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A Fortran IV Program for Computing the Static Deflections of Structural Cable Arrays

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ABSTRACT

DESADE is a Fortran IV program for computing the current-induced static deflections of Structural Cable Arrays. As dimensioned, the program can handle arbitrarily configured arrays of up to 22 cables. The cables can be electromechanical, wire rope, or synthetic. Any number of discrete devices (buoyancy elements, current meters, tensiometers, etc.) can be incorporated in the array. An option for parametric studies is included in the program, as is an option for incorporating arbitrary current fields. As written, DESADE should be compilable on most Fortran IV compilers with Boolean algebra capabilities.

PROBLEM STATUS

This is a final report on one phase of a continuing NRL Problem.

AUTHORIZATION

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A FORTRAN IV PROGRAM FOR COMPUTING THE STATIC DEFLECTIONS OF STRUCTURAL CABLE ARRAYS

INTRODUCTION

DESADE is a Fortran IV program for computing the current-induced static deflections of structural cable arrays. The solution algorithm is the Method of Imaginary Reactions (1, 2) combined with the method of successive approximations for treating position- and configuration-dependent forces (3, 4).

As dimensioned, the program can handle arbitrarily configured arrays of up to 22 cables. The cables can be electromechanical, wire rope, or synthetic. Any number of discrete devices (buoyancy elements, current meters, tensiometers, etc.) can be incorporated in the array.

Certain limitations are placed on the structural characteristics of the arrays which can be analyzed by this program. These limitations are as follows:

1. No cables or cable segments can lie on the ocean floor.

2. The dimensions of each discrete device must be small compared to overall array dimensions. Thus, for example, the application of this program to the analysis of an anchorage for a submerged submarine is not valid.

3. All parts of the array must be submerged. Thus, an array containing a surface buoy cannot be validly analyzed using this program. (The reason for this is that a surface buoy generates only one geometric constraint on its location.) An exception occurs when all three coordinates of a device on the surface can be specified—for example, the coordinates of a ship handling a crown line.

Also, certain hydromechanical assumptions are incorporated in the program as written. These are as follows:

1. The only hydrodynamic force considered to be acting on the discrete devices is a drag force. Lift forces are neglected as being small compared to the weight, buoyancy, and drag forces on these devices.

2. The only hydrodynamic force considered to be acting on the cables is the normal drag force. Tangential drag forces and Magnus effect forces are neglected, as they produce small effects compared to the normal drag force. (See Ref. 5 for a comprehensive discussion of cable loading functions.)

3. The current, though depth dependent in magnitude, is unidirectional and horizontal. Options exist within the program, however, both for varying the relative direction between current and array and for specifying an arbitrary current field.

An option for parametric studies (changes in weights, diameters, cable lengths, anchor locations, etc.) is included in the program. DESADE also contains a series of error checks which insure that all input data are properly formulated.

The computer program is available on written request to the authors.

COMPUTER REQUIREMENTS

As written, DESADE should be compilable on most Fortran IV compilers with Boolean algebra capabilities. Memory requirements for the program are approximately 30,000 words in single precision. Access to one, two, or three magnetic tape units, depending on the I/O options chosen, is required by the program.

PROGRAM OPERATION

The overall operation of the program DESADE is shown in the flow diagram in Fig. 1. The source language listing of the program is given in Appendix A, and numerical examples in Appendix B.

ARRAY DESCRIPTION

Typical cable arrays which can be analyzed using DESADE are shown in Figs. 2a-2d. The figures also show the numbering and coordinate system conventions required for transmitting the array geometry to DESADE. These conventions are as follows:

1. The cables comprising the array must be numbered consecutively from one to the total number of cables in the array (C1, C2, ... in Fig. 2). Each cable so designated must have uniform properties (weight, drag coefficient, diameter, and constitutive relation) along its length. A change in property also requires a change in cable number as illustrated in Fig. 2a.

2. The termination points of the cables in the array are called junctions. A junction may designate an anchor, the intersection point of two or more cables, or the free end of a cable such as illustrated by junction J9 in Fig. 2c. The junctions must also be numbered consecutively from one to the total number of junctions in the array (J1, J2, ... in Fig. 2).

3. A fixed, right-handed (X, Y, Z) Cartesian coordinate system must be chosen to describe the configuration of the array in space. The origin of the coordinate system can be arbitrarily located. The Z axis must be defined parallel to the direction of gravity and increasing upward. All coordinates are measured in feet.

4. The junction numbers corresponding to anchors and the coordinates of the anchors must be tabulated according to the scheme illustrated in Table 1.

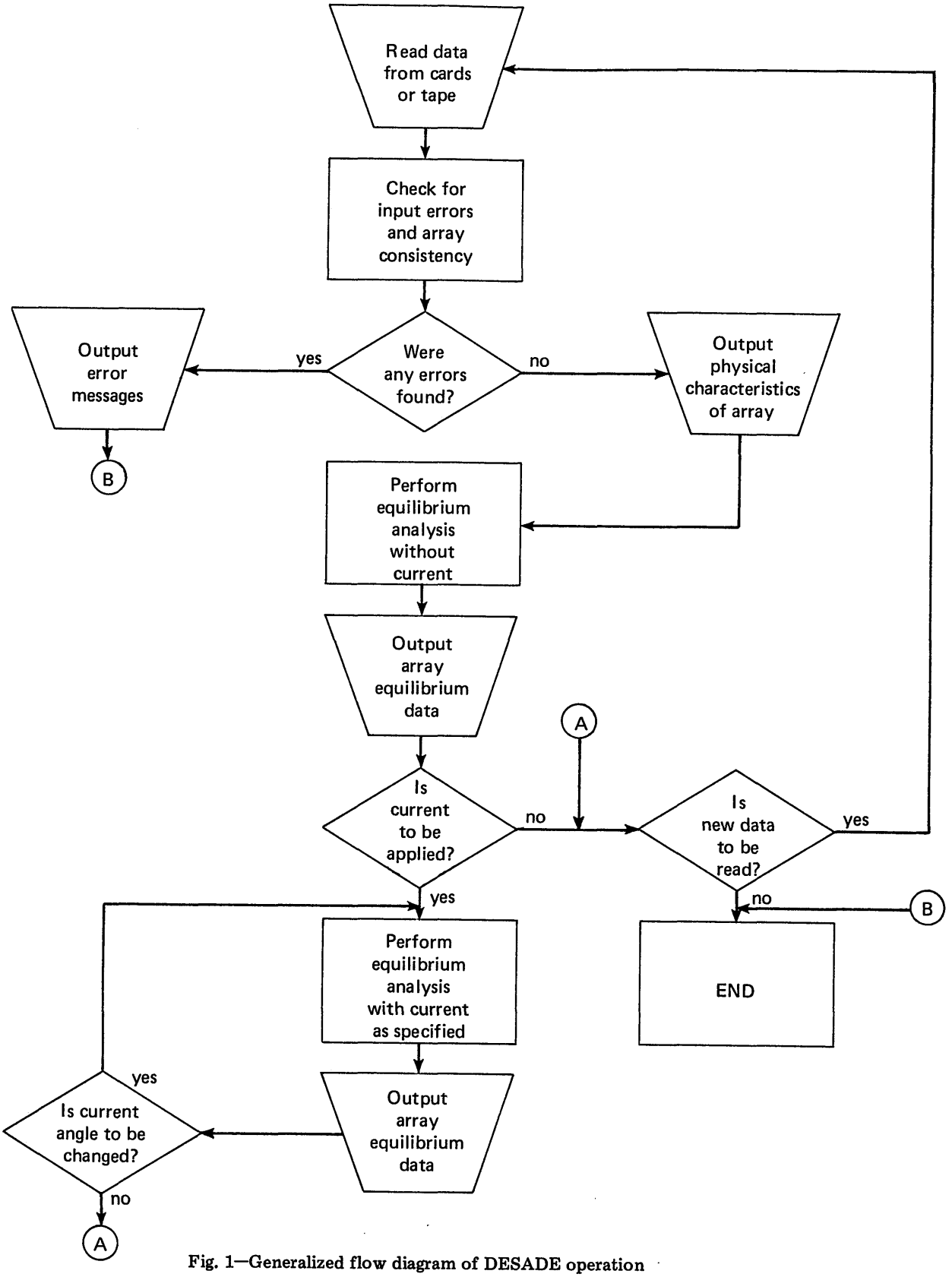


Fig. 1—Generalized flow diagram of DESADE operation

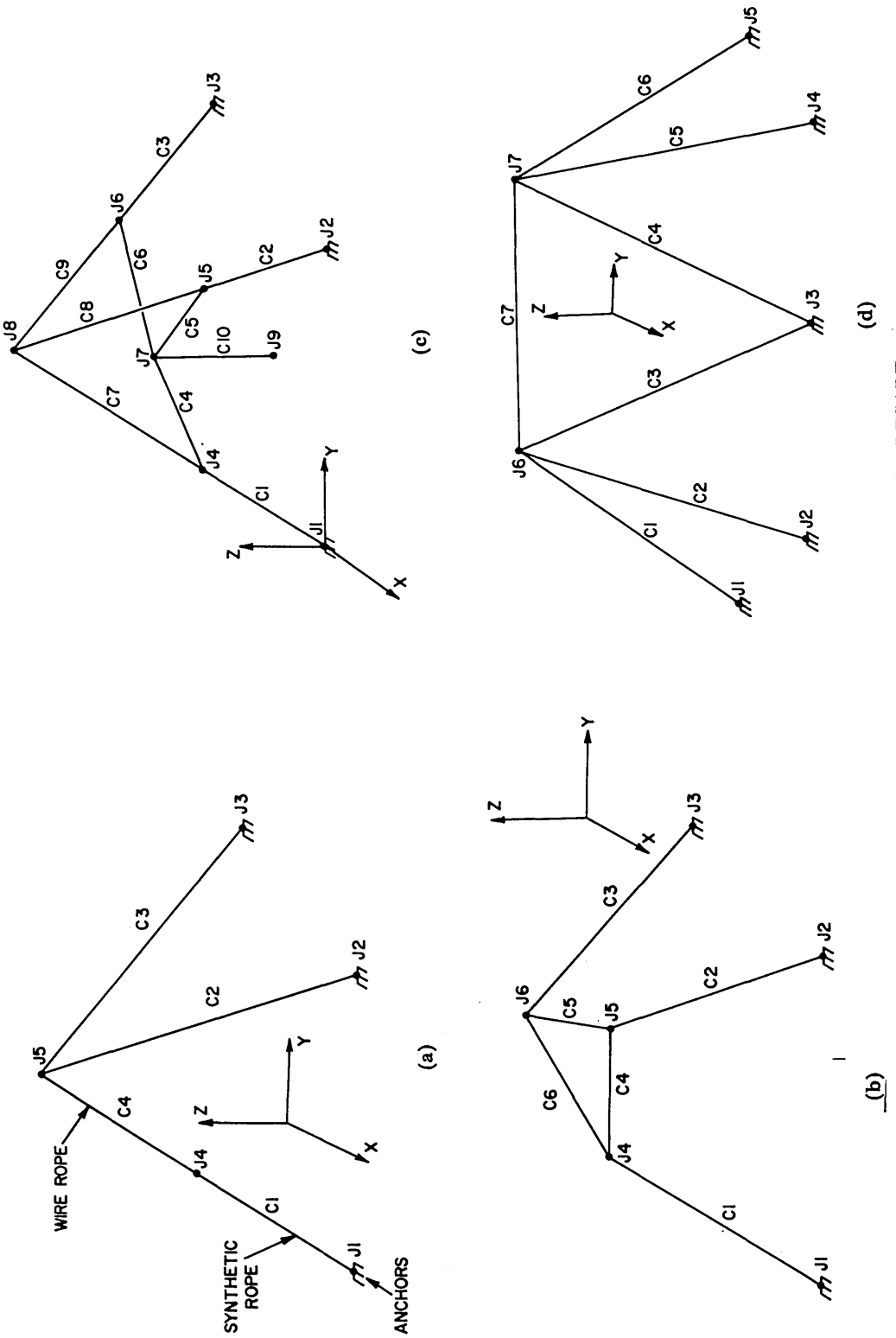


Fig. 2—Typical cable arrays which can be analyzed using DESADE

Table 1. Anchor Tabulation

Column 1	Column 2	Column 3	Column 4
Junction number of Anchor	X coordinate (ft)	Y coordinate (ft)	Z coordinate (ft)

REDUCTION TO A STATICALLY DETERMINATE ARRAY

Before an arbitrary cable array can be analyzed by DESADE, a sufficient number of cuts must be made in the array to reduce it to a statically determinate structure. The effects of the constraints removed by these cuts are replaced by imaginary and equilibrating reactions (1, 2).

The number of cuts required to reduce a cable array to a statically determinate structure is determined uniquely from the relation

$$\text{number of cuts} = \text{number of cables} + \text{number of anchors} - \text{number of junctions}. \quad (1)$$

Certain rules must be adhered to as the required cuts are made. These rules are as follows:

1. All required cuts must be made at points directly adjacent to array junctions—that is, at end points of the cables comprising the array.

2. The first group of cuts must be made so as to release all but one cable from an anchor.

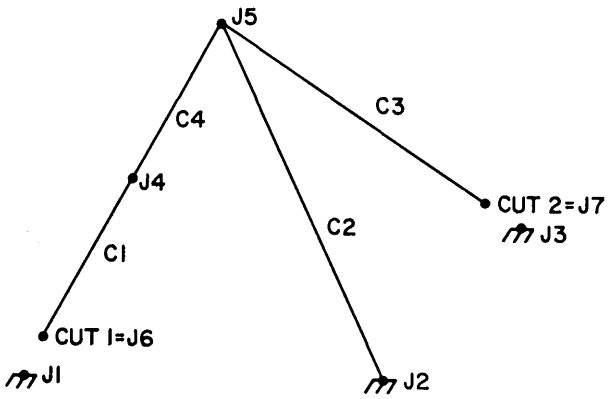
3. The remaining required cuts are made within the array structure and must be located so as not to break the array into two (or more) parts.

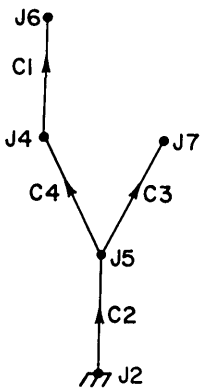
4. As cuts are made, each new cut must be assigned a consecutive junction number, continuing from the last-used junction number. Also, the junction number (in the original array) at which the cut is made must be tabulated.

In effect, applying rules 1-3 reduces the array to the equivalent of a topological tree. As the name implies, this is a continuous structure containing only *one* fixed point and for which a unique (nonduplicative) path exists from any point to any other point.

Examples of proper reductions to statically determinate structures for the arrays illustrated in Figs. 2a-2d are shown in Figs. 3a-3d, respectively. In each of these figures, the left-hand schematic shows the reduced array while the right-hand schematic depicts the topological tree representation of the reduced array. The information required by rule 4, which represents geometric constraints on the reduced array, is tabulated below the left-hand schematic in each figure.

Finally, it is necessary to define directions of increasing arc length along the cables comprising the array. The tree representation of the reduced array is used primarily for

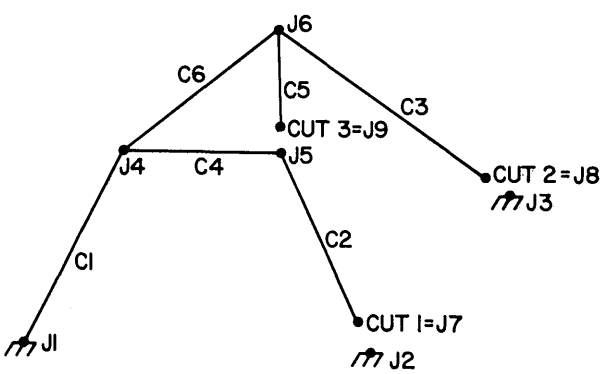


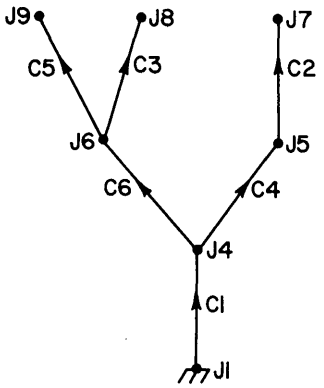


CUT #	JUNCTION # ASSIGNED TO CUT	JUNCTION # AT WHICH CUT MADE
1	6	1
2	7	3

(a)

CABLE #	JUNCTION # AT s=0	JUNCTION # AT s=L
1	4	6
2	2	5
3	5	7
4	5	4



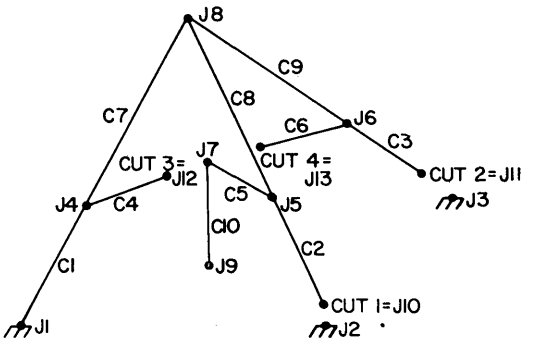


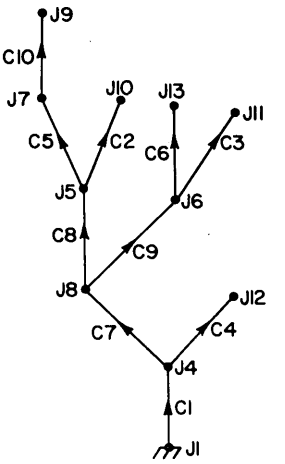
CUT #	JUNCTION # ASSIGNED TO CUT	JUNCTION # AT WHICH CUT MADE
1	7	2
2	8	3
3	9	5

(b)

CABLE #	JUNCTION # AT s=0	JUNCTION # AT s=L
1	1	4
2	5	7
3	6	8
4	4	5
5	6	9
6	4	6

Fig. 3—Examples of proper reductions to statically determinate structures for the arrays shown in Figs. 2a and 2b.

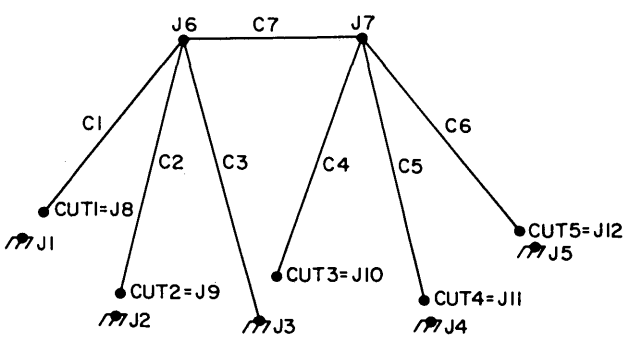


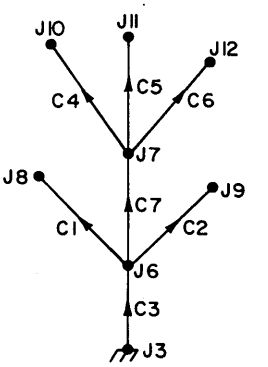


CUT #	JUNCTION # ASSIGNED TO CUT	JUNCTION # AT WHICH CUT MADE
1	10	2
2	11	3
3	12	7
4	13	7

CABLE #	JUNCTION # AT s=0	JUNCTION # AT s=L
1	1	4
2	5	10
3	6	11
4	4	12
5	5	7
6	6	13
7	4	8
8	8	5
9	8	6
10	7	9

(c)





CUT #	JUNCTION # ASSIGNED TO CUT	JUNCTION # AT WHICH CUT MADE
1	8	1
2	9	2
3	10	3
4	11	4
5	12	5

CABLE #	JUNCTION # AT s=0	JUNCTION # AT s=L
1	6	8
2	6	9
3	3	6
4	7	10
5	7	11
6	7	12
7	6	7

(d)

Fig. 3—Continued. Examples of proper reductions to statically determinate structures for the arrays shown in Figs. 2c and 2d.

this purpose. These directions, indicated by the arrowheads in the right-hand schematic of each figure, are identified by starting from the base of the tree and climbing "up" the tree.

Let the measure of arc length along a cable be denoted by s which increases from zero to the total length of the cable L. Then, the required information on increasing directions of arc length can be summarized in terms of array junctions as shown in the table below the right-hand schematic in each figure.

Once an array has been reduced to the state represented by Fig. 3, it is amenable to analysis by the program DESADE.

STANDARD CURRENT FIELD

The standard current field is taken to be unidirectional and horizontal, though depth dependent in value. Thus, if the angular direction of the flow with respect to the X axis is denoted by θ (Fig. 4a), the standard current field V_s can be written as

$$V_s = V(Z) \; [\hat{i} \cos\theta + \hat{j} \sin\theta]$$

Here, $\hat{i}$ and $\hat{j}$ are unit vectors in the X and Y directions, respectively. V(Z) specifies the value of the current as a function of the Z coordinate. This functional relationship must be tabulated as in Table 2.

Table 2. Current Tabulation

Column 1	Column 2
Z coordinate (ft)	V(Z) (knots)

Up to 25 rows are permitted in Table 2. At least one of the Z coordinates in Table 2 must be less than or equal to the minimum Z coordinate in Table 1.

Program DESADE takes the data in Table 2 and fits it by a series of straight-line segments between values of V at adjacent values of Z (Fig. 4b). The current below the minimum Z value is considered constant and is given the value of V at the minimum Z. Similarly, the current above the maximum Z is considered constant and given the value of V at the maximum Z.

An option exists for substituting an arbitrary current field for the standard current field (see Appendix C).

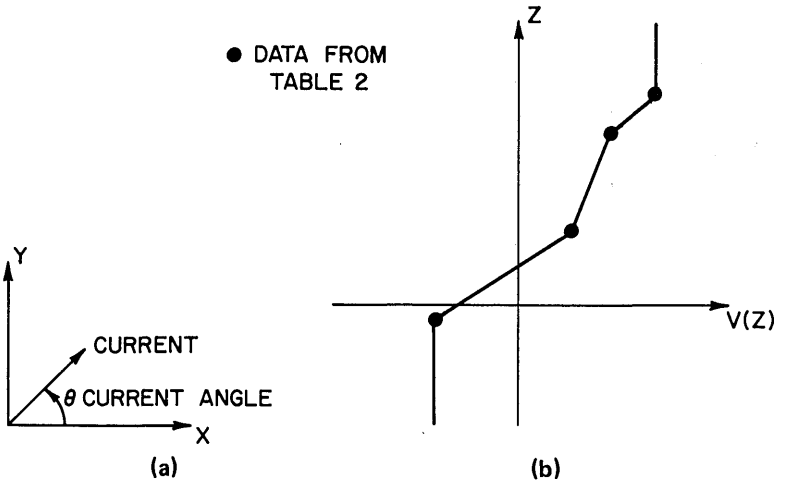


Fig. 4—Standard current field used in DESADE
(a) Current angle, θ, (b) Current profile, V(Z)

INPUT CARDS

Each input card to DESADE contains a 4-digit integer (-999 to 9999) card number in columns 1-4, a 4-character card type identifier in columns 5-8, and descriptive properties of the array in the remaining fields.

