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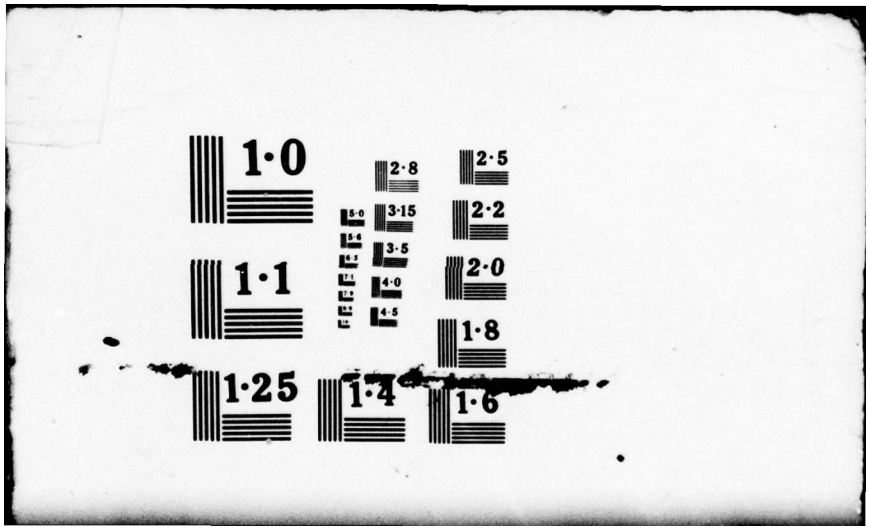
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VOLAR:A Digital Computer Program for Simulating VSTOL Aircraft Launch and Recovery from Small Ships

Volume II - Appendices

Julian Wolkovitch
Billy B. Brassell

14 December 1978

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Volume II. Appendices.

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A digital computer program has been developed for simulating the launch and recovery of VSTOL aircraft operating from small ships. Volume I of this report describes the program, Volume II is the user's manual. The program, known as VOLAR (Vought Launch and Recovery Dynamics Program), employs the computational technique of nonlinear covariance propagation. This permits the time histories of the means and variances of all system state variables to be computed from a single run, as opposed to the Monte Carlo technique,

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which requires multiple runs, plus subsequent averaging. Typically, VOLAR requires approximately 7 percent of the computer time required for comparable Monte Carlo simulations.

The program includes a general airframe mathematical model suitable for helicopters or fixed-wing aircraft. The airwake of a small ship is also modeled and ship motion models are included. Two alternative models of the human pilot are supplied, one is based on verbal adjustment rules, the other is based on optimal control theory, utilizing performance index parameters deduced from manned simulator experiments. The program is demonstrated for AV-8A recovery on a small ship. The trends predicted by VOLAR are shown to agree with flight test data.

FOREWORD

The work described in this report was sponsored by the Flight Dynamics Branch of Air Vehicle Technology Department of the Naval Air Development Center. Mr. Ronald L. Nave served as project engineer and technical monitor for the Naval Air Development Center Mr. Carmen J. Mazza was NADC program manager.

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SUMMARY

A digital computer program has been developed for simulating the launch and recovery of VSTOL aircraft operating from small ships. The program, known as VOLAR (Vought Launch and Recovery Dynamics Program), employs the computational technique of non-linear covariance propagation. This permits the time histories of the means and variances of all system state variables to be computed from a single run, as opposed to the Monte Carlo technique, which requires multiple runs, plus subsequent averaging. Typically, VOLAR requires approximately 7 percent of the computer time required for comparable Monte Carlo simulations.

The program includes a general airframe mathematical model suitable for helicopters or fixed-wing aircraft. The airwake of a small ship is also modeled and ship motion models are included. Two alternative models of the human pilot are supplied, one is based on verbal adjustment rules, the other is based on optimal control theory, utilizing performance index parameters deduced from manned simulator experiments. The program is demonstrated for AV-8A recovery on a small ship. The trends predicted by VOLAR are shown to agree with flight test data.

Volume I of this report describes the program, Volume II is the user's manual.

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APPENDIX A

USER'S MANUAL

APPENDIX A
USER'S MANUAL

A.1 Philosophy

VOLAR is designed to be a useful analytical tool for any task involving covariance propagation. It definitely is not limited or restricted to the examples presented in this user's guide. VOLAR is not a simple routine to learn, but once mastered it provides the familiar user with a powerful analytical tool. The intended user should have knowledge of differential equations, matrix algebra, aerodynamics, modeling, control system analysis and synthesis, and Fortran programming.

VOLAR is a relatively flexible program. The basic structure allows one to tailor the routine to his/her particular need or requirement. Then once a problem is run, the user may select from several types of output; including line printer, printer plots, CalComp plots and punch cards.

The program is written in Fortran IV and COMPASS for CDC 6000 or CYBER series computers. Each COMPASS subroutine has a Fortran equivalent.

The subroutines include many comment statements; and for some users, will serve as their own best user's guide. Great care was taken to program in a simple concise manner. When complex programming appears, the authors felt it was necessary due to speed and/or efficiency considerations.

A.2 Some Comments on the Use of VOLAR

The user's guide should be regarded as just that - a guide. VOLAR cannot be completely learned from a book. The prospective user must get hands-on experience. It is highly recommended that VOLAR be activated and exercised thoroughly. The two sample problems presented in this document provide a good starting point.

The first step in the learning process is to review the general purpose and function of each subroutine (Section A.3). Next, the user should read Section A.4 which introduces the I and R arrays and then become familiar with the main program, VOLAR, and its options (Section A.5). After this, select one of the sample cases and compare the problem-specific programming (refer to Appendices B and C) in the subroutines (particularly DEQU, PROP, and SETUP) with the general descriptions in Section A.3. The explanation of the input decks in Section A.8 or Section A.9 is next. Following this,

activate VOLAR on your system. After running the sample cases, try changing a gain or time constant; CalComp plot a new variable; or change output forms. The important point is; roll up your sleeves and dig in.

A.3 Description of Subroutines

This section presents a brief description of the subroutines. There are basically two types of subroutines. The first type falls into the broad category of "support". These subroutines perform canned operations (e.g. matrix multiplication, integration, etc.) and do not change from problem to problem. The second type of subroutine is very much problem dependent. Through these subroutines the user tailors VOLAR to model and solve his particular problem. Subroutines requiring user interface are so noted in the descriptions which follow.

ADAMS - This subroutine performs second order Adams integration. It is the simplest of the three integration techniques available to the user. All the integration subroutines are constructed to integrate a set of first order differential equations describing the means and three covariance matrices (three are required when an optimal pilot is used). The calling routine is VOLAR.

AIRWAKE - This subroutine calculates airwake disturbance, means and standard deviations, due to the ship's presence. The programmed equations are from Reference 12. The calling routine is DEQU.

AIRWTBL - The airwake data tables of Reference 12 are contained here in DATA statements. This subroutine is called once by SETUP to construct a case-particular particular (V_{WOD}, Ψ_{WOD}) set of airwake tables to be used by AIRWAKE.

AXIS - This subroutine produces a coordinate axis for CalComp plots. The calling routine is CALPLT.

CALPLT - This is a general purpose CalComp plot routine. The calling program is VOLAR.

DASPLT - This subroutine draws dashed lines on CalComp plots. The calling routine is CALPLT.

DEQU - This subroutine contains the differential equations describing the propagation of the means, the aero data table look ups and open loop control inputs. The reference flight values about which the trajectory is linearized are defined and updated here. DEQU is one of the user defined subroutines. It must be programmed by the user to meet the requirements of his particular application. DEQU is called by SETUP and the integration subroutines ADAMS, RUNGE, and KUTTA.

DESCRIB - This routine calculates single-valued nonlinear describing functions of one variable. TABRD must be called before the first call to DESCRIB. The calling routine for DESCRIB is DEQU.

ELLIPSE - This routine draws a 50 percent probability ellipse on CalComp trajectories. These ellipses can be scaled differently from the trajectory to increase the clarity of presentation. The calling routine is CALPLT.

ERF - This routine evaluates the error function associated with the normal distribution curve. The calling routine is DESCRIB.

KUTTA - One of three integration subroutines. This subroutine performs third order Runge-Kutta integration. The calling program is VOLAR.

MATINV - This subroutine calculates the inverse of a matrix. The calling routine is SOLVR.

MATRIX - This routine handles general matrix operations. The operations include adding two matrices, subtracting two matrices, multiplying two matrices, multiplying one matrix by the transpose of another matrix, matrix transposition, and laying a matrix into another matrix. MATRIX is programmed in COMPASS. The FORTRAN equivalent operations appear as comments in MATRIX. The COMPASS version executes about 20 percent faster than the FORTRAN version. The calling routines are PROP and SOLVR.

MISCAL - This subroutine handles miscellaneous calculations that have no logical place to go. MISCAL is called by VOLAR before the output file is written. This subroutine is user specified.

PRNPLT - This is a general purpose line-printer plot routine. A 7 by 7 inch plot is produced. The calling routine is VOLAR.

PROP - This subroutine contains the matrix differential equation for covariance propagation. The user must define the elements of the F and G matrices in PROP. These matrices define the linearized system equations and are normally composed of several smaller submatrices. PROP is called by SETUP and the integration subroutines ADAMS, RUNGE, and KUTTA.

ROTATE - This subroutine rotates a coordinate system through any angle. The calling routines are CALPLT and ELLIPSE.

RUNGE - This subroutine performs fourth order Runge-Kutta integration. It is the more accurate but most time-consuming of the three integration methods available in VOLAR. The calling program is VOLAR.

SETUP - This subroutine initializes the integrators. Any calculations to be initialized and one-time-only calculations also appear in SETUP. For example, ship scaling factors and wind over deck are calculated here because they are fixed for a given run. Because of its problem dependence, SETUP is user defined. SETUP is called by VOLAR.

SOLVR - This subroutine solves for the steady-state ($t \to \infty$) solution of the matrix Riccati equation. It may be used to initialize the covariance matrix, P, before running a time history. It will not work when more than one covariance matrix (e.g. the optimal pilot model case) is involved. The calling routine is PROP.

TABRD - This subroutine decomposes nonlinear functions into even and odd describing function elements. The inputs to TABRD are a table of independent variables, a table of dependent variables, and the number of variables in the tables. TABRD must be called once for each nonlinear element before DESCRIB can calculate the appropriate describing function. The calling routine is SETUP.

TLU - This routine is used to look up a series of dependent variables. Linear interpolation is used to generate the dependent variables. With one call, several dependent variables can be made available to COMMON provided that all the dependent variable tables are associated with the same independent variable table. The calling subroutines are DEQU and PROP.

VOLAR - This routine is the main program and handles almost all the program input and output through its various options.

A.4 Description of the I and R Arrays

The I and R arrays contain all the integer and real variables of the program respectively. The I array is equivalenced to the elements of the labeled common, "INTEGER". The R array is equivalenced to elements of blank common. The arrays not only handle the communication between the subroutines but also all of the programs input and output. The I and R arrays are user defined.

A.4.1 Program Modification

If the user wishes to modify the program, any new variables would be added to the common blocks (I or R arrays). This gives the user the capability of inputting or outputting the variables. The new variables may be added any where within the commons.

A.4.2 Input and Output through the I and R Arrays

All of the programs input and output were designed around the I and R arrays. Since the I and R arrays (common blocks) have many variables and arrays within them, bookkeeping the variables is difficult. To simply the bookkeeping, the I and R arrays are divided into segments and elements. Each segment is defined by a specific number of elements. The segments are classified by groups of elements which are defined by a collection of simple variables or subscripted variables. The lengths of the segments are specified in the problem initialization phase (A.5.1). The initialization phase actually

aligns the commons with the I and R arrays. Care must be taken in setting the lengths of the segments after program modification because the input and output will be malaligned. Figure A.1 is an example of a simple R array. In this example, DTOUT may be referred to as segment 1, element 4. The fifth element of TABV2 is segment 3, element 5. Once the user has established the order of variables in the R array, then each variable may be referred to by its segment number and element number within that segment. This facilitates input/output and simplifies modifications to the program. Understanding the concept of the I and R arrays is extremely important to the use of VOLAR.

```
CØMMØN  TIME, TØ, DTIME, DTØUT, DTØUT2, TMAX
CØMMØN  TABV1(6), TABV2(10)
```

Variable	Segment No.	Element No.
TIME	1	1
TØ	1	2
DTIME	1	3
DTØUT	1	4
DTØUT2	1	5
TMAX	1	6
TABV1	2	1-6
TABV2	3	1-10

Figure A.1

Appendix E presents the variables in the R and I arrays for the analysis reported in this document.

A.5 The Main Program (Description of Options)

The program is divided into two input phases. The first phase is program initialization which defines the lengths for the R and I arrays. The second phase is user defined and directs the program through the various program options.

A.5.1 Program Initialization (Phase I)

Definition of the R and I array lengths are input through the following namelist. The lengths of the segments, defined in the program input, must be compatible with the number of variables in blank and labeled COMMON. The segment lengths allow the main program to bookkeep the absolute location of a variable in COMMON.

1	2 - 80
	$SEGMNT NSEGI=_____, NSEGR=_____, NPRNT=_____,

1	2 - 80
	NI(1)=___,___,___,...

1	2 - 80
	NR(1)=___,___,___,...

1	2 - 80
	$END

where:

NSEGI - Number of segments in the I array.

NSEGR - Number of segments in the R array.

NPRNT - Print option to display the segments and elements.
NPRNT = 0 - No print.
NPRNT ≠ 0 - Print.

NI - Array containing the number of elements in each I array segment.

NR - Array containing the number of elements in each R array segment.

NOTE: See paragraph A.5.3.1 for a sample input.

A.5.2 Program Options (Phase II)

The program is divided into 28 options to handle problem execution, input, and output. The definition of the options are as follows:

Option	Task
1	Write I and R array I/O instructions on a file.
2	Store data into the I array and write I array data on a file.
3	Print data from the I array.
4	Store data into the R array and write R array data on a file.
5	Print data from the R array.
6	Setup the differential equations.
7	Designate the time history variables from the R array to be written to a file by option 21.
8-9	Inactive.
10	Read data from input and generate a file compatible for options 14, 15, 17, or 18.
11	Store tabulating or punching instructions on a file. The file will be used in option 14 or 15.
12	Store printer plotter instructions on a file. The file will be used by option 17.
13	Store CalComp plotter instructions on a file. The file will be used by option 18.
14	Print the time history output in a tabular form.
15	Punch cards from the time history output.
16	Inactive.
17	Plot the time history output on the printer.
18	Plot the time history output on a CalComp plotter.
19	Print the contents of a file in blocked form.
20	Inactive.
21	Generate a time history.
22-27	Inactive.
28	Store the R array on Tape 28 or retrieve the R array from Tape 28.

A.5.2.1 Option 1 - Write I and R array I/O instructions on a file

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

3.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

4.

1-40	41-80
FMTI	FMTØ

where:

NOPT	-	Option number (input a 1 for this option).	(I5)
LBLØUT	-	Description of option.	(7A10)
NLIST	-	File where the instructions will be written.	(I5)
I	-	Beginning segment number of the I or R array.	(I5)
J	-	Beginning element number of the I or R array.	(I5)
K	-	Ending segment number of the I or R array.	(I5)
L	-	Ending element number of the I or R array.	(I5)
LABEL	-	Variable names for the elements defined between 1,J and K,L.	(5A10)
SCALE	-	Scale factor to be applied to the elements. Default is one.	(E10.3)
FMTI	-	Variable input format.	(4A10)
FMTØ	-	Variable output format	(4A10)

NOTE:

1. Multiple sets of cards 3 and 4 may be input.
2. FMTI and FMTØ are input only if I < 0.
3. Option 1 is terminated when a blank card is input for I,J,K,L.
4. See Paragraph A.5.3.2 for a sample input.

A.5.2.2 Option 2 - Store data into the I array

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	11-15	
NLIST	NDATA	NPF	

Input the following cards if NLIST = 5.

3.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

4.

1-40	41-80
FMTI	FMTØ

5.

1-5	6-10	11-15		76-80
IN(K+I)	IN(K+I+1)	IN(K+I+2)	. . .	IN(J+L)

where:

NØPT - Option number (input a 2 for this option). (I5)

LBLØUT - Option description. (7A10)

NLIST - File containing input instructions. (I5)

NDATA	-	File containing I array data.	(I5)
NPF	-	File to be created containing I array data. If NPF = 0, no file is created.	(I5)
I	-	Beginning segment number of the I array.	(I5)
J	-	Beginning element number of the I array.	(I5)
K	-	Ending segment number of the I array.	(I5)
L	-	Ending element number of the I array.	(I5)
LABEL	-	Variable names for the elements defined between I,J and K,L.	(5A10)
SCALE	-	Scale factor to be applied to the elements in the I array between I,J and K,L.	(E10.3)
FMTI	-	Variable input format.	(4A10)
FMTØ	-	Variable output format.	(4A10)
IN	-	I array elements (Default is 16I5 and may be changed to FMTI).	

NOTE:

1. Multiple sets of cards 3, 4 and 5 may be input.
2. The format for card 5 may be changed by specifying a negative I on card 3 and inputting the format on card 4.
3. If NLIST and NDATA are not equal to 5, cards 3, 4, and 5 are input from files NLIST and NDATA.
4. Option 2 is terminated when a blank card is input for I,J,K,L.
5. See Paragraph A.5.3.3 for a sample input.

A.5.2.3 Option 3 - Print from the I array

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

Input the following cards if NLIST = 5.

3.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

4.

1-40	
FMTØ	

where:

NØPT	-	Option number (input a 3 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where print instructions reside.	(I5)
I	-	Beginning segment number of the I array.	(I5)
J	-	Beginning element number of the I array.	(I5)
K	-	Ending segment number of the I array.	(I5)
L	-	Ending element number of the I array.	(I5)
LABEL	-	Variable names for the elements defined between I,J and K,L.	(5A10)
SCALE	-	Scale factor to be applied to the I array elements between I,J and K,L when printed. Default is one.	(E10.3)
FMTØ	-	Variable output format.	(4A10)

NOTE:

1. Multiple sets of cards 3 and 4 may be input.
2. The print format may be changed by specifying a negative I and inputting the format on card 4. The format is maintained until it is reset or another option is specified.
3. The option is terminated when a blank card is input for I,J,K,L.
4. See Paragraph A.5.3.4 for a sample input.

A.5.2.4 Option 4 - Store data into the R array, and write the R array on to a file

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	11-15	
NLIST	NDATA	NPF	

Input the following 2 cards if NLIST = 5.

3.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

4.

1-40	41-80
FMTI	FMTØ

Input the following card if NDATA = 5.

5.

1-10	11-20	21-30		71-80
R(K+I)	R(K+I+1)	R(K+I+2)	...	R(J+L)

where:

NØPT	-	Option number (input a 4 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File containing input instructions.	(I5)
NDATA	-	File containing R array data.	(I5)
NPF	-	File containing R array data is to be created. If NPF = 0, no file is created.	(I5)
I	-	Beginning segment number of the R array.	(I5)
J	-	Beginning element number of the R array.	(I5)
K	-	Ending segment number of the R array.	(I5)
L	-	Ending element number of the R array.	(I5)
LABEL	-	Variable names for the elements defined between I,J and K,L.	(5A10)
SCALE	-	Scale factor to be applied to the R array elements between I,J and K,L. Default is one.	(E10.3)
FMTI	-	Variable input format.	(4A10)
FMTØ	-	Variable output format.	(4A10)
R	-	R array elements (Default is 8F10.3 and may be changed to FMTI).	

NOTE:

1. The format for card 5 may be changed by specifying a negative I on card 3, and inputting the format on card 4. The format is maintained until it is reset or another option is specified.

2. If NLIST and NDATA are not equal to 5, cards 3, 4, and 5 are input from files NLIST and NDATA.

3. Multiple sets of cards 3, 4, and 5 may be input.

4. Option 4 is terminated when a blank card is input for I,J,K,L.

5. See Paragraph A.5.3.5 for a sample input.

A.5.2.5 Option 5 - Print from the R array.

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NTAP	

Input the following cards if NTAP = 5.

3.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

4.

1-40	
FMTØ	

where:

NØPT	-	Option number (input a 5 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NTAP	-	File where write instructions reside.	(I5)
I	-	Beginning segment number of the R array.	(I5)
J	-	Beginning element number of the R array.	(I5)
K	-	Ending segment number of the R array.	(I5)
L	-	Ending element number of the R array.	(I5)
LABEL	-	Variable names for the elements defined between I,J and K,L.	(5A10)
SCALE	-	Scale factor to be applied to the R array elements when printed. Default is one.	(E10.3)
FMTØ	-	Variable output format.	(4A10)

NOTE:

1. If NTAP is not equal to 5, cards 3 and 4 are input from file NTAP.
2. The default print format of (7F14.5) may be changed to FMTØ by specifying a negative I and inputting the new format. The new format remains in effect until reset or a new option is input.
3. Multiple sets of cards 3 and 4 may be input.
4. Option 5 is terminated by inputting a blank card for I,J,K,L.
5. See Paragraph A.5.3.6 for a sample input.

A.5.2.6 Option 6 - Set up differential equations.

This option is composed of five groups of data:

1. Derivative indices.
2. State indices.
3. PDØT and P indices.
4. PEDØT and PE indices.
5. PXDØT and PX indices.

Groups 3, 4, and 5 above must be input in the order specified. Each group of data is composed of cards 2 and 3 below.

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	
M	N	

3.

1-5	6-10	11-15	16-20	21-70
I	J	K	L	LABEL

where:

NØPT	-	Option number (input a 6 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
M	-	The segment number of the I array where the R array location of the differential equation elements will be stored.	(I5)
N	-	The element number of the I array where the R array location of the differential equation elements will be stored.	(I5)
I	-	Beginning segment number of the R array where the differential equation elements will be stored.	(I5)
J	-	Beginning element number of the R array where the differential equation elements will be stored.	(I5)
K	-	Ending segment number of the R array where the differential equation elements will be stored.	(I5)
L	-	Ending segment number of the R array where the differential equation elements will be stored.	(I5)
LABEL	-	Variable names for the elements defined between I,J and K,L.	(5A10)

NOTE:

1. Multiple sets of card 3 may be specified.
2. Each group of indices will be terminated when a blank card is specified for I,J,K,L.
3. PDØT and P indices are defined by I,J and K,L respectively.
4. PEDØT and PE indices are defined by I,J and K,L respectively.
5. PXDØT and PX indices are defined by I,J and K,L respectively.
6. See Paragraph A.5.3.7 for a sample input.

A.5.2.7 Option 7 - Designate the time history variables to be output

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	11-15	16-20	21-70
I	J	K	L	LABEL

where:

NØPT	-	Option number (input a 7 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
I	-	Beginning segment number of the R array to be output.	(I5)
J	-	Beginning element number of the R array to be output.	(I5)
K	-	Ending segment number of the R array to be output.	(I5)
L	-	Ending element number of the R array to be output.	(I5)
LABEL	-	Variable names for the elements defined between I,J and K,L.	(5A10)

NOTE:

1. Multiple sets of card 2 may be input
2. Option 7 is terminated when a blank card for I,J,K,L is input.
3. See Paragraph A.5.3.8 for a sample input.

A.5.2.8 Option 10 - Read data from input and generate a file compatible for options 14, 15, 17, and 18.

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

3.

1-5	6-10	11-15	
K1	K2	L	

Input the following card K1 times.

4.

1-10	11-20	21-30		71-80
RØW(1)	RØW(2)	RØW(3)	. . .	RØW(K2)

where:

NØPT	-	Option number (input a 10 for the option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where data is to be written.	(I5)
K1	-	Number of rows of data.	(I5)
K2	-	Number of columns of data.	(I5)
L	-	Data Flag	(I5)

L = 0 - Number of data points equal to the number of rows.

L ≠ 0 - First data point indicates the number of data points in a floating point number.

RØW	-	Data point array.	

NOTE:

1. See Paragraph A.5.3.9 for a sample input.

A.5.2.9 Option 11 - Store tabulating or punching instructions on a file

A. Cards for tabulating instructions.

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

3.

1-5	6-10	11-80
K1		TITLE

Input the following card K1 times.

4.

1-5	6-10	11-20	21-70	71-80
NTAP	K2	L	LABEL	SCALE

B. Cards for punching instructions.

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	
NLIST	I	

3.

1-5	6-10	11-20	21-70	71-80
NTAP	K2	L	LABEL	SCALE

where:

NØPT	-	Option number (input an 11 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where instructions will be written.	(I5)
I	-	Punching instruction flag.	(I5)
		I = 0 - Tabulating instruction.	
		I ≠ 0 - Punching instruction.	
K1	-	Number of columns for tabulated data (Maximum = 10).	(I5)
TITLE	-	Title for tabulated data.	(7A10)
NTAP	-	File where the instructions will reside.	(I5)
K2	-	Data column to be tabulated or punched.	(I5)
L	-	Column heading.	(A10)
LABEL	-	Variable description.	(5A10)
SCALE	-	Scale factor to be applied to the data (Default-1.0).	(E10.3)

NOTE:

1. K2 is the sequential number for the variable as ordered in option 7.
2. For tabulating instructions, multiple sets of cards 3 and 4 may be input. The option is terminated when a blank card is input for K1.
3. For punching instructions, a multiple set of card 3 may be input. The option is terminated wher a blank card for NTAP and K2 is input.
4. The file NLIST will be used in option 14 or 15.
5. See Paragraph A.5.3.10 for a sample input.

A.5.2.10 Option 12 - Store printer plot instructions on a file.

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

3.

1-5	
K1	

Input the following cards K1 times.

4.

1-80
TITLE

5.

1-80
TITLE

6.

1-80
TITLE

7.

1-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70
NCURVS		XPLØT	YPLØT	DELX	DELY	STARTX	STARTY

8.

1-40	41-80
FMTI	FMTØ

Input the following cards NCURVS times.

9.

1-40	41-45	46-50	51-55	56-57	58	59-60	61-70	71-80
LABEL	NDATA	NCØLX	NCØLY		NSYM		SCALEX	SCALEY

where:

NØPT	-	Option number (input a 12 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where instructions will be written.	(I5)
K1	-	Number of plots.	(I5)
TITLE	-	Three card plot title.	(8A10)
NCURVS	-	Number of curves per plot.	(I5)
XPLØT	-	Number of inches from left paper margin to the left end of the X axis.	(F10.3)
YPLØT	-	Number of inches from top of the paper to the bottom of the Y axis.	(F10.3)
DELX	-	Increment per inch on the X axis.	(F10.3)
DELY	-	Increment per inch on the Y axis.	(F10.3)
STARTX	-	X value at axis intersection.	(F10.3)
STARTY	-	Y value at axis intersection.	(F10.3)
FMTI	-	Label on X axis.	(4A10)
FMTØ	-	Label on Y axis.	(4A10)
LABEL	-	Legend associated with a curve.	(4A10)
NDATA	-	File where data for the curve is located.	(I5)
NCØLX	-	Column number on the file where the X data is located.	(I5)
NCØLY	-	Column number on the file where the Y data is located.	(I5)
NSYM	-	Plotting symbol.	(A1)
SCALEX	-	Scale factor to be applied to the X data (Default = 1.0).	(F10.3)
SCALEY	-	Scale factor to be applied to the Y data (Default = 1.0).	(F10.3)

NOTE:

1. See Paragraph A.5.3.11 for a sample input.

A.5.2.11 Option 13 - Store CalComp plotting instructions on a file

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

3.

1-10	11-20	
PCØDE	NTAP	

4.

1-5	6-10	11-15	
K1		L	

Input the following cards K1 times.

5.

1	2-80
	$PLØTD NCURVS=____,ANGLE=____,XPLOT=____,

6.

1	2-80
	YPLØT=____, XEXIT=____, YEXIT=____, XLEGND=____,

7.

1	2-80
	YLEGND=____, XØRG=____, YØRG=____, LNGTHX=____,

8.

1	2-80
	LNGTHY=____, STARTX=____, STARTY=____, DELX=____,

9.

1	2-80
	DELY=____, ISØPT=____$END

Input the following four cards if bit zero of ISØPT is one.

10.

1-80
TITLE

11.

1-80
TITLE

12.

1-80
TITLE

13.

1-80
TITLE

Input the following card if bit one of ISØPT is one.

14.

1-40	
LABELX	

Input the following card if bit two of ISØPT is one.

15.

1-40	
LABELY	

Input the following card if bit three of ISØPT is one.

16.

1-40	
LEGEND	

Input the next five cards if bit four of ISØPT is one.

17.

1-10	11-20	
X	Y	

18.

1-80
TITLE

19.

1-80
TITLE

20.

1-80
TITLE

21.

1-80
TITLE

Input the following cards NCURVS times.

22.

1	2-80
	$CURVE NDATA=____, NCØLX=____, NCØLY=____, NCX=____,

23.

1	2-80
	NCY=____, NCXY=____, LINTYP=____, DASH=____,

24.

1	2-80
	NSYM=____, SCALEX=____, SCALEY=____, SCALXX=____,

25.

1	2-80
	SCALYY=____ $END

26.

1-6	7-10	11-50	
K		LABEL	

where:

NØPT	-	Option number (input a 13 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
PCØDE	-	CalComp plot code.	(A10)
NTAP	-	File produced by CalComp.	(A10)
NLIST	-	File where plotting instructions will be written.	(I5)
K1	-	Number of plots to be produced.	(I5)
L	-	Indicator for plotting on centimeter paper. L = "C.M."	(A4)
NCURVS	-	Number of curves per plot	

ANGLE - Plot rotation angle in degrees (0 or 90 degrees).

XPLØT - Distance in inches for which the origin of the plot is to be moved in the X direction.

YPLØT - Distance in inches for which the origin of the plot is to be moved in the Y direction.

XEXIT - Final pen movement in the X direction.

YEXIT - Final pen movement in the Y direction.

XLEGND - X coordinate of the plot legend in inches.

YLEGND - Y coordinate of the plot legend in inches.

XØRG - X value at which axes intercept.

YØRG - Y value at which axes intercept.

LNGTHX - Length of X axis in inches.

LNGTHY - Length of Y axis in inches.

STARTX - Initial value on the X axis.

STARTY - Initial value on the Y axis.

DELX - Increment per inch on the X axis.

DELY - Increment per inch on the Y axis.

ISØPT - Bit array for read option. See Figure A.4.

BIT(0) = 1 - Read title to be centered over plot.
BIT(1) = 1 - Read X axis label.
BIT(2) = 1 - Read Y axis label.
BIT(3) = 1 - Read legend title.
BIT(4) = 1 - Read coordinates of the title and the title.

TITLE - Four card title. (8A10)

LABELX - X axis label. (4A10)

LABELY - Y axis label. (4A10)

LEGEND - Legend for the curve. (4A10)

X	-	X coordinate for the title.	(F10.3)
Y	-	Y coordinate for the title.	(F10.3)
NDATA	-	File where data to be plotted is located.	
NCØLX	-	Column number on the file where the X data is located.	
NCØLY	-	Column number on the file where the Y data is located.	
NCX	-	Column number where the X elliptical axis data is located.	
NCY	-	Column number where the Y elliptical axis data is located.	
LINTYP	-	Line type for plot.	
		LINTYP = Zero, line only (no symbol)	
		LINTYP = Negative, symbol only (no line)	
		LINTYP = Positive, both line and symbol	
DASH	-	Length of plotting segments for dashed line in inches. See Table A.1.	
NSYM	-	CalComp symbol code (99 if ellipse).	
SCALEX	-	Scale factor for the X data (Default = 1.0).	
SCALEY	-	Scale factor for the Y data (Default = 1.0).	
SCALXX	-	Scale factor for the X elliptical axis (Default = SCALEX).	
SCALYY	-	Scale factor for the Y elliptical axis (Default = SCALEY).	
K	-	Line style. See Table A.1.	(Ø6)
LABEL	-	Legend for line style.	(4A10)

NOTE:

1. See Paragraph A.5.3.12 for a sample input.
2. See Figure A.3 for a plot of ellipses of probability.
3. See Figure A.2 for a diagram of plotting variables.

