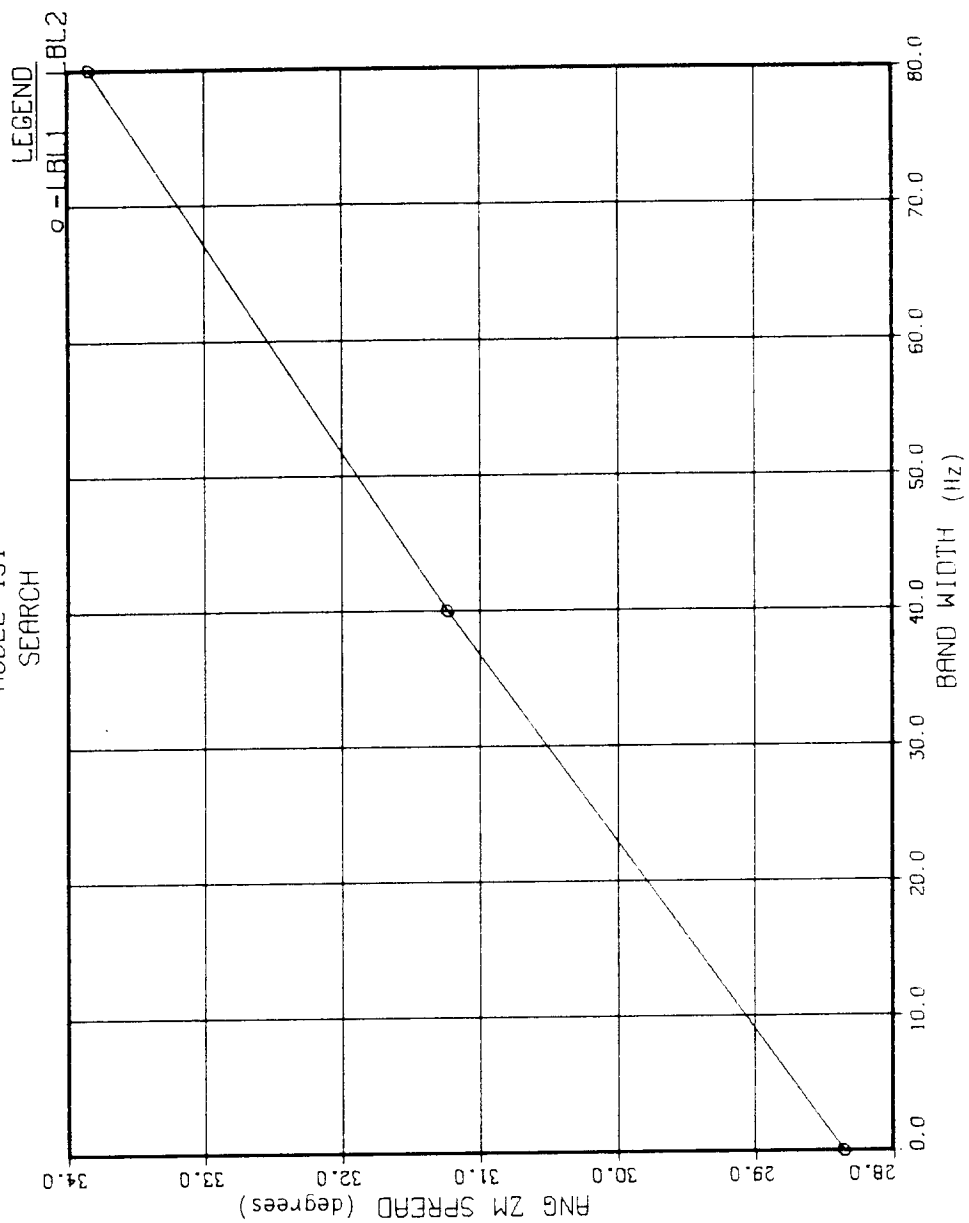


Figure D.5. (Continued).

APPENDIX E

FIND PARAMETERS EXAMPLE

The linear approximation iteration technique used to compute the set of ceramic parameters is described in this appendix. The technique designated "find parameters" computes the ceramic parameters $\left[s_{3333}^D, g_{333}, E_{33}^T, s_{3333}^D I, g_{333} I, E_{33}^T I \right]$ from the experimentally measured set of quantities $[f_m, f_n, C(f_{LO}), |Y_m|, |Y_n|, \text{ and } D(f_{LO})]$, where

f_m = the frequency of maximum admittance magnitude,

f_n = the frequency of minimum admittance magnitude,

$|Y_m|$ = the electrical admittance magnitude at frequency f_m ,

$|Y_n|$ = the electrical admittance magnitude at frequency f_n ,

C = the electrical input parallel capacitance at a frequency f_{LO} which is below f_m and near the lower frequency limit of the actual transponder operating frequency band (called CLO in program),

and D = the dissipation factor at the frequency f_{LO} (called CLOM in program).

**The absolute value signs will be omitted from Y_m and Y_n henceforth in this section even though absolute values are used.*

For simplicity of explanation of the method employed, the subscripts and superscripts on the ceramic parameters will be omitted in the remainder of this presentation, except to designate which set is being discussed. That is, the set of ceramic parameters will be $[s, g, E, sl, gl, EI]$.

The equations used to calculate the "measured" quantities from the parameters are dependent upon the exact configuration of the stack under investigation. The complete mathematical model of the stack will dictate the equations to be used. However, in general each of the "measured" quantities is a function of every material parameter, as implied by the following set of equations:

$$f_m = f_m(s, g, E, sl, gl, EI)$$

$$f_n = f_n(s, g, E, sl, gl, EI)$$

$$C(f_{LO}) = C(s, g, E, sl, gl, EI) = \frac{\text{imag part of } Y_{f_{LO}}}{2\pi \times f_{LO}}$$

$$Y_m = Y_m(s, g, E, sl, gl, EI)$$

$$Y_n = Y_n(s, g, E, sl, gl, EI)$$

$$D(f_{LO}) = D(s, g, E, sl, gl, EI) = \frac{\text{real part of } Y_{f_{LO}}}{\text{imag part of } Y_{f_{LO}}}$$

(1)

A useful relationship can be set up between these quantities by taking the total differentials, where f_{LO} is considered to be a constant for any particular case. This yields the following expression:

$$\begin{bmatrix} dfm \\ dfn \\ dC \\ dYm \\ dYn \\ dD \end{bmatrix} = \begin{bmatrix} \frac{\partial fm}{\partial s} & \frac{\partial fm}{\partial g} & \frac{\partial fm}{\partial E} & \frac{\partial fm}{\partial sl} & \frac{\partial fm}{\partial gl} & \frac{\partial fm}{\partial EI} \\ \frac{\partial fn}{\partial s} & \frac{\partial fn}{\partial g} & . & . & . & . \\ \frac{\partial C}{\partial s} & . & . & . & . & . \\ \frac{\partial Ym}{\partial s} & . & . & . & . & . \\ \frac{\partial Yn}{\partial s} & . & . & . & . & . \\ \frac{\partial D}{\partial s} & . & . & . & . & \frac{\partial D}{\partial EI} \end{bmatrix} \begin{bmatrix} ds \\ dg \\ dE \\ dsl \\ dgl \\ dEI \end{bmatrix} \quad (2)$$

Although equation (2) is developed for infinitesimals, it should have approximate validity for finite differences. One estimates a set of material parameters $[s, g, E, sl, gl, EI]$. From this initial estimate one calculates a set of quantities, $[fm, fn, C, Ym, Yn, D]$, from the equations of the complete mathematical model.

A set of increments $[\Delta s, \Delta g, \Delta E, \Delta sl, \Delta gl, \Delta EI]$ is prescribed. A 10% change in s, g, E, sl, gl , and EI is used. One augments each of the initially estimated material parameters one at a time leaving the others alone. A new set, $[fm, fn, C, Ym, Yn, D]$, is then calculated for each of the six augmentations. For example, when Δs is chosen to augment s , and no other material parameters are augmented, one obtains the following set of values:

$$\begin{aligned}
& f_m(s + \Delta s, g, E, s_l, g_l, EI) , \\
& f_n(s + \Delta s, g, E, s_l, g_l, EI) , \\
& C(s + \Delta s, g, E, s_l, g_l, EI) , \\
& Y_m(s + \Delta s, g, E, s_l, g_l, EI) , \\
& Y_n(s + \Delta s, g, E, s_l, g_l, EI) , \\
& \text{and } D(s + \Delta s, g, E, s_l, g_l, EI) .
\end{aligned} \tag{3}$$

If we subtract the quantities computed prior to augmentation, expand in a Taylor series and ignore the higher terms, we have

$$f_m(s + \Delta s, g, \dots) - f_m = \frac{\partial f_m}{\partial s} \Delta s, \text{ etc.}$$

Thus, the following linear approximations are obtained:

$$\begin{aligned}
\frac{\partial f_m}{\partial s} & \doteq \frac{f_m(s + \Delta s, g, \dots) - f_m}{\Delta s}, \dots, \frac{\partial f_m}{\partial EI} \doteq \frac{f_m(s, \dots, EI + \Delta EI) - f_m}{\Delta EI} \\
\frac{\partial f_n}{\partial s} & \doteq \frac{f_n(s + \Delta s, g, \dots) - f_n}{\Delta s} \\
\frac{\partial D}{\partial s} & \doteq \frac{D(s + \Delta s, g, \dots) - D}{\Delta s} \qquad \frac{\partial D}{\partial EI} \doteq \frac{D(s, \dots, EI + \Delta EI) - D}{\Delta EI}
\end{aligned} \tag{4}$$

By this procedure, a numerical value is obtained for each of the entries of the partial differential matrix described above in equation (1). After this matrix is obtained, its inverse matrix, A, is found. Now one can write the finite differences of the set [s, g, E, sI, gI, EI] in terms of the finite differences of the set [fm, fn, C, Ym, Yn, D]. This equation has the form

$$\begin{bmatrix} \Delta s \\ \Delta g \\ \Delta E \\ \Delta sI \\ \Delta gI \\ \Delta EI \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} & A_{14} & A_{15} & A_{16} \\ A_{21} & A_{22} & A_{23} & A_{24} & A_{25} & A_{26} \\ A_{31} & & & & & \\ A_{41} & & & & & \\ A_{51} & & & & & \\ A_{61} & & & & & A_{66} \end{bmatrix} \begin{bmatrix} \Delta fm \\ \Delta fn \\ \Delta C \\ \Delta Ym \\ \Delta Yn \\ \Delta D \end{bmatrix} \quad (5)$$

One now chooses Δfm to be the difference between the experimentally measured value, fm_{ex} and the value fm_o calculated from the estimated ceramic parameters, and likewise for the other quantities. Thus

$$\Delta fm = fm_{ex} - fm_o,$$

$$\Delta fn = fn_{ex} - fn_o,$$

$$\Delta C = C_{ex} - C_o,$$

$$\Delta Ym = Ym_{ex} - Ym_o, \quad (6)$$

$$\Delta Yn = Yn_{ex} - Yn_o,$$

$$\text{and } \Delta D = D_{ex} - D_o.$$

After the matrix multiplication indicated in equation (5) is completed, the resulting changes in the material parameters $[\Delta s, \Delta g, \Delta E, \Delta sl, \Delta gl, \Delta EI]$ are added to the initial estimates $[s, g, E, sl, gl, EI]$ to obtain the first corrected set of material parameters $[s, g, E, sl, gl, EI]$. If the equations were nothing more than a linear set of equations, this corrected set of material parameters would be the exact solution which goes with the experimentally measured quantities. But since this is not the case, this corrected set of material parameters $[s, g, E, sl, gl, EI]$ is substituted into equation (1) to obtain a second calculated set $[fm, fn, C, Ym, Yn, D]$. To insure a refinement, a new set of increments $[\Delta s, \Delta g, \Delta E, \Delta sl, \Delta gl, \Delta EI]$ is also formed, each member of which is formed from the old increments by multiplying such increments by 0.1: $\Delta s = \Delta s \cdot 0.1$, etc. Thus, starting with the procedure described below equation (2), this iteration may be repeated as many times as desired. The iteration is terminated if each of the following terms is less than the corresponding member of some preset list of increments.

$$\left| \frac{fm_{ex} - fm}{fm_{ex}} \right| < \delta fm$$

$$\left| \frac{fn_{ex} - fn}{fn_{ex}} \right| < \delta fn$$

$$\left| \frac{C_{ex} - C}{C_{ex}} \right| < \delta C$$

(7)

$$\left| \frac{Ym_{ex} - Ym}{Ym_{ex}} \right| < \delta Ym$$

$$\left| \frac{Yn_{ex} - Yn}{Yn_{ex}} \right| < \delta Yn$$

$$\left| \frac{D_{ex} - D}{D_{ex}} \right| < \delta D$$

This test is made just following the calculation of each corrected set of material parameters. With $\delta f_m = \delta f_n = \delta C = .3 \times 10^{-4}$ and $\delta Y_m = \delta Y_n = \delta D = 10^{-3}$, not more than two iterations are in general necessary if one uses reasonably good initial estimates of the material parameters.

A word of caution is appropriate here. The program can converge to impossible parameters if there are errors in the transducer input data or experimental data. Therefore, close inspection of the results should be made to insure validity.

Figure E.1 shows a diagram of the transducer used in the find parameters example, and the associated interconnection schematic. Figure E.2 shows a listing of the required control routine and printed output.

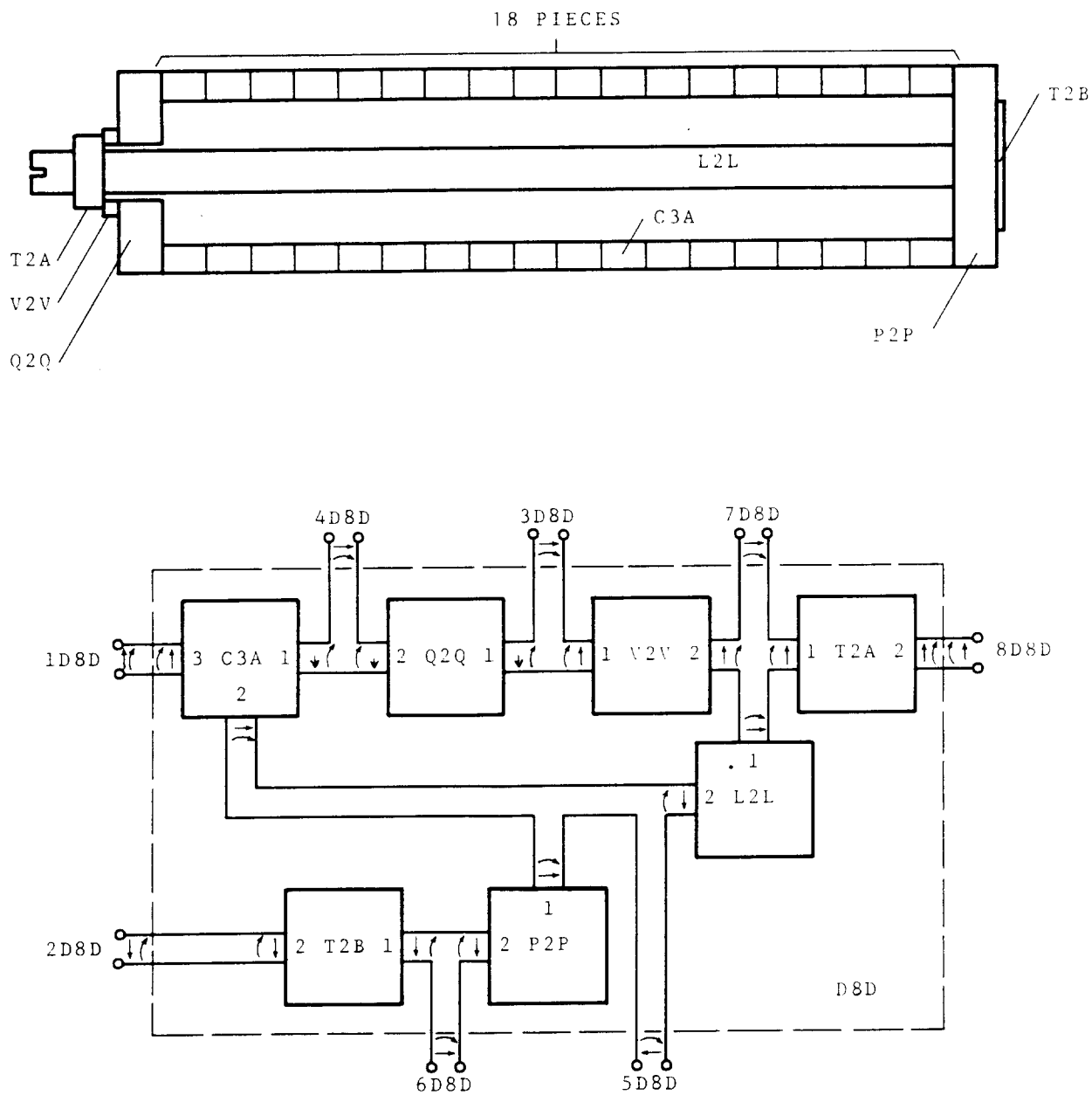


Figure E.1. Transducer Diagram And Interconnection Schematic.

Figure E.2.

Listing and Output of the Control
Routine Used in Find Parameters.

Figure E.2. (Continued).

[illegible]

THUG.P SEADUCEK RUN 8000 FOR TP-228 APPENDIX E.

JASGOT B. 10,279
 • SEAFUENK VERSION 1 (DOUBLE PRECISION)

SEADUCER RUN 00006 FOR TP-22B APPENDIX E

SCUPIN B., TFS.
FURPUR 023A-10/20-13:30
112 SYM 112 REL

DATE 102072 PAGE 1

IFREE 8.

Figure E.2. (Continued).

SEADUCER RUN 80006 FOR TP-228 APPENDIX E

WFOR,IS CONTRL,CONTRL
FOR 0010-10/20/72-13:36:55 (,0)

MAIN PROGRAM

STORAGE USED: CODE(1) 0003331 DATA(0) 0002231 BLANK COMMON(2) 003720

COMMON BLOCKS:

0003 BASIC8 000006
0004 DATOT 000001

EXTERNAL REFERENCES (BLOCK, NAME)

0005 SETCLK
0006 PAGE
0007 SIRLIN
0010 LDPORT
0011 LDOT1
0012 LDOT2
0013 LDOT11
0014 TIME
0015 ENDERM
0016 PRPTBL
0017 PRCTLG
0020 WINTRS
0021 NPRTS
0022 NIOT5
0023 NSTOPS

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

0000 000000 5F 0002 0 000000 DATA 0003 0 000000 DF 0003 0 000002 DOMEGA 0003 0 000004 DPI
0004 1 000000 MXDATA

CONTRL
CONTRL

00101 1* DOUBLE PRECISION DATA
00103 2* DOUBLE PRECISION DF, DOMEGA, DPI
00104 3* COMMON / BASIC 8 / U, F, D OMEGA, D PI
00105 4* COMMON / DTA TOT / MX DATA
00106 5* COMMON / DATA(1000)
00107 6* MX DATA = 1000
00110 7*
00110 8* CALL SETCLK
00111 9* CALL PAGE
00112 10* CALL STR LIN
00113 11* PRINT 5
00115 12* 5 FORMAT(, SEADUCER RUN 80006 (LIKE MOD 7 RUN 70443) MAY 14, 1970,
/ , TO CHECKOUT FIND PARAMETERS ,)
00116 13*
00116 14* CALL LD POKT('S', '1080', '3C3A', 'S')
00116 15* CALL LD POKT('S', '2080', '2T2B', 'S')
00117 16* CALL LD POKT('S', '3080', '1Q2U', '1V2V', 'S')
00120 17*

Figure E.2. (Continued).

```

00121 18* CALL LD PORT('S', '4080', 1C3A, -+2020,'S')
00122 19* CALL LD PORT('S', '5080', 1P2P, -+2C3A,'S')
00123 20* CALL LD PORT('S', '6080', 2P2P, -+1T2B,'S')
00124 21* CALL LD PORT('S', '7080', 1L2L, 1T2A, -+2V2V,'S')
00125 22* CALL LD PORT('S', '8080', 2T2A,'S')
00126 23*
00126 24* CALL LD DT 1
00126 25* / ('T2A1S', 7663.51, .0766601E-2,0.0., 3.55801E-3, 5043.8,0.0.0.)
00127 26* CALL LD DT 2
00127 27* / ('T2A2S', 7663.51, .0766601E-2,0.0.0.,
00127 28* .0467602E-2,0.0.0., 4.06401E-3, 5043.8,0.0.0.)
00127 29*
00130 30* CALL LD DT 1
00130 31* / ('T2A3S', 7663.51, .0467602E-2,0.0.0., 10.4648E-3, 5043.8,0.0.0.)
00131 32* CALL LD DT 1
00131 33* / ('V2V1S', 7696.86, .101971E-2,0.0.0., 3.14961E-3, 5116.0,0.0.0.)
00132 34* CALL LD DT 1
00132 35* / ('G201S', 7822.86, .427004E-2,0.0.0., 31.7628E-3, 5116.0,0.0.0.)
00133 36* CALL LD DT 1
00133 37* / ('P2P1S', 7919.77, .455735E-2,0.0.0., 31.7628E-3, 5116.0,0.0.0.)
00134 38* CALL LD DT 1
00134 39* / ('T2P1S', 7807.65, .0255E-2,0.0.0., 3.73381E-3, 5043.8,0.0.0.)
00135 40* CALL LD DT 1
00135 41* / ('L2L1S', 7807.65, .0255E-2,0.0.0., 10.4902E-3, 5043.8,0.0.0.)
00136 42* CALL LD DT 1
00136 43* / ('L2L2S', 7807.65, .0285785E-2,0.0.0., 35.1791E-3, 5043.8,0.0.0.)
00137 44* CALL LD DT 1
00137 45* / ('L2L3S', 7807.65, .0198250E-2,0.0.0., 329.286E-3, 5043.8,0.0.0.)
00140 46* CALL LD DT 1
00140 47* / ('L2L4S', 7807.65, .0255E-2,0.0.0., 3.87351E-3, 5043.8,0.0.0.)
00141 48* CALL LD DT 11('C3A', 18.7555., .253355E-2,0.0.0., 19.1065E-3,
00141 49* E 1325.18E-6, 0.00, .00229500,
00141 50* G .0220500, 0.00, .000355300,
00142 51* S .906160J-11, 0.00, .00173100 )
00142 52*
00143 53* CALL TIME
00143 54* CALL END PRM('CA', 3526., 4268., .130, 2.43E-6,
00143 55* / 26261.3E-12, .0017065, 500., 3 )
00144 56* CALL TIME
00144 57* CALL PAGE
00145 58* CALL PR PT-1L
00145 59* CALL PAGE
00146 60* CALL PR CTG
00147 61* CALL PAGE
00148 62* CALL TIME
00149 63* STOP
00150 64* END

```

END OF COMPILATION: NO DIAGNOSTICS.