LUN Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^LUN	
3	9-16	I8	Unit number of card reader	
4	17-24	I8	Unit number of line printer	
5	25-32	I8	Unit number of temporary storage tape	
6	33-40	I8	Input option (0 or 1)	See notes
7	41-48	I8	Blank if input option = 0. Unit number of source tape if input option = 1.	
8	49-56	I8	Output option (0, 1, or 2)	See notes
9	57-64	I8	Blank if output option = 0. Unit number of output tape or card punch if output option = 1 or 2.	
10	65-72		not used	
11	73-77		" "	
12	78-80		" "	

Notes: The LUN card is used to transmit the logical unit numbers of the I/O devices and the I/O options. The LUN card must be the first card in the input deck.

Two input options are available:

0—the physical characteristics of the array are to be read from the cable array source deck (see CABLE ARRAY SOURCE DECK)

1—the physical characteristics of the array are to be read from the cable array source tape (see CABLE ARRAY SOURCE TAPE).

Three output options are available:

0—a structural output to the line printer (see STRUCTURAL OUTPUT)

1—a device location output to tape or cards (see DEVICE LOCATION OUTPUT)

2—both of the above.

NJNC Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	NJNC	
3	9-16	I8	Number of junctions in original (unreduced) array	2- 44
4	17-24		not used	
5	25-32		" "	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Note: The NJNC card is used to transmit the number of junctions in the original (unreduced) array.

ANC Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^ANC	
3	9-16	I8	Junction number of anchor	1-44
4	17-24	F8.0	X coordinate of anchor	ft
5	25-32	F8.0	Y coordinate of anchor	ft
6	33-40	F8.0	Z coordinate of anchor	ft
7	41-48		not used	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Note: The ANC cards are used to transmit the data in Table 1. There must be one ANC card for each anchor in the array.

IR Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^^IR	
3	9-16	I8	Junction number assigned to a cut in the reduced array	1-44
4	17-24	I8	Junction number at which cut is made in the original array	1-44
5	25-32		not used	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Note: The IR cards are used to transmit the information contained in the table below the left-hand schematic in each of Figs. 3a-3d. There must be one IR card for each cut made in going from the original to the reduced array.

CAB Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^CAB	
3	9-16	I8	Cable number	1-22
4	17-24	I8	s = 0 junction number	1-44
5	25-32	I8	s = L junction number	1-44
6	33-40	F8.0	Cable weight per length in surrounding fluid; + if positively buoyant, – if negatively buoyant	lb/ft
7	41-48	F8.0	Normal drag coefficient of cable	
8	49-56	F8.0	Cable diameter	in.
9	57-64	F8.0	Total cable length (unstressed)	ft
10	65-72	F8.0	Cable rigidity, C (see notes)	lb
11	73-77	F5.0	Exponent in constitutive relation, k (see notes)	$\geqslant 0$
12	78-80	I3	Number of finite elements by which cable is to be represented	$>0, \leqslant 50$

Notes: The CAB cards are used to transmit the information contained in the table below the right-hand schematic in Figs. 3a-3d (fields 3 to 5), the physical characteristics of the cables in the array (fields 6 to 11), and the fineness by which the cables in the array are to be modeled (field 12). There must be one CAB card for each cable in the array.

The constitutive relation for a cable can, in general, be written (6) as $\epsilon = [T/C]^k$ where ϵ is the strain and T the tension. C and k are constants which depend on the cable material and construction. Fields 10 and 11 transmit the values of C and k, respectively. An inextensible cable is transmitted to DESADE by leaving fields 10 and 11 blank.

DCAB Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	DCAB	
3	9-16	I8	Number of cable to which device is attached	1-22
4	17-24	I8	Device type (1, 2, 3, or 4)	See notes
5	25-32	I8	Device index if Type 1 or 2	1-1000
6	33-40	F8.0	Device weight in surrounding fluid; + if positively buoyant, – if negatively buoyant	lb
7	41-48	F8.0	Device drag coefficient	
8	49-56	F8.0	Frontal area on which drag coefficient is based (Type 2 or 4) Diameter on which drag coefficient is based (Type 1 or 3)	ft^2 in
9	57-64	F8.0	Device length (Type 1 or 3 only)	ft
10	65-72	F8.0	Unstressed distance of device from s = 0 junction of the cable	ft
11	73-77		not used	
12	78-80		” ”	

Notes: The DCAB cards are used to transmit the physical characteristics of the discrete devices (buoyancy elements, current meters, etc.,) attached to the cables in the array. There must be one DCAB card for each such device in the array.

Two types of devices are permitted:

a. In-line cylindrical (Type 1 or 3); any elongated device (cylinder, ellipse, etc.) attached so that its longitudinal axis is forced to align with the cable axis.

b. Free (Type 2 or 4); all other devices.

The Type 1 and 2 DCAB devices (along with Type 2 DJNC devices) are used to control output from DESADE (see STRUCTURAL OUTPUT and DEVICE LOCATION OUTPUT). These devices must be indexed consecutively (Field 5) from one to the total number of Type 1 and 2 devices in the array.

A device contained entirely inside the cable should be typed 2 or 4 and fields 7 and 8 should be blank.

DJNC Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	DJNC	
3	9-16	I8	Number of junction to which device is attached	1-44
4	17-24	I8	Device type (2 or 4)	See notes
5	25-32	I8	Device index if Type 2	1-1000
6	33-40	F8.0	Device weight in surrounding fluid; + if positively buoyant, - if negatively buoyant	lb
7	41-48	F8.0	Device drag coefficient	
8	49-56	F8.0	Frontal area on which drag coefficient is based	ft^2
9	57-64		not used	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Notes: The DJNC cards are used to transmit the physical characteristics of the discrete devices attached to the junctions in the array. There must be one DJNC card for each such device in the array.

Since an in-line device cannot physically exist at a junction (cable termination), only free (Type 2 or 4) devices are permitted at a junction. The Type 2 DJNC devices (along with Type 1 and 2 DCAB devices) are used to control the output from DESADE (see STRUCTURAL OUTPUT and DEVICE LOCATION OUTPUT). These devices must be indexed consecutively (Field 5) from one to the total number of Type 1 and 2 devices in the array.

DEN Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^DEN	
3	9-16	F8.0	Density of fluid in which array is suspended	lb s^2 ft^{-4}
4	17-24		not used	
5	25-32		" "	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Note: The DEN card is used to transmit the density of the fluid in which the array is suspended.

EOD Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^EOD	
3	9-16		not used	
4	17-24		” ”	
5	25-32		” ”	
6	33-40		” ”	
7	41-48		” ”	
8	49-56		” ”	
9	57-64		” ”	
10	65-72		” ”	
11	73-77		” ”	
12	78-80		” ”	

Note: The EOD card is used to specify the end of data transmission.

NDAT Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	NDAT	
3	9-16	I8	Current field option (0, 1, or 2)	See notes
4	17-24		not used	
5	25-32		" "	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Notes: The NDAT card is used to specify that new, modified, or additional data follow and to transmit the current field option.

Three current field options are available:

0—no current;

1—standard current field (the no-current configuration is also calculated as part of this option, Fig. 1);

2—nonstandard current field (see Appendix C; the no-current configuration is also calculated as part of this option, Fig. 1).

COMP Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	COMP	
3	9-16	F8.0	Accuracy required in array equilibrium calculations	ft
4	17-24		not used	
5	25-32		" "	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Notes: The COMP card is used to transmit the accuracy requirement imposed on the array equilibrium calculations. This accuracy requirement, specified in Field 3, insures that the calculated coordinates of every point in the array are within ± Field 3 of their exact values.

The accuracy obtainable is limited by the significant-figure capacity of the computer being used and by the largest linear dimension in the array. Let the number of significant figures carried in single precision be n, and let the characteristic of the common logarithm of the largest linear dimension be m. Then, the value of Field 3 is usually bounded by Field 3 $\geqslant 10^{m-n+3}$. (For example, suppose n = 8 and the largest dimension is 25,000 ft. Then, Field 3 $\geqslant$ 0.1 ft.) Occasionally, a larger minimum value must be used. A COMP card must appear after the first NDAT card. See PARAMETRIC STUDY SOURCE DECKS.

VEL Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^VEL	
3	9-16	F8.0	Z coordinate at which current velocity is specified	ft
4	17-24	F8.0	Velocity of current at above Z coordinate	knots
5	25-32		not used	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Notes: The VEL cards are used to transmit the data in Table 2. There must be one VEL card for each value of Z at which the current velocity is specified.

Up to 25 VEL cards are permitted. At least one of the Z coordinates transmitted by the VEL cards must be less than or equal to the minimum Z coordinate transmitted by the ANC cards. For further information see STANDARD CURRENT FIELD.

The VEL cards must not appear after an NDAT card specifying a current field option = 0. All VEL cards required to transmit the current profile must appear after the first NDAT card specifying a current field option = 1. See PARAMETRIC STUDY SOURCE DECKS.

ANG Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^ANG	
3	9-16	F8.0	Initial current angle	deg
4	17-24	F8.0	Increment in current angle	deg, >0
5	25-32	F8.0	Final current angle	deg, $\geqslant$ Field 3
6	33-40		not used	
7	41-48		” ”	
8	49-56		” ”	
9	57-64		” ”	
10	65-72		” ”	
11	73-77		” ”	
12	78-80		” ”	

Notes: The ANG card is used to transmit instructions for changing the angular direction of the current with respect to the X axis (see STANDARD CURRENT FIELD). DESADE calculates the array response to the specified current profile from the initial to the final current angles in increments transmitted by Field 4 (Fig. 1).

An ANG card must not appear after an NDAT card specifying a current field option = 0. One ANG card must appear after the first NDAT card specifying a current field option = 1. See PARAMETRIC STUDY SOURCE DECKS.

EOP Card

Field	Columns	Format	Contents	Comments
1	1-4	I4	Card number	-999 to 9999
2	5-8	A4	^EOP	
3	9-16		not used	
4	17-24		" "	
5	25-32		" "	
6	33-40		" "	
7	41-48		" "	
8	49-56		" "	
9	57-64		" "	
10	65-72		" "	
11	73-77		" "	
12	78-80		" "	

Note: The EOP card is used to specify the end of the problem and is required for a normal termination.

CABLE ARRAY SOURCE DECK

The cable array source deck contains all of the cards required to describe the physical characteristics of the cable array under consideration. The last card in the cable array source deck must be an EOD card to signify the end of data transmission. The form of the cable array source deck is given below.

Cable Array Source Deck

Card Type*	Comments
NJNC	
ANC	One for each array anchor
IR	One for each cut in going from original to reduced array
CAB	One for each array cable
DCAB	One for each discrete device attached to a cable
DJNC	One for each discrete device attached at a junction
DEN	
EOD	Must be last card in source deck

*These cards may be arbitrarily ordered except for the EOD card. *It is strongly recommended that the cards in the cable array source deck be given unique card numbers (Field 1 of each card).* Note that LUN, NDAT, COMP, VEL, ANG, and EOP cards are not permitted in the cable array source deck.

CABLE ARRAY SOURCE TAPE

The cable array source tape is an alternate means of transmitting to DESADE the physical characteristics of the cable array under consideration. A recommended program for generating the cable array source tape from the cable array source deck is given below.

Cable Array Source Tape Generation

```
    PRØGRAM STAPE
    DIMENSIØN DATA (10)
    DATA (IREAD = Unit number of card reader)
    DATA (ITAPE = Unit number of source tape)
  1 READ (IREAD, 10) (DATA(I), I = 1, 10), EX, NSEG
    WRITE (ITAPE, 11) (DATA(I), I = 1, 10), EX, NSEG
    IF (DATA(2). EQ. 4H EØD) GØ TØ 2
    GØ TØ 1
 10 FØRMAT (F4.0, A4, 8F8.0, F5.0, I3)
 11 FØRMAT (F4.0, A4, 8E15.8, /, E12.5, I3)
  2 REWIND ITAPE
    END
```

Cable Array Source Deck

PARAMETRIC STUDY SOURCE DECKS

The parametric study source decks are used to transmit accuracy requirements, current fields, and changes in the physical properties of the cable array under consideration to DESADE. Each parametric study source deck must begin with an NDAT card and end with an EOD card. The form of the parametric study source decks is given below.

Parametric Study Source Decks

Card Type*	Comments
NDAT	Must be first card in parametric study source deck. Field 3 (current option) can change as $0 \rightleftarrows 0 \rightleftarrows 1 \rightleftarrows 1$ or $0 \rightleftarrows 0 \rightleftarrows 2 \rightleftarrows 2$. The change $1 \rightleftarrows 2$, even with intermediate zeros, is not permitted.
COMP	Must appear after first NDAT card. The accuracy requirement transmitted is retained until the appearance of a COMP card in another parametric study source deck.
VEL	Must not appear after NDAT card containing current option 0. All VEL cards required to transmit a current profile must appear after the first NDAT card containing current option 1. The current profile transmitted is retained until the appearance of a VEL card in another parametric study source deck. The appearance of the first VEL card in a parametric study source deck zeros the entire current profile. Thus, to change from one current profile to another, all VEL cards required to specify the new profile must appear in the appropriate parametric study source deck.
ANG	Must not appear after NDAT card containing current option 0. One ANG card must appear after the first NDAT card containing current option 1. The current angles transmitted are retained until the appearance of an ANG card in another parametric study source deck.
ANC	Used to change anchor data. See Note.
CAB	Used to change cable data. See Note.
DCAB	Used to change discrete device on cable data. See Note.
DJNC	Used to change discrete device at junction data. See Note.
EOD	Must be last card in parametric study source deck.

*These cards may be arbitrarily ordered except for the NDAT and EOD cards. Note that LUN, NJNC, IR, DEN, and EOP cards are not permitted in the parametric study source decks.

Note. The array design changes which are permitted are those changing the physical data of the array but not the overall geometric layout of, or the number of discrete

devices on, the array. These changes are keyed by matching the card number and type appearing in a parametric study source deck to the card number and type appearing in the cable array source deck (or tape). A summary of permitted and not-permitted changes in the array physical data is given below.

Summary of Changes in the Array Physical Data
Permitted (P) and Not Permitted (NP)

Card Type	Field number											
	1	2	3	4	5	6	7	8	9	10	11	12
ANC	NP	NP	NP	P	P	P	not used →					
CAB	NP	NP	NP	NP	NP	P	P	P	P	P	P	P
DCAB	NP	NP	NP	1⇄2 3⇄4	NP	P	P	P	P	P	not used	
DJNC	NP	NP	NP	NP	NP	P	P	P	not used →			

OVERALL INPUT DECK

The overall input deck consists of a LUN card specifying the I/O options and the logical unit numbers of the required I/O devices, followed by the cable array source deck (or tape), followed by any number of parametric study source decks, and ended by an EOP card signifying the end of the problem. The form of the overall input deck is given below.

Overall Input Deck

LUN Card

Cable Array Source Deck (or Tape)
Parametric Study Source Decks

EOP Card

Some examples follow.

1. *Compilation of cable array source deck errors only.*

1000^LUN^^^^^^60^^^^^^61^^^^^^24 Blank →

Cable Array Source Deck

1001^EØP Blank →

2. *Deflections of the source deck cable array due to a standard current profile.*

1000^LUN^^^^^^60^^^^^^61^^^^^^24 I/O options and units

Cable Array Source Deck (or Tape)

1001NDAT^^^^^^^ 1 Blank ⟶

1002CØMP

1003^VEL

↓

1010^VEL

1011^ANG

1012^EØD

1013^EØP

3. *Deflections of the source deck cable array due to a standard current profile and effects of buoyancy changes on these deflections*

1000^LUN^^^^^^60^^^^^^61^^^^^^24 I/O options and units

Cable Array Source Deck (or Tape) containing a card

^^^9DJNC^^^^^^^3^^^^^^^4^^^^^^^^^^^10000^^^^1.95^^^^35.3 Blank

1001NDAT^^^^^^^1 Blank ⟶

1002CØMP

1003^VEL

↓

1010^VEL

1011^ANG

1012^EØD

1013NDAT^^^^^^^1 Blank ⟶

^^^9DJNC^^^^^^^3^^^^^^^4^^^^^^^^^^^12500^^^^1.95^^^^35.3 Blank

1014^EØD

1015^EØP

ERROR MESSAGES

DESADE contains a series of internal error checks that insure that correctness of the reduction of the original cable array to a statically determinate array, the consistency of the input data, and the proper deck structure. As errors are found, they are transmitted to the line printer under the heading

ERRORS IN PARAMETRIC STUDY SOURCE DECK NUMBER xxx

TYPE CARD NO. CARD TYPE OTHER INFORMATION

Note that source deck number "0" refers to the cable array source deck or tape while source deck numbers 1, 2, etc. refer to the corresponding parametric study source deck in the overall input deck. The identification of errors in a particular source deck terminates program operation after that source deck has been read. The type errors identified by DESADE are summarized below.

Type 0

A Type 0 error indicates that the card type identifier (Field 2) is not recognizable.

Type 1

Type 1 errors indicate certain obvious typographic errors and certain numbering errors. A breakdown of Type 1 errors by card type follows.

LUN Card

a. Field 6 $\neq$ 0 or 1

b. Field 8 $\neq$ 0, 1, or 2

c. Non-unique numbers assigned to required I/O units.

NJNC Card

a. 2 > Field 3 > 44

ANC Card

a. 1 > Field 3 > 44

IR Card

a. Field 3 = Field 4

b. 1 > Fields 3 or 4 > 44

CAB Card

a. 1 > Field 3 > 22

b. Field 4 = Field 5

c. $1 >$ Fields 4 or $5 > 44$

d. Fields 7, 8 or $9 \leqslant 0$

e. Fields 10 or $11 < 0$

f. Field $10 = 0$ and Field $11 \neq 0$

g. Field $10 \neq 0$ and Field $11 = 0$

h. $1 >$ Field $12 > 50$

DCAB Card

a. $1 >$ Field $3 > 22$

b. $1 >$ Field $4 > 4$

c. Field $4 = 1$ or 2 and $1 >$ Field $5 > 1000$

d. Field $4 = 3$ or 4 and Field $5 \neq 0$

e. Field $4 = 1$ or 3 and Field $9 \leqslant 0$

f. Field $4 = 2$ or 4 and Field $9 \neq 0$

g. Fields 7, 8, or $10 < 0$

DJNC Card

a. $1 >$ Field $3 > 44$

b. Field $4 \neq 2$ or 4

c. Field $4 = 2$ and $1 >$ Field $5 > 1000$

d. Field $4 = 4$ and Field $5 \neq 0$

e. Field 7 or $8 < 0$

DEN Card

a. Field $3 \leqslant 0$

NDAT Card

a. Field $3 \neq 0$, 1, or 2

COMP Card

a. Field $3 \leqslant 0$

ANG Card

a. Field $4 \leqslant 0$

b. Field $5 <$ Field 3

Type 2

Type 2 errors indicate an improper reduction of the original cable array to a statically determinate array or an improper numbering of array junctions. A breakdown of Type 2 errors by card type follows.

ANC Card

a. The junction number assigned to the anchor (Field 3) has previously been assigned on a preceding ANC card; or,

b. The junction number assigned to the anchor (Field 3) has previously been assigned to an s = L junction (Field 5) on a preceding CAB card.

CAB Card

a. The junction number assigned to the s = L junction (Field 5) has previously been assigned on a preceding CAB card; or,

b. The junction number assigned to the s = L junction (Field 5) has previously been assigned to an anchor junction (Field 3) on a preceding ANC card.

Type 3

A Type 3 error appears only in conjunction with a CAB card and indicates that the number assigned to the cable (Field 3) has previously been assigned on a preceding CAB card.

Type 4

A Type 4 error appears only in conjunction with an IR card and indicates certain typographic, numbering, or array reduction errors. Either

a. The junction number assigned in Field 3 has previously been assigned in fields 3 or 4 of a preceding IR card; or,

b. The junction number assigned in Field 4 has previously been assigned in Field 3 of a preceding IR card.

Type 5

Type 5 errors indicate improper discrete device indexing. A breakdown of Type 5 errors by card type follows.

DCAB Card

a. The index assigned to a Type 1 or 2 discrete device (Field 5) has previously been assigned on a preceding DCAB card; or,

b. The index assigned to a Type 1 or 2 discrete device (Field 5) has previously been assigned to a Type 2 discrete device (Field 5) on a preceding DJNC card.

DJNC Card

a. The index assigned to a Type 2 discrete device (Field 5) has previously been assigned on a preceding DJNC card; or,

b. The index assigned to a Type 2 discrete device (Field 5) has previously been assigned to a Type 1 or 2 discrete device (Field 5) on a preceding DCAB card.

Type 6

Type 6 errors indicate an excess of information in a particular source deck. A breakdown of Type 6 errors by card type follows.

NJNC Card

a. An NJNC card has previously appeared in the particular source deck.

DEN Card

a. A DEN card has previously appeared in the particular source deck.

COMP Card

a. A COMP card has previously appeared in the particular source deck.

VEL Card

a. Twenty-five VEL cards have previously appeared in the particular source deck.

b. The Z coordinate at which the current velocity is specified (Field 3) has previously been used on a preceding VEL card in the particular source deck.

ANG Card

a. An ANG card has previously appeared in the particular source deck.

Type 7

A Type 7 error indicates an inadequacy of information in the cable array source deck (or tape). The "OTHER INFORMATION" column under the error heading contains a 1×3 matrix, the elements of which give respectively the number of NJNC cards read, the number of DEN cards read, and the number of ANC cards read. A zero element is an error (see CABLE ARRAY SOURCE DECK).

Type 8

A Type 8 error indicates a discontinuity in numbering the cables in the array. The "OTHER INFORMATION" column under the error heading contains a 1×22 matrix, the elements of which contain one or zero indicating, respectively, the use or non-use of the corresponding column number as a cable number. Zeros interspersed with ones are in error (see ARRAY DESCRIPTION).

Type 9

A Type 9 error indicates a discontinuity in numbering the junctions in the array. The "OTHER INFORMATION" column under the error heading contains a 1 × 44 matrix, the elements of which contain one or zero indicating respectively, the use or non-use of the corresponding column number as a junction number. Zeros interspersed with ones are in error (see ARRAY DESCRIPTION and REDUCTION TO A STATICALLY DETERMINATE ARRAY).

Type 10

A Type 10 error indicates a discontinuity in indexing the Type 1 and 2 discrete devices in the array. The "OTHER INFORMATION" column under the error heading contains a 1 × 1000 matrix (printed out in rows of 100 elements), the elements of which contain one or zero, indicating respectively, the use or non-use of the corresponding column number as a device index. Zeros interspersed with ones are in error (see DCAB and DJNC cards).

Type 11

A Type 11 error indicates an improper reduction of the original cable array to a statically determinate array or an absence of certain input cards in the cable array source deck (or tape). The "OTHER INFORMATION" column under the error heading contains a 1 × 5 matrix, the elements of which give, respectively, the number of CAB cards read, the number of ANC cards read, the number of junctions in the original cable array (Field 3 of the NJNC card), the number of required cuts (Eq. (1)) calculated from the preceding information, and the number of IR cards read. Column 5 not equal to column 4 is an error (see REDUCTION TO A STATICALLY DETERMINATE ARRAY).

Type 12

Type 12 errors indicate certain typographic, numbering, or array reduction errors. A breakdown of Type 12 errors by card type follows.