Table A.1

LINE	LSTYLE	DASH
	177610	.01
	177610	.05
	177430	.01
	177430	.05
	177070	.01
	177070	.05
	177774	.01
	177774	.05
	177400	.01
	177400	.05
	177752	.01
	177752	.05
	177714	.01
	177714	.05
	125452	.01
	125452	.05
	170360	.01
	170360	.05
	177744	.01
	177744	.05
	177444	.01
	177444	.05
	146314	.01
	146314	.05
	176314	.01
	176314	.05
	177777	ANY

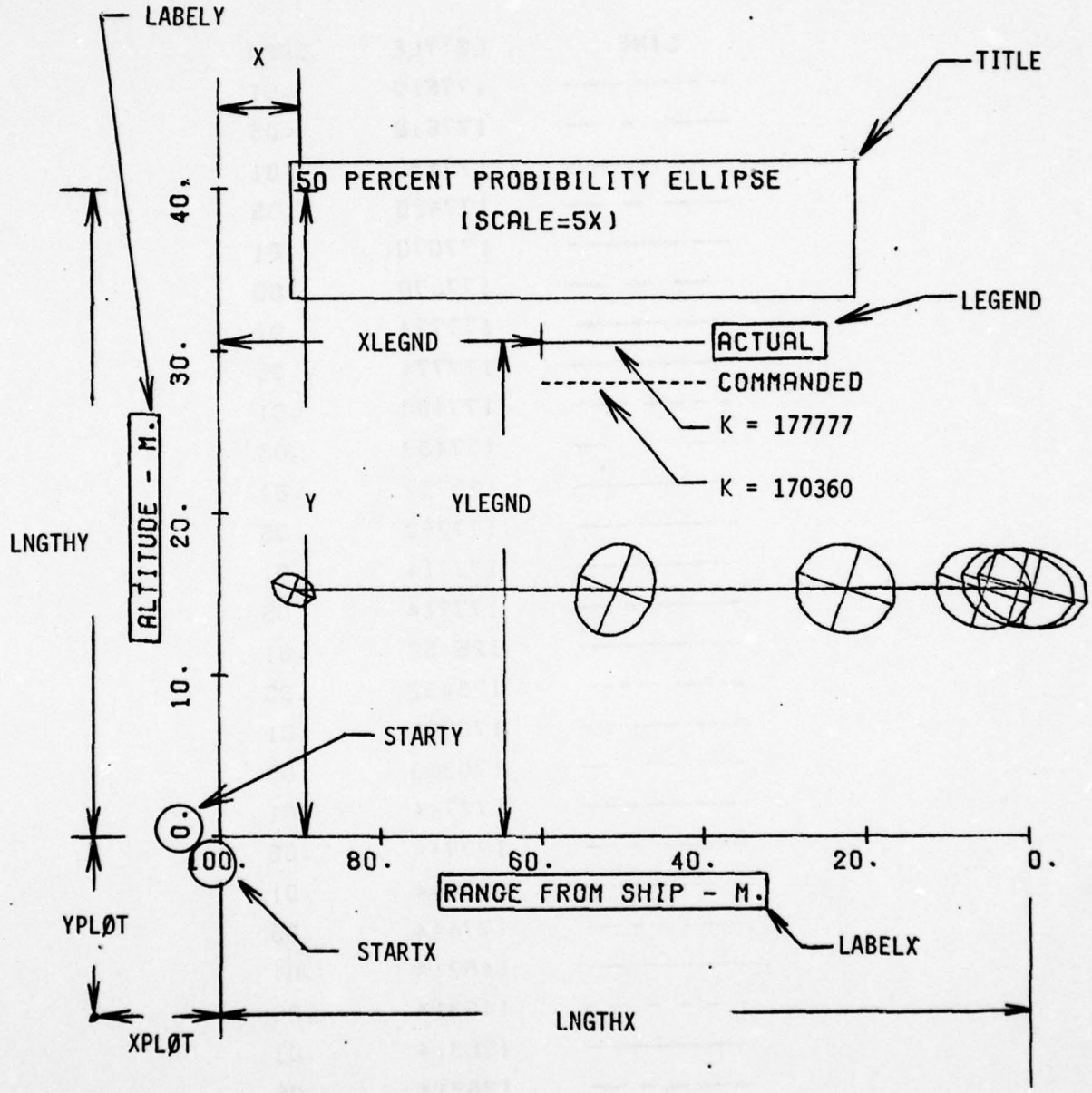
LABELY
X
TITLE
50 PERCENT PROBIBILITY ELLIPSE
(SCALE=5X)
LEGEND
XLEGND
ACTUAL
COMMANDED
K = 177777
K = 170360
Y
YLEGND
LNGTHY
ALTITUDE - M.
40.
30.
20.
10.
0.
STARTY
100.
80.
60.
40.
20.
0.
RANGE FROM SHIP - M.
YPLØT
STARTX
LABELX
LNGTHX
XPLØT

Figure A.2

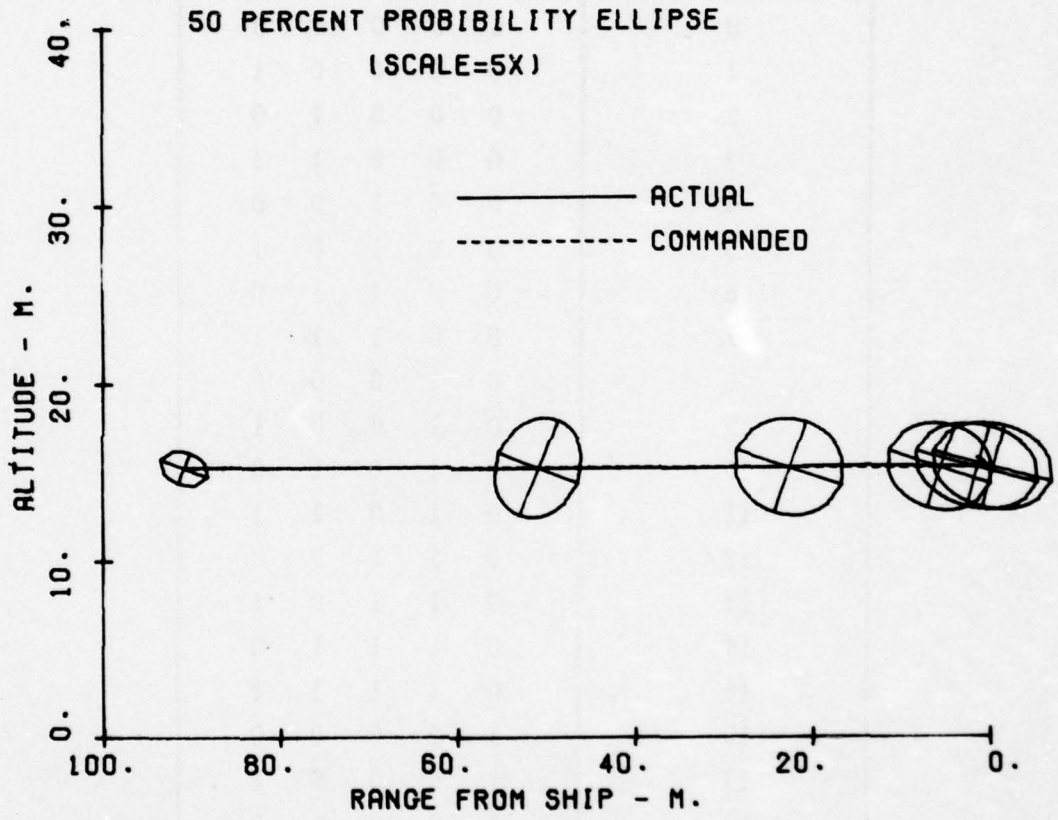

Figure A.3 Example of Probability Ellipses

60 BITS/WORD	
BITS 59 - 6	BITS 5 - 0

BIT #	4	3	2	1	0
VALUE	2^4	2^3	2^2	2^1	2^0

ISØPT	BIT PATTERN
0	0 0 0 0 0
1	0 0 0 0 1
2	0 0 0 1 0
3	0 0 0 1 1
4	0 0 1 0 0
5	0 0 1 0 1
6	0 0 1 1 0
7	0 0 1 1 1
8	0 1 0 0 0
9	0 1 0 0 1
10	0 1 0 1 0
11	0 1 0 1 1
12	0 1 1 0 0
13	0 1 1 0 1
14	0 1 1 1 0
15	0 1 1 1 1
16	1 0 0 0 0
17	1 0 0 0 1
18	1 0 0 1 0
19	1 0 0 1 1
20	1 0 1 0 0
21	1 0 1 0 1
22	1 0 1 1 0

Figure A.4

A.5.2.12 Option 14 - Print the time history in a tabular form

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

where:

NØPT	-	Option number (input a 14 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where tabulating instructions are located.	(I5)

NOTE:

1. File NLIST is generated by option 11.
2. See Paragraph A.5.3.13 for a sample input.

A.5.2.13 Option 15 - Punch the time history

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NLIST	

where:

NØPT	-	Option number (input a 15 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where the punching instructions are located	(I5)

NOTE:

1. File NLIST is generated by Option 11.
2. See Paragraph A.5.3.14 for a sample input.

A.5.2.14 Option 17 - Produce a printer plot of the time history

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	
NLIST	NPRNT	

Input the following cards if NLIST = 5.

3.

1-5	
NPLØTS	

Input the following cards NPLØTS times.

4.

1-80
TITLE

5.

1-80
TITLE

6.

1-80
TITLE

7.

1-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70
NCURVS		XØRG	YØRG	DELX	DELY	STARTX	STARTY

8.

1-40	41-80
LABELX	LABELY

Input the following card NCURVS times.

9.

1-40	41-45	46-50	51-55	56-57	58	59-60	61-70	71-80
LEGEND	NDATA	NCØLX	NCØLY		ISYM		SCALEX	SCALEY

where:

NØPT	-	Option number (input a 17 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where the plotting instructions are located.	(I5)
NPRNT	-	Print option to display input. NPRNT = 0 - no print NPRNT = 1 - print	(I5)
NPLØTS	-	Number of plots to be produced.	(I5)
TITLE	-	Three card plot title.	(8A10)
NCURVS	-	Number of curves per plot.	(I5)
XØRG	-	Number of inches from the left paper margin to begin the X axis.	(E10.3)
YØRG	-	Number of inches from the top of the paper margin to begin the Y axis.	(E10.3)
DELX	-	Increment per inch on the X axis.	(E10.3)
DELY	-	Increment per inch on the Y axis.	(E10.3)
STARTX	-	First value on the X axis.	(E10.3)
STARTY	-	First value on the Y axis.	(E10.3)
LABELX	-	X axis label.	(4A10)
LABELY	-	Y axis label.	(4A10)
LEGEND	-	Legend for the curve.	(4A10)
NDATA	-	File where the X and Y data are located.	(I5)

NCØLX	-	Column on the data file where the X data is located.	(I5)
NCØLY	-	Column on the data file where the Y data is located.	(I5)
ISYM	-	Curve plotting symbol.	(R1)
SCALEX	-	Scale factor to be applied to the X data.	(E10.3)
SCALEY	-	Scale factor to be applied to the Y data.	(E10.3)

NOTE:

1. Cards 3 through 9 may be eliminated by using option 12.
2. See Paragraph A.5.3.15 for a sample input.

A.5.2.15 Option 18 - Produce a CalComp plot of the time history

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	6-10	
NLIST	NPRNT	

3.

1-10	11-20	
K1	NTAP	

Input the following cards if NLIST = 5.

4.

1-5	6-10	11-4	
NPLØTS		I	

Input the following cards NPLØTS times.

5.

1	2-80
	$PLØTD NCURVS=___, ANGLE=___, XPLØT=___, YPLØT=___,

6.

1	2-80
	XEXIT=____, YEXIT=____, XLEGND=____, YLEGND=____,

7.

1	2-80
	XØRG=__, YØRG=__, LNGTHX=__, LNGTHY=__, STARTX=__,

8.

1	2-80
	STARTY=____, DELX=____, DELY=____, ISØPT=____ $END

Input the following 4 cards if bit zero of ISØPT is one.

9.

1-80
TITLE

10.

1-80
TITLE

11.

1-80
TITLE

12.

1-80
TITLE

Input the following card if bit one of ISØPT is one.

13.

1-40	
LABELX	

Input the following card if bit two of ISØPT is one.

14.

1-40	
LABELY	

Input the following card if bit three of ISØPT is one.

15.

1-40	
LEGEND	

Input the following 5 cards if bit four of ISØPT is one.

16.

1-10	11-20	
X	Y	

17.

1-80
TITLE

18.

1-80
TITLE

19.

1-80
TITLE

20.

1-80
TITLE

Input the following cards NCURVS times.

21.

1	2-80
	$CURVE NDATA=___, NCØLX=___, NCØLY=___, NCX=___,

22.

1	2-80
	NCY=___, NCXY=___, LINTYP=___, DASH=___, NSYM=___,

23.

1	2-80
	SCALEX=___, SCALEY=___, SCALXX=___, SCALYY=___ $END

24. 1-6 7-10 11-50

LABEL

where:

NØPT	-	Option number (input an 18 for this option).	(I5)
LBLØUT	-	Option description.	(7A10)
NLIST	-	File where the plot instructions are located.	(I5)
NPRNT	-	Print flag to display input (NPRNT=0, no print)	(I5)
K1	-	CalComp plot code.	(A10)
NTAP	-	File where CalComp writes its data.	(A10)
NPLØTS	-	Number of plots to be produced.	(I5)
I	-	Centimeter plot indicator. I = "C.M." pen movements are in centimeter.	(A4)
NCURVS	-	Number of curves per plot.	
ANGLE	-	Plot rotation angle in degrees.	
XPLØT	-	Distance in inches for which the origin of the plot is to be moved in the X direction.	
YPLØT	-	Distance in inches for which the origin of the plot is to be moved in the Y direction.	
XEXIT	-	Final pen movement in the X direction in inches.	
YEXIT	-	Final pen movement in the Y direction in inches.	
XLEGND	-	X coordinate of the plot legend in inches.	
YLEGND	-	Y coordinate of the plot legend in inches.	
XØRG	-	X value at which axes intercept (Default = 0.0).	
YØRG	-	Y value at which axes intercept (Default = 0.0).	
LNGTHX	-	Length of X axis in inches.	
LNGTHY	-	Length of Y axis in inches.	

STARTX	-	Initial value on the X axis.	
STARTY	-	Initial value on the Y axis.	
DELX	-	Increment per inch on the X axis.	
DELY	-	Increment per inch on the Y axis.	
ISØPT	-	Bit array for read option. See Figure A.4	
		BIT(0) = 1 - Read title to be centered over plot.	
		BIT(1) = 1 - Read X axis label.	
		BIT(2) = 1 - Read Y axis label.	
		BIT(3) = 1 - Read legend title.	
		BIT(4) = 1 - Read coordinates of the point and the title.	
TITLE	-	Four card plot title.	(8A10)
LABELX	-	X axis label.	(4A10)
LABELY	-	Y axis label.	(4A10)
LEGEND	-	Legend for the curve.	(4A10)
X	-	X coordinate for plot title.	(F10.0)
Y	-	Y coordinate for plot title.	(F10.0)
NDATA	-	File where the plot data is located.	
NCØLX	-	Column number on the data file where the X data is located.	
NCØLY	-	Column number on the data file where the Y data is located.	
NCX	-	Column number on the data file where the X elliptical axis data is located.	
NCY	-	Column number on the data file where the Y elliptical axis data is located.	
NCYY	-	Column number on the data file where the cross correlation data is located.	

LINTYP - Type of line for the plot.

LINTYP = zero, line only (no symbol)

LINTYP = negative, symbol only (no line)

LINTYP = positive, both line and symbol

DASH - Length of plotting segments for dashed lines in inches. See Table A.1.

NSYM - CalComp symbol code (99 if ellipse).

SCALEX - Scale factor to be supplied to the X data (Default = 1.0).

SCALEY - Scale factor to be applied to the Y data (Default = 1.0).

SCALXX - Scale factor to be applied to the X elliptical axis (Default = 1.0).

SCALYY - Scale factor to be applied to the Y elliptical axis (Default = 1.0).

LSTYLE - Line style. See Table A.1. (Ø6)

LABEL - Legend for line style. (4A10)

NOTE:

1. Cards 3 through 24 may be input from file NLIST generated by option 13.
2. Ellipses of probability may be plotted by specifying NSYM = 99, NCX, NCY, and NCXY. See Figure A.3 for an example of a plot with ellipses of probability.
3. See Paragraph A.5.3.16 for a sample input.
4. See Figure A.2 for a diagram of the plot variables.

A.5.2.16 Option 19 - Print the time history in a blocked form

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
NTAP	

where:

NØPT - Option number (input a 19 for this option). (I5)

LBLØUT - Option description. (7A10)

NTAP - File to be printed. (I5)

NOTE:

1. See Paragraph A.5.3.17 for a sample input.

A.5.2.17 Option 21 - Generate a time history

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-80
TITLE

3.

1-80
TITLE

4.

1-80
TITLE

5.

1-80
TITLE

6.

1-5	6-10	11-15	16-20	21-25	
NLIST	NTAP	NDATA	INT	NPRNT	

Input the following three cards as many times as needed if NLIST = 5.

7.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

8.

1-40	41-80
FMTI	FMTØ

9.

1-10	11-20	21-30		71-80
R(I+J)	R(I+J+1)	R(I+J+2)	. . .	R(K+L)

Input the following two cards as many times as needed if NTAP = 5.

10.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

Input the following card if I < 0.

11.

1-40	
FMTØ	

where:

NØPT	-	Option number (input a 21 for this option)	(I5)
LBLØUT	-	Option description.	(7A10)
TITLE	-	Four card title for problem definition.	(8A10)
NLIST	-	File containing the R array input instructions for the integration variables.	(I5)
NTAP	-	File containing the R array output instructions for the initial integration print.	(I5)
NDATA	-	File to be written containing the time history output. Variables set up by option 7.	(I5)

INT	-	Integration option. INT = 1 - Fourth order Runge-Kutta. INT = 2 - Third order Runge-Kutta. INT = 3 - Second order Adams.	(I5)
NPRNT	-	Print the time history as a block of data.	(I5)
I	-	Beginning segment number of the R array.	(I5)
J	-	Beginning element number of the R array.	(I5)
K	-	Ending segment number of the R array.	(I5)
L	-	Ending element number of the R array.	(I5)
LABEL	-	Variable names for the elements between I,J and K,L.	(4A10)
SCALE	-	Scale factor to be applied to R array data between I,J and K,L.	(E10.3)
FMTI	-	Variable input format for inputting data into the R array for card 9 above.	(4A10)
FMTØ	-	Variable output format for printing data from the R array. (Default = 7F14.5).	(4A10)
R	-	R array elements.	(F10.3)

NOTE:

1. Cards 7, 8, and 9 are input through Option 4. The branch to Option 4 occurs within Option 21 and is invisible to the user. Any R array element may be input through this option. To terminate the read for cards 7, 8, and 9, a blank card for I,J,K,L must be input.

2. If NLIST ≠ 5, cards 7 and 8 are input through file NLIST. Card 9 is input through file 5 (INPUT).

3. Cards 10 and 11 are input through option 5. These cards print the results of trim and the call to Setup. Any R array elements may be printed at this time. To terminate the read for cards 10 and 11, input a blank card for I,J,K,L.

4. If NTAP ≠ 5, input cards 10 and 11 through file NTAP.

5. See Paragraph A.5.3.18 for a sample input.

A.5.2.18 Option 28 - Store or retrieve R array data to or from a file (TAPE28)

1.

1-5	6-10	11-80
NØPT		LBLØUT

2.

1-5	
K1	

3.

1-5	6-10	11-15	16-20	21-70	71-80
I	J	K	L	LABEL	SCALE

where:

NØPT - Option number (input a 28 for this option). (I5)

LBLØUT - Option description. (7A10)

K1 - Data option flag. (I5)

K1 = 0 - Read data from a file (TAPE28).

K1 ≠ 0 - Write data to a file (TAPE28).

I - Beginning segment number of the R array to be read/written from/to the file. (I5)

J - Beginning element number of the R array to be read/written from/to the file. (I5)

K - Ending segment number of the R array to be read/written from/to the file. (I5)

L - Ending element number of the R array to be read/written from/to the file. (I5)

LABEL	-	Variable names appearing between segments I,J to K,L.	(5A10)
SCALE	-	Scale factor to be applied to the R array.	(E10.3)

NOTE:

1. Multiple sets of card 3 may be input.
2. To terminate option 28, a blank card for I,J,K,L must be input.
3. See Paragraph A.5.3.19 for a sample input.

A.5.3 Sample Input for Each Program Option

The following examples are sample inputs for the initialization phase and the program options.

A.5.3.1 Sample of program initialization

```
$SEGMNT NSEGI=7, NSEGR=143, NPRNT=1,
        NI(1)=10,0,0,14,14,6,
        NR(1)=6,17,17,26,18,11,37,66,9,37,
        NR(11)=14,18,6,10,0,6,19,0,0,10,
        NR(21)=10,10,10,10,10,0,6,6,6,6,
        NR(31)=6,6,6,6,6,6,6,6,6,6,
        NR(41)=6,6,6,6,6,6,6,6,0,289,
        NR(51)=289,289,44,16,50,50,75,75,75,75,
        NR(61)=75,75,6,6,6,6,6,6,6,6,
        NR(71)=6,6,6,6,6,6,6,6,6,6,
        NR(81)=36,24,42,49,28,1,1,1,1,24,
        NR(91)=16,1,1,1,1,1,1,1,1,1,
        NR(101)=1,1,1,1,1,1,12,6,6,6,
        NR(111)=6,6,6,6,6,6,6,6,6,6,
        NR(121)=6,6,6,6,6,6,6,6,6,6,
        NR(131)=6,6,6,6,10,10,10,10,10,4,
        NR(141)=4,4,4,
$END
```

A.5.3.2 Sample of Option 1

```
  1        STORE R ARRAY INSTRUCTIONS ON A FILE.
  3
  6    1     6     6  WEIGHT,G,IX,IY,IZ,IXZ
  6    7     6     9  LM, WM, LTDM
  7    9     7     9  TAUD
  7   28     7    29  OMEGAV, KV
  7   30     7    35  TAUA, K1, K2, KY, B1, B2
 13    1    13     6  TABV1  (V TABLE FOR AERO DATA)                          1.688
 14    1    14    10  TABV2  (TIME TABLE FOR OPEN LOOP INPUTS)
 20    1    20    10  TABTC  (OPEN LOOP THETA)
120    1   120     6  TYV
121    1   121     6  TYP
122    1   122     6  TYR
123    1   123     6  TYDA
124    1   124     6  TYDR
125    1   125     6  TLV
126    1   126     6  TLP
127    1   127     6  TLR
128    1   128     6  TLDA
129    1   129     6  TLDR
130    1   130     6  TNV
131    1   131     6  TNP
132    1   132     6  TNR
133    1   133     6  TNDA
134    1   134     6  TNDR
135    1   135    10  TABUB
136    1   136    10  TABWB
137    1   137    10  TXAPP
138    1   138    10  TZAPP
139    1   139    10  TXSP
140    1   140     4  TDAIN
141    1   141     4  TDAOUT
142    1   142     4  TDRIN
143    1   143     4  TDROUT
                      BLANK CARD FOR READ R
```

A.5.3.3 Sample of Option 2

```
  2        READ INTO I ARRAY
  5    5     0
  1    3     1     6  NSTATES, NPA, NOM, NGM
 11   17     4    11
  1    7     1    10  NPE, NPX, NOAW, NOINIT
  1    1     0     1
                      BLANK CARD FOR READ I
```

A.5.3.4 Sample of Option 3

```
3        PRINT DATA FROM THE I ARRAY
5
1    3    1    6  NSTATES, NPA, NOM, NGM
1    7    1   10  NPE, NPX, NOAW, NOINIT
                  BLANK CARD TO TERMINATE OPTION 3
```

A.5.3.5 Sample of Option 4

```
4        READ R   (CASE-PARTICULAR INPUT)
5    5   0
8   14   8   14  VAMB                                          1.688
20.
8   15   8  -15  PSIAMB                                       .01745329
150.
8   10   8   10  V5  (SHIP SPEED)                             1.688
20.
8   11   8   11  PSI5 ((SHIP HEADING)                         .01745329
30.
8    3   8    5  UAS, VAS, WAS
74.71     -7.012     10.495
3   15   3   16  PHI, PSI                                     .01745329
-1.       0.
5   10   5   12  SUMFYO, SUMLO, SUMNO
290.41    0.         0.
2   17   2   17  YSP
0.
2   14   2   14  YAPP
0.
7   36   7   37  TL1, TL2
10.       2.
16   5  16    6  GAINDA, GAINDR
1.        1.
                  BLANK CARD TO TERMINATE OPTION 4
```

A.5.3.6 Sample of Option 5

```
5        PRINT DATA FROM THE R ARRAY
5
2    1    2    5  UDOT, WDOT, QDOT, TDOT, XAPPDOT
-8   1    8    6  ALT, VAIR, UBAS, VBAS, WBAS, ALPHA
(6E20.10)
                  BLANK CARD TO TERMINATE OPTION 5
```

A.5.3.7 Sample of Option 6

```
 6          SETUP DIFFERENTIAL EQUATIONS
 4    1
 2   11     2   17  VDOT,PDOT,ROOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT
12   15    12   18  DA1D,DA2D,DP1D,DR2D
                    BLANK CARD TO TERMINATE DERIVATIVES
 5    1
 3   11     3   17  VB, PB, RB, YAPP, PHI, PSI, YSP
12   11    12   14  DA1,DA2,DR1,DR2
                    BLANK CARD TO TERMINATE STATES
 6    1
52    1    51    1  PDOT, P
                    BLANK CARD
 6    3
100   1    99    1  PED, PE
                    BLANK CARD
 6    5
104   1   103    1  PXHATD, PXHAT
                    BLANK CARD, END OF OPTION 6
```

A.5.3.8 Sample of Option 7

```
 7          DESIGNATE OUTPUT VARIABLES
 1    1     1    1  TIME
 8    1     8    2  ALT, VAIR
 3    5     3    6  XAPP, ZAPP
 3   14     3   14  YAPP
 3   17     3   17  YSP
 3   15     3   16  PHI, PSI
12    7    12    8  DA, DR
16    3    16    4  SIGDA, SIGDR
 3   11     3   11  VB
 3    1     3    2  UB, WB
 8   27     8   29  XM, YM, ZM
 8   30     8   32  PSIA, THETAA, PHIA
 8   33     8   35  SIGMAVX, SIGMAVY, SIGMAVZ
 8   39     8   42  UWIND, UMEAN, UR, UAW
 8   43     8   46  VWIND, VMEAN, VR, VAW
 8   47     8   50  WWIND, WMEAN, WR, WAW
55    1    55   17  SIGMAS OF THE STATES
11    9    11    9  ERY
16    1    16    2  SIGDAP, SIGDRP
                    BLANK CARD TO TERMINATE OPTION 7
```

A.5.3.9 Sample of Option 10

```
10          CREATE A FILE COMPATIBLE FOR OPTION 18
 5
 5    8    0
1.0       2.0       3.0       4.0       5.0       6.0       7.0       8.0
1.1       2.1       3.1       4.1       5.1       6.1       7.1       8.1
1.2       2.2       3.2       4.2       5.2       6.2       7.2       8.2
1.3       2.3       3.3       4.3       5.3       6.3       7.3       8.3
1.4       2.4       3.4       4.4       5.4       6.4       7.4       8.4
1.5       2.5       3.5       4.5       5.5       6.5       7.5       8.5
```

A.5.3.10 Sample of Option 11

```
11          STORE TABBING INSTRUCTIONS
 2     0
 9
10     1    TIME
10     2    ALT
10     3    VA-KTS                                          .5924
10     8    PHI                                            57.3
10     9    PSI                                            57.3
10     4    XAPP
10     6    YAPP
10     7    YSP
10    55    ERY
10
10     1    TIME
10    14    VB
10    30    VWIND
10    31    VMEAN
10    33    VAW
10    24  SIGMAVY
10    10    DA
10    11    DR
10    12   SIGDA
10    13   SIGDR
10
10     1    TIME
10    38   SIGV
10    39  SIGP-DEG                                        57.3
10    40  SIGR-DEG                                        57.3
10    41   SIGPHI                                         57.3
10    42   SIGPSI                                         57.3
10    43   SIGY
10    20   PSIA                                           57.3
10    21   THETAA                                         57.3
10    22   PHIA                                           57.3
 5
10     1    TIME
10    56   SIGDAP
10    57    SIGDRP
10    12    SIGDA
10    13    SIGDR
                    BLANK CARD TO TERMINATE OPTION 11
```

A.5.3.11 Sample of Option 12

```
12       STORE PRINTER PLOTTER INSTRUCTIONS ON A FILE.
 3
 3
                        VOLAR CHECKOUT - 16 FEB 78
                    EFFECT OF AIRWAKE ON SIMPLE MODEL
                              UAW VS TIME
   1     0.0       7.0       3.0       1.0
            TIME - SEC.                                  UAW     FT/SEC.
UAW IN FEET PER SECOND.                        10    1   40  U  1.0       1.0
                        VOLAR CHECKOUT - 16 FEB 78
                    EFFECT OF AIRWAKE ON SIMPLE MODEL
                              WAW VS TIME
   1     0.0       0.0       3.0       1.0
            TIME - SEC.                                  WAW     FT/SEC.
WAW IN FEET PER SECOND.                        10    1   48  W  1.0       1.0
                        VOLAR CHECKOUT - 16 FEB 78
                    EFFECT OF AIRWAKE ON SIMPLE MODEL
                              VAW VS TIME
   1     0.0       7.0       3.0       1.0
            TIME - SEC.                                  VAW     FT/SEC.
VAW IN FEET PER SECOND.                        10    1   44  V  1.0       1.0
```

A.5.3.12 Sample of Option 13

```
   13        STORE CALCOMP PLOTTER INSTRUCTIONS ON A FILE.
    2
CAL34       PLOT
    9
 $PLOTD NCURVS=1,XPLOT=2.0,YPLOT=0.5,ANGLE=0.0,LNGTHX=5.0,STARTX=500.0,
        DELX=-100.0,XORG=500.0,LNGTHY=4.0,STARTY=0.0,DELY=2.0,YORG=0.0,
        ISOPT=22,$END
          RANGE FROM SHIP - FT.
          SIGMA APP. PATH - FT.
5.0       9.75
     VOLAR CHECKOUT
       14 FEB 78
  EFFECT OF AIRWAKE
   ON SIMPLE MODEL
 $CURVE NDATA=10,NCOLX=21,NCOLY=31,LINTYP=0,DASH=0.01,SCALEX=1.0,
        SCALEY=1.0,$END
177777
 $PLOTD NCURVS=2,XPLOT=0.0,YPLOT=5.5,XLEGND=0.25,YLEGND=1.00,
        DELY=50.0,ISOPT=12,$END
             ALTITUDE - FT.
50 PERCENT PROB. ELLIPSE X 5
 $CURVE NCOLY=2,NSYM=99,LINTYP=10,NCX=23,NCY=24,NCXY=53,
        SCALXX=5.0,SCALYY=5.0,$END
177777    ACTUAL
 $CURVE NCOLY=16,LINTYP=0,SCALEY=-1.0,$END
170360    COMMANDED
 $PLOTD NCURVS=1,XPLOT=7.5,YPLOT=0.0,DELY=2.0,ISOPT=4,$END
          SIGMA XAP - FT.
 $CURVE NCOLY=23,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=-5.5,DELY=2.0,$END
          SIGMA ZAP - FT.
 $CURVE NCOLY=24,$END
177777
 $PLOTD   XPLOT=9.5,YPLOT=0.,DELY=2.     $END
            SIGMA THETA - DEG.
 $CURVE   NCOLY=22, SCALEY=57.3    $END
177777
 $PLOTD XPLOT=0.0,YPLOT=5.5,STARTY=-8.0,DELY=4.0,$END
              THETA - DEG.
 $CURVE   NCOLY=4   $END
177777
 $PLOTD   XPLOT=7.5,YPLOT=0.,STARTY=-.2,DELY=.1   $END
            DE - UNITS
 $CURVE   NCOLY=7, SCALEY=1.  $END
177777
 $PLOTD   XPLOT=0.,YPLOT=-5.5,STARTY=0.,DELY=.05  $END
           SIGMA DE - UNITS
 $CURVE   NCOLY=28  $END
177777
 $PLOTD   XPLOT=9.5,YPLOT=0.,DELY=10.0  $END
            SIGMA RPM - RPM
 $CURVE   NCOLY=25  $END
177777
```

A.5.3.13 Sample of Option 14

```
14      TAB THE OUTPUT
 2      TAB INSTRUCTIONS STORED ON FILE 2
```

A.5.3.14 Sample of Option 15

```
15        PUNCH TIME HISTORY
 3
```

A.5.3.15 Sample of Option 17

```
17       PRODUCE PRINTER PLOTS
 5    1
 3
                        VOLAR CHECKOUT - 16 FEB 78
                     EFFECT OF AIRWAKE ON SIMPLE MODEL
                                UAW VS TIME
   1     0.0       7.0       3.0       1.0
              TIME - SEC.                                UAW     FT/SEC.
UAW IN FEET PER SECOND.                    10    1   4C  U  1.0       1.0
                        VOLAR CHECKOUT - 16 FEB 78
                     EFFECT OF AIRWAKE ON SIMPLE MODEL
                                WAW VS TIME
   1     0.0       0.0       3.0       1.0
              TIME - SEC.                                WAW     FT/SEC.
WAW IN FEET PER SECOND.                    10    1   48  W  1.0       1.0
                        VOLAR CHECKOUT - 16 FEB 78
                     EFFECT OF AIRWAKE ON SIMPLE MODEL
                                VAW VS TIME
   1     0.0       7.0       3.0       1.0
              TIME - SEC.                                VAW     FT/SEC.
VAW IN FEET PER SECOND.                    10    1   44  V  1.0       1.0
```

A.5.3.16 Sample of Option 18

```
   18       PRODUCE CALCOMP PLOTS
    5    1
CAL34       PLOT
   10
 $PLOTD NCURVS=2,XPLOT=.75,YPLOT=0.0,ANGLE=0.0,LNGTHX=4.0,STARTX=0.0,
        DELX=5.0,XORG=0.0,LNGTHY=4.0,STARTY=00.0,DELY=40.0,YORG=0.0,
        ISOPT=6 ,XLEGND=2.0,YLEGND=1.0 $END
              TIME - SEC.
             LATERAL POS. - M.
 $CURVE DASH=.01,NDATA=10,NCOLX=1,NCOLY=6,LINTYP=0,SCALEX=1.0,SCALEY=.3048 $END
177777
 $CURVE DASH=.01,NDATA=10,NCOLY=7,$END
170360     COMMANDED
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY= 1.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
          SIGMA LAT. POS. - M.
 $CURVE DASH=.01,NDATA=10,NCOLY=43,SCALEX=1.0,SCALEY=.3048 $END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=-4.0,DELY=2.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=3.5 $END
             BANK ANGLE - DEG.
 $CURVE DASH=.01,NDATA=10,NCOLY=8,SCALEX=1.0,SCALEY=57.3 $END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY= 2.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
             SIGMA PHI - DEG.
 $CURVE DASH=.01,NDATA=10,NCOLY=41,SCALEX=1.0,SCALEY=57.3 $END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=-0.2,DELY=0.1,YORG=0.0,
        ISOPT=4,$END
          ROLL CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=10,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=.20,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
       SIGMA ROLL CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=56,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=6.0,YPLOT=-5.0,LNGTHY=4.0,STARTY= -.02,DELY=.01,
        YORG=0.0,ISOPT=4,$END
          YAW CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=11,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=  .01,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
      SIGMA YAW CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=57,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY= -2.0,DELY=1.0,
        YORG=0.0,ISOPT=4,$END
          LAT. POS. ERROR - M.
 $CURVE DASH=.01,NDATA=10,NCOLY=55,SCALEX=1.0,SCALEY=.3048,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=1.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
              YAW - M/SEC.
 $CURVE DASH=.01,NDATA=10,NCOLY=33,SCALEX=1.0,SCALEY=.3048,$END
177777
```

A.5.3.17 Sample of Option 19

```
19          PRINT A FILE IN BLOCKED FORM.
18
```

A.5.3.18 Sample of Option 21

```
21          GENERATE A TIME HISTORY BY COVARIANCE PROPAGATION.
             ****************************
             **          AV-8A           **
             **    35 KT WOD, LAT/DIR    **
             ****************************
 5     5    10     3     0
 1     3     1     6 DTIME, DTOUT, DTOUT2, TMAX
0.0125    0.2          5.0         5.0
                       BLANK CARD FOR READ R
 8     1     8    66   PRINT SEGMENT 8
                       BLANK CARD FOR WRITE R
```

A.5.3.19 Sample of Option 28

```
28          STORE R ARRAY VALUES ON TAPE28
 1          FILE TO BE CREATED
51     1     51 2764   P ARRAY
99     1     99  324   PE ARRAY
103    1    103  324   PXHAT ARRAY
93     1     93    9   VU ARRAY
94     1     94   36   VY ARRAY
                       BLANK CARD TO TERMINATE OPTION 28
```

A.5.4 Program Output

The program's output is divided into four categories: disk storage, printed output, plotted output and punched output. Before the time history output can be printed, plotted, or punched, it has to be stored on a file.

A.5.4.1 Disk storage

Disk storage is divided into two sections: instructions and time history.

A.5.4.1.1 Instruction storage

Option 1 stores I or R array instructions on a file. Options 2 and 4 have the capability of storing I and R array instructions with the data on a file by specifying the NPF parameter. Options 11, 12, and 13 store tabulating and plotting instructions on a file. Option 28 stores only the R array values on a file.

A.5.4.1.2 Time history storage

Option 21 stores the time history output (specified by Option 7) on a file. Option 10 reads input and creates a file of the same structure as the time history file. This file is thus compatible with the program's output features.

A.5.4.2 Printer output

The time history output can be printed in two forms: tabular and blocked.

A.5.4.2.1 Tabular output

Once the time history has been generated and stored on a file (A.5.4.1.2), a tabular print of the output can be produced by using Options 11 and 14. Option 11 designates which elements from the stored file (A.5.4.1.2) are to be printed along with page title and column headings. Option 14 produces the tabular print. See paragraphs A.5.3.10 and A.5.3.13 for examples of Options 11 and 14 respectively.

A.5.4.2.2 Blocked output

The contents of a file can be printed in a blocked form by using Option 19. The output elements are not titled but appear in the same order as they appear on the file being dumped. Option 21 has the capability to print the time history in a blocked form by specifying NPRNT $\neq$ 0. This is to be used for debugging because the print is generated every DTØUT seconds until job

termination. When using Option 14 to tab the output, the job must have executed normally. See paragraphs A.5.3.17 and A.5.3.19 for examples of Options 19 and 21 respectively.

A.5.4.3 Plot output

The time history output can be plotted in two forms: CalComp plots and printer plots.

A.5.4.3.1 CalComp plots

After the time history has been placed on a file (A.5.4.1.2), a CalComp plot can be produced by using Option 18. See the text for examples of the plots. See paragraph A.5.3.16 for an example of Option 18.