Figure E.2. (Continued).

QPREP IPFS
 FURBUR 023A-10/20-13:37

UPRT, T IPFS.

LM6010314522*IPFS ELEMENT TABLE

Q NAME	VERSION	TYPE	DATE	TIME	SEQ #	SIZE-PRG+TEXT	(CYCLE WORD)	PSRMODE	LOCATION
* CONTRL		FOR SYMB	28 MAR 72	23:16:43	1	26	5	0	1792
* CONTRL		RELOCATABLE	28 MAR 72	23:16:45	2	38	5	0	1818
LDPORT		FOR SYMB	28 MAR 72	23:16:45	3	20	5	0	1859
LDPORT		RELOCATABLE	28 MAR 72	23:16:47	4	15	5	0	1879
BDMTR		FOR SYMB	28 MAR 72	23:16:48	5	10	5	0	1896
BDMTR		RELOCATABLE	28 MAR 72	23:16:49	6	11	5	0	1915
BDMTR		FOR SYMB	28 MAR 72	23:16:50	7	26	5	0	1928
BDMTR		RELOCATABLE	28 MAR 72	23:16:52	8	16	5	0	1954
BDMTR		FOR SYMB	28 MAR 72	23:16:53	9	30	5	0	1973
BDMTR		RELOCATABLE	28 MAR 72	23:16:55	10	30	5	0	2012
LDREQ		FOR SYMB	28 MAR 72	23:16:56	11	3	5	0	2044
LDREQ		RELOCATABLE	28 MAR 72	23:16:57	12	11	5	0	2048
UPRTBL		FOR SYMB	28 MAR 72	23:16:58	13	17	5	0	2053
UPRTBL		RELOCATABLE	28 MAR 72	23:17:00	14	17	5	0	2064
ENDLCJ		FOR SYMB	28 MAR 72	23:17:02	15	11	5	0	2073
ENDLCJ		RELOCATABLE	28 MAR 72	23:17:03	16	8	5	0	2090
ALOCAT		FOR SYMB	28 MAR 72	23:17:04	17	4	5	0	2103
ALOCAT		RELOCATABLE	28 MAR 72	23:17:06	18	3	5	0	2111
CHKSTR		FOR SYMB	28 MAR 72	23:17:06	19	3	5	0	2117
CHKSTR		RELOCATABLE	28 MAR 72	23:17:07	20	9	5	0	2120
ENDNET		FOR SYMB	28 MAR 72	23:17:07	21	6	5	0	2125
ENDNET		RELOCATABLE	28 MAR 72	23:17:08	22	4	5	0	2141
LOCNTR		FOR SYMB	28 MAR 72	23:17:09	23	3	5	0	2145
LOCNTR		RELOCATABLE	28 MAR 72	23:17:10	24	3	5	0	2149
LOCNAM		FOR SYMB	28 MAR 72	23:17:11	25	3	5	0	2152
LOCNAM		RELOCATABLE	28 MAR 72	23:17:12	26	4	5	0	2156
ENDNTR		FOR SYMB	28 MAR 72	23:17:13	27	3	5	0	2160
ENDNTR		RELOCATABLE	28 MAR 72	23:17:13	28	3	5	0	2164
ENDNTR		FOR SYMB	28 MAR 72	23:17:15	29	3	5	0	2167
ENDNTR		RELOCATABLE	28 MAR 72	23:17:15	30	16	5	0	2171
CASCODE		FOR SYMB	28 MAR 72	23:17:17	31	9	5	0	2187
CASCODE		RELOCATABLE	28 MAR 72	23:17:18	32	15	5	0	2198
TYPICAL		FOR SYMB	28 MAR 72	23:17:19	33	12	5	0	2213
TYPICAL		RELOCATABLE	28 MAR 72	23:17:20	34	23	5	0	2227
LDOT1		FOR SYMB	28 MAR 72	23:17:22	35	13	5	0	2250
LDOT1		RELOCATABLE	28 MAR 72	23:17:23	36	13	5	0	2269
LDOT1		FOR SYMB	28 MAR 72	23:17:24	37	9	5	0	2282
LDOT1		RELOCATABLE	28 MAR 72	23:17:25	38	25	5	0	2293
LDOT2		FOR SYMB	28 MAR 72	23:17:27	39	19	5	0	2318
LDOT2		RELOCATABLE	28 MAR 72	23:17:29	40	17	5	0	2339
LDOT2		FOR SYMB	28 MAR 72	23:17:30	41	13	5	0	2356
LDOT2		RELOCATABLE	28 MAR 72	23:17:30	42	10	5	0	2371
LDOT4		FOR SYMB	28 MAR 72	23:17:30	43	10	5	0	2371

Figure E.2. (Continued).

LDUT4	RELUCATABLE	28 MAR 72	23:17:32	44	2	13	5	0	1	2300
LDUT5	FOR SYMB	28 MAR 72	23:17:33	45		17				2405
LDUT6	RELUCATABLE	28 MAR 72	23:17:34	46	2	11	5	0	1	2422
LDUT7	FOR SYMB	28 MAR 72	23:17:36	47		30				2435
LDUT7	RELUCATABLE	28 MAR 72	23:17:38	48	2	30	5	0	1	2486
LDUT7	FOR SYMB	28 MAR 72	23:17:39	49		28				2518
LDUT7	RELUCATABLE	28 MAR 72	23:17:42	50	1	23	5	0	1	2546
LDUT8	FOR SYMB	28 MAR 72	23:17:42	51		22				2570
LDUT8	RELUCATABLE	28 MAR 72	23:17:44	52	3	20	5	0	1	2592
LDUT9	FOR SYMB	28 MAR 72	23:17:46	53		22				2615
LDUT9	RELUCATABLE	28 MAR 72	23:17:48	54	3	20	5	0	1	2637
LDUT10	FOR SYMB	28 MAR 72	23:17:49	55		26				2660
LDUT11	RELUCATABLE	28 MAR 72	23:17:51	56	3	19	5	0	1	2686
LDUT11	FOR SYMB	28 MAR 72	23:17:52	57		31				2708
LDUT11	RELUCATABLE	28 MAR 72	23:17:55	58	2	29	5	0	1	2739
LDUT11	FOR SYMB	28 MAR 72	23:17:57	59		11				2770
LDUT11	RELUCATABLE	28 MAR 72	23:17:58	60	2	11	5	0	1	2781
LDUT14	FOR SYMB	28 MAR 72	23:17:58	61		25				2794
LDUT14	RELUCATABLE	28 MAR 72	23:18:00	62	3	19	5	0	1	2819
LDUT14	FOR SYMB	28 MAR 72	23:18:00	63		3				2841
LDUT14	RELUCATABLE	28 MAR 72	23:18:01	64	1	2	5	0	1	2844
LDUT15	FOR SYMB	28 MAR 72	23:18:03	65		26				2847
LDUT15	RELUCATABLE	28 MAR 72	23:18:04	66	3	21	5	0	1	2873
LDUT15	FOR SYMB	28 MAR 72	23:18:05	67		3				2897
LDUT15	RELUCATABLE	28 MAR 72	23:18:06	68	1	2	5	0	1	2900
LDUT15	FOR SYMB	28 MAR 72	23:18:07	69		9				2903
LDUT15	RELUCATABLE	28 MAR 72	23:18:08	70	2	10	5	0	1	2912
LDUT15	FOR SYMB	28 MAR 72	23:18:09	71		13				2924
LDUT15	RELUCATABLE	28 MAR 72	23:18:11	72	2	20	5	0	1	2943
LDUT20	FOR SYMB	28 MAR 72	23:18:12	73		19				2955
LDUT20	RELUCATABLE	28 MAR 72	23:18:13	74	2	14	5	0	1	2984
LDUT20	FOR SYMB	28 MAR 72	23:18:14	75		13				3000
LDUT20	RELUCATABLE	28 MAR 72	23:18:15	76	2	10	5	0	1	3013
LDUT21	FOR SYMB	28 MAR 72	23:18:16	77		17				3025
LDUT21	RELUCATABLE	28 MAR 72	23:18:18	78	2	12	5	0	1	3042
LDUT21	FOR SYMB	28 MAR 72	23:18:19	79		5				3056
LDUT21	RELUCATABLE	28 MAR 72	23:18:21	80	1	3	5	0	1	3061
LDUT22	FOR SYMB	28 MAR 72	23:18:21	81		17				3065
LDUT22	RELUCATABLE	28 MAR 72	23:18:22	82	2	12	5	0	1	3092
LDUT22	FOR SYMB	28 MAR 72	23:18:22	83		5				3096
LDUT22	RELUCATABLE	28 MAR 72	23:18:24	84	1	4	5	0	1	3101
LDUT24	FOR SYMB	28 MAR 72	23:18:25	85		17				3106
LDUT24	RELUCATABLE	28 MAR 72	23:18:26	86	2	12	5	0	1	3123
LDUT24	FOR SYMB	28 MAR 72	23:18:27	87		5				3137
LDUT24	RELUCATABLE	28 MAR 72	23:18:28	88	1	4	5	0	1	3142
LDUT25	FOR SYMB	28 MAR 72	23:18:29	89		17				3147
LDUT25	RELUCATABLE	28 MAR 72	23:18:30	90	2	12	5	0	1	3164
LDUT25	FOR SYMB	28 MAR 72	23:18:31	91		5				3178
LDUT25	RELUCATABLE	28 MAR 72	23:18:32	92	1	4	5	0	1	3183
LDUT26	FOR SYMB	28 MAR 72	23:18:33	93		19				3207
LDUT26	RELUCATABLE	28 MAR 72	23:18:34	94	2	14	5	0	1	3223
LDUT26	FOR SYMB	28 MAR 72	23:18:35	95		14				3237
LDUT26	RELUCATABLE	28 MAR 72	23:18:37	96	2	13	5	0	1	3252
LDUT26	FOR SYMB	28 MAR 72	23:18:37	97		12				3264
LDUT26	RELUCATABLE	28 MAR 72	23:18:39	98	1	8	5	0	1	3273
LDUT26	FOR SYMB	28 MAR 72	23:18:39	99		9				3277
LDUT26	RELUCATABLE	28 MAR 72	23:18:40	100	1	9				

Figure E.2. (Continued).

LZ2HY2	FOR SYMB	28 MAR 72	23:18:40	101		4	5	0	1	3280
LZ2HY2	RELOCATABLE	28 MAR 72	23:18:42	102	1	2				3284
LZ3UY3	FOR SYMB	28 MAR 72	23:18:42	103		4	5	0	1	3287
LZ3UY3	RELOCATABLE	28 MAR 72	23:18:43	104	1	2				3291
LZ6Y2	FOR SYMB	28 MAR 72	23:18:44	105		4	5	0	1	3294
LZ6Y2	RELOCATABLE	28 MAR 72	23:18:45	106	1	2				3298
LY3UY3	FOR SYMB	28 MAR 72	23:18:46	107		4	5	0	1	3301
LY3UY3	RELOCATABLE	28 MAR 72	23:18:47	108	1	2				3305
LDDRI1	FOR SYMB	28 MAR 72	23:18:48	109		5	5	0	1	3308
LDDRI1	RELOCATABLE	28 MAR 72	23:18:49	110	1	4				3313
LDSB11	FOR SYMB	28 MAR 72	23:18:49	111		7	5	0	1	3318
LDSB11	RELOCATABLE	28 MAR 72	23:18:51	112	1	3				3325
LS1415	FOR SYMB	28 MAR 72	23:18:51	113		6	5	0	1	3329
LS1415	RELOCATABLE	28 MAR 72	23:18:52	114	1	3				3335
FNDTMS	FOR SYMB	28 MAR 72	23:18:53	115		9	5	0	1	3339
FNDTMS	RELOCATABLE	28 MAR 72	23:18:54	116	2	5				3348
FNDT1	FOR SYMB	28 MAR 72	23:18:55	117		13	5	0	1	3355
FNDT1	RELOCATABLE	28 MAR 72	23:18:56	118	2	9				3368
MTRMOV	FOR SYMB	28 MAR 72	23:18:57	119		4	5	0	1	3379
MTRMOV	RELOCATABLE	28 MAR 72	23:18:58	120	1	3				3383
MTRMUL	FOR SYMB	28 MAR 72	23:18:59	121		12	5	0	1	3387
MTRMUL	RELOCATABLE	28 MAR 72	23:19:00	122	1	11				3399
DLETRC	FOR SYMB	28 MAR 72	23:19:01	123		11	5	0	1	3411
DLETRC	RELOCATABLE	28 MAR 72	23:19:03	124	1	7				3422
LDIMTR	FOR SYMB	28 MAR 72	23:19:03	125		4	5	0	1	3430
LDIMTR	RELOCATABLE	28 MAR 72	23:19:04	126	1	4				3434
DECOMB	FOR SYMB	28 MAR 72	23:19:06	127		45	5	0	1	3439
DECOMB	RELOCATABLE	28 MAR 72	23:19:10	128	2	55				3484
AT0Z	FOR SYMB	28 MAR 72	23:19:10	129		10	5	0	1	3541
AT0Z	RELOCATABLE	28 MAR 72	23:19:12	130	2	9				3551
ZTOA	FOR SYMB	28 MAR 72	23:19:13	131		10	5	0	1	3562
ZTOA	RELOCATABLE	28 MAR 72	23:19:15	132	2	9				3572
ATOY	FOR SYMB	28 MAR 72	23:19:16	133		9	5	0	1	3583
ATOY	RELOCATABLE	28 MAR 72	23:19:17	134	2	11				3592
YTOA	FOR SYMB	28 MAR 72	23:19:18	135		9	5	0	1	3605
YTOA	RELOCATABLE	28 MAR 72	23:19:19	136	2	11				3614
DACMUL	FOR SYMB	28 MAR 72	23:19:20	137		3	5	0	1	3627
DACMUL	RELOCATABLE	28 MAR 72	23:19:21	138	1	2				3630
DCMMUL	FOR SYMB	28 MAR 72	23:19:22	139		3	5	0	1	3633
DCMMUL	RELOCATABLE	28 MAR 72	23:19:23	140	1	2				3636
DCMDIV	FOR SYMB	28 MAR 72	23:19:24	141		3	5	0	1	3639
DCMDIV	RELOCATABLE	28 MAR 72	23:19:25	142	1	3				3642
DCRCIP	FOR SYMB	28 MAR 72	23:19:25	143		3	5	0	1	3646
DCRCIP	RELOCATABLE	28 MAR 72	23:19:27	144	1	2				3649
DCSURT	FOR SYMB	28 MAR 72	23:19:28	145		10	5	0	1	3652
DCSURT	RELOCATABLE	28 MAR 72	23:19:29	146	1	9				3662
DCANG1	FOR SYMB	28 MAR 72	23:19:30	147		8	5	0	1	3672
DCANG1	RELOCATABLE	28 MAR 72	23:19:31	148	1	6				3680
DCACSH	FOR SYMB	28 MAR 72	23:19:32	149		5	5	0	1	3687
DCACSH	RELOCATABLE	28 MAR 72	23:19:33	150	1	4				3692
DSHCH	FOR SYMB	28 MAR 72	23:19:34	151		4	5	0	1	3697
DSHCH	RELOCATABLE	28 MAR 72	23:19:35	152	1	3				3701
DSNCNS	FOR SYMB	28 MAR 72	23:19:36	153		5	5	0	1	3705
DSNCNS	RELOCATABLE	28 MAR 72	23:19:37	154	1	3				3710
DCSHCH	FOR SYMB	28 MAR 72	23:19:37	155		5	5	0	1	3714
DCSHCH	RELOCATABLE	28 MAR 72	23:19:39	156	1	3				3719
PRMTR	FOR SYMB	28 MAR 72	23:19:40	157		5	5	0	1	3723

Figure E.2. (Continued).

PRIMR	RELOCATABLE	28 MAR 72	23:19:41	158	1	5	5	0	1	3728
PRIMBN	FOR SYMB	28 MAR 72	23:19:42	159	1	5	5	0	1	3734
PRIMBN	RELOCATABLE	28 MAR 72	23:19:43	160	1	5	5	0	1	3739
PRMARI	FOR SYMB	28 MAR 72	23:19:43	161	2	6	6	0	1	3745
PRMARI	RELOCATABLE	28 MAR 72	23:19:45	162	2	6	6	0	1	3753
HEAD24	FOR SYMB	28 MAR 72	23:19:45	163	1	6	6	0	1	3761
HEAD24	RELOCATABLE	28 MAR 72	23:19:47	164	1	6	6	0	1	3767
PAGE	FOR SYMB	28 MAR 72	23:19:48	165	1	2	2	0	1	3774
PAGE	RELOCATABLE	28 MAR 72	23:19:49	166	1	2	2	0	1	3775
STRLIN	FOR SYMB	28 MAR 72	23:19:49	167	1	2	2	0	1	3778
STRLIN	RELOCATABLE	28 MAR 72	23:19:51	168	1	2	2	0	1	3780
SKPLIN	FOR SYMB	28 MAR 72	23:19:51	169	1	2	2	0	1	3783
SKPLIN	RELOCATABLE	28 MAR 72	23:19:52	170	1	2	2	0	1	3785
PRPTBL	FOR SYMB	28 MAR 72	23:19:53	171	1	5	5	0	1	3788
PRPTBL	RELOCATABLE	28 MAR 72	23:19:54	172	1	5	5	0	1	3795
PRCTLG	FOR SYMB	28 MAR 72	23:19:55	173	1	5	5	0	1	3795
PRCTLG	RELOCATABLE	28 MAR 72	23:19:55	174	2	5	5	0	1	3801
UNPACK	FOR SYMB	28 MAR 72	23:19:57	175	1	26	26	0	1	3807
UNPACK	RELOCATABLE	28 MAR 72	23:19:59	176	1	22	22	0	1	3814
BLKOTA	FOR SYMB	28 MAR 72	23:20:00	177	1	15	15	0	1	3840
BLKOTA	RELOCATABLE	28 MAR 72	23:20:00	178	4	5	5	0	1	3863
TIME	FOR SYMB	28 MAR 72	23:20:01	179	1	5	5	0	1	3878
TIME	RELOCATABLE	28 MAR 72	23:20:02	180	1	3	3	0	1	3885
ZLT022	FOR SYMB	28 MAR 72	23:20:03	181	1	6	6	0	1	3890
ZLT022	RELOCATABLE	28 MAR 72	23:20:04	182	1	6	6	0	1	3894
DCPCT2	FOR SYMB	28 MAR 72	23:20:05	183	1	7	7	0	1	3902
DCPCT2	RELOCATABLE	28 MAR 72	23:20:06	184	1	7	7	0	1	3909
FNDKRC	FOR SYMB	28 MAR 72	23:20:07	185	2	26	26	0	1	3918
FNDKRC	RELOCATABLE	28 MAR 72	23:20:09	186	2	20	20	0	1	3926
SRCHBC	FOR SYMB	28 MAR 72	23:20:12	187	4	101	101	0	1	3952
SRCHBC	RELOCATABLE	28 MAR 72	23:20:16	188	4	76	76	0	1	3974
MINCHK	FOR SYMB	28 MAR 72	23:20:16	189	1	3	3	0	1	4075
MINCHK	RELOCATABLE	28 MAR 72	23:20:18	190	1	3	3	0	1	4155
MAXCHK	FOR SYMB	28 MAR 72	23:20:18	191	1	3	3	0	1	4158
MAXCHK	RELOCATABLE	28 MAR 72	23:20:19	192	1	2	2	0	1	4164
CMPZ5	FOR SYMB	28 MAR 72	23:20:19	193	2	5	5	0	1	4167
CMPZ5	RELOCATABLE	28 MAR 72	23:20:21	194	2	3	3	0	1	4172
PREPZV	FOR SYMB	28 MAR 72	23:20:22	195	2	16	16	0	1	4177
PREPZV	RELOCATABLE	28 MAR 72	23:20:23	196	2	19	19	0	1	4193
FNDZV	FOR SYMB	28 MAR 72	23:20:24	197	2	7	7	0	1	4213
FNDZV	RELOCATABLE	28 MAR 72	23:20:25	198	2	5	5	0	1	4220
LDZVR	FOR SYMB	28 MAR 72	23:20:25	199	2	5	5	0	1	4232
LDZVR	RELOCATABLE	28 MAR 72	23:20:27	200	2	3	3	0	1	4237
SRMIDB	FOR SYMB	28 MAR 72	23:20:29	201	4	57	57	0	1	4294
SRMIDB	RELOCATABLE	28 MAR 72	23:20:32	202	4	50	50	0	1	4348
LDAMZ5	FOR SYMB	28 MAR 72	23:20:33	203	3	15	15	0	1	4367
LDAMZ5	RELOCATABLE	28 MAR 72	23:20:34	204	3	16	16	0	1	4385
CMPGAM	FOR SYMB	28 MAR 72	23:20:36	205	2	14	14	0	1	4401
CMPGAM	RELOCATABLE	28 MAR 72	23:20:37	206	2	14	14	0	1	4417
FSRCH	FOR SYMB	28 MAR 72	23:20:41	207	5	123	123	0	1	4559
FSRCH	RELOCATABLE	28 MAR 72	23:20:48	208	2	10	10	0	1	4687
RLIMMG	FOR SYMB	28 MAR 72	23:20:48	209	2	6	6	0	1	4697
RLIMMG	RELOCATABLE	28 MAR 72	23:20:49	210	2	5	5	0	1	4705
FMEN	FOR SYMB	28 MAR 72	23:20:50	211	2	5	5	0	1	4711
FMEN	RELOCATABLE	28 MAR 72	23:20:51	212	1	14	14	0	1	4718
POLE0	FOR SYMB	28 MAR 72	23:20:52	213	1	15	15	0	1	4732
POLE0	RELOCATABLE	28 MAR 72	23:20:54	214						

Figure E.2. (Continued).