IR Card

a. The junction number assigned in Field 3 is less than or equal to the number of junctions in the original (unreduced) array (Field 3 of the NJNC card);

b. The junction number assigned in Field 3 is greater than the number of junctions in the original (unreduced) array plus the number of cuts made in reducing the array (Eq. (1)); or

c. The junction number assigned in Field 4 is greater than the number of junctions in the original (unreduced) array.

CAB Card

a. The junction number assigned in Field 4 is greater than the number of junctions in the original (unreduced) array (Field 3 of the NJNC card) plus the number of cuts made in reducing the array (Eq. (1)).

DCAB Card

a. The cable number assigned in Field 3 does not correspond to a cable number assigned to a cable (Field 3 of the CAB cards); or

b. The distance of the discrete device from the s = 0 junction of the cable (Field 10) is greater than or equal to the length of the corresponding cable (Field 9 of the CAB card).

DJNC Card

a. The junction number assigned in Field 3 does not correspond to either a junction number assigned to an anchor (Field 3 of the ANC cards) or a junction number assigned to an s = L junction of a cable (Field 5 of the CAB cards).

Type 13

A Type 13 error indicates that the original cable array has not been properly reduced to a statically determinate array or that junctions have been improperly numbered. The "OTHER INFORMATION" column under the error heading contains the message, "IMPROPER ARRAY REDUCTION OR JUNCTION NUMBERING. CHECK TREE REPRESENTATION OF ARRAY (SEE ARRAY REDUCTION SECTION OF USERS MANUAL) AGAINST JUNCTION NUMBERING ON ANC AND CAB CARDS."

Type 14

A Type 14 error indicates an inadequacy of information in a parametric study source deck. The "OTHER INFORMATION" column under the error heading contains a 1×5 matrix, the elements of which give, respectively, the number of COMP cards read, the current field option, the number of VEL cards read, the number of VEL cards containing a Z coordinate (Field 3) less than or equal to the minimum Z coordinate transmitted by the ANC cards (Field 6 of the ANC cards), and the number of ANG cards read. The following possible errors exist:

a. If column 1 contains a zero, then a COMP card has not appeared after the first NDAT card (see PARAMETRIC STUDY SOURCE DECKS).

b. If column 2 contains a one and any of columns 3, 4, or 5 contain a zero, then the standard current field has not been properly formulated (see PARAMETRIC STUDY SOURCE DECKS and STANDARD CURRENT FIELD).

Type 15

A Type 15 error indicates that an unpermitted change has been attempted in a parametric study source deck. The card number and type listed under the error heading corresponds to the card on which the unpermitted change has been attempted (see PARAMETRIC STUDY SOURCE DECKS).

Type 16

A Type 16 error indicates an improper deck structure and causes an immediate program termination. The card number and type listed under the error heading

correspond to the out-of-place card (see CABLE ARRAY SOURCE DECK, PARAMETRIC STUDY SOURCE DECKS, and OVERALL INPUT DECK).

Type 17

A Type 17 error indicates that the cable array source deck (or tape) contains more than 2150 records and causes an immediate program termination. The "OTHER INFORMATION" column under the error heading contains the message "COMMON/B1/ BOUND EXCEEDED. SEE USERS MANUAL."

A Type 17 error is readily correctable if the machine being used has sufficient core storage. This correction is achieved by changing the row dimension of DATAT on cards DES025 and INP022 from 2150 to a number exceeding the number of records in the cable array source deck (or tape). Simultaneously, the comparison value on card INP615 must be changed from 2150 to the new row dimension of DATAT.

Type 18

A Type 18 error indicates that the accuracy required for the array equilibrium calculations (Field 3 of the COMP card) has not been obtained during the calculations. Thi is for one of two possible reasons.

a. Some cable segments have gone slack (that is, the segments have near zero tension An examination of the tensions printed out in conjunction with a Type 18 error will reveal if this is the reason. If it is, see the section on STATICALLY UNSTABLE CABLE ARRAYS in Ref. 2 for possible remedial actions. If it is not, then

b. The accuracy required for the equilibrium calculations is simply too stringent for the computer to handle (see COMP card). An examination of the final value of the accuracy obtained, printed out in conjunction with a Type 18 error, will reveal the best accuracy obtainable. Field 3 of the COMP card should be modified to reflect this information.

ARRAY DESCRIPTIVE OUTPUT

Following each error-free reading of a parametric study source deck, DESADE transmits to the line printer a description of the physical characteristics of the cable array under study. This printout includes anchor junctions and locations, information concerning the reduction of the original cable array to a statically determinate array, properties of the cables in the array, properties of the discrete devices located at array junctions total number of Type 1 and 2 devices, current field option and current profile if option 1 and calculational accuracy requirements.

The format of the array descriptive output is self-explanatory. A sample printout is given in Appendix B.

STRUCTURAL OUTPUT

If output option 0 or 2 is selected, DESADE transmits to the line printer a structural output. The structural printout follows and refers to the array characterized in the array descriptive output and contains information giving

a. A description of the current field (i.e., no current or current from xxx degrees)

b. The cable forces and angles at each anchor

c. The position coordinates of the original (unreduced) array junctions, the displacement of these coordinates from the no-current coordinates, and the cable forces and angles at each junction

d. The maximum and minimum tensions and their locations for each array cable and the maximum displacement from the no-current condition and its location for each cable

e. The position coordinates, the displacement of these coordinates from the no-current coordinates, and the tension at each Type 1 and 2 DCAB device in the array.

This latter information is printed out in the same order that the Type 1 and 2 DCAB devices are indexed (Field 5 of the DCAB card). *Note that it is possible to obtain the latter information for any point on any cable in the array by defining a "dummy" type 2 DCAB device to be located at the point.* A dummy Type 2 DCAB device is simply one for which fields 6, 7, and 8 of the DCAB card are left blank so that the "device" has no effect on the array equilibrium calculations.

The format of the structural output is self-explanatory. A sample printout is given in Appendix B;

DEVICE LOCATION OUTPUT

If output option 1 or 2 is selected, DESADE transmits to tape or cards a device location output. The device location output contains information giving

1. A description of the current field (i.e., no current or current from xxx degrees)

2. The position coordinates of each Type 1 and 2 discrete device in the array.

Four types of records are associated with the device location output. Each of these records is written with the format

(A4, I4, 3F10.2).

REC Record

Field	Format	Contents
1	A4	^ REC
2	I4	Record number
3	F10.2	not used
4	F10.2	" "
5	F10.2	" "

Note: The REC record is used to identify the cable array under study. The record number (Field 2) is referenced in the array descriptive output in the statement, "DEVICE LOCATION OUTPUT RECORD XX REFERS TO THIS ARRAY." The information following a REC record refers to the identified array.

CUR Record

Field	Format	Contents
1	A4	^CUR
2	I4	0 if no current acting on array 1 if current is acting on array
3	F10.2	Blank if Field 2 = 0 Current angle if Field 2 = 1
4	F10.2	not used
5	F10.2	" "

Note: The CUR record is used to describe the current field (i.e., no current or current from xxx degrees). The information following a CUR record refers to the identified current field.

DEV Record

Field	Format	Contents
1	A4	^DEV
2	I4	Discrete device index (Field 5 of the DCAB and DJNC cards)
3	F10.2	X coordinate of device
4	F10.2	Y coordinate of device
5	F10.2	Z coordinate of device

Notes: The DEV records are used to transmit the position coordinates of the type 1 and 2 discrete devices in the array. There is one DEV record for each indexed (types 1 and 2) device for each identified current field.

EOP Record

Field	Format	Contents
1	A4	^EOP
2	I4	not used
3	F10.2	" "
4	F10.2	" "
5	F10.2	" "

Note: The EOP record is used to signify the end of output transmission.

A typical overall device location output file is illustrated below.

^REC^^^1

^CUR^^^0

DEV Records (one for each indexed device)

^CUR^^^1 current angle

DEV Records

^CUR^^^1 current angle

DEV Records

^REC^^^2

^CUR^^^0

DEV Records

^EOP

A sample image of a device location output file is given in Appendix B.

REFERENCES

1. R. A. Skop, and G. J. O'Hara, "The Static Equilibrium Configuration of Cable Arrays by Use of the Method of Imaginary Reactions," NRL Report 6819, Feb. 1969.
2. R. A. Skop, and G. J. O'Hara, "The Analysis of Internally Redundant Structural Cable Arrays," NRL Report 7296, Sept. 1971.
3. R. A. Skop, and R. E. Kaplan, "The Static Configuration of a Tri-Moored, Subsurface, Buoy-Cable Array Acted on by Current-Induced Forces," NRL Report 6894, May 1969.
4. R. A. Skop, "The Method of Imaginary Reactions: Applications to N-Point Moors," Marine Technology 1970, Preprints of 6th Annual Marine Technology Society Conference, June 29-July 1, 1970, Washington, D.C., Vol. 1, pp. 1-22.
5. M. J. Casarella, and M. Parsons, "Cable Systems Under Hydrodynamic Loading," Marine Technology Society Journal 4 (No. 4), 27-44, (July-Aug. 1970).
6. B. W. Wilson, "Elastic Characteristics of Moorings," Waterways and Harbors Div., ASCE, 93 (No. WW4), 27-56 (Nov. 1967).