A.5.4.3.2 Printer plots

After the time history has been placed on a file (A.5.4.1.2), a printer plot can be produced by Option 17. The plots consist of a 7 by 7 inch grid with one plot per page. See paragraph A.5.3.15 for an example of Option 17. See Figure A.5.4.3.2 for a sample printer plot.

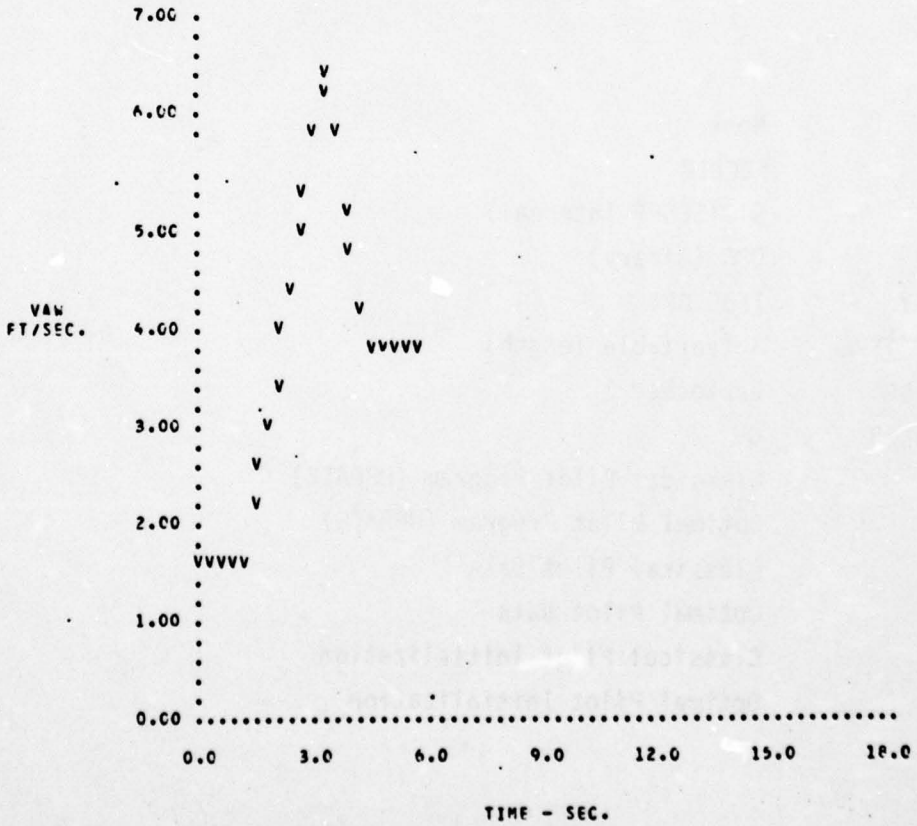

Figure A.5.4.3.2

A.5.4.4 Punched output

After the time history has been placed on a file (A.5.4.1.2), punched cards can be produced by using Options 11 and 15. Option 11 designates which elements from the stored file are to be punched. Option 15 produces the punched cards. See paragraphs A.5.4.10 and A.5.4.14 for examples of Options 11 and 15 respectively.

A.6 Program Flow

An overall picture of program flow is illustrated in Figure A.5.

A.7 Discussion of Control Cards

The following discussion of control cards is sufficient to place the VOLAR program online and execute its sample problems.

A.7.1 Transferring the Data from Magnetic Tape to Disk

Table A.2 is a description of how the tape was created.

Table A.2

TRACK	9
LABEL	None
CODE	EBCDIC
FORMAT	SI (SCOPE Internal)
PARITY	ODD (Binary)
DENSITY	1600 BPI
RECORD TYPE	S (Variable length)
BLOCKING	Unblocked
NO. FILES	6
1	Classical Pilot Program (UPDATE)
2	Optimal Pilot Program (UPDATE)
3	Classical Pilot Data
4	Optimal Pilot Data
5	Classical Pilot Initialization
6	Optimal Pilot Initialization

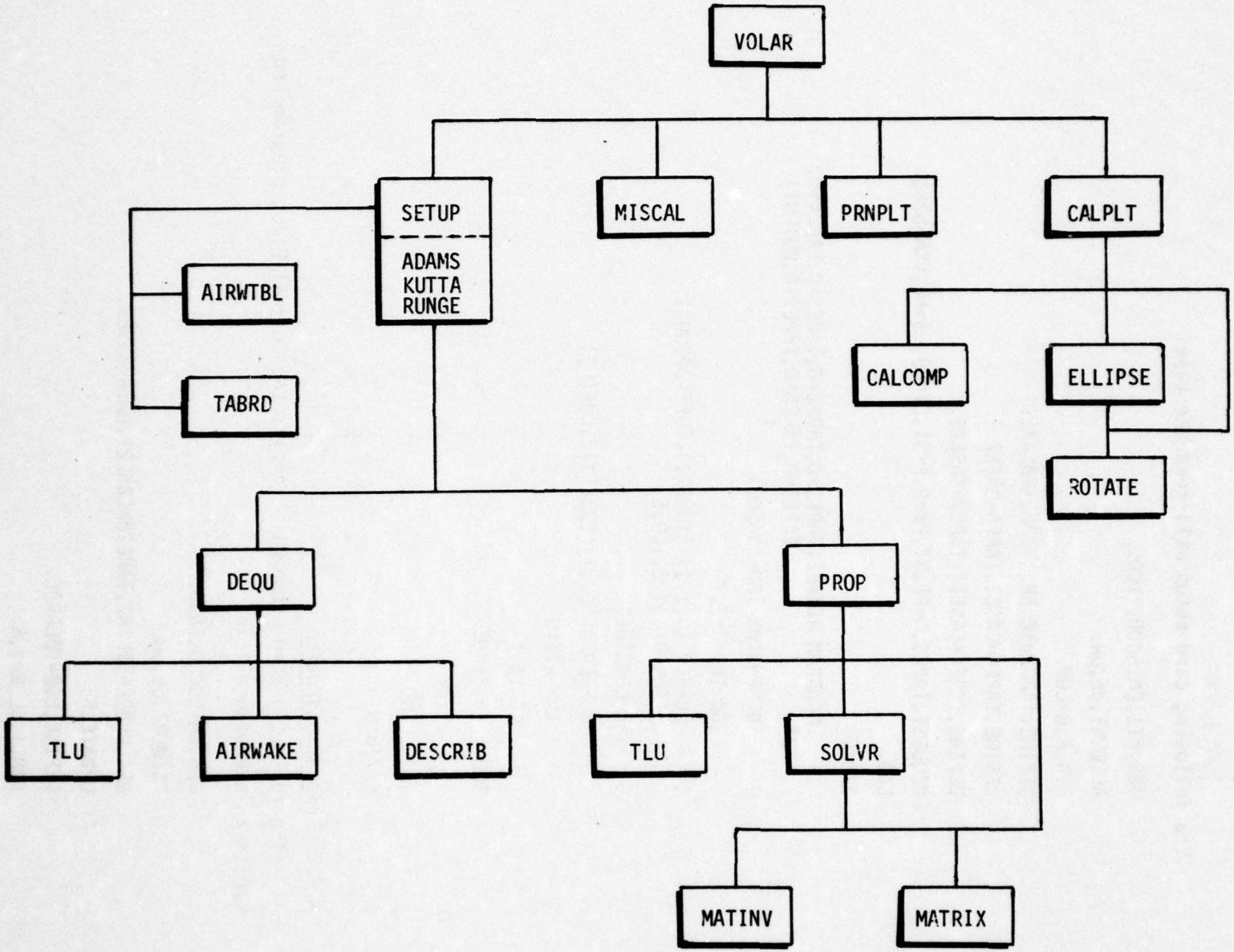
VOLAR
SETUP
ADAMS
KUTTA
RUNGE
MISCAL
PRNPLT
CALPLT
AIRWTBL
TABRD
CALCOMP
ELLIPSE
ROTATE
DEQU
PROP
TLU
AIRWAKE
DESCRIB
TLU
SOLVR
MATINV
MATRIX

Figure A.5

The following card setup will read the tape:

```
JØB,NT1,CM15000,T100.
ACCØUNT,cn,pw.
FTN,A,B=LGØ.
DEFINE,TAPE2=VØLAR1,TAPE3=VØLAR2.
DEFINE,TAPE4=CASE1,TAPE5=CASE2.
DEFINE,TAPE6=CASE1I,TAPE7=CASE2I.
REQUEST,TAPE1,D=PE,NT,PØ=R,F=SI,CV=EB,LB=KL,VSN=5251.
LGØ.
7/8/9
      PRØGRAM RDTAPE(TAPE1=0,TAPE2=0,TAPE3=0,TAPE4=0,
     *               TAPE5=0,TAPE6=0,TAPE7=0,ØUTPUT)
      DIMENSIØN IBUF(30000)
      DØ 100 J=2,7
1     BUFFER IN(1,1) (IBUF(1),IBUF(30000))
      IF(UNIT(1)) 5,100,5
5     L=LENGTH(1)
      BUFFER ØUT(J,1)(IBUF(1),IBUF(L))
      IN=UNIT(J)
      GØ TØ 1
100   CØNTINUE
      STØP
      END
6/7/8/9
```

A.7.2 Program Execution

The following card setup will compile the Optimal Pilot program and create an executable file:

```
JØB,CM150000,T500.
ACCØUNT,cn,pw.
GET,ØLDPL=VØLAR2,TAPE28=CASE2I,DATA=CASE2.
UPDATE,F.
DEFINE,LGØ=VØLAR2E.
FTN,I,SL,R=3,A.
```

```
MAP,FULL.
LDSET,PRESET=ZERØ,LIB=CALCØMP.
LGØ,DATA.
7/8/9
6/7/8/9
```

A.7.3 Program Modification

The following card setup will modify one of the routines in the Optimal Pilot program and execute the program.

```
JØB,CM150000,T500.
ACCØUNT,cn,pw
GET,ØLDPL=VØLAR2,ØLD=VØLAR2E.
UPDATE.
FTN,I,SL,R=3,A.
CØPYL.
MAP,FULL.
LDSET,PRESET=ZERØ,LIB=CALCØMP.
NEW.
7/8/9
    UPDATE CHANGE CARDS GØ HERE.
7/8/9
    INPUT DATA CARDS GØ HERE.
6/7/8/9
```

A.8 Discussion of Input Deck for the Classical Pilot Model Simulation

The purpose of this section is to lead the prospective user of VOLAR through a sample input deck. The discussion here will focus on the necessary flow of options to generate a time history and point out any special input requirements that might not be obvious to the new user. This input deck is identical to the one which generated the AV-8A classical pilot model simulation and plots for the case with control limiting. After studying this section the user should run this case on his computer.

A schematic of the job setup to run this case is presented in Figure A.6. Figure A.7 is a listing of the input deck. The circled numbers provide a cross reference to this test; i.e., the cards following ④ are discussed below in Section A.8.4.

Throughout the discussion of this input deck, it may be beneficial to the reader to refer to the description in Section A.5 of the main program and its options.

A.8.1 Namelist Input

The first step is to provide the main program with the information required to bookkeep the I and R arrays. The namelist SEGMNT establishes the number of segments in each array and the number of elements in each segment. The format for NAMELIST inputs can be found in the CDC FORTRAN manual.

The namelist SEGMNT is the one and only mandatory input. All other inputs are either user selected options or input required by the chosen option.

For this case the I array is seven segments long, and the R array is composed of 143 segments. The NPRNT = 1 causes the I and R array segmentation information to be output. The lengths of the segments are consistent with the I and R arrays presented in Appendix E.

A.8.2 Option 2

Integer values that define system size and control the selection of certain calculations are input here. These parameters are defined in Appendix E.

Although NPE and NPX are dimensions of matrices used only in the optimal pilot case, they are given a value of one (1) here. The reason is the

integration subroutines expect to integrate a set of means and three matrices. By giving NPE and NPX a small value, a negligible increase in run time is traded for the simplicity of having only one set of integration subroutines. This keeps the number of problem dependent subroutines to an absolute minimum.

This run will include the ship airwake (NOAW = 0) and is not an initialization run (NOINIT = 1).

A.8.3 Option 4

Required values of the R array are input next. At Vought fixed geometric and aerodynamic properties are input here. Case-dependent information is input later in the deck. At the beginning of job execution, the 'LDSET, PRESET = ZERO' control card initializes core to zero. Therefore, parameters not initialized through Option 4 begin with a value of zero.

Note that the inertias are input here as 1 (obviously not the true value). However, they are not required to generate accelerations (Vought used dimensional derivatives) but inertias do appear in SETUP in a denominator. This is all related to the calculation of forces and moments in DEQU, where the total forces and moments that drive the mean equations must be obtained from a reference condition and the perturbation forces and moments.

Tables defining the independent variable arrays, open loop inputs, aerodynamic data and nonlinear elements are also input here.

The weight and aerodynamic derivatives are from Reference 15. The ship geometry inputs represent a DD-963. Feedback gains and time constants are for the classical pilot model discussed in Section 6. The values of TABUB, TABWB, TXAPP, TZAPP, and TXSP were derived from the task description. These tables provide the reference longitudinal values required by the lateral/directional equations. The final four tables define the nonlinear functions (control limiters) discussed in Section 4.

A.8.4 Option 6

Here the user specifies the variables that are to be integrated and the variables that contain the integrated values. This option allows one to use any variable in blank COMMON as an integrand or integrated value.

Note that the setup includes the matrices PED, PE, PXHATD, and PXHAT. These are associated with the optimal pilot model and not required by the classical model. In Section A.8.2 it was noted that these are specified as 1 by 1 matrices (NPE and NPX) and included in this setup to avoid the need for two sets of integration subroutines.

A.8.5 Option 7

The variables specified here appear on the output file. Their selection is totally up to the user. All of the output features (tabbing, plotting, etc.) access the file containing the Option 7 specified variables.

A.8.6 Option 11

The variables to be tabbed are user defined. Here it was attempted to tabulate all the key parameters for interpreting the performance of a given task.

A.8.7 Option 4

The case-particular input goes here. The order is not important.

The first two terms in this input are ambient wind magnitude and direction. The ambient wind gets into the calculation of airspeed and wind over deck.

The ship's speed and heading are also input. The ambient wind and ship conditions were selected to give 35 knots wind over deck comming at 30 degrees to port. This value is a 'breakpoint' in the ship airwake model data tables.

The initial body axis components of airspeed are necessary to initialize the airplane inertial speed. Aside from this exception, airspeeds are calculated in DEQU from inertial speeds. This particular representation was chosen because it was felt that most often the airplane flight conditions would be specified by stating an airspeed, angle-of-attack, and sideslip. If this is undesirable, the user can modify DEQU to meet his needs. The mean components of the airwake, that enter into the calculation of airspeed, may be obtained by requesting a zero second time history after specifying the airplane and ship positions in space.

The initial aircraft bank angle is -1 degree, and the aircraft's heading is zero degrees. The bank angle is required to balance out the initial side force on the airplane. The initial side force is due to the non-zero value of sideslip (VAS $\neq$ 0).

The value of SUMFYO was obtained from Y_v. The initial values of SUMLO and SUMNO are zero. It is assumed that the roll and yaw controls would trim out the moments due to N'_v and L'_v so that the total moments on the airplane are zero. SUMFYO, SUMLO, and SUMNO are total force and moments on the airplane and are required in subroutine SETUP to initialize YO, LO, and NO.

The initial displacements of the ship and airplane along the y earth axis are input as zero. The x-axis displacements of the ship and airplane, and the z axis displacement of the airplane were previously input in table form.

A.8.8 Option 28

This option reads data stored from a previous run. It is used here to initialize the P matrix.

In the previous run, NOINIT was set to -1 (all other input discussed to this point remains unchanged). This froze the means and integrated only the covariance matrix. When NOINIT = -1, Option 28 should follow Option 21. Refer to Section A.5 for using Option 28 in a BUFFER IN or BUFFER OUT mode.

This initialization is necessary to start the P matrix at realistic values. Because the airplane did not suddenly appear at a point 16 seconds away from the ship, beginning with P = 0 is unrealistic. The airplane flew through the atmosphere (and its disturbances) to get to the point in the trajectory where the VOLAR simulation picks it up. The question then becomes one of determining what is a realistic method to use for initializing the covariance matrix.

Subroutine SOLVR provides a method for initializing P. SOLVR calculates the steady-state (i.e. $t \to \infty$) value of P. This solution would provide an upperbound on the uncertainties (i.e. the value of P). However, SOLVR will not work for the optimal pilot cases because there are three inter-related covariance matrices, and it is programmed to solve only one. Also, one might argue that $t \to \infty$ statistics may not be realistic either. Note that if the system is unstable, $P \to \infty$ as $t \to \infty$.

The approach selected here was to integrate the P matrix for some period of time. Five seconds was selected. For a stable system, the P matrix will approach its steady state value fairly rapidly. This is something the user

must evaluate on a case by case basis. For the runs presented here, 5 seconds was quite adequate. One more comment is in order. When making initialization runs, it is often necessary to use a lower integration increment and/or a higher order integration scheme than in the simulation runs. The reason is the elements of the P matrix often undergo wild perturbations, before settling out, when all the elements are initialized to zero.

A.8.9 Option 21

This option generates time histories of the means and covariances. The example presented here asks for a 20 second time history using Adams integration. The covariance matrix will be printed out at the initial time point (t = 0) and every 20 seconds. The output file is TAPE10.

After the call to SETUP, before the integration process begins, the elements of segment eight will be output. This was done to check on the parameters associated with the airwake calculations. It is not necessary to output anything here. But often, the user desires to know some parameter values but does not want to take up space on the output file. This is a convenient place to look at the values of such parameters.

For a given stepsize, Adams integration is three times faster than the third order Runge-Kutta and four times faster than the fourth order. However, the Adams integration stepsize will normally have to be lower than the Runge-Kutta stepsizes to obtain the same degree of accuracy. We have found the stepsize change does not offset the speed advantage; and for production running, Adams integration is preferable. As the user modifies these routines and/or treats new problems, he should spot check his integration to confirm the accuracy of the simulation. Integration problems normally manifest themselves as time history divergence, indefinite parameter values, or infinite parameter values.

A.8.10 Option 14

This option causes the output file to be tabbed according to the instructions stored by Option 11.

A.8.11 Option 18

For some runs, the user may desire CalComp plots as well as tabbed output. The final option in this setup directs the plotting of 15 parameters from the output file. Normally one does not plot in the same run that generates the output file. It is difficult to know a priori good scales for the plots. The scales presenting these data were selected after having seen a tab output of the desired parameters.

A good description of the input required by the plot package has already been presented in Section A.5.2. The best approach to setting up plot instructions is to lay out the desired axes on regular graph paper, and use the grids to develop the distances for pen movement, etc.

A.9 Discussion of an Input Deck for the Optimal Pilot Model Simulation

The purpose of this section is to lead the prospective user of VOLAR through a sample input deck for the optimal pilot-model simulation. The user should be familiar with Section A.5 which discusses the main program and its options. The discussion here will focus on the necessary flow of options to generate a time history and point out any special inputs that might not be obvious to the new user. This input deck is identical to the one which generated the 20 second sea state 5 time histories appearing in Figure 26.

A schematic of the job setup to run this case is presented in Figure A.8. Figure A.9 is a listing of the input deck. The circled numbers were added to provide a cross reference to this text; i.e. the cards following ④ are discussed below in Section A.9.4.

After studying this example, the user should run this case on his computer.

A.9.1 Namelist Input

The first step is to provide the main program with the information required to bookkeep the I and R arrays. The namelist SEGMNT establishes the number of segments in each array and the number of elements in each segment.

The namelist SEGMNT is the one and only mandatory input. All other inputs are either user selected options or input required by the chosen option.

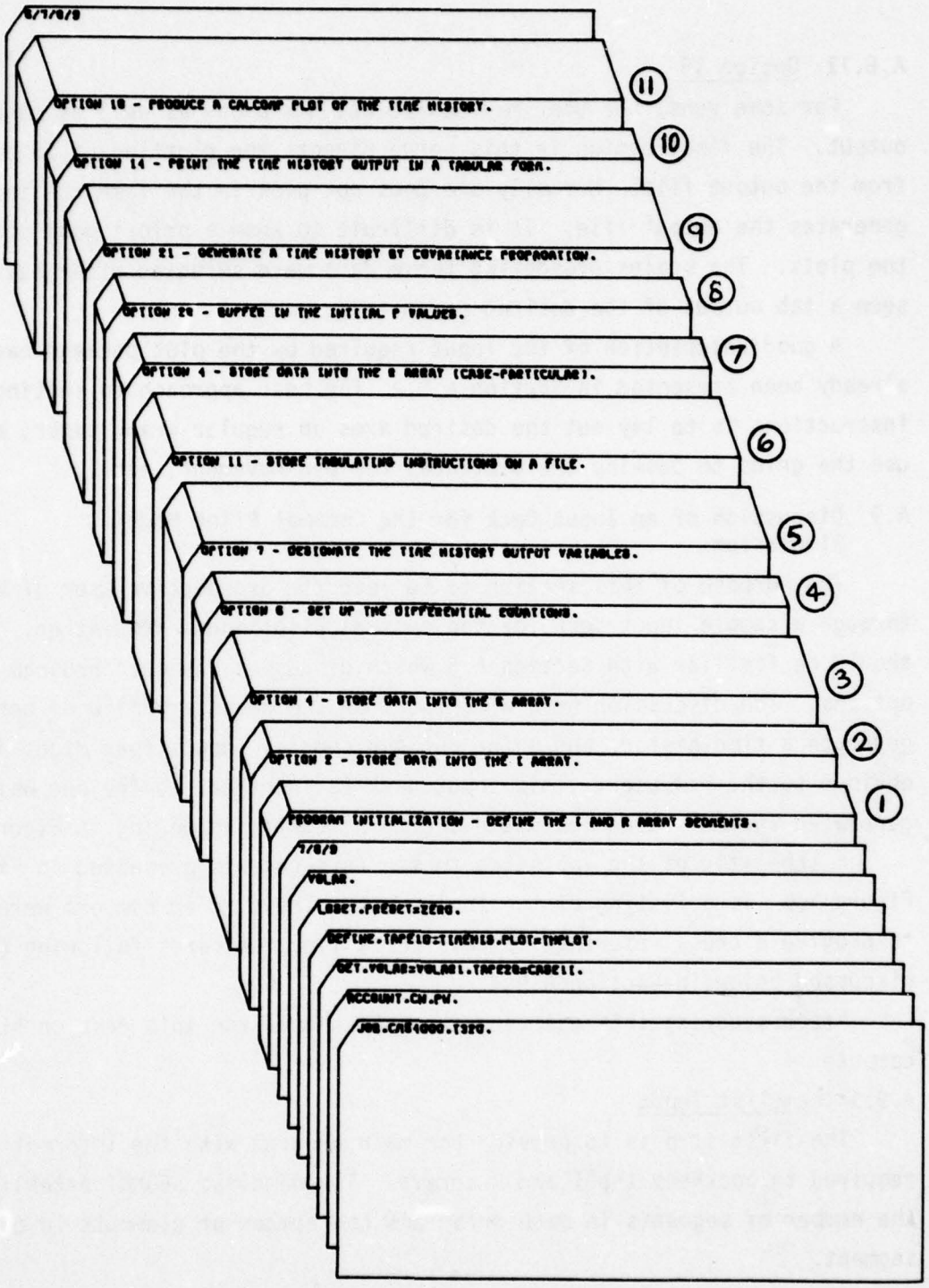
6/7/8/9
OPTION 10 - PRODUCE A CALCOMP PLOT OF THE TIME HISTORY.
11
OPTION 14 - PRINT THE TIME HISTORY OUTPUT IN A TABULAR FORM.
10
OPTION 21 - GENERATE A TIME HISTORY BY COVARIANCE PROPAGATION.
9
OPTION 20 - BUFFER IN THE INITIAL P VALUES.
8
OPTION 4 - STORE DATA INTO THE R ARRAY (CASE-PARTICULAR).
7
OPTION 11 - STORE TABULATING INSTRUCTIONS ON A FILE.
6
OPTION 7 - DESIGNATE THE TIME HISTORY OUTPUT VARIABLES.
5
OPTION 6 - SET UP THE DIFFERENTIAL EQUATIONS.
4
OPTION 4 - STORE DATA INTO THE E ARRAY.
3
OPTION 2 - STORE DATA INTO THE I ARRAY.
2
PROGRAM INITIALIZATION - DEFINE THE I AND R ARRAY SEGMENTS.
1
7/8/9
VOLAR.
LGSET.PRESET=ZERO.
DEFINE.TAPE10=TIMEHIS.PLOT=TMPLOT.
GET.VOLAR=VOLAR1.TAPE22=CASE11.
ACCOUNT.CW.PW.
JOB.CM64000.T320.

Figure A.6

```
① $SEGMNT NSEGI=7, NSEGR=143, NPRNT=1,
          NI(1)=10,0,0,14,14,6,
          NR(1)=6,17,17,26,18,11,37,66,9,37,
          NR(11)=14,18,6,10,0,6,19,0,0,10,
          NR(21)=10,10,10,10,10,0,6,6,6,6,
          NR(31)=6,6,6,6,6,6,6,6,6,6,
          NR(41)=6,6,6,6,6,6,6,6,0,289,
          NR(51)=289,289,44,16,50,50,75,75,75,75,
          NR(61)=75,75,6,6,6,6,6,6,6,6,
          NR(71)=6,6,6,6,6,6,6,6,6,6,
          NR(81)=36,24,42,49,28,1,1,1,1,24,
          NR(91)=16,1,1,1,1,1,1,1,1,1,
          NR(101)=1,1,1,1,1,1,12,6,6,6,
          NR(111)=6,6,6,6,6,6,6,6,6,6,
          NR(121)=6,6,6,6,6,6,6,6,6,6,
          NR(131)=6,6,6,6,10,10,10,10,10,4,
          NR(141)=4,4,4,
   $END
② 2        READ INTO I ARRAY
   5   5    0
   1   3    1    6  NSTATES, NPA, NOM, NGM
  11  17    4   11
   1   7    1   10  NPE, NPX, NOAW, NOINIT
   1   1    0    1
                    BLANK CARD FOR READ I
③ 4        READ R
   5   5    0
   6   1    6    6  WEIGHT,G,IX,IY,IZ,IXZ
16300.     32.174    1.        1.        1.        0.
   6   7    6    9  LM, WM, LTDM
438.       46.75     348.
   7   9    7    9  TAUD
0.2
   7  28    7   29  OMEGAV, KV
2.         3.
   7  30    7   35  TAUA, K1, K2, KY, B1, B2
0.1        1.12      2.83      .010      1.        2.
   7  36    7   37  TL1, TL2
10.        2.
  13   1   13    6  TABV1  (V TABLE FOR AERO DATA)                              1.688
0.         30.       50.       65.       80.       105.
  14   1   14   10  TABV2  (TIME TABLE FOR OPEN LOOP INPUTS)
0.         2.        4.        6.        8.        10.       12.
14.        16.       20.
  16   5   16    6  GAINDA, GAINDR
1.         1.
  20   1   20   10  TABTC  (OPEN LOOP THETA)
.13964     .13964    .13964    .13964    .13964    .13964    .13964
.13964     .13964    .13964
 120   1  120    6  TYV
-.034      -.063     -.088     -.104     -.120     -.138
 121   1  121    6  TYP
 0.        0.        0.        0.        0.        0.
 122   1  122    6  TYR
-.225      -.240     -.24      -.235     -.235     -.215
 123   1  123    6  TYDA
0.         -.006     -.015     -.026     -.039     -.065
 124   1  124    6  TYDR
-.68       -.67      -.70      -.75      -.80      -.90
 125   1  125    6  TLV
-.002      -.0144    -.0197    -.0204    -.0184    -.0104
 126   1  126    6  TLP
-.13       -.42      -.62      -.79      -1.0      -1.38
```

Figure A.7

```
 127     1  127     6  TLR
.015        .15        .24        .31        .375       .49
 128     1  128     6  TLDA
.5          .5         .5         .5         .5         .5
 129     1  129     6  TLDR
-.06        -.065      -.075      -.08       -.095      -.13
 130     1  130     6  TNV
-.0036      -.0021     -.0010     0.         .0014      .0047
 131     1  131     6  TNP
-.005       -.032      -.053      -.072      -.091      -.126
 132     1  132     6  TNR
-.042       -.088      -.12       -.142      -.164      -.203
 133     1  133     6  TNDA
.03         .03        .031       .033       .035       .040
 134     1  134     6  TNDR
.225        .235       .243       .248       .255       .265
 135     1  135    10  TABUB
65.869      61.254     56.640     52.025     47.410     42.796     38.181
33.566      28.952     28.952
 136     1  136    10  TABWB
9.257       8.608      7.96       7.311      6.663      6.014      5.366
4.717       4.069      4.069
 137     1  137    10  TXAPP
0.          128.372    247.425    357.157    457.57     548.662    630.434
702.887     766.02     882.964
 138     1  138    10  TZAPP
-50.        -50.       -50.       -50.       -50.       -50.       -50.
-50.        -50.       -50.
 139     1  139    10  TXSP
298.24      356.712    415.185    473.657    532.13     590.602    649.07
707.547     766.02     882.964
 140     1  140     4  TDAIN
-5.         -.9        .9         5.
 141     1  141     4  TDAOUT
-.9         -.9        .9         .9
 142     1  142     4  TDRIN
-5.         -.532      .532       5.
 143     1  143     4  TDROUT
-.532       -.532      .532       .532
                       BLANK CARD FOR READ R
④  6        SETUP DIFFERENTIAL EQUATIONS
   4     1
   2    11    2    17  VDOT,PDOT,RDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT
  12    15   12    18  DA1D,DA2D,DR1D,DR2D
                       BLANK CARD TO TERMINATE DERIVATIVES
   5     1
   3    11    3    17  VB, PB, RB, YAPP, PHI, PSI, YSP
  12    11   12    14  DA1,DA2,DR1,DR2
                       BLANK CARD TO TERMINATE STATES
   6     1
  52     1   51     1  PDOT, P
                       BLANK CARD
   6     3
 100     1   99     1  PED, PE
                       BLANK CARD
   6     5
 104     1  103     1  PXHATD, PXHAT
                       BLANK CARD, END OF OPTION 6
⑤  7        DESIGNATE OUTPUT VARIABLES
   1     1    1     1  TIME
   8     1    8     2  ALT, VAIR
   3     5    3     6  XAPP, ZAPP
   3    14    3    14  YAPP
   3    17    3    17  YSP
   3    15    3    16  PHI, PSI
  12     7   12     8  DA, DR
```

Figure A.7 (cont'd)

```
 16    3   16    4  SIGDA, SIGDR
  3   11    3   11  VR
  3    1    3    2  UB, WB
  8   27    8   29  XM, YM, ZM
  8   30    8   32  PSIA, THETAA, PHIA
  8   33    8   35  SIGMAVX, SIGMAVY, SIGMAVZ
  8   39    8   42  UWIND, UMEAN, UR, UAW
  8   43    8   46  VWIND, VMEAN, VR, VAW
  8   47    8   50  WWIND, WMEAN, WR, WAW
 55    1   55   17  SIGMAS OF THE STATES
 11    9   11    9  ERY
 16    1   16    2  SIGDAP, SIGDRP
  3   12    3   13  PB, RB
 55    2   55    3  SIGPB, SIGRB
                     BLANK CARD TO TERMINATE OPTION 7
⑥ 11         STORE TABBING INSTRUCTIONS
  2    0
  9
 10    1   TIME
 10    2   ALT
 10    3   VA-KTS                                          .5924
 10    8   PHI                                            57.3
 10    9   PSI                                            57.3
 10    4   XAPP
 10    6   YAPP
 10    7   YSP
 10   55   ERY
 10
 10    1   TIME
 10   14   VB
 10   30   VWIND
 10   31   VMEAN
 10   33   VAW
 10   24 SIGMAVY
 10   10   DA
 10   11   DR
 10   12 SIGDA
 10   13 SIGDR
 10
 10    1   TIME
 10   38 SIGV
 10   39 SIGP-DEG                                        57.3
 10   40 SIGR-DEG                                        57.3
 10   41 SIGPHI                                          57.3
 10   42 SIGPSI                                          57.3
 10   43 SIGY
 10   20 PSIA                                            57.3
 10   21 THETAA                                          57.3
 10   22 PHIA                                            57.3
  9
 10    1   TIME
 10   56 SIGDAP
 10   57   SIGDRP
 10   12   SIGDA
 10   13   SIGDR
 10   58    PB
 10   59    RB
 10   60   SIGPB
 10   61   SIGRB
                     BLANK CARD TO TERMINATE OPTION 11
⑦  4         READ R   (CASE-PARTICULAR INPUT)
  5    5     0
  8   14    8   14  VAMB                                1.688
20.
  8   15    8   15  PSIAMB                              .01745329
150.
```

Figure A.7 (Cont'd)

```
    6   10    6   10  VS  (SHIP SPEED)                                  1.688
20.
    8   11    8   11  PSIS ((SHIP HEADING)                             .01745329
30.
    8    3    8    5  UAS, VAS, WAS
74.71     -7.012     10.495
    3   15    3   16  PHI, PSI                                         .01745329
-1.       0.
    5   10    5   12  SUMFYO, SUMLG, SUMNO
290.41    0.         0.
    2   17    2   17  YSP
0.
    2   14    2   14  YAPP
0.
                      BLANK CARD TO TERMINATE OPTION 4
(8) 28          BUFFER IN INITIAL P VALUES
    0
   51    1   51  289   P
                      BLANK CARD
(9) 21          COVARIANCE PROPAGATION
      ****************************
      **          AV-8A           **
      **    35 KT WOD, LAT/DIR    **
      ****************************
    5    5   10    3    0
    1    3    1    6 DTIME, DTOUT, DTOUT2, TMAX
0.0125    0.2       20.0      20.0
                      BLANK CARD FOR READ R
    8    1    8   66  PRINT SEGMENT 8
                      BLANK CARD FOR WRITE R
(10) 14     TAB THE OUTPUT
    2       TAB INSTRUCTIONS STORED ON FILE 2
(11) 18     PRODUCE CALCOMP PLOTS
    5    1
CAL34       PLOT
   15
 $PLOTD NCURVS=2,XPLOT=.75,YPLOT=0.0,ANGLE=0.0,LNGTHX=4.0,STARTX=0.0,
        DELX=5.0,XORG=0.0,LNGTHY=4.0,STARTY=00.0,DELY=40.0,YORG=0.0,
        ISOPT=6 ,XLEGND=2.0,YLEGND=1.0 $END
              TIME - SEC.
            LATERAL POS. - M.
 $CURVE DASH=.01,NDATA=10,NCOLX=1,NCOLY=6,LINTYP=0,SCALEX=1.0,SCALEY=.3048 $END
177777
 $CURVE DASH=.01,NDATA=10,NCOLY=7,$END
170360    COMMANDED
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY= 1.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
          SIGMA LAT. POS. - M.
 $CURVE DASH=.01,NDATA=10,NCOLY=43,SCALEX=1.0,SCALEY=.3048 $END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=-4.0,DELY=2.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=3.5 $END
            BANK ANGLE - DEG.
 $CURVE DASH=.01,NDATA=10,NCOLY=8,SCALEX=1.0,SCALEY=57.3 $END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY= 2.0,YORG=0.0,
        ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
            SIGMA PHI - DEG.
 $CURVE DASH=.01,NDATA=10,NCOLY=41,SCALEX=1.0,SCALEY=57.3 $END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=-0.2,DELY=0.1,YORG=0.0,
        ISOPT=4,$END
          ROLL CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=10,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=.20,YORG=0.0,
```

Figure A.7 (Cont'd)

```
       ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
      SIGMA ROLL CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=56,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=6.0,YPLOT=-5.0,LNGTHY=4.0,STARTY= -.02,DELY=.01,
       YORG=0.0,ISOPT=4,$END
         YAW CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=11,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=  .01,YORG=0.0,
       ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
      SIGMA YAW CONTROL - UNITS
 $CURVE DASH=.01,NDATA=10,NCOLY=57,SCALEX=1.0,SCALEY=1.0,$END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY= -2.0,DELY=1.0,
       YORG=0.0,ISOPT=4,$END
         LAT. POS. ERROR - M.
 $CURVE DASH=.01,NDATA=10,NCOLY=55,SCALEX=1.0,SCALEY=.3048,$END
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=1.0,YORG=0.0,
       ISOPT=4,XLEGND=2.0,YLEGND=4.5,$END
             YAW - M/SEC.
 $CURVE DASH=.01,NDATA=10,NCOLY=33,SCALEX=1.0,SCALEY=.3048,$END
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=-.8,DELY=.4,YORG=0.0,
       ISOPT=4,XLEGND=2.0,YLEGND=4.5 $
         ROLL RATE - DEG/SEC.
 $CURVE DASH=.01,NDATA=10,NCOLY=58,SCALEX=1.0,SCALEY=57.3 $
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=0.0,DELY=2.0,YORG=0.0,
       ISOPT=4,XLEGND=2.0,YLEGND=4.5 $
      SIGMA ROLL RATE - DEG/SEC.
 $CURVE DASH=.01,NDATA=10,NCOLY=60,SCALEX=1.0,SCALEY=57.3 $
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=-.04,DELY=.02,YORG=0.0,
       ISOPT=4,XLEGND=2.0,YLEGND=4.5 $
         YAW RATE - DEG/SEC.
 $CURVE DASH=.01,NDATA=10,NCOLY=59,SCALEX=1.0,SCALEY=57.3 $
177777
 $PLOTD NCURVS=1,XPLOT=0.0,YPLOT=5.0,LNGTHY=4.0,STARTY=-.4,DELY=.2,YORG=0.0,
       ISOPT=4,XLEGND=2.0,YLEGND=4.5 $
      SIGMA YAW RATE - DEG/SEC.
 $CURVE DASH=.01,NDATA=10,NCOLY=61,SCALEX=1.0,SCALEY=57.3 $
177777
 $PLOTD NCURVS=1,XPLOT=5.5,YPLOT=-5.0,LNGTHY=4.0,STARTY=0.0,DELY=1.0,YORG=0.0,
       ISOPT=20,XEXIT=17.0,YEXIT=0.0 $END
          SIGMAVY - M/SEC.
1.0       9.0
AV-8A APPROACHES A DD-963
    LAT./DIR. CASE


 $CURVE DASH=.01,NDATA=10,NCOLY=24,SCALEX=1.0,SCALEY=.3048 $END
177777
```

Figure A.7 (Cont'd)

Here the I array is seven segments long and the R array is composed of 119 segments. The R array is shorter than the previous example because at Vought we actually ran the longitudinal example first then later expanded the R array to include the additional lateral/directional terms. The new parameters were mostly added to the end of current segments or new segments generated for them. The expanded R array will work for this case provided the segment length information is adjusted to the correct values here. The lengths which need to change are those which define matrix sizes. These have the word 'varies' under the column 'element' in Section E.2. Note that in the previous listing, segment 51 (the P matrix) was 289 long and here it is 1521 long. This is because P went from a 17 by 17 matrix in the classical pilot example to a 39 by 39 matrix in the optimal pilot example.