PRFIT	FOR SYMB	28 MAR 72	23:20:54	215	9	5	0	1	4746
PRFIT	RELOCATABLE	28 MAR 72	23:20:55	216	1	7			4755
PRPRM	FOR SYMB	28 MAR 72	23:20:57	217	40	5	0	1	4763
PRPRM	RELOCATABLE	28 MAR 72	23:21:00	218	29	5	0	1	4803
PRDFP	FOR SYMB	28 MAR 72	23:21:00	219	8	5	0	1	4836
PRDFP	RELOCATABLE	28 MAR 72	23:21:01	220	3	5	0	1	4844
PRDFP	FOR SYMB	28 MAR 72	23:21:02	221	6	5	0	1	4849
PRDFP	RELOCATABLE	28 MAR 72	23:21:03	222	4	5	0	1	4855
PRPRM	FOR SYMB	28 MAR 72	23:21:04	223	14	5	0	1	4861
PRPRM	RELOCATABLE	28 MAR 72	23:21:05	224	9	5	0	1	4875
CONTR	FOR SYMB	20 OCT 72	13:36:55	225	17	5	0	1	4886
CONTR	RELOCATABLE	20 OCT 72	13:37:04	226	22	5	0	1	4903
CONTR	RELOCATABLE	20 OCT 72	13:37:04	226	22	5	0	1	4927

NEXT AVAILABLE LOCATION

ASSEMBLER PROCEDURE TABLE EMPTY

COBOL PROCEDURE TABLE EMPTY

FORTRAN PROCEDURE TABLE EMPTY

ENTRY POINT TABLE

U NAME	LINK	U NAME	LINK	U NAME	LINK	U NAME	LINK	D NAME	LINK
ALDOD	78	ALOCAT	18	ATCY	134	ATZ	130	BLOCKL	130
3LDMTH	6	CASCOE	32	CHKSTP	20	CMFGAM	206	CMPZS	194
DACMUL	138	OCACSH	150	DCANG1	148	DCMDIV	142	DCMMUL	140
DCPCT2	134	DCPCIP	144	DCSHCH	156	DCSNCS	154	DCSGRT	146
DECOM6	129	DELETRC	124	DSHCH	152	FMFN	212	ENDFDP	220
FNDFZV	178	FNDRKRC	186	FNOLCU	16	FNDMTR	28	FNHMAN	30
ENUNET	42	FNDRPRM	218	FNDTL	118	FORMAINS	116	FORMAINS	222
FSRCH	208	HEAD24	164	LA2RY2	100	LDAM2S	204	LDRCOL	222
LDURIM	110	LDUT1	36	LDUT11	56	LDUT14	62	LDUT15	66
LDUT2	40	LDUT20	74	LDUT21	78	LDUT22	82	LDUT24	86
LDUT25	50	LDUT25	94	LDUT4	44	LDUT5	46	LDUT7	48
LDUT8	52	LDUT9	54	LDUT10	12	LDUT11	126	LDUT12	4
LDUT11	112	LDUT12	200	LDUT13	24	LDUT14	26	LDUT15	114
LY2RY2	105	LY3RY3	108	LY4RY4	102	LY5RY5	104	MAXCHK	192
MINCHK	190	MINCHK	120	MINCHK	122	MINCHK	166	POLE0	214
PRFIT	216	PRFIT	174	PRFIT	196	PRFIT	162	PRFIT	172
PRFIT	130	PRFIT	158	PRFIT	224	PRFIT	10	RLIMMG	210
SKPLIN	170	SKPLIN	188	SKPLIN	202	SKPLIN	168	TIME	180
TP1415	72	TP1415	34	TP1415	38	TP1415	58	TYPE14	64
TYPE15	68	TYPE15	42	TYPE15	76	TYPE15	80	TYPE22	64
TYPE24	38	TYPE24	92	TYPE24	96	TYPE24	50	TYPE22	60
TI4155	70	TI4155	176	TI4155	14	TI4155	136	TI4155	132
Z11022	132	Z11022	176	Z11022	14	Z11022	136	Z11022	132

Figure E.2. (Continued).

MAP,X1B SYMRUN,ABSRU,4
MAP 0022-10/20-13:37 -(,0)

1. IN CONTRL

2. IN BLKOTA

ADDRESS LIMITS 001000 031614 040000 056710
STARTING ADDRESS 031262

WORDS DECIMAL 12005 10ANK 7625 09ANK

SEGMENT	MAIN	001000	031614	040000	056710
NBDCVS/FORS7	1	001000	001133	2	040000 040037
NFTVS/FOR	1	001134	001156	2	040040 040127
NCHVTs/FORS7	1	001137	001411	2	040130 040232
NIOERS/FORS7	1	001412	001530	2	040233 040263
NQUTS/FORS7-UNIV	1	001531	002500	2	040264 040302
NFTS/FORS7	1	002501	003405	2	040303 040341
NTABs/FOR					
ERUS/57					
DEXPS/FORS4	1	003406	003554	2	040342 040375
ULOGs/FORS4	1	003555	003675	2	040376 040502
DSINCOs/FORS7	1	003676	004037	2	040503 040561
DATANS/FORS4	1	004040	004166	2	040562 040644
DSWRTs/FORS7	1	004167	004236	2	040645 040663
ULOG10s/FORS4	1	004237	004247	2	040664 040667
NEAP1s/FORS4	1	004256	004303	0	040670 040670
SGRTs/FORS5	1	004304	004343	2	040671 040702
NERES/FORS7-NUC	1	004344	004705	2	040703 041057
POSTOPs/NUC	1	004706	004731	2	041060 041066
NIERS/FORS2	1	004732	005014	2	041067 041216
NOSTMS/FORS7	1	005015	005247	2	041217 041224
NINTRs/NUC	1	005250	005304	2	041225 041244
DATE-TIME/NUC-PAK	1	005305	005334	0	041245 041302
114155	1	005335	005577	0	041303 041326
	3	CS1415		2	BLANK\$COMMON
DSHCH	1	005630	005636	4	CM1415
LYJUY3	1	005637	005606	2	041327 041343
LD1-1TR	3	CY3BY3		0	BLANK\$COMMON
	1	005607	005757	2	041344 041354
CS1415 (COMMON BLOCK)				0	BLANK\$COMMON
				2	041355 041400
				2	BLANK\$COMMON
				2	041401 041404

Figure E.2. (Continued).

SEAUJECR RUN 80006 FOR TP-220 APPL. WIA E

TP1415	1	005700	006524	0	041405	041471
	3	CS1415		2	BLANK\$COMMON	
	3	CM1415		4	BASIC9	
UCSHCH	1	006505	006604	6	CZ3BY3	
UCACSH	1	006605	006676	0	041472	041510
LZ3UY3	1	006677	006726	2	BLANK\$COMMON	
	3	CZ3UY3		0	041511	041533
	1	006727	007153	2	BLANK\$COMMON	
LT0A	3	CA2UY2		0	041534	041544
	3			2	BLANK\$COMMON	
UC5HCS	1	007154	007236	2	041545	041603
LY2UY2	1	007237	007266	0	BLANK\$COMMON	
LZ2UY2	1	007267	007316	4	CZ2BY2	
LA2UY2	1	007317	007346	0	041604	041622
	3	CA2UY2		2	BLANK\$COMMON	
COM126 (COMMON BLOCK)				2	041623	041633
CY3UY3 (COMMON BLOCK)				0	BLANK\$COMMON	
TYPE26	1	007347	007714	2	041634	041644
	3	BASIC6		0	BLANK\$COMMON	
TYPE25	1	007715	007776	2	041645	041655
TYPE24	1	007777	010076	2	HLANK\$COMMON	
TYPE22	1	010077	010175	0	041656	041671
TYPE21	1	010176	010256	0	041672	041713
TYPE20	1	010257	010512	2	041714	041755
	3	BASIC6		2	BLANK\$COMMON	
CMN15C (COMMON BLOCK)				4	CY3BY3	
TYPE15	1	010513	010537	0	041756	041775
TYPE14	1	010538	010564	2	BLANK\$COMMON	
CZ3UY3 (COMMON BLOCK)				2	041776	042015
TYPE11	1	010565	011601	0	042016	042035
TYPE7	1	011602	012434	0	BLANK\$COMMON	
TYPE2	1	012435	012772	2	042036	042055
TYPE1	1	012773	013207	2	BLANK\$COMMON	
	3	BASIC6		0	042056	042143
CY2UY2 (COMMON BLOCK)				4	BLANK\$COMMON	
AT0Y	1	013210	013515	0	CA2BY2	
	3	CA2UY2		4	042144	042145
				0	042146	042152
				2	BLANK\$COMMON	
				0	042153	042157
				2	BLANK\$COMMON	
				0	042160	042201
				2	042202	042272
				0	BLANK\$COMMON	
				4	CMN11	
				0	042273	042365
				2	BLANK\$COMMON	
				0	042366	042506
				2	BLANK\$COMMON	
				4	CA2BY2	
				0	042507	042600
				2	BLANK\$COMMON	
				4	CA2BY2	
				0	042601	042610
				2	042611	042640
				0	BLANK\$COMMON	
				2		

Figure E.2. (Continued).

SEADUCER RUN 80006 FOR TP-22R APPENDIX E

DCSRT	1	021042	021270	2	BLANK\$COMMON
				0	044022 044056
HEAD24	1	021271	021413	2	BLANK\$COMMON
	3	CPTWRO		0	044057 044100
PRIPRM	1	021414	021551	2	BLANK\$COMMON
	3	CFNDPR		0	044101 044221
				4	BLANK\$COMMON
VALDET (COMMON BLOCK)	1	021552	023513	4	CNAMEFP
DECMR	3	VALDET		0	044222 044225
	5	DCMSUL		0	044226 044452
LDBCOL	1	023514	023606	2	BLANK\$COMMON
	3	CFNDPR		4	DECOND
				0	044453 044501
FNDOPD	1	023607	023661	2	BLANK\$COMMON
	3	CFNDPR		4	CMTTRP
	5	CEMMPR		0	044502 044530
CM1415 (COMMON BLOCK)	1	023662	023730	2	BLANK\$COMMON
LS1415	3	CM1415		0	044563 044575
				4	CEGSFP
FNDMTR	1	023731	024006	0	044576 044606
	3	CATALG		2	BLANK\$COMMON
LOCMT	1	024007	024063	0	044607 044620
	3	CATALG		2	BLANK\$COMMON
TIISBR	1	024064	024360	0	044621 044655
	3	COMN11		2	BLANK\$COMMON
LDRIM	1	024361	024443	0	044656 044666
	3	DTASUB		2	ELANK\$COMMON
LS611	1	024444	024512	0	044667 044701
	3	COMN11		2	BLANK\$COMMON
CHKSTR	1	024513	024543	4	CEGSFP
	3	CTAT01		0	044702 044717
SKPLIN	1	024544	024576	2	BLANK\$COMMON
				0	044720 044727
ALOCAT	1	024577	024660	2	BLANK\$COMMON
	3	CATALG		0	044730 044754
FNDNAM	1	024661	024724	4	DTASUB
	3	CATALG		2	BLANK\$COMMON
AIDOD	1	024725	025116	0	044755 044765
				2	BLANK\$COMMON
UPPTBL	1	025117	025310	0	044766 045010
	3	PRTTBL		2	BLANK\$COMMON
UNPACK	1	025311	026074	4	CPTBL
	3	CPTWRO		0	045034 045141
PRCTLG	1	026075	026151	2	BLANK\$COMMON
	3	CATALG		0	045142 045217
PRPTBL	1	026152	026230	2	BLANK\$COMMON
	3	PRTTBL		4	DTASUB
CNAMEFP (COMMON BLOCK)	1	026230		0	045220 045276
CMTTRP (COMMON BLOCK)	3	PRTTBL		2	BLANK\$COMMON
CEGSFP (COMMON BLOCK)				0	045277 045301
				2	045302 045302
				0	045303 045310

Figure E.2. (Continued).

SEADUCER RUN 80006 FOR TP-22A APPENDIX E			
11	CBLD	10	CFLGAZ
13	CPRTII	12	CMAGIC
15	CSTACK	14	CNMPDC
17	CUPTEL	16	CPRBFT
19	PRGMR	18	CSRMTN
21	CMNEAN	20	CEMUPR
		22	CSRHBC
SYS\$RLIBS. LEVEL 57			
END OF COLLECTION - TIME 4.411 SECONDS			

Figure E.2. (Continued).

SEARCHER RUN 80006 FOR TR-228 APPLICIX E
NEXT A3SRUN

DATE 102072

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Figure E.2. (Continued).

SEADUCER RUJ 80006 FOR TH-22A APPENDIX E

 SEADUCER RUJ 80006 (LIKE RUJ 70443) MAY 14, 1970
 TO CHECKOUT FIND PARAMETERS

***** JD 8 NETWORK TABLE

S 1080, 3C3A,\$
 S 2080, 2120,\$
 S 3080, 1420, 1V2V,\$
 S 4080, 1C3A, -+2J20,\$
 S 5080, 1P2P, -+2L2L, -+2C3A,\$
 S 6080, 2P2P, -+112J,\$
 S 7080, 1L2L, 1T2A, -+2V2V,\$
 S 8080, 212A,\$

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
T2A1\$	7683.51 C REAL 5043.80	.766601-03 C IMAG .000000	.000000 C MULT .000000	.000000	.003556	.02095

TYPE 2	RHO	A1	ID1	OD1	LENGTH	MASS
T2A2\$	7683.51 C REAL 5043.80	.766601-03 A2 .467602-03 C IMAG .000000	.000000 ID2 .000000 C MULT .000000	.000000	.004064	.01900

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
T2A3\$	7683.51 C REAL 5043.80	.467602-03 C IMAG .000000	.000000 C MULT .000000	.000000	.010465	.03760

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
V2V1\$	7696.80 C REAL 5116.00	.101971-02 C IMAG .000000	.000000 C MULT .000000	.000000	.003150	.02472

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
Q2Q1\$	7822.86 C REAL 5116.00	.427004-02 C IMAG .000000	.000000 C MULT .000000	.000000	.011763	1.06100

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
P2P1\$	7919.77 C REAL 5116.00	.455735-02 C IMAG .000000	.000000 C MULT .000000	.000000	.011763	1.14642

TYPE 1	RHO	AREA	ID	OD	LENGTH	MASS
T2B1\$	7807.65 C REAL 5043.80	.255000-03 C IMAG .000000	.000000 C MULT .000000	.000000	.003734	.00743

Figure E.2. (Continued).

TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
L2L1s	7807.65	.255000-03	.000000	.000000	.010490	.02039
	C REAL	C IMAG	C MULT			
	5043.80	.000000	.000000			
TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
L2L2s	7807.65	.285785-03	.000000	.000000	.035179	.07850
	C REAL	C IMAG	C MULT			
	5043.80	.000000	.000000			
TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
L2L3s	7807.65	.198250-03	.000000	.000000	.329286	.50909
	C REAL	C IMAG	C MULT			
	5043.80	.000000	.000000			
TYPE 1	RHO	AREA	ID	ON	LENGTH	MASS
L2L4s	7807.65	.255000-03	.000000	.000000	.003874	.00771
	C REAL	C IMAG	C MULT			
	5043.80	.000000	.000000			
TYPE 11	RHO	AREA	ID	ON	LENGTH	MASS
C3As	7555.00	.253355-02	.000000	.000000	.019107	6.58291
	C REAL	C IMAG	C MULT	N	PIECES	
	3821.90	.330786+01	.865499-03	1R		
	REAL	IMAG				
E33T	.1325100000+04	-.3041288100+01			.2295000000-02	
G33	.2205000000-01	-.7834365000-05			.3553000000-03	
S33D	.9091600000-11	-.1568562960-13			.1731000000-02	
K33	.6215604474+00	-.2430639033-03				
LAST TIME INTERVAL =	.363 SEC				TOTAL RUN TIME =	.363 SEC

Figure E.2. (Continued).

SEADUCEP R111 60006 FOR TP-22R APPENDIX E

* * * * * SEADUCEP FIND PARAMETERS * * * * *

	EXPERIMENT	THEORY	GUESS	ERROR
FLO	.5000000000+00			
FM	.3526000000+04	.3527572090+04	.3493751762+04	.45-03
FN	.4268000000+04	.4271200752+04	.4230159993+04	.75-03
CLO	.2626130002-07	.2625936206-07	.2626501073-07	.74-04
YM	.1300000000+00			
ZM	.7692307644+04	.7712460307+04	.100A811533+02	.20-02
YN	.2429999999-03	.2442311673-05	.2368592649-05	.51-02
CLOM	.1706499999-02	.1704630565-02	.2119534606-02	.11-02

GUESS	REAL	IMAG	MULT
E33T	.1325180000+04	-.3041268100+01	.2295000000-02
G33	.2205000000-01	-.7834265000-05	.3553000000-03
S33D	.9061600000-14	-.1560302960-13	.1731000000-02

THEORY	REAL	IMAG	MULT
E33T	.1322977464+04	-.2361743064+01	.1785172573-02
G33	.2178529660-01	.2951138578-05	-.1354656135-03
S33D	.8868324985-14	-.1624467098-13	.1832349515-02

ITERATION 1 MATRIX CONDITION WAS 1.26

Figure E.2. (Continued).

```

* * * * * SEADUCER FIND PARAMETERS * * * * *
EXPERIMENT      THEORY      GUESS      ERROR
FLO      .5000000000+00      .3527572090+04      .66-05
FM      .3526000000+04      .4271200752+04      .17-04
FN      .4268000000+04      .2626130161-07      .61-07
CLO      .2626130002-07      .7692299629+01      .10-05
YM      .1300000008+00      .2429977740-05      .92-05
ZM      .7692307644+01      .1706496574-02      .20-05
YN      .2429999995-05      .1706496574-02      .20-05
CLOM      .1706499999-02      .1706496574-02      .20-05

GUESS      REAL      IMAG      MULT
E33T      .1322977464+04      -.2361743084+01      .1785172573-02
G33      .2178529666-01      .2951158578-05      -.1354656135-03
S33D      .8868324985-11      -.1624907098-13      .1832349515-02

THEORY      REAL      IMAG      MULT
E33T      .1323056087+04      -.2364381405+01      .1787060601-02
G33      .2178409103-01      .2974214549-05      -.1365314966-03
S33D      .8888430599-11      -.1617350809-13      .1820683443-02

ITERATION 2      MATRIX CONDITION WAS 1.69
FINAL ANSWER
LAST TIME INTERVAL = 10.524 SEC      TOTAL RUN TIME = 18.887 SEC

```

Figure E.2. (Continued).

***** COMMON PRT TBL *****

U	NET	1	SIGN	J	IN	NA	NUM	NUM	U	BACK	U
...	SP	C	D	PORT	PURTS	NA	APD	UPO	AHEAD		ROW
1	S	1	1	1	8	DU	1	-1	3	0	1
2	S	1	1	3	3	CA	1	3	17	14	609
3	S	1	1	2	6	DU	2	-2	5	1	2
4	S	1	1	2	2	TU	2	5	6	17	461
5	S	1	1	2	6	DU	3	-3	8	3	3
6	S	1	1	1	2	DU	3	6	10	4	382
7	S	1	1	1	2	VV	3	8	21	10	343
8	S	1	1	1	8	DU	4	-4	11	5	4
9	S	1	1	1	3	CA	4	1	14	0	607
10	S	-1	1	2	2	DU	4	7	7	6	383
11	S	1	1	5	8	DU	5	-5	15	8	5
12	S	1	1	1	2	PP	5	10	16	21	421
13	S	-1	1	2	2	LL	5	13	20	19	500
14	S	-1	1	2	3	CA	5	2	2	9	608
15	S	1	1	2	8	DU	6	-6	18	11	6
16	S	1	1	2	2	PP	6	11	19	12	422
17	S	-1	1	4	2	TJ	6	4	4	2	460
18	S	1	1	7	8	DU	7	-7	22	15	7
19	S	1	1	1	2	LL	7	12	13	16	429
20	S	1	1	1	2	TA	7	14	23	13	257
21	S	-1	1	2	2	VV	7	9	12	7	304
22	S	1	1	2	2	DU	8	-8	0	18	8
23	S	1	1	2	2	TA	8	15	0	20	258

Figure E.2. (Continued).

SEARCHED RUN 800'S FOR TP-22R APPEALIA E
LAST TIME INTERVAL = .260 SEC

DATE 102072

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TOTAL RUN TIME = 19.155 SEC

***** PRINT *****

RUNID: M8000E ACCOUNT: 1E0170010000 PROJECT: LMED10314522

LOAD 88000E 9/4 PROFILE -1 M8000E

M8000E+M56: 30-2135

BREAKPOINT IN THIS RUN

*M8000E PRITAPE SAVE=2911

LOAD 279 9/7 B -1 M8000E

BREAKPOINT IN THIS RUN

TIME: 00:00:26.825 IN: 24 OUT: 0 PAGES: 30

WDS XFRO(E2): 5233 I/O REFS: 1739 CORE SEC: 1150

INITIATION TIME: 13:22:43-OCT 20, 1972 VERSION: 2E-70.150 10

TERMINATION TIME: 13:58:16-OCT 20, 1972

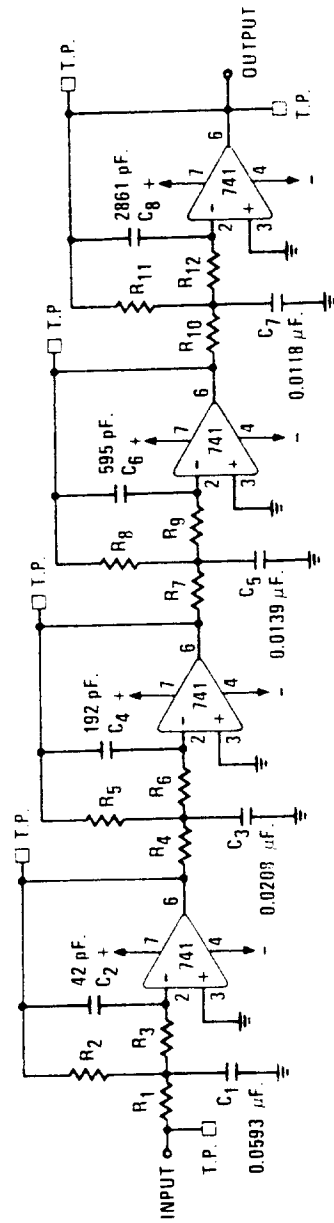
Figure E.2. (Continued).

APPENDIX F

ACTIVE BAND-PASS FILTER ANALYSIS EXAMPLE

An active band-pass filter analysis is obtained by cascading an eighth-order Chebyshev low-pass filter (figures F.1 and F.5) with an eighth-order Chebyshev high-pass filter (figures F.2 and F.5). The high-pass and low-pass filters are each composed of four individual second-order active stages (figure F.3) in cascade. Each stage is modeled using Type 26 Operational Amplifier (figure F.4) in conjunction with Type 21 Series Impedance and Type 22 Parallel Impedance (figure F.5).

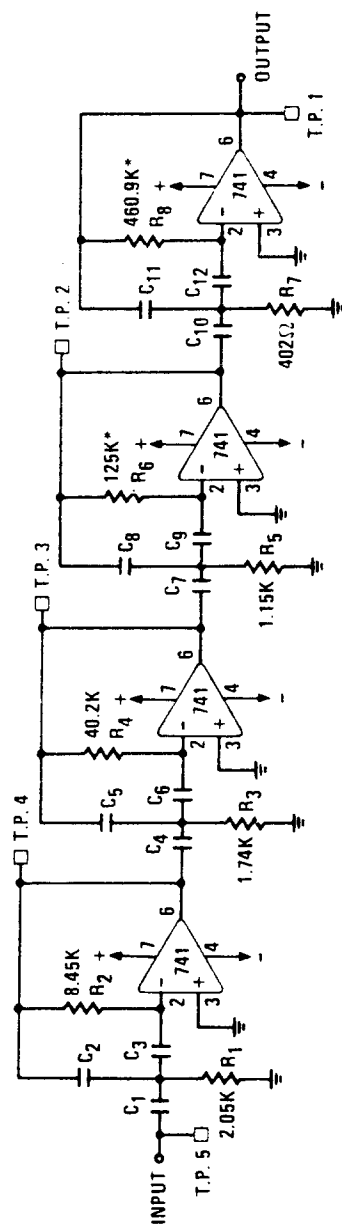
The voltage gain of the composite band-pass filter is computed as a function of frequency and is plotted in dB (referenced to unity gain) along with the measured response of the prototype circuit being modeled (figure F.6).