Appendix A
SOURCE LANGUAGE LISTING

```
      PROGRAM DESADE
C
C A FORTRAN IV PROGRAM FOR COMPUTING THE STATIC DEFLECTIONS
C OF STRUCTURAL CABLE ARRAYS
C
C BY RICHARD A. SKOP AND JAMES MARK, OCEAN TECHNOLOGY DIVISION,
C NAVAL RESEARCH LABORATORY, WASHINGTON, D. C.
C
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG,
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,
     4WCAB,IDEV,ICHECK,NDEV,NDATC
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44
     1)
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22)
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)
      DIMENSION ICHECK(44)
      DIMENSION DATAT(2150,10)
      EQUIVALENCE (DATAT(1),FEJUNC(1))
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG
      INTEGER PATH
      REAL IR,IRS
C
C CALL INPUT TO READ DATA AND IDENTIFY ERRORS
C
      ITIME=1
 1000 CALL INPUT
C
C CHECK TO SEE IF ANY ERRORS IN DATA
C
      IF(FATE.NE.0.) GO TO 10000
C
C GET HERE IF NO ERRORS -- PRINT OUT PHYSICAL CHARACTERISTICS OF ARRAY
C
      WRITE(IPRNT,1001)
 1001 FORMAT(///,5X,18HNO ERRORS DETECTED)
      CALL PHSOUT
C
C KMULT IS A MULTIPLIER FOR CHANGING CURRENT ANGLE THETA
C
      KMULT=0
C
C JUMP=0---NO CURRENT   JUMP=1---CURRENT
C
      JUMP=0
C
C GET HERE TO CALCULATE FORCES AND IF SUCCESSIVE APPROXIMATION ROUTINE
C NOT SATISFIED -- ZERO FORCES
```

```
C
 2011 DO 2012 J=1,NJUNC
      DO 2012 I=1,3
 2012 FEJUNC(I,J)=0.
      DO 2013 N=1,NCAB
      INNN=NNODE(N)
      DO 2013 M=1,INNN
      DO 2013 I=1,3
 2013  FCAB(I,M,N)=0.
C
C PICK UP DISCRETE DEVICE DATA FROM TEMPORARY STORAGE TAPE AND
C CALCULATE DEVICE FORCES -- DJNC FORCES ARE STORED IN FEJUNC --
C DCAB FORCES IN FCAB -- EFORCE(I) IS ROUTINE FOR CALCULATING
C DEVICE FORCES IN DIRECTION I
C
 2015 READ(INTAPE,1)  (DATA(K),K=1,10)
    1 FORMAT(F4.0,A4,8E15.8)
      IF(DATA(2).EQ.TEST(3))  GO TO 2017
      IF(DATA(2).EQ.TEST(4))  GO TO 2019
      IF(DATA(2).EQ.TEST(9))  GO TO 2021
      GO TO 2015
 2017 K=DATA(3)
      DO 2018 J=1,3
      I=J
 2018 FEJUNC(I,K)=FEJUNC(I,K)+EFORCE(I)
      GO TO 2015
 2019 K= DATA(3)
      M= DATA(10)/H(K) + 1
      DO 2020 J=1,3
      I=J
 2020  FCAB(I,M,K) =  FCAB(I,M,K) + EFORCE(I)
      GO TO 2015
C
C GET HERE AT END OF TAPE
C
 2021 REWIND INTAPE
C
C NOW CALCULATE THE FORCE/LENGTH IN DIRECTION I AT NODE M ON CABLE N
C CFORCE(I,M,N) IS ROUTINE FOR DOING THIS -- INTEGRATE BY TRAPEZOIDAL
C RULE OVER SEGMENT TO GET TOTAL FORCE AND ADD TO DCAB FORCES
C
      DO 2022 J=1,NCAB
      K=J
      INNN=NNODE(K)-1
      DO 2022 MM=1,INNN
      M=MM
      DO 2022 II=1,3
      I=II
 2022 FCAB(I,M,K)=(CFORCE(I,M,K)+CFORCE(I,M+1,K))*H(K)/2.+FCAB(I,M,K)
C
C ALL FORCES ARE NOW CALCULATED AND EQUILIBRIUM CAN BE DETERMINED
C  LEAP = 1  FIRST TIME THROUGH IMAGINARY REACTION ROUTINE
C  LEAP = 2  ANY OTHER TIME
C SKIP THIS SECTION IF NO IR'S
C
      IF(NIR.EQ.0) GO TO 2031
      IF(JUMP.EQ.0) CALL START
      LEAP=1
C
```

```
C INITIALIZE DELTA
C
      DELTA=DELTAI
C
C GET HERE TO INITIALIZE TOTAL FORCES AT THE JUNCTIONS, TFJUNC, AND
C IF THE IMAGINARY REACTION ITERATION NOT SATISFIED -- ALSO IF NO IR'S
C
 2031 DO 2032 J=1,NJUNC
      DO 2032 I=1,3
 2032 TFJUNC(I,J) = FEJUNC(I,J)
C
C ADD APPROPRIATE REACTIONS TO TFJUNC -- SKIP THIS SECTION IF NO IR'S
C
      IF(NIR.EQ.0) GO TO 2036
      DO 2035 J=1,NJUNC
      DO 2035 K=1,NIR
      IF( (J.EQ.IRJUNC(K)).OR.(J.EQ.ERJUNC(K)) )  GO TO 2033
      GO TO 2035
 2033 DO 2034 I=1,3
 2034 TFJUNC(I,J) = TFJUNC(I,J) + IR(I,J)
 2035 CONTINUE
C
C TFJUNC IS NOW DETERMINED AND THE REACTIVE FORCES IN THE ARRAY, RCAB,
C CAN BE CALCULATED BY SUMMING FROM THE FREE ENDS TO THE FIXED ANCHOR
C
 2036 DO 2047 N=1,NCAB
      INDEX= NCAB+1-N
      K= PATH(INDEX)
      INNN=NNODE(K)
      INLJ=LJUNC(K)
      DO 2041 I=1,3
 2041 RCAB(I,INNN,K)=TFJUNC(I,INLJ)
      DO 2044 L=1,NCAB
      IF(LJUNC(K).EQ.ZJUNC(L)) GO TO 2042
      GO TO 2044
 2042 DO 2043 I=1,3
 2043 RCAB(I,INNN,K)=RCAB(I,INNN,K)+RCAB(I,1,L)
 2044 CONTINUE
      DO 2046 MM=1,INNN
      M=INNN+1-MM
      IF(M.EQ.1) GO TO 2047
      DO 2045 I=1,3
 2045 RCAB(I,M-1,K)=RCAB(I,M,K)+ FCAB(I,M-1,K)
 2046 CONTINUE
 2047 CONTINUE
C
C ALL REACTIVE FORCES ARE NOW DETERMINED AND THE CONFIGURATION OF THE
C ARRAY, PCAB AND PJUNC, CAN BE FOUND BY INTEGRATING FROM THE FIXED
C ANCHOR TO THE FREE ENDS -- INTEGRATION BY THE TRAPEZOIDAL RULE IS
C AGAIN USED
C
      DO 2054 N=1,NCAB
      K=PATH(N)
      INLN=LJUNC(K)
      INNN=NNODE(K)
      INZJ=ZJUNC(K)
      DO 2051  I=1,3
 2051 PCAB(I,1,K)=PJUNC(I,INZJ)
      DO 2052 MM=2,INNN
```

```
      M=MM                                                              DES174
      DO 2052 II=1,3                                                    DES175
      I=II                                                              DES176
 2052 PCAB(I,M,K)=PCAB(I,M-1,K)+(EXCAB(M-1,K)*RCAB(I,M-1,K)/TCAB(M-1,K) DES177
     1+EXCAB(M,K)*RCAB(I,M,K)/TCAB(M,K))*H(K)/2.                        DES178
      DO 2053 I=1,3                                                     DES179
 2053 PJUNC(I,INLN)=PCAB(I,INNN,K)                                      DES180
 2054 CONTINUE                                                          DES181
C                                                                       DES182
C ARRAY CONFIGURATION NOW DETERMINED -- CHECK TO SEE IF IT SATISFIES    DES183
C GEOMETRIC CONSTRAINTS -- SKIP THIS SECTION IF NO IR'S                 DES184
C                                                                       DES185
      IF(NIR.EQ.0) GO TO 2071                                           DES186
C                                                                       DES187
C  CALCULATE ERROR E                                                    DES188
C                                                                       DES189
      E2=0.                                                             DES190
      DO 2061 N=1,NIR                                                   DES191
      KEN=ERJUNC(N)                                                     DES192
      KIN=IRJUNC(N)                                                     DES193
      DO 2061 I=1,3                                                     DES194
 2061 E2=E2+( PJUNC(I,KEN) - PJUNC(I,KIN) )**2                          DES195
      E=SQRT(E2)                                                        DES196
C                                                                       DES197
C COMPARE ERROR TO ACCURACY REQUIREMENTS                                DES198
C                                                                       DES199
      IF(E.LE.COMPD/10.) GO TO 2071                                     DES200
C                                                                       DES201
C GET HERE IF GEOMETRIC CONSTRAINTS NOT SATISFIED                       DES202
C                                                                       DES203
      GO TO (2062,2065),LEAP                                            DES204
C                                                                       DES205
C GET HERE FIRST TIME THROUGH IMAGINARY REACTION ROUTINE                DES206
C                                                                       DES207
 2062 LEAP=2                                                            DES208
C                                                                       DES209
C STORE SUCCESSFUL POSITIONS AND REACTIONS                              DES210
C                                                                       DES211
 2063 ES=E                                                              DES212
      DO 2064 N=1,NIR                                                   DES213
      KEN=ERJUNC(N)                                                     DES214
      KIN=IRJUNC(N)                                                     DES215
      DO 2064 I=1,3                                                     DES216
      PJUNCS(I,KEN)=PJUNC(I,KEN)                                        DES217
      PJUNCS(I,KIN)=PJUNC(I,KIN)                                        DES218
 2064 IRS(I,KIN)=IR(I,KIN)                                              DES219
      GO TO 2066                                                        DES220
C                                                                       DES221
C GET HERE ANY OTHER TIME THROUGH IMAGINARY REACTION ROUTINE            DES222
C SEE IF ITERATION SUCCESSFUL                                           DES223
C                                                                       DES224
 2065 IF(E.LT.ES) GO TO 2063                                            DES225
C                                                                       DES226
C REDUCE DELTA IF NOT SUCCESSFUL INTERATION                             DES227
C                                                                       DES228
      DELTA=DELTA/2.                                                    DES229
C                                                                       DES230
C CALCULATE NEW IMAGINARY AND EQUILIBRATING REACTIONS AND GO BACK TO    DES231
C RECALCULATE ARRAY EQUILIBRIUM                                         DES232
```

```
C
 2066 DO 2067 N=1,NIR
      KEN=ERJUNC(N)
      DO 2067 I=1,3
 2067 IR(I,KEN)=0.
      DO 2068 N=1,NIR
      KEN=ERJUNC(N)
      KIN=IRJUNC(N)
      DO 2068 I=1,3
      IR(I,KIN)=IRS(I,KIN)+DELTA*(PJUNCS(I,KEN)-PJUNCS(I,KIN))/ES
 2068 IR(I,KEN)=IR(I,KEN)-IR(I,KIN)
C
C CHECK CHANGES IN IMAGINARY REACTIONS
C
      DO 2070 N=1,NIR
      KIN=IRJUNC(N)
      DO 2070 I=1,3
 2070 IF(IR(I,KIN).NE.IRS(I,KIN)) GO TO 2031
C
C NO CHANGES -- TIME TO QUIT
C
      CALL ERROR
      GO TO 10000
C
C GET HERE IF ACCURACY REQUIREMENTS SATISFIED OR NO IR'S
C OUTPUT EQUILIBRIUM IF NO CURRENT -- IF CURRENT, FIRST CHECK TO SEE
C IF ACCURACY REQUIREMENT SATISFIED BY SUCCESSIVE APPROXIMATIONS
C
 2071 JUM=JUMP+1
      GO TO (2072,2075),JUM
 2072 IF((OFLG.EQ.0).OR.(OFLG.EQ.2)) CALL STROUT
      IF((OFLG.EQ.1).OR.(OFLG.EQ.2)) CALL TAPOUT
      IF(OFLG.EQ.1) GO TO 2100
      IF(JUM.NE.1) GO TO 2100
      DO 2200 N=1,NCAB
      INNN=NNODE(N)
      DO 2200 M=1,INNN
      DO 2200 I=1,3
      PCABO(I,M,N)=PCAB(I,M,N)
 2200 RCABO(I,M,N)=RCAB(I,M,N)
      DO 2201 N=1,NJUNC
      DO 2201 I=1,3
 2201 PJUNCO(I,N)=PJUNC(I,N)
C
C APPLY CURRENT IF REQUIRED
C
 2100 IF(IVOPT.EQ.0)  GO TO 9999
      JUMP=1
      THETA=THETAB + KMULT*THETAS
      IF(THETA.GT.THETAE) GO TO 9999
      KMULT=KMULT+1
C
C STORE EXISTING CONFIGURATION FOR COMPARISON PURPOSES
C
 2073 DO 2074 N=1,NCAB
      INNN=NNODE(N)
      DO 2074 M=1,INNN
      DO 2074 I=1,3
 2074 PCABE(I,M,N)=PCAB(I,M,N)
```

```
C                                                                       DES292
C RECALCULATE FORCES                                                    DES293
C                                                                       DES294
      GO TO 2011                                                        DES295
C                                                                       DES296
C GET HERE IF CURRENT -- CHECK SUCCESSIVE APPROXIMATION ACCURACY        DES297
C                                                                       DES298
 2075 DO 2077 N=1,NCAB                                                  DES299
      DO 2077 M=1,INNN                                                  DES300
      U=0.                                                              DES301
      DO 2076 I=1,3                                                     DES302
 2076 U=U+(PCABE(I,M,N)-PCAB(I,M,N))**2                                 DES303
C                                                                       DES304
C IF NOT ACCURATE STORE CONFIGURATION AND RECALCULATE FORCES            DES305
C                                                                       DES306
      IF(SQRT(U).GT.COMPD) GO TO 2073                                   DES307
 2077 CONTINUE                                                          DES308
C                                                                       DES309
C GET HERE IF POSITION ACCURATE AND OUTPUT POSITION                     DES310
C                                                                       DES311
      GO TO 2072                                                        DES312
C                                                                       DES313
C GO BACK FOR MORE DATA                                                 DES314
C                                                                       DES315
 9999 GO TO 1000                                                        DES316
10000 CONTINUE                                                          DES317
      WRITE(IPRNT,10001)                                                DES318
10001 FORMAT(1H1)                                                       DES319
      END                                                               DES320
```

```
      SUBROUTINE INPUT
C
C THIS ROUTINE READS ALL DATA AND IDENTIFIES ERRORS IN
C DATA, DECK STRUCTURE, AND ARRAY REPRESENTATION
C
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG,
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,
     4WCAB,IDEV,ICHECK,NDEV,NDATC
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44
     1)
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22)
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)
      DIMENSION ICHECK(44)
      DIMENSION DATAT(2150,10)
      DIMENSION ITEST(14)
      EQUIVALENCE (DATAT(1),FEJUNC(1))
      EQUIVALENCE (ITEST(1),TEST(1))
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG
      INTEGER PATH
      REAL IR,IRS
C
C THIS IS THE BEGINNING OF THE INPUT SECTION
C INITIALIZE ALL CONSTANTS, FLAGS, ARRAYS, AND COUNTERS
C
      IF(ITIME.NE.1)  GO TO 999
          ITEST(1)=4H  IR
          ITEST(2)=4H ANC
          ITEST(3)=4HDJNC
          ITEST(4)=4HDCAB
          ITEST(5)=4H CAB
          ITEST(6)=4H DEN
          ITEST(7)=4HCOMP
          ITEST(8)=4H ANG
          ITEST(9)=4H EOD
          ITEST(10)=4HNJNC
          ITEST(11)=4H VEL
          ITEST(12)=4HNDAT
          ITEST(13)=4H LUN
          ITEST(14)=4H EOP
      PIP=3.14159265/180.
      IFEOD=0
      NDATC=0
      KFLG=0
      DO 1000 I=1,1000
 1000 IDEV(I)=0
      DO 1001 I=1,44
 1001 ICHECK(I)=0
      DO 1002 I=1,22
 1002 ICAB(I)=0
      NANC=0
```

```
      IFRHO=0                                                           INP059
      IFJNC=0                                                           INP060
      NIR=0                                                             INP061
      IROW=1                                                            INP062
  999 FATE=0.                                                           INP063
C                                                                       INP064
C CHECK LOGICAL UNITS                                                   INP065
C                                                                       INP066
      IF(ITIME.GT.1)  GO TO  1003                                       INP067
      ITIME=2                                                           INP068
      READ 1004,(DATA(I),I=1,10)                                        INP069
 1004 FORMAT(F4.0,A4,8F8.0,F5.0,I3)                                     INP070
      IF(DATA(2).NE.TEST(13)) GO TO 9018                                INP071
      IPRNT=DATA(4)                                                     INP072
C                                                                       INP073
C GENERATE ERROR MESSAGE HEADER                                         INP074
C                                                                       INP075
 998  WRITE(IPRNT,9100) NDATC                                           INP076
 9100 FORMAT(1H1,46HERRORS IN PARAMETRIC STUDY SOURCE DECK NUMBER ,I2,//INP077
     1 12X,4HCARD,3X,4HCARD,6X,5HOTHER/1H ,4X,4HTYPE,4X,3HNO.,3X,4HTYPE,INP078
     23X,11HINFORMATION )                                               INP079
      IF(IFEOD.EQ.0) GO TO 13                                           INP080
      IF(IFEOD.NE.0) GO TO 12701                                        INP081
C                                                                       INP082
C READ ONE INPUT RECORD INTO DATA ARRAY                                 INP083
C                                                                       INP084
 1003 CONTINUE                                                          INP085
      IF(IFLG.EQ.0) READ(IREAD,1004) (DATA(I),I=1,10),EX,NSEG           INP086
      IF(IFLG.EQ.1) READ(IREAD,1104) (DATA(I),I=1,10),EX,NSEG           INP087
 1104 FORMAT(F4.0,A4,8E15.8,/E12.5,I3)                                  INP088
C                                                                       INP089
C TYPE AND BRANCH                                                       INP090
C                                                                       INP091
      IF(IFEOD.EQ.0)  GO TO 1006                                        INP092
      IF((DATA(2).EQ.TEST(12)).OR.(DATA(2).EQ.TEST(14)))  GO TO 1006    INP093
      GO TO 9018                                                        INP094
 1006 DO 1005 I=1,14                                                    INP095
      IF(DATA(2).EQ.TEST(I)) GO TO (1,2,3,4,5,6,9018,9018,9,10,9018,    INP096
     1 12,9018,14),I                                                    INP097
 1005 CONTINUE                                                          INP098
C                                                                       INP099
C GET HERE IF CARD UNIDENTIFIABLE                                       INP100
C                                                                       INP101
      GO TO 9000                                                        INP102
C                                                                       INP103
C GET HERE IF IR CARD READ                                              INP104
C                                                                       INP105
    1 IF(DATA(3)-DATA(4))  101,9001,101                                 INP106
  101 DO 102 I=3,4                                                      INP107
      IF( (DATA(I).LT. 1.).OR.(DATA(I).GT.44.))  GO TO 9001             INP108
  102 CONTINUE                                                          INP109
C                                                                       INP110
C GET HERE IF DATA OK                                                   INP111
C COUNT IR AND STORE DATA                                               INP112
C                                                                       INP113
      NIR=NIR+1                                                         INP114
      IRJUNC(NIR)=DATA(3)                                               INP115
      ERJUNC(NIR)=DATA(4)                                               INP116
      DO 103 N=1,NIR                                                    INP117
```

```
      IF(IRJUNC(NIR).EQ.ERJUNC(N))  GO TO 9004                          INP118
      IF( (IRJUNC(NIR).EQ.IRJUNC(N) ) .AND. (NIR.NE.N) )     GO TO 9004  INP119
      IF( (ERJUNC(NIR).EQ.IRJUNC(N))) GO TO 9004                        INP120
  103 CONTINUE                                                          INP121
      GO TO 8000                                                        INP122
C                                                                       INP123
C GET HERE IF ANC CARD READ                                             INP124
C                                                                       INP125
    2 INDEX=DATA(3)                                                     INP126
      IF((DATA(3).LT.1.).OR.(DATA(3).GT.44.))  GO TO 9001               INP127
      IF(ICHECK(INDEX).NE.0) GO TO 9002                                 INP128
C                                                                       INP129
C GET HERE IF DATA OK -- COUNT ANCHOR AND STORE DATA                    INP130
C                                                                       INP131
      NANC=NANC+1                                                       INP132
      ANJUNC(NANC)=DATA(3)                                              INP133
      ICHECK(INDEX)=1                                                   INP134
   22 DO 21 I=1,3                                                       INP135
   21 PJUNC(I,INDEX)=DATA(I+3)                                          INP136
      GO TO 8000                                                        INP137
C                                                                       INP138
C GET HERE IF DJNC CARD READ                                            INP139
C                                                                       INP140
    3 IF( (DATA(4).EQ.1.).OR.(DATA(4).EQ.3.) ) GO TO 9001               INP141
      IF( (DATA(4).EQ.2.).AND.(DATA(5).LT.1.) ) GO TO 9001              INP142
      IF(DATA(5).GT.1000.)  GO TO 9001                                  INP143
      IF(DATA(4).GT.4.)  GO TO 9001                                     INP144
      IF(DATA(4).LT.1.)  GO TO 9001                                     INP145
      IF( (DATA(3).LT.1.).OR.(DATA(3).GT.44.))  GO TO 9001              INP146
      IF( (DATA(4).EQ.4.).AND.(DATA(5).NE.0.) ) GO TO 9001              INP147
      IF( (DATA(7).LT.0.).OR.(DATA(8).LT.0.)) GO TO 9001                INP148
      IF( DATA(4).EQ.4. )  GO TO 8000                                   INP149
      INDEX=DATA(5)                                                     INP150
      IF(  IDEV(INDEX).NE.0 ) GO TO 9005                                INP151
      IDEV(INDEX)=1                                                     INP152
      GO TO 8000                                                        INP153
C                                                                       INP154
C GET HERE IF DCAB CARD READ                                            INP155
C                                                                       INP156
    4 DO 41 I=1,4                                                       INP157
      ID=DATA(4)                                                        INP158
      IF(ID.EQ.I) GO TO 42                                              INP159
   41 CONTINUE                                                          INP160
      GO TO 9001                                                        INP161
   42 IF(((DATA(4).EQ.3.).OR.(DATA(4).EQ.4.)).AND.(DATA(5).NE.0.)) GO TOINP162
     1 9001                                                             INP163
      IF( (DATA(3).LT.1.).OR.(DATA(3).GT.22.)) GO TO9001                INP164
      IF(((DATA(4).EQ.1.).OR.(DATA(4).EQ.2.)).AND.((DATA(5).LT.1.).OR.(DINP165
     1ATA(5).GT.1000.)) ) GO TO 9001                                    INP166
      IF( (DATA(7).LT.0.).OR.(DATA(8).LT.0.))  GO TO 9001               INP167
      IF( ((DATA(4).EQ.2.).OR.(DATA(4).EQ.4.)).AND.(DATA(9).NE.0.) )    INP168
     1 GO TO 9001                                                       INP169
      IF( ((DATA(4).EQ.1.).OR.(DATA(4).EQ.3.)).AND.(DATA(9).LE.0.) )    INP170
     1GO TO 9001                                                        INP171
      IF( DATA(10).LT.0. ) GO TO 9001                                   INP172
      IF( (DATA(4).EQ.3.) .OR. (DATA(4).EQ.4.) )  GO TO 8000            INP173
      INDEX=DATA(5)                                                     INP174
      IF( IDEV(INDEX).NE.0 ) GO TO 9005                                 INP175
      IDEV(INDEX)=1                                                     INP176
```

```
      GO TO 8000
C
C GET HERE IF CAB CARD READ
C
    5 INDEX=DATA(3)
      IF( (DATA(3).LT.1.).OR.(DATA(3).GT.22.))  GO TO 9001
      IF( DATA(4).EQ.DATA(5) ) GO TO 9001
      IF( (DATA(4).GT.44.).OR.(DATA(5).GT.44.))  GO TO 9001
      IF( (DATA(4).LT.1.).OR.(DATA(5).LT.1.))  GO TO 9001
      IF( (DATA(7).LE.0.).OR.(DATA(8).LE.0.).OR.(DATA(9).LE.0.)
     1 .OR.(EX.LT.0.).OR.(DATA(10).LT.0.))  GO TO 9001
      IF((DATA(10).EQ.0.).AND.(EX.NE.0.))  GO TO 9001
      IF((DATA(10).NE.0.).AND.(EX.EQ.0.))  GO TO 9001
      IF( (NSEG.LT.1).OR.(NSEG.GT.50) ) GO TO 9001
      IF(ICAB(INDEX).NE.0) GO TO 9003
      ICAB(INDEX)=1
      INDEX=DATA(5)
      IF(ICHECK(INDEX).NE.0) GO TO 9002
      ICHECK(INDEX)=1
C
C GET HERE IF DATA OK
C
      INDEX=DATA(3)
      ZJUNC(INDEX)= DATA(4)
      LJUNC(INDEX)= DATA(5)
   51 NNODE(INDEX)= NSEG+1
      WCAB(INDEX)= DATA(6)
      CDCAB(INDEX)=DATA(7)
      DCAB(INDEX)=DATA(8)
      H(INDEX)= DATA(9)/NSEG
      ECICAB(INDEX)= DATA(10)
      EXPCAB(INDEX)= EX
      GO TO 8000
C
C GET HERE IF DEN CARD READ
C
    6 IF(DATA(3).LE.0.) GO TO 9001
      IFRHO=IFRHO+1
      IF( IFRHO.GT.1 )  GO TO 9006
      RHO= DATA(3)
      GO TO 1003
C
C GET HERE IF EOD CARD READ
C
    9 IFEOD=IFEOD+1
      DO 90 J=1,10
   90 DATAT(IROW,J)=DATA(J)
      IRMAX=IROW
      IF(FATE.NE.0.) RETURN
      IF(IFLG.EQ.1) GO TO 91
      GO TO 500
   91 IREAD=ISAV1
      IFLG=0
      GO TO 500
C
C GET HERE IF NJNC CARD READ
C
   10 IF( (DATA(3).LT.2.).OR.(DATA(3).GT.44.) )  GO TO 9001
      IFJNC=IFJNC+1
```

```
      IF(IFJNC.GT.1)  GO TO 9006                                        INP236
      NOJUNC=DATA(3)                                                    INP237
      GO TO 1003                                                        INP238
C                                                                       INP239
C GET HERE IF NDAT CARD READ                                            INP240
C                                                                       INP241
   12 NDATC=NDATC+1                                                     INP242
      IF(NDATC.NE.IFEOD) GO TO 9018                                     INP243
      GO TO 998                                                         INP244
12701 IFCOMP=0                                                          INP245
      INDAT=0                                                           INP246
      IFVEL=0                                                           INP247
      IFANG=0                                                           INP248
      IF((DATA(3).LT.0.).OR.(DATA(3).GT.2.))  GO TO 9001                INP249
      IVOPT=DATA(3)                                                     INP250
      IF (NDATC.EQ.1) GO TO 1270                                        INP251
      IF (IVOPT.EQ.0) GO TO 1201                                        INP252
      IF (KFLG.EQ.0) GO TO 1271                                         INP253
      IF (IVOPT.EQ.KCUR) GO TO 1201                                     INP254
      GO TO 9117                                                        INP255
 1270 IF (IVOPT.EQ.0) GO TO 1275                                        INP256
 1271 KFLG=1                                                            INP257
      KCUR=IVOPT                                                        INP258
      GO TO 1201                                                        INP259
 1275 KFLG=0                                                            INP260
C                                                                       INP261
C READ ONE INPUT RECORD FROM PARAMETRIC STUDY SOURCE DECK               INP262
C                                                                       INP263
 1201 READ(IREAD,1004) (DATN(I),I=1,10),EXX,NNSEG                       INP264
      DO 1209 I=1,14                                                    INP265
      IF(DATN(2).EQ.TEST(I)) GO TO (9018,1208,1208,1208,1208,9018,1207, INP266
     1 1203,1260,9018,1202,9018,9018,9018),I                            INP267
 1209 CONTINUE                                                          INP268
      CALL SWTCH                                                        INP269
      GO TO 9000                                                        INP270
C                                                                       INP271
C GET HERE IF VEL CARD READ                                             INP272
C                                                                       INP273
 1202 IFVEL=IFVEL+1                                                     INP274
      CALL SWTCH                                                        INP275
      IF(IVOPT.EQ.0)  GO TO 9018                                        INP276
      IF(IFVEL.NE.1) GO TO 1225                                         INP277
      NVSEG=0                                                           INP278
      DO 1224 I=1,25                                                    INP279
      ZVEL(I)=0.                                                        INP280
 1224 VELZ(I)=0.                                                        INP281
 1225 NVSEG=NVSEG+1                                                     INP282
      IF(NVSEG.GT.25)  GO TO 9006                                       INP283
      ZVEL(NVSEG)=DATA(3)                                               INP284
      DO 111 K=1,NVSEG                                                  INP285
      IF((ZVEL(NVSEG).EQ.ZVEL(K)).AND.(K.NE.NVSEG))  GO TO 9006         INP286
  111 CONTINUE                                                          INP287
      VELZ(NVSEG)=DATA(4)                                               INP288
      GO TO 1201                                                        INP289
C                                                                       INP290
C GET HERE IF ANG CARD READ                                             INP291
C                                                                       INP292
 1203 IFANG=IFANG+1                                                     INP293
      CALL SWTCH                                                        INP294
```

```
      IF(IVOPT.EQ.0) GO TO 9018                                         INP295
      IF(IFANG.EQ.1)  NANG=0                                            INP296
      IF(DATA(4).LE.0.) GO TO 9001                                      INP297
      IF( DATA(5).LT.DATA(3) ) GO TO 9001                               INP298
      THETAB=DATA(3)                                                    INP299
      THETAS= DATA(4)                                                   INP300
      THETAE= DATA(5)                                                   INP301
      NANG=NANG+1                                                       INP302
      IF( NANG.GT.1)  GO TO 9006                                        INP303
      GO TO 1201                                                        INP304
C                                                                       INP305
C GET HERE IF COMP CARD READ                                            INP306
C                                                                       INP307
 1207 IFCOMP=IFCOMP+1                                                   INP308
      CALL SWTCH                                                        INP309
      IF(IFCOMP.EQ.1) NCOMP=0                                           INP310
      IF(DATA(3).LE.0.) GO TO 9001                                      INP311
       NCOMP= NCOMP+1                                                   INP312
      IF( NCOMP.GT.1) GO TO 9006                                        INP313
      COMPD=DATA(3)                                                     INP314
      GO TO 1201                                                        INP315
C                                                                       INP316
C GET HERE IF PARAMETERS ARE BEING CHANGED                              INP317
C LOCATE RECORD TO BE CHANGED AND BRANCH                                INP318
C                                                                       INP319
 1208 IF(INDAT.NE.0) GO TO 12081                                        INP320
      READ(INTAPE,31)  ((DATAT(I,J),J=1,10),I=1,IRMAX)                  INP321
      REWIND INTAPE                                                     INP322
      INDAT=1                                                           INP323
12081 DO 1290 I=1,IRMAX                                                 INP324
      IROW=I                                                            INP325
      IF((DATN(1).EQ.DATAT(IROW,1)).AND.(DATN(2).EQ.DATAT(IROW,2)))     INP326
     1 GO TO 1205                                                       INP327
      IF(DATAT(IROW,2).EQ.TEST(9)) GO TO 9017                           INP328
 1290 CONTINUE                                                          INP329
 1205 DO 12051 J=1,10                                                   INP330
12051 DATA(J)=DATAT(IROW,J)                                             INP331
      DO 1206 I=1,5                                                     INP332
      IF(DATN(2).EQ.TEST(I)) GO TO (1206,1210,1220,1230,1240),I         INP333
 1206 CONTINUE                                                          INP334
C                                                                       INP335
C GET HERE IF ANC CARD READ                                             INP336
C                                                                       INP337
 1210 IF(DATA(3).NE.DATN(3)) GO TO 9017                                 INP338
      CALL SWTCH                                                        INP339
      INDEX=DATA(3)                                                     INP340
      GO TO 22                                                          INP341
C                                                                       INP342
C GET HERE IF DJNC CARD READ                                            INP343
C                                                                       INP344
 1220 DO 1222 I=3,5                                                     INP345
      IF(DATA(I).NE.DATN(I)) GO TO 9017                                 INP346
 1222 CONTINUE                                                          INP347
      CALL SWTCH                                                        INP348
      IF((DATA(7).LT.0.).OR.(DATA(8).LT.0.)) GO TO 9001                 INP349
      GO TO 8000                                                        INP350
C                                                                       INP351
C GET HERE IF DCAB CARD READ                                            INP352
C                                                                       INP353
```

```
 1230 IF((DATA(3).NE.DATN(3)).OR.(DATA(5).NE.DATN(5))) GO TO 9017        INP354
      DO 1231 I=1,3,2                                                    INP355
      F=I                                                                INP356
      G=I+1                                                              INP357
      IF(((DATA(4).EQ.F).OR.(DATA(4).EQ.G)).AND.((DATN(4).EQ.F).OR.(DATNINP358
     1(4).EQ.G))) GO TO 1232                                             INP359
 1231 CONTINUE                                                           INP360
      GO TO 9017                                                         INP361
 1232 CALL SWTCH                                                         INP362
      IF( ((DATA(4).EQ.2.).OR.(DATA(4).EQ.4.)).AND.(DATA(9).NE.0.) )     INP363
     1 GO TO 9001                                                        INP364
      IF( (DATA(7).LT.0.).OR.(DATA(8).LT.0.)) GO TO 9001                 INP365
      IF( ((DATA(4).EQ.1.).OR.(DATA(4).EQ.3.)).AND.(DATA(9).LE.0.) )     INP366
     1GO TO 9001                                                         INP367
      IF( DATA(10).LT.0. ) GO TO 9001                                    INP368
      GO TO 8000                                                         INP369
C                                                                        INP370
C GET HERE IF CAB CARD READ                                              INP371
C                                                                        INP372
 1240 DO 1241 I=3,5                                                      INP373
      IF(DATA(I).NE.DATN(I)) GO TO 9017                                  INP374
 1241 CONTINUE                                                           INP375
      CALL SWTCH                                                         INP376
      EX=EXX                                                             INP377
      NSEG=NNSEG                                                         INP378
      INDEX=DATA(3)                                                      INP379
      IF( (DATA(7).LE.0.).OR.(DATA(8).LE.0.).OR.(DATA(9).LE.0.)          INP380
     1 .OR.(EX.LT.0.).OR.(DATA(10).LT.0.)) GO TO 9001                    INP381
      IF((DATA(10).EQ.0.).AND.(EX.NE.0.)) GO TO 9001                     INP382
      IF((DATA(10).NE.0.).AND.(EX.EQ.0.)) GO TO 9001                     INP383
      IF( (NSEG.LT.1).OR.(NSEG.GT.50) ) GO TO 9001                       INP384
      GO TO 51                                                           INP385
C                                                                        INP386
C GET HERE IF EOD CARD READ                                              INP387
C                                                                        INP388
 1260 IFEOD=IFEOD+1                                                      INP389
      IF(FATE.NE.0.) RETURN                                              INP390
      GO TO 501                                                          INP391
C                                                                        INP392
C GET HERE IF LUN CARD READ                                              INP393