One should compare blank COMMON for the two listings in Appendices B and C. Note that they are essentially the same except for the new segments and the added terms on the end of segments; then, verify the segment lengths.

Remember that the main program uses the information input by SEGMNT to establish a one to one relationship with the elements of blank COMMON. If the segment lengths are incorrectly specified, the program will self destruct; or at best, not run.

A.9.2 Option 2

Integer values that define system size and control the selection of certain calculations are input here. The elements of the I array are defined in Appendix E.

There are 11 mean equations to be integrated. The three covariance matrices, P, PE, and PXHAT are n by n matrices where n is 39, 18, and 18 respectively. QM is a 15 by 15 matrix (NQM = 15) and GM is 32 (NGM = 32) by 15 (NQM). This run will include the ship airwake calculations (NØAW = 0) and is not an initialization run (NØINIT = 1).

A.9.3 Option 4

Required values of the R array are input next. At Vought, we normally input fixed geometric and aerodynamic properties here; inputting case dependent information later in the deck. At the beginning of job execution, the control card 'LDSET,PRESET = ZERØ.' initializes core to zero; therefore parameters not initialized through an Option 4 begin with a value of zero.

Note that the value of IY is 1; obviously not a realistic inertia. The 1 is used because the inertias are not needed to generate accelerations (because of dimensional derivatives) but inertia does appear as a denominator in SETUP. The numerator term is zero so anything in the denominator will work. This is all related to the calculation of forces and moments in DEQU, where the total forces and moments that drive the mean equations must be obtained from a reference condition and perturbation forces and moments.

All the tables that define the open loop inputs, dimensional derivatives, and optimal pilot feedback gains are input here. They are consistent with the independent variable arrays TABV1 and TABV2.

The ship geometry terms are for a DD-963 and the aerodynamic derivatives are from Reference 15. The optimal pilot feedback gains were determined consistent with the derivation in Section 7.

Note the breakpoints in TABV1 (segment 13, elements 1 - 6). The only two 'legitimate' points are 35. and 56.6 knots. The data tables that are a function of airspeed are input with the same value at 0 as 35 knots and the same values for 60., 61., and 62. knots as 56.6 knots. This was done to fill up the tables, and in the case of 0 knots, to keep the computer from extrapolating to speeds lower than 35 knots. Here the simulation uses 35 knots data for any airspeed that drops below 35 knots. Thirty-five knots is the lowest airspeed the airplane should have (35 is WOD speed) and the 56.6 knots was a value initially selected for the beginning of the time history. The pilot feedback gains and the dimensional derivatives are assumed to vary linearly between these speeds. To cut down on run time, the airplane was moved closer to the ship, to start the simulation, and the initial airspeed became 44.7 knots. There was no requirement to change the data tables because the table look-up routine will give values for 44.7 knots just as it will for all airspeeds between 35 knots and 56.6 knots.

A.9.4 Option 6

The user next specifies the variables that are to be integrated and the locations which contain the integrated values. There is no restriction on the number of variables one desires to integrate as long as the fourth and fifth I array segments are long enough to keep all the R array indices.

Also note that the number of mean equations should equal NSTATES (I array segment 1, element 3). The integration subroutines will only integrate the first NSTATES derivatives specified in the first part of Option 6. When setting up matrices to be integrated it is only necessary to define the R array location of the first element. The number of matrix elements integrated is determined internally from the matrix size information read in previously (Option 2).

Option 6 expects location information for all three pairs of matrices (PDOT and P, etc.) whether the user intends to integrate these or not. A good example of this is the classical pilot model. Refer to Sections A.8.2 and A.8.4 for additional comments on this matter.

A.9.5 Option 7

The variables specified here appear on the output file. Their selection is totally up to the user. All of the output features (tabbing, plotting, etc.) access the file containing the Option 7 specified variables.

A.9.6 Option 11

The variables to be tabbed are user defined. Here we have attempted to tabulate all the key parameters for interpreting the performance of a given task.

A.9.7 Option 4

The case-particular input goes here; i.e., the things necessary to define the environment (wind speed, etc.) and the initial conditions of the airplane and ship.

The initial components of airspeed (segment 8, elements 3 - 5) and initial forces and moment (segment 5, elements 1 - 3) are required. The airspeed requirement could be relaxed, if desired, according to the discussion of Section A.8.7. If the equations describing the means in DEQU were perturbation equations or it was not desired to integrate the means then the initial forces and moment requirement would not longer be valid.

The ship motion inputs KZS, ZETAZS, and WNZS were obtained from Section 9 of this report. The value of KZS is the value of K_Z from the table multiplied by ω_n squared. ZETAZS and WNZS are the damping, ζ, and natural frequency, ω_n, presented in Table 9 of Section 9.

A.9.8 Option 28

This option reads data stored from a previous run. It is used here to initialize the matrices P, PE, PXHAT, VU, and VY. A good discussion of the reason for this initialization appears in Section A.8.8 and will not be repeated here.

The important thing is that this setup expects a TAPE28 to be ATTACH'ed (GET'ed) to this job; and for this file to contain numerical values for all the elements of the above mentioned matrices.

To generate the TAPE28 file for initialization the user makes the following changes to the run deck. In Option 2 the value of NSTATES is reduced by one and the value of NØINIT is set to -1. The cards setting RCD as an integrand and RC as the integrator's output should be removed from Option 6. In one of the Option 4's, input RCD (segment 11, element 2) with the value -37.28 (its t = 0 value). Run a 5 second time history using third or fourth order Runge-Kutta integration. An integration stepsize of .025 is adequate. Following the time history (Option 21) call Option 28 and store the desired matrices; remembering to include the necessary control cards to catalog this file for future use.

A.9.9 Option 21

This option generates time histories of the means and covariances. The example presented here asks for a 20 second time history using Adams integration. The output of MISCAL will be printed at the initial time (t = 0) and every 20 seconds. The output file is TAPE10.

After the initial call to setup, before the integration process begins the elements of segment eight will be output. This was done to check on the parameters associated with the airwake calculations. It is not necessary to output anything here. But often, the user desires to know some parameter values but does not want to take up space on the output file. This is a convenient place to look at the values of such parameters.

A.9.10 Option 14

This option causes the output file to be tabbed according to the instructions stored by Option 11.

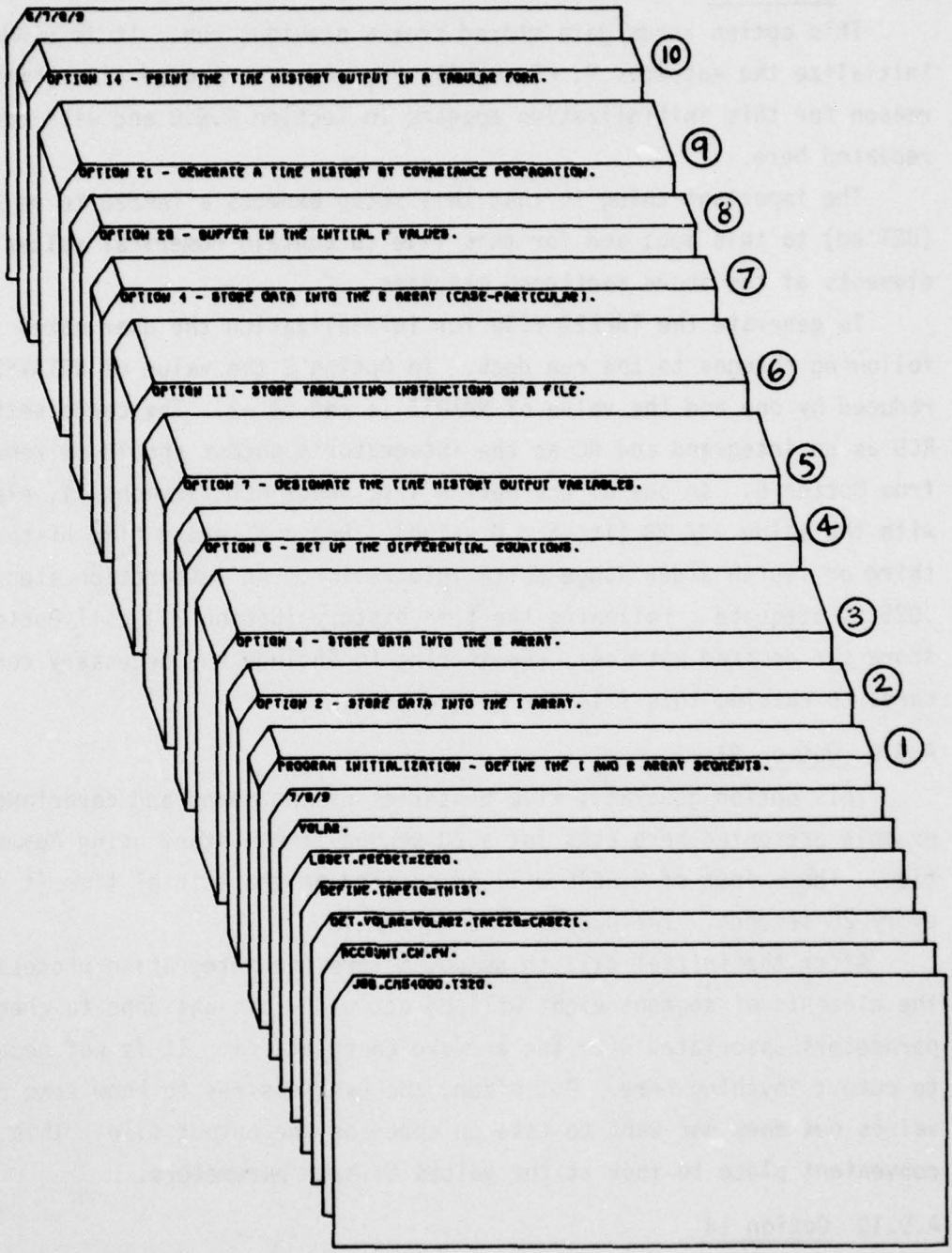
6/7/8/9
10
OPTION 14 - PRINT THE TIME HISTORY OUTPUT IN A TABULAR FORM.
9
OPTION 21 - GENERATE A TIME HISTORY BY COVARIANCE PROPAGATION.
8
OPTION 20 - BUFFER IN THE INITIAL P VALUES.
7
OPTION 4 - STORE DATA INTO THE R ARRAY (CASE-PARTICULAR).
6
OPTION 11 - STORE TABULATING INSTRUCTIONS ON A FILE.
5
OPTION 7 - DESIGNATE THE TIME HISTORY OUTPUT VARIABLES.
4
OPTION 6 - SET UP THE DIFFERENTIAL EQUATIONS.
3
OPTION 4 - STORE DATA INTO THE R ARRAY.
2
OPTION 2 - STORE DATA INTO THE I ARRAY.
1
PROGRAM INITIALIZATION - DEFINE THE I AND R ARRAY SEGMENTS.
7/8/9
VOLAB.
LGET.PRESET=ZERO.
DEFINE.TAPE10=THIST.
GET.VOLAB=VOLAB2.TAPE20=CASE2(.
ACCOUNT.CN.PW.
JOB.CRS4000.T320.

Figure A.8

```
(1) $SEGMNT NSEGI=7, NSEGR=119, NPRNT=1,
            NI(1)=10,0,0,14,14,6,
            NR(1)=6,10,10,1f,9,11,27,66,7,22,
            NR(11)=8,6,6,10,7,7,19,0,0,10,
            NR(21)=10,10,10,10,10,0,6,6,6,6,
            NR(31)=6,6,6,6,6,6,6,6,6,6,
            NR(41)=6,6,6,6,6,6,6,6,0,1521,
            NR(51)=1521,1521,480,225,50,50,75,75,75,75,
            NR(61)=75,75,6,6,6,6,6,6,6,6,
            NR(71)=6,6,6,6,6,6,6,6,6,6,
            NR(81)=49,21,56,64,40,36,42,36,42,45,
            NR(91)=9,25,9,36,36, 9,324,324,324,324,
            NR(101)=10E,324,324,324,324,9,12,6,6,6,
            NR(111)=6,6,6,6,6,6,6,6,6,6,
    $END
(2)    2        READ INTO I ARRAY
       5    5    0
       1    3    1    6   NSTATES, NPA, NGM, NGM
      11   39   15   32
       1    7    1   10   NPE, NPX, NOAW, NOINIT
      18   18    0    1
                          BLANK CARD FOR READ I
(3)    4        READ INTO THE R ARRAY
       5    5    0
       6    1    6    6  WEIGHT,G,IX,IY,IZ,IXZ
   16300.     32.174     0.          1.          0.          0.
       6    7    6    9  LM, WM,LTDM
   438.0      46.75      348.0
       7    1    7    6  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN
   2.          2.          3.          3.          1.          0.
       7    7    7    9  TAUENG,TAUCDN,TAUD
   .2          .1          .4
      13    1   13    6  TABV1 (V TABLE FOR AERO DATA)                    1.688
   0.0        35.0        56.6        60.0        61.0        62.0
      14    1   14   10  TABV2 (T TABLE FOR OPEN LOOP CNTRLS)
   0.          2.          4.          6.          8.          10.         12.
   14.         16.         20.
      15    1   15    7  TABEZP
   -10000.    -1000.      -100.       0.          100.        1000.       10000.
      16    1   16    7  TABEZ
   -10000.    -1000.      -100.       0.          100.        1000.       10000.
      20    1   20   10  TABTC
   .13963     .13963      .13963      .13963      .13963      .13963      .13963    THETAC
   .13963     .13963      .13963                                                    THETAC
      21    1   21   10  TRPMOL
   0.          0.          0.          0.          0.          0.          0.        RPM 1
   0.          0.          0.                                                        RPM 2
      22    1   22   10  TCDNOL
   0.          0.          0.          0.          0.          0.          0.        CON 1
   0.          0.          0.                                                        CON 2
      23    1   23   10  TDEOL
   0.          0.          0.          0.          0.          0.          0.        DE 1
   0.          0.          0.                                                        DE 2
      24    1   24   10  TABR
   0.0         0.0         0.0         0.0         0.0         0.0         0.0
   0.0         0.0         0.0
      25    1   25   10  TABRD                                                    1.69
   0.0         0.0         0.0         0.0         0.0         0.0         0.0
   0.0         0.0         0.0
      27    1   27    6  TXU
   -.044      -.044       -.044       -.044       -.044       -.044               XU
      28    1   28    6  TXb
   .0009      .0009       .00636      .00636      .00636      .00636              XU
```

Figure A.9

```
  29    1   24    6  TXQ
.035        .035       .0509     .0509     .0509     .0509      XQ
  30    1   30    6  TXRPM
.2905       .2905      .2457     .2457     .2457     .2457      XRPM
  31    1   31    6  TXCDN
0.          0.         0.        0.        0.        0.         XCDN
  32    1   32    6  TXPIGV
0.          0.         0.        0.        0.        0.         XPDIGV
  33    1   33    6  TXDE
-.1495      -.1495     -.1424    -.1424    -.1424    -.1424     XDE
  34    1   34    6  TZU
-.0307      -.0307     -.0663    -.0663    -.0663    -.0663     ZU
  35    1   35    6  TZW
-.1425      -.1425     -.2148    -.2148    -.2148    -.2148     ZW
  36    1   36    6  TZQ
-.3175      -.3175     -.4308    -.4308    -.4308    -.4308     ZQ
  37    1   37    6  TZRPM
-2.4375     -2.4375    -2.322    -2.322    -2.322    -2.322     ZRPM
  38    1   38    6  TZCDN
0.          0.         0.        0.        0.        0.         ZCDN
  39    1   39    6  TZPIGV
0.          0.         0.        0.        0.        0.         ZPDIGV
  40    1   40    6  TZDE
-.3388      -.3388     -.3328    -.3328    -.3328    -.3328     ZDE
  41    1   41    6  TMU
-.0012      -.0012     -.00226   -.00226   -.00226   -.00226    MU
  42    1   42    6  TMW
.00453      .00453     .00316    .00316    .00316    .00316     MW
  43    1   43    6  TMWD
0.          0.         0.        0.        0.        0.         MWD
  44    1   44    6  TMQ
-.1285      -.1285     -.1736    -.1736    -.1736    -.1736     MQ
  45    1   45    6  TMRPM
-.036       -.036      -.036     -.036     -.036     -.036      MRPM
  46    1   46    6  TMCDN
0.          0.         0.        0.        0.        0.         MCDN
  47    1   47    6  TMPIGV
0.          0.         0.        0.        0.        0.         MPDIGV
  48    1   48    6  TMDE
.2355       .2355      .2383     .2383     .2383     .2383      MDE
  63    1   63    6  TKDEU
-9.064      -9.064     -9.027    -9.027    -9.027    -9.027
  64    1   64    6  TKDEW
-1.729      -1.729     -1.677    -1.677    -1.677    -1.677
  65    1   65    6  TKDEQ
214.67      214.67     213.16    213.16    213.16    213.16
  66    1   66    6  TKDET
368.23      368.23     387.05    387.05    387.05    387.05
  67    1   67    6  TKDEX
-4.289      -4.289     -4.29     -4.29     -4.29     -4.29
  68    1   68    6  TKDEZ
-1.444      -1.444     -1.447    -1.447    -1.447    -1.447
  69    1   69    6  TKDEN
-.6123      -.6123     -.5986    -.5986    -.5986    -.5986
  70    1   70    6  TKDEDE
9.9987      9.9987     10.       10.       10.       10.
  71    1   71    6  TKDEDT
-.2425      -.2425     -.2366    -.2366    -.2366    -.2366
  72    1   72    6  TKDTU
33.44       33.44      36.17     36.17     36.17     36.17
  73    1   73    6  TKDTW
-19.524     -19.524    -20.189   -20.189   -20.189   -20.189
  74    1   74    6  TKDTQ
-655.11     -655.11    -693.91   -693.91   -693.91   -693.91
  75    1   75    6  TKDTT
-409.81     -409.81    513.86    513.86    513.86    513.86
```

Figure A.9 (Cont'd)

```
  76    1    76    6  TKDTX
13.34      13.34      14.05     14.05     14.05     14.05
  77    1    77    6  TKDTZ
-39.627    -39.627    -41.653   -41.653   -41.653   -41.653
  78    1    78    6  TKDTN
10.503     10.503     10.524    10.524    10.524    10.524
  79    1    79    6  TKDTDE
-20.697    -20.697    -22.298   -22.298   -22.298   -22.298
  80    1    80    6  TKDTDT
10.00      10.0       9.9985    9.9985    9.9985    9.9985
 108    1   108    6  TDEUR
-.1684     -.1684     -.149     -.149     -.149     -.149
 109    1   109    6  TDEWR
-.1993     -.1993     -.1723    -.1723    -.1723    -.1723
 110    1   110    6  TDEVX
-.3552     -.3552     -.3428    -.3428    -.3428    -.3428
 111    1   111    6  TDEVXD
-.2248     -.2248     -.2372    -.2372    -.2372    -.2372
 112    1   112    6  TDEVZ
-.263      -.263      -.2329    -.2329    -.2329    -.2329
 113    1   113    6  TDEVZD
-.04412    -.04412    -.0432    -.0432    -.0432    -.0432
 114    1   114    6  TDTUR
.3245      .3245      .06174    .06174    .06174    .06174
 115    1   115    6  TDTWR
-.19146    -.19146    -.6403    -.6403    -.6403    -.6403
 116    1   116    6  TDTVX
.8613      .8613      .5995     .5995     .5995     .5995
 117    1   117    6  TDTVXD
.68496     .68496     .7478     .7478     .7478     .7478
 118    1   118    6  TDTVZ
-.3777     -.3777     -.9717    -.9717    -.9717    -.9717
 119    1   119    6  TDTVZD
-.0884     -.0884     -.1678    -.1678    -.1678    -.1678
                      BLANK CARD FOR READ R
④   6       SETUP DIFFERENTIAL EQUATIONS
    4    1
    2    1     2    6  UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT
    2    7     2    7  DFRPMD
    2    8     2    8  XSPDOT
   12    4    12    5  DED,DTD
   11    2    11    2  RCD
                      BLANK CARD TO TERMINATE DERIVATIVES
    5    1
    3    1     3    6  UB,WB,QB,THETA,XAPP,ZAPP
    3    7     3    7  DFRPM
    3    8     3    8  XSP
   12    1    12    2  DE,DT
   11    1    11    1  RC
                      BLANK CARD TO TERMINATE STATES
    6    1
   52    1    51    1  PDOT,P

    6    3
  100    1    99    1  PED, PE

    6    5
  104    1   103    1  PXHATD, PXHAT
                      BLANK CARD TO TERMINATE OPTION 6
⑤   7       DESIGNATE OUTPUT VARIABLES
    1    1     1    1 TIME
    8    1     8    2  ALT, VAIR
    3    4     3    4  THETA
    3    5     3    6  XAPP, ZAPP
   12    1    12    2  DE, DT
   12    3    12    3  DCDN
```

Figure A.9 (Cont'd)

```
 3    1    3    3  UR, WR, GB
 8    6    8    6  ALPHA
 8   65    8   65  ZGS
 9    1    9    4  THETAC,FRPNOL,CONOL,DEOL
 9    6    9    6  ACTUAL RANGE
55    4   55    6  SIG THETA, SIG XAP, SIG ZAP
55    7   55    7  SIG FRPM
55   17   55   17  SIG DT
55   16   55   16  SIG DE
 3    7    3    7  DFRPM
55   40   55   41  SIG EGS, SIG TD
 9    7    9    7  VAIRC
 8   27    8   29  XM, YM, ZM
 8   30    8   30  PSIA
 8   33    8   35  SIGMAVX, SIGMAVY, SIGMAVZ
 8   39    8   42  UWIND, UMEAN, UR, UAW
 8   43    8   46  VWIND, VMEAN, VR, VAW
 8   47    8   50  WWIND, WMEAN, WP, WAW
56    6   56    6  SIGMA XZ
11    1   11    2  RC, RCD
56    4   56    5
56    7   56    7
56   16   56   17
56   37   56   38
 3    8    3    8  XSP
                  BLANK CARD
11        STORE TABRING INSTRUCTIONS
 2    0     NTAP, IPUNCH
 9
10    1    TIME
10    2    ALT
10    3    VA                                          .592417
10    4    THETA                                     57.29578
10    5    XAP
10   14    ZGS                                          -1.
10    6    ZAP                                          -1.
10   50    RC
10   59    XSP
 9
10    1    TIME
10    7     DE
10    8     DT
10   16    RPNOL
10   17    CONOL
10   18     DEOL
10   19     RANGE
10   26    DFRPM
10    9    DCON
 9
10    1    TIME
10   20  SIG THETA                                      57.3
10   21   SIG XAP
10   22   SIG ZAP
10   23  SIG FRPM
10   24   SIG DT
10   25   SIG DE
10   49   SIG XZ
10   28    SIG TD
10
10    1    TIME
10   30     XM
10   31     YM
10   32     ZM
10   33    PSIA                                        57.3
10   37    UWIND                                       .5917
10   40    UAW                                         .5917
```

Figure A.9 (Cont'd)

```
   10   45   WWIND                                                    .5917
   10   48   WAW                                                     .5917
   10   41   VWIND                                                   .5917
                    BLANK CARD
⑦   4        READ INTO THE R ARRAY (CASE PARTICULAR)
    5    5     0
    8   14     8   14  VAMB                                        1.69
20.
    8   15     8   15  PSIAMB                                      0.01745329
150.
    8   10     8   10  V5  (SHIP SPEED)                            1.69
20.
    8   11     8   11  PSI5  (SHIP HEADING)                        .01745329
30.
    3    8     3    8  XSP
298.24
    3    6     3    6  ZAP
-50.
    3    5     3    5  XAP
0.0
    3    4     3    4  THETA  (A/P)
.13962
    9    5     9    5  GAMMA G S
0.
    8   66     8   66  ZBIAS
-50.0
    8    3     8    5  UAS, VAS, WAS
74.714    0.0        10.495
    5    1     5    3  SUMFX,SUMFZ,SUMM
1099.54   -16306.1   0.0
   17    1    17    6  KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS
0.0       0.0        0.0        2.34517  .443      .654
   17   19    17   19  TAUPRT
1.7
                    BLANK CARD
⑧  28        BUFFER IN INITIAL P VALUES
    0
   51    1    51 1521   P
   99    1    99  324   PE
  103    1   103  324   PXHAT
   93    1    93    9   VU
   94    1    94   36   VY
                    BLANK CARD
⑨  21        COVARIANCE PROPAGATION
     ****************************
     **         AV-8A          **
     **       35KT WOD         **
     ****************************
    5    5   10    3    0
    1    3    1    6 DTIME, DTOUT, DTOUT2, TMAX
0.025     .20       20.0       20.0
                  BLANK CARD FOR READ R
    8    1    8   66  PRINT SEGMENT 8
                  BLANK CARD FOR WRITE R
⑩  14        TAB THE OUTPUT
    2      TAB INSTRUCTIONS STORED ON FILE 2
```

Figure A.9 (Cont'd)

A.10 A Discussion of the Programmed Equations in Subroutines DEQU and PROP.

DEQU and PROP are the primary subroutines whereby the user defines his problem for analysis. Their importance warrants a more detailed explanation than previously presented in Section A.3.

This discussion addresses the "classical pilot model" example. Once the user is familiar with this example, transition to the more complex "optimal pilot model" example will be simple. Sub-section titles appearing below in quotation marks are the same "Titles" preceding a group of calculations in the subroutines. This provides the user with a one-to-one correspondence between this section and the listings of Appendix B.

DEQU

Subroutine DEQU provides the main program with the differential equations for the mean values of all state and control variables. It also provides the zero subscripted (reference) values of these variables which define the conditions about which the motions are linearized.

"Look-Up Values of Required Longitudinal Parameters"

Recall that the classical pilot model example (Volume I, p. 41) employs lateral/directional airplane dynamics. Nevertheless, the associated equations require some longitudinal parameters. As an example, consider the equation for rate of change of roll attitude:

$$\dot{\Phi} = P + Q \sin(\Phi) \tan(\Theta) + R \cos(\Phi) \tan(\Theta)$$

Q and Θ are longitudinal parameters. Required to generate $\dot{\Phi}$.

This section of coding provides the necessary longitudinal parameters as a function of time. Values of the longitudinal parameters for the reference trajectory are stored in the appropriate tables; at the desired time instant, values are determined by table-look-up. When performing an initialization run the table-look-ups are made only once.

"Miscellaneous Calculations"

Calculations performed here include:

(a) $\Theta = \Theta_c$. This sets airplane pitch attitude equal to the pitch attitude from the table-look-up of the previous section.

(b) Ship vertical position is set to zero (ZSP = 0).

(c) Perturbation values for roll rate and yaw rate are evaluated; for example, $p = P - P_0$, where p is the perturbation, P is the total roll rate and P_0 is the reference value. The reference values are updated at the end of each integration increment as part of the quasilinearization process.

(d) The remaining calculations are performed to minimize the number of calls to the trigonometric functions used throughout the remainder of the subroutine.

"Altitude"

Due to the standard axis convention, altitude is "minus z".

"Airplane With-Respect-To Ship, Earth Axis"

Both the ship and the airplane are referenced to a fixed earth axis system. These equations calculate the x, y, and z components distance between the aircraft c.g. and the ship c.g. in that earth axis system.

"Airplane With-Respect-To Ship, Ship Wind Axis"

The airwake model requires the coordinates of the airplane relative to the ship to be in ship wind axes. These equations transform the earth axis distances to ship wind axes. The parameters DXM145, etc. were calculated in subroutine SETUP.

"Euler Angles for Airwake Model"

These are Euler angles of the airplane with respect to the ship wind axes and are necessary inputs to the airwake model equations. They are simplified greatly because the airwake model used does not pitch and roll with the ship.

"Ship Airwake"

If ship airwake is desired (NOAW = 0) subroutine AIRWAKE is called. Following the call to AIRWAKE, the airwake related parameters are available in COMMON.

"Airplane Body Axis Components of Ambient Wind"

These equations transform the ambient wind velocity, which is given in earth axes, to the aircraft body axes. Wind velocities are defined consistent with the earth axis reference, i.e. a positive x-axis wind is oriented in the positive earth axis direction.

AD-A066 173 VOUGHT CORP DALLAS TEX F/G 1/2
VOLAR: A DIGITAL COMPUTER PROGRAM FOR SIMULATING VSTOL AIRCRAFT--ETC(U)
DEC 78 J WOLKOVITCH, B B BRASSELL N62269-77-R-0389
UNCLASSIFIED 2-32000/8R-51672-VOL-2 NADC-77123-30-VOL-2 NL

2 OF 4
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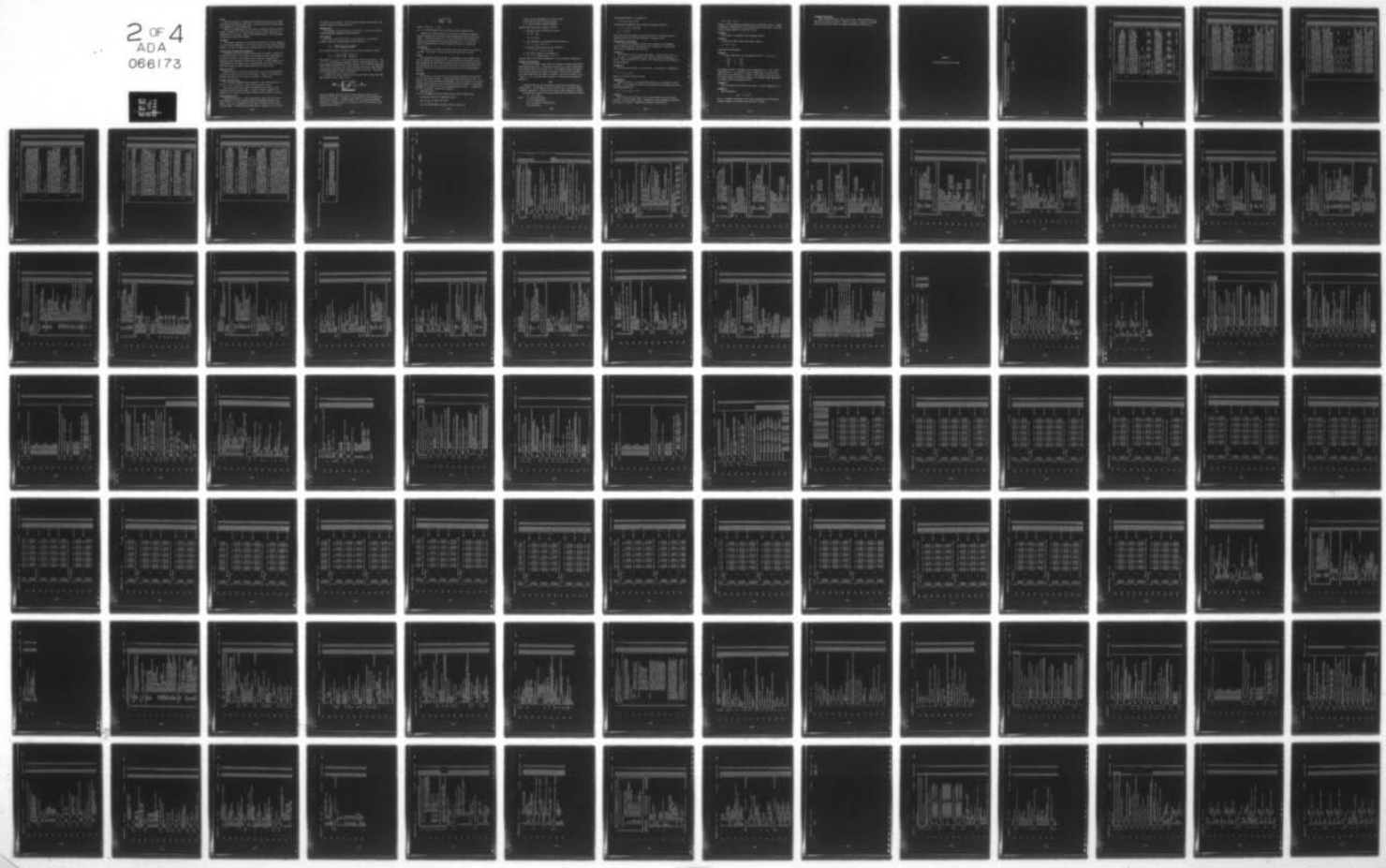
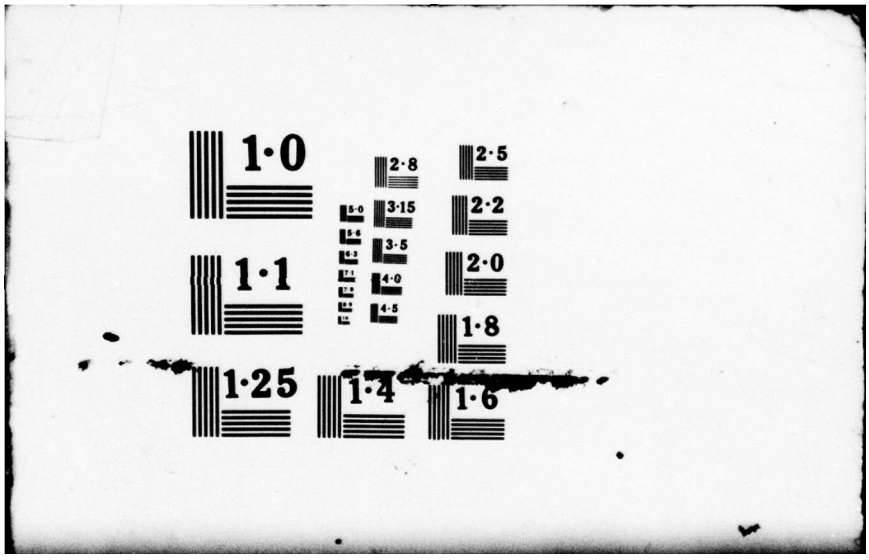



1·0
1·1
1·25
2·8
3·15
3·5
4·0
4·5
2·5
2·2
2·0
1·8
1·4
1·6

"Wind"

Total wind velocity is composed of the ambient wind and the non-random disturbances introduced by the airwake. This section defines the non-random wind components in aircraft body axes.