□ T.P. = TEST POINT

R_1 TO R_{12} ARE $32.4K \pm 1\%$
 $\pm \frac{1}{2}$ dB CHEBYSHEV, $f_c = 2850$ Hz

Figure F.1. Low-Pass Filter.

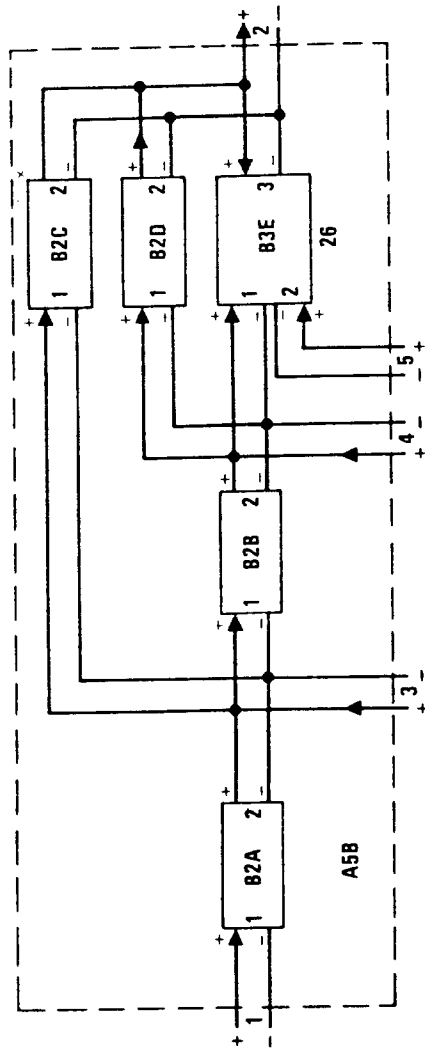


* = EXACT VALUE, OTHERS
ARE TO NEAREST
1% VALUE

□ T.P. = TEST POINT

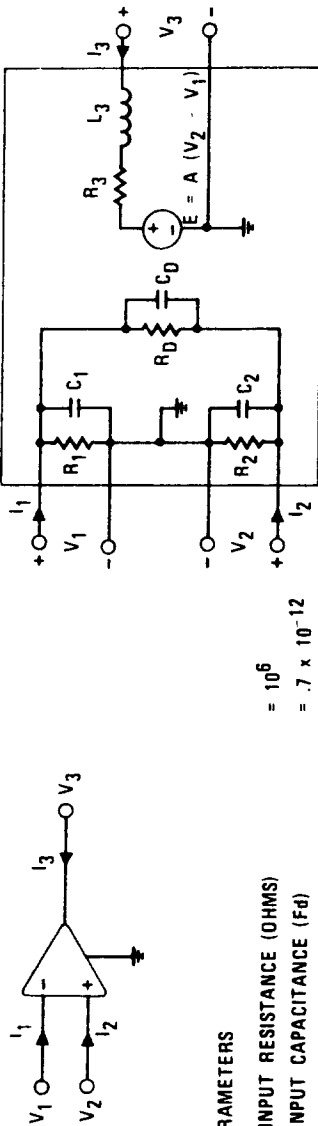
ALL CAPACITORS ARE 5300 pF, ±1%
± 1/2 dB CHEBYSHEV, $f_c = 2150$ Hz

Figure F.2. High-Pass Filter.



CALL LD PORT ('P', '1A5B, 1B2A,S')
 CALL LD PORT ('P', '2A5B, 2B2C, 2B2D, -+3B3E,S')
 CALL LD PORT ('P', '3A5B, -+2B2A, 1B2B, 1B2C,S')
 CALL LD PORT ('P', '4A5B, -+2B2B, 1B2D, 1B3E,S')
 CALL LD PORT ('P', '5A5B, 2B3E,S')

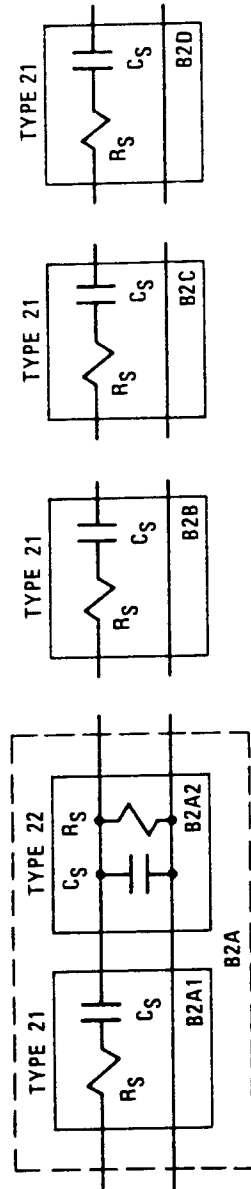
Figure F.3. Individual Second-Order Active Filter Stage Showing Sign Convention Diagram and Corresponding Computer Input.



INPUT PARAMETERS

R_1 = INPUT RESISTANCE (OHMS)	$= 10^6$
C_1 = INPUT CAPACITANCE (Fd)	$= .7 \times 10^{-12}$
R_2 = INPUT RESISTANCE (OHMS)	$= 10^{10}$
C_2 = INPUT CAPACITANCE (Fd)	$= 10^{-10}$
R_D = DIFFERENTIAL INPUT RESISTANCE (OHMS)	$= 10^6$
C_D = DIFFERENTIAL INPUT CAPACITANCE (Fd)	$= .7 \times 10^{-12}$
R_3 = OUTPUT RESISTANCE (OHMS)	$= 75$
L_3 = OUTPUT INDUCTANCE (Hv)	$= 0$
A_0 = DC OPEN LOOP GAIN	$= 70000$
$\omega_1, \omega_2, \omega_3$ = FIRST THREE POLE FREQUENCIES OF THE OPEN LOOP TRANSFER FUNCTION (RAD/SEC)	$= 2\pi \times 10$ $2\pi \times 3 \times 10^6$ $2\pi \times 10^9$
AND: f = FREQUENCY (Hz) = 1000 TO 10000	$\omega = 2\pi f$

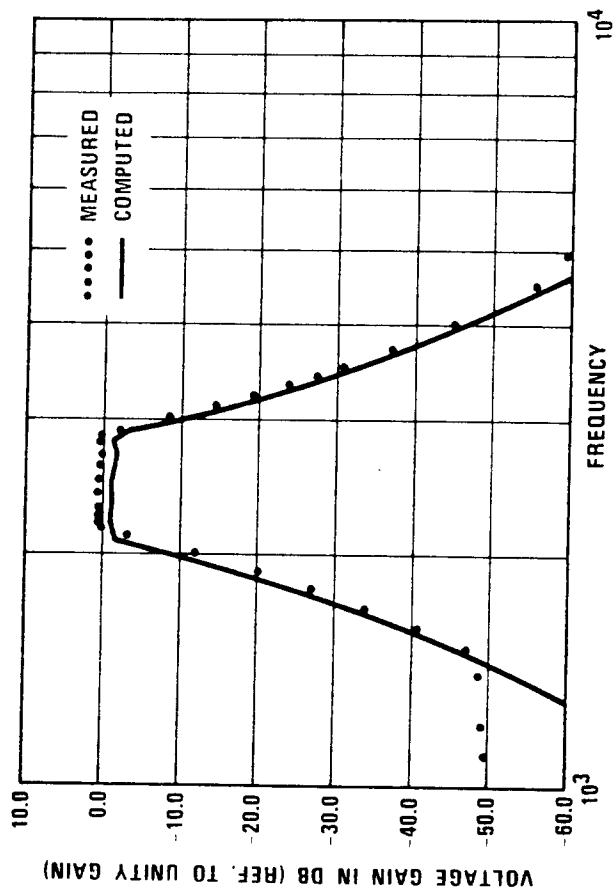
Figure F.4. Type 26: Linear Model Of a Differential Input Operational Amplifier With Active Filter Input Values.



LOW-PASS: $R_S = 32.4K$ FOR B2A1, B2B, B2C, $R_S = 0$ FOR B2A2, B2D
 $C_S = C_1, C_3, C_5, C_7$ FOR B2A2 FOR STAGES 1-4 RESPECTIVELY
 $C_S = C_2, C_4, C_6, C_8$ FOR B2D FOR STAGES 1-4 RESPECTIVELY
 $C_S = \infty$ FOR B2A1, B2B, B2C

HIGH-PASS: $C_S = 5300$ pF. FOR B2A1, B2B, B2C, $C_S = \infty$ FOR B2A2, B2D
 $R_S = R_1, R_3, R_5, R_7$ FOR B2A2 FOR STAGES 1-4 RESPECTIVELY
 $R_S = R_2, R_4, R_6, R_8$ FOR B2D FOR STAGES 1-4 RESPECTIVELY
 $R_S = 0$ FOR B2A1, B2B, B2C

Figure F.5. Series And Parallel Impedance Input For Individual Active Filter Stages.



SEADUCER RUN 80117F MAR 21, 1972
 HI PASS - LO PASS CASCADE
 W/ 1/2 DB RIPPLE FACTOR, (FLP-2850, FHP-2150)

Figure F.6. Plot of Voltage Gain as a Function of Frequency.

Figure F.7.

Listing and Output of the Control Routine
for an Active Band-Pass Filter Analysis.

A diagram of a 10x10 grid of 100 small squares. The top row is shaded gray. The first column is shaded gray. The intersection of the first row and first column is a single square.

WASGOT B.01.279 . SEADUCER VERSION 1 (DOUBLE PRECISION)

F-10

SEADUCEP NDU, BU117 FOR TP-228 APPENDIX A F
*COPIN E, TPFF.
FURTHER 023A-10/20-15:20
112 SYM 112 REL

DATE 102072

PAGE 1

*FREE B.

Figure F.7. (Continued).

SEADUCER RUI 80117 FOR TP-228 APPLE VIA F
 SFUP,IS CONTROL,COMIRL
 FOR 0010-10/20/72-15:24:00 (,0)

MAIN PROGRAM

STORAGE USED: CODE(1) 000720; DATA(0) 000341; BLANK COMMON(2) 003720

COMMON BLOCKS:

0003 CATALG 001275
 0004 PFTOFF 000001
 0005 STATOT 000001

EXTERNAL REFERENCES (BLOCK, NAME)

0006 SETCLY
 0007 PAGE
 0010 STRLIM
 0011 LDPURT
 0012 LDD14
 0013 LDD126
 0014 LDFREO
 0015 LDD121
 0016 LDD122
 0017 ULDA1P
 0020 FNDHAM
 0021 LOCATP
 0022 YTOA
 0023 STRMOV
 0024 UCRCIP
 0025 CASCDE
 0026 UCANG1
 0027 HEAD24
 0030 PPTMTR
 0031 PPTIBL
 0032 PRCTLG
 0033 TIME
 0034 NINTRS
 0035 MPRI\$
 0036 NI02\$
 0037 MWDC\$
 0040 HEXPI\$
 0041 USORT
 0042 ALOGIN
 0043 HSTOP\$

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

0001	000347 10L	0001	000417 15L	0001	000145 100C	0001	000201 173G	0001	000446 20L
0001	000251 2050	0001	000335 39L	0001	000667 39L	0001	000676 40L	0000	000063 5F
0000	000240 50F	0001	000502 52L	0001	000524 55L	0000	000255 60F	0000	R 000041 CS
0000	R 000002 C1	0000	R 000006 C2	0002	D 000000 DATA	0025	000000 UCANG1	0000	D 000036 DDF
0000	U 000000 D14	0000	U 000052 DKL	0000	I 000030 I	0000	000054 IAA2A	0000	I 000050 IAA2R
0000	I 000045 IAA2A	0000	I 000051 IAA2AL	0003	001274 ICLJ5R	0000	000027 IEXPHI	0000	I 000026 IEXPLO
0000	I 000031 IEXPLO	0000	I 000035 IF	0000	I 000044 IRTF	0003	000110 IPC	0003	000620 ITPF

Figure F.7. (Continued).

```

0000 I 000047 IYA2B 0000 I 000043 LL 0000 I 000034 J 0000 I 000033 JH1 0000 I 000032 JLO
0000 I 000022 L 0000 I 000043 LL 0000 I 000034 J 0000 I 000033 JH1 0000 I 000032 JLO
0003 000144 MTRSI2 0005 I 000000 MXDATA 0003 000000 NAME 0003 000764 NDTSTR 0004 I 000000 NOPRT
0003 000454 NPC101 0000 R 000023 OMEGA1 0000 R 000024 OMEGA2 0000 R 000025 OMEGA3 0000 R 000057 RANG
0000 R 000056 ROB 0000 R 000060 RUF 0000 R 000062 RIMAG 0000 R 000055 RMAG 0000 R 000061 RREAL
0000 R 000042 RS 0000 R 000012 RI 0000 R 000016 R2

```

```

00101 1* IMPLICIT DOUBLE PRECISION (D)
00103 2* COMMON / CATALG / NAME(100), MIR_SIZ(100), I_PC(100),
00103 3* 1 N PC TOT(100), I_TYPE(100), N_DT STR(100), LOC(100), I CLG SR
00104 4* COMMON / PRT OFF / NO PRT
00105 5* COMMON / DTA TOT / MX DATA
00106 6* COMMON / DATA(1000)
00107 7* DIMENSION C1(4), C2(4)
00110 8* DIMENSION R1(4), R2(4)
00111 9* DATA (C1(L), L=1,4) / .0593E-6, .0208E-6, .0139E-6, .0118E-6 /
00113 10* DATA (C2(L), L=1,4) / 42.E-12, 192.E-12, 595.E-12, 2861.E-12 /
00115 11* DATA(R1(L), L=1,4) / 2.05E3, 1.74E3, 1.15E3, 402. /
00117 12* DATA(R2(L), L=1,4) / 8.45E3, 40.2E3, 125.E3, 460.9E3 /
00121 13* MX DATA = 1000
00122 14*
00123 15* CALL SETCLK
00123 16* CALL PAGE
00124 17* CALL STR LIN
00125 18* PRINT 5
00127 19* 5 FORMAT(' SEADUCER RUN 80117F MAR 21, 1972 $' /
00127 20* / ' HI PASS - LO PASS CASCADE $' /
00127 21* / ' W/ 1/2 DB RIPPLE FACTOR, (FLP=2850, FHP=2150) $' /
00127 22* / ' CHARGE TO 16000401 AMPLIFIERS' )
00130 23*
00130 24* CALL LD POKT( 'P', '1A5B', 182A,$ )
00131 25* CALL LD POKT( 'P', '2A5B', 282C, -+383E,$ )
00132 26* CALL LD POKT( 'P', '3A5B', -+282A, 182B, 182C,$ )
00133 27* CALL LD POKT( 'P', '4A5B', -+282R, 182D, 183E,$ )
00134 28*
00135 29* CALL LD DT 4('A2A1$', 1. )
00135 30* CALL LD DT 4('A2A2$', 1. )
00136 31* CALL LD DT 4('A2A3$', 1. )
00137 32* CALL LD DT 4('A2A4$', 1. )
00140 33* CALL LD DT 4('A2A5$', 1. )
00141 34* CALL LD DT 4('A2A6$', 1. )
00142 35* CALL LD DT 4('A2A7$', 1. )
00143 36* CALL LD DT 4('A2A7$', 1. )
00144 37* CALL LD DT 4('A2A8$', 1. )
00145 38* CALL LD DT 4('A2A9$', 1. )
00145 39* OMEGA1 = 2.*3.14159 * 10.
00146 40* OMEGA2 = 2.*3.14159 * 3.E6
00147 41* OMEGA3 = 2.*3.14159 * 1.E9
00150 42* CALL LD DT 26('B3E$', 1.E6, 7E-12, 1.E-10, 1.E-10, 1.E6, 7E-12,
00150 43* 75., 0., 70000., OMEGA1, OMEGA2, OMEGA3)
00151 44*
00151 45* PUNCH 5
00153 46* PUNCH 50
00155 47*

```

Figure F.7. (Continued).

SEAUCER RUN 80117 FOR TP-22R APPENDIX F

```

00155 40*      1 EXP LO = 3
00156 49*      1 EXP HI = 3
00157 50*      1 EXP LO = 1 EXP LO, 1 EXP HI
00162 51*      1 EXP = 10*(1-1)
00163 52*      1 LO = 1
00164 53*      1 HI = 9
00165 54*      1 IF ( 1.EQ. 1 EXP HI ) JHI = 1
00167 55*      1 LO = 10
00170 56*      1 HI = 100
00171 57*      1 HI = 50
00172 58*      1 EXP LO = 1 EXP LO, 1 HI
00175 59*      1 IF ( 1.EQ. 1 EXP LO ) JHI = 1
00176 60*      1 EXP = 10
00177 61*      1 EXP HI = 100
00200 62*      1 EXP = 1
00201 63*      1 EXP LO = 1 EXP LO, 1 EXP HI
00202 64*      1 EXP HI = 100
00203 65*      1 EXP = 1
00204 66*      1 EXP LO = 1 EXP LO, 1 EXP HI
00205 67*      1 EXP HI = 100
00210 68*      1 EXP LO = 1 EXP LO, 1 EXP HI
00212 70*      1 EXP HI = 100
00214 71*      1 EXP LO = 1 EXP LO, 1 EXP HI
00215 72*      1 EXP HI = 100
00217 73*      1 EXP LO = 1 EXP LO, 1 EXP HI
00217 74*      1 EXP HI = 100
00221 75*      1 EXP LO = 1 EXP LO, 1 EXP HI
00222 76*      1 EXP HI = 100
00223 77*      1 EXP LO = 1 EXP LO, 1 EXP HI
00224 78*      1 EXP HI = 100
00225 79*      1 EXP LO = 1 EXP LO, 1 EXP HI
00226 80*      1 EXP HI = 100
00227 81*      1 EXP LO = 1 EXP LO, 1 EXP HI
00230 82*      1 EXP HI = 100
00230 83*      1 EXP LO = 1 EXP LO, 1 EXP HI
00231 84*      1 EXP HI = 100
00232 85*      1 EXP LO = 1 EXP LO, 1 EXP HI
00233 86*      1 EXP HI = 100
00234 87*      1 EXP LO = 1 EXP LO, 1 EXP HI
00235 88*      1 EXP HI = 100
00236 89*      1 EXP LO = 1 EXP LO, 1 EXP HI
00237 90*      1 EXP HI = 100
00240 91*      1 EXP LO = 1 EXP LO, 1 EXP HI
00241 92*      1 EXP HI = 100
00241 93*      1 EXP LO = 1 EXP LO, 1 EXP HI
00242 94*      1 EXP HI = 100
00243 95*      1 EXP LO = 1 EXP LO, 1 EXP HI
00244 96*      1 EXP HI = 100
00245 97*      1 EXP LO = 1 EXP LO, 1 EXP HI
00246 98*      1 EXP HI = 100
00247 99*      1 EXP LO = 1 EXP LO, 1 EXP HI
00250 100*     1 EXP HI = 100
00251 101*     1 EXP LO = 1 EXP LO, 1 EXP HI
00252 102*     1 EXP HI = 100
00253 103*     1 EXP LO = 1 EXP LO, 1 EXP HI
00254 104*     1 EXP HI = 100

```

Figure F.7. (Continued).

SEADUCER RUN 80117 FOR TP-22R APPENDIX F

```

00255 105* CALL DCRCIP(DATA(IAA29),DATA(IAA2P+4), DRL,DIM)
00256 106* GO TO 55
00257 107* 52 CONTINUE
00260 108* CALL CASCDE(I A2A)
00261 109* 1A A2A = LCC(I A2A) + B
00262 110* CALL DCRCIP(DATA(IA A2A), DATA(IA A2A+4), DRL, DIM)
00263 111* 55 CONTINUE
00264 112* RMAG = DSQRT(DRL**2+DIM**2)
00265 113* HOB = 20.*ALOG10(RMAG)
00266 114* RANG = DCANG1( DRL, DIM ) * 180./3.14159265
00267 115* RDF = DDF
00270 116* RREAL = DRL
00271 117* RIMAG = DIM
00272 118* IF ( IF .EQ. 1000 ) CALL PAGE
00274 119* IF ( L .EQ. 1 ) PRINT 50
00277 120* 50 FORMAT( ' F,5X,
00277 121* / ' UB,5X, ' MAG,5X, ' ANG DEG ', ' REAL,5X, ' IMAG' )
00300 122* PRINT 60, RDF, RDB, RMAG, RANG, RREAL, RIMAG
00310 123* 60 FORMAT(BE10.4)
00311 124*
00311 125* IF (L.EQ.LTOP) PUNCH 60, RDF, RDB, RMAG, RANG, RREAL, RIMAG
00322 126*
00322 127* IF ( IF .EQ. 1000 ) GO TO 38
00324 128* GO TO 40
00325 129* 38 CONTINUE
00326 130* IF ( L .EQ. LTOP ) GO TO 39
00330 131* CALL HEAD 24( ' Y A5B ' )
00331 132* CALL PRT MIR(1YA5B, 5)
00332 133* CALL HEAD 24( ' Y A2B ' )
00333 134* CALL PRT MIR(1YA2B, 2)
00334 135* CALL HEAD 24( ' A A2B ' )
00335 136* CALL PRT MIR(1AA2B, 2)
00336 137* GO TO 40
00337 138* 39 CONTINUE
00340 139* CALL HEAD 24( ' A A2A ' )
00341 140* CALL PRT MIR(1A A2A, 2)
00342 141* 40 CONTINUE
00343 142* 300 CONTINUE
00345 143* 100 CONTINUE
00347 144* 200 CONTINUE
00351 145*
00351 146* CALL PAGE
00352 147* CALL PR PTBL
00353 148* CALL PR CTLG
00354 149* CALL TIME
00355 150* STOP
00356 151* END

```

END OF COMPILATION: NO DIAGNOSTICS.

Figure F.7. (Continued).