C                                                                        INP394
   13 INTAPE=DATA(5)                                                     INP395
      IFLG=DATA(6)                                                       INP396
      IF((IFLG.LT.0).OR.(IFLG.GT.1)) GO TO 9001                          INP397
      ISAV1=DATA(3)                                                      INP398
      IF(IFLG.EQ.0) IREAD=DATA(3)                                        INP399
      IF(IFLG.EQ.1) IREAD=DATA(7)                                        INP400
      OFLG=DATA(8)                                                       INP401
      IF((OFLG.LT.0).OR.(OFLG.GT.2)) GO TO 9001                          INP402
      IF(OFLG.EQ.0) OUTAPE=DATA(4)                                       INP403
      IF(OFLG.NE.0) OUTAPE=DATA(9)                                       INP404
      IF((IPRNT.EQ.IREAD).OR.(IPRNT.EQ.INTAPE).OR.((OFLG.NE.0).AND.      INP405
     1(IPRNT.EQ.OUTAPE)).OR.(INTAPE.EQ.IREAD).OR.(INTAPE.EQ.OUTAPE).OR.  INP406
     2(IREAD.EQ.OUTAPE).OR.((IFLG.EQ.1).AND.(IREAD.EQ.ISAV1)))GO TO 9001INP407
      GO TO 1003                                                         INP408
   14 IF((IFEOD-NDATC).NE.1) GO TO 9018                                  INP409
      IF(OFLG.EQ.0) GO TO 141                                            INP410
      WRITE(OUTAPE,142) TEST(14)                                         INP411
  142 FORMAT(A4,I4,3E15.8)                                               INP412
```

```
  141 WRITE(IPRNT,140)
  140 FORMAT(1H1,18HANALYSIS COMPLETED)
      FATE=1.
      RETURN
C
C CHECK TO SEE IF SUSPENDED ARRAY SOURCE DECK COMPLETE
C
  500 IF((IFJNC.EQ.0).OR.(IFRHO.EQ.0).OR.(NANC.EQ.0)) GO TO 9007
  510 IF(FATE.EQ.0.)  GO TO 2000
      RETURN
C
C CHECK TO SEE IF PARAMETRIC STUDY SOURCE DECK COMPLETE
C
  501 IF((IVOPT.EQ.0).OR.(IVOPT.EQ.2)) GO TO 5101
      NZL=0
      IF(NVSEG.EQ.0) GO TO 9008
      IF(IFVEL.EQ.0) GO TO 549
C
C SORT VELOCITY PROFILE BY Z-COORDINATE
C
  550 DO 555 I=1,NVSEG
      K=I
      DO 555 J=K,NVSEG
      IF(ZVEL(I).LE.ZVEL(J)) GO TO 555
      TEMP=ZVEL(I)
      ZVEL(I)=ZVEL(J)
      ZVEL(J)=TEMP
      TEMP=VELZ(I)
      VELZ(I)=VELZ(J)
      VELZ(J)=TEMP
  555 CONTINUE
  549 INDEX=ANJUNC(1)
      ZANCM=PJUNC(3,INDEX)
      IF(NANC.EQ.1) GO TO 511
      DO 508 N=2,NANC
      INDEX=ANJUNC(N)
      IF(PJUNC(3,INDEX).LT.ZANCM) ZANCM=PJUNC(3,INDEX)
  508 CONTINUE
  511 DO 509 N=1,NVSEG
      IF(ZVEL(N).LE.ZANCM) NZL=NZL+1
  509 CONTINUE
      IF((NZL.EQ.0).OR.(NANG.EQ.0)) GO TO 9008
 5101 IF (NCOMP.EQ.0) GO TO 9008
      IF (INDAT.NE.0) GO TO 4000
  505 CONTINUE
      RETURN
C
C CHECK ON CONTINUITY OF CABLE NUMBERING AND COUNT CABLES
C
 2000 NCAB=ICAB(22)
      DO 2001 N=1,21
      NCAB=NCAB+ICAB(N)
      J=ICAB(N)-ICAB(N+1)
      IF (J.LT.0) GO TO 9009
 2001 CONTINUE
      IF (NCAB.EQ.0) GO TO 9009
C
C CHECK ON CONTINUITY OF JUNCTION NUMBERING AND COUNT JUNCTIONS
C
```

```
 2002 NJUNC=ICHECK(44)
      DO 2003 N=1,43
      NJUNC=NJUNC+ICHECK(N)
      J=ICHECK(N)-ICHECK(N+1)
      IF (J.LT.0) GO TO 9010
 2003 CONTINUE
C
C CHECK ON CONTINUITY OF DEVICE NUMBERING AND COUNT DEVICES
C
 2004 NDEV=IDEV(1000)
      DO 2005 N=1,999
      NDEV=NDEV+IDEV(N)
      J=IDEV(N)-IDEV(N+1)
      IF (J.LT.0) GO TO 9011
 2005 CONTINUE
 2007 IF (FATE.EQ.0.) GO TO 3000
      RETURN
C
C GET HERE IF ARRAY NUMBERED CORRECTLY
C CHECK TO SEE IF NIR CONSISTENT
C
 3000 NIRC=NCAB+NANC-NOJUNC
      IF (NIR.NE.NIRC) GO TO 9013
 3001 IF (FATE.EQ.0.) GO TO 4000
      RETURN
C
C GET HERE TO MAKE FINAL CHECK ON INTAPE
C
 4000 I=1
 4009 DO 4001J=1,10
 4001 DATA(J)=DATAT(I,J)
      I=I+1
      IF (DATA(2).EQ.TEST(1)) GO TO 4002
      IF (DATA(2).EQ.TEST(3)) GO TO 4003
      IF (DATA(2).EQ.TEST(4)) GO TO 4004
      IF (DATA(2).EQ. TEST(5)) GO TO 4005
      IF (DATA(2).EQ.TEST(9)) GO TO 4006
      GO TO 4009
C
C GET HERE FOR IR
C
 4002 ID1=DATA(3)
      ID2=DATA(4)
      IF((ID2.GT.NOJUNC).OR.(ID1.LE.NOJUNC).OR.(ID1.GT.NJUNC))GO TO 9014
      GO TO 4009
C
C GET HERE FOR DJNC
C
 4003 ID=DATA(3)
      IF(ID.GT.NJUNC) GO TO 9014
      GO TO 4009
C
C GET HERE FOR DCAB
C
 4004 ID=DATA(3)
      IF (ID.GT.NCAB) GO TO 9014
      RL=H(ID)*(NNODE(ID)-1)
      IF (DATA(10).GE.RL) GO TO 9014
      GO TO 4009
```

```
C
C GET HERE FOR CAB
C
 4005 ID=DATA(4)
      IF(ID.GT.NJUNC) GO TO 9014
      GO TO 4009
C
C GET HERE FOR EOD
C
 4006 WRITE(INTAPE,31) ((DATAT(I,J),J=1,10),I=1,IRMAX)
   31 FORMAT(F4.0,A4,8E15.8)
      REWIND INTAPE
      IF(NDATC.NE.0) RETURN
      IF (FATE.EQ.0.) GO TO 5000
      RETURN
C
C GET HERE IF ALL OK AND CALCULATE PATH
C K IS CABLE COUNTER
C
 5000 K=0
C
C LOOP=1 LOOKING FOR CABLES LEAVING ANCHORS
C
      LOOP=1
C
C JMINP REMEMBERS FIRST VALUE OF K ON A LEVEL OF TREE
C
      JMINP=1
C
C JMAX REMEMBERS NUMBER OF CABLES ON A LEVEL OF TOPOGRAPHIC TREE
C
      JMAX=NANC
      IF(LOOP.EQ.1) GO TO 5002
 5001 JMAX=K
      IF ((LOOP.EQ.1).AND.(K.NE.1)) GO TO 9015
      IF ((LOOP.EQ.2).AND.(JMIN.EQ.JMINP)) GO TO 9015
      IF (K.EQ.NCAB) GO TO 5008
      LOOP=2
 5002 JMIN=JMINP
      DO 5009 J=JMIN,JMAX
C
C LOOKING FOR CABLES LEAVING A JUNCTION
C
      DO 5007 N=1,NCAB
      GO TO (5003,5004),LOOP
 5003 IF(ZJUNC(N).EQ.ANJUNC(J)) GO TO 5005
      GO TO 5007
 5004 IPATHJ=PATH(J)
      IF(ZJUNC(N).EQ.LJUNC(IPATHJ)) GO TO 5005
      GO TO 5007
C
C GET HERE IF CABLE N STARTS AT JUNCTION M
C
 5005 K=K+1
      PATH(K)=N
      GO TO (5007,5006),LOOP
C
C REMEMBER HERE FIRST VALUE OF K ON TREE LEVEL
C
```

```
 5006 IF(JMAX.EQ.(K-1)) JMINP=K                                         INP590
 5007 CONTINUE                                                          INP591
 5009 CONTINUE                                                          INP592
      GO TO 5001                                                        INP593
 5008 CONTINUE                                                          INP594
      IF(FATE.NE.0.) RETURN                                             INP595
      WRITE(IPRNT,5010)                                                 INP596
 5010 FORMAT(///,5X,18HNO ERRORS DETECTED)                              INP597
      GO TO 1003                                                        INP598
C                                                                       INP599
C PUT DATA INTO DATA ARRAY                                              INP600
C                                                                       INP601
 8000 IF(IFEOD.NE.0) GO TO 8003                                         INP602
      IF(((DATA(2).EQ.TEST(3)).OR.(DATA(2).EQ.TEST(4)))                 INP603
     1.AND.(DATA(5).NE.0.)) GO TO 8001                                  INP604
      GO TO 8003                                                        INP605
 8001 ID=DATA(5)                                                        INP606
      DO 8002 J=1,10                                                    INP607
      DATAT(IROW,J)=DATAT(ID,J)                                         INP608
 8002 DATAT(ID,J)=DATA(J)                                               INP609
      GO TO 8005                                                        INP610
 8003 DO 8004 J=1,10                                                    INP611
 8004 DATAT(IROW,J)=DATA(J)                                             INP612
      IF(IFEOD.NE.0) GO TO 1201                                         INP613
 8005 IROW=IROW+1                                                       INP614
      IF(IROW.LE.2150) GO TO 1003                                       INP615
      WRITE(IPRNT,8006)                                                 INP616
 8006 FORMAT(6X,2H17,18X,45HCOMMON/B1/ BOUND EXCEEDED.  SEE USERS MANUALINP617
     1.)                                                                INP618
      GO TO 1003                                                        INP619
C                                                                       INP620
C THIS SECTION GENERATES ALL ERROR MESSAGES                             INP621
C                                                                       INP622
 9116 FATE=1.                                                           INP623
      WRITE(IPRNT,9500) IER,DATA(1),DATA(2)                             INP624
 9500 FORMAT(6X,I2,4X,F4.0,3X,A4)                                       INP625
      IF(IER.EQ.12) GO TO 4009                                          INP626
      IF(IER.EQ.16) RETURN                                              INP627
      IF(NDATC.EQ.0) GO TO 1003                                         INP628
      GO TO 1201                                                        INP629
 9000 IER=0                                                             INP630
      GO TO 9116                                                        INP631
 9001 IER=1                                                             INP632
      GO TO 9116                                                        INP633
 9002 IER=2                                                             INP634
      GO TO 9116                                                        INP635
 9003 IER=3                                                             INP636
      GO TO 9116                                                        INP637
 9004 IER=4                                                             INP638
      GO TO 9116                                                        INP639
 9005 IER=5                                                             INP640
      GO TO 9116                                                        INP641
 9006 IER=6                                                             INP642
      GO TO 9116                                                        INP643
 9007 IER =7                                                            INP644
      WRITE(IPRNT,9501) IER,IFJNC,IFRHO,NANC                            INP645
 9501 FORMAT(6X,I2,18X,5I3)                                             INP646
      FATE=1                                                            INP647
      GO TO 510                                                         INP648
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```
9008 IER=14
     FATE=1
     WRITE(IPRNT,9501) IER,NCOMP,IVOPT,NVSEG,NZL,NANG
     GO TO 505
9009 IER=8
     FATE=1
     WRITE(IPRNT,9502) IER,(ICAB(I),I=1,22)
     GO TO 2002
9010 IER=9
     FATE=1
     WRITE(IPRNT,9502) IER,(ICHECK(I),I=1,44)
9502 FORMAT(6X,I2,18X,44I2)
     GO TO 2004
9011 IER=10
     FATE=1
     WRITE(IPRNT,9504) IER,(IDEV(I),I=1,1000)
9504 FORMAT(6X,I2,12X,100I1,9(/,20X,100I1))
     GO TO 2007
9013 IER=11
     FATE=1
     WRITE(IPRNT,9501) IER,NCAB,NANC,NOJUNC,NIRC,NIR
     GO TO 3001
9014 IER=12
     GO TO 9116
9015 IER=13
     FATE=1
     WRITE(IPRNT,9507) IER
     GO TO 5008
9507 FORMAT(6X,I2,18X,94HIMPROPER ARRAY REDUCTION OR JUNCTION NUMBERING
    1.  CHECK TREE REPRESENTATION OF ARRAY (SEE ARRAY,/,20X,83HREDUCTIO
    2N SECTION OF USERS MANUAL) AGAINST JUNCTION NUMBERING ON ANC AND C
    3AB CARDS.)
9017 DATA(1)=DATN(1)
     DATA(2)=DATN(2)
9117 IER=15
     GO TO 9116
9018 IER=16
     IF(IFEOD.EQ.0) GO TO 9116
     DATA(1)=DATN(1)
     DATA(2)=DATN(2)
     GO TO 9116
     END
```

```
      SUBROUTINE PHSOUT                                                 PHS001
C                                                                       PHS002
C THIS ROUTINE GENERATES INFORMATION CONCERNING THE PHYSICAL            PHS003
C CHARACTERISTICS OF THE STRUCTURAL CABLE ARRAY                         PHS004
C                                                                       PHS005
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,PHS006
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        PHS007
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           PHS008
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, PHS009
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               PHS010
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    PHS011
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       PHS012
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44PHS013
     1)                                                                 PHS014
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  PHS015
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            PHS016
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) PHS017
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      PHS018
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       PHS019
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         PHS020
      DIMENSION ICHECK(44)                                              PHS021
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          PHS022
      INTEGER PATH                                                      PHS023
      REAL IR,IRS                                                       PHS024
      WRITE(IPRNT,25)                                                   PHS025
   25 FORMAT(1H1, 54HPHYSICAL CHARACTERISTICS OF THE STRUCTURAL CABLE ARPHS026
     1RAY)                                                              PHS027
      WRITE(IPRNT,1) NANC                                               PHS028
    1 FORMAT(///,19H NO. OF ANCHORS IS ,I2,//5X,64HJUNCTION NO.    X-COOPHS029
     1RDINATE       Y-COORDINATE       Z-COORDINATE)                   PHS030
      DO 2 N=1,NANC                                                     PHS031
      INDEX=ANJUNC(N)                                                   PHS032
    2 WRITE(IPRNT,3) INDEX,(PJUNC(I,INDEX),I=1,3)                       PHS033
    3 FORMAT(10X,I2,4X,3(5X,F10.2,3X))                                  PHS034
      NOJUNC=NCAB+NANC-NIR                                              PHS035
      WRITE(IPRNT,4) NOJUNC                                             PHS036
    4 FORMAT(//,39H NO. OF JUNCTIONS IN ORIGINAL ARRAY IS ,I2)          PHS037
      WRITE(IPRNT,5) NIR                                                PHS038
    5 FORMAT(//,39H NO. OF CUTS MADE IN ORIGINAL ARRAY IS ,I2//1H ,2(5X,PHS039
     112HJUNCTION NO.),/,8X,6HOF CUT,6X,17HAT WHICH CUT MADE)           PHS040
      IF(NIR.EQ.0) GO TO 30                                             PHS041
      DO 6 N=1,NIR                                                      PHS042
    6 WRITE(IPRNT,7) IRJUNC(N),ERJUNC(N)                                PHS043
    7 FORMAT(10X,I2,15X,I2)                                             PHS044
   30 WRITE(IPRNT,8) NCAB                                               PHS045
    8 FORMAT(//,18H NO. OF CABLES IS ,I2,//5X,16HCABLE  S=0   S=L,43X,4HPHS046
     1DRAG,19X,22HCONSTITUTIVE    NO. OF,/,6X,3HNO.,1X,2(2X,4HJUNC),3X, PHS047
     26HLENGTH,03X,8HDIAMETER,3X,13HWEIGHT/LENGTH,3X,11HCOEFFICIENT,3X, PHS048
     38HRIGIDITY,6X,8HEXPONENT,5X,8HELEMENTS)                           PHS049
      DO 9 N=1,NCAB                                                     PHS050
      NSEG=NNODE(N)-1                                                   PHS051
      RL=H(N)*NSEG                                                      PHS052
    9 WRITE(IPRNT,10) N,ZJUNC(N),LJUNC(N),RL,DCAB(N),WCAB(N),CDCAB(N),  PHS053
     1ECICAB(N),EXPCAB(N),NSEG                                          PHS054
   10 FORMAT(6X,I2,5X,I2,4X,I2,1X,F9.1,3(3X,F7.3,4X),   F10.0,7X,F6.3,  PHS055
     19X,I2 )                                                           PHS056
      WRITE(IPRNT,11)                                                   PHS057
   11 FORMAT(//,63H PROPERTIES OF THE DEVICES LOCATED AT JUNCTIONS ARE APHS058
     1S FOLLOWS ,//6X,6HDEVICE,10X,6HDEVICE,9X,11HDEVICE DRAG,4X,14HDEVIPHS059
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```
   2CE FRONTAL,/,5X,9HJUNC. NO.,8X,6HWEIGHT,9X,11HCOEFFICIENT,9X,      PHS060
   34HAREA)                                                            PHS061
 12 READ(INTAPE,13) (DATA(I),I=1,10)                                   PHS062
 13 FORMAT(F4.0,A4,8E15.8)                                             PHS063
    IF(DATA(2).EQ.TEST(3)) GO TO 14                                    PHS064
    IF(DATA(2).EQ.TEST(9)) GO TO 16                                    PHS065
    GO TO 12                                                           PHS066
 14 JUNC=DATA(3)                                                       PHS067
    WRITE(IPRNT,15) JUNC,(DATA(K),K=6,8)                               PHS068
 15 FORMAT(8X,I2,9X,F10.2,6X,F10.3,6X,F10.2)                           PHS069
    GO TO 12                                                           PHS070
 16 REWIND INTAPE                                                      PHS071
    WRITE(IPRNT,24) NDEV                                               PHS072
 24 FORMAT(//,32H TOTAL NO. OF INDEXED DEVICES IS,I4)                  PHS073
    WRITE(IPRNT,17) IVOPT                                              PHS074
 17 FORMAT(//,25H CURRENT FIELD OPTION IS ,I1)                         PHS075
    IV=IVOPT+1                                                         PHS076
    GO TO (22,18,22),IV                                                PHS077
 18 WRITE(IPRNT,19)                                                    PHS078
 19 FORMAT(/7X12HZ-COORDINATE,6X,11HVELOCITY OF,/,8X,10HOF CURRENT,7X,PHS079
   112HCURRENT AT Z)                                                   PHS080
    DO 20 N=1,NVSEG                                                    PHS081
 20 WRITE(IPRNT,21) ZVEL(N),VELZ(N)                                    PHS082
 21 FORMAT(2X,5X,F10.2,10X,F7.2)                                       PHS083
 22 WRITE(IPRNT,23) COMPD                                              PHS084
 23 FORMAT(//,38H ACCURACY REQUIRED IN CALCULATIONS IS ,F6.2)          PHS085
    IF(OFLG.NE.0) WRITE(IPRNT,111) NDATC                               PHS086
111 FORMAT(//,30H DEVICE LOCATION OUTPUT RECORD,I3,21H REFERS TO THIS PHS087
   1ARRAY  )                                                           PHS088
    RETURN                                                             PHS089
    END                                                                PHS090
```

```
      SUBROUTINE STROUT                                                 STR001
C                                                                       STR002
C THIS ROUTINE GENERATES THE ARRAY STRUCTURAL OUTPUT                    STR003
C                                                                       STR004
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,STR005
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        STR006
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           STR007
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, STR008
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               STR009
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    STR010
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       STR011
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44STR012
     1)                                                                 STR013
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  STR014
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            STR015
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) STR016
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      STR017
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       STR018
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         STR019
      DIMENSION ICHECK(44)                                              STR020
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          STR021
      INTEGER PATH                                                      STR022
      REAL IR,IRS                                                       STR023
      DIMENSION TEMP1(3),TEMP2(3),TEMP3(3),DISP(3),PSPACE(3)            STR024
      DIMENSION A(3),B(3),D(3),U(3),V(3),W(3),C(4),RQ(3),RI(3)          STR025
      NOJUNC=NCAB+NANC-NIR                                              STR026
      JUM=JUMP+1                                                        STR027
      GO TO(100,200),JUM                                                STR028
  100 WRITE(IPRNT,1002)                                                 STR029
 1002 FORMAT(1H1,33HARRAY EQUILIBRIUM WITH NO CURRENT ///)              STR030
      GO TO 300                                                         STR031
  200 WRITE(IPRNT,1001) THETA                                           STR032
 1001 FORMAT(1H1,35HARRAY EQUILIBRIUM WITH CURRENT FROM,F8.2, 9H DEGREESSTR033
     1 ///)                                                             STR034
C                                                                       STR035
C GENERATE ANCHOR HEADERS                                               STR036
C                                                                       STR037
  300 WRITE(IPRNT,1003)                                                 STR038
 1003 FORMAT(1H ,13HARRAY ANCHORS    )                                  STR039
      WRITE(IPRNT,10031)                                                STR040
10031 FORMAT(1H ,13H----- -------/)                                     STR041
      WRITE(IPRNT,1004)                                                 STR042
 1004 FORMAT(1H ,  32HJUNC. NO.  CABLE AT   TENSION AT    ,14X,26HFORCE CSTR043
     1OMPONENTS AT ANCHOR,13X,16HCABLE ANGLES WRT)                      STR044
      WRITE(IPRNT,1005)                                                 STR045
 1005 FORMAT(1H ,30HOF ANCHOR   ANCHOR      ANCHOR8X,6HX-COMP,6X,6HY-COMSTR046
     1P,6X,6HZ-COMP,3X,9HHOR.-COMP,5X,16HX-AXIS  XY-PLANE)              STR047
C                                                                       STR048
C THIS SECTION CALCULATES FORCES AND ANGLES AT ANCHORS                  STR049
C                                                                       STR050
      DO 401 J1=1,NANC                                                  STR051
      J3=0                                                              STR052
  402 J2=1                                                              STR053
  404 IF (ANJUNC(J1).EQ.ZJUNC(J2)) GO TO 403                            STR054
  414 J2=J2+1                                                           STR055
      IF(J2.LE.NCAB) GO TO 404                                          STR056
      IF(NIR.EQ.0) GO TO 401                                            STR057
  412 J3=1                                                              STR058
  411 IF(ANJUNC(J1).EQ.ERJUNC(J3)) GO TO 405                            STR059
```

```
  413 J3=J3+1                                                           STR060
      IF(J3.LE.NIR)    GO TO 411                                        STR061
      GO TO 401                                                         STR062
  405 INDEX=IRJUNC(J3)                                                  STR063
      DO 406 J4=1,NCAB                                                  STR064
      IF(INDEX.EQ.LJUNC(J4)) GO TO 407                                  STR065
  406 CONTINUE                                                          STR066
      GO TO 401                                                         STR067
  407 MM=J4                                                             STR068
      MX=NNODE(J4)                                                      STR069
      T=TCAB(MX,MM)                                                     STR070
      RX=-RCAB(1,MX,MM)                                                 STR071
      RY=-RCAB(2,MX,MM)                                                 STR072
      RZ=-RCAB(3,MX,MM)                                                 STR073
      GO TO 408                                                         STR074
  403 MM=J2                                                             STR075
      T=TCAB(1,MM)                                                      STR076
      RX=RCAB(1,1,MM)                                                   STR077
      RY=RCAB(2,1,MM)                                                   STR078
      RZ=RCAB(3,1,MM)                                                   STR079
  408 RH=SQRT(RX**2 + RY**2)                                            STR080
      A1=ASIN(RY/RH)/PIP                                                STR081
      A2=ASIN(RZ/T)/PIP                                                 STR082
      IF((RX.LT.0.).AND.(RY.GE.0.)) A1=180.-A1                          STR083
      IF((RX.LT.0.).AND.(RY.LT.0.)) A1=-180.-A1                         STR084
      WRITE(IPRNT,1006) ANJUNC(J1),MM,T,RX,RY,RZ,RH,A1,A2               STR085
 1006 FORMAT(1H ,3X,I2,9X,I2,5X,F10.1,3X,4(F10.1,2X),2(2X,F7.2,1X))     STR086
      IF(J2.LT.NCAB) GO TO 414                                          STR087
      IF( (J2.EQ.NCAB).AND.(J3.EQ.0) ) GO TO 412                        STR088
      IF( (J2.EQ.NCAB).AND.(J3.NE.NJUNC) ) GO TO 413                    STR089
  401 CONTINUE                                                          STR090
C                                                                       STR091
C GENERATE CABLE HEADERS                                                STR092
C                                                                       STR093
      WRITE(IPRNT,2000)                                                 STR094
 2000 FORMAT(1H ,///1H ,12HARRAY CABLES )                               STR095
      WRITE(IPRNT,2001)                                                 STR096
 2001 FORMAT(1H ,12H----- ------/)                                       STR097
      WRITE(IPRNT,2002)                                                 STR098
 2002 FORMAT(1H ,120HCABLE  MAXIMUM  S-COORD  MINIMUM  S-COORD  MAXIMUM STR099
     1 S-COORD     LOCATION OF THIS POINT     NO CURRENT LOC. OF THIS POSTR100
     2INT )                                                             STR101
      WRITE(IPRNT,2003)                                                 STR102
 2003 FORMAT(1H ,120H NO.   TENSION    OF     TENSION    OF      DISP.  STR103
     1   OF      X-COORD   Y-COORD   Z-COORD   X-COORD   Y-COORD   Z-COOSTR104
     2RD  )                                                             STR105
C                                                                       STR106
C THIS SECTION CALCULATES MAXIMUM AND MINIMUM CABLE TENSIONS            STR107
C AND MAXIMUM CABLE DISPLACEMENTS FROM NO CURRENT LOCATION              STR108
C BY EXTRAPOLATION BETWEEN CABLE NODES                                  STR109
C                                                                       STR110
C INITIALIZE EXTREMA                                                    STR111
C                                                                       STR112
      DO 799 NN=1,NCAB                                                  STR113
      N=NN                                                              STR114
      TMAX=TCAB(1,N)                                                    STR115
      STMAX=0.                                                          STR116
      TMIN=TMAX                                                         STR117
      STMIN=0.                                                          STR118
```

```
      GO TO (802,801),JUM
  801 DMAX=0.
      DO 700 I=1,3
  700 DMAX=DMAX+(PCAB(I,1,N)-PCABO(I,1,N))**2
      DMAX=SQRT(DMAX)
      SDMAX=0.
  802 MX=NNODE(N)-1
      DO 750 MM=1,MX
      M=MM
      M1=MM+1
C
C CALCULATE EXTRAPOLATION QUANTITIES
C
      RR=0.
      RD=0.
      DD=0.
      DO 701 I=1,3
      D(I)=(RCAB(I,M1,N)-RCAB(I,M,N))/H(N)
      GO TO  (804,803) ,JUM
  803 A(I)=EXCAB(M,N)*RCAB(I,M,N)/TCAB(M,N)
      B(I)=(EXCAB(M1,N)*RCAB(I,M1,N)/TCAB(M1,N)-A(I))/H(N)
      U(I)=PCAB(I,M,N)-PCABO(I,M,N)
  804 RR=RR+RCAB(I,M,N)*RCAB(I,M,N)
      RD=RD+RCAB(I,M,N)*D(I)
  701 DD=DD+D(I)*D(I)
      GO TO (806,805),JUM
  805 DO 702 I=1,3
      TEMP1(I)=RCAB(I,M,N)
      TEMP2(I)=RCAB(I,M1,N)
      RCAB(I,M,N)=RCABO(I,M,N)
  702 RCAB(I,M1,N)=RCABO(I,M1,N)
      UU=0.
      UV=0.
      UVW=0.
      VW=0.
      WW=0.
      DO 703 I=1,3
      V(I)=EXCAB(M,N)*RCAB(I,M,N)/TCAB(M,N)
      W(I)=(EXCAB(M1,N)*RCAB(I,M1,N)/TCAB(M1,N)-V(I))/H(N)
      V(I)=A(I)-V(I)
      W(I)=(B(I)-W(I))/2.
      UU= UU+U(I)*U(I)
      UV=UV+U(I)*V(I)
      UVW=UVW+2.*U(I)*W(I)+V(I)*V(I)
      VW=VW+V(I)*W(I)
  703 WW=WW+W(I)*W(I)
      DO 704 I=1,3
      RCAB(I,M,N)=TEMP1(I)
  704 RCAB(I,M1,N)=TEMP2(I)
  806 C(4)=0.
      C(3)=0.
      C(2)=DD
      C(1)=RD
      CALL RPOLY(C,RQ,RI)
C
C CALCULATE TENSION EXTREMA IN SEGMENT
C
      JTIME=0
      DO 719 I=1,3
```

```
      IF( RI(I).NE.0.) GO TO 719                                        STR178
      IF((RQ(I).LE.0.).OR.(RQ(I).GE.H(N))) GO TO 719                    STR179
      SIG=RQ(I)                                                         STR180
  710 TE=SQRT(RR+2.*RD*SIG+DD*SIG**2)                                   STR181
      IF(TE.GT.TMAX)    GO TO 712                                       STR182
      IF(TE.LT.TMIN) GO TO 713                                          STR183
  711 IF(JTIME.EQ.0) GO TO 719                                          STR184
      GO TO 715                                                         STR185
  712 TMAX=TE                                                           STR186
      STMAX=H(N)*(M-1)+SIG                                              STR187
      GO TO 711                                                         STR188
  713 TMIN=TE                                                           STR189
      STMIN=H(N)*(M-1)+SIG                                              STR190
      GO TO 711                                                         STR191
  719 CONTINUE                                                          STR192
      JTIME=1                                                           STR193
      SIG=H(N)                                                          STR194
      GO TO 710                                                         STR195
  715 GO TO(750,716),JUM                                                STR196
  716 C(4)=2.*WW                                                        STR197
      C(3)=3.*VW                                                        STR198
      C(2)=UVW                                                          STR199
      C(1)=1                                                            STR200
      CALL RPOLY(C,RQ,RI)                                               STR201
C                                                                       STR202
C CALCULATE MAXIMUM DISPLACEMENT IN SEGMENT                             STR203
C                                                                       STR204
      JTIME=0                                                           STR205
      DO 729 I=1,3                                                      STR206
      IF (RI(I).NE.0.) GO TO 729                                        STR207
      IF((RQ(I).LE.0.).OR.(RQ(I).GE.H(N))) GO TO 729                    STR208
      SIG=RQ(I)                                                         STR209
  720 DE=SQRT(UU+2.*UV*SIG+UVW*SIG**2+2.*VW*SIG**3+WW*SIG**4)           STR210
      IF(DE.GT.DMAX) GO TO 722                                          STR211
  721 IF(JTIME.EQ.0) GO TO 729                                          STR212
      GO TO 750                                                         STR213
  722 DMAX=DE                                                           STR214
      SDMAX= H(N)*(M-1)+SIG                                             STR215
      GO TO 721                                                         STR216
  729 CONTINUE                                                          STR217
      JTIME=1                                                           STR218
      SIG=H(N)                                                          STR219
      GO TO 720                                                         STR220
  750 CONTINUE                                                          STR221
C                                                                       STR222
C EXTREMA ALONG A CABLE NOW DETERMINED                                  STR223
C CALCULATE FINAL AND INITIAL COORDINATES OF MAXIMALLY DISPLACED POINT  STR224
C                                                                       STR225
      GO TO (810,809),JUM                                               STR226
  809 RL=H(N)*MX                                                        STR227
      IF(SDMAX.LT.RL) GO TO 760                                         STR228
      K=LJUNC(N)                                                        STR229
      DO 751 I=1,3                                                      STR230
      A(I)=PJUNC(I,K)                                                   STR231
  751 B(I)=PJUNCO(I,K)                                                  STR232
      GO TO 780                                                         STR233
  760 DATA(2)=TEST(4)                                                   STR234
      DATA(3)=N                                                         STR235
      DATA(10)=SDMAX                                                    STR236
```

```
      J=(SDMAX/H(N))+1
      J1=J+1
      DO 761 II=1,3
      I=II
  761 A(I)=SPACE(I)
      DO 762 I=1,3
      TEMP1(I)=RCAB(I,J,N)
      TEMP2(I)=RCAB(I,J1,N)
      TEMP3(I)=PCAB(I,J,N)
      RCAB(I,J,N)=RCABO(I,J,N)
      RCAB(I,J1,N)=RCABO(I,J1,N)
  762 PCAB(I,J,N)=PCABO(I,J,N)
      DO 763 II=1,3
      I=II
  763 B(I)=SPACE(I)
      DO 764 I=1,3
      RCAB(I,J,N)=TEMP1(I)
      RCAB(I,J1,N)=TEMP2(I)
  764 PCAB(I,J,N)=TEMP3(I)
  780 CONTINUE
      WRITE(IPRNT,781)N,TMAX,STMAX,TMIN,STMIN,DMAX,SDMAX,(A(I),I=1,3),
     1 (B(I),I=1,3)
      GO TO 799
  810 WRITE(IPRNT,781)N,TMAX,STMAX,TMIN,STMIN
  781 FORMAT(1H ,I4,1X,6F9.1,6F10.1)
  799 CONTINUE
C
C GENERATE JUNCTION HEADERS
C
      WRITE(IPRNT,1007)
 1007 FORMAT(1H ///1H ,15HARRAY JUNCTIONS)
      WRITE(IPRNT,10071)
10071 FORMAT(1H ,15H----- --------- / )
      WRITE(IPRNT,1008)
 1008 FORMAT(1H ,27HJUNC.  CABLE AT  TENSION AT,3X,16HCABLE ANGLES WRT,
     110X,17HJUNCTION LOCATION,10X,33HDISPLACEMENT FROM NO CURRENT LOC.)
      WRITE(IPRNT,1009)
 1009 FORMAT(1H ,15H NO.   JUNCTION3X,8HJUNCTION4X,16HX-AXIS  XY-PLANE,
     168H    X-COORD    Y-COORD    Z-COORD      X-DISP     Y-DISP     Z-
     2DISP  )
C
C THIS SECTION CALCULATES JUNCTION FORCES, LOCATIONS AND DISPLACEMENTS
C
      IF=0
      DO 601 J1=1,NOJUNC
      DO 605 K=1,NANC
      IF(ANJUNC(K).EQ.J1) GO TO 601
  605 CONTINUE
      GO TO (602,603),JUM
  603 DO 604 J2=1,3
  604 DISP(J2)=PJUNC(J2,J1)-PJUNCO(J2,J1)
  602 J6=1
  608 IF(J1.EQ.ZJUNC(J6)) GO TO 606
  615 IF(J1.EQ.LJUNC(J6)) GO TO 607
  617 J6=J6+1
      IF(J6.LE.NCAB) GO TO 608
      IF(NIR.EQ.0) GO TO 601
      J7=1
  609 IF(J1.EQ.ERJUNC(J7)) GO TO 610
```

```
  616 J7=J7+1
      IF(J7.LE.NIR)   GO TO 609
      GO TO 601
  606 MM=J6
      T=TCAB(1,MM)
      RX=RCAB(3,1,MM)
      RY=RCAB(2,1,MM)
      RZ=RCAB(3,1,MM)
      GO TO 611
  610 INDEX=IRJUNC(J7)
      DO 612 J8=1,NCAB
      IF(INDEX.EQ.LJUNC(J8))GO TO 613
  612 CONTINUE
  613 MM=J8
      GO TO 614
  607 MM=J6
  614 MX=NNODE(MM)
      T=TCAB(MX,MM)
      RX=-RCAB(1,MX,MM)
      RY=-RCAB(2,MX,MM)
      RZ=-RCAB(3,MX,MM)
  611 RH=SQRT(RX**2+RY**2)
      A1=ASIN(RY/RH)/PIP
      A2=ASIN(RZ/T)/PIP
      IF((RX.LT.0.).AND.(RY.GE.0.)) A1=180.-A1
      IF((RX.LT.0.).AND.(RY.LT.0.)) A1=-180.-A1
      IF((IF.EQ.0).AND.(JUM.EQ.1)) WRITE(IPRNT,620) J1,MM,T,A1,A2,(PJUNC
     1(K,J1),K=1,3)
      IF((IF.EQ.0).AND.(JUM.EQ.2)) WRITE(IPRNT,620) J1,MM,T,A1,A2,(PJUNC
     1(K,J1),K=1,3) ,(DISP(I),I=1,3)
      IF(IF.EQ.1) WRITE(IPRNT,620) J1,MM,T,A1,A2
      IF=1
  620 FORMAT(1H ,I4,6X,I2,4X,F10.1,3X,F7.2,3X,F7.2,3(1X,F10.1),1X,3(1X,
     1F10.1))
      IF((J6.LT.NCAB).AND.(J1.EQ.ZJUNC(J6))) GO TO 615
      IF((J6.LT.NCAB).AND.(J1.EQ.LJUNC(J6))) GO TO 617
  601 IF=0
C
C GENERATE INDEXED DEVICE HEADERS
C
      WRITE(IPRNT,519 )
  519 FORMAT(1H ,///1H ,34HINDEXED DEVICES ALONG ARRAY CABLES  )
      WRITE(IPRNT,5191)
 5191 FORMAT(1H ,34H------- ------- -  -- --- - *       /)
      WRITE(IPRNT,520 )
  520 FORMAT(1H ,7HDEVICE ,5HCABLE,6X,1HS,7X,10HTENSION AT,13X,15HDEVICE
     1 LOCATION,12X,36H   DISPLACEMENT FROM NO CURRENT LOC. )
      WRITE(IPRNT,521 )
  521 FORMAT(1H ,109HINDEX   NO.   COORDINATE    DEVICE        X-COORD
     1  Y-COORD      Z-COORD          X-DISP      Y-DISP      Z-DISP)
C
C THIS SECTION CALCULATES TENSIONS AT INDEXED DEVICES,
C DEVICE LOCATIONS, AND DEVICE DISPLACEMENTS
C
      IF (NDEV.EQ.0) GO TO 511
      DO 510 N=1,NDEV
      READ (INTAPE,501) (DATA(I),I=1,10)
  501 FORMAT (I4,A4,8E15.8)
      IF (DATA(2).EQ.TEST(3)) GO TO 510
```

```
      K=DATA(3)                                                         STR355
      M=DATA(10)/H(K) + 1                                               STR356
      INDEX=DATA(5)                                                     STR357
      SIGMA=DATA(10)-(M-1)*H(K)                                         STR358
      TEN2=0.                                                           STR359
      DO 502 II=1,3                                                     STR360
      I=II                                                              STR361
      PSPACE(I)=SPACE(I)                                                STR362
  502 TEN2=TEN2+(RCAB(I,M,K)+(RCAB(I,M+1,K)-RCAB(I,M,K))*SIGMA/H(K))**2 STR363
      TEN=SQRT(TEN2)                                                    STR364