VOLAR is currently set-up to initialize on airspeeds instead of inertial speeds. Equations for initializing total inertial velocity components are contained in this section. They are calculated once only. This calculation is controlled by the ICEES parameter.

"Airspeed"

Wind velocity components are subtracted from inertial velocity components to yield airspeed components in the aircraft body axis system. Angle-of-attack, sideslip, and total airspeed are calculated according to standard conventions.

"Look Up Aero. and Open Loop Parameters"

Aerodynamic stability and control derivatives are stored in tables as a function of airspeed. This section of the program performs a table-look-up of these derivatives at the current value of airspeed. Subroutine TLU evaluates several dependent variables with one call. Fifteen parameters, YV through NDR (R array, segment 10), are determined by the single call to TLU. Open loop aileron and rudder control deflections are set to zero.

"Range From Ship"

Range from ship is arbitrarily defined here as the distance between the x earth axis positions of the ship and airplane. "Range", as defined here, provides some measure of how close the airplane is to the ship.

"Lateral Position Error"

The aircraft's commanded lateral position is the lateral position of the ship. Error in position is the difference between the two.

This section begins the build-up of parameters associated with the calculation of pilot control inputs. Figure 8 (Volume I, page 40) is a schematic of the classical pilot model employed for the AV-8A at low speed.

"Roll Attitude Error"

Commanded bank angle is a gain multiplied by lateral position error. Bank angle error is the difference between the commanded and actual bank angles. This error is modified by a bias term to account for the initial trim bank angle. A non-zero initial bank angle is necessary to trim out the

side forces on the airplane. These side forces result from the steady side velocity required for tracking the ship.

"Heading Error"

The commanded aircraft heading is zero degrees. Heading error is the difference between commanded and actual heading.

"Roll Control"

The pilot's roll control input is calculated here. From Figure 8 (Volume I, page 40) the appropriate transfer function is:

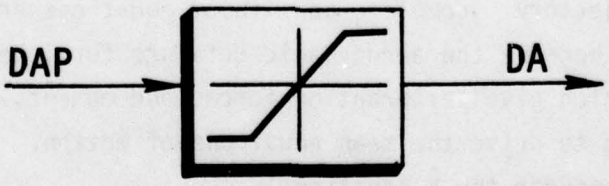
$$Y_{P_\phi} = \frac{-112.0\ (s + 0.1)\ (s - 10.0)}{(s + 10.0)\ (s + 10.0)}$$

This transfer function was obtained from the following transfer function.

$$Y_{P_\phi} = K_1\ \frac{(\tau_{L1}\ s + 1.0)}{(\tau_a\ s + 1.0)}\ \frac{(2/\tau_d - s)}{(2/\tau_d + s)}$$

The quantity $K_1\ (\tau_{L1}\ s + 1)$ is the compensation applied by the pilot. A lag, $(\tau_a\ s + 1)$, is introduced to represent actuator and neuromuscular lags. The final numerator and denominator factors provide a first order Padé approximation to a pure time delay. This delay represents the time it takes the pilot to generate an output strategy following sensing of the error. Time delays are a standard feature in most pilot models.

As presented in block diagram form below, the pilots' output, DAP, must pass through a control system limiter.



Subroutine DESCRIB calculates the non-linear describing function which represents the limiter. A necessary input to DESCRIB is the standard deviation of the signal DAP. A general equation for calculating the standard deviation of a parameter which is a function of the state variables but not a state variable itself is:

$$y = \sqrt{\left(\frac{\partial y}{\partial \underline{x}}\right)^T P \left(\frac{\partial y}{\partial \underline{x}}\right)}$$

where $y = f(x_1, x_2, \ldots, x_n)$

and P is the Covariance matrix associated with the state vector $\underline{x}$.

Normally the standard deviation of the control would be evaluated by describing functions and the mean would be determined by applying the true limiter. This was not done here. For this application, the difference in results was insignificant and so the modified mean (i.e. its describing function representation) was used to reduce the number of calculations.

"Yaw Control"

This section is so similar in layout to the previous one it will not be discussed. The output is, of course, the yaw control from the pilot.

"Ship"

Only the mean lateral ship motion is considered for this example. The ship is steaming with velocity V5 in a direction PSI5 with respect to north. When integrated, the differential equation in this section yeilds the y earth-axis position of the ship. The x and z earth-axis positions were defined in previous sections of this subroutine; one by table look-up and the other by equation.

"Airframe"

This section of coding defines the differential equations which describe the aircraft's mean trajectory. Complete non-linear equations are used. This creates a small problem because the aerodynamic data are furnished as dimensional stability derivatives which give perturbation forces and moments. Total forces and moments are required to drive the mean equations of motion. To demonstrate how this is overcome, consider the $\dot{V}$ equation.

Some definitions:

Let Y_o be the total side force divided by mass at some reference time.

δ_A and δ_R are the pilot commanded positions

$\delta_{A_{OL}}$ and $\delta_{R_{OL}}$ are open loop inputs

v_{as} is the perturbation airspeed along the y body axis

p and r are the perturbation roll and yaw rates.

P and R are the total roll and yaw rates

U, V, and W are total airspeed components

Based on these definitions proceed as follows:

1. the total control deflection is given as:

$$\delta_4 = \delta_A + \delta_{A_{OL}}$$

$$\delta_5 = \delta_R + \delta_{R_{OL}}$$

2. the incremental or perturbation force-over-mass is:

$$\Delta Y = Y_v v_{as} + Y_p p + Y_r r$$

3. the total force-over-mass on the airplane is:

$$Y = Y_o + \Delta Y + Y_{\delta_A} \delta_4 + Y_{\delta_R} \delta_5$$

4. the rate of change of side velocity is:

$$\dot{V} = Y + g \cos(\Theta) \sin(\phi) - R U + P W$$

Thus the total y-axis velocity component, V, can be found by integrating $\dot{V}$.

"Update Sub Zero Values"

The zero subscripted values define the reference trajectory about which quasilinearisation occurs. Perturbation quantities are found by subtracting the reference value from the total value. The reference values are updated prior to each integration increment and remain fixed during the increment. Zero subscripted terms also appear as elements, or parts of elements, in the F matrix. (F is the system matrix appearing in the covariance propagation equation.)

PROP

Subroutine PROP has only one purpose; to furnish the integration subroutine with $\dot{P}$. The prospective user should keep this in mind when reading through the subroutine. Familiarity with state variable notation is helpful.

As an overview, consider the system governed by the differential equation.

$$\dot{\underline{z}} = F \underline{z} + G_M \underline{w}$$

where $\underline{z}$ is the state vector,

F is the system matrix

G_M is a control or coupling matrix

$\underline{w}$ is white noise

The covariance matrix, P, is defined by:

$$P \overset{\Delta}{=} E\{(\underline{z} - \overline{\underline{z}})(\underline{z} - \overline{\underline{z}})^T\}$$

and obtained by integrating the following differential equation.

$$\dot{P} = F P + P F^T + G_M Q_M G_M^T$$

$$Q_m \overset{\Delta}{=} E\{\underline{w}\,\underline{w}^T\}$$

Each of the titles preceding a group of calculations in subroutine PROP is explained below, with the titles repeated in quotation marks.

"Miscellaneous Calculations"

This group of calculations provides some frequently used parameters. They are grouped here for "one time per call" calculation. This minimizes calls to the trigonometric functions, etc.

"F1 Matrix"

The F1 matrix is the aircraft system matrix. Aircraft states are v, p, r, ϕ, ψ, and y. F1 is developed from the standard linearized equations of motion. Refer to Section 2.0 in Volume I for a description of the linearized aircraft equations.

"G1 Matrix"

G1 is the control matrix for the airplane. The airplane is represented by:

$$\dot{\underline{x}} = F_1 \underline{x} + G_1 \underline{u}$$

where $\underline{u}$ is a vector of control inputs.

"Gamma Matrix"

Gamma is the matrix for coupling the colored noise disturbances with the airplane. If $\underline{w}'$ represents a vector of colored noises, the equations describing the airplane motion are.

$$\dot{\underline{x}} = F_1 \underline{x} + G_1 \underline{u} + \Gamma \underline{w}'$$

"A Matrix"

The A matrix and the B matrix (next section) define the noise coloring processes. In this example, noise is composed of Dryden atmospheric turbulence, plus the ship's airwake. Equations for the noise take the form:

$$\dot{\underline{w}}' = A\,\underline{w}' + B\,\underline{w}$$

where $\underline{w}'$ is the colored noise (output) and $\underline{w}$ is white noise (input). Dryden turbulence is represented by a first order filter (in each axis). Each axis of ship airwake requires a second order filter.

"B Matrix"

The B matrix is explaned in the preceeding section.

"C Matrix"

C and R_L are used to define the control input, $\underline{u}$.

$$\dot{\underline{u}} = C\underline{x} + R_L\,\underline{u}$$

$\underline{x}$ and $\underline{u}$ are explained above.

"F Matrix"

F is the system matrix for the augmented vector $\underline{z}^T = (\underline{x}, \underline{w}', \underline{u})$:

$$F = \begin{bmatrix} F_1 & \Gamma & G_1 \\ 0 & A & 0 \\ C & 0 & R_L \end{bmatrix}$$

The subroutine LAYIN is designed to store submatrices (F_1, Γ, etc.) into a larger matrix (F). By building F from its submatrices; (1) the user has more visibility of the pieces, (2) there is less chance of an error in row or column placement of individual elements, (3) elemental model additions or size changes can be incorporated quickly.

"GM Matrix"

G_M is the multiplier of white noise inputs. For this example $G_M \equiv B$.

"QM Matrix"

Q_M is defined by:

$$Q_M = E\,\{\underline{w}\ \underline{w}^T\}$$

The (1, 1) element corresponds to the Dryden turbulence and the remaining diagonal elements are associated with the ship's airwake.

"Propagate Covariances"

These operations develop $\dot{P}$ from F, G_M, and Q_M. Matrix operations are identified in subroutine MATRIX. MATRIX is written in COMPASS; but FORTRAN equivalent subroutines appear as comments preceeding each ENTRY point.