FOR SW PRIMTR, PRIMTR, PRIMTR
 FOR 0010-10/20/72-15:24:07 (0+0)
 -19,19
 ...100 FORMAT(216, 2D18.10)

SUBROUTINE PRIMTR ENTRY POINT 000077

STORAGE USED: CODE(1) 000105; DATA(0) 000026; BLANK COMMON(2) 000310

EXTERNAL REFERENCES (BLOCK, NAME)

0003 NPRT\$
 0004 NI02\$
 0005 NI01\$
 0006 HERK3\$

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

0000 000005 100F 0000 000010 110F 0001 000020 1130 0001 000023 1166 0002 000000 DATA
 0000 1 000004 I 0000 000011 INUP\$ 0000 1 000003 J 0000 1 000001 K 0000 1 000002 L
 0000 1 000000 MTRM\$

00101	1*	SUBROUTINE PRIMTR (N MTR, MTR SZ)	PRIMTR
00103	2*	DOUBLE PRECISION DATA	
00104	3*	COMMON / DATA(100)	
00104	4*	C * * * * * PROGRAMMED BY L. E. MCCLEARY	NUC CODE 601 * * * * *
00105	5*		
00105	6*	MTR MN = MTR SZ**2	
00106	7*	L = N MTR	
00107	8*	L = N MTR + MTR MN	
00110	9*	PRINT 110	
00112	10*	DO 20 J = 1, MTR SZ	
00115	11*	DO 10 I = 1, MTR SZ	
00120	12*	PRINT 100, I, J, DATA(K), DATA(L)	
00126	13*	KK+1	
00127	14*	LL+1	
00130	15*	10 CONTINUE	
00132	16*	PRINT 110	
00134	17*	20 CONTINUE	
00136	18*	RETURN	
00137	19*	100 FORMAT(216, 2D18.10)	
00140	20*	110 FORMAT(1H)	
00141	21*	END	

END OF COMPILATION: NO DIAGNOSTICS.

NEW
 -01

Figure F.7. (Continued).

WPREP TPFS
 FURPUR 023A-10/20-15:24

PRINT TPFS.

LM001031452*TPFS ELEMENT TABLE

U NAME	VERSION	TYPE	DATE	TIME	SEQ #	SIZE-PRG,TEXT	(CYCLE WORD)	PSRMODF	LOCATION
* CONTRL		FOR SYMB	28 MAR 72	23:16:43	1	26	5	0	1792
* CONTRL		RELOCATABLE	28 MAR 72	23:16:45	2	3	5	0	1818
LDUPRT		FOR SYMB	28 MAR 72	23:16:45	3	20	5	0	1859
LDUPRT		RELOCATABLE	28 MAR 72	23:16:47	4	15	5	0	1879
SLDMTR		FOR SYMB	28 MAR 72	23:16:48	5	19	5	0	1896
SLDMTR		RELOCATABLE	28 MAR 72	23:16:49	6	11	5	0	1915
BLDKKL		FOR SYMB	28 MAR 72	23:16:50	7	26	5	0	1928
BLDKKL		RELOCATABLE	28 MAR 72	23:16:52	8	16	5	0	1954
RDUPRT		FOR SYMB	28 MAR 72	23:16:53	9	39	5	0	1973
RDUPRT		RELOCATABLE	28 MAR 72	23:16:55	10	2	5	0	2012
LDFRE0		FOR SYMB	28 MAR 72	23:16:56	11	4	5	0	2044
LDFRE0		RELOCATABLE	28 MAR 72	23:16:57	12	3	5	0	2048
UPPTRL		FOR SYMB	28 MAR 72	23:16:58	13	11	5	0	2053
UPPTRL		RELOCATABLE	28 MAR 72	23:17:00	14	7	5	0	2064
FNDLCJ		FOR SYMB	28 MAR 72	23:17:00	15	17	5	0	2073
FNDLCJ		RELOCATABLE	28 MAR 72	23:17:02	16	11	5	0	2090
ALOCAT		FOR SYMB	28 MAR 72	23:17:03	17	8	5	0	2103
ALOCAT		RELOCATABLE	28 MAR 72	23:17:04	18	4	5	0	2111
CHKSTR		FOR SYMB	28 MAR 72	23:17:04	19	3	5	0	2117
CHKSTR		RELOCATABLE	28 MAR 72	23:17:06	20	3	5	0	2120
FNDNET		FOR SYMB	28 MAR 72	23:17:06	21	9	5	0	2125
FNDNET		RELOCATABLE	28 MAR 72	23:17:07	22	1	5	0	2134
LOCMTN		FOR SYMB	28 MAR 72	23:17:08	23	4	5	0	2191
LOCMTN		RELOCATABLE	28 MAR 72	23:17:09	24	1	5	0	2145
LOCNAM		FOR SYMB	28 MAR 72	23:17:10	25	3	5	0	2149
LOCNAM		RELOCATABLE	28 MAR 72	23:17:11	26	1	5	0	2152
FNDMTR		FOR SYMB	28 MAR 72	23:17:12	27	4	5	0	2156
FNDMTR		RELOCATABLE	28 MAR 72	23:17:13	28	1	5	0	2160
FNDNAM		FOR SYMB	28 MAR 72	23:17:13	29	3	5	0	2164
FNDNAM		RELOCATABLE	28 MAR 72	23:17:15	30	1	5	0	2167
CASCODE		FOR SYMB	28 MAR 72	23:17:15	31	16	5	0	2171
CASCODE		RELOCATABLE	28 MAR 72	23:17:17	32	9	5	0	2187
TYPICAL		FOR SYMB	28 MAR 72	23:17:18	33	15	5	0	2198
TYPICAL		RELOCATABLE	28 MAR 72	23:17:19	34	2	5	0	2213
LDOT1		FOR SYMB	28 MAR 72	23:17:20	35	23	5	0	2227
LDOT1		RELOCATABLE	28 MAR 72	23:17:22	36	2	5	0	2250
TYPE1		FOR SYMB	28 MAR 72	23:17:23	37	13	5	0	2269
TYPE1		RELOCATABLE	28 MAR 72	23:17:24	38	2	5	0	2282
LDOT2		FOR SYMB	28 MAR 72	23:17:25	39	25	5	0	2293
LDOT2		RELOCATABLE	28 MAR 72	23:17:27	40	19	5	0	2318
TYPE2		FOR SYMB	28 MAR 72	23:17:28	41	17	5	0	2339
TYPE2		RELOCATABLE	28 MAR 72	23:17:30	42	13	5	0	2356
LDOT4		FOR SYMB	28 MAR 72	23:17:30	43	19	5	0	2371

Figure F.7. (Continued).

DATE 102072

SEADUCER RUN 80117 FOR TP-22R APPENDIX F

LDOT4	RELOCATABLE	28 MAR 72	23:17:32	44	2	13	5	0	1	2390
LDOT5	FOR SYMB	28 MAR 72	23:17:33	45	2	17	5	0	1	2405
LDOT6	RELOCATABLE	28 MAR 72	23:17:34	46	2	11	5	0	1	2422
LDOT7	FOR SYMB	28 MAR 72	23:17:36	47	2	51	5	0	1	2435
LDOT7	RELOCATABLE	28 MAR 72	23:17:38	48	2	30	5	0	1	2486
LDOT7	FOR SYMB	28 MAR 72	23:17:39	49	2	28	5	0	1	2518
TYPE7	RELOCATABLE	28 MAR 72	23:17:42	50	1	23	5	0	1	2546
LDOT8	FOR SYMB	28 MAR 72	23:17:42	51	3	22	5	0	1	2570
LDOT8	RELOCATABLE	28 MAR 72	23:17:44	52	3	20	5	0	1	2592
LDOT9	FOR SYMB	28 MAR 72	23:17:46	53	3	22	5	0	1	2615
LDOT9	RELOCATABLE	28 MAR 72	23:17:48	54	3	20	5	0	1	2637
LDOT11	FOR SYMB	28 MAR 72	23:17:49	55	3	26	5	0	1	2660
LDOT11	RELOCATABLE	28 MAR 72	23:17:51	56	3	19	5	0	1	2686
TYPE11	FOR SYMB	28 MAR 72	23:17:52	57	2	31	5	0	1	2708
TYPE11	RELOCATABLE	28 MAR 72	23:17:55	58	2	29	5	0	1	2739
TI15BR	FOR SYMB	28 MAR 72	23:17:55	59	2	11	5	0	1	2770
TI15BR	RELOCATABLE	28 MAR 72	23:17:57	60	2	11	5	0	1	2781
LDOT14	FOR SYMB	28 MAR 72	23:17:58	61	3	25	5	0	1	2794
LDOT14	RELOCATABLE	28 MAR 72	23:18:00	62	3	19	5	0	1	2819
TYPE14	FOR SYMB	28 MAR 72	23:18:00	63	3	2	5	0	1	2841
TYPE14	RELOCATABLE	28 MAR 72	23:18:01	64	1	2	5	0	1	2844
LDOT15	FOR SYMB	28 MAR 72	23:18:03	65	3	26	5	0	1	2847
LDOT15	RELOCATABLE	28 MAR 72	23:18:04	66	3	21	5	0	1	2873
TYPE15	FOR SYMB	28 MAR 72	23:18:05	67	1	3	5	0	1	2897
TYPE15	RELOCATABLE	28 MAR 72	23:18:06	68	1	2	5	0	1	2900
TI1415S	FOR SYMB	28 MAR 72	23:18:07	69	2	9	5	0	1	2903
TI1415S	RELOCATABLE	28 MAR 72	23:18:08	70	2	10	5	0	1	2912
TP1415	FOR SYMB	28 MAR 72	23:18:09	71	2	19	5	0	1	2924
TP1415	RELOCATABLE	28 MAR 72	23:18:11	72	2	20	5	0	1	2943
LDOTJ20	FOR SYMB	28 MAR 72	23:18:12	73	2	19	5	0	1	2965
LDOTJ20	RELOCATABLE	28 MAR 72	23:18:13	74	2	14	5	0	1	3000
TYPE20	FOR SYMB	28 MAR 72	23:18:14	75	2	13	5	0	1	3013
TYPE20	RELOCATABLE	28 MAR 72	23:18:15	76	2	10	5	0	1	3025
LDOT21	FOR SYMB	28 MAR 72	23:18:16	77	2	17	5	0	1	3042
LDOT21	RELOCATABLE	28 MAR 72	23:18:18	78	2	12	5	0	1	3056
TYPE21	FOR SYMB	28 MAR 72	23:18:19	79	1	3	5	0	1	3061
TYPE21	RELOCATABLE	28 MAR 72	23:18:21	80	2	17	5	0	1	3065
LDOT22	FOR SYMB	28 MAR 72	23:18:22	81	2	12	5	0	1	3082
LDOT22	RELOCATABLE	28 MAR 72	23:18:22	82	2	5	5	0	1	3096
TYPE22	FOR SYMB	28 MAR 72	23:18:24	83	1	4	5	0	1	3101
TYPE22	RELOCATABLE	28 MAR 72	23:18:25	84	2	17	5	0	1	3106
LDOT24	FOR SYMB	28 MAR 72	23:18:26	85	2	12	5	0	1	3123
LDOT24	RELOCATABLE	28 MAR 72	23:18:27	86	2	5	5	0	1	3137
TYPE24	FOR SYMB	28 MAR 72	23:18:26	87	1	4	5	0	1	3142
TYPE24	RELOCATABLE	28 MAR 72	23:18:29	88	2	17	5	0	1	3147
LDOT25	FOR SYMB	28 MAR 72	23:18:30	89	2	12	5	0	1	3164
LDOT25	RELOCATABLE	28 MAR 72	23:18:31	90	2	5	5	0	1	3178
TYPE25	FOR SYMB	28 MAR 72	23:18:32	91	1	4	5	0	1	3183
TYPE25	RELOCATABLE	28 MAR 72	23:18:33	92	1	10	5	0	1	3188
LDOT26	FOR SYMB	28 MAR 72	23:18:34	93	2	14	5	0	1	3207
LDOT26	RELOCATABLE	28 MAR 72	23:18:35	94	2	14	5	0	1	3223
TYPE26	FOR SYMB	28 MAR 72	23:18:37	95	2	13	5	0	1	3237
TYPE26	RELOCATABLE	28 MAR 72	23:18:37	96	2	12	5	0	1	3252
AI000	FOR SYMB	28 MAR 72	23:18:39	97	1	4	5	0	1	3264
AI000	RELOCATABLE	28 MAR 72	23:18:39	98	1	4	5	0	1	3273
LA2HY2	FOR SYMB	28 MAR 72	23:18:39	99	1	2	5	0	1	3277
LA2HY2	RELOCATABLE	28 MAR 72	23:18:40	100	1	2				

Figure F.7. (Continued).

LZ2BY2	FOR SYMB	28 MAR 72	23:18:40	101		4	5	0	1	3280
LZ2BY2	RELOCATABLE	28 MAR 72	23:18:42	102	1	2				3284
LZ3BY3	FOR SYMB	28 MAR 72	23:18:42	103		4	5	0	1	3287
LZ3BY3	RELOCATABLE	28 MAR 72	23:18:43	104	1	2				3291
LY2BY2	FOR SYMB	28 MAR 72	23:18:44	105		4	5	0	1	3294
LY2BY2	RELOCATABLE	28 MAR 72	23:18:45	106	1	2				3298
LY3BY3	FOR SYMB	28 MAR 72	23:18:46	107		4	5	0	1	3301
LY3BY3	RELOCATABLE	28 MAR 72	23:18:47	108	1	2				3305
LDDRIM	FOR SYMB	28 MAR 72	23:18:48	109		5	5	0	1	3308
LDDRIM	RELOCATABLE	28 MAR 72	23:18:49	110	1	4				3313
LDSB11	FOR SYMB	28 MAR 72	23:18:49	111		7	5	0	1	3318
LDSB11	RELOCATABLE	28 MAR 72	23:18:51	112	1	3				3325
LS1415	FOR SYMB	28 MAR 72	23:18:51	113		6	5	0	1	3329
LS1415	RELOCATABLE	28 MAR 72	23:18:52	114	1	3				3335
FNDTMS	FOR SYMB	28 MAR 72	23:18:53	115		9	5	0	1	3339
FNDTMS	RELOCATABLE	28 MAR 72	23:18:54	116	2	5				3348
FNDTIL	FOR SYMB	28 MAR 72	23:18:55	117		13	5	0	1	3355
FNDTIL	RELOCATABLE	28 MAR 72	23:18:56	118	2	9				3368
MTRMOV	FOR SYMB	28 MAR 72	23:18:57	119		4	5	0	1	3379
MTRMOV	RELOCATABLE	28 MAR 72	23:18:58	120	1	3				3383
MTRMUL	FOR SYMB	28 MAR 72	23:18:59	121		12	5	0	1	3387
MTRMUL	RELOCATABLE	28 MAR 72	23:19:00	122	1	11				3399
DLEIRC	FOR SYMB	28 MAR 72	23:19:01	123		11	5	0	1	3411
DLEIRC	RELOCATABLE	28 MAR 72	23:19:03	124	1	7				3422
LOIMTR	FOR SYMB	28 MAR 72	23:19:03	125		4	5	0	1	3430
LOIMTR	RELOCATABLE	28 MAR 72	23:19:04	126	1	4				3434
DECOMB	FOR SYMB	28 MAR 72	23:19:06	127		45	5	0	1	3439
DECOMB	RELOCATABLE	28 MAR 72	23:19:10	128	2	55				3444
ATOZ	FOR SYMB	28 MAR 72	23:19:10	129		10	5	0	1	3541
ATOZ	RELOCATABLE	28 MAR 72	23:19:12	130	2	9				3551
ZIOA	FOR SYMB	28 MAR 72	23:19:13	131		10	5	0	1	3562
ZIOA	RELOCATABLE	28 MAR 72	23:19:15	132	2	9				3572
ATOY	FOR SYMB	28 MAR 72	23:19:16	133		9	5	0	1	3583
ATOY	RELOCATABLE	28 MAR 72	23:19:17	134	2	11				3592
YIOA	FOR SYMB	28 MAR 72	23:19:18	135		9	5	0	1	3605
YIOA	RELOCATABLE	28 MAR 72	23:19:19	136	2	11				3614
JACMUL	FOR SYMB	28 MAR 72	23:19:20	137		3	5	0	1	3627
JACMUL	RELOCATABLE	28 MAR 72	23:19:21	138	1	2				3630
JCMNUL	FOR SYMB	28 MAR 72	23:19:22	139		3	5	0	1	3633
JCMNUL	RELOCATABLE	28 MAR 72	23:19:23	140	1	2				3636
JCMNUL	FOR SYMB	28 MAR 72	23:19:24	141		3	5	0	1	3639
JCMNUL	RELOCATABLE	28 MAR 72	23:19:25	142	1	3				3642
JCMNUL	FOR SYMB	28 MAR 72	23:19:25	143		3	5	0	1	3646
JCMNUL	RELOCATABLE	28 MAR 72	23:19:27	144	1	2				3649
JCMNUL	FOR SYMB	28 MAR 72	23:19:28	145		10	5	0	1	3652
JCMNUL	RELOCATABLE	28 MAR 72	23:19:29	146	1	9				3662
JCMNUL	FOR SYMB	28 MAR 72	23:19:30	147		3	5	0	1	3672
JCMNUL	RELOCATABLE	28 MAR 72	23:19:31	148	1	6				3680
JCMNUL	FOR SYMB	28 MAR 72	23:19:32	149		5	5	0	1	3687
JCMNUL	RELOCATABLE	28 MAR 72	23:19:33	150	1	4				3692
JCMNUL	FOR SYMB	28 MAR 72	23:19:34	151		4	5	0	1	3697
JCMNUL	RELOCATABLE	28 MAR 72	23:19:35	152	1	3				3701
JCMNUL	FOR SYMB	28 MAR 72	23:19:36	153		5	5	0	1	3705
JCMNUL	RELOCATABLE	28 MAR 72	23:19:37	154	1	3				3710
JCMNUL	FOR SYMB	28 MAR 72	23:19:37	155		5	5	0	1	3714
JCMNUL	RELOCATABLE	28 MAR 72	23:19:39	156	1	3				3719
JCMNUL	FOR SYMB	28 MAR 72	23:19:40	157		5	5	0	1	3723

*

Figure F.7. (Continued).

* PRIMR	RELOCATABLE	28 MAR 72	23:19:41	158	1	5	5	0	1	3728
PRIMBN	FOR SYMB	28 MAR 72	23:19:42	159	1	5	5	0	1	3734
PRIMBN	RELOCATABLE	28 MAR 72	23:19:43	160	1	5	5	0	1	3739
PRMARI	FOR SYMB	28 MAR 72	23:19:43	161	2	6	6	0	1	3745
PRMARI	RELOCATABLE	28 MAR 72	23:19:45	162	2	6	6	0	1	3753
HEAD24	FOR SYMB	28 MAR 72	23:19:45	163	1	6	6	0	1	3761
HEAD24	RELOCATABLE	28 MAR 72	23:19:47	164	1	6	6	0	1	3767
PAGE	FOR SYMB	28 MAR 72	23:19:48	165	1	2	1	5	0	3774
PAGE	RELOCATABLE	28 MAR 72	23:19:49	166	1	2	1	5	0	3775
STRLIN	FOR SYMB	28 MAR 72	23:19:49	167	1	2	2	5	0	3778
STRLIN	RELOCATABLE	28 MAR 72	23:19:51	168	1	2	2	5	0	3780
SKPLIN	FOR SYMB	28 MAR 72	23:19:51	169	1	2	2	5	0	3783
SKPLIN	RELOCATABLE	28 MAR 72	23:19:53	170	1	2	2	5	0	3785
PRPTBL	FOR SYMB	28 MAR 72	23:19:53	171	1	7	7	5	0	3788
PRPTBL	RELOCATABLE	28 MAR 72	23:19:54	172	1	5	5	0	1	3795
PRCTLG	FOR SYMB	28 MAR 72	23:19:55	173	2	6	6	5	0	3801
PRCTLG	RELOCATABLE	28 MAR 72	23:19:55	174	2	5	5	0	1	3807
UNPACK	FOR SYMB	28 MAR 72	23:19:57	175	1	26	26	5	0	3814
UNPACK	RELOCATABLE	28 MAR 72	23:19:59	176	1	22	22	5	0	3840
BLKDTA	FOR SYMB	28 MAR 72	23:20:00	177	4	15	15	5	0	3863
BLKDTA	RELOCATABLE	28 MAR 72	23:20:00	178	4	3	3	5	0	3878
TIME	FOR SYMB	28 MAR 72	23:20:01	179	1	5	5	5	0	3885
TIME	RELOCATABLE	28 MAR 72	23:20:02	180	1	3	3	5	0	3890
Z110Z2	FOR SYMB	28 MAR 72	23:20:03	181	1	6	6	5	0	3894
Z110Z2	RELOCATABLE	28 MAR 72	23:20:04	182	1	9	9	5	0	3902
DCPCT2	FOR SYMB	28 MAR 72	23:20:05	183	1	7	7	5	0	3909
DCPCT2	RELOCATABLE	28 MAR 72	23:20:06	184	1	26	26	5	0	3918
FNDKRC	FOR SYMB	28 MAR 72	23:20:07	185	2	20	20	5	0	3926
FNDKRC	RELOCATABLE	28 MAR 72	23:20:09	186	2	101	101	5	0	3952
SRCHBC	FOR SYMB	28 MAR 72	23:20:12	187	4	76	76	5	0	3974
SRCHBC	RELOCATABLE	28 MAR 72	23:20:16	188	1	3	3	5	0	4075
MINCHK	FOR SYMB	28 MAR 72	23:20:16	189	1	2	2	5	0	4155
MINCHK	RELOCATABLE	28 MAR 72	23:20:18	190	1	3	3	5	0	4158
MAXCHK	FOR SYMB	28 MAR 72	23:20:18	191	1	2	2	5	0	4161
MAXCHK	RELOCATABLE	28 MAR 72	23:20:19	192	2	5	5	5	0	4164
CMPZS	FOR SYMB	28 MAR 72	23:20:21	193	2	3	3	5	0	4167
CMPZS	RELOCATABLE	28 MAR 72	23:20:21	194	2	16	16	5	0	4172
PREPZV	FOR SYMB	28 MAR 72	23:20:22	195	2	18	18	5	0	4177
PREPZV	RELOCATABLE	28 MAR 72	23:20:23	196	2	7	7	5	0	4193
FNDPZV	FOR SYMB	28 MAR 72	23:20:24	197	2	5	5	5	0	4213
FNDPZV	RELOCATABLE	28 MAR 72	23:20:25	198	2	5	5	5	0	4220
LDZVR	FOR SYMB	28 MAR 72	23:20:25	199	2	5	5	5	0	4227
LDZVR	RELOCATABLE	28 MAR 72	23:20:27	200	2	3	3	5	0	4232
SRMIDB	FOR SYMB	28 MAR 72	23:20:29	201	4	57	57	5	0	4237
SRMIDB	RELOCATABLE	28 MAR 72	23:20:32	202	4	50	50	5	0	4294
LDAM2S	FOR SYMB	28 MAR 72	23:20:33	203	3	19	19	5	0	4348
LDAM2S	RELOCATABLE	28 MAR 72	23:20:34	204	3	15	15	5	0	4367
CMPGAM	FOR SYMB	28 MAR 72	23:20:36	205	2	16	16	5	0	4385
CMPGAM	RELOCATABLE	28 MAR 72	23:20:37	206	2	14	14	5	0	4401
FSRCH	FOR SYMB	28 MAR 72	23:20:41	207	5	142	142	5	0	4417
FSRCH	RELOCATABLE	28 MAR 72	23:20:48	208	5	123	123	5	0	4559
RLIMMG	FOR SYMB	28 MAR 72	23:20:48	209	2	10	10	5	0	4687
RLIMMG	RELOCATABLE	28 MAR 72	23:20:49	210	2	6	6	5	0	4697
FMEN	FOR SYMB	28 MAR 72	23:20:50	211	2	5	5	5	0	4705
FMEN	RELOCATABLE	28 MAR 72	23:20:51	212	2	14	14	5	0	4711
POLEO	FOR SYMB	28 MAR 72	23:20:52	213	1	13	13	5	0	4718
POLEO	RELOCATABLE	28 MAR 72	23:20:54	214	1	13	13	5	0	4732

Figure F.7. (Continued).