      GO TO (503,505),JUM                                               STR365
  503 WRITE (IPRNT,509) INDEX,K,DATA(10),TEN,(PSPACE(I),I=1,3)          STR366
      GO TO 510                                                         STR367
  505 DO 506 I=1,3                                                      STR368
      TEMP1(I)=RCAB(I,M,K)                                              STR369
      TEMP2(I)=RCAB(I,M+1,K)                                            STR370
      TEMP3(I)=PCAB(I,M,K)                                              STR371
      RCAB(I,M,K)=RCABO(I,M,K)                                          STR372
      RCAB(I,M+1,K)=RCABO(I,M+1,K)                                      STR373
  506 PCAB(I,M,K)=PCABO(I,M,K)                                          STR374
      DO 507 II=1,3                                                     STR375
      I=II                                                              STR376
  507 DISP(I)=PSPACE(I)-SPACE(I)                                        STR377
      DO 508 I=1,3                                                      STR378
      RCAB(I,M,K)=TEMP1(I)                                              STR379
      RCAB(I,M+1,K)=TEMP2(I)                                            STR380
  508 PCAB(I,M,K)=TEMP3(I)                                              STR381
      WRITE(IPRNT,509) INDEX,K,DATA(10),TEN,(PSPACE(I),I=1,3),          STR382
     1(DISP(I),I=1,3)                                                   STR383
  509 FORMAT(1H ,I4,4X,I2,4X,F9.1,3X,F9.1,1X,3(2X,F10.1),4X,3(1X,F10.1))STR384
  510 CONTINUE                                                          STR385
  511 REWIND INTAPE                                                     STR386
      RETURN                                                            STR387
      END                                                               STR388
```

```
      SUBROUTINE TAPOUT                                                 TAP001
C                                                                       TAP002
C THIS ROUTINE GENERATES THE TAPE OR CARDS GIVING                       TAP003
C THE LOCATIONS OF THE INDEXED DEVICES                                  TAP004
C                                                                       TAP005
      COMMON /B1/ FEJUNC,IR,DELTA1,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,TAP006
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        TAP007
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           TAP008
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, TAP009
     2OFLG,NI-,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               TAP010
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    TAP011
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       TAP012
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44TAP013
     1)                                                                 TAP014
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  TAP015
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            TAP016
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) TAP017
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      TAP018
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       TAP019
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         TAP020
      DIMENSION ICHECK(44)                                              TAP021
      DIMENSION PSPACE(3)                                               TAP022
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          TAP023
      INTEGER PATH                                                      TAP024
      REAL IR,IRS                                                       TAP025
      ID1=4H CUR                                                        TAP026
      ID2=4H DEV                                                        TAP027
      ID3=4H REC                                                        TAP028
    1 FORMAT(A4,I4,3F10.2)                                              TAP029
      JUM=JUMP+1                                                        TAP030
      GO TO (2,3) JUM                                                   TAP031
    2 WRITE(OUTAPE,1) ID3,NDATC                                         TAP032
      WRITE(OUTAPE,1) ID1,JUMP                                          TAP033
      GO TO 4                                                           TAP034
    3 WRITE(OUTAPE,1)ID1,JUMP,THETA                                     TAP035
    4 IF (NDEV.EQ.0) GO TO 8                                            TAP036
      DO 7 NN=1,NDEV                                                    TAP037
      READ(INTAPE,5) (DATA(K),K=1,10)                                   TAP038
    5 FORMAT(F4.0,A4,8E15.8)                                            TAP039
      INDEX=DATA(5)                                                     TAP040
C                                                                       TAP041
C CALCULATE LOCATION OF DEVICE IN SPACE                                 TAP042
C                                                                       TAP043
      DO 6 J=1,3                                                        TAP044
      I=J                                                               TAP045
    6 PSPACE(I)=SPACE(I)                                                TAP046
      WRITE(OUTAPE,1)ID2,INDEX,(PSPACE(I),I=1,3)                        TAP047
    7 CONTINUE                                                          TAP048
    8 CONTINUE                                                          TAP049
      REWIND +NTAPE                                                     TAP050
      RETURN                                                            TAP051
      END                                                               TAP052
```

```
      SUBROUTINE ERROR                                                  ERR001
C                                                                       ERR002
C THIS ROUTINE GENERATES A TYPE 18 ERROR MESSAGE                        ERR003
C GET HERE IF ALL IMAGINARY REACTIONS DO NOT CHANGE                     ERR004
C                                                                       ERR005
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,ERR006
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        ERR007
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           ERR008
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, ERR009
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               ERR010
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    ERR011
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       ERR012
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44ERR013
     1)                                                                 ERR014
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  ERR015
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            ERR016
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) ERR017
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      ERR018
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       ERR019
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         ERR020
      DIMENSION ICHECK(44)                                              ERR021
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          ERR022
      INTEGER PATH                                                      ERR023
      REAL IR,IRS                                                       ERR024
      E=E*10.                                                           ERR025
      WRITE(IPRNT,1)                                                    ERR026
    1 FORMAT(1H1,52H  TYPE 18 ERROR.  STRUCTURAL ANALYSIS NOT COMPLETED.ERR027
     1/60H  PRINTOUT GIVEN FOR DIAGNOSTIC PURPOSES.  SEE USERS MANUAL./)ERR028
      JUM=JUMP+1                                                        ERR029
      GO TO (4,6),JUM                                                   ERR030
    4 WRITE(IPRNT,5)                                                    ERR031
    5 FORMAT(5X,40HEXISTING CURRENT CONDITION IS NO CURRENT  /)         ERR032
      GO TO 8                                                           ERR033
    6 WRITE(IPRNT,7) THETA                                              ERR034
    7 FORMAT(5X,38HEXISTING CURRENT CONDITION IS THETA = ,F3.0/)        ERR035
    8 WRITE(IPRNT,9) E                                                  ERR036
    9 FORMAT(5X,35HBEST VALUE OF ACCURACY OBTAINED IS ,F6.2)            ERR037
      DO 2  N=1,NCAB                                                    ERR038
      NN=N                                                              ERR039
      WRITE(IPRNT,10) NN                                                ERR040
   10 FORMAT(//5X,29HTHE TENSIONS IN CABLE NUMBER ,I2,4H ARE,/)         ERR041
      L=NNODE(N)                                                        ERR042
      DO 2  M=1,L                                                       ERR043
      MM=M                                                              ERR044
      T=TCAB(MM,NN)                                                     ERR045
      S=H(NN)*(MM-1.)                                                   ERR046
    2 WRITE(IPRNT,3) T,S                                                ERR047
    3 FORMAT(7X,2HT=,F10.2,6H AT S=,F10.2)                              ERR048
      RETURN                                                            ERR049
      END                                                               ERR050
```

```
      SUBROUTINE RPOLY(C,RR,RI)
C
C THIS ROUTINE FINDS REAL ROOTS OF POLYNOMIAL EQUATIONS UP TO
C C(4)*(X**3) + C(3)*(X**2) + C(2)*X + C(1) = 0  FOR USE IN
C EVALUATING MAXIMUM CABLE DISPLACEMENTS AND TENSION EXTREMA
C
C REAL PARTS OF ROOTS ARE PLACED IN RR, IMAGINARY PARTS IN RI
C SINCE ONLY REAL ROOTS ARE OF INTEREST, ALL NON-REAL OR
C NON-EXISTING ROOTS RETURN RR=0 , RI=1
C
      DIMENSION C(4),RR(3),RI(3)
      IF(C(4).NE.0.) GO TO 30
      IF(C(3).NE.0.) GO TO 20
      IF(C(2).NE.0.) GO TO 10
C
C GET HERE IF EQUATION IDENTICALLY SATISFIED
C
  100 DO 1 I=1,3
      RR(I)=0.
    1 RI(I)=1.
      RETURN
C
C GET HERE IF EQUATION LINEAR
C
   10 RR(1)=-C(1)/C(2)
      RI(1)=0.
  200 DO 11 I=2,3
      RR(I)=0.
   11 RI(I)=1.
      RETURN
C
C GET HERE IF EQUATION QUADRATIC
C
   20 DISC=C(2)**2-4.*C(1)*C(3)
      IF(DISC.GE.0.) GO TO 21
      GO TO 100
   21 RR(I)=(-C(2)+SQRT(DISC))/(2.*C(3))
      RI(1)=0.
      RR(2)=(-C(2)-SQRT(DISC))/(2.*C(3))
      RI(2)=0.
      RR(3)=0.
      RI(3)=1.
      RETURN
C
C GET HERE IF EQUATION CUBIC
C
   30 P=C(3)/C(4)
      Q=C(2)/C(4)
      R=C(1)/C(4)
      A=(3.*Q-P**2)/3.
      B=(2.*P**3-9.*P*Q+27.*R)/27.
      DISC= (B**2)/4.+(A**3)/27.
      IF(DISC)32,31,31
   31 DISC= SQRT(DISC)
      CAPA=(((-B/2.+DISC)**4)**(1./3.))/(-B/2.+DISC)
      CAPB=(((-B/2.-DISC)**4)**(1./3.))/(-B/2.-DISC)
      RR(1)=CAPA+CAPB-P/3.
      RI(1)=0.
      IF(DISC.GT.0.)   GO TO 200
```

```
      RR(2)=-CAPA-P/3.                                                  RP0060
      RI(2)=0.                                                          RP0061
      RR(3)=RR(2)                                                       RP0062
      RI(3)=0.                                                          RP0063
      RETURN                                                            RP0064
   32 DISC=2.*SQRT(-A/3.)                                               RP0065
      PHI=ACOS((-3.*B)/(A*DISC))/3.                                     RP0066
      RR(1)=-P/3.+DISC*COS(PHI)                                         RP0067
      RR(2)=-P/3.+DISC*COS(PHI+3.14159265*(2./3.))                      RP0068
      RR(3)=-P/3.+DISC*COS(PHI+3.14159265*(4./3.))                      RP0069
      RI(1)=0.                                                          RP0070
      RI(2)=0.                                                          RP0071
      RI(3)=0.                                                          RP0072
      RETURN                                                            RP0073
      END                                                               RP0074
```

```
      SUBROUTINE SWTCH                                                  SWT001
C                                                                       SWT002
C THIS ROUTINE SWITCHES INPUT DATA                                      SWT003
C                                                                       SWT004
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,SWT005
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        SWT006
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           SWT007
     1CDCAB,DCAB,FATE,NANG,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, SWT008
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               SWT009
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    SWT010
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       SWT011
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44SWT012
     1)                                                                 SWT013
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  SWT014
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            SWT015
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) SWT016
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      SWT017
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       SWT018
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         SWT019
      DIMENSION ICHECK(44)                                              SWT020
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          SWT021
      INTEGER PATH                                                      SWT022
      REAL IR,IRS                                                       SWT023
      DO 1 I=1,10                                                       SWT024
    1 DATA(I)=DATN(I)                                                   SWT025
      RETURN                                                            SWT026
      END                                                               SWT027
```

```
      SUBROUTINE START                                                  STA001
C                                                                       STA002
C THIS ROUTINE CALCULATES THE INITIAL GUESSES AT THE IMAGINARY          STA003
C AND EQUILIBRATING REACTIONS AND THE INITIAL DELTA BASED ON            STA004
C THE TOTAL WEIGHT OF THE ARRAY                                         STA005
C                                                                       STA006
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,STA007
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        STA008
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           STA009
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, STA010
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               STA011
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    STA012
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       STA013
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44STA014
     1)                                                                 STA015
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  STA016
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            STA017
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) STA018
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      STA019
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       STA020
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         STA021
      DIMENSION ICHECK(44)                                              STA022
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          STA023
      INTEGER PATH                                                      STA024
      REAL IR,IRS                                                       STA025
      WEIGHT=0.                                                         STA026
      DO 1 J=1,NJUNC                                                    STA027
    1 WEIGHT=WEIGHT+FEJUNC(3,J)                                         STA028
      DO 2 N=1,NCAB                                                     STA029
      INNN=NNODE(N)-1                                                   STA030
      DO 2 M=1,INNN                                                     STA031
    2 WEIGHT=WEIGHT+ FCAB(3,M,N)                                        STA032
      DO 3 N=1,NIR                                                      STA033
      KER=ERJUNC(N)                                                     STA034
      DO 3 I=1,3                                                        STA035
    3 IR(I,KER)=0.                                                      STA036
      DO 4 N=1,NIR                                                      STA037
      KIR=IRJUNC(N)                                                     STA038
      KER=ERJUNC(N)                                                     STA039
      IR(1,KIR)=0.                                                      STA040
      IR(2,KIR)=0.                                                      STA041
      IR(3,KIR)=-WEIGHT/(NIR+1)                                         STA042
    4 IR(3,KER)=IR(3,KER)-IR(3,KIR)                                     STA043
      DELTAI= ABS(WEIGHT)/(NIR+1)                                       STA044
      RETURN                                                            STA045
      END                                                               STA046
```

```
      FUNCTION TCAB(M,K)                                                TCA001
C                                                                       TCA002
C THIS ROUTINE CALCULATES THE TENSION AT NODE M OF CABLE K              TCA003
C                                                                       TCA004
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,TCA005
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        TCA006
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           TCA007
     1CDCAB,DCAB,FATE,NANG,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, TCA008
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               TCA009
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    TCA010
     4WCAB,IDEV,ICHECK,NDEV                                             TCA011
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44TCA012
     1)                                                                 TCA013
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  TCA014
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            TCA015
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) TCA016
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      TCA017
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       TCA018
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         TCA019
      DIMENSION ICHECK(44)                                              TCA020
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          TCA021
      INTEGER PATH                                                      TCA022
      REAL IR,IRS                                                       TCA023
      TCAB     =SQRT(RCAB(1,M,K)**2 + RCAB(2,M,K)**2 + RCAB(3,M,K)**2 ) TCA024
      RETURN                                                            TCA025
      END                                                               TCA026
```

```
      FUNCTION EXCAB(M,K)                                               EXC001
C                                                                       EXC002
C THIS ROUTINE CALCULATES (1 + STRAIN) AT NODE M OF CABLE K             EXC003
C                                                                       EXC004
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,EXC005
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        EXC006
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           EXC007
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, EXC008
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               EXC009
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    EXC010
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       EXC011
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44EXC012
     1)                                                                 EXC013
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  EXC014
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            EXC015
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) EXC016
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      EXC017
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       EXC018
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         EXC019
      DIMENSION ICHECK(44)                                              EXC020
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          EXC021
      INTEGER PATH                                                      EXC022
      REAL IR,IRS                                                       EXC023
      IF(EXPCAB(K).EQ.0.) GO TO 1                                       EXC024
      EXCAB=1.+(TCAB(M,K)/ECICAB(K))**EXPCAB(K)                         EXC025
      RETURN                                                            EXC026
    1 EXCAB=1.                                                          EXC027
      RETURN                                                            EXC028
      END                                                               EXC029
```

```
      FUNCTION EFORCE(I)
C
C THIS ROUTINE CALCULATES THE DEVICE FORCES IN DIRECTION I
C USING THE NORMAL DRAG APPROXIMATION FOR IN-LINE DEVICES
C
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG,
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,
     4WCAB,IDEV,ICHECK,NDEV,NDATC
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44
     1)
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22)
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)
      DIMENSION ICHECK(44)
      DIMENSION WTEL(3),VNORM(3),PSPACE(3)
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG
      INTEGER PATH
      REAL IR,IRS
C
C CALCULATE THE WEIGHT VECTOR OF A DEVICE
C
      WTEL(1)=0.
      WTEL(2)=0.
      WTEL(3)=DATA(6)
C
C CHECK TO SEE IF CURRENT OR NO CURRENT
C
      JUM=JUMP+1
      GO TO(1,2),JUM
C
C GET HERE IF NO CURRENT
C
    1 EFORCE = WTEL(I)
      RETURN
C
C GET HERE IF CURRENT
C CALCULATE LOCATION OF DEVICE IN SPACE
C
    2 DO 3 KK=1,3
      K=KK
    3 PSPACE(K)=SPACE(K)
C
C CHECK IF DEVICE IS IN-LINE OR FREE
C
      IJMP=DATA(4)
      GO TO (5,4,5,4),IJMP
C
C GET HERE IF FREE TYPE DEVICE -- CALCULATE MAGNITUDE OF THE CURRENT
C
    4 VMAG=SQRT(VELOC(1,PSPACE)**2 + VELOC(2,PSPACE)**2 + VELOC(3,PSPACE
     1)**2 )
C
```

```
C CALCULATE THE FORCE ON THE FREE DEVICE
C
      EFORCE = WTEL(I)+(RHO/2.)*DATA(7)*DATA(8)*VMAG*VELOC(I,PSPACE)
      RETURN
C
C GET HERE IF IN-LINE DEVICE
C CALCULATE THE TANGENTIAL PROJECTION OF THE CURRENT ON THE DEVICE
C TANG(I) EVALUATES THE UNIT TANGENT TO A CABLE AT ANY POINT
C
    5 VPROJ=0.
      DO 6 KK=1,3
      K=KK
    6 VPROJ=VPROJ + VELOC(K,PSPACE)*TANG(K)
C
C CALCULATE THE NORMAL COMPONENT OF THE CURRENT AND ITS MAGNITUDE
C
      DO 7 KK=1,3
      K=KK
    7 VNORM(K)=VELOC(K,PSPACE)-VPROJ*TANG(K)
      VNMAG=SQRT(VNORM(1)**2 + VNORM(2)**2 + VNORM(3)**2)
C
C CALCULATE THE FORCE ON THE IN-LINE DEVICE
C
      EFORCE=WTEL(I)+(RHO/2.)*DATA(7)*(DATA(8)/12.)*DATA(9)*VNMAG
     1 *VNORM(I)
      RETURN
      END
```

```
      FUNCTION CFORCE (I,M,N)                                           CF0001
C                                                                       CF0002
C THIS ROUTINE CALCULATES THE FORCE/LENGTH IN DIRECTION I AT NODE M     CF0003
C ON CABLE N USING THE NORMAL DRAG FORCE APPROXIMATION                  CF0004
C                                                                       CF0005
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,CF0006
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        CF0007
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           CF0008
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, CF0009
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               CF0010
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    CF0011
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       CF0012
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44CF0013
     1)                                                                 CF0014
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  CF0015
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            CF0016
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) CF0017
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      CF0018
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       CF0019
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         CF0020
      DIMENSION ICHECK(44)                                              CF0021
      DIMENSION WTCAB(3),VNORM(3),PSPACE(3)                             CF0022
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,CFLG                          CF0023
      INTEGER PATH                                                      CF0024
      REAL IR,IRS                                                       CF0025
C                                                                       CF0026
C CALCULATE THE WEIGHT/LENGTH VECTOR                                    CF0027
C                                                                       CF0028
      WTCAB(1)=0.                                                       CF0029
      WTCAB(2)=0.                                                       CF0030
      WTCAB(3)=WCAB(N)                                                  CF0031
C                                                                       CF0032
C CHECK TO SEE IF CURRENT OR NO CURRENT                                 CF0033
C                                                                       CF0034
      JUM=JUMP+1                                                        CF0035
      GO TO (1,2),JUM                                                   CF0036
C                                                                       CF0037
C GET HERE IF NO CURRENT                                                CF0038
C                                                                       CF0039
    1 CFORCE=WTCAB(I)                                                   CF0040
      RETURN                                                            CF0041
C                                                                       CF0042
C GET HERE IF CURRENT                                                   CF0043
C CALCULATE LOCATION OF NODE IN SPACE                                   CF0044
C                                                                       CF0045
    2 DO 3 K=1,3                                                        CF0046
    3 PSPACE(K)=PCAB(K,M,N)                                             CF0047
C                                                                       CF0048
C CALCULATE THE TANGENTIAL PROJECTION OF THE CURRENT ON THE CABLE       CF0049
C                                                                       CF0050
      VPROJ=0.                                                          CF0051
      DO 4 KK=1,3                                                       CF0052
      K=KK                                                              CF0053
    4 VPROJ=VPROJ + VELOC(K,PSPACE) * RCAB(K,M,N) / TCAB(M,N)           CF0054
C                                                                       CF0055
C CALCULATE THE NORMAL COMPONENT OF THE CURRENT AND ITS MAGNITUDE       CF0056
C                                                                       CF0057
      DO 5 KK=1,3                                                       CF0058
      K=KK                                                              CF0059
```

```
    5 VNORM(K)= VELOC(K,PSPACE) - VPROJ * RCAB(K,M,N) / TCAB(M,N)        CF0060
      VNMAG = SQRT(VNORM(1)**2 + VNORM(2)**2 + VNORM(3)**2 )             CF0061
C                                                                        CF0062
C CALCULATE THE FORCE/LENGTH                                             CF0063
C                                                                        CF0064
      CFORCE=WTCAB(I)+(RHO/2.)*CDCAB(N)*(DCAB(N)/12.)*EXCAB(M,N)*VNMAG   CF0065
     1 *VNORM(I)                                                         CF0066
      RETURN                                                             CF0067
      END                                                                CF0068
```

```
      FUNCTION SPACE(I)                                                  SPA001
C                                                                        SPA002
C THIS ROUTINE CALCULATES THE LOCATION IN SPACE                          SPA003
C OF ANY POINT ON THE ARRAY                                              SPA004
C                                                                        SPA005
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,SPA006
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                         SPA007
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,            SPA008
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG,  SPA009
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,                SPA010
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,     SPA011
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                        SPA012
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44SPA013
     1)                                                                  SPA014
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)   SPA015
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)             SPA016
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22)  SPA017
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)       SPA018
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)        SPA019
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)          SPA020
      DIMENSION ICHECK(44)                                               SPA021
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                           SPA022
      INTEGER PATH                                                       SPA023
      REAL IR,IRS                                                        SPA024
      IF(DATA(2).EQ.TEST(3))  GO TO 1                                    SPA025
      IF(DATA(2).EQ.TEST(4))  GO TO 2                                    SPA026
C                                                                        SPA027
C GET HERE IF JUNCTION POINT                                             SPA028
C                                                                        SPA029
    1 K=DATA(3)                                                          SPA030
      SPACE = PJUNC(I,K)                                                 SPA031
      RETURN                                                             SPA032
C                                                                        SPA033
C GET HERE IF POINT ON A CABLE                                           SPA034
C                                                                        SPA035
    2 N=DATA(3)                                                          SPA036
      M=   (DATA(10)/H(N)) +1                                            SPA037
C                                                                        SPA038
C CALCULATE DISTANCE, SIGMA, OF POINT FROM NODE M                        SPA039
C                                                                        SPA040
      SIGMA = DATA(10) - (M-1)*H(N)                                      SPA041
C                                                                        SPA042
C CALCULATE EXTRAPOLATION QUANTITIES                                     SPA043
C                                                                        SPA044
      EM=EXCAB(M,N)*RCAB(I,M,N)/TCAB(M,N)                                SPA045
      EM1=EXCAB(M+1,N)*RCAB(I,M+1,N)/TCAB(M+1,N)                         SPA046
C                                                                        SPA047
C CALCULATE LOCATION                                                     SPA048
C                                                                        SPA049
      SPACE = PCAB(I,M,N)+EM*SIGMA+((EM1-EM)/H(N))*(SIGMA**2)/2.         SPA050
      RETURN                                                             SPA051
      END                                                                SPA052
```

```
      FUNCTION TANG(I)                                                  TAN001
C                                                                       TAN002
C THIS ROUTINE CALCULATES THE UNIT TANGENT TO A CABLE AT ANY POINT      TAN003
C                                                                       TAN004
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,TAN005
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO                        TAN006
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,           TAN007
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG, TAN008
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,               TAN009
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,    TAN010
     4WCAB,IDEV,ICHECK,NDEV,NDATC                                       TAN011
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44TAN012
     1)                                                                 TAN013
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)  TAN014
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)            TAN015
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22) TAN016
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)      TAN017
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)       TAN018
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)         TAN019
      DIMENSION ICHECK(44)                                              TAN020
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG                          TAN021
      INTEGER PATH                                                      TAN022
      REAL IR,IRS                                                       TAN023
      N=DATA(3)                                                         TAN024
      M=   (DATA(10)/H(N)) + 1                                          TAN025
C                                                                       TAN026
C CALCULATE DISTANCE, SIGMA, OF POINT FROM NODE M                       TAN027
C                                                                       TAN028
      SIGMA= DATA(10) - (M-1)*H(N)                                      TAN029
C                                                                       TAN030
C CALCULATE EXTRAPOLATION QUANTITIES                                    TAN031
C                                                                       TAN032
      EM= RCAB(I,M,N)/TCAB(M,N)                                         TAN033
      EM1= RCAB(I,M+1,N)/TCAB(M+1,N)                                    TAN034
C                                                                       TAN035
C CALCULATE TANGENT                                                     TAN036
C                                                                       TAN037
      TANG= EM+((EM1-EM)/H(N)) * SIGMA                                  TAN038
      RETURN                                                            TAN039
      END                                                               TAN040
```

```
      FUNCTION VELOC(I,PSPACE)
C
C THIS ROUTINE SPECIFIES THE I COMPONENT OF THE CURRENT FIELD
C AT AN ARBITRARY POINT IN SPACE, PSPACE(I)
C
      COMMON /B1/ FEJUNC,IR,DELTAI,DELTA,IRS,TFJUNC,E,ES,FCAB,RCAB,JUMP,
     1PJUNCS,PCAB,PCABE,PCABO,RCABO,THETA,PJUNCO
      COMMON /B2/ NCAB,NNODE,ERJUNC,IRJUNC,DATA,DATN,H,PJUNC,
     1CDCAB,DCAB,FATE,NANC,ANJUNC,IREAD,IPRNT,INTAPE,OUTAPE,ITIME,IFLG,
     2OFLG,NIR,THETAS,THETAE,COMPD,THETAB,NJUNC,RHO,TEST,
     3NVSEG,ZVEL,VELZ,PIP,ECICAB,EXPCAB,ZJUNC,LJUNC,PATH,ICAB,IVOPT,
     4WCAB,IDEV,ICHECK,NDEV,NDATC
      DIMENSION FEJUNC(3,44),IR(3,44),IRS(3,44),TFJUNC(3,44),PJUNCO(3,44
     1)
      DIMENSION FCAB(3,51,22),RCAB(3,51,22),PJUNCS(3,44),PCAB(3,51,22)
      DIMENSION PCABE(3,51,22),PCABO(3,51,22),RCABO(3,51,22)
      DIMENSION NNODE(22),ERJUNC(44),IRJUNC(44),DATA(10),DATN(10),H(22)
      DIMENSION PJUNC(3,44),CDCAB(22),DCAB(22),ANJUNC(44),TEST(14)
      DIMENSION ZVEL(25),VELZ(25),ECICAB(22),EXPCAB(22),ZJUNC(22)
      DIMENSION LJUNC(22),PATH(22),ICAB(22),WCAB(22),IDEV(1000)
      DIMENSION ICHECK(44)
      DIMENSION PSPACE(3)
      INTEGER  OUTAPE,ZJUNC,ERJUNC,ANJUNC,OFLG
      INTEGER PATH
      REAL IR,IRS
      GO TO (10,10,30),I
   10 Z=PSPACE(3)
      DO 11 KK=1,NVSEG
      K=KK
      IF(Z.GT.ZVEL(K))  GO TO 11
      GO TO 12
   11 CONTINUE
      VFPS=(1.6878)*VELZ(K)
      GO TO 14
   12 IF(K.NE.1)  GO TO 13
      VFPS=(1.6878)*VELZ(K)
      GO TO 14
   13 SIGMA=Z-ZVEL(K-1)
      SLOPE=(VELZ(K)-VELZ(K-1))/(ZVEL(K)-ZVEL(K-1))
      VFPS=(1.6878)*(VELZ(K-1)+SLOPE*SIGMA)
   14 GO TO (21,22),I
   21 VELOC=VFPS*COS(THETA*PIP)
      RETURN
   22 VELOC=VFPS*SIN(THETA*PIP)
      RETURN
   30 VELOC=0.
      RETURN
      END
```