APPENDIX B

LISTING FOR CLASSICAL PILOT MODEL

```
>>>
```

```
*************************************************************************
*                                                                       *
*    I.   INTRODUCTION                                                  *
*                                                                       *
*         THE VOLAR (VOUGHT LAUNCH AND RECOVERY) PROGRAM WAS            *
*         DEVELOPPED BY VOUGHT CORPORATION UNDER CONTRACT NUMBER        *
*         N62269-77-C-0389 11 OCT 77. THE PURPOSE OF THIS DISCUSSION    *
*         IS TO PROVIDE THE PROGRAMMER (OR USER) WITH DOCUMENTATION     *
*         TO BE USED AS AN AID IN MODIFING THE EXISTING PROGRAM.        *
*                                                                       *
*    II.  ROUTINE CLASSIFICATION                                        *
*                                                                       *
*         ALL ROUTINES INCLUDED IN THIS PROGRAM MAY BE CLASSIFIED AS    *
*         MEMBERS IN ONE OF TWO MAJOR CLASSIFICATIONS. CLASS I          *
*         ROUTINES INCLUDE THOSE ROUTINES WHOSE OPERATION IS DEPENDENT  *
*         UPON EQUATIONS DERIVED FOR THE SPECIFIC PROBLEM AT HAND.      *
*         CLASS II ROUTINES INCLUDE THOSE ROUTINES WHOSE OPERATION IS   *
*         INDEPENDENT OF THE SPECIFIC PROBLEM WITH THE POSSIBLE         *
*         EXCEPTION OF ARRAY DIMENSIONS.                                *
*                                                                       *
*         CLASS I ROUTINES INCLUDE :                                    *
*                                                                       *
*         DEQU      MISCAL    PROP      SETUP                           *
*                                                                       *
*         CLASS II ROUTINES INCLUDE :                                   *
*                                                                       *
*         VOLAR     ADAMS     AIRWAKE   AIRWTBL   AXIS      CALPLT      *
*         DASPLT    DESCRIB   ELLIPSE   KUTTA     MATINV    MATRIX      *
*         PRNPLT    ROTATE    RUNGE     SOLVR     TABRD     TLU         *
*                                                                       *
*    III. SOURCE CODE FORMAT                                            *
*                                                                       *
*         DUE TO THE NATURE OF THE PROBLEM (I.E. CHANGES IN PROBLEM     *
*         SPECIFICATIONS REQUIRE CHANGES IN SOURCE CODE), THE ORIGINAL  *
*         SOURCE CODE WAS DEVELOPPED AND DELIVERED IN CDC *UPDATE*      *
*         FORMAT AND WE STRONGLY RECOMMEND MAINTAINING THE PROGRAM IN   *
*         THAT FORMAT. ALL ROUTINES DELIVERED WERE MAINTAINED AS        *
*         SEPERATE *DECK*S AND ALL COMMON AREAS WERE MAINTAINED AS      *
*         SEPERATE *COMDECK*S.                                          *
*                                                                       *
*         THE *DECK* NAMES INCLUDE :                                    *
*                                                                       *
*         VOLAR     ADAMS     AIRWAKE   AIRWTBL   AXIS      CALPLT      *
*         DASPLT    DEQU      DESCRIB   ELLIPSE   KUTTA     MATINV      *
*         MATRIX    MISCAL    PRNPLT    PROP      RUNGE     ROTATE      *
*         SETUP     SOLVR     TABRD     TLU                             *
*                                                                       *
*         THE *COMDECK* NAMES INCLUDE :                                 *
*                                                                       *
*         R         R2        I         I2        SEGMENT   INTEG       *
*         GDF                                                           *
*                                                                       *
*************************************************************************
```

```
*****************************************************************************  NOTES   60
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*                                                                           *  NOTES   63
*         PROBLEM-SPECIFIC INTEGER AND REAL VARIABLES ARE COLLECTED         *  NOTES   64
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*         GROUPPED TOGETHER INTO I OR R ARRAY SEGMENTS. AT PROBLEM          *  NOTES   66
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*         AIRWAVE   AIRWTBL   DFQU      MISCAL    PROP      SETUP         *  NOTES   85
*                                                                           *  NOTES   86
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*         *COMDECK* R IS CALLED FROM *DECK*S :                        * NOTES     83
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*                                                                     * NOTES     88
*         ADAMS     COVAR     KUTTA     RUNGE                       * NOTES     89
*                                                                     * NOTES     90
*         *COMDECK* I IS CALLED FROM *DECK*S :                        * NOTES     91
*                                                                     * NOTES     92
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*         SETLP                                                       * NOTES     94
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*         LOCATED IN A LABELLED COMMON BLOCK, /INTEGER/. THEREFORE A  * NOTES    111
*         CHANGE IN *COMDECK* I SHOULD ALSO BE REFLECTED IN *COMDECK* * NOTES    112
*         I2.                                                         * NOTES    113
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*         THE INITIAL INPUT TO THE PROGRAM IS A NAMELIST, SEGMNT,         * NOTES
*         WHICH DEFINES THE NUMBER OF SEGMENTS AND THE LENGTH OF EACH     * NOTES
*         SEGMENT CONTAINED IN THE I AND R ARRAYS. THIS INFORMATION       * NOTES
*         IS STORED IN A LABELLED COMMON BLOCK, /SEGMENT/, CONTAINED      * NOTES
*         IN *COMDECK* SEGMENT. ADDING OR DELETING VARIABLES FROM AN      * NOTES
*         EXISTING SEGMENT REQUIRES A CHANGE TO THE ASSOCIATED INPUT      * NOTES
*         FOR THAT SEGMENT. ADDING SEGMENTS TO THE TAIL END OF THE I      * NOTES
*         OR R ARRAY REQUIRES AN ADDITIONAL INPUT FOR EACH ADDITIONAL     * NOTES
*         SEGMENT AND A POSSIBLE INCREASE IN THE ARRAY DIMENSION FOR      * NOTES
*         THE ASSOCIATED I OR R ARRAY DESCRIPTOR IN *COMDECK* SEGMENT.    * NOTES
*                                                                         * NOTES
*         *COMDECK* SEGMENT IS CALLED FROM *DECK*S :                      * NOTES
*                                                                         * NOTES
*         VOLAR                                                           * NOTES
*                                                                         * NOTES
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*                                                                         * NOTES
*         THIS *COMDECK* CONTAINS A LABELLED COMMON BLOCK, /INTEG/,       * NOTES
*         WHICH IS USED TO HOLD TWO SINGLE-DIMENSIONED ARRAYS OF          * NOTES
*         LENGTH NEQU WHERE NEQL IS THE SUM OF THE NUMBER OF STATE        * NOTES
*         VARIABLES AND THE SQUARE OF THE NUMBER OF ROWS IN THE           * NOTES
*         COVARIANCE MATRIX. THESE ARRAYS ARE USED TO HOLD TEMPORARY      * NOTES
*         INTEGRATION VALUES. IT SHOULD BE NOTED THAT THESE ARRAYS ARE    * NOTES
*         ALSO USED AS SCRATCH MATRICIES IN ROUTINE SOLVR WHICH           * NOTES
*         PREVENTS SOLVR FROM BEING CALLED FROM WITHIN THE INTEGRATION    * NOTES
*         LOOP (SEE SOLVR NOTES). AN INCREASE IN THE NUMBER OF STATE      * NOTES
*         VARIABLES OR NUMBER OF ROWS IN THE COVARIANCE MATRIX REQUIRE    * NOTES
*         A CHANGE IN THE ARRAY DIMENSIONS.                               * NOTES
*                                                                         * NOTES
*         *COMDECK* INTEG IS CALLED FROM *DECK*S :                        * NOTES
*                                                                         * NOTES
*         ADAMS     KUTTA     PROP      RUNGE     SETUP                   * NOTES
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*         FUNCTIONS THEMSELVES AND INDEXES FOR THE FUNCTIONS.  IF THE     * NOTES
*         NUMBER OF DESCRIBING FUNCTION INCREASE, THE DIMENSION ON THE    * NOTES
*         FUNCTION VALUES (TABLE) MAY NEED TO BE INCREASED.               * NOTES
*                                                                         * NOTES
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*                                                                         * NOTES
*         DESCRIB   TABRD                                                 * NOTES
*                                                                         * NOTES
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*         IN THE ABOVE MENTIONED ORDER. TO REDUCE THE AMOUNT OF CODING      *  NOTES  183
*         NECESSARY TO PERFORM THE TABLE LOOKUPS, ALL SIX TABLES ARE        *  NOTES  184
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*         THESE LOCATIONS ARE THEN STORED INTO THE I ARRAY TO BE USED       *  NOTES  196
*         BY THE INTEGRATORS. TO REDUCE THE AMOUNT OF STORAGE REQUIRED      *  NOTES  197
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*         PLACED INTO AN ARRAY AND TO SAVE SPACE THE 61 COLUMNS ARE         *  NOTES  216
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*         STORING THE PLOT INTO A 61 BY 36 ARRAY RATHER THAN A 7 BY 36      *  NOTES  218
*         ARRAY.                                                            *  NOTES  219
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*                                                                         * NOTES
*         THIS ROUTINE IS CALLED PRIOR TO INITIATING THE INTEGRATION      * NOTES
*         LOOP. IT IS USED TO HACK THE INITIAL VALUES USED BY THE         * NOTES
*         INTEGRATORS. IT IS ALSO USED TO HACK NON-TIME VARING NUMBERS.* NOTES
*         AS AN EXAMPLE, THE AIRWAKE MODEL REQUIRES THE WIND-OVER-DECK * NOTES
*         AND SHIP HEADING WHICH, ONCE SET, NEVER VARY. TO KEEP THESE  * NOTES
*         HACKS OUT OF THE INTEGRATION LOOP, THEY ARE PERFORMED IN        * NOTES
*         SETUP.                                                          * NOTES
*                                                                         * NOTES
*      F. TABLE LOOKUP ROUTINE - *DECK* TLU                               * NOTES
*                                                                         * NOTES
*         THIS ROUTINE IS USED TO LOOK UP A SERIES OF VALUES BASED UPON* NOTES
*         A SERIES OF TABLES AND A SINGLE INDEPENDENT VARIABLE. THIS      * NOTES
*         REQUIRES THAT ALL DEPENDENT VARIABLE TABLES TO BE LOOKED UP     * NOTES
*         BY A SINGLE CALL MUST HAVE THE SAME NUMBER OF ITEMS IN THE      * NOTES
*         TABLE AND BE LOCATED IN CONSECUTIVE AREAS OF CORE. THE          * NOTES
*         DEPENDENT VARIABLE VALUES WILL BE PLACED IN A CONTIGUOUS        * NOTES
*         AREA OF CORE IN THE SAME ORDER AS THEIR TABLES ARE ARRANGED. * NOTES
*                                                                         * NOTES
*      G. COVARIANCE MATRIX INITIALIZATION - *DECK* SOLVR                 * NOTES
*                                                                         * NOTES
*         THIS ROUTINE SOLVES FOR P IN THE RICCATI EQUATION               * NOTES
*                                                                         * NOTES
*         P * F TRANSPOSE + F * P + G * Q * G TRANSPOSE = 0               * NOTES
*                                                                         * NOTES
*         TO INITIALIZE THE COVARIANCE MATRIX. THE ROUTINE NEEDS 3 N      * NOTES
*         BY N SCRATCH MATRICIES (N = NUMBER OF ROWS IN COVARIANCE        * NOTES
*         MATRIX P). TO SAVE SPACE, THE COVARIANCE DERIVATIVE MATRIX      * NOTES
*         AND THE TWO SCRATCH INTEGRATION MATRICIES ARE USED FOR THIS     * NOTES
*         PURPOSE. THIS PREVENTS CALLING SOLVR INSIDE THE INTEGRATION     * NOTES
*         LOOP TO FIND THE STEADY-STATE P MATRIX. THIS CAN BE ACHIEVED    * NOTES
*         BY ADDING 3 ADDITIONAL N BY N MATRICIES TO ROUTINE PROP AND     * NOTES
*         PLACING THESE MATRICIES INTO THE CALL TO SOLVR.                 * NOTES
*                                                                         * NOTES
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*                                                                         * NOTES
*         SEVERAL MATRIX MANIPULATIONS (ADD, MULTIPLY AND TRANSPOSE)      * NOTES
*         OCCUR IN GENERATING THE COVARIANCE MATRIX. SINCE THE TIME       * NOTES
*         REQUIRED TO MULTIPLY TWO MATRICIES RISES EXPONENTIALLY WITH     * NOTES
*         THE SIZE OF THE MATRIX, THESE ROUTINES HAVE BEEN COLLECTED      * NOTES
*         INTO AN ASSEMBLY LANGUAGE ROUTINE. THIS ROUTINE IS DESIGNED     * NOTES
*         TO KEEP ALL LOOPING INSIDE THE INSTRUCTION STACK LOCATED        * NOTES
*         INSIDE THE CPU OF THE 6600, THEREBY REDUCING THE EXECUTION      * NOTES
*         TIME SIGNIFICANTLY. WE REALIZE THIS MAKES DEBUGGING AND         * NOTES
*         MODIFICATION OF THIS ROUTINE MORE DIFFICULT BUT, CONSIDERING    * NOTES
*         THE SIZE OF THE MATRICIES INVOLVED AND THE NUMBER OF TIMES      * NOTES
*         THESE ROUTINES ARE CALLED, WE FEEL IT IS ADVANTAGEOUS TO USE    * NOTES
*         THE ROUTINE IN ITS PRESENT FORM. THE FORTRAN EQUIVALENT OF      * NOTES
*         THESE ROUTINES HAVE BEEN GENERATED AND ARE AVAILABLE FOR USE    * NOTES
*         SHOULD THIS ROUTINE BE UNDESIRABLE.                             * NOTES
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*         COVARIANCE MATRICIES ARE SQUARE MATRICIES AND ARE NOT OVER- * NOTES  284
*         DIMENSIONED. OVER-DIMENSIONING CAUSES SO MANY PROBLEMS WE   * NOTES  285
*         FEEL IT IS MANDITORY THAT THESE MATRICIES BE KEPT WITH THE  * NOTES  286
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0 END NOTES 291

500008 CM STORAGE USED 290 STATEMENTS 0 SYMBOLS
MODEL 74 ASSEMBLY 0.806 SECONDS 0 REFERENCES

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      PROGRAM VOLAR(INPUT,OUTPUT,PUNCH,TAPE2=10028,TAPE3=10028,TAPE10,
     *              TAPE28=0,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7=PUNCH)
C*****************************************************************
C*                                                               *
C*      VOUGHT LAUNCH AND RECOVERY PROGRAM (DRIVER ROUTINE)      *
C*      DEVELOPED UNDER CONTRACT NO. N62269-77-C-0389  11 OCT 77.*
C*                                                               *
C*****************************************************************
      DIMENSION FMTI(4),FMTO(4),HDG(10),ID(200),LABEL(5),LBLOUT(7),
     A          NC(10),NCOL(10),NFIL(10),NP(10),OUT(10),ROW(200),
     B          SCAL(10),TITLE(32),LABELX(4),LABELY(4),LEGEND(4)
      REAL      LNGTHX,LNGTHY
      INTEGER   FMTI,FMTO
C  *
C  ***    REAL VARIABLES (PROBLEM DEPENDENT).
C  *
      COMMON R(6)
C  *
C  ***    INTEGRATION VARIABLES (LOCATIONS ARE PROBLEM DEPENDENT).
C  *
      EQUIVALENCE (TI,R(1)),(TO,R(2)),(DT,R(3)),(DTOUT,R(4)),
     A            (DTOUT2,R(5)),(TMAX,R(6))
C  *
C  ***    INTEGER VARIABLES (PROBLEM DEPENDENT).
C  *
      COMMON/INTEGER/IN(44)
C  *
C  ***    SEGMENT DESCRIPTORS FOR I AND R ARRAYS (PROBLEM DEPENDENT).
C  *
      COMMON/SEGMENT/NSEGI,NI(25),NSEGR,NR(150)
C  *
C  ***    NAMELIST DEFINITIONS.
C  *
      NAMELIST/CURVE/ NDATA,NCOLX,NCOLY,NCX,NCY,NCXY,LINTYP,DASH,NSYM,
     A                SCALEX,SCALEY,SCALXX,SCALYY
      NAMELIST/PLOTD/ NCURVS,ANGLE,XPLOT,YPLOT,XEXIT,YEXIT,XLEGND,
     A                YLEGND,XORG,YORG,LNGTHX,LNGTHY,STARTX,STARTY,
     B                DELX,DELY,ISOPT
      NAMELIST/SEGMNT/ NSEGI,NI,NSEGR,NR,NPRNT
C*****************************************************************
C*                                                               *
C*      INITIALIZE SEGMENT DESCRIPTORS FOR I AND R ARRAYS.       *
C*                                                               *
C*****************************************************************
      READ(5,SEGMNT)
C  *
C  ***    CONVERT I ARRAY SEGMENT DESCRIPTORS TO RELATIVE FWAS.
C  *
      IF(NPRNT .NE. 0) WRITE(6,25002)
      I     = 1
      J     = NI(I)
      NI(I) = 0
      IF(NPRNT .NE. 0) WRITE(6,31004) I,NI(I),J
      DO 10 I=2,NSEGI
      K     = J
      J     = NI(I)
      NI(I) = NI(I-1) + K
```

```
VOLAR    3
VOLAR    4
VOLAR    5
VOLAR    6
VOLAR    7
VOLAR    8
VOLAR    9
VOLAR   10
VOLAR   11
VOLAR   12
VOLAR   13
VOLAR   14
VOLAR   15
R2       2
R2       3
R2       4
R2       5
R2       6
R2       7
R2       8
R2       9
R2      10
I2       2
I2       3
I2       4
I2       5
SEGMENT  2
SEGMENT  3
SEGMENT  4
SEGMENT  5
VOLAR   19
VOLAR   20
VOLAR   21
VOLAR   22
VOLAR   23
VOLAR   24
VOLAR   25
VOLAR   26
VOLAR   27
VOLAR   28
VOLAR   29
VOLAR   30
VOLAR   31
VOLAR   32
VOLAR   33
VOLAR   34
VOLAR   35
VOLAR   36
VOLAR   37
VOLAR   38
VOLAR   39
VOLAR   40
VOLAR   41
VOLAR   42
VOLAR   43
VOLAR   44
VOLAR   45
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      IF(NPRNT .NE. 0) WRITE(6,31004) I,NI(),J                          VOLAR      46
   10 CONTINUE                                                          VOLAR      47
   60 C  *                                                              VOLAR      48
      C  ***    CONVERT R ARRAY SEGMENT DESCRIPTORS TO RELATIVE FWAS.    VOLAR      49
      C  *                                                              VOLAR      50
      IF(NPRNT .NE. 0) WRITE(6,31002)                                   VOLAR      51
      I     = 1                                                         VOLAR      52
   65 J     = NR(I)                                                     VOLAR      53
      NR(I) = 0                                                         VOLAR      54
      IF(NPRNT .NE. 0) WRITE(6,31004) I,NR(),J                          VOLAR      55
      DO 20 I=2,NSEGR                                                   VOLAR      56
      K     = J                                                         VOLAR      57
   70 J     = NR(I)                                                     VOLAR      58
      NR(I) = NR(I-1) + K                                               VOLAR      59
      IF(NPRNT .NE. 0) WRITE(6,31004) I,NR(),J                          VOLAR      60
   20 CONTINUE                                                          VOLAR      61
      C*****************************************************************VOLAR      62
   75 C*                                                               * VOLAR      63
      C*OPTION CONTROL                                                 * VOLAR      64
      C*                                                               * VOLAR      65
      C*  NOPT = 1 - WRITE I AND R ARRAY I/O INSTRUCTIONS ON A FILE.   * VOLAR      66
      C*         2 - READ  DATA INTO I ARRAY AND WRITE THE INPUT ON A FILE. * VOLAR 67
   80 C*         3 - PRINT DATA FROM I ARRAY.                         * VOLAR      68
      C*         4 - READ  DATA INTO R ARRAY AND WRITE THE INPUT ON A FILE. * VOLAR 69
      C*         5 - PRINT DATA FROM R ARRAY.                         * VOLAR      70
      C*         6 - SET UP DIFFERENTIAL EQUATIONS.                   * VOLAR      71
      C*         7 - DESIGNATE TIME HISTORY OUTPUT VARIABLES.         * VOLAR      72
   85 C*       8-9 - INACTIVE.                                        * VOLAR      73
      C*        10 - READ DATA FROM INPUT AND WRITE A FILE COMPATIBLE FOR * VOLAR 74
      C*             OPTIONS 14, 15, 17 AND 18.                      * VOLAR      75
      C*        11 - STORE TABBING OR PUNCHING INSTRUCTIONS ON A FILE. * VOLAR      76
      C*        12 - STORE PRINTER PLOTTING INSTRUCTIONS ON A FILE.    * VOLAR      77
   90 C*        13 - STORE CALCOMP PLOTTING INSTRUCTIONS ON A FILE.    * VOLAR      78
      C*        14 - PRINT THE TIME HISTORY IN A TABULAR FORM.         * VOLAR      79
      C*        15 - PUNCH TIME HISTORY OUTPUT.                        * VOLAR      80
      C*        16 - INACTIVE.                                         * VOLAR      81
      C*        17 - PRODUCE PRINTER PLOT.                             * VOLAR      82
   95 C*        18 - PRODUCE CALCOMP PLOT.                             * VOLAR      83
      C*        19 - PRINT A TIME HISTORY FILE IN BLOCKED FORM.        * VOLAR      84
      C*        21 - GENERATE A TIME HISTORY (MEANS AND/OR COVARIANCES). * VOLAR   85
      C*     22-27 - INACTIVE                                          * VOLAR      86
      C*        28 - STORE OR RETRIEVE R ARRAY ON TAPE28               * VOLAR      87
  100 C*                                                               * VOLAR      88
      C*****************************************************************VOLAR      89
      100  READ(5,34012) NOPT,LBLOUT                                   VOLAR      90
      IF(NOPT.EQ.0.OR.EOF(5).NE.0.0) STOP                               VOLAR      91
      WRITE(6,34011) NOPT,LBLOUT                                        VOLAR      92
  105 GO TO ( 30001 , 30002 , 30003 , 30004 , 30005 , 30006 , 30007 ,   VOLAR      93
     1          100 ,   100 , 30010 , 30011 , 30012 , 30013 , 30014 ,  VOLAR      94
     2        30015 ,   100 , 30017 , 30018 , 30019 ,   100 , 30021 ,  VOLAR      95
     3          100 ,   100 ,   100 ,   100 ,   100 ,   100 , 30028 ), VOLAR      96
     4 NOPT                                                             VOLAR      97
  110 C*****************************************************************VOLAR      98
      C*                                                               * VOLAR      99
      C*NOPT=1  WRITE I AND R ARRAY I/O INSTRUCTIONS ON A FILE.         * VOLAR     100
      C*                                                               * VOLAR     101
      C*   DEFINITIONS                                                 * VOLAR     102
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      C*         NLIST     FILE WHERE INSTRUCTIONS WILL RESIDE.                 * VOLAR     103
      C*         I,J       J TH ELEMENT I TH SEGMENT OF I OR R ARRAY.           * VOLAR     104
      C*         K,L       L TH ELEMENT K TH SEGMENT OF I OR R ARRAY.           * VOLAR     105
      C*         I,J,K,L   I/O FROM I,J TO K,L LOCATION OF I OR R ARRAY.        * VOLAR     106
      C*         LABEL     VARIABLE NAMES APPEARING BETWEEN I,J AND K,L.        * VOLAR     107
      C*         SCALE     SCALE FACTOR APPLIED TO I/O VALUES (DEFAULT=1.0).    * VOLAR     108
      C*         FMTI      VARIABLE INPUT FORMAT.                               * VOLAR     109
      C*         FMTO      VARIABLE OUTPUT FORMAT.                              * VOLAR     110
      C*                                                                        * VOLAR     111
      C*   OPTION IS TERMINATED BY A BLANK CARD.                                * VOLAR     112
      C*                                                                        * VOLAR     113
      C************************************************************************ VOLAR     114
      30001 READ(5,31001) NLIST                                                  VOLAR     115
            WRITE(6,23001)NLIST                                                  VOLAR     116
            REWIND NLIST                                                         VOLAR     117
      200   READ(5,31008) I,J,K,L,LABEL,SCALE                                    VOLAR     118
            WRITE(6,31009)I,J,K,L,LABEL,SCALE                                    VOLAR     119
            IF(I.LT.0) READ(5,26002) FMTI,FMTO                                   VOLAR     120
            IF(I.LT.0) WRITE(6,26003)FMTI,FMTO                                   VOLAR     121
            WRITE(NLIST) I,J,K,L,LABEL,SCALE                                     VOLAR     122
            IF(I.LT.0) WRITE(NLIST) FMTI,FMTO                                    VOLAR     123
            IF(I.NE.0) GO TO 200                                                 VOLAR     124
            GO TO 100                                                            VOLAR     125
      C************************************************************************ VOLAR     126
      C*                                                                       * VOLAR     127
      C*NOPT=2  READ DATA INTO I ARRAY AND WRITE INPUT ONTO A FILE.             * VOLAR     128
      C*                                                                       * VOLAR     129
      C*   DEFINITIONS                                                         * VOLAR     130
      C*         NLIST     CONTAINS INPUT INSTRUCTIONS.                         * VOLAR     131
      C*         NDATA     CONTAINS I ARRAY DATA.                               * VOLAR     132
      C*         NPF       PERMANENT FILE FOR SAVING INPUT.                     * VOLAR     133
      C*         I,J       J TH ELEMENT I TH SEGMENT OF I ARRAY.                * VOLAR     134
      C*         K,L       L TH ELEMENT K TH SEGMENT OF I ARRAY.                * VOLAR     135
      C*         I,J,K,L   READ I,J TO K,L LOCATIONS OF I ARRAY.                * VOLAR     136
      C*         LABEL     VARIABLE NAMES APPEARING BETWEEN I,J AND K,L.        * VOLAR     137
      C*         SCALE     SCALE FACTOR APPLIED TO INPUT VALUES (DEFAULT=1.0).  * VOLAR     138
      C*         FMTI      VARIABLE INPUT FORMAT.                               * VOLAR     139
      C*         FMTO      VARIABLE OUTPUT FORMAT.                              * VOLAR     140
      C*                                                                        * VOLAR     141
      C*   OPTION IS TERMINATED BY A BLANK CARD.                                * VOLAR     142
      C*                                                                        * VOLAR     143
      C************************************************************************ VOLAR     144
      30002 READ(5,31001) NLIST,NDATA,NPF                                        VOLAR     145
            WRITE(6,25010)NLIST,NDATA,NPF                                        VOLAR     146
            IF(NLIST.NE.5) REWIND NLIST                                          VOLAR     147
            IF(NDATA.NE.5) REWIND NDATA                                          VOLAR     148
            IF(NPF.NE.0)   REWIND NPF                                            VOLAR     149
            FMTI(1) = 10H(16I5)                                                  VOLAR     150
            FMTO(1) = 10H(5X,16I5)                                               VOLAR     151
      11    IF(NLIST.EQ.5) READ(5,31008) I,J,K,L,LABEL,SCALE                     VOLAR     152
            IF(NLIST.NE.5) READ(NLIST)   I,J,K,L,LABEL,SCALE                     VOLAR     153
            IF(NPF.NE.0)   WRITE(NPF)    I,J,K,L,LABEL,SCALE                     VOLAR     154
            WRITE(6,31009)               I,J,K,L,LABEL,SCALE                     VOLAR     155
            IF(I.EQ.0) GO TO 100                                                 VOLAR     156
            IF(I.GT.0) GO TO 12                                                  VOLAR     157
            IF(NLIST.EQ.5) READ(5,26002) FMTI,FMTO                               VOLAR     158
            IF(NLIST.NE.5) READ(NLIST)   FMTI,FMTO                               VOLAR     159
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      IF(NPF.NE.0)   WRITE(NPF)    FMTI,FMTO                          VOLAR   160
      WRITE(6,26003)               FMTI,FMTO                          VOLAR   161
      I       = IABS(I)                                               VOLAR   162
175   12  K1      = NI(I) + J                                         VOLAR   163
      K2      = NI(K) + L                                             VOLAR   164
      IF(NDATA.EQ.5) READ(5,FMTI)  (IN(I),I=K1,K2)                    VOLAR   165
      IF(NDATA.NE.5) READ(NDATA)   (IN(I),I=K1,K2)                    VOLAR   166
      IF(NPF.NE.0)   WRITE(NPF)    (IN(I),I=K1,K2)                    VOLAR   167
180   WRITE(6,FMTO)                (IN(I),I=K1,K2)                    VOLAR   168
      IF(SCALE.EQ.0.0) GO TO 11                                       VOLAR   169
      DO 13 I=K1,K2                                                   VOLAR   170
      IN(I)   = SCALE*IN(I)                                           VOLAR   171
      13  CONTINUE                                                    VOLAR   172
185   GO TO 11                                                        VOLAR   173
C*****************************************************************  VOLAR   174
C*                                                               *  VOLAR   175
C*NOPT=3  PRINT DATA FROM I ARRAY.                                *  VOLAR   176
C*                                                               *  VOLAR   177
190   C*   DEFINITIONS                                             *  VOLAR   178
C*        NLIST     FILE WHERE WRITE INSTRUCTIONS RESIDE.        *  VOLAR   179
C*        I,J       J TH ELEMENT I TH SEGMENT OF I ARRAY.        *  VOLAR   180
C*        K,L       L TH ELEMENT K TH SEGMENT OF I ARRAY.        *  VOLAR   181
C*        I,J,K,L   WRITE I,J TO K,L LOCATIONS OF I ARRAY.       *  VOLAR   182
195   C*        LABEL     VARIABLE NAMES APPEARING BETWEEN I,J AND K,L.  *  VOLAR   183
C*        SCALE     SCALE FACTOR TO BE APPLIED TO OUTPUT VALUES.  *  VOLAR   184
C*        FMTO      VARIABLE OUTPUT FORMAT.                      *  VOLAR   185
C*                                                               *  VOLAR   186
C*   OPTION IS TERMINATED BY A BLANK CARD.                       *  VOLAR   187
200   C*                                                           *  VOLAR   188
C*****************************************************************  VOLAR   189
30003 READ(5,31001) NLIST                                          VOLAR   190
      WRITE(6,23001)NLIST                                          VOLAR   191
      IF(NLIST.NE.5) REWIND NLIST                                  VOLAR   192
205   FMTO(1) = 10H(5X,16I5)                                       VOLAR   193
31    IF(NLIST.EQ.5) READ(5,31008) I,J,K,L,LABEL,SCALE             VOLAR   194
      IF(NLIST.NE.5) READ(NLIST)   I,J,K,L,LABEL,SCALE             VOLAR   195
      WRITE(6,31009)               I,J,K,L,LABEL,SCALE             VOLAR   196
      IF(I.EQ.0) GO TO 100                                         VOLAR   197
210   IF(I.GT.0) GO TO 32                                          VOLAR   198
      IF(NLIST.EQ.5) READ(5,26002) FMTO                            VOLAR   199
      IF(NLIST.NE.5) READ(NLIST)   FMTO                            VOLAR   200
      WRITE(6,26003)               FMTO                            VOLAR   201
      I       = IABS(I)                                            VOLAR   202
215   32  K1      = NI(I) + J                                      VOLAR   203
      K2      = NI(K) + L                                          VOLAR   204
      IF(SCALE.EQ.0.0) GO TO 34                                    VOLAR   205
      DO 33 I=K1,K2                                                VOLAR   206
      IN(I)   = SCALE*IN(I)                                        VOLAR   207
220   33  CONTINUE                                                 VOLAR   208
      34  WRITE(6,FMTO)                (IN(I),I=K1,K2)            VOLAR   209
      IF(SCALE.EQ.0.0) GO TO 31                                    VOLAR   210
      SCALE   = 1.0/SCALE                                          VOLAR   211
      DO 35 I=K1,K2                                                VOLAR   212
225   IN(I)   = SCALE*IN(I)                                        VOLAR   213
      35  CONTINUE                                                 VOLAR   214
      GO TO 31                                                     VOLAR   215
C*****************************************************************  VOLAR   216
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      C*                                                                    * VOLAR    217
230   C*NOPT=4  READ DATA INTO R ARRAY AND WRITE INPUT ON A FILE.           * VOLAR    218
      C*                                                                    * VOLAR    219
      C*   DEFINITIONS                                                      * VOLAR    220
      C*        NLIST     FILE WHERE INPUT INSTRUCTIONS RESIDE.            * VOLAR    221
      C*        NDATA     FILE CONTAINING R ARRAY DATA.                    * VOLAR    222
235   C*        NPF       PERMANENT FILE FOR SAVING INPUT.                 * VOLAR    223
      C*        I,J       J TH ELEMENT I TH SEGMENT OF R ARRAY.            * VOLAR    224
      C*        K,L       L TH ELEMENT K TH SEGMENT OF R ARRAY.            * VOLAR    225
      C*        I,J,K,L   READ I,J TO K,L LOCATIONS OF R ARRAY.            * VOLAR    226
      C*        LABEL     VARIABLE NAMES APPEARING BETWEEN I,J AND K,L.    * VOLAR    227
240   C*        SCALE     SCALE FACTOR TO BE APPLIED TO INPUT VARIABLES.   * VOLAR    228
      C*        FMTI      VARIABLE INPUT FORMAT.                           * VOLAR    229
      C*        FMTO      VARIABLE OUTPUT FORMAT.                          * VOLAR    230
      C*                                                                    * VOLAR    231
      C*   OPTION IS TERMINATED BY A BLANK CARD.                            * VOLAR    232
245   C*                                                                    * VOLAR    233
      C*   CODE MAY BE ENTERED AT STMT 310 BY OPTION 21 - EXITS TO STMT 1100.* VOLAR   234
      C*                                                                    * VOLAR    235
      C**********************************************************************VOLAR    236
      30C04 READ(5,31001) NLIST,NDATA,NPF                                   VOLAR    237
250         WRITE(6,31013)NLIST,NDATA,NPF                                   VOLAR    238
      310   IF(NLIST.NE.5) REWIND NLIST                                     VOLAR    239
            IF(NDATA.NE.5) REWIND NDATA                                     VOLAR    240
            IF(NPF.NE.0)   REWIND NPF                                       VOLAR    241
            FMTI(1) = 10H(7F10.3)                                           VOLAR    242
255         FMTO(1) = 10H(7F14.5)                                           VOLAR    243
      301   IF(NLIST.EQ.5) READ(5,31008) I,J,K,L,LABEL,SCALE                VOLAR    244
            IF(NLIST.NE.5) READ(NLIST)   I,J,K,L,LABEL,SCALE                VOLAR    245
            IF(NPF.NE.0)   WRITE(NPF)    I,J,K,L,LABEL,SCALE                VOLAR    246
            WRITE(6,31009)               I,J,K,L,LABEL,SCALE                VOLAR    247
260         IF(I.EQ.0.AND.NOPT.EQ.4) GO TO 100                              VOLAR    248
            IF(I.EQ.0) GO TO 1100                                           VOLAR    249
            IF(I.GT.0) GO TO 302                                            VOLAR    250
            IF(NLIST.EQ.5) READ(5,26002) FMTI,FMTO                          VOLAR    251
            IF(NLIST.NE.5) READ(NLIST)   FMTI,FMTO                          VOLAR    252
265         IF(NPF.NE.0)   WRITE(NPF)    FMTI,FMTO                          VOLAR    253
            WRITE(6,26003)               FMTI,FMTO                          VOLAR    254
            I       = IABS(I)                                               VOLAR    255
      302   K1      = NR(I) + J                                             VOLAR    256
            K2      = NR(K) + L                                             VOLAR    257
270         IF(NDATA.EQ.5) READ(5,FMTI)  (R(I),I=K1,K2)                     VOLAR    258
            IF(NDATA.NE.5) READ(NDATA)   (R(I),I=K1,K2)                     VOLAR    259
            IF(NPF.NE.0)   WRITE(NPF)    (R(I),I=K1,K2)                     VOLAR    260
            WRITE(6,FMTO)                (R(I),I=K1,K2)                     VOLAR    261
            IF(SCALE.EQ.0.0) GO TO 301                                      VOLAR    262
275         DO 303 I=K1,K2                                                  VOLAR    263
            R(I)    = SCALE*R(I)                                            VOLAR    264
      303   CONTINUE                                                        VOLAR    265
            GO TO 301                                                       VOLAR    266
      C**********************************************************************VOLAR    267
280   C*                                                                    * VOLAR    268
      C*NOPT=5  PRINT DATA FROM R ARRAY.                                    * VOLAR    269
      C*                                                                    * VOLAR    270
      C*   DEFINITIONS                                                      * VOLAR    271
      C*        NTAP      FILE WHERE WRITE INSTRUCTIONS RESIDE.            * VOLAR    272
285   C*        I,J       J TH ELEMENT I TH SEGMENT OF R ARRAY.            * VOLAR    273
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C*        K,L       L TH ELEMENT K TH SEGMENT OF R ARRAY.                    * VOLAR   274
C*        I,J,K,L   WRITE I,J TO K,L LOCATIONS OF R ARRAY.                   * VOLAR   275
C*        LABEL     VARIABLE NAMES APPEARING BETWEEN I,J AND K,L.            * VOLAR   276
C*        SCALE     SCALE FACTOR TO BE APPLIED TO OUTPUT VARIABLES.          * VOLAR   277
C*        FMTO      VARIABLE OUTPUT FORMAT.                                  * VOLAR   278
C*                                                                           * VOLAR   279
C*   OPTION IS TERMINATED BY A BLANK CARD.                                   * VOLAR   280
C*                                                                           * VOLAR   281
C*   CODE MAY BE ENTERED AT STMT 402 BY OPTION 21 - EXITS TO STMT 1111.      * VOLAR   282
C*                                                                           * VOLAR   283
C*************************************************************************** VOLAR   284
30005 READ(5,31001) NTAP                                                     VOLAR   285
      WRITE(6,23001)NTAP                                                     VOLAR   286
402   IF(NTAP.NE.5) REWIND NTAP                                              VOLAR   287
      FMTO(1) = 10H(7F14.5)                                                  VOLAR   288
403   IF(NTAP.EQ.5) READ(5,31008)  I,J,K,L,LABEL,SCALE                       VOLAR   289
      IF(NTAP.NE.5) READ(NTAP)     I,J,K,L,LABEL,SCALE                       VOLAR   290
      WRITE(6,31009)               I,J,K,L,LABEL,SCALE                       VOLAR   291
      IF(I.EQ.0.AND.NOPT.EQ.5) GO TO 100                                     VOLAR   292
      IF(I.EQ.0) GO TO 1111                                                  VOLAR   293
      IF(I.GT.0) GO TO 404                                                   VOLAR   294
      IF(NTAP.EQ.5) READ(5,26002) FMTO                                       VOLAR   295
      IF(NTAP.NE.5) READ(NTAP)    FMTO                                       VOLAR   296
      WRITE(6,26003)              FMTO                                       VOLAR   297
      I      = IABS(I)                                                       VOLAR   298
404   K1     = NP(I) + J                                                     VOLAR   299
      K2     = NR(K) + L                                                     VOLAR   300
      IF(SCALE.EQ.0.0) GO TO 406                                             VOLAR   301
      DO 405 I=K1,K2                                                         VOLAR   302
      R(I)   = SCALE*R(I)                                                    VOLAR   303
405   CONTINUE                                                               VOLAR   304
406   WRITE(6,FMTO)               (R(I),I=K1,K2)                             VOLAR   305
      IF(SCALE.EQ.0.0) GO TO 403                                             VOLAR   306
      SCALE  = 1.0/SCALE                                                     VOLAR   307
      DO 407 I=K1,K2                                                         VOLAR   308
      R(I)   = SCALE*R(I)                                                    VOLAR   309
407   CONTINUE                                                               VOLAR   310
      GO TO 403                                                              VOLAR   311
C*************************************************************************** VOLAR   312
C*                                                                           * VOLAR   313
C*NOPT=6  SET UP DIFFERENTIAL EQUATIONS.                                     * VOLAR   314
C*                                                                           * VOLAR   315
C*   DEFINITIONS                                                             * VOLAR   316
C*        M,J       J TH ELEMENT M TH SEGMENT OF I ARRAY WHERE R ARRAY       * VOLAR   317
C*                  LOCATIONS OF DIFFERENTIAL EQUATION ELEMENTS WILL         * VOLAR   318
C*                  BE STORED.                                               * VOLAR   319
C*        I,J       J TH ELEMENT I TH SEGMENT OF R ARRAY.                    * VOLAR   320
C*        K,L       L TH ELEMENT K TH SEGMENT OF R ARRAY.                    * VOLAR   321
C*        I,J,K,L   LOCATIONS I,J THRU K,L OF R ARRAY CONTAIN                * VOLAR   322
C*                  DIFFERENTIAL EQUATION ELEMENTS WHOSE LOCATION WILL       * VOLAR   323
C*                  BE STORED IN THE NEXT SEQUENTIAL LOCATIONS OF THE        * VOLAR   324
C*                  I ARRAY BEGINNING WITH M,J.                              * VOLAR   325
C*        LABEL     R ARRAY VARIABLE NAMES BETWEEN I,J AND K,L.              * VOLAR   326
C*                                                                           * VOLAR   327
C*   OPTION WILL BE TERMINATED BY A BLANK CARD.                              * VOLAR   328
C*                                                                           * VOLAR   329
C*************************************************************************** VOLAR   330
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      30006 NTAP  = 1                                                          VOLAR     331
      1201  READ(5,31008) M,J                                                  VOLAR     332
345         IF(NTAP.EQ.1) WRITE(6,27002) M,J                                   VOLAR     333
            IF(NTAP.EQ.2) WRITE(6,27003) M,J                                   VOLAR     334
            IF(NTAP.EQ.3) WRITE(6,27004) M,J                                   VOLAR     335
            IF(NTAP.EQ.4) WRITE(6,27005) M,J                                   VOLAR     336
            IF(NTAP.EQ.5) WRITE(6,27006) M,J                                   VOLAR     337
350         M     = NI(M) + J - 1                                              VOLAR     338
      1202  READ(5,31008) I,J,K,L,LABEL                                        VOLAR     339
            WRITE(6,31005)I,J,K,L,LABEL                                        VOLAR     340
            IF(I.EQ.0) GO TO 1205                                              VOLAR     341
            K1    = NR(I) + J                                                  VOLAR     342
355         K2    = NR(K) + L                                                  VOLAR     343
            IF(NTAP.GE.3) GO TO 1204                                           VOLAR     344
            DO 1203 I=K1,K2                                                    VOLAR     345
            M     = M + 1                                                      VOLAR     346
            IN(M) = I                                                          VOLAR     347
360   1203  CONTINUE                                                           VOLAR     348
            GO TO 1202                                                         VOLAR     349
      1204  M     = M + 1                                                      VOLAR     350
            IN(M) = K1                                                         VOLAR     351
            M     = M + 1                                                      VOLAR     352
365         IN(M) = K2                                                         VOLAR     353
            GO TO 1202                                                         VOLAR     354
      1205  NTAP  = NTAP + 1                                                   VOLAR     355
            IF(NTAP.GT.5) GO TO 100                                            VOLAR     356
            GO TO 1201                                                         VOLAR     357
370   C*************************************************************************VOLAR     358
      C*                                                                      * VOLAR     359
      C*NOPT=7  DESIGNATE TIME HISTORY OUTPUT VARIABLES.                      * VOLAR     360
      C*                                                                      * VOLAR     361
      C*   DEFINITIONS                                                       * VOLAR     362
375   C*        I,J       J TH ELEMENT I TH SEGMENT OF R ARRAY.              * VOLAR     363
      C*        K,L       L TH ELEMENT K TH SEGMENT OF R ARRAY.              * VOLAR     364
      C*        I,J,K,L   LOCATIONS I,J THRU K,L OF R ARRAY ARE TO BE OUTPUT * VOLAR     365
      C*                  WITH TIME HISTORY INFORMATION.                     * VOLAR     366
      C*        LABEL     R ARRAY VARIABLE NAMES BETWEEN I,J AND K,L.        * VOLAR     367
380   C*                                                                      * VOLAR     368
      C*   OPTION WILL BE TERMINATED BY A BLANK CARD.                         * VOLAR     369
      C*                                                                      * VOLAR     370
      C*   MAX OF 200 VARIABLES MAY BE SPECIFIED AS OUTPUT VARIABLES.         * VOLAR     371
      C*                                                                      * VOLAR     372
385   C*************************************************************************VOLAR     373
      30007 NOUT    = 0                                                        VOLAR     374
            M       = 0                                                        VOLAR     375
      40    READ(5,25006) I,J,K,L,LABEL                                        VOLAR     376
            WRITE(6,25007)I,J,K,L,LABEL                                        VOLAR     377
390         IF(I.EQ.0) GO TO 100                                               VOLAR     378
            K1      = NR(I) + J                                                VOLAR     379
            K2      = NR(K) + L                                                VOLAR     380
            DO 42 I=K1,K2                                                      VOLAR     381
            NOUT    = NOUT + 1                                                 VOLAR     382
395         IF(NOUT.GT.200) GO TO 41                                           VOLAR     383
            ID(NOUT)= I                                                        VOLAR     384
            GO TO 42                                                           VOLAR     385
      41    M       = M + 1                                                    VOLAR     386
            IF(M.EQ.1) WRITE(6,33001)                                          VOLAR     387
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      NOUT    = 200                                                     VOLAR
42    CONTINUE                                                          VOLAR
      GO TO 40                                                          VOLAR
C*********************************************************************** VOLAR
C*                                                                     * VOLAR
C*NOPT=10  READ DATA FROM INPUT AND WRITE A FILE COMPATIBLE FOR        * VOLAR
C*         OPTIONS 14, 15, 17 AND 18.                                  * VOLAR
C*                                                                     * VOLAR
C*   DEFINITIONS                                                       * VOLAR
C*        NLIST      FILE WHERE DATA WILL RESIDE.                      * VOLAR
C*        K1         NUMBER OF ROWS OF DATA.                           * VOLAR
C*        K2         NUMBER OF COLUMNS OF DATA.                        * VOLAR
C*        L          .EQ. 0 IF NUMBER OF POINTS EQUALS NUMBER OF ROWS. * VOLAR
C*                   .NE. 0 IF NUMBER OF POINTS IS INCLUDED IN FIRST   * VOLAR
C*                   ROW AS A FLOATING POINT NUMBER.                   * VOLAR
C*        ROW(J)     DATA POINTS FOR THE I TH ROW.                     * VOLAR
C*                                                                     * VOLAR
C*   OPTION IS TERMINATED WHEN LAST ROW HAS BEEN READ.                 * VOLAR
C*                                                                     * VOLAR
C*   MAX ALLOWABLE VALUE FOR K2 IS 200.                                * VOLAR
C*                                                                     * VOLAR
C*********************************************************************** VOLAR
30010 READ(5,31001) NLIST                                               VOLAR
      WRITE(6,23001)NLIST                                               VOLAR
      REWIND NLIST                                                      VOLAR
      READ(5,31001) K1,K2,L                                             VOLAR
      WRITE(NLIST)  K1,K2,L                                             VOLAR
      DO 800 I=1,K1                                                     VOLAR
      READ(5,23002) (ROW(J),J=1,K2)                                     VOLAR
      WRITE(NLIST)  (ROW(J),J=1,K2)                                     VOLAR
800   CONTINUE                                                          VOLAR
      GO TO 100                                                         VOLAR
C*********************************************************************** VOLAR
C*                                                                     * VOLAR
C*NOPT=11  STORE TABBING OR PUNCHING INSTRUCTIONS ON A FILE.           * VOLAR
C*                                                                     * VOLAR
C*   DEFINITIONS                                                       * VOLAR
C*        NLIST      FILE WHERE INSTRUCTIONS WILL RESIDE.              * VOLAR
C*        I          .NE. 0 DESIGNATES PUNCHING INSTRUCTIONS.          * VOLAR
C*        K1         NUMBER OF COLUMNS IN TABULATION.                  * VOLAR
C*        LBLOUT     TITLE FOR TABULATED DATA.                         * VOLAR
C*        NTAP       FILE WHERE DATA RESIDES.                          * VOLAR
C*        K2         DATA COLUMN TO BE TABBED.                         * VOLAR
C*        L          COLUMN HEADING.                                   * VOLAR
C*        LABEL      VARIABLE DESCRIPTION.                             * VOLAR
C*        SCALE      SCALE FACTOR TO BE APPLIED TO DATA (DEFAULT=1.0). * VOLAR
C*                                                                     * VOLAR
C*   OPTION IS TERMINATED BY A BLANK CARD.                              VOLAR
C*                                                                     * VOLAR
C*   MAX ALLOWABLE VALUE FOR K1 IS 10.                                 * VOLAR
C*                                                                     * VOLAR
C*********************************************************************** VOLAR