PRBFIIT	FOR SYMB	28 MAR 72	23:20:54	215		9	5	0	1	4746
PRBFIIT	RELOCATABLE	28 MAR 72	23:20:55	216	1	7				4755
FIDPRM	FOR SYMB	28 MAR 72	23:20:57	217		49	5	0	1	4763
FNDPRM	RELOCATABLE	28 MAR 72	23:21:00	218	4	29				4803
FNDOP	FOR SYMB	28 MAR 72	23:21:00	219		8	5	0	1	4836
FNDOP	RELOCATABLE	28 MAR 72	23:21:01	220	2	3				4844
LDBCOL	FOR SYMB	28 MAR 72	23:21:02	221		6	5	0	1	4849
LDBCOL	RELOCATABLE	28 MAR 72	23:21:03	222	2	4				4855
PRTPRM	FOR SYMB	28 MAR 72	23:21:04	223		14	5	0	1	4861
PRTPRM	RELOCATABLE	28 MAR 72	23:21:05	224	2	9				4875
CONTRL	FOR SYMB	20 OCT 72	15:24:02	225		34	5	0	1	4886
CONTRL	RELOCATABLE	20 OCT 72	15:24:04	226	4	38				4920
PRMTWR	FOR SYMB	20 OCT 72	15:24:07	227		5	5	0	1	4962
PRMTWR	RELOCATABLE	20 OCT 72	15:24:09	228	1	5				4967
NEXT AVAILABLE LOCATIONS:-										

ASSEMBLER PROCEDURE TABLE EMPTY

CONTROL PROCEDURE TABLE FIFTY

FORTRAN PROCEDURE TABLE EMPTY

ENTRY POINT TABLE

[illegible]

Figure F.7. (Continued).

SEADUCER RUJ 80117 FOR TP-22R APPENDIX F									
TP1415	1	006174	006740	0	041445	041531	0	041445	041531
	3	CS1415		2	BLANK\$COMMON		2	BLANK\$COMMON	
	5	CM1415		6	RASICR		6	CZ3RY3	
CM1415 (COMMON BLOCK)	1	006741	007007	0	041532	041563	0	041532	041563
LS1415	3	CM1415		2	BLANK\$COMMON		2	041564	041576
UCSHCH	1	007010	007007	4	CF6SFP		4	BLANK\$COMMON	
UCACSH	1	007070	007161	0	041577	041615	0	BLANK\$COMMON	
T115BR	1	007102	007456	2	041616	041640	2	BLANK\$COMMON	
L23RY3	3	COMN11		2	BLANK\$COMMON		2	041641	041675
	1	007427	007506	2	BLANK\$COMMON		2	BLANK\$COMMON	
CEGSFP (COMMON BLOCK)	3	CZ3RY3		2	041676	041706	2	041676	041706
LS5511	1	007507	007555	0	BLANK\$COMMON		0	BLANK\$COMMON	
	3	COMN11		2	041707	041714	2	041707	041714
ZTUA	1	007555	010002	4	041715	041727	4	041715	041727
	3	CA23Y2		4	CF6SFP		4	BLANK\$COMMON	
DCS4CS	1	010003	010055	2	041730	041766	2	041730	041766
LZ2BY2	1	010055	010115	4	BLANK\$COMMON		4	BLANK\$COMMON	
CY3BY3 (COMMON BLOCK)	3	CZ2BY2		2	CZ2RY2		2	041767	042005
TYPE26	1	010116	010463	0	BLANK\$COMMON		0	BLANK\$COMMON	
	3	RASICR		2	042006	042016	2	042006	042016
TYPE25	3	COMN11		2	BLANK\$COMMON		2	BLANK\$COMMON	
TYPE24	1	010464	010545	4	042017	042040	4	042017	042040
TYPE22	3	PAS1CB		0	042041	042102	0	042041	042102
TYPE22	1	010546	010744	2	BLANK\$COMMON		2	BLANK\$COMMON	
TYPE21	3	PAS1CB		4	042123	042142	4	042123	042142
TYPE20	1	010745	011025	0	BLANK\$COMMON		0	BLANK\$COMMON	
	3	PAS1CB		2	BLANK\$COMMON		2	042143	042162
	3	011026	011251	0	042163	042202	0	042163	042202
CMN15C (COMMON BLOCK)	1	011251	011306	2	BLANK\$COMMON		2	BLANK\$COMMON	
TYPE15	3	CMN15C		4	042203	042270	4	042203	042270
TYPE14	1	011307	011353	2	BLANK\$COMMON		2	BLANK\$COMMON	
CZ3BY3 (COMMON BLOCK)	1	011354	012350	0	CA2BY2		0	CA2BY2	
COMN11 (COMMON BLOCK)	3	PAS1CB		0	042271	042272	0	042271	042272
TYPE11	5	CZ3BY3		2	042273	042277	2	042273	042277
TYPE7	1	012354	013203	0	BLANK\$COMMON		0	BLANK\$COMMON	
TYPE2	3	PAS1CB		2	042300	042304	2	042300	042304
	3	013204	013541	0	BLANK\$COMMON		0	BLANK\$COMMON	
	3	PAS1CB		4	042305	042326	4	042305	042326
	3	013541	013541	0	042327	042367	0	042327	042367
	3	PAS1CB		2	042370	042460	2	042370	042460
	3	PAS1CB		2	BLANK\$COMMON		2	BLANK\$COMMON	
	3	PAS1CB		4	COMN11		4	COMN11	
	3	PAS1CB		0	042461	042553	0	042461	042553
	3	PAS1CB		2	BLANK\$COMMON		2	BLANK\$COMMON	
	3	PAS1CB		0	042554	042674	0	042554	042674
	3	PAS1CB		2	BLANK\$COMMON		2	BLANK\$COMMON	
	3	PAS1CB		4	CA2RY2		4	CA2RY2	

Figure F.7. (Continued).

SEA JUCER RU, 80117 FOR TH-22A APPENDIX F

TYPE1	1	013542	013756	0	042675	042766
	3	BASIC		2	BLANK\$COMMON	
DCMSOL (COMMON BLOCK)				4	CA2RY2	
UECOND (COMMON BLOCK)					042767	043404
VALUE1 (COMMON BLOCK)					043405	043406
UECUMB					043407	043412
	1	013757	015720	0	043413	043637
	3	VALUE1		2	BLANK\$COMMON	
UCMJIV	5	DCMSOL		4	DECOND	
	1	015721	015766	0	043640	043652
FNULCJ	1	015767	016266	2	BLANK\$COMMON	
	3	PRITBL		0	043653	043701
				2	BLANK\$COMMON	
FNULRET	1	016267	016437	4	CATALG	
	3	PRITBL		0	043702	043724
MTMUL	1	016440	016710	2	BLANK\$COMMON	
	1	016711	017216	2	043725	044022
ATOY	3	CA2BY2		2	BLANK\$COMMON	
				0	044023	044052
CZ2BY2 (COMMON BLOCK)				2	BLANK\$COMMON	
ATOZ	1	017217	017443	4	CY2BY2	
	3	CA2BY2		0	044053	044062
				2	044063	044121
TYPCAL	1	017444	017746	4	BLANK\$COMMON	
	3	CATALG		2	CZ2PY2	
DACMUL	1	017747	020007	0	044122	044146
				2	BLANK\$COMMON	
DCMMUL	1	020010	020044	0	044147	044155
				2	BLANK\$COMMON	
LY2BY2	1	020045	020074	0	044156	044164
	3	CY2BY2		2	BLANK\$COMMON	
LA2BY2	1	020075	020124	2	044165	044175
	3	CA2BY2		2	BLANK\$COMMON	
RDCPRI	1	020125	021143	0	044176	044206
	3	CATALG		2	BLANK\$COMMON	
				2	044207	044330
BLUKKL	1	021144	021555	4	BLANK\$COMMON	
	3	PRITBL		2	CNMKDC	
	5	CNMKDC		0	044331	044415
	7	CMAGIC		2	BLANK\$COMMON	
				4	CATALG	
				5	CPRTIN	
FNUMTR	1	021556	021633	8	CFL6AZ	
	3	CATALG		0	044416	044426
LDIMTR	1	021634	021724	2	BLANK\$COMMON	
				0	044427	044452
CHKSTR	1	021725	021755	2	BLANK\$COMMON	
	3	DTATOT		0	044453	044470
SKPLIN	1	021756	022010	2	BLANK\$COMMON	
				0	044471	044500
ALOCAT	1	022011	022072	2	BLANK\$COMMON	
	3	CATALG		0	044501	044525
				2	BLANK\$COMMON	
UPPTBL	1	022073	022264	4	DIASUB	
	3	PRITBL		0	044526	044550
				2	BLANK\$COMMON	
				4	CUPTBL	

Figure F.7. (Continued).

SEAUJER RUN 80117 FOR TP-228 APPENDIX F

UNPACK	1	022265	023050	0	044551	044656
TIME	3	CPTWKO	023077	2	BLANK\$COMMON	
	1	023051	023077	0	044657	044703
PRCTLG	1	023100	023154	2	BLANK\$COMMON	
	3	CATLG		0	044704	044761
				2	BLANK\$COMMON	
PRPTBL	1	023155	023233	4	DTASUB	
	3	PRITBL		0	044762	045040
PRIMTR	1	023234	023340	2	BLANK\$COMMON	
				0	045041	045066
HEAD24	1	023341	023463	2	BLANK\$COMMON	
	3	CPTWKO		0	045067	045110
DCANG1	1	023464	023622	2	BLANK\$COMMON	
				0	045111	045133
CASCODE	1	023623	024055	2	BLANK\$COMMON	
	3	CATLG		0	045134	045156
				2	BLANK\$COMMON	
DCRCIP	1	024056	024110	4	CFLGZ	
				0	045157	045165
MTRNOV	1	024111	024157	2	BLANK\$COMMON	
				0	045166	045203
CY2BY2 (COMMON BLOCK)				2	BLANK\$COMMON	
CABBY2 (COMMON BLOCK)						
YTOA	1	024160	024463	0	045204	045213
	3	CA2BY2		0	045214	045223
				2	045224	045251
LOCMTB	1	024464	024540	4	BLANK\$COMMON	
	3	CATLG		2	CY2BY2	
ENDJAM	1	024541	024604	0	045252	045263
				0	045264	045274
BLUMTR	1	024605	025003	2	BLANK\$COMMON	
	3	PRITBL		0	045275	045326
	5	CPTWKO		2	BLANK\$COMMON	
	7	CMAGLC		4	CATLG	
				6	CNMRDC	
LDUT22	1	025064	025341	8	CBLD	
	3	CATLG		0	045327	045410
LDUT21	1	025342	025617	2	BLANK\$COMMON	
	3	PRITBL		4	DTASUB	
LDPRE0	1	025618	025650	2	045411	045472
	3	BASIC0		2	BLANK\$COMMON	
				4	DTASUB	
COMU26 (COMMON BLOCK)				0	045473	045506
LDUT26	1	025651	026172	4	BLANK\$COMMON	
	3	CATLG		2	PRTOFF	
	5	PRTOFF		0	045507	045522
LDUT4	1	026173	026465	2	045523	045635
	3	CATLG		4	BLANK\$COMMON	
LDPORT	1	026466	027010	0	DTASUB	
	3	PRITBL		0	045727	046016
				2	BLANK\$COMMON	
STRLIN	1	027011	027025	4	CPTWKO	
				0	046017	046042

Figure F.7. (Continued).

SEAJUCER KUJ4 BUI17 FOR TP-SEP APPE-LIA F
WXUJ ABSPUN

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Figure F.7. (Continued).

SEADUCER RUN 80117 FOR TP-22R APPENDIX F

 SEADUCER RUN 80117F MAR 21,1972 S
 HI PASS - LO PASS CASCADE S
 W/ 1/2 DB RIPPLE FACTOR, (FLP=285U, FHP=2150) S
 CHARGE TO 16000401 AMPLIFIERS

***** AB 5 NETWORK TABLE

P 1A5B, 1B2A,\$
 P 2A5B, 2B2C, +3B3E,\$
 P 3A5B, +2B2A, 1B2D, 1B2C,\$
 P 4A5B, +2B2B, 1B2D, 1B3E,\$
 P 5A5B, 2B3E,\$

TYPE 4 UNIT MAIRIX
 A2A1\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A2\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A3\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A4\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A5\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A6\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A7\$ 1.00

TYPE 4 UNIT MAIRIX
 A2A8\$ 1.00

TYPE 26 R1 C1 R2 C2
 B3E\$.100000+07 .700000-12 .100000-09 .100000-09
 RU CD R3 L3
 .100000+07 .700000-12 .750000+02 .000000
 A0 OMEGA1 OMEGA2 OMEGA3
 .700000+05 .629310+02 .168495+08 .628310+10

Figure F.7. (Continued).

SEAUJECR RUN 80117 FOR TP-22R APPE-UIA F						
F	DB	UAG	ANG DEG	REAL	IVAC	
.1000+04	- .3434+02	.1918-01	- .1103+02	.1877-01	- .3949-02	
Y A2R						
1	1	.0000000000			.3330088209-004	
2	1	.0000000000			.0000000000	
3	1	.0000000000			- .3330088209-004	
4	1	.0000000000			.0000000000	
5	1	.0000000000			.0000000000	
1	2	.0000000000			.0000000000	
2	2	- .1345167653-001			- .3330088209-004	
3	2	.0000000000			- .3330088209-004	
4	2	- .1183431953-003			- .222982791-041	
5	2	.0000000000			.0000000000	
1	3	.0000000000			- .3330088209-004	
2	3	.0000000000			.3330088209-004	
3	3	.4878047780-003			.9990264628-004	
4	3	.0000000000			- .3330088209-004	
5	3	.0000000000			.0000000000	
1	4	.0000000000			.0000000000	
2	4	- .908535753-001			.343422371+001	
3	4	.0000000000			- .3330088209-004	
4	4	.1203431953-003			.3330967855-004	
5	4	- .1000000000-005			- .1398229723-008	
1	5	.0000000000			.0000000000	
2	5	.9020370072-001			- .333422371+001	
3	5	.0000000000			.0000000000	
4	5	- .1000000000-005			- .4398229723-008	
5	5	.1000000000+011			.6327167579-006	
Y A2B						
1	1	.2151089024-005			.3287820161-004	
2	1	- .7192004976-001			- .1472234110+000	
1	2	.4009038208-005			- .1552596380-005	
2	2	.2088853724+001			.0283490378+001	
A A2R						
1	1	.5102032354+002			.1073559207+002	
2	1	- .2392000642-003			.1699197102-002	
1	2	- .2678863319+001			.5483747532+001	
2	2	- .1860562304-003			- .7628017916-004	

Figure F.7. (Continued).

SEAUCER RUN 80117 FOR TP-22R APPENDIX F

.1000+04 -.2164+02 .8280-01 -.1078+02 .8134-01 -.1549-01
Y A5B

1 1 .0000000000 .3330088209-004
2 1 .0000000000 .0000000000
3 1 .0000000000 -.3330088209-004
4 1 .0000000000 .0000000000
5 1 .0000000000 .0000000000

1 2 .0000000000 .0000000000
2 2 -.1335820896-001 -.3330088209-004
3 2 .0000000000 -.3330088209-004
4 2 -.2487562189-004 -.9844453238-043
5 2 .0000000000 .0000000000

1 3 .0000000000 -.3330088209-004
2 3 .0000000000 .3330088209-004
3 3 .574712937-003 .9990264628-004
4 3 .0000000000 -.3330088209-004
5 3 .0000000000 .0000000000

1 4 .0000000000 .0000000000
2 4 -.901782510-001 .933422371+001
3 4 .0000000000 -.3330088209-004
4 4 .2687562189-004 .3330967855-004
5 4 -.1000000000-005 -.4396229723-008

1 5 .0000000000 .0000000000
2 5 .9020370072-001 -.933422371+001
3 5 .0000000000 .0000000000
4 5 -.1300000000-005 -.4396229723-008
5 5 .1000000000+011 .6327167579-006

Y A2B

1 1 .1842800278-005 .3305223052-004
2 1 -.3447546656+000 -.2134847160+000
1 2 .2403013612-005 -.1173004428-005
2 2 .3607950398+001 .3311273067+001

A A2B

1 1 .1186368741+002 .2258293362+001
2 1 -.5037502670-004 .3951101294-003
1 2 -.2096646071+001 .1296320040+001
2 2 -.4677628207-004 -.0630615489-004

Figure F.7. (Continued).

SEAUSER RUN 80117 FOR TP-22R APPL WIA F

.1000+04 -.1446+02 .1632+00 -.7932+01 .1874+00 -.2611-01

Y A5B

1	1	.0000000000	.3330088209-004
2	1	.0000000000	.0000000000
3	1	.0000000000	-.3330088209-004
4	1	.0000000000	.0000000000
5	1	.0000000000	.0000000000

1	2	.0000000000	.0000000000
2	2	-.133413333-001	-.3330088209-004
3	2	.0000000000	-.3330088209-004
4	2	-.000000000-005	-.1016591640-043
5	2	.0000000000	.0000000000

1	3	.0000000000	-.3330088209-004
2	3	.0000000000	.3330088209-004
3	3	.8695652174-003	.9990264628-004
4	3	.0000000000	-.3330088209-004
5	3	.0000000000	.0000000000

1	4	.0000000000	.0000000000
2	4	-.9019570072-001	.932422371+001
3	4	.0000000000	-.3330088209-004
4	4	.1000000000-004	.3330967855-004
5	4	-.1000000000-005	-.4396229723-008

1	5	.0000000000	.0000000000
2	5	.9020370072-001	-.932422371+001
3	5	.0000000000	.0000000000
4	5	-.1000000000-005	-.4396229723-008
5	5	.1000000000+011	.6327167579-006

Y A2R

1	1	.1254173603-005	.3320188386-004
2	1	-.3292821296+000	-.7451386540-001
1	2	.1315312201-005	-.3016574562-006
2	2	.1669270600+001	.6301982737+000

A A2B

1	1	.5234490102+001	.7293325594+000
2	1	-.16333493857-004	.1743277845-003
1	2	-.2808970975+001	.6537506139+000
2	2	-.2532901405-004	-.9509936391-004

Figure F.7. (Continued).

SEAUCER RUN 80117 FOR TP-228 APPENDIX F									
Y A5B									
1	1	1	0000000000	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
2	1	1	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
3	1	1	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
4	1	1	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
5	1	1	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
1	2	2	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2	2	2	133350300-001	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
3	2	2	0000000000	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
4	2	2	216968001-005	7492154369-045	0000000000	0000000000	0000000000	0000000000	0000000000
5	2	2	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
1	3	3	0000000000	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
2	3	3	0000000000	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
3	3	3	2487562169-002	9990264628-004	0000000000	0000000000	0000000000	0000000000	0000000000
4	3	3	0000000000	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
5	3	3	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
1	4	4	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2	4	4	9020153105-001	9332422371+001	0000000000	0000000000	0000000000	0000000000	0000000000
3	4	4	0000000000	3330088209-004	0000000000	0000000000	0000000000	0000000000	0000000000
4	4	4	416368001-005	3330967855-004	0000000000	0000000000	0000000000	0000000000	0000000000
5	4	4	1000000000-005	4396229723-008	0000000000	0000000000	0000000000	0000000000	0000000000
1	5	5	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2	5	5	9020370072-001	9332422371+001	0000000000	0000000000	0000000000	0000000000	0000000000
3	5	5	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
4	5	5	1000000000-005	4396229723-008	0000000000	0000000000	0000000000	0000000000	0000000000
5	5	5	1000000000+011	6327167579-006	0000000000	0000000000	0000000000	0000000000	0000000000
Y A2B									
1	1	1	44474051-0-006	3326890101-004	0000000000	0000000000	0000000000	0000000000	0000000000
2	1	1	1229780975+000	1324187760-001	0000000000	0000000000	0000000000	0000000000	0000000000
1	2	2	4475424768-006	4659907055-007	0000000000	0000000000	0000000000	0000000000	0000000000
2	2	2	4596257677+000	7320971734-001	0000000000	0000000000	0000000000	0000000000	0000000000
A A2R									
1	1	1	3759690675+001	2067368845+000	0000000000	0000000000	0000000000	0000000000	0000000000
2	1	1	4762411762-005	1252075156-003	0000000000	0000000000	0000000000	0000000000	0000000000
1	2	2	8038279563+001	1655299100+000	0000000000	0000000000	0000000000	0000000000	0000000000
2	2	2	4236749806-004	2672005565-003	0000000000	0000000000	0000000000	0000000000	0000000000

Figure F.7. (Continued).

SEAUGER RUN 80117 FOR TP-22P APPENDIX F									
.1000+04		.1122+01	.1336+01	.1701+03	-.1137+01	.5731-01			
Y A2R									
1	1	.3086419753-004		.1516107908-042					
2	1	.0000000000		.0000000000					
3	1	-.3086419753-004		-.1516107908-042					
4	1	.0000000000		.0000000000					
5	1	.0000000000		.0000000000					
1	2	.0000000000		.0000000000					
2	2	-.1336419753-001		-.2636937618-006					
3	2	-.3086419753-004		-.1516107908-042					
4	2	.0000000000		-.2636937618-006					
5	2	.0000000000		.0000000000					
1	3	-.3086419753-004		-.1516107908-042					
2	3	.3086419753-004		.1516107908-042					
3	3	.92592529-004		.3725928889-003					
4	3	-.3086419753-004		-.1516107908-042					
5	3	.0000000000		.0000000000					
1	4	.0000000000		.0000000000					
2	4	-.9020370072-001		.6334422635+001					
3	4	-.3086419753-004		-.1516107908-042					
4	4	.3286419753-004		.2726902413-006					
5	4	-.1000000000-005		-.4396229723-008					
1	5	.0000000000		.0000000000					
2	5	.9020370072-001		-.4332422371+001					
3	5	.0000000000		.0000000000					
4	5	-.1000000000-005		-.43324223723-008					
5	5	.1000000004+011		.6327167579-006					
Y A2R									
1	1	.3044061692-004		.2482756600-005					
2	1	.7048710544+000		.1212472734+000					
1	2	-.4435435759-006		.2479522964-005					
2	2	.6156417140+000		.1266121713+000					
A A2R									
1	1	-.0783673742+000		-.2681735891-001					
2	1	-.2711004178-004		-.5794693715-006					
1	2	.1377926214+001		-.2376221302+000					
2	2	.4253345364-004		-.3794036743-005					

Figure F.7. (Continued).