Appendix B
EXAMPLE

As an example, the Seacon II array being designed for mooring motion experiments by the Naval Civil Engineering Laboratory, Port Hueneme, California is considered. This array has the same overall geometric configuration as the array shown in Fig. 2b. The reduction of this array to a statically determinate array is illustrated in Fig. 3b.

The image of the Seacon II array input deck is shown below.* Note that various devices representing tensiometers, current meters, etc., are included in the array. A brief parametric study of anchor misplacement is also included.

```
 1 LUN      60      61      24                      2      62
11NJNC       6
21 ANC       1   -3808       0       0
22 ANC       2    1904   -3298       0
23 ANC       3    1904    3298       0
31  IR       7       2
32  IR       8       3
33  IR       9       5
41 CAB       1       1       4   -.310     1.2    .727    4128 2457000     1 50
42 CAB       2       5       7   -.310     1.2    .727    4128 2457000     1 50
43 CAB       3       6       8   -.310     1.2    .727    4128 2457000     1 50
44 CAB       4       4       5   -.310     1.2    .727    1000 2457000     1 20
45 CAB       5       6       9   -.310     1.2    .727    1000 2457000     1 20
46 CAB       6       4       6   -.310     1.2    .727    1000 2457000     1 20
51DJNC       4       2       1    1700     0.5   18.55
52DJNC       5       2       5    1700     0.5   18.55
53DJNC       6       2       5    1700     0.5   18.55
61DCAB       4       2       2     -20     1.2    .875             500
62DCAB       5       2       4     -20     1.2    .875             500
63DCAB       6       2       6     -20     1.2    .875             500
64DCAB       1       4             -20     1.2    .875            2064
65DCAB       1       3             -10     1.2       5       1     0.5
66DCAB       1       3             -10     1.2       5       1  4127.5
67DCAB       4       3             -10     1.2       5       1     0.5
68DCAB       4       3             -10     1.2       5       1   999.5
69DCAB       6       3             -10     1.2       5       1     0.5
71 DEN    1.99
 2 EOD
101NDAT      1
111COMP      1
121 VEL      0     .15
122 VEL   1860     .40
123 VEL   2360     .60
131 ANG      0      30      60
102 EOD
201NDAT      1
 22 ANC      2    1900   -3335      15
 23 ANC      3    1925    3250      30
202 EOD
301 EOP
```

*The authors would like to thank Dr. Norm Albertson for supplying the Seacon II array physical characteristics.

The computer printouts of the array descriptive and structured outputs follow.