30011 READ(5,31001) NLIST,I                                             VOLAR
      WRITE(6,32001)NLIST,I                                             VOLAR
      IF(I.NE.0) GO TO 501                                              VOLAR
500   READ(5,23006) K1,LBLOUT                                           VOLAR
      WRITE(6,23007)K1,LBLOUT                                           VOLAR
```

```
      WRITE(NLIST)  K1,LBLOUT                                          VOLAR
      IF(K1.EQ.0) GO TO 100                                            VOLAR
  501 K        = 0                                                     VOLAR
  502 READ(5,32002) NTAP,K2,L,LABEL,SCALE                              VOLAR
      WRITE(6,32003)NTAP,K2,L,LABEL,SCALE                              VOLAR
      WRITE(NLIST)  NTAP,K2,L,SCALE                                    VOLAR
      K        = K + 1                                                 VOLAR
      IF(K.EQ.K1.AND.I.EQ.0) GO TO 500                                 VOLAR
      IF(K2.GT.0) GO TO 502                                            VOLAR
      GO TO 100                                                        VOLAR
C*********************************************************************** VOLAR
C*                                                                    * VOLAR
C*NOPT=12  STORE PRINTER PLOTTER INSTRUCTIONS ON A FILE.              * VOLAR
C*                                                                    * VOLAR
C*   DEFINITIONS                                                      * VOLAR
C*        NLIST     FILE WHERE PLOT INSTRUCTIONS WILL RESIDE.         * VOLAR
C*        K1        NUMBER OF PLOTS TO BE PRODUCED.                   * VOLAR
C*   DEFINITIONS FOR PLOT DATA                                        * VOLAR
C*        DELX      INCREMENT PER INCH ON X AXIS.                     * VOLAR
C*        DELY      INCREMENT PER INCH ON Y AXIS.                      VOLAR
C*        FMTI      X AXIS LABEL.                                     * VOLAR
C*        FMTO      Y AXIS LABEL.                                     * VOLAR
C*        NCURVS    NUMBER OF CURVES TO BE PRODUCED ON A PLOT.        * VOLAR
C*        TITLE     3-CARD PLOT TITLE.                                * VOLAR
C*        STARTX    X VALUE AT AXIS INTERSECTION.                     * VOLAR
C*        STARTY    Y VALUE AT AXIS INTERSECTION.                     * VOLAR
C*        XPLOT     NUMBER OF INCHES FROM LEFT TO PLACE *STARTX*.     * VOLAR
C*        YPLOT     NUMBER OF INCHES FROM TOP TO PLACE *STARTY*.      * VOLAR
C*   DEFINITIONS FOR CURVE DATA                                       * VOLAR
C*        LABEL     LEGEND ASSOCIATED WITH A CURVE.                   * VOLAR
C*        NCOLX     COLUMN WHERE DATA FOR X IS LOCATED.               * VOLAR
C*        NCOLY     COLUMN WHERE DATA FOR Y IS LOCATED.               * VOLAR
C*        NDATA     FILE WHERE DATA FOR CURVE RESIDES.                * VOLAR
C*        SCALEX    SCALE FACTOR FOR X (DEFAULT=1.0).                 * VOLAR
C*        NSYM      PLOTTING SYMBOL.                                  * VOLAR
C*        SCALEY    SCALE FACTOR FOR Y (DEFAULT=1.0).                 * VOLAR
C*                                                                    * VOLAR
C*********************************************************************** VOLAR
30012 READ(5,31001)      NLIST                                         VOLAR
      WRITE(6,23001)     NLIST                                         VOLAR
      READ(5,31001)      K1                                            VOLAR
      WRITE(6,31005)     K1                                            VOLAR
      REWIND NLIST                                                     VOLAR
      WRITE(NLIST,31001) K1                                            VOLAR
C  *                                                                   VOLAR
C  ***    READ DATA FOR EACH PLOT.                                     VOLAR
      DO 2001 I=1,K1                                                   VOLAR
      READ(5,24002)      (TITLE(J),J=1,24)                             VOLAR
      WRITE(6,24006)     (TITLE(J),J=1,24)                             VOLAR
      WRITE(NLIST,24002) (TITLE(J),J=1,24)                             VOLAR
      READ(5,24003)      NCURVS,XPLOT,YPLOT,DELX,DELY,STARTX,STARTY    VOLAR
      WRITE(6,24004)     NCURVS,XPLOT,YPLOT,DELX,DELY,STARTX,STARTY    VOLAR
      WRITE(NLIST,24003) NCURVS,XPLOT,YPLOT,DELX,DELY,STARTX,STARTY    VOLAR
      READ(5,24002)      FMTI,FMTO                                     VOLAR
      WRITE(6,24006)     FMTI,FMTO                                     VOLAR
      WRITE(NLIST,24002) FMTI,FMTO                                     VOLAR
C  ***    READ CURVE DATA.                                             VOLAR
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```
      DO 2000 J=1,NCURVS                                                VOLAR
      READ(5,25021)      (LABEL(K),K=1,4),NDATA,NCOLX,NCOLY,NSYM,SCALEX, VOLAR
     1                   SCALEY                                         VOLAR
      WRITE(6,25022)     (LABEL(K),K=1,4),NDATA,NCOLX,NCOLY,NSYM,SCALEX, VOLAR
     1                   SCALEY                                         VOLAR
      WRITE(NLIST,25021) (LABEL(K),K=1,4),NDATA,NCOLX,NCOLY,NSYM,SCALEX, VOLAR
     1                   SCALEY                                         VOLAR
 2000 CONTINUE                                                          VOLAR
 2001 CONTINUE                                                          VOLAR
      GO TO 100                                                         VOLAR
C*********************************************************************** VOLAR
C*                                                                     * VOLAR
C*NOPT=13  STORE CALCOMP PLOTTER INSTRUCTIONS ON A FILE.               * VOLAR
C*                                                                     * VOLAR
C*   DEFINITIONS                                                       * VOLAR
C*        K1         NUMBER OF PLOTS TO BE PRODUCED.                   * VOLAR
C*        L          =4HC.M. IF PLOTTING ON CENTIMETER PAPER.          * VOLAR
C*        NLIST      FILE WHERE PLOTTING INSTRUCTIONS WILL RESIDE.     * VOLAR
C*        PCODE      CALCOMP PLOT CODE                                 * VOLAR
C*        NTAP       FILE PRODUCED BY CALCOMP                          * VOLAR
C*   DEFINITIONS FOR PLOT DATA                                         * VOLAR
C*        ANGLE      PLOT ROTATION ANGLE (DEGREES).                    * VOLAR
C*        DELX       INCREMENT PER INCH ON X AXIS.                     * VOLAR
C*        DELY       INCREMENT PER INCH ON Y AXIS.                     * VOLAR
C*        ISOPT      SPECIAL INDICATOR BIT ARRAY.                      * VOLAR
C*                   BIT(0)=1 READ TITLE TO BE CENTERED OVER PLOT.     * VOLAR
C*                   BIT(1)=1 READ X AXIS LABEL.                       * VOLAR
C*                   BIT(2)=1 READ Y AXIS LABEL.                       * VOLAR
C*                   BIT(3)=1 READ LEGEND TITLE.                       * VOLAR
C*                   BIT(4)=1 READ TITLE AND COORDINATES.              * VOLAR
C*        LABELX     LABEL FOR X AXIS.                                 * VOLAR
C*        LABELY     LABEL FOR Y AXIS.                                 * VOLAR
C*        LEGEND     LEGEND TITLE.                                     * VOLAR
C*        LNGTHX     LENGTH OF X AXIS (INCHES).                        * VOLAR
C*        LNGTHY     LENGTH OF Y AXIS (INCHES).                        * VOLAR
C*        NCURVS     NUMBER OF CURVES APPEARING ON PLOT.               * VOLAR
C*        TITLE      3 CARD PLOT TITLE                                 * VOLAR
C*        STARTX     FIRST X VALUE.                                    * VOLAR
C*        STARTY     FIRST Y VALUE.                                    * VOLAR
C*        X          X COORDINATE FOR PLOT TITLE.                      * VOLAR
C*        XEXIT      FINAL X PEN MOVEMENT (INCHES).                    * VOLAR
C*        XLEGND     X COORDINATE (REL TO XPLOT) OF PLOT LEGEND (INCHES)* VOLAR
C*        XORG       X VALUE AT WHICH AXES INTERCEPT.                  * VOLAR
C*        XPLOT      DISTANCE (INS) BETWEEN LAST X-AXIS ORG AND PRESENT.* VOLAR
C*        Y          Y COORDINATE FOR PLOT TITLE.                      * VOLAR
C*        YEXIT      FINAL Y PEN MOVEMENT (INCHES).                    * VOLAR
C*        YLEGND     Y COORDINATE (REL TO YPLOT) OF PLOT LEGEND (INCHES)* VOLAR
C*        YORG       Y VALUE AT WHICH AXES INTERCEPT.                  * VOLAR
C*        YPLOT      DISTANCE (INS) BETWEEN LAST Y-AXIS ORG AND PRESENT.* VOLAR
C*   DEFINITIONS FOR CURVE DATA                                        * VOLAR
C*        DASH       LENGTH OF PLOTTING SEGMENTS IN DASH PLOT (INCHES). * VOLAR
C*        K          LINE STYLE.                                       * VOLAR
C*        LINTYP     LINE TYPE.                                        * VOLAR
C*                   =0 IF NO SYMBOLS (LINE ONLY).                     * VOLAR
C*                   =- IF NO LINE    (SYMBOL ONLY).                   * VOLAR
C*                   =+ IF BOTH LINE AND SYMBOL.                       * VOLAR
C*        NCOLX      COLUMN ON FILE WHERE X DATA RESIDES.              * VOLAR
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C*        NCOLY     COLUMN IN FILE WHERE Y DATA RESIDES.                  * VOLAR   559
C*        NCX       COLUMN WHERE X ELLIPTICAL AXIS DATA RESIDES.          * VOLAR   560
C*        NCY       COLUMN WHERE Y ELLIPTICAL AXIS DATA RESIDES.          * VOLAR   561
C*        NCXY      COLUMN WHERE XY CROSS CORRELATION DATA RESIDES.       * VOLAR   562
C*        NDATA     FILE WHERE DATA RESIDES.                              * VOLAR   563
C*        NSYM      CALCOMP SYMBOL CODE (99 IF ELLIPSE).                  * VOLAR   564
C*        SCALEX    SCALE FACTOR FOR X DATA (DEFAULT=1.0).                * VOLAR   565
C*        SCALEY    SCALE FACTOR FOR Y DATA (DEFAULT=1.0).                * VOLAR   566
C*        SCALXY    SCALE FACTOR FOR X ELLIPTICAL AXIS (DEFAULT=SCALEX)   * VOLAR   567
C*        SCALYY    SCALE FACTOR FOR Y ELLIPTICAL AXIS (DEFAULT=SCALEX)   * VOLAR   568
C*                                                                        * VOLAR   569
C************************************************************************ VOLAR   570
30013 READ(5,31001)       NLIST                                           VOLAR   571
      WRITE(6,23001)      NLIST                                           VOLAR   572
      READ(5,19001) PCODE,NTAP                                            VOLAR   573
      WRITE(6,19002)PCODE,NTAP                                            VOLAR   574
      WRITE(NLIST,19001) PCODE,NTAP                                       VOLAR   575
      READ(5,31025)       K1,L                                            VOLAR   576
      WRITE(6,31005)      K1                                              VOLAR   577
      REWIND NLIST                                                        VOLAR   578
      WRITE(NLIST,31025) K1,L                                             VOLAR   579
C  *                                                                      VOLAR   580
C  ***     READ DATA FOR PLOT.                                            VOLAR   581
C  *                                                                      VOLAR   582
      DO 908 I=1,K1                                                       VOLAR   583
      READ(5,PLOTD)                                                       VOLAR   584
      WRITE(NLIST,PLOTD)                                                  VOLAR   585
      DO 906 J=1,5                                                        VOLAR   586
      K         = ISCPT.AND.SHIFT(MASK(1),J)                              VOLAR   587
      IF(K.EQ.0) GO TO 906                                                VOLAR   588
      GO TO (901,902,903,904,905),J                                       VOLAR   589
901   READ(5,24002)       TITLE                                           VOLAR   590
      WRITE(NLIST,24002) TITLE                                            VOLAR   591
      WRITE(6,24006)      TITLE                                           VOLAR   592
      GO TO 906                                                           VOLAR   593
902   READ(5,24002)       LABELX                                          VOLAR   594
      WRITE(NLIST,24002) LABELX                                           VOLAR   595
      GO TO 906                                                           VOLAR   596
903   READ(5,24002)       LABELY                                          VOLAR   597
      WRITE(NLIST,24002) LABELY                                           VOLAR   598
      GO TO 906                                                           VOLAR   599
904   READ(5,24002)       LEGEND                                          VOLAR   600
      WRITE(NLIST,24002) LEGEND                                           VOLAR   601
      WRITE(6,24006)      LEGEND                                          VOLAR   602
      GO TO 906                                                           VOLAR   603
905   READ(5,24002)       X,Y                                             VOLAR   604
      WRITE(NLIST,24002) X,Y                                              VOLAR   605
      WRITE(6,24006)      X,Y                                             VOLAR   606
      READ(5,24002)       TITLE                                           VOLAR   607
      WRITE(NLIST,24002) TITLE                                            VOLAR   608
      WRITE(6,24006)      TITLE                                           VOLAR   609
906   CONTINUE                                                            VOLAR   610
      WRITE(6,24007)      NCURVS,XPLOT,YPLOT,XLEGND,YLEGND,ANGLE          VOLAR   611
      WRITE(6,24008)      LABELX,LNGTHX,STARTX,DELX,XORG                  VOLAR   612
      WRITE(6,24008)      LABELY,LNGTHY,STARTY,DELY,YORG                  VOLAR   613
C  ***     READ CURVE DATA.                                               VOLAR   614
      DO 907 J=1,NCURVS                                                   VOLAR   615
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      READ(5,CURVE)                                                          VOLAR     616
      WRITE(NLIST,CURVE)                                                     VOLAR     617
630   READ(5,24010)      K,(LABEL(L),L=1,4)                                  VOLAR     618
      WRITE(NLIST,24010) K,(LABEL(L),L=1,4)                                  VOLAR     619
      WRITE(6,24011)     (LABEL(L),L=1,4),NDATA,NCOLX,NCOLY,NSYM,LINTYP,     VOLAR     620
     1                   DASH,SCALEX,SCALEY,SCALXX,SCALYY                    VOLAR     621
907   CONTINUE                                                               VOLAR     622
635   908   CONTINUE                                                         VOLAR     623
      GO TO 100                                                              VOLAR     624
C*************************************************************************  VOLAR     625
C*                                                                       *  VOLAR     626
C*NOPT=14 TAB OUTPUT.                                                     *  VOLAR     627
640   C*                                                                   *  VOLAR     628
C*    DEFINITIONS                                                        *  VOLAR     629
C*         NLIST     FILE WHERE TAP INSTRUCTIONS RESIDE.                 *  VOLAR     630
C*         K1        NUMBER OF COLUMNS IN TABULATION.                    *  VOLAR     631
C*         LBLOUT    HEADING FOR TABULATED DATA.                         *  VOLAR     632
645   C*         NFIL(I)   FILE WHERE DATA RESIDES.                        *  VOLAR     633
C*         NCOL(I)   DATA COLUMNS TO BE TABBED.                          *  VOLAR     634
C*         HDG(I)    COLUMN HEADINGS.                                    *  VOLAR     635
C*         SCAL(I)   SCALE FACTOR TO BE APPLIED TO DATA (DEFAULT=1.0).   *  VOLAR     636
C*         NC(I)     NUMBER OF COLUMNS OF DATA ON I TH FILE.             *  VOLAR     637
650   C*         NP(I)     NUMBER OF POINTS ON I TH FILE.                  *  VOLAR     638
C*         K2        NUMBER OF ROWS IN TABULATION.                       *  VOLAR     639
C*         ROW(J)    DATA ON J TH ROW OF I TH FILE.                      *  VOLAR     640
C*         OUT(J)    TABULAR DATA FOR J TH ROW OF OUTPUT.                *  VOLAR     641
C*                                                                       *  VOLAR     642
655   C*    MAX ALLOWABLE VALUE FOR K1 IS 10.                              *  VOLAR     643
C*                                                                       *  VOLAR     644
C*    MAX ALLOWABLE VALUE FOR NC(I) IS 200.                              *  VOLAR     645
C*                                                                       *  VOLAR     646
C*************************************************************************  VOLAR     647
660   30014 READ(5,31001) NLIST                                            VOLAR     648
      WRITE(6,23001)NLIST                                                    VOLAR     649
      REWIND NLIST                                                           VOLAR     650
601   READ(NLIST)   K1,LBLOUT                                                VOLAR     651
      IF(K1.LE.0) GO TO 100                                                  VOLAR     652
665   WRITE(6,23005)LBLOUT                                                   VOLAR     653
      DO 602 I=1,K1                                                          VOLAR     654
      READ(NLIST)   NFIL(I),NCOL(I),HDG(I),SCAL(I)                           VOLAR     655
602   CONTINUE                                                               VOLAR     656
      IF(K1.EQ.1) GO TO 605                                                  VOLAR     657
670   C  *                                                                   VOLAR     658
C  ***    MARK MULTIPLE FILE ENTRIES.                                      VOLAR     659
C  *                                                                       VOLAR     660
      L       = K1 - 1                                                       VOLAR     661
      DO 604 I=1,L                                                           VOLAR     662
675   IF(NFIL(I).LT.0) GO TO 604                                             VOLAR     663
      J       = I + 1                                                        VOLAR     664
      DO 603 K=J,K1                                                          VOLAR     665
      IF(NFIL(K).EQ.NFIL(I)) NFIL(K) = -NFIL(I)                              VOLAR     666
603   CONTINUE                                                               VOLAR     667
680   604   CONTINUE                                                         VOLAR     668
C  *                                                                       VOLAR     669
C  ***    FIND NUMBER OF POINTS ON EACH FILE.                              VOLAR     670
C  *                                                                       VOLAR     671
605   K2      = 0                                                            VOLAR     672
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      DO 607 I=1,K1                                                     VOLAP     673
      IF(NFIL(I).LT.0) GO TO 607                                        VOLAP     674
      NTAP    = NFIL(I)                                                 VOLAP     675
      REWIND NTAP                                                       VOLAP     676
      READ(NTAP)    M,NC(I),L                                           VOLAP     677
      K       = NC(I)                                                   VOLAP     678
      IF(L.NE.0) READ(NTAP) (ROW(J),J=1,K)                              VOLAP     679
      DO 606 J=1,K1                                                     VOLAP     680
      IF(IABS(NFIL(J)).NE.NFIL(I)) GO TO 606                            VOLAP     681
      NP(J)   = M                                                       VOLAP     682
      IF(L.NE.0) NP(J) = IFIX(ROW(NCOL(J)) + 0.001)                     VOLAP     683
      IF(NP(J).GT.K2) K2 = NP(J)                                        VOLAP     684
606   CONTINUE                                                          VOLAP     685
607   CONTINUE                                                          VOLAP     686
C  *                                                                    VOLAP     687
C  ***    PRODUCE TABULATION.                                          VOLAP     688
C  *                                                                    VOLAP     689
      WRITE(6,32005) (HDG(I),I=1,K1)                                    VOLAP     690
      DO 610 I=1,K2                                                     VOLAP     691
      DO 609 J=1,K1                                                     VOLAP     692
      IF(NFIL(J).LT.0) GO TO 609                                        VOLAP     693
      NTAP    = NFIL(J)                                                 VOLAP     694
      K       = NC(J)                                                   VOLAP     695
      READ(NTAP)    (ROW(L),L=1,K)                                      VOLAP     696
      IF(EOF(NTAP).NE.0.0) BACKSPACE NTAP                               VOLAP     697
      DO 608 L=1,K1                                                     VOLAP     698
      IF(IABS(NFIL(L)).NE.NFIL(J)) GO TO 608                            VOLAP     699
      OUT(L)  = 0.0                                                     VOLAP     700
      IF(I.GT.NP(L)) GO TO 608                                          VOLAP     701
      OUT(L)  = ROW(NCOL(L))                                            VOLAP     702
      IF(SCAL(L).NE.0.0) OUT(L) = OUT(L)*SCAL(L)                        VOLAP     703
608   CONTINUE                                                          VOLAP     704
609   CONTINUE                                                          VOLAP     705
      WRITE(6,32006)(OUT(J),J=1,K1)                                     VOLAP     706
610   CONTINUE                                                          VOLAP     707
      GO TO 601                                                         VOLAP     708
C*****************************************************************    VOLAP     709
C*                                                               *    VOLAP     710
C*OPT=15 PUNCH OUTPUT.                                           *    VOLAP     711
C*                                                               *    VOLAP     712
C*   DEFINITIONS                                                 *    VOLAP     713
C*        NLIST     FILE WHERE PUNCHING INSTRUCTIONS RESIDE.     *    VOLAP     714
C*        NTAP      FILE WHERE DATA RESIDES.                     *    VOLAP     715
C*        K1        DATA COLUMN TO BE PUNCHED.                   *    VOLAP     716
C*        LABEL(1)  COLUMN HEADING.                              *    VOLAP     717
C*        SCALE     SCALE FACTOR TO BE APPLIED TO DATA.          *    VOLAP     718
C*        K         NUMBER OF ROWS ON DATA FILE.                 *    VOLAP     719
C*        K2        NUMBER OF COLUMNS ON DATA FILE.              *    VOLAP     720
C*        ROW(J)    J TH ROW OF DATA ON FILE.                    *    VOLAP     721
C*        OUT(I)    DATA FOR I TH PUNCHED CARD.                  *    VOLAP     722
C*                                                               *    VOLAP     723
C*   MAX ALLOWABLE VALUE FOR K1 AND K2 IS 200.                   *    VOLAP     724
C*                                                               *    VOLAP     725
C*****************************************************************    VOLAP     726
30015 READ(5,31001) NLIST                                               VOLAP     727
      WRITE(6,23001)NLIST                                               VOLAP     728
      REWIND NLIST                                                      VOLAP     729
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      701   READ(NLIST)   NTAP,K1,LABEL(1),SCALE                          VOLAR   730
            IF(K1.LE.0) GO TO 100                                         VOLAR   731
            REWIND NTAP                                                   VOLAR   732
      745   READ(NTAP)    K,K2,J                                          VOLAR   733
            IF(J.EQ.0) GO TO 702                                          VOLAR   734
            READ(NTAP)    (ROW(J),J=1,K2)                                 VOLAR   735
            K       = IFIX(ROW(K1) + 0.001)                               VOLAR   736
      702   M       = 0                                                   VOLAR   737
      750   L       = 0                                                   VOLAR   738
            DO 703 I=1,K                                                  VOLAR   739
            READ(NTAP)    (ROW(J),J=1,K2)                                 VOLAR   740
            M       = M + 1                                               VOLAR   741
            OUT(M)  = ROW(K1)                                             VOLAR   742
      755   IF(SCALE.NE.0.0) OUT(M) = SCALE*OUT(M)                        VOLAR   743
            IF(M.LT.7) GO TO 703                                          VOLAR   744
            L       = L + 1                                               VOLAR   745
            WRITE(7,32008)(OUT(J),J=1,7),LABEL(1),L                       VOLAR   746
            M       = 0                                                   VOLAR   747
      760   703   CONTINUE                                                VOLAR   748
            IF(M.EQ.0) GO TO 701                                          VOLAR   749
            L       = L + 1                                               VOLAR   750
            M       = M + 1                                               VOLAR   751
            DO 704 I=M,7                                                  VOLAR   752
      765   OUT(I)  = 0.0                                                 VOLAR   753
      704   CONTINUE                                                      VOLAR   754
            WRITE(7,32008)(OUT(J),J=1,7),LABEL(1),L                       VOLAR   755
            GO TO 701                                                     VOLAR   756
           C*************************************************************** VOLAR   757
      770  C*                                                            * VOLAR   758
           C*NOPT=17 PRINTER PLOT                                        * VOLAR   759
           C*                                                            * VOLAR   760
           C*   DEFINITIONS                                              * VOLAR   761
           C*        NLIST     FILE WHERE PLOT INSTRUCTIONS RESIDE.      * VOLAR   762
      775  C*        NPRNT     =0 IF PLOT INSTRUCTIONS ARE NOT TO BE PLAYED BACK * VOLAR 763
           C*                     ON THE OUTPUT FILE.                    * VOLAR   764
           C*        ROW       SCRATCH ARRAY USED BY PLOT ROUTINE.       * VOLAR   765
           C*                                                            * VOLAR   766
           C*************************************************************** VOLAR   767
      780  30017 READ(5,31001) NLIST,NPRNT                                VOLAR   768
            WRITE(6,23001)NLIST                                           VOLAR   769
            CALL PRNPLT(ROW,NLIST,NPRNT)                                  VOLAR   770
            GO TO 100                                                     VOLAR   771
           C*************************************************************** VOLAR   772
      785  C*                                                            * VOLAR   773
           C*NOPT=18 CALCOMP PLOT.                                       * VOLAR   774
           C*                                                            * VOLAR   775
           C*   DEFINITIONS                                              * VOLAR   776
           C*        K1        CALCOMP PLOT CODE.                        * VOLAR   777
      790  C*        NLIST     FILE WHERE PLOT INSTRUCTIONS RESIDE.      * VOLAR   778
           C*        NPRNT     =0 IF PLOT INSTRUCTIONS ARE NOT TO BE PLAYED BACK * VOLAR 779
           C*                     ON THE OUTPUT FILE.                    * VOLAR   780
           C*        NTAP      FILE PRODUCED BY CALCOMP.                 * VOLAR   781
           C*        ROW       SCRATCH ARRAY USED BY PLOT ROUTINE.       * VOLAR   782
      795  C*                                                            * VOLAR   783
           C*************************************************************** VOLAR   784
           30018 READ(5,31001) NLIST,NPRNT                                VOLAR   785
                 WRITE(6,23001)NLIST                                      VOLAR   786
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      READ(5,19001) K1,NTAP                                              VOLAR     787
800   WRITE(6,19002)K1,NTAP                                              VOLAR     788
      CALL PLOTS(K1,0,NTAP)                                              VOLAR     789
      CALL CALPLT(ROW,NLIST,NPRNT)                                       VOLAR     790
      GO TO 100                                                          VOLAR     791
C*************************************************************************VOLAR     792
805   C*                                                                 *VOLAR     793
      C*NOPT=19 PRINT THE TIME HISTORY IN A BLOCKED FORM.                 *VOLAR     794
      C*                                                                 *VOLAR     795
      C*   DEFINITIONS                                                   *VOLAR     796
      C*        NTAP      SCRATCH FILE TO BE PRINTED.                    *VOLAR     797
810   C*        K1        NUMBER OF ROWS OF DATA ON FILE.                *VOLAR     798
      C*        K2        NUMBER OF COLUMNS OF DATA ON FILE.             *VOLAR     799
      C*        M         NO. PASSES THRU FILE REQUIRED TO PRINT ALL COLUMNS.*VOLAR  800
      C*        J         FIRST COLUMN OF DATA CURRENTLY BEING PRINTED.  *VOLAR     801
      C*        K         LAST COLUMN OF DATA CURRENTLY BEING PRINTED.   *VOLAR     802
815   C*        ROW(L)    L TH ROW OF DATA ON FILE.                      *VOLAR     803
      C*                                                                 *VOLAR     804
      C*   OPTION IS TERMINATED BY A BLANK CARD.                         *VOLAR     805
      C*                                                                 *VOLAR     806
      C*   MAX ALLOWABLE VALUE FOR K2 IS 200.                            *VOLAR     807
820   C*                                                                 *VOLAR     808
      C*************************************************************************VOLAR 809
      30019 READ(5,31001) NTAP                                           VOLAR     810
      WRITE(6,23009)NTAP                                                 VOLAR     811
      IF(NTAP.EQ.0) GO TO 100                                            VOLAR     812
825   REWIND NTAP                                                        VOLAR     813
      READ(NTAP)    K1,K2,L                                              VOLAR     814
      M         = (K2 + 9)/10                                            VOLAR     815
      DO 560 I=1,M                                                       VOLAR     816
      J         = 10*(I - 1) + 1                                         VOLAR     817
830   K         = J + 9                                                  VOLAR     818
      IF(K.GT.K2) K = K2                                                 VOLAR     819
      DO 550 NLIST=1,K1                                                  VOLAR     820
      READ(NTAP)    (ROW(L),L=1,K2)                                      VOLAR     821
      WRITE(6,23011)(ROW(L),L=J,K)                                       VOLAR     822
835   550   CONTINUE                                                     VOLAR     823
      IF(I.EQ.M) GO TO 560                                               VOLAR     824
      REWIND NTAP                                                        VOLAR     825
      READ(NTAP)    K1,K2,L                                              VOLAR     826
      560   CONTINUE                                                     VOLAR     827
840   GO TO 30019                                                        VOLAR     828
      C*************************************************************************VOLAR 829
      C*                                                                 *VOLAR     830
      C*NOPT=21 GENERATE A TIME HISTORY (MEANS AND/OR COVARIANCES)        *VOLAR     831
      C*                                                                 *VOLAR     832
845   C*   DEFINITIONS                                                   *VOLAR     833
      C*        TITLE     4-CARD PROBLEM TITLE.                          *VOLAR     834
      C*        NLIST     FILE CONTAINING R ARRAY INPUT INSTRUCTIONS.(NOPT=4)*VOLAR  835
      C*        NTAP      FILE CONTAINING R ARRAY OUTPUT INSTRUCTIONS(NOPT=5)*VOLAR  836
      C*        NDATA     FILE WHERE OUTPUT FROM NOPT=7 WILL RESIDE.     *VOLAR     837
850   C*        INT       INTEGRATION OPTION.                            *VOLAR     838
      C*                  =1 4 TH ORDER RUNGE-KUTTA INTEGRATION.         *VOLAR     839
      C*                  =2 3 RD ORDER RUNGE-KUTTA INTEGRATION.         *VOLAR     840
      C*                  =3 2 ND ORDER ADAMS INTEGRATION.               *VOLAR     841
      C*        NPRNT     .NE. 0 CAUSES DATA TO PRINT AS BLOCK NOT TAB.  *VOLAR     842
855   C*        T0        INITIAL INTEGRATION TIME.                      *VOLAR     843
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C*          TI          CURRENT INTEGRATION TIME.                          * VOLAR
C*          DT          DELTA INTEGRATION TIME.                            * VOLAR
C*          DTOUT       DELTA PRINT TIME.                                  * VOLAR
C*          DTOUT2      DELTA COVARIANCE MATRIX PRINT TIME.                * VOLAR
C*          TMAX        MAX INTEGRATION TIME.                              * VOLAR
C*                                                                         * VOLAR
C*    EXITS TO STMT 310 OF NOPT=4 TO READ INTEGRATION CONTROL VARIABLES.* VOLAR
C*    RETURNS FROM NOPT=4 AT STMT 1100.                                  * VOLAR
C*                                                                         * VOLAR
C*    EXITS TO STMT 402 OF NOPT=5 TO PRINT INITIAL R ARRAY VALUES.       * VOLAR
C*    RETURNS FROM NOPT=5 AT STMT 1111.                                  * VOLAR
C*                                                                         * VOLAR
C*************************************************************************** VOLAR
30021 READ(5,26002) TITLE                                                  VOLAR
      WRITE(6,26003)TITLE                                                  VOLAR
      READ(5,31001) NLIST,NTAP,NDATA,INT,NPRNT                             VOLAR
      WRITE(6,25001)NLIST,NTAP,NDATA,INT,NPRNT                             VOLAR
      WRITE(6,34003)                                                       VOLAR
      CALL SECOND(SEC1)                                                    VOLAR
      TO      = TI                                                         VOLAR
C  *                                                                       VOLAR
C  ***    SET UP CALL TO OPTION 4 TO READ INTEGRATION CONTROL VARIABLES. VOLAR
C  *                                                                       VOLAR
      N1      = NDATA                                                      VOLAR
      NDATA   = 5                                                          VOLAR
      NPF     = 0                                                          VOLAR
      GO TO 310                                                            VOLAR
C  *                                                                       VOLAR
C  ***    SET UP CALL TO OPTION 5 FOR INITIAL INTEGRATION PRINT.          VOLAR
C  *                                                                       VOLAR
1100  NDATA   = N1                                                         VOLAR
      M       = IFIX(DTOUT/DT + 0.001)                                     VOLAR
      L       = IFIX(TMAX/DTOUT + 0.001) + 1                               VOLAR
      N1      = IFIX(DTOUT2/DTOUT + 0.001)                                 VOLAR
      IF(DTOUT2.LT.DTOUT) N1 = 1                                           VOLAR
      N2      = N1                                                         VOLAR
      REWIND NDATA                                                         VOLAR
      J       = 0                                                          VOLAR
      WRITE(NDATA)  L,NOUT,J                                               VOLAR
      CALL SETUP(INT)                                                      VOLAR
      WRITE(6,34005)                                                       VOLAR
      GO TO 402                                                            VOLAR
C  *                                                                       VOLAR
C  ***    PERFORM INTEGRATION FOR THIS PRINT INTERVAL.                    VOLAR
C  *                                                                       VOLAR
1105  DO 1110 I=1,M                                                        VOLAR
      IF(INT.EQ.1) CALL RUNGE                                              VOLAR
      IF(INT.EQ.2) CALL KUTTA                                              VOLAR
      IF(INT.EQ.3) CALL ADAMS                                              VOLAR
1110  CONTINUE                                                             VOLAR
C  *                                                                       VOLAR
C  ***    PRINT RESULTS FOR THIS INTERVAL.                                VOLAR
C  *                                                                       VOLAR
1111  N1      = N1 + 1                                                     VOLAR
      I       = 0                                                          VOLAR
      IF(DTOUT2.GT.0.0.AND.N1.GE.N2) I = 1                                 VOLAR
      CALL MISCAL(I)                                                       VOLAR
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      IF(N1.GE.N2) N1 = 0                                                    VOLAR     901
      DO 1112 I=1,NOUT                                                       VOLAR     902
915   ROW(I)  = R(IO(I))                                                     VOLAR     903
1112  CONTINUE                                                               VOLAR     904
      IF(IPRNT.EQ.0) GO TO 1113                                              VOLAR     905
      WRITE(6,34001)                                                         VOLAR     906
      WRITE(6,34002)(ROW(I),I=1,NOUT)                                        VOLAR     907
920   1113  WRITE(NDATA)  (ROW(I),I=1,NOUT)                                  VOLAR     908
      L       = L - 1                                                        VOLAR     909
      IF(L.GE.0.OR.(TO+0.001).LT.TMAX) GO TO 1105                            VOLAR     910
      CALL SECOND(SEC2)                                                      VOLAR     911
      SEC2    = SEC2 - SEC1                                                  VOLAR     912
925   WRITE(6,34013) SEC2                                                    VOLAR     913
      GO TO 100                                                              VOLAR     914
C*****************************************************************************VOLAR     915
C*                                                                           *VOLAR     916
C*NOPT=28  STORE OR RETRIEVE R ARRAY VALUES ON TAPE28.                       *VOLAR     917
930   C*                                                                     *VOLAR     918
C*   DEFINITIONS                                                           *VOLAR     919
C*        NLIST     FILE WHERE DATA DOES OR WILL RESIDE.                   *VOLAR     920
C*        N1        .GT. 0 DATA IS WRITTEN TO TAPE.                        *VOLAR     921
C*                  .LE. 0 DATA IS READ FROM TAPE.                         *VOLAR     922
935   C*        I,J       J TH ELEMENT I TH SEGMENT OF R ARRAY.            *VOLAR     923
C*        K,L       L TH ELEMENT K TH SEGMENT OF R ARRAY.                  *VOLAR     924
C*        I,J,K,L   I/O PERFORMED FROM I,J TO K,L LOCATIONS OF R ARRAY.    *VOLAR     925
C*        LABEL     VARIABLE NAMES APPEARING BETWEEN I,J AND K,L.         *VOLAR     926
C*        SCALE     SCALE FACTOR TO BE APPLIED TO DATA.                    *VOLAR     927
940   C*                                                                     *VOLAR     928
C*   OPTION IS TERMINATED BY A BLANK CARD.                                 *VOLAR     929
C*                                                                           *VOLAR     930
C*****************************************************************************VOLAR     931
30028 READ(5,31001)  N1                                                      VOLAR     932
945   WRITE(6,31005) N1                                                      VOLAR     933
      REWIND 28                                                              VOLAR     934
19C0  READ(5,31008) I,J,K,L,LABEL,SCALE                                      VOLAR     935
      WRITE(6,31009)I,J,K,L,LABEL,SCALE                                      VOLAR     936
      IF(I.LE.0) GO TO 100                                                   VOLAR     937
950   J       = NR(I) + J                                                    VOLAR     938
      L       = NR(K) + L                                                    VOLAR     939
      IF(SCALE.EQ.0.0) GO TO 1902                                            VOLAR     940
      DO 1901 I=J,L                                                          VOLAR     941
      R(I)    = SCALE*R(I)                                                   VOLAR     942
955   1901  CONTINUE                                                         VOLAR     943
1902  IF(N1.LE.0) GO TO 1903                                                 VOLAR     944
      BUFFER OUT(28,1) (R(J),R(L))                                           VOLAR     945
      IF(UNIT(28)) 1900,100,100                                              VOLAR     946
1903  BUFFER IN(28,1) (R(J),R(L))                                            VOLAR     947
960   IF(UNIT(28)) 1900,10C,10C                                              VOLAR     948
C                                                                            VOLAR     949
19001 FORMAT(2A10)                                                           VOLAR     950
19002 FORMAT(/5X,2A10)                                                       VOLAR     951
23001 FORMAT(5X,5HFILE=,I2/)                                                 VOLAR     952
965   23002 FORMAT(7F10.2)                                                   VOLAR     953
23005 FORMAT(// ///5X,7A10//)                                                VOLAR     954
23006 FORMAT(I5,5X,7A10)                                                     VOLAR     955
23007 FORMAT(5X,I5,5X,7A10)                                                  VOLAR     956
23009 FORMAT(//5X5HFILE=,I2/)                                                VOLAR     957
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      23011 FORMAT(5X,10F12.5)                                                  VOLAR     958
      24002 FORMAT(8A10)                                                        VOLAR     959
      24003 FORMAT(15,5X,6A10)                                                  VOLAR     960
      24004 FORMAT(5X,15,5X,6A10)                                               VOLAR     961
      24006 FORMAT(5X,8A10)                                                     VOLAR     962
975   24007 FORMAT(5X,I5,5X,5F10.4)                                             VOLAR     963
      24008 FORMAT(5X,4A10,4F10.4)                                              VOLAR     964
      24010 FORMAT(D6,4X,4A10)                                                  VOLAR     965
      24011 FORMAT(5X,4A10,5I3,F5.3,2F7.4,D6)                                   VOLAR     966
      25001 FORMAT(5X,16I5)                                                     VOLAR     967
980   25002 FORMAT(1H1,5X,15HSECMENT I-ARRAY //13X,1HI,8X,5HNI(I),3X,           VOLAR     968
     1 9HLENGTH(I)   /)                                                         VOLAR     969
      25006 FORMAT(4I5,6A10)                                                    VOLAR     970
      25007 FORMAT(5X,4I5,6A10)                                                 VOLAR     971
      25010 FORMAT(                          5X6HFILEI=,I2/5X6HFILED=,I2/5X     VOLAR     972
985  1  6HFILEW=,I2/)                                                          VOLAR     973
      25021 FORMAT(4A10,3A5,2X,A1,2X,2A10)                                      VOLAR     974
      25022 FORMAT(5X,4A10,3A5,2X,A1,2X,2A10)                                   VOLAR     975
      26002 FORMAT(8A10)                                                        VOLAR     976
      26003 FORMAT(5X,8A10)                                                     VOLAR     977
990   27002 FORMAT(5X,67HDERIVATIVE INDICES ARE STORED INTO THE I ARRAY BEGINN  VOLAR     978
     1ING AT SEGMENT,I2,8H ELEMENT,I2,1H.)                                      VOLAR     979
      27003 FORMAT(5X,62HSTATE INDICES ARE STORED INTO THE I ARRAY BEGINNING A  VOLAR     980
     1T SEGMENT,I2,8H ELEMENT,I2,1H.)                                           VOLAR     981
      27004 FORMAT(5X,67HPDOT AND P INDICES ARE STORED INTO THE I APRAY BEGINN  VOLAR     982
995  1ING AT SEGMENT,I2,8H ELEMENT,I2,1H.)                                      VOLAR     983
      27005 FORMAT(5X,69HPEDOT AND PE INDICES ARE STORED INTO THE I ARRAY BEGI  VOLAR     984
     1NNING AT SEGMENT,I2,8H ELEMENT,I2,1H.)                                    VOLAR     985
      27006 FORMAT(5X,69HPXDOT AND PX INDICES ARE STORED INTO THE I ARRAY BEGI  VOLAR     986
     1NNING AT SEGMENT,I2,8H ELEMENT,I2,1H.)                                    VOLAR     987
1000  31001 FORMAT(16I5)                                                        VOLAR     988
      31002 FORMAT(1H1,5X,15HSEGMENT R-ARRAY //13X,1HI,8X,5HNR(I),3X,           VOLAR     989
     1 9HLENGTH(I)  /)                                                          VOLAR     990
      31004 FORMAT(5X,3I10)                                                     VOLAR     991
      31005 FORMAT(///5X,16I5)                                                  VOLAR     992
1005  31008 FORMAT(4I5,5A10,   E10.3)                                           VOLAR     993
      31009 FORMAT(5X,4I5,5A10,   F13.5)                                        VOLAR     994
      31013 FORMAT(                          5X6HFILEI=,I2/5X6HFILED=,I2/5X     VOLAR     995
     1  6HFILEW=,I2/)                                                          VOLAR     996
      31025 FORMAT(I5,5X,A4)                                                    VOLAR     997
1010  32001 FORMAT(                                                             VOLAR     998
     1  5X5HFILE=,I2/5X7HIPUNCH=,I2/)                                          VOLAR     999
      32002 FORMAT(2I5,6A10,F10.3)                                              VOLAR    1000
      32003 FORMAT(2I5,6A10,F10.3)                                              VOLAR    1001
      32005 FORMAT(5X,11(2X,A10))                                               VOLAR    1002
1015  32006 FORMAT(5X,10F12.5)                                                  VOLAR    1003
      32008 FORMAT(1P7E10.3,A8,I2)                                              VOLAR    1004
      33001 FORMAT(5X,45HWARNING.....WARNING.....WARNING.....WARNING.. /        VOLAR    1005
     1       5X,45H  THE USER HAS SCREWED UP.  IN NCPT=7 THE     /              VOLAR    1006
     2       5X,45H  MAXIMUM NUMBER OF OUTPUT VARIABLES IS       /              VOLAR    1007
1020 3       5X,45H  200 (DIMENSIONS ON IC AND OUT).  THROUGH    /              VOLAR    1008
     4       5X,45H  THE WISDOM AND FORESIGHT OF THIS ROUTINES   /              VOLAR    1009
     5       5X,45H  AUTHOR, THE USER HAS BEEN PROTECTED.  THE   /              VOLAR    1010
     6       5X,45H  ROUTINE WILL CONTINUE TO READ AS IF NO      /              VOLAR    1011
     7       5X,45H  SCREW UP HAD OCCURED, BUT NOUT WILL BE      /              VOLAR    1012
1025 8       5X,45H  SET TO 200 AND THE ROUTINE WILL PROCEED     /              VOLAR    1013
     9       5X,45H  AS IF ONLY THE FIRST 200 OUTPUT VARIABLES   /              VOLAR    1014
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          A        5X,45H  WERE DESIGNATED.                          /        VOLAR    1015
          B        5X,45HWARNING.....WARNING.....WARNING.....WARNING.. )      VOLAR    1016
      34001 FORMAT(//)                                                        VOLAR    1017
      34002 FORMAT(7F12.5)                                                    VOLAR    1018
      34003 FORMAT(//4X50H INPUT DESIRED INFO FOR TIME HISTORY....        /) VOLAR    1019
      34005 FORMAT(//4X50H RESULTS OF TRIM AND THE CALL TO SETUP....      /) VOLAR    1020
      34011 FORMAT(///5X5HNOPT=,I2,7A10//)                                    VOLAR    1021
      34012 FORMAT(I5,5X,7A10)                                                VOLAR    1022
      34013 FORMAT(//5X,F7.3,30H CP SECONDS USED IN OPTION 21.  //)           VOLAR    1023
            END                                                               VOLAR    1024
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      SUBROUTINE ADAMS                                                  ADAMS
C     ******************************************************************* ADAMS
C     ***                                                               ADAMS
C     ***    ROUTINE TO PERFORM SECOND ORDER ADAMS INTEGRATION.         ADAMS
C     ***                                                               ADAMS
C     ******************************************************************* ADAMS
C     *                                                                 R2
C     ***    REAL VARIABLES (PROBLEM DEPENDENT).                        R2
C     *                                                                 R2
      COMMON R(6)                                                       R2
C     *                                                                 R2
C     ***    INTEGRATION VARIABLES (LOCATIONS ARE PROBLEM DEPENDENT).   R2
C     *                                                                 R2
      EQUIVALENCE (TI,R(1)),(TO,R(2)),(DT,R(3)),(DTOUT,R(4)),           R2
     A            (DTOUT2,R(5)),(TMAX,R(6))                             R2
C     *                                                                 I
C     ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                     I
C     *                                                                 I
      COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NOAW,NOINIT I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                    I
C     *                                                                 I