SEADUCR RUN 80117 FOR TP-228 APPENDIX F									
Y A5B									
1	1	.1000+04	.1550+01	.1195+01	.1717+03	-.1183+01	.1714+00		
2	1	.3086419753-004							
3	1	.0000000000							
4	1	-.3086419753-004							
5	1	.0000000000							
1	2	.0000000000							
2	2	-.1336419753-001							
3	2	-.3086419753-004							
4	2	.0000000000							
5	2	.0000000000							
1	3	-.3086419753-004							
2	3	.3086419753-004							
3	3	.929293239-004							
4	3	-.3086419753-004							
5	3	.0000000000							
1	4	.0000000000							
2	4	-.9020370072-001							
3	4	-.3086419753-004							
4	4	.3286419753-004							
5	4	-.1000000000-005							
1	5	.0000000000							
2	5	.9020370072-001							
3	5	.0000000000							
4	5	-.1000000000-005							
5	5	.1000000000+011							
Y A2B									
1	1	.2803259762-004							
2	1	.1684876563+001							
1	2	-.3050324466-005							
2	2	.1303787228+001							
A A2B									
1	1	-.8278961635+000							
2	1	-.2555364453-004							
1	2	.4936384352+000							
2	2	.1513957906-004							

Figure F.7. (Continued).

SEAUCER RUN 80117 FOR TP-22R APPENDIX F			
Y A5B			
1	1	.1000+04 .2521+01 .1537+01 .1507+03 -.1166+01 .6541+00	
2	1	.3086419753-004 .1516107908-042	
3	1	.0000000000 .0000000000	
4	1	-.3086419753-004 -.1516107908-042	
5	1	.0000000000 .0000000000	
1	2	.0000000000 .0000000000	
2	2	-.1336419753-001 -.3736495262-005	
3	2	-.3086419753-004 -.1516107908-042	
4	2	.0000000000 .0000000000	
5	2	.0000000000 .0000000000	
1	3	-.3086419753-004 -.1516107908-042	
2	3	.3086419753-004 .1516107908-042	
3	3	.9252525252-004 .3736627602-004	
4	3	-.3086419753-004 -.1516107908-042	
5	3	.0000000000 .0000000000	
1	4	.0000000000 .0000000000	
2	4	-.9020370072-001 .9332426110+001	
3	4	-.3086419753-004 -.1516107908-042	
4	4	.3286419753-004 .3747291721-005	
5	4	-.1000000000-005 -.4396229723-008	
1	5	.0000000000 .0000000000	
2	5	.9020370072-001 -.9332422371+001	
3	5	.0000000000 .0000000000	
4	5	-.1000000000-005 -.4396229723-008	
5	5	.1000000000+011 .6327167579-006	
Y A2B			
1	1	.2590901634-004 .7015798017-005	
2	1	.2113810541+001 .1165116564+001	
1	2	-.5805664044-005 .6549274366-005	
2	2	.9452805601+000 .1547028052+001	
A A2B			
1	1	-.6524349901+000 -.3660759603+000	
2	1	-.2014162002-004 -.7513038699-005	
1	2	.3599363868+000 -.2016012770+000	
2	2	.1074173435-004 -.2703378989-005	

Figure F.7. (Continued).

SEADJUCER RUN 80117 FOR TP-22R APPENDIX A

.1000+04 -.5080+01 .5372+00 .7355+02 .1258+00 .5428+00

Y A5R

1	1	.3086419753-004	.1516107908-042
2	1	.0000000000	.0000000000
3	1	-.3086419753-004	-.1516107908-042
4	1	.0000000000	.0000000000
5	1	.0000000000	.0000000000
1	2	.0000000000	.0000000000
2	2	-.1336419753-001	-.179619312-004
3	2	-.3086419753-004	-.1516107908-042
4	2	.0000000000	-.1797619312-004
5	2	.0000000000	.0000000000
1	3	-.3086419753-004	-.1516107908-042
2	3	.3086419753-004	.1516107908-042
3	3	.925923259-004	.7414158648-004
4	3	-.3086419753-004	-.1516107908-042
5	3	.0000000000	.0000000000

1	4	.0000000000	.0000000000
2	4	-.902037002-001	.9332440347+001
3	4	-.3086419753-004	-.1516107908-042
4	4	.3286419753-004	.1796498958-004
5	4	-.1000000000-005	-.4396229723-008
1	5	.0000000000	.0000000000
2	5	.902037002-001	-.9332442371+001
3	5	.0000000000	.0000000000
4	5	-.1000000000-005	-.4396229723-008
5	5	.1000000000+011	.532167579-006

Y A2B

1	1	.2546297143-004	.6635480913-005
2	1	.2092203102+001	.4070296041+000
1	2	-.9436436353-005	.3090467671-005
2	2	-.1559507494+001	.3493203240+001

A A2B

1	1	.4052606604+000	-.1740466776+001
2	1	.1248262034-004	-.3394159251-004
1	2	.4605336744+000	-.959475180-001
2	2	.1232105959-004	.7745137787-006

Figure F.7. (Continued).

SEADUCER RUN 80117 FOR TP-22R APPENDIX F									
A A2A									
.1000+04	-.8185+02	.8085-04	-.1762+03	-.8068-04	-.5318-05				
F									
1	1	-.1234127686+005	.8134926955+003						
2	1	-.5412253636-001	-.4034435188+000						
1	2	-.1509331443+004	-.2859075627+004						
2	2	.9053119877-001	-.5591187619-001						
F									
.1100+04	-.3269+02	.2520-01	-.1309+02	.2260-01	-.5252-02				
.1100+04	-.1986+02	.1016+00	-.1204+02	.9937-01	-.2119-01				
.1100+04	-.1246+02	.2582+00	-.9079+01	.2352+00	-.3758-01				
.1100+04	-.9311+01	.3423+00	-.3677+01	.3416+00	-.2196-01				
.1100+04	.1377+01	.1172+01	.1779+03	-.1171+01	.4347-01				
.1100+04	.1909+01	.1446+01	.1705+03	-.1229+01	.2052+00				
.1100+04	.3029+01	.1417+01	.1452+03	-.1164+01	.8047+00				
.1100+04	-.6220+01	.4687+00	.6999+02	.1672+00	.4591+00				
.1100+04	-.7423+02	.1944-03	.1657+03	-.1883-03	.4796-04				
F									
.1200+04	-.3118+02	.2760-01	-.1429+02	.2674-01	-.6813-02				
.1200+04	-.1822+02	.1228+00	-.1335+02	.1195+00	-.2835-01				
.1200+04	-.1056+02	.2965+00	-.1036+02	.2917+00	-.5333-01				
.1200+04	-.7155+01	.4388+00	-.4306+01	.4376+00	-.3295-01				
.1200+04	.1665+01	.1211+01	.1776+03	-.1210+01	.5062-01				
.1200+04	.2517+01	.1506+01	.1692+03	-.1282+01	.2458+00				
.1200+04	.3543+01	.1504+01	.1367+03	-.1129+01	.9927+00				
.1200+04	-.7360+01	.4285+00	.6398+02	.1880+00	.3851+00				
.1200+04	-.6695+02	.4494-03	.1471+03	-.3774-03	.2440-03				
F									
.1300+04	-.2980+02	.3237-01	-.1550+02	.3120-01	-.8653-02				
.1300+04	-.1668+02	.1465+00	-.1473+02	.1417+00	.3727-01				
.1300+04	-.8727+01	.3061+00	-.1182+02	.3584+00	-.7500-01				
.1300+04	-.5008+01	.5019+00	-.5073+01	.5597+00	-.4969-01				
.1300+04	.1989+01	.1257+01	.1773+03	-.1256+01	.5900-01				
.1300+04	.2780+01	.1377+01	.1676+03	-.1345+01	.2960+00				
.1300+04	.4020+01	.1589+01	.1310+03	-.1041+01	.1200+01				
.1300+04	-.8481+01	.3767+00	.5681+02	.1951+00	.3222+00				
.1300+04	-.5990+02	.1012-02	.1275+03	-.6162-03	.8022-03				
F									
.1400+04	-.2851+02	.3752-01	-.1672+02	.3594-01	-.1079-01				
.1400+04	-.1527+02	.1731+00	-.1619+02	.1662+00	-.4925-01				
.1400+04	-.6940+01	.4498+00	-.1350+02	.4374+00	-.1050+00				
.1400+04	-.2820+01	.7228+00	-.6637+01	.7188+00	-.7602-01				
.1400+04	.2354+01	.1511+01	.1770+03	-.1309+01	.6900-01				
.1400+04	.3304+01	.1463+01	.1658+03	-.1418+01	.3595+00				
.1400+04	.4394+01	.1658+01	.1219+03	-.8767+00	.1408+01				
.1400+04	-.9570+01	.3323+00	.5034+02	.1237+00	.2700+00				
.1400+04	-.5302+02	.2232-02	.1866+03	-.6366-03	.2140-02				
F									
.1500+04	-.2732+02	.4305-01	-.1794+02	.4096-01	-.1326-01				
.1500+04	-.1387+02	.2026+00	-.1773+02	.1930+00	-.6162-01				
.1500+04	-.5179+01	.5510+00	-.1346+02	.5310+00	-.1464+00				
.1500+04	-.5421+00	.9395+00	-.7297+01	.9319+00	-.1193+00				
.1500+04	.2763+01	.1374+01	.1766+03	-.1372+01	.8110-01				
.1500+04	.3696+01	.1266+01	.1636+03	-.1503+01	.4411+00				
.1500+04	.4584+01	.1695+01	.1117+03	-.6263+00	.1575+01				

Figure F.7. (Continued).

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SEQUENCER RUN 80117 FOR TP-22A APPENDIX F
.1500+04 -.1062+02 .2945+00 .5346+02 .1875+00 .2271+00
F .1500+04 -.4622+02 .4053-02 .0397+02 .5095-03 .4326-02
    MAG DEG REAL IMAG
.1600+04 -.2621+02 .4095-01 -.1515+02 .4624-01 -.1607-01
.1600+04 -.1256+02 .2354+00 .1536+02 .2221+00 -.7805-01
.1600+04 -.3421+01 .6745+00 .1779+02 .6422+00 -.2060+00
.1600+04 .1697+01 .1444+01 -.9028+01 .1229+01 -.1952+00
.1600+04 .3222+01 .1449+01 .1762+03 -.1446+01 .9598-01
.1600+04 .4566+01 .1091+01 .1611+03 -.1600+01 .5484+06
.1600+04 .4513+01 .1691+01 .1607+03 -.3115+00 .1652+01
.1600+04 -.1163+02 .2022+00 .4767+02 .1786+00 .1920+00
.1600+04 -.3962+02 .1045-01 .5968+02 .5276-02 .9022-02
    MAG DEG REAL IMAG
.1700+04 -.2515+02 .5221-01 -.2640+02 .5175-01 -.1924-01
.1700+04 -.1132+02 .2716+00 .2111+02 .2535+00 -.9788-01
.1700+04 -.1651+01 .8269+00 .2061+02 .7739+00 -.2911+00
.1700+04 .4602+01 .1099+01 .1157+02 .1464+01 -.3407+00
.1700+04 .3739+01 .1338+01 .1757+03 -.1534+01 .1147+00
.1700+04 .5316+01 .1044+01 .1579+03 -.1709+01 .6925+00
.1700+04 .4142+01 .1011+01 .5958+02 .1173-01 .1611+01
.1700+04 -.1259+02 .2346+00 .4409+02 .1685+00 .1633+00
.1700+04 -.3291+02 .2261-01 .5365+02 .1082-01 .1253-01
    MAG DEG REAL IMAG
.1800+04 -.2417+02 .6185-01 -.2163+02 .5749-01 -.2280-01
.1800+04 -.1012+02 .3120+00 .2297+02 .2873+00 -.1219+00
.1800+04 .1472+00 .1017+01 .2410+02 .9284+00 .4153+00
.1800+04 .7742+01 .2438+01 -.1589+02 .2347+01 -.0595+00
.1800+04 .4322+01 .1045+01 .1752+03 -.1639+01 .1386+00
.1800+04 .6161+01 .2033+01 .1540+03 -.1027+01 .0900+00
.1800+04 .3492+01 .1495+01 .7913+02 .2820+00 .1468+01
.1800+04 -.1352+02 .2109+00 .4146+02 .1581+00 .1397+00
.1800+04 -.2593+02 .5050-01 .5378+01 .5027-01 .4733-02
    MAG DEG REAL IMAG
.1900+04 -.2324+02 .6084-01 -.2267+02 .6343-01 -.2676-01
.1900+04 -.6954+01 .3065+00 .2498+02 .5231+00 -.1505+00
.1900+04 .1987+01 .1257+01 .2205+02 .1105+01 -.6001+00
.1900+04 .1162+02 .3009+01 .2345+02 .3494+01 -.1516+01
.1900+04 .4983+01 .1775+01 .1745+03 -.1767+01 .1700+00
.1900+04 .7100+01 .2255+01 .1490+03 -.1942+01 .1165+01
.1900+04 .2634+01 .1354+01 .0362+02 .4673+00 .1271+01
.1900+04 -.1440+02 .1905+00 .5912+02 .1478+00 .1202+00
.1900+04 -.1827+02 .1420+00 .2737+02 .1083+00 .5608-01
    MAG DEG REAL IMAG
.2000+04 -.2236+02 .7020-01 -.2412+02 .6953-01 -.3118-01
.2000+04 -.7640+01 .4055+00 .2713+02 .3609+00 -.1849+00
.2000+04 .3670+01 .1361+01 .3422+02 .1291+01 -.0780+00
.2000+04 .1664+02 .6789+01 .4203+02 .5043+01 .4545+01
.2000+04 .5739+01 .1936+01 .1737+03 .1924+01 .2125+00
.2000+04 .8121+01 .2347+01 .1425+03 .2021+01 .1550+01
.2000+04 .1649+01 .1209+01 .6164+02 .5706+00 .1066+01
.2000+04 -.1525+02 .1726+00 .3702+02 .1380+00 .1040+00
.2000+04 -.9422+01 .3380+00 .7251+02 .1016+00 .5224+00
    MAG DEG REAL IMAG
.2100+04 -.2152+02 .8391-01 -.2538+02 .7582-01 -.3596-01
.2100+04 -.6755+01 .4594+00 .2946+02 .4000+00 -.2260+00
.2100+04 .5774+01 .1944+01 .4174+02 .1451+01 -.1294+01
.2100+04 .2059+02 .1071+02 .9327+02 .4244+00 .1070+02

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Figure F.7. (Continued).

SEADUCER RUN 80117 FOR TP-22A APPENDIX F

.2100+04	.6606+01	.2140+01	.1727+03	-.2123+01	.2719+00
.2100+04	.9175+01	.2676+01	.1339+03	-.1993+01	.2074+01
.2100+04	.6074+00	.1072+01	.5215+02	.6129+00	.8801+00
.2100+04	-.1606+02	.1574+00	.3513+02	.1287+00	.9056+01
.2100+04	-.1576+01	.8339+00	-.1522+03	-.7374+00	-.3893+00
F	DE	MAV	ANG DEG	REAL	IMAG
.2200+04	-.2073+02	.9196+01	-.2664+02	.8221+01	-.4124+01
.2200+04	-.5703+01	.5186+00	-.3199+02	.4399+00	-.2747+00
.2200+04	.7625+01	.2406+01	-.5173+02	.1490+01	-.1889+01
.2200+04	.1740+02	.7741+01	-.1390+03	-.5598+01	-.4866+01
.2200+04	.7622+01	.2405+01	.1714+03	-.2378+01	.3589+00
.2200+04	.1014+02	.3215+01	.1225+03	-.1725+01	.2713+01
.2200+04	-.4432+00	.9502+00	.4958+02	.6161+00	.7234+00
.2200+04	-.1684+02	.1439+00	.3343+02	.1201+00	.7925+01
.2200+04	-.9233+00	.8992+00	.1275+03	-.5469+00	.7137+00
F	DB	MAV	ANG DEG	REAL	IMAG
.2300+04	-.1997+02	.1004+00	-.2790+02	.8871+01	-.4699+01
.2300+04	-.4680+01	.5634+00	-.3472+02	.4795+00	-.3323+00
.2300+04	.9254+01	.2902+01	-.6471+02	.1240+01	-.2624+01
.2300+04	.1375+02	.4672+01	-.1553+03	-.4445+01	-.1993+01
.2300+04	.8620+01	.2760+01	.1697+03	-.2716+01	.4931+00
.2300+04	.1080+02	.3466+01	.1061+03	-.1076+01	.3297+01
.2300+04	-.1474+01	.8439+00	.4494+02	.5973+00	.5961+00
.2300+04	-.1759+02	.1320+00	.3108+02	.1121+00	.6971+01
.2300+04	-.1082+01	.8629+00	.7159+02	.2817+00	.8367+00
F	DB	MAV	ANG DEG	REAL	IMAG
.2400+04	-.1924+02	.1091+00	-.2918+02	.9529+01	-.5320+01
.2400+04	-.3689+01	.6540+00	-.3770+02	.5174+00	-.3999+00
.2400+04	.1039+02	.3309+01	-.8039+02	.5521+00	-.3262+01
.2400+04	.1124+02	.3646+01	-.1231+03	-.3488+01	-.1062+01
.2400+04	.1026+02	.3260+01	.1673+03	-.3181+01	.7157+00
.2400+04	.1088+02	.3498+01	.9171+02	-.1044+00	.3496+01
.2400+04	-.2470+01	.7525+00	.4106+02	.5674+00	.4942+00
.2400+04	-.1831+02	.1215+00	.3047+02	.1047+00	.6160+01
.2400+04	-.9345+00	.8980+00	.2019+02	.8428+00	.3100+00
F	DB	MAV	ANG DEG	REAL	IMAG
.2500+04	-.1855+02	.1182+00	-.3046+02	.1019+00	-.5992+01
.2500+04	-.2730+01	.7303+00	-.4393+02	.5517+00	-.4785+00
.2500+04	.1082+02	.3477+01	-.9598+02	-.4224+00	-.3451+01
.2500+04	.9440+01	.2965+01	-.1670+03	-.2889+01	-.6685+00
.2500+04	.1205+02	.4006+01	.1637+03	-.3845+01	.1122+01
.2500+04	.1026+02	.3258+01	.7570+02	.8049+00	.3157+01
.2500+04	-.3425+01	.6742+00	.3778+02	.5329+00	.4130+00
.2500+04	-.1900+02	.1122+00	.2917+02	.9796+01	.5468+01
.2500+04	-.1117+01	.8793+00	-.2699+02	.7691+00	-.4262+00
F	DB	MAV	ANG DEG	REAL	IMAG
.2600+04	-.1788+02	.1276+00	-.3174+02	.1085+00	-.6714+01
.2600+04	-.1806+01	.8123+00	-.4445+02	.5799+00	-.5688+00
.2600+04	.1059+02	.3585+01	-.1120+03	-.1268+01	-.3138+01
.2600+04	.8088+01	.2538+01	-.1594+03	-.2494+01	-.4669+00
.2600+04	.1434+02	.5213+01	.1578+03	-.4826+01	.1971+01
.2600+04	.9129+01	.2860+01	.6210+02	.1339+01	.2528+01
.2600+04	-.4335+01	.6071+00	.3498+02	.4974+00	.3480+00
.2600+04	-.1967+02	.1039+00	.2798+02	.9175+01	.4875+01
.2600+04	-.1530+01	.8385+00	-.7478+02	.2201+00	-.8091+00
F	DB	MAV	ANG DEG	REAL	IMAG
.2700+04	-.1724+02	.1573+00	-.3304+02	.1151+00	-.7488+01

Figure F.7. (Continued).

.2700+04	-.9203+00	.8995+00	-.4826+02	.5983+00	-.6711+00
.2700+04	.9957+01	.3147+01	-.1241+03	-.1764+01	-.2606+01
.2700+04	.7031+01	.2247+01	-.1711+03	-.2219+01	-.3493+00
.2700+04	.1734+02	.7366+01	.1464+03	-.6136+01	.4074+01
.2700+04	.7756+01	.2442+01	.5151+02	.1520+01	.1912+01
.2700+04	-.5203+01	.5494+00	.3257+02	.4630+00	.2958+00
.2700+04	-.2031+02	.9648+01	.2668+02	.8606+01	.4363+01
.2700+04	-.1573+01	.8343+00	-.1191+03	-.4060+00	-.7289+00
	DB	MAG	ANG DEG	REAL	IMAG
.2800+04	-.1663+02	.1474+00	-.3433+02	.1217+00	-.8313+01
.2800+04	-.7985+01	.9908+00	-.5237+02	.6049+00	-.7848+00
.2800+04	.9172+01	.2673+01	-.1333+03	-.1971+01	-.2093+01
.2800+04	.6179+01	.2037+01	-.1723+03	-.2018+01	-.2742+00
.2800+04	.2088+02	.1107+02	.1208+03	-.5660+01	.9514+01
.2800+04	.6338+01	.2074+01	.4353+02	.1504+01	.1429+01
.2800+04	.6028+01	.4995+00	.3048+02	.4305+00	.2534+00
.2800+04	-.2093+02	.8983+01	.2387+02	.8083+01	.3919+01
.2800+04	-.1079+01	.8831+00	-.1718+03	-.8741+00	-.1261+00
	DB	MAG	ANG DEG	REAL	IMAG
.2900+04	-.1604+02	.1577+00	-.3564+02	.1282+00	-.9190+01
.2900+04	.7086+00	.1085+01	-.5680+02	.5941+00	-.9079+00
.2900+04	.8381+01	.2625+01	-.1402+03	-.2016+01	-.1680+01
.2900+04	.5476+01	.1678+01	-.1732+03	-.1865+01	-.2230+00
.2900+04	.2157+02	.1199+02	.7368+02	.3328+01	.1152+02
.2900+04	.4971+01	.1772+01	.3750+02	.1406+01	.1079+01
.2900+04	.6815+01	.4563+00	.2065+02	.4004+00	.2188+00
.2900+04	-.2153+02	.8583+01	.2492+02	.7602+01	.5533+01
.2900+04	.3280+01	.6655+00	.1109+03	-.3312+00	.6002+00
	DB	MAG	ANG DEG	REAL	IMAG
.3000+04	-.1548+02	.1684+00	-.3695+02	.1345+00	-.1012+00
.3000+04	.1437+01	.1180+01	-.6151+02	.5628+00	-.1037+01
.3000+04	.7644+01	.2411+01	-.1455+03	-.1986+01	-.1367+01
.3000+04	.4886+01	.1755+01	-.1739+03	-.1745+01	-.1863+00
.3000+04	.1800+02	.7946+01	.4103+02	.5994+01	.5216+01
.3000+04	.3690+01	.1529+01	.3207+02	.1285+01	.6300+00
.3000+04	.7566+01	.4185+00	.2704+02	.3727+00	.1903+00
.3000+04	-.2211+02	.7641+01	.2405+02	.7160+01	.3195+01
.3000+04	-.9508+01	.3346+00	.6701+02	.1307+00	.3081+00
	DB	MAG	ANG DEG	REAL	IMAG
.3100+04	-.1493+02	.1793+00	-.3827+02	.1407+00	-.1110+00
.3100+04	.2097+01	.1273+01	-.6649+02	.5078+00	-.1167+01
.3100+04	.6981+01	.2234+01	-.1495+03	-.1925+01	-.1133+01
.3100+04	.4385+01	.1657+01	-.1745+03	-.1649+01	-.1569+00
.3100+04	.1446+02	.5281+01	.2570+02	.4718+01	.2373+01
.3100+04	.2502+01	.1534+01	.2924+02	.1164+01	.6516+00
.3100+04	.8283+01	.3653+00	.2561+02	.3475+00	.1665+00
.3100+04	.2268+02	.7349+01	.2323+02	.6753+01	.2898+01
.3100+04	-.1548+02	.1682+00	.3569+02	.1363+00	.9862+01
	DB	MAG	ANG DEG	REAL	IMAG
.3200+04	-.1440+02	.1904+00	-.3959+02	.1468+00	-.1214+00
.3200+04	.2681+01	.1562+01	-.7159+02	.4279+00	-.1293+01
.3200+04	.6390+01	.2087+01	-.1528+03	-.1956+01	-.9853+00
.3200+04	.3952+01	.1576+01	-.1750+03	-.1570+01	-.1378+00
.3200+04	.1167+02	.3833+01	.1959+02	.3611+01	.1285+01
.3200+04	.1402+01	.1175+01	.2634+02	.1053+01	.5214+00
.3200+04	-.8970+01	.3561+00	.2432+02	.3244+00	.1466+00
.3200+04	-.2322+02	.6902+01	.2246+02	.6578+01	.2637+01

Figure F.7. (Continued).