PHYSICAL CHARACTERISTICS OF THE STRUCTURAL CABLE ARRAY

NO. OF ANCHORS IS 3

JUNCTION NO.	X-COORDINATE	Y-COORDINATE	Z-COORDINATE
1	-3808.00	0.00	0.00
2	1904.00	-3298.00	0.00
3	1904.00	3298.00	0.00

NO. OF JUNCTIONS IN ORIGINAL ARRAY IS 6

NO. OF CUTS MADE IN ORIGINAL ARRAY IS 3

JUNCTION NO. OF CUT	JUNCTION NO. AT WHICH CUT MADE
7	2
8	3
9	5

NO. OF CABLES IS 6

CABLE NO.	S=0 JUNC	S=L JUNC	LENGTH	DIAMETER	WEIGHT/LENGTH	DRAG COEFFICIENT	RIGIDITY	CONSTITUTIVE EXPONENT	NO. OF ELEMENTS
1	1	4	4128.0	0.727	-0.310	1.200	2457000	1.000	50
2	5	7	4128.0	0.727	-0.310	1.200	2457000	1.000	50
3	6	8	4128.0	0.727	-0.310	1.200	2457000	1.000	50
4	4	5	1000.0	0.727	-0.310	1.200	2457000	1.000	20
5	6	9	1000.0	0.727	-0.310	1.200	2457000	1.000	20
6	4	6	1000.0	0.727	-0.310	1.200	2457000	1.000	20

PROPERTIES OF THE DEVICES LOCATED AT JUNCTIONS ARE AS FOLLOWS

DEVICE JUNC. NO.	DEVICE WEIGHT	DEVICE DRAG COEFFICIENT	DEVICE FRONTAL AREA
4	1700.00	0.500	18.55
5	1700.00	0.500	18.55
6	1700.00	0.500	18.55

TOTAL NO. OF INDEXED DEVICES IS 6

CURRENT FIELD OPTION IS 1

Z-COORDINATE OF CURRENT	VELOCITY OF CURRENT AT Z
0.00	0.15
1860.00	0.40
2360.00	0.60

ACCURACY REQUIRED IN CALCULATIONS IS 1.00

DEVICE LOCATION OUTPUT RECORD 1 REFERS TO THIS ARRAY

ARRAY EQUILIBRIUM WITH NO CURRENT

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	902.6	901.1	0.4	51.5	901.1	0.03	3.27
2	2	904.7	-450.2	781.2	73.5	901.7	119.95	4.66
3	3	905.6	-450.9	-781.6	76.0	902.4	-119.98	4.81

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1640.8	4128.0	902.6	0.0								
2	1626.1	0.0	904.7	4128.0								
3	1628.5	0.0	905.6	4128.0								
4	551.6	1000.0	519.9	501.3								
5	547.4	0.0	521.2	517.2								
6	550.0	1000.0	520.7	493.3								

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1640.8	-179.97	-56.69	-565.2	1.5	2312.5			
4	4	545.8	-122.54	-17.70						
4	6	545.6	122.02	-17.37						
5	2	1626.1	-150.00	-56.32	285.8	-490.0	2328.1			
5	4	551.6	149.99	-19.50						
5	5	546.0	90.00	-17.34						
6	3	1628.5	150.03	-56.35	285.8	493.1	2333.2			
6	5	547.4	-107.79	-17.79						
6	6	550.0	-149.99	-18.78						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	519.9	-138.5	-244.9	2238.3			
4	5	500.0	521.3	285.8	1.9	2249.2			
6	6	500.0	520.7	-138.2	248.2	2241.2			

ARRAY EGUILIBRIUM WITH CURRENT FROM 0.00 DEGREES

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	1059.1	1053.1	0.6	112.3	1053.1	0.03	6.09
2	2	834.9	-389.0	737.4	45.6	833.7	117.81	3.13
3	3	835.9	-389.7	-737.9	48.2	834.5	-117.84	3.31

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1781.5	4128.0	1059.1	0.0	82.1	4128.0	-499.4	1.8	2263.4	-565.2	1.5	2312.5
2	1562.2	0.0	834.9	4128.0	73.9	577.9	524.8	-767.5	1872.0	453.6	-781.2	1857.7
3	1564.8	0.0	835.9	4128.0	73.9	577.9	524.8	770.5	1877.2	453.6	784.0	1862.5
4	622.6	1000.0	580.7	370.1	82.1	0.0	-499.4	1.8	2263.4	-565.2	1.5	2312.5
5	460.0	0.0	428.6	516.9	86.8	500.0	372.6	2.0	2251.7	285.8	1.9	2249.2
6	621.7	1000.0	582.2	358.5	82.1	0.0	-499.4	1.8	2263.4	-565.2	1.5	2312.5

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1781.5	-179.97	-54.82	-499.4	1.8	2263.4	65.7	0.3	-49.1
4	4	593.9	-113.75	-12.02						
4	6	594.6	113.10	-11.66						
5	2	1562.2	-151.08	-56.87	353.7	-485.6	2346.9	67.9	4.4	18.8
5	4	622.6	149.34	-21.59						
5	5	458.6	85.47	-20.79						
6	3	1564.8	151.11	-56.99	353.6	488.8	2352.3	67.8	-4.3	19.1
6	5	460.0	-111.30	-21.24						
6	6	621.7	-149.37	-20.99						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	582.1	-65.6	-241.9	2231.5	72.9	3.0	-6.8
4	5	500.0	428.8	372.6	2.0	2251.7	86.8	0.1	2.6
6	6	500.0	583.9	-65.4	245.5	2234.6	72.8	-2.7	-6.5

ARRAY EQUILIBRIUM WITH CURRENT FROM 30.00 DEGREES

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	1037.7	1032.6	19.3	101.0	1032.8	1.07	5.59
2	2	906.8	-415.8	802.8	70.4	904.1	117.38	4.45
3	3	782.8	-378.1	-684.9	26.8	782.3	-118.90	1.96

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1760.7	4128.0	1037.7	0.0	85.5	4128.0	-506.0	41.0	2265.2	-565.2	1.5	2312.5
2	1625.0	0.0	906.8	4128.0	86.2	825.6	602.9	-868.7	1654.3	530.5	-914.7	1663.6
3	1517.6	0.0	782.8	4128.0	76.5	0.0	342.5	527.6	2371.2	285.8	493.1	2333.2
4	639.8	1000.0	605.2	426.2	86.1	450.0	-113.2	-171.7	2219.2	-181.8	-219.9	2239.1
5	478.2	0.0	439.3	539.3	86.8	550.0	360.6	-4.3	2246.9	285.8	-48.1	2249.7
6	577.9	1000.0	533.0	339.1	85.5	0.0	-506.0	41.0	2265.2	-565.2	1.5	2312.5

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1760.7	179.45	-55.12	-506.0	41.0	2265.2	59.1	39.5	-47.3
4	4	621.6	-116.78	-13.09						
4	6	545.3	113.41	-12.16						
5	2	1625.0	-150.48	-56.19	350.3	-446.8	2317.7	64.5	43.2	-10.4
5	4	639.8	147.93	-19.22						
5	5	461.3	87.22	-17.57						
6	3	1517.6	151.46	-57.54	342.5	527.6	2371.2	56.7	34.6	38.1
6	5	478.2	-113.73	-23.68						
6	6	577.9	-150.17	-23.17						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	605.6	-69.7	-196.3	2220.5	68.8	48.6	-17.8
4	5	500.0	440.2	360.4	45.7	2248.7	74.6	43.8	-0.5
6	6	500.0	535.3	-74.4	288.6	2239.1	63.8	40.4	-2.0

ARRAY EQUILIBRIUM WITH CURRENT FROM 60.00 DEGREES

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	978.1	974.6	35.5	74.9	975.2	2.09	4.39
2	2	979.9	-456.1	861.9	96.5	975.1	117.89	5.65
3	3	764.9	-382.3	-662.3	18.1	764.7	-120.00	1.35

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1705.0	4128.0	978.1	0.0	85.8	4645.4	-574.8	71.2	2209.3	-611.0	1.5	2243.7
2	1690.0	0.0	979.9	4128.0	86.0	165.1	375.7	-504.9	2156.6	332.1	-570.4	2191.4
3	1501.1	0.0	764.9	4128.0	80.3	0.0	319.2	552.5	2375.7	285.8	493.1	2333.2
4	635.7	1000.0	608.2	500.6	93.8	500.0	-93.4	-166.3	2214.1	-138.5	-244.9	2238.3
5	518.8	0.0	476.4	599.3	85.9	1000.0	326.4	-423.7	2291.9	285.8	-490.0	2328.1
6	523.5	1000.0	477.7	372.0	85.6	0.0	-527.9	70.1	2277.3	-565.2	1.5	2312.5

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1705.0	178.50	-55.84	-527.9	70.1	2277.3	37.2	68.6	-35.2
4	4	630.3	-120.87	-15.19						
4	6	493.7	116.96	-14.55						
5	2	1690.0	-149.63	-55.50	326.4	-423.7	2291.9	40.7	66.3	-36.2
5	4	635.7	146.92	-16.88						
5	5	492.2	89.39	-14.43						
6	3	1501.1	151.41	-57.82	319.2	552.5	2375.7	33.4	59.4	42.5
6	5	518.8	-113.91	-23.90						
6	6	523.5	-151.54	-24.76						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	608.2	-93.4	-166.3	2214.1	45.1	78.7	-24.2
4	5	500.0	478.3	327.4	71.9	2245.2	41.6	70.1	-4.0
6	6	500.0	479.3	-98.9	319.7	2238.2	39.3	71.5	-2.9

PHYSICAL CHARACTERISTICS OF THE STRUCTURAL CABLE ARRAY

NO. OF ANCHORS IS 3

JUNCTION NO.	X-COORDINATE	Y-COORDINATE	Z-COORDINATE
1	-3808.00	0.00	0.00
2	1900.00	-3335.00	15.00
3	1925.00	3250.00	30.00

NO. OF JUNCTIONS IN ORIGINAL ARRAY IS 6

NO. OF CUTS MADE IN ORIGINAL ARRAY IS 3

JUNCTION NO. OF CUT	JUNCTION NO. AT WHICH CUT MADE
7	2
8	3
9	5

NO. OF CABLES IS 6

CABLE NO.	S=0 JUNC	S=L JUNC	LENGTH	DIAMETER	WEIGHT/LENGTH	DRAG COEFFICIENT	RIGIDITY	CONSTITUTIVE EXPONENT	NO. OF ELEMENTS
1	1	4	4128.0	0.727	-0.310	1.200	2457000	1.000	50
2	5	7	4128.0	0.727	-0.310	1.200	2457000	1.000	50
3	6	8	4128.0	0.727	-0.310	1.200	2457000	1.000	50
4	4	5	1000.0	0.727	-0.310	1.200	2457000	1.000	20
5	6	9	1000.0	0.727	-0.310	1.200	2457000	1.000	20
6	4	6	1000.0	0.727	-0.310	1.200	2457000	1.000	20

PROPERTIES OF THE DEVICES LOCATED AT JUNCTIONS ARE AS FOLLOWS

DEVICE JUNC. NO.	DEVICE WEIGHT	DEVICE DRAG COEFFICIENT	DEVICE FRONTAL AREA
4	1700.00	0.500	18.55
5	1700.00	0.500	18.55
6	1700.00	0.500	18.55

TOTAL NO. OF INDEXED DEVICES IS 6

CURRENT FIELD OPTION IS 1

Z-COORDINATE OF CURRENT	VELOCITY OF CURRENT AT Z
0.00	0.15
1860.00	0.40
2360.00	0.60

ACCURACY REQUIRED IN CALCULATIONS IS 1.00

DEVICE LOCATION OUTPUT RECORD 2 REFERS TO THIS ARRAY

ARRAY EQUILIBRIUM WITH NO CURRENT

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	907.4	905.5	-8.9	58.6	905.5	-0.57	3.70
2	2	905.9	-451.7	781.8	74.1	902.9	120.02	4.69
3	3	898.8	-453.8	-772.8	68.3	896.2	-120.42	4.36

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1649.1	4128.0	907.4	0.0								
2	1627.3	0.0	905.9	4128.0								
3	1618.7	0.0	898.8	4128.0								
4	558.5	1000.0	526.5	495.9								
5	543.2	0.0	515.9	521.2								
6	550.1	1000.0	519.1	477.4								

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1649.1	179.43	-56.69	-570.2	-32.0	2323.5			
4	4	551.4	-121.62	-17.27						
4	6	542.6	121.59	-16.93						
5	2	1627.3	-149.99	-56.30	278.3	-528.4	2342.9			
5	4	558.5	149.67	-19.48						
5	5	540.1	89.70	-17.22						
6	3	1618.7	150.17	-56.38	283.5	454.3	2353.2			
6	5	543.2	-108.25	-18.24						
6	6	550.1	-150.33	-19.32						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	526.5	-144.5	-281.0	2252.2			
4	5	500.0	516.1	280.9	-36.3	2265.8			
6	6	500.0	519.1	-141.2	212.4	2256.5			

ARRAY EQUILIBRIUM WITH CURRENT FROM 0.00 DEGREES

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	1067.2	1060.2	-9.7	121.0	1060.3	-0.52	6.51
2	2	835.6	-389.7	737.7	45.6	834.3	117.85	3.13
3	3	827.2	-391.1	-727.8	39.7	826.2	-118.25	2.75

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1792.8	4128.0	1067.2	0.0	83.4	4128.0	-503.6	-30.6	2273.3	-570.2	-32.0	2323.5
2	1562.5	0.0	835.6	4128.0	74.4	577.9	518.2	-805.0	1886.0	446.5	-819.5	1872.6
3	1553.0	0.0	827.2	4128.0	74.4	577.9	525.1	730.2	1897.0	453.4	743.8	1882.5
4	631.3	1000.0	588.8	360.3	83.4	0.0	-503.6	-30.6	2273.3	-570.2	-32.0	2323.5
5	454.4	0.0	421.6	520.7	87.9	500.0	368.8	-35.5	2267.2	280.9	-36.3	2265.8
6	623.3	1000.0	581.6	338.7	83.4	0.0	-503.6	-30.6	2273.3	-570.2	-32.0	2323.5

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1792.8	179.45	-54.81	-503.6	-30.6	2273.3	66.6	1.4	-50.2
4	4	601.2	-112.74	-11.58						
4	6	592.8	112.32	-11.10						
5	2	1562.5	-151.08	-56.83	346.6	-523.1	2360.7	68.3	5.2	17.8
5	4	631.3	148.97	-21.59						
5	5	451.0	85.00	-20.77						
6	3	1553.0	151.30	-56.93	351.7	450.4	2372.3	68.3	-3.9	19.1
6	5	454.4	-111.95	-21.89						
6	6	623.3	-149.73	-21.57						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	590.4	-71.1	-276.9	2244.4	73.5	4.1	-7.8
4	5	500.0	421.8	368.8	-35.5	2267.2	87.9	0.8	1.4
6	6	500.0	583.7	-67.8	210.4	2249.7	73.4	-2.0	-6.8

ARRAY EQUILIBRIUM WITH CURRENT FROM 30.00 DEGREES

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	1044.8	1039.1	9.7	109.0	1039.1	0.54	5.99
2	2	908.9	-416.9	804.5	70.8	906.1	117.39	4.47
3	3	773.9	-379.2	-674.4	18.3	773.6	-119.35	1.35

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1771.0	4128.0	1044.8	0.0	88.0	4128.0	-509.8	9.7	2274.8	-570.2	-32.0	2323.5
2	1626.4	0.0	908.9	4128.0	88.3	825.6	597.2	-905.2	1667.9	523.7	-953.1	1678.6
3	1505.6	0.0	773.9	4128.0	77.6	0.0	340.7	490.2	2391.5	283.5	454.3	2353.2
4	648.2	1000.0	613.2	418.1	88.7	400.0	-161.4	-180.7	2231.1	-230.8	-230.5	2254.9
5	473.6	0.0	433.0	543.3	88.9	600.0	356.3	-90.4	2262.7	280.3	-136.2	2268.8
6	578.6	1000.0	531.3	320.6	88.0	0.0	-509.8	9.7	2274.8	-570.2	-32.0	2323.5

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1771.0	178.87	-55.11	-509.8	9.7	2274.8	60.4	41.6	-48.7
4	4	628.8	-115.84	-12.70						
4	6	542.5	112.65	-11.60						
5	2	1626.4	-150.45	-56.13	343.8	-483.1	2330.8	65.6	45.2	-12.1
5	4	648.2	147.58	-19.21						
5	5	454.4	86.86	-17.45						
6	3	1505.6	151.64	-57.61	340.7	490.2	2391.5	57.2	35.9	38.2
6	5	473.6	-114.40	-24.35						
6	6	578.6	-150.54	-23.79						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	613.8	-74.6	-230.2	2232.8	69.9	50.8	-19.4
4	5	500.0	434.1	356.7	9.5	2264.1	75.8	45.8	-1.7
6	6	500.0	534.2	-76.4	254.6	2254.1	64.8	42.2	-2.4

ARRAY EQUILIBRIUM WITH CURRENT FROM 60.00 DEGREES

ARRAY ANCHORS

JUNC. NO. OF ANCHOR	CABLE AT ANCHOR	TENSION AT ANCHOR	FORCE COMPONENTS AT ANCHOR X-COMP	Y-COMP	Z-COMP	HOR.-COMP	CABLE ANGLES WRT X-AXIS	XY-PLANE
1	1	983.7	979.9	26.7	82.0	980.2	1.56	4.78
2	2	983.2	-457.7	864.7	97.4	978.4	117.89	5.69
3	3	756.2	-383.3	-651.8	9.7	756.2	-120.46	0.73

ARRAY CABLES

CABLE NO.	MAXIMUM TENSION	S-COORD OF	MINIMUM TENSION	S-COORD OF	MAXIMUM DISP.	S-COORD OF	LOCATION OF THIS POINT X-COORD	Y-COORD	Z-COORD	NO CURRENT LOC. OF THIS POINT X-COORD	Y-COORD	Z-COORD
1	1713.7	4128.0	983.7	0.0	88.9	4045.4	-578.4	40.7	2219.1	-616.0	-31.5	2254.7
2	1692.7	0.0	983.2	4128.0	89.5	82.6	344.9	-499.8	2237.0	301.4	-568.3	2274.4
3	1489.4	0.0	756.2	4128.0	82.1	0.0	317.4	515.6	2396.0	283.5	454.3	2353.2
4	643.8	1000.0	616.1	493.0	97.2	500.0	-98.0	-199.7	2226.3	-144.5	-281.0	2252.2
5	515.3	0.0	471.2	610.0	89.4	1000.0	320.3	-459.4	2304.7	278.3	-528.4	2342.9
6	523.5	1000.0	475.2	355.7	88.7	0.0	-531.6	39.2	2287.1	-570.2	-32.0	2323.5

ARRAY JUNCTIONS

JUNC. NO.	CABLE AT JUNCTION	TENSION AT JUNCTION	CABLE ANGLES WRT X-AXIS	XY-PLANE	JUNCTION LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
4	1	1713.7	177.92	-55.83	-531.6	39.2	2287.1	38.6	71.1	-36.4
4	4	637.3	-119.98	-14.82						
4	6	490.1	116.34	-14.06						
5	2	1692.7	-149.59	-55.44	320.3	-459.5	2304.8	42.0	68.9	-38.2
5	4	643.8	146.59	-16.85						
5	5	486.3	89.12	-14.22						
6	3	1489.4	151.58	-57.88	317.4	515.6	2396.0	33.9	61.3	42.7
6	5	515.3	-114.52	-24.51						
6	6	523.5	-151.96	-25.42						

INDEXED DEVICES ALONG ARRAY CABLES

DEVICE INDEX	CABLE NO.	S COORDINATE	TENSION AT DEVICE	DEVICE LOCATION X-COORD	Y-COORD	Z-COORD	DISPLACEMENT FROM NO CURRENT LOC. X-DISP	Y-DISP	Z-DISP
2	4	500.0	616.1	-98.0	-199.7	2226.3	46.5	81.3	-25.9
4	5	500.0	473.4	323.6	36.3	2260.9	42.7	72.6	-4.9
6	6	500.0	477.3	-100.8	286.4	2253.0	40.4	74.0	-3.5

The image of the Seacon II array device location output file is shown below.

```
REC   1
CUR   0
DEV   1   -565.16      1.50   2312.50
DEV   2   -138.52   -244.92   2238.29
DEV   3    285.77   -489.98   2328.12
DEV   4    285.80      1.86   2249.19
DEV   5    285.82    493.08   2333.17
DEV   6   -138.16    248.16   2241.16
CUR   1      0.00
DEV   1   -499.41      1.80   2263.40
DEV   2    -65.62   -241.92   2231.52
DEV   3    353.71   -485.59   2346.90
DEV   4    372.56      2.00   2251.74
DEV   5    353.59    488.83   2352.27
DEV   6    -65.39    245.49   2234.62
CUR   1     30.00
DEV   1   -506.03     41.05   2265.15
DEV   2    -69.73   -196.35   2220.48
DEV   3    350.27   -446.82   2317.73
DEV   4    360.36     45.68   2248.73
DEV   5    342.50    527.63   2371.24
DEV   6    -74.37    288.59   2239.14
CUR   1     60.00
DEV   1   -527.94     70.14   2277.33
DEV   2    -93.43   -166.26   2214.05
DEV   3    326.43   -423.70   2291.88
DEV   4    327.38     71.91   2245.19
DEV   5    319.18    552.49   2375.65
DEV   6    -98.91    319.66   2238.21
REC   2
CUR   0
DEV   1   -570.20    -31.96   2323.52
DEV   2   -144.54   -281.00   2252.19
DEV   3    278.27   -528.37   2342.92
DEV   4    280.87    -36.29   2265.83
DEV   5    283.46    454.31   2353.22
DEV   6   -141.21    212.40   2256.51
CUR   1      0.00
DEV   1   -503.62    -30.55   2273.32
DEV   2    -71.08   -276.93   2244.40
DEV   3    346.56   -523.13   2360.74
DEV   4    368.77    -35.47   2267.19
DEV   5    351.71    450.37   2372.34
DEV   6    -67.77    210.40   2249.67
CUR   1     30.00
DEV   1   -509.82      9.66   2274.84
DEV   2    -74.60   -230.24   2232.77
DEV   3    343.83   -483.13   2330.80
DEV   4    356.68      9.54   2264.11
DEV   5    340.69    490.23   2391.46
DEV   6    -76.41    254.58   2254.08
CUR   1     60.00
DEV   1   -531.57     39.15   2287.11
DEV   2    -98.03   -199.73   2226.26
DEV   3    320.32   -459.47   2304.76
DEV   4    323.56     36.32   2260.94
DEV   5    317.38    515.63   2395.96
DEV   6   -100.82    286.38   2253.00
EOP
```

Appendix C
NONSTANDARD CURRENT FIELD

By changing the arithmetic calculations in the subprogram VELOC(I,PSPACE) [see Appendix A—Source Language Listing], it is possible to introduce an arbitrary current field into DESADE. *No other changes in DESADE are necessary.*

Within VELOC, PSPACE(I) is a position vector giving the location of an arbitrary point in space referred to the fixed Cartesian coordinate system, in which X = PSPACE(1), Y = PSPACE(2), and Z = PSPACE(3). Similary, VELOC(1,PSPACE) is the X component of the current at this point in space, VELOC(2,PSPACE) is the Y component, and VELOC(3,PSPACE) is the Z component. Note that the calculations must yield VELOC in feet per second.

The current angle THETA is available as a variable in VELOC [that is, one can change the direction of the nonstandard current field with respect to the X axis if desired]. Also, PIP = $\pi/180$ for conversion from degrees to radians.

An ANG card must appear after the first NDAT card specifying a current field option = 2 whether or not THETA is used in VELOC (see PARAMETRIC STUDY SOURCE DECKS). If THETA is not used in VELOC, the ANG card serves as a "dummy" card allowing DESADE to run, and it suffices to leave fields 3 and 5 blank and to set Field 4 as an arbitrary, but positive, number (see ANG card).

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13. ABSTRACT

DESADE is a Fortran IV program for computing the current-induced static deflections of Structural Cable Arrays. As dimensioned, the program can handle arbitrarily configured arrays of up to 22 cables. The cables can be electromechanical, wire rope, or synthetic. Any number of discrete devices (buoyancy elements, current meters, tensiometers, etc.) can be incorporated in the array. An option for parametric studies is included in the program, as is an option for incorporating arbitrary current fields. As written, DESADE should compile on most Fortran IV compilers with Boolean algebra capabilities.

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Cable structures						
Moorings						
Ocean structures						
Cable structural analysis						
Cable structural design						
Mooring structural analysis						
Structural analysis						
Imaginary Reactions						

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