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.3200+04	DB	-.2051+02	MAG	.9430-01	ANG DEG	.1363+02	REAL	.9164-01	IMAG	.2222-01
F										
.3300+04		-.1390+02		.2019+00		-.4092+02		.1526+00		-.1322+00
.3300+04		.3183+01		.1443+01		-.1703+02		.3239+00		-.1406+01
.3300+04		.5868+01		.1965+01		-.1594+03		-.1786+01		-.8101+00
.3300+04		.3576+01		.1309+01		-.1754+03		-.1505+01		-.1211+00
.3300+04		.9445+01		.2967+01		.1547+02		.2859+01		.7910+00
.3300+04		.3812+00		.1945+01		.2397+02		.9547+00		.4245+00
.3300+04		-.9628+01		.3301+00		.2317+02		.3035+00		.1299+00
.3300+04		-.2375+02		.6494-01		.2174+02		.6032-01		.2406-01
.3300+04		-.2483+02		.5734-01		-.4419+01		.5717-01		-.4418-02
F										
.3400+04	DB	-.1341+02	MAG	.2136+00	ANG DEG	-.4225+02	REAL	.1581+00	IMAG	-.1436+00
.3400+04		.3599+01		.1513+01		-.8243+02		.1993+00		-.1500+01
.3400+04		.5404+01		.1063+01		-.1375+03		-.1721+01		-.7125+00
.3400+04		.3246+01		.1453+01		-.1758+03		-.1449+01		-.1077+00
.3400+04		.7603+01		.2400+01		.1279+02		.2340+01		.5312+00
.3400+04		-.5684+00		.9367+00		.2201+02		.8684+00		.3510+00
.3400+04		-.1026+02		.3069+00		.2212+02		.2843+00		.1156+00
.3400+04		-.2426+02		.6121-01		.2107+02		.5712-01		.2200-01
.3400+04		-.2866+02		.3092-01		-.2102+02		.3469-01		-.1264-01
F										
.3500+04	DB	-.1294+02	MAG	.2255+00	ANG DEG	-.4359+02	REAL	.1633+00	IMAG	-.1555+00
.3500+04		.3928+01		.1372+01		-.8782+02		.5978-01		-.1571+01
.3500+04		.4993+01		.1777+01		-.1593+03		-.1662+01		-.6277+00
.3500+04		.2955+01		.1405+01		-.1761+03		-.1402+01		-.9856-01
.3500+04		.6631+01		.2002+01		.1092+02		.1966+01		.3782+00
.3500+04		-.1456+01		.8457+00		.2035+02		.7929+00		.2941+00
.3500+04		-.1087+02		.2862+00		.2117+02		.2669+00		.1034+00
.3500+04		-.2476+02		.5780-01		.2543+02		.5416-01		.2018-01
.3500+04		-.3212+02		.2477-01		-.3395+02		.2055-01		-.1384-01
F										
.3600+04	DB	-.1248+02	MAG	.2376+00	ANG DEG	-.4493+02	REAL	.1682+00	IMAG	-.1678+00
.3600+04		.4174+01		.1617+01		-.9210+02		-.8747-01		-.1615+01
.3600+04		.4626+01		.1703+01		-.1608+03		-.1609+01		-.5591+00
.3600+04		.2695+01		.1364+01		-.1763+03		-.1361+01		-.6727-01
.3600+04		.4660+01		.1710+01		.9534+01		.1686+01		.2832+00
.3600+04		-.2287+01		.7085+00		.1594+02		.7269+00		.2494+00
.3600+04		-.1145+02		.2676+00		.2033+02		.2510+00		.9285-01
.3600+04		-.2525+02		.5465-01		.1463+02		.5141-01		.1854-01
.3600+04		-.3532+02		.1714-01		-.4863+02		.1177-01		-.1246-01
F										
.3700+04	DB	-.1204+02	MAG	.2300+00	ANG DEG	-.4627+02	REAL	.1728+00	IMAG	-.1806+00
.3700+04		.4344+01		.1049+01		-.9620+02		-.2352+00		-.1632+01
.3700+04		.4297+01		.1040+01		-.1621+03		-.1561+01		-.5023+00
.3700+04		.2463+01		.1320+01		-.1766+03		-.1325+01		-.7939-01
.3700+04		.3441+01		.1488+01		.6471+01		.1470+01		.2184+00
.3700+04		-.3071+01		.7022+00		.1772+02		.6689+00		.2137+00
.3700+04		-.1201+02		.2900+00		.1950+02		.2364+00		.8373-01
.3700+04		-.2572+02		.5176-01		.1927+02		.4806-01		.1708-01
.3700+04		-.3631+02		.1215-01		-.5027+02		.6391-02		-.1034-01
F										
.3800+04	DB	-.1162+02	MAG	.2625+00	ANG DEG	-.4762+02	REAL	.1769+00	IMAG	-.1939+00
.3800+04		.4446+01		.1068+01		-.1031+03		-.3769+00		-.1625+01
.3800+04		.4002+01		.1385+01		-.1033+03		-.1518+01		-.4559+00
.3800+04		.2254+01		.1236+01		-.1768+03		-.1294+01		-.7262-01
.3800+04		.2343+01		.1310+01		.7028+01		.1298+01		.1734+00

Figure F.7. (Continued).

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.3800+04	-1.3810+01	.6449+00	.1666+02	.6178+00	.1849+00
.3800+04	-1.1256+02	.2356+00	.1677+02	.2231+00	.7579-01
.3800+04	-1.2618+02	.4209-01	.1873+02	.4649-01	.1576-01
.3800+04	-1.4112+02	.8787-02	.6901+02	.3147-02	-.8204-02
F	DB	MAG	ANG DEG	REAL	IMAG
.3900+04	-1.1121+02	.2752+00	.4498+02	.1806+00	-.2076+00
.3900+04	.4491+01	.1677+01	-.1076+03	-.5079+00	.1598+01
.3900+04	.3736+01	.1537+01	-.1643+03	-.1480+01	-.4164+00
.3900+04	.2066+01	.1268+01	-.1770+03	-.1267+01	-.6675-01
.3900+04	.1393+01	.1167+01	.6941+01	.1159+01	.1411+00
.3900+04	-.4511+01	.5949+00	.1572+02	.5726+00	.1612+00
.3900+04	-1.1308+02	.2217+00	.1809+02	.2108+00	.6885-01
.3900+04	-.2663+02	.4862-01	.1822+02	.4428-01	.1458-01
.3900+04	-.4380+02	.6457-02	-.7894+02	.1238-02	-.6337-02
F	DB	MAG	ANG DEG	REAL	IMAG
.4000+04	-1.1081+02	.2880+00	-.5033+02	.1839+00	-.2217+00
.4000+04	.4487+01	.1676+01	-.1119+03	-.6251+00	-.1555+01
.4000+04	.3494+01	.1995+01	-.1632+03	-.1945+01	-.3827+00
.4000+04	.1894+01	.1244+01	-.1772+03	-.1242+01	-.6160-01
.4000+04	.4231+00	.1050+01	.6371+01	.1043+01	.1165+00
.4000+04	-.5178+01	.5510+00	.1489+02	.5325+00	.1416+00
.4000+04	-.1359+02	.2091+00	.1746+02	.1995+00	.6274-01
.4000+04	-.2707+02	.4433-01	.1774+02	.4223-01	.1351-01
.4000+04	-.4635+02	.4814-02	-.2814+02	.1563-03	-.4811-02
F	DB	MAG	ANG DEG	REAL	IMAG
.4100+04	-.1043+02	.3010+00	-.5169+02	.1866+00	-.2362+00
.4100+04	.4446+01	.1668+01	-.1158+03	-.7272+00	-.1502+01
.4100+04	.3275+01	.1458+01	-.1660+03	-.1414+01	-.3539+00
.4100+04	.1739+01	.1222+01	-.1773+03	-.1220+01	-.5705-01
.4100+04	-.4293+00	.9218+00	.5889+01	.9468+00	.9765-01
.4100+04	-.5813+01	.5121+00	.1415+02	.4966+00	.1252+00
.4100+04	-.1408+02	.1976+00	.1687+02	.1891+00	.5735-01
.4100+04	-.2744+02	.4221-01	.1728+02	.4031-01	.1254-01
.4100+04	-.4879+02	.3635-02	-.9667+02	-.4220-03	-.3611-02
F	DB	MAG	ANG DEG	REAL	IMAG
.4200+04	-.1006+02	.3141+00	-.5305+02	.1888+00	-.2510+00
.4200+04	.4376+01	.1655+01	-.1195+03	-.8144+00	-.1441+01
.4200+04	.3075+01	.1425+01	-.1667+03	-.1386+01	-.3286+00
.4200+04	.1596+01	.1202+01	-.1775+03	-.1201+01	-.5299-01
.4200+04	-.1224+01	.8685+00	.5476+01	.8646+00	.8289-01
.4200+04	-.6420+01	.4775+00	.1348+02	.4644+00	.1113+00
.4200+04	-.1456+02	.1670+00	.1632+02	.1795+00	.5256-01
.4200+04	-.2791+02	.4024-01	.1684+02	.3851-01	.1166-01
.4200+04	-.5113+02	.2777-02	-.1046+03	-.6994-03	-.2688-02
F	DB	MAG	ANG DEG	REAL	IMAG
.4300+04	-.9701+01	.3273+00	-.3441+02	.1905+00	-.2662+00
.4300+04	.4284+01	.1638+01	-.1228+03	-.8875+00	-.1376+01
.4300+04	.2892+01	.1395+01	-.1673+03	-.1361+01	-.3066+00
.4300+04	.1466+01	.1184+01	-.1776+03	-.1183+01	-.4935-01
.4300+04	-.1970+01	.7971+00	.5118+01	.7939+00	.7110-01
.4300+04	-.7001+01	.4466+00	.1287+02	.4354+00	.9949-01
.4300+04	-.1503+02	.1773+00	.1561+02	.1706+00	.4831-01
.4300+04	-.2631+02	.3639-01	.1643+02	.3683-01	.1086-01
.4300+04	-.5337+02	.2145-02	-.1120+03	-.8819-03	-.1989-02
F	DB	MAG	ANG DEG	REAL	IMAG
.4400+04	-.9355+01	.3406+00	-.5577+02	.1916+00	-.2816+00
.4400+04	.4177+01	.1016+01	-.1159+03	-.9479+00	-.1311+01

Figure F.7. (Continued).

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.4400+04	.2724+01	.1500+01	-.1679+03	-.1338+01	-.2872+00
.4400+04	.1346+01	.1160+01	-.1777+03	-.1167+01	-.4506+01
.4400+04	-.2672+01	.7552+00	.4404+01	.7326+00	.6157-01
.4400+04	-.7559+01	.4189+00	.1232+02	.4092+00	.0938-01
.4400+04	-.1548+02	.1083+00	.1533+02	.1623+00	.4450-01
.4400+04	-.2871+02	.3066+01	.1603+02	.3525+01	.1013-01
.4400+04	-.5553+02	.1073-02	-.1169+03	-.8067-03	-.1466-02
F	DB	ANG	ANG DEG	REAL	IMAG
.4500+04	-.9021+01	.3339+00	-.5712+02	.1921+00	-.2973+00
.4500+04	.4060+01	.1596+01	-.1287+03	-.9972+00	-.1246+01
.4500+04	.2570+01	.1944+01	-.1364+03	-.1317+01	-.2699+00
.4500+04	.1235+01	.1153+01	-.1779+03	-.1152+01	-.4307-01
.4500+04	-.3336+01	.6011+00	.4525+01	.6790+00	.5374-01
.4500+04	-.8095+01	.3938+00	.1182+02	.3854+00	.0644-01
.4500+04	-.1591+02	.1000+00	.1468+02	.1547+00	.4110-01
.4500+04	-.2910+02	.3507-01	.1505+02	.3377-01	.9463-02
.4500+04	-.5760+02	.1318-02	-.1252+03	-.7603-03	-.1076-02
F	DB	ANG	ANG DEG	REAL	IMAG
.4600+04	-.1869+01	.3074+00	-.5248+02	.1920+00	-.3132+00
.4600+04	.3937+01	.1573+01	-.1312+03	-.1037+01	-.1103+01
.4600+04	.2427+01	.1322+01	-.1639+03	-.1298+01	-.2545+00
.4600+04	.1133+01	.1139+01	-.1760+03	-.1139+01	-.4034-01
.4600+04	-.3966+01	.6334+00	.4277+01	.6316+00	.4724-01
.4600+04	-.8611+01	.3711+00	.1135+02	.3638+00	.7305-01
.4600+04	-.1634+02	.1324+00	.1445+02	.1476+00	.3803-01
.4600+04	-.2944+02	.3557-01	.1529+02	.3238-01	.6053-02
.4600+04	-.5960+02	.1047-02	-.1313+03	-.6903-03	-.7364-03
F	DB	ANG	ANG DEG	REAL	IMAG
.4700+04	-.8387+01	.3308+00	-.5984+02	.1513+00	-.3292+00
.4700+04	.3910+01	.1351+01	-.1336+03	-.1069+01	-.1123+01
.4700+04	.2296+01	.1302+01	-.1394+03	-.1280+01	-.2406+00
.4700+04	.1036+01	.1127+01	-.1761+03	-.1126+01	-.3704-01
.4700+04	-.4567+01	.5911+00	.4354+01	.5096+00	.4719-01
.4700+04	-.9109+01	.3504+00	.1493+02	.3440+00	.6642-01
.4700+04	-.1676+02	.1453+00	.1405+02	.1409+00	.3327-01
.4700+04	-.2985+02	.3216-01	.1694+02	.3108-01	.8294-02
.4700+04	-.6153+02	.6285-03	-.1309+03	-.6124-03	-.5728-03
F	DB	ANG	ANG DEG	REAL	IMAG
.4800+04	-.8085+01	.3942+00	-.6119+02	.1900+00	-.3454+00
.4800+04	.3682+01	.1326+01	-.1357+03	-.1094+01	-.1067+01
.4800+04	.2173+01	.1284+01	-.1698+03	-.1264+01	-.2281+00
.4800+04	.9500+00	.1110+01	-.1782+03	-.1115+01	-.3553-01
.4800+04	-.5140+01	.5534+00	.3353+01	.5521+00	.3714-01
.4800+04	-.9591+01	.3315+00	.1053+02	.3253+00	.6060-01
.4800+04	-.1716+02	.1386+00	.1367+02	.1347+00	.3277-01
.4800+04	-.3022+02	.3084-01	.1461+02	.2984-01	.7780-02
.4800+04	-.6339+02	.6769-03	-.1422+03	-.5351-03	-.4145-03
F	DB	ANG	ANG DEG	REAL	IMAG
.4900+04	-.7794+01	.4070+00	-.6254+02	.1880+00	-.3617+00
.4900+04	.3555+01	.1306+01	-.1377+03	-.1114+01	-.1013+01
.4900+04	.2060+01	.1268+01	-.1702+03	-.1249+01	-.2163+00
.4900+04	.8682+00	.1105+01	-.1783+03	-.1105+01	-.3339-01
.4900+04	-.5689+01	.5195+00	.3669+01	.5184+00	.3325-01
.4900+04	-.1006+02	.3142+00	.1417+02	.3093+00	.5546-01
.4900+04	-.1756+02	.1325+00	.1331+02	.1289+00	.3050-01
.4900+04	-.3057+02	.2960-01	.1429+02	.2863-01	.7307-02
.4900+04	-.6519+02	.5503-03	-.1473+03	-.4630-03	-.2975-03

Figure F.7. (Continued).

SEADUCLR RUN 80117 FOR T1-22R APPX W1X F

F	DR	IMAG	ARG	DEG	REAL	IMAG
.5000+04	-.7513+01	.4211+00	-.6369+02	.1053+00	-.5781+00	
.5000+04	.2430+01	.1484+01	-.1395+03	-.1129+01	-.9637+00	
.5000+04	.1955+01	.1252+01	-.1705+03	-.1235+01	-.2064+00	
.5000+04	.7919+00	.1095+01	-.1764+03	-.1095+01	-.5140-01	
.5000+04	-.6215+01	.4089+00	.3502+01	.4880+00	.2986-01	
.5000+04	-.1051+02	.2983+00	.9825+01	.2939+00	.5090-01	
.5000+04	-.1794+02	.1267+00	.1297+02	.1235+00	.2044-01	
.5000+04	-.3092+02	.2043-01	.1398+02	.2759-01	.6871-02	
.5000+04	-.6693+02	.4505-03	-.1520+03	-.3979-03	-.2112-03	

Figure F.7. (Continued).

***** COMMON PRT TdL *****													
N	NET	I	SIGN	J	N	NET	NUM	NUM	N	N	LC	J	ROW
SP	C	D	PORT	PORTS	NAM	APD	NPD	AHEAD	BACK				
1	P	1	1	1	5	AB	1	-1	3	0			1
2	P	1	1	1	2	BA	1	1	8	0			357
3	P	1	1	1	5	AB	2	-2	7	1			2
4	P	1	1	2	2	BC	2	4	13	10			447
5	P	1	1	2	2	BU	2	6	14	13			482
6	P	-1	1	3	3	BE	2	9	9	16			311
7	P	1	1	3	5	AB	3	-3	11	3			3
8	P	-1	1	2	2	BA	3	2	10	2			358
9	P	1	1	1	2	BB	3	10	12	6			411
10	P	1	1	1	2	BC	3	3	4	8			446
11	P	1	1	4	5	AB	4	-4	15	7			4
12	P	-1	1	2	2	BB	4	11	0	9			412
13	P	1	1	1	2	BU	4	5	5	4			481
14	P	1	1	1	3	BE	4	7	16	5			309
15	P	1	1	3	5	AB	5	-5	0	11			5
16	P	1	1	2	3	BE	5	8	6	14			310

***** COMMON CATALG *****													
I	NAME	MTR	I	PC	N	PC	I	N	UT	LOC			
		SIZ											
1	AB	5	0	0	0	0	0	0		1			
2	AA	2	0	0	0	0	0			101			
3	AA	2	1	0	4	0	0			117			
4	AA	2	2	0	8	4	0			141			
5	AA	2	3	0	8	4	0			165			
6	AA	2	4	0	8	4	0			189			
7	AA	2	5	0	8	4	0			213			
8	AA	2	6	0	8	4	0			237			
9	AA	2	7	0	8	4	0			261			
10	AA	2	8	0	8	4	0			285			
11	BE	3	0	0	26	12	0			309			
12	BA	2	0	0	2	0	0			357			
13	BA	2	1	0	2	21	3			373			
14	BA	2	2	0	2	22	3			392			
15	BB	2	0	0	1	0	0			411			
16	BB	2	1	0	1	21	3			427			
17	BC	2	0	0	1	0	0			446			
18	BC	2	1	0	1	21	3			462			
19	BD	2	0	0	1	0	0			481			
20	BD	2	1	0	1	21	3			497			
21	AB	2	0	0	0	0	0			516			
22	AB	0	0	0	0	0	0			532			
23	AB	0	0	0	0	0	0			568			

TOTAL DATA CELLS USED IN MASTER STORAGE										591	TOTAL RUN TIME = 13.153 SEC		
LAST TIME INTERVAL = 13.153 SEC													

Figure F.7. (Continued).

DBKPT PRINTS

RUNID: M80117 ACCOUNT: 1E0170010000 PROJECT: LMED1031NS22

LOAD 800117 9/5 PROFILE -1 M80117

M80117+M56: 50 2154

BREAKPOINT IN THIS RUN

*M80117 SAVE PROFILE IS 722

LOAD 219 9/6 8

-1 M80117

BREAKPOINT IN THIS RUN

TIME: 00:00:21.332 IN: 174 OUT: 46 PAGES: 44

WDS VERCE11: 555C I/O REF5: 1954 CORE SEC: 95E

INITIATION TIME: 15:22:31-OCT-20-1972 VERSION: 2E.73.198 10

TERMINATION TIME: 15:25:05-OCT-20-1972

Figure F.7. (Continued).

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A working guide to use of the SEADUCER (Steadystate Evaluation and Analysis of TransDUCERs) computer program is presented. SEADUCER is applied in this paper primarily to math models for longitudinal electromechanical vibrators. However, the multiport interconnection techniques used in SEADUCER are applicable to the analysis of a wide variety of transducers as well as to steady state modeling of any linear system (electrical, thermal, optical, etc.) which can be described as an M-port interconnection of N p_N-port networks. SEADUCER has been written in ASA Standard FORTRAN so that it can easily be installed on most medium- to large-scale digital computers. The program is in use at the Naval Undersea Center and at other installations and is available to government and private organizations.			

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- programs (computers)
- routines (computer programming)**
- sonar transducer analysis
- Multiport network interconnections**
- active filter analysis