      COMMON/INTEGER/ INDX1(14)                                         I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 5 - STATE INDICES.                         I
C     *                                                                 I
      COMMON/INTEGER/ INDX2(14)                                         I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                       I
C     *                                                                 I
      COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX        I
C     ***************************************************************  C I
C     *                                                                 INTEG
C     ***    TEMPORARY INTEGRATION STORAGE.                             INTEG
C     ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2      INTEG
C     *                                                                 INTEG
      COMMON/INTEG/ RI(2187),RT(2187)                                   INTEG
C     *                                                                 ADAMS
C     ***    COMPLETE INTEGRATION AT THIS INTEGRATION STEP.             ADAMS
C     *                                                                 ADAMS
      TEMP1       = 0.5*DT                                              ADAMS
C     ***    STATES.                                                    ADAMS
      DO 10 I=1,NSTATES                                                 ADAMS
      R(INDX2(I)) = R(INDX2(I)) + TEMP1*(3.0*R(INDX1(I)) - RT(I))       ADAMS
      RT(I)       = R(INDX1(I))                                         ADAMS
   10 CONTINUE                                                          ADAMS
C     ***    P.                                                         ADAMS
      NL1         = NSTATES + 1                                         ADAMS
      NU1         = NSTATES + NPA * NPA                                 ADAMS
      I1          = INDXPD                                              ADAMS
      I2          = INDXP                                               ADAMS
      DO 20 I=NL1,NU1                                                   ADAMS
      R(I2)       = R(I2) + TEMP1*(3.0*R(I1) - RT(I))                   ADAMS
      RT(I)       = R(I1)                                               ADAMS
      I1          = I1 + 1                                              ADAMS
      I2          = I2 + 1                                              ADAMS
   20 CONTINUE                                                          ADAMS
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      C  ***    PE.                                                          ADAMS     31
            NL2          = NL1 + 1                                           ADAMS     32
            NU2          = NL1 + NPE * NPE                                   ADAMS     33
            I1           = INDXPED                                           ADAMS     34
            I2           = INDXPE                                            ADAMS     35
            DO 30 I=NL2,NU2                                                  ADAMS     36
            R(I2)        = P(I2) + TEMP1*(3.0*R(I1) - RT(I))                 ADAMS     37
            RT(I)        = R(I1)                                             ADAMS     38
            I1           = I1 + 1                                            ADAMS     39
            I2           = I2 +1                                             ADAMS     40
      30    CONTINUE                                                         ADAMS     41
      C  ***    PX.                                                          ADAMS     42
            NL3          = NU2 + 1                                           ADAMS     43
            NEQU         = NU2 + NPX * NPX                                   ADAMS     44
            I1           = INDXPXD                                           ADAMS     45
            I2           = INDXPX                                            ADAMS     46
            DO 40 I=NL3,NEQU                                                 ADAMS     47
            R(I2)        = R(I2) + TEMP1*(3.0*R(I1) - RT(I))                 ADAMS     48
            RT(I)        = R(I1)                                             ADAMS     49
            I1           = I1 + 1                                            ADAMS     50
            I2           = I2 + 1                                            ADAMS     51
      40    CONTINUE                                                         ADAMS     52
      C  *                                                                   ADAMS     53
      C  ***    GENERATE DERIVATIVES AND STATES FOR NEXT INTEGRATION STEP.   ADAMS     54
      C  *                                                                   ADAMS     55
            TI           = TI + DT                                           ADAMS     56
            TO           = TO + DT                                           ADAMS     57
            CALL DEQU                                                        ADAMS     58
            CALL PROP                                                        ADAMS     59
            RETURN                                                           ADAMS     60
            END                                                              ADAMS     61
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      SUBROUTINE AIRWAKE                                                    AIRWAKE    2
C*************************************************************************AIRWAKE    3
C*                                                                       *AIRWAKE    4
C*        AIRWAKE MATH MODEL - REPORT NUMBER 2-5330C/7R-3397.            *AIRWAKE    5
C*                                                                       *AIRWAKE    6
C*************************************************************************AIRWAKE    7
      DIMENSION OUT(6),AWTAB(5,5,18),XTAB(5),YTAB(5),ZTAB(3)            AIRWAKE    8
      EQUIVALENCE (VXX,AWTAB)                                           AIRWAKE    9
C  *                                                                     P          2
C  ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                     P          3
C  *                                                                     R          4
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                            R          5
C  *                                                                     R          6
C  ***    R ARRAY SEGMENT 2 - DERIVATIVES.                              R          7
C  *                                                                     R          8
      COMMON UDOT,VDOT,WDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,         P          9
     A       ZSPDOT,TSPDOT,                                             R         10
     B       VDOT,PBDOT,RBDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT              P         11
C  *                                                                     R         12
C  ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                          R         13
C  *                                                                     R         14
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,             R         15
     A        VB,PB,RB,YAPP,PHI,PSI,YSP                                 R         16
C  *                                                                     R         17
C  ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.      R         18
C  *                                                                     R         19
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,URASO,WRASO,WASDO,    R         20
     A       THETAAO,PSIAO,PHIAO,RCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,   R         21
     B       NO,VBASO                                                   R         22
      REAL   MO,LO,NO                                                   R         23
C  *                                                                     R         24
C  ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                 R         25
C  *                                                                     R         26
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,           R         27
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN               R         28
C  *                                                                     R         29
C  ***    R ARRAY SEGMENT 6 - GEOMETRY.                                 R         30
C  *                                                                     R         31
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTCS                   R         32
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTCS                             R         33
C  *                                                                     R         34
C  ***    R ARRAY SEGMENT 7 - CONSTANTS.                                R         35
C  *                                                                     R         36
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCON,TAUENG,TAUCON,TAUD,        R         37
     1         KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,          R         38
     2         KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,          R         39
     3        OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                     R         40
      REAL   KU,KW,KFRPM,KCON,                                          R         41
     1       KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,           R         42
     2       KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,           R         43
     3        K1,K2,KY,KV                                              R         44
C  *                                                                     R         45
C  ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.     R         46
C  *                                                                     R         47
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X10WS, R         48
     A       Y10WS,VAMB,PSIAMB,X10WA,Y10WA,Z10WA,VWOD,PSIWOD,PSI3,PSISP, R         49
     B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,     R         50
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                C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,     R          51
                D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1,  R          52
     60         E       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,        R          53
                F       ZBIASP                                                       R          54
              C  *                                                                   R          55
              C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                    R          56
              C  *                                                                   R          57
     65         COMMON THETAC,DFPPMOL,DCDNOL,DEOL,GAMMAGS,RANGE,VAIPC,               R          58
                1       DAOL,DROL                                                    R          59
              C  *                                                                   R          60
              C  ***    R ARRAY SEGMENT 10 - AERO DATA.                              R          61
              C  *                                                                   R          62
     70         COMMON XU,XW,XQ,XFRPM,XCDN,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCDN,ZPDIGV,     R          63
                A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE,                    R          64
                B        YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,                 R          65
                C        NDA,NDR                                                     R          66
                 REAL   MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE                        R          67
     75          REAL  LV,LP,LP,LDA,LDR,NV,NP,NR,NDA,NDR                            R          68
              C  *                                                                   R          69
              C  ***    R ARRAY SEGMENT 11                                           R          70
              C  *                                                                   R          71
                COMMON  PC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA,             R          72
     80        1         ERY,ERPHI,ERPSI,YCOM,PHICOM,PSICOM                         R          73
              C  *                                                                   R          74
              C  ***    R ARRAY SEGMENT 12 - CONTROLS.                               R          75
              C  *                                                                   R          76
                COMMON  DE,DT,DCDN,DED,DTD,DCDND,                                    R          77
     85        1         DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D          R          78
              C  *                                                                   R          79
              C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.     R          80
              C  *                                                                   R          81
                COMMON TABV1(6)                                                      R          82
     90       C  *                                                                   R          83
              C  ***    R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE L R          84
              C  *                                                                   R          85
                COMMON TABV2(10)                                                     R          86
              C  *                                                                   R          87
     95       C  ***    R ARRAY SEGMENT 15 - UNUSED                                  R          88
              C  *                                                                   R          89
              C  *                                                                   R          90
              C  ***    R ARRAY SEGMENT 16 - GDF RELATED STUFF                       R          91
              C  *                                                                   R          92
    100         COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR                  R          93
              C  *                                                                   R          94
              C  ***    R ARRAY SEGMENT 17 - SHIP MOTION                             R          95
              C  *                                                                   R          96
                COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WATS,              R          97
    105        1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT       R          98
                REAL KXS,KZS,KTS,KYS,KRS,KPS                                         R          99
              C  *                                                                   R         100
              C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.           R         101
              C  *                                                                   R         102
    110         COMMON TABTC(10)                                                     R         103
                COMMON TPPMDL(10)                                                    R         104
                COMMON TCDNDL(10)                                                    R         105
                COMMON TDEDL(10)                                                     R         106
              C  *                                                                   R         107
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      C  ***    R ARRAY SEGMENTS 24-25                                        R      108
      C  *                                                                    R      109
            COMMON TABR(10)                                                   R      110
            COMMON TABRDCT(10)                                                R      111
      C  *                                                                    R      112
      C  ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AERO DATA TABLES        R      113
      C  *                                                                    R      114
            COMMON TXU(6)                                                     R      115
            COMMON TXW(6)                                                     R      116
            COMMON TXQ(6)                                                     R      117
            COMMON TXRPM(6)                                                   R      118
            COMMON TXCON(6)                                                   R      119
            COMMON TXPIGV(6)                                                  R      120
            COMMON TXDE(6)                                                    R      121
            COMMON TZU(6)                                                     R      122
            COMMON TZW(6)                                                     R      123
            COMMON TZQ(6)                                                     R      124
            COMMON TZRPM(6)                                                   R      125
            COMMON TZCON(6)                                                   R      126
            COMMON TZPIGV(6)                                                  R      127
            COMMON TZDE(6)                                                    R      128
            COMMON TMU(6)                                                     R      129
            COMMON TMW(6)                                                     R      130
            COMMON TMWD(6)                                                    R      131
            COMMON TMQ(6)                                                     R      132
            COMMON TMRPM(6)                                                   R      133
            COMMON TMCON(6)                                                   R      134
            COMMON TMPIGV(6)                                                  R      135
            COMMON TMDE(6)                                                    R      136
      C  *                                                                    R      137
      C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIME R      138
      C  *                                                                    R      139
            COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)            R      140
      C  *                                                                    R      141
      C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.                 R      142
      C  *                                                                    R      143
            COMMON SIGMA(50)                                                  R      144
            COMMON SIGMAXY(50)                                                R      145
      C  *                                                                    R      146
      C  ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES                       R      147
      C  *                                                                    R      148
            COMMON VXX(5,5,3)                                                 R      149
            COMMON VYY(5,5,3)                                                 R      150
            COMMON VZZ(5,5,3)                                                 R      151
            COMMON SVXX(5,5,3)                                                R      152
            COMMON SVYY(5,5,3)                                                R      153
            COMMON SVZZ(5,5,3)                                                R      154
      C  *                                                                    R      155
      C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS             R      156
      C  *                                                                    R      157
            COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),         R      158
           1        TKDEZ(6), TKDEM(6), TKDEDE(6), TKDEDT(6),                 R      159
           2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),         R      160
           3        TKDTZ(6), TKDTM(6), TKDTDE(6), TKDTDT(6)                  R      161
      C  *                                                                    R      162
      C  ***    R ARRAY SEGMENTS 81-106                                       R      163
      C  *                                                                    R      164
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      COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),    R          165
     1       H(1,6),D(1,1),C(4,6),PL(4,4),W(1,1),VU(1,1),VY(1,1),         R          166
     2       VYI(1,1),S(1,1),FE(1,1),CE(1,1),PE(1,1),PED(1,1),            R          167
175  3       KG(1,1),FXHAT(1,1),PXHAT(1,1),PXHATD(1,1),PX(1,1),           R          168
     4       CS(1,1)                                                      R          169
      REAL M1,M2,KG                                                       R          170
C  *                                                                       R          171
C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE REL  R          172
180 C  *                                                                  R          173
      COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                       R          174
     1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                        R          175
C  *                                                                       R          176
C  ***    R ARRAY SEGMENTS 108-119                                        R          177
185 C  *                                                                  R          178
      COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),          R          179
     1        TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),        R          180
     2        TDTVZ(6), TDTVZD(6)                                         R          181
C  *                                                                       R          182
190 C  ***    R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES          R          183
C  *                                                                       R          184
      COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),                   R          185
     1        TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),                   R          186
     2        TNV(6), TNP(6), TNR(6), TNDA(6), TNDR(6)                    R          187
195 C  *                                                                  R          188
C  ***    R ARRAY SEGMENTS 135-139 - LONG. TERMS RECD FOR LAT/DIR CASE    R          189
C  *                                                                       R          190
      COMMON  TABUB(10),TABWB(10),TXAPP(10),TZAPP(10),TXSP(10)            R          191
C  *                                                                       R          192
200 C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS     R          193
C  *                                                                       R          194
      COMMON TDAIN(4), TDAOUT(4), TDRIN(4),TDROUT(4)                      R          195
C  ********************************************************************* C R          196
C  *                                                                                AIRWAKE    11
205 C  ***    LOOKUP TABLE VALUES.                                                   AIRWAKE    12
C  *                                                                                AIRWAKE    13
      DATA XTAB/   0.00 ,  37.00 ,  90.00 , 125.00 , 250.0 /                       AIRWAKE    14
      DATA YTAB/ -18.75 ,   0.00 ,  18.75 ,  54.00 , 104.0 /                       AIRWAKE    15
      DATA ZTAB/ -14.58 , -25.00 , -44.58 /                                        AIRWAKE    16
210 C  *                                                                           AIRWAKE    17
C  ***    PRESET OUTPUT VARIABLES.                                                AIRWAKE    18
C  *                                                                                AIRWAKE    19
      SIGMAVX = SIGMAVY = SIGMAVZ = 0.0                                            AIRWAKE    20
      VXAW    = VYAW    = VZAW    = 0.0                                            AIRWAKE    21
215   UAW     = VAW     = WAW     = 0.0                                            AIRWAKE    22
C  *                                                                           AIRWAKE    23
C  ***    SCALING RELATIONS.                                                      AIRWAKE    24
C  *                                                                                AIRWAKE    25
      XD1     = 46.75/WM                                                           AIRWAKE    26
220   X       = XM*XD1                                                             AIRWAKE    27
      Y       = YM*XD1                                                             AIRWAKE    28
      Z       = ZM*XD1                                                             AIRWAKE    29
C  *                                                                           AIRWAKE    30
C  ***    SHAPING FUNCTION FORMULATION.                                           AIRWAKE    31
225 C  *                                                                           AIRWAKE    32
      XD1     = Y/PSIST + TS4                                                      AIRWAKE    33
      XD2     = Y/PSIST - TS4                                                      AIRWAKE    34
      XD3     = 1.0                                                                AIRWAKE    35
                                                                                   AIRWAKE    92
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      C  ***    CHECK FOR LIMITING CASES.                                    AIRWAKE    36
230         IF(Y.LE.TS1.OR.Y.GE.TS2.OR.X.LE.-1000.0.OR.X.GE.XD1.OR.Z.LE.-100.) AIRWAKE    37
           1 XD3    =-1.0                                                   AIRWAKE    38
            FY1 = FY2 = FY3 = FX1 = FX2 = FX3 = FZ1 = XD3                    AIRWAKE    39
            IF(XD3.EQ.-1.0) GO TO 110                                        AIRWAKE    40
      C  ***    ADJUST DATA BASE.                                            AIRWAKE    41
235         IF(Y.LT.-18.75.AND.X.LE.TS3)                                     AIRWAKE    42
           1 FY1    = COS(3.14159*(Y + 18.75)/(18.75 + TS1))                 AIRWAKE    43
            IF(Y.LT.-18.75.AND.X.GT.TS3)                                     AIRWAKE    44
           1 FY2    = COS(3.14159*(Y + 18.75)/(18.75 - TS5 + X*PSIST))       AIRWAKE    45
            IF(Y.GT.104.0)                                                   AIRWAKE    46
240        1 FY3    = COS(3.14159*(Y - 104.0)/(TS4 - 104.0))                 AIRWAKE    47
            IF(X.GT.0.0.AND.Y.LT.TS5)                                        AIRWAKE    48
           1 FX1    = COS(3.14159*X/XD1)                                     AIRWAKE    49
            IF(X.GE.XD2.AND.Y.GT.TS5)                                        AIRWAKE    50
           1 FX2    = COS(1.570796*(X - XD2)/TS4)                            AIRWAKE    51
245         IF(X.LT.-250.0)                                                  AIRWAKE    52
           1 FX3    = COS(-0.00418879*(X + 250.0))                           AIRWAKE    53
            IF(Z.LT.-44.58)                                                  AIRWAKE    54
           1 FZ1    = COS(-0.0568698*(Z + 44.58))                            AIRWAKE    55
            FONE     = 0.0078125*(1.0 + FY1)*(1.0 + FY2)*(1.0 + FY3)*        AIRWAKE    56
250        1                    (1.0 + FX1)*(1.0 + FX2)*(1.0 + FX3)*         AIRWAKE    57
           2                    (1.0 + FZ1)                                  AIRWAKE    58
            IF(FONE.EQ.0.0) GO TO 110                                        AIRWAKE    59
      C  *                                                                   AIRWAKE    60
      C  ***    TABLE LOOKUP EQUATIONS.                                      AIRWAKE    61
255   C  *                                                                   AIRWAKE    62
            I    = J    = K    = 2                                          AIRWAKE    63
            XD1 = XD2 = XD3 = 1.0                                            AIRWAKE    64
      C  ***    LOCATE SECTION OF TABLE TO BE INTERPOLATED.                  AIRWAKE    65
            IF(Z.GE.ZTAB(1)) GO TO 30                                        AIRWAKE    66
260         DO 20 I=2,3                                                      AIRWAKE    67
            IF(Z.LT.ZTAB(I)) GO TO 20                                        AIRWAKE    68
            XD1      = (ZTAB(I) - Z)/(ZTAB(I) - ZTAB(I-1))                   AIRWAKE    69
            GO TO 30                                                         AIRWAKE    70
      20    CONTINUE                                                         AIRWAKE    71
265         I        = 3                                                     AIRWAKE    72
            XD1      = 0.0                                                   AIRWAKE    73
      30    IF(Y.LE.YTAB(1)) GO TO 50                                        AIRWAKE    74
            DO 40 J=2,5                                                      AIRWAKE    75
            IF(Y.GT.YTAB(J)) GO TO 40                                        AIRWAKE    76
270         XD2      = (YTAB(J) - Y)/(YTAB(J) - YTAB(J-1))                   AIRWAKE    77
            GO TO 50                                                         AIRWAKE    78
      40    CONTINUE                                                         AIRWAKE    79
            J        = 5                                                     AIRWAKE    80
            XD2      = 0.0                                                   AIRWAKE    81
275   50    IF(X.GE.XTAB(1)) GO TO 70                                        AIRWAKE    82
            DO 60 K=2,5                                                      AIRWAKE    83
            IF(ABS(X).GT.XTAB(K)) GO TO 60                                   AIRWAKE    84
            XD3      = (XTAB(K) - ABS(X))/(XTAB(K) - XTAB(K-1))              AIRWAKE    85
            GO TO 70                                                         AIRWAKE    86
280   60    CONTINUE                                                         AIRWAKE    87
            K        = 5                                                     AIRWAKE    88
            XD3      = 0.0                                                   AIRWAKE    89
      C  ***    INTERPOLATE.                                                 AIRWAKE    90
      70    DO 100 L=1,6                                                     AIRWAKE    91
285         II       = 3*(L - 1) + I                                         AIRWAKE    92
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      DO 90 M=1,2                                                       AIRWAKE   93
      JJ      = J                                                       AIRWAKE   94
      DO 80 N=1,2                                                       AIRWAKE   95
      XD5     = AWTAB(K,JJ,II) - XD3*(AWTAB(K,JJ,II) - AWTAB(K-1,JJ,II)) AIRWAKE   96
      IF(N.EQ.1) XD4 = XD5                                              AIRWAKE   97
      JJ      = JJ - 1                                                  AIRWAKE   98
   80 CONTINUE                                                          AIRWAKE   99
      XD6     = XD4 - XD2*(XD4 - XD5)                                   AIRWAKE  100
      IF(M.EQ.1) OUT(L) = XD6                                           AIRWAKE  101
      II      = II - 1                                                  AIRWAKE  102
   90 CONTINUE                                                          AIRWAKE  103
      OUT(L)  = OUT(L) - XD1*(OUT(L) - XD6)                             AIRWAKE  104
  100 CONTINUE                                                          AIRWAKE  105
C  *                                                                    AIRWAKE  106
C  ***    SIGMAS.                                                       AIRWAKE  107
C  *                                                                    AIRWAKE  108
      SIGMAVX = OUT(4)*FONE                                             AIRWAKE  109
      SIGMAVY = OUT(5)*FONE                                             AIRWAKE  110
      SIGMAVZ = OUT(6)*FONE                                             AIRWAKE  111
C  *                                                                    AIRWAKE  112
C  ***    INCREMENTAL AIRWAKE VELOCITIES, SHIP WIND AXIS.               AIRWAKE  113
C  *                                                                    AIRWAKE  114
      VXAW    = (VWOD - OUT(1))*FONE                                    AIRWAKE  115
      VYAW    = OUT(2)*FONE                                             AIRWAKE  116
      VZAW    = OUT(3)*FONE                                             AIRWAKE  117
C  *                                                                    AIRWAKE  118
C  ***    TRANSFORMATION TO AIRCRAFT BODY AXIS.                         AIRWAKE  119
C  *                                                                    AIRWAKE  120
      XD1     = COS(THETAA)                                             AIRWAKE  121
      XD2     = SIN(THETAA)                                             AIRWAKE  122
      XD3     = COS(PSIA)                                               AIRWAKE  123
      XD4     = SIN(PSIA)                                               AIRWAKE  124
      XD5     = COS(PHIA)                                               AIRWAKE  125
      XD6     = SIN(PHIA)                                               AIRWAKE  126
      UAW     = VXAW*XD1*XD3 + VYAW*XD1*XD4 - VZAW*XD2                  AIRWAKE  127
      VAW     = VXAW*(XD2*XD3*XD6 - XD4*XD5) +                          AIRWAKE  128
     1          VYAW*(XD2*XD4*XD6 + XD3*XD5) +                          AIRWAKE  129
     2          VZAW*XD1*XD6                                            AIRWAKE  130
      WAW     = VXAW*(XD2*XD3*XD5 + XD4*XD6) +                          AIRWAKE  131
     1          VYAW*(XD2*XD4*XD5 - XD3*XD6) +                          AIRWAKE  132
     2          VZAW*XD1*XD5                                            AIRWAKE  133
  110 RETURN                                                            AIRWAKE  134
      END                                                               AIRWAKE  135
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      SUBROUTINE AIRWTBL                                                AIRWTBL
C     ******************************************************************  AIRWTBL
C     ***                                                            ***  AIRWTBL
C     ***    CALCULATE TABLES FOR AIRWAKE MATH MODEL                 ***  AIRWTBL
C     ***                                                            ***  AIRWTBL
C     ******************************************************************  AIRWTBL
C     *                                                                  R
C     ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                  R
C     *                                                                  R
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                            R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 2 - DERIVATIVES.                            R
C     *                                                                  R
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,         R
     A       ZSPDOT,TSPDOT,                                             R
     B       VDOT,PBDOT,RBDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT              R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                        R
C     *                                                                  R
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,             R
     A        VB,PB,RB,YAPP,PHI,PSI,YSP                                 R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.    R
C     *                                                                  R
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,    R
     A       THETAAO,PSIAO,PHIAO,RCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,   R
     B       NO,VBASO                                                   R
      REAL   MO,LO,NO                                                   R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.               R
C     *                                                                  R
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,           R
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN               R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 6 - GEOMETRY.                               R
C     *                                                                  R
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                   R
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                             R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 7 - CONSTANTS.                              R
C     *                                                                  R
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,        R
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,           R
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,           R
     3       OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                      R
      REAL  KU,KW,KFRPM,KCDN,                                           R
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,             R
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,             R
     3       K1,K2,KY,KV                                                R
C     *                                                                  R
C     ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.   R
C     *                                                                  R
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X1DWS, R
     A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP, R
     B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,     R
     C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,   R
     D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1, R
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      F       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,
      F       ZBIASP
C  *
C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.
C  *
      COMMON THETAC,DFRPMOL,DCDNOL,DEOL,GAMMAGS,RANGE,VAIRC,
     1       DAOL,DROL
C  *
C  ***    R ARRAY SEGMENT 10 - AERO DATA.
C  *
      COMMON XU,XW,XO,XFRPM,XCDN,XPDIGV,XDE,ZU,ZW,ZC,ZFRPM,ZCDN,ZPDIGV,
     A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE,
     B        YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,
     C        NDA,NDR
      REAL   MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE
      REAL  LV,LP,LR,LDA,LDR,NV,NP,NR,NDA,NDR
C  *
C  ***    R ARRAY SEGMENT 11
C  *
      COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA,
     1        ERY,ERPHI,ERPSI,YCOM,PHICOM,PSICOM
C  *
C  ***    R ARRAY SEGMENT 12 - CONTROLS.
C  *
      COMMON  DE,DT,DCDN,DED,DTD,DCDND,
     1        DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D
C  *
C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.
C  *
      COMMON TABV1(6)
C  *
C  ***    R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE L
C  *
      COMMON TABV2(10)
C  *
C  ***    R ARRAY SEGMENT 15 - UNUSED
C  *
C  *
C  ***    R ARRAY SEGMENT 16 - GDF RELATED STUFF
C  *
      COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR
C  *
C  ***    R ARRAY SEGMENT 17 - SHIP MOTION
C  *
      COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,
     1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT
      REAL KXS,KZS,KTS,KYS,KRS,KPS
C  *
C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.
C  *
      COMMON TABTC(10)
      COMMON TRPMOL(10)
      COMMON TCDNOL(10)
      COMMON TDEOL(10)
C  *
C  ***    R ARRAY SEGMENTS 24-25
C  *
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      COMMON TARR(10)                                                    R        110
      COMMON TARRDOT(10)                                                 R        111
C  *                                                                     R        112
C  ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AERO DATA TABLES         R        113
C  *                                                                     R        114
      COMMON TXU(6)                                                      R        115
      COMMON TXW(6)                                                      R        116
      COMMON TXQ(6)                                                      R        117
      COMMON TXRPM(6)                                                    R        118
      COMMON TXCON(6)                                                    R        119
      COMMON TXPIGV(6)                                                   R        120
      COMMON TXDE(6)                                                     R        121
      COMMON TZU(6)                                                      R        122
      COMMON TZW(6)                                                      R        123
      COMMON TZQ(6)                                                      R        124
      COMMON TZRPM(6)                                                    R        125
      COMMON TZCON(6)                                                    R        126
      COMMON TZPIGV(6)                                                   R        127
      COMMON TZDE(6)                                                     R        128
      COMMON TMU(6)                                                      R        129
      COMMON TMW(6)                                                      R        130
      COMMON TMWD(6)                                                     R        131
      COMMON TMQ(6)                                                      R        132
      COMMON TMRPM(6)                                                    R        133
      COMMON TMCON(6)                                                    R        134
      COMMON TMPIGV(6)                                                   R        135
      COMMON TMDE(6)                                                     R        136
C  *                                                                     R        137
C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIME R        138
C  *                                                                     R        139
      COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)             R        140
C  *                                                                     R        141
C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.                  R        142
C  *                                                                     R        143
      COMMON SIGMA(50)                                                   R        144
      COMMON SIGMAXY(50)                                                 R        145
C  *                                                                     R        146
C  ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES                        R        147
C  *                                                                     R        148
      COMMON VXX(5,5,3)                                                  R        149
      COMMON VYY(5,5,3)                                                  R        150
      COMMON VZZ(5,5,3)                                                  R        151
      COMMON SVXX(5,5,3)                                                 R        152
      COMMON SVYY(5,5,3)                                                 R        153
      COMMON SVZZ(5,5,3)                                                 R        154
C  *                                                                     R        155
C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS              R        156
C  *                                                                     R        157
      COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),          R        158
     1        TKDEZ(6), TKDEN(6), TKDEDE(6), TKDEDT(6),                  R        159
     2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),          R        160
     3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)                   R        161
C  *                                                                     R        162
C  ***    P ARRAY SEGMENTS 81-106                                        R        163
C  *                                                                     R        164
      COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),   R        165
     1       H(1,1),D(1,1),C(4,6),RL(4,4),W(1,1),VU(1,1),VY(1,1),       Plotted  166
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     2        VYI(1,1),S(1,1),FE(1,1),QE(1,1),PF(1,1),PED(1,1),
     3        KG(1,1),FXHAT(1,1),PXHAT(1,1),PXHATD(1,1),PX(1,1),
     4        CS(1,1)
      REAL M1,M2,KG
C  *
C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE REL
C  *
      COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,
     1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD
C  *
C  ***    R ARRAY SEGMENTS 108-119
C  *
      COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),
     1        TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),
     2        TDTVZ(6), TDTVZD(6)
C *
C ***     R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES
C *
      COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),
     1        TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),
     2        TNV(6), TNP(6), TNR(6), TNDA(6), TNDR(6)
C *
C ***     R ARRAY SEGMENTS 135-139 - LONG. TERMS REQD FOR LAT/DIR CASE
C *
      COMMON  TABUB(10),TABWB(10),TXAPP(10),TZAPP(10),TXSP(10)
C  *
C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS
C  *
      COMMON TDAIN(4), TDAOUT(4), TDRIN(4),TDROUT(4)
C  ***************************************************************  C
C
      DIMENSION TAB1(5,5,108) , TAB2(5,5,18), TABWOD(3)
C
      DIMENSION TABIA(5,5,3) , TABIB(5,5,3) , TABIC(5,5,3) ,
     A          TABID(5,5,3) , TABIE(5,5,3) , TABIF(5,5,3)
C
      DIMENSION TABIIA(5,5,3) , TABIIB(5,5,3) , TABIIC(5,5,3) ,
     A          TABIID(5,5,3) , TABIIE(5,5,3) , TABIIF(5,5,3)
C
      DIMENSION TABIIIA(5,5,3) , TABIIIB(5,5,3) , TABIIIC(5,5,3) ,
     A          TABIIID(5,5,3) , TABIIIE(5,5,3) , TABIIIF(5,5,3)
C
      DIMENSION TABIVA(5,5,3) , TABIVB(5,5,3) , TABIVC(5,5,3) ,
     A          TABIVD(5,5,3) , TABIVE(5,5,3) , TABIVF(5,5,3)
C
      DIMENSION TABVA(5,5,3) , TABVB(5,5,3) , TABVC(5,5,3) ,
     A          TABVD(5,5,3) , TABVE(5,5,3) , TABVF(5,5,3)
C
      DIMENSION TABVIA(5,5,3) , TABVIB(5,5,3) , TABVIC(5,5,3) ,
     A          TABVID(5,5,3) , TABVIE(5,5,3) , TABVIF(5,5,3)
C
      EQUIVALENCE (TABIA   , TAB1(1,1,  1)) , (TABIB   , TAB1(1,1,  4)),
     A            (TABIC   , TAB1(1,1,  7)) , (TABID   , TAB1(1,1, 10)),
     B            (TABIE   , TAB1(1,1, 13)) , (TABIF   , TAB1(1,1, 16)),
     C            (TABIIA  , TAB1(1,1, 19)) , (TABIIB  , TAB1(1,1, 22)),
     D            (TABIIC  , TAB1(1,1, 25)) , (TABIID  , TAB1(1,1, 28)),
     E            (TABIIE  , TAB1(1,1, 31)) , (TABIIF  , TAB1(1,1, 34)),
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      F           (TAB1IIA , TAB1(1,1, 37)) , (TAB1IIB , TAB1(1,1, 40)), AIRWTBL    36
230   G           (TAB1IIC , TAB1(1,1, 43)) , (TAB1IID , TAB1(1,1, 46)), AIRWTBL    37
      H           (TAB1IIE , TAB1(1,1, 49)) , (TAB1IIF , TAB1(1,1, 52)), AIRWTBL    38
      I           (TAB1VA  , TAB1(1,1, 55)) , (TAB1VB  , TAB1(1,1, 58)), AIRWTBL    39
      J           (TAB1VC  , TAB1(1,1, 61)) , (TAB1VD  , TAB1(1,1, 64)), AIRWTBL    40
      K           (TAB1VE  , TAB1(1,1, 67)) , (TAB1VF  , TAB1(1,1, 70)), AIRWTBL    41
235   L           (TAB2A   , TAB1(1,1, 73)) , (TAB2B   , TAB1(1,1, 76)), AIRWTBL    42
      M           (TAB2C   , TAB1(1,1, 79)) , (TAB2D   , TAB1(1,1, 82)), AIRWTBL    43
      N           (TAB2E   , TAB1(1,1, 85)) , (TAB2F   , TAB1(1,1, 88)), AIRWTBL    44
      O           (TAB2IA  , TAB1(1,1, 91)) , (TAB2IB  , TAB1(1,1, 94)), AIRWTBL    45
      P           (TAB2IC  , TAB1(1,1, 97)) , (TAB2ID  , TAB1(1,1,100)), AIRWTBL    46
240   Q           (TAB2IE  , TAB1(1,1,103)) , (TAB2IF  , TAB1(1,1,106))  AIRWTBL    47
C                                                                         AIRWTBL    48
      EQUIVALENCE (VXX,TAB2)                                              AIRWTBL    49
C  *                                                                      AIRWTBL    50
C  ***    TABLE 1A. VX AT VSS = 20 KT AND SIS = 30 DEG.                   AIRWTBL    51
245   C  *                                                                AIRWTBL    52
      DATA TAB1A/                                                         AIRWTBL    53
C                                                                         AIRWTBL    54
C  Y          X =    0.00   37.00 . 90.00   125.0   250.0     ZTAB = -14 AIRWTBL    55
C                                                                         AIRWTBL    56
250   -18.75            28.46 , 15.68 , 17.25 , 17.19 , 13.70 ,           AIRWTBL    57
        0.0             3.10 , 12.34 , 19.84 , 19.53 , 16.14 ,            AIRWTBL    58
       18.75           24.62 , 16.13 , 21.17 , 22.99 , 19.63 ,            AIRWTBL    59
       54.0            18.66 , 16.14 , 18.43 , 21.71 , 28.63 ,            AIRWTBL    60
      104.0            13.52 , 22.08 , 27.99 , 29.34 , 29.97 ,            AIRWTBL    61
255   C                                                                   AIRWTBL    62
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL    63
C                                                                         AIRWTBL    64
      -18.75            29.12 , 27.11 , 16.19 , 18.03 , 18.80 ,           AIRWTBL    65
        0.0             19.07 , 19.86 , 21.42 , 21.28 , 15.52 ,           AIRWTBL    66
260    18.75            29.67 , 21.91 , 26.80 , 26.00 , 18.39 ,           AIRWTBL    67
       54.0             22.70 , 20.73 , 25.02 , 25.41 , 29.99 ,           AIRWTBL    68
      104.0             17.59 , 23.37 , 27.80 , 28.77 , 29.21 ,           AIRWTBL    69
C                                                                         AIRWTBL    70
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL    71
265   C                                                                   AIRWTBL    72
      -18.75            31.68 , 31.56 , 28.79 , 23.84 , 23.89 ,           AIRWTBL    73
        0.0             31.81 , 32.08 , 27.85 , 23.35 , 20.52 ,           AIRWTBL    74
       18.75            31.77 , 31.55 , 29.03 , 27.40 , 14.65 ,           AIRWTBL    75
       54.0             30.29 , 30.86 , 30.73 , 31.09 , 30.67 ,           AIRWTBL    76
270    104.0            26.22 , 27.64 , 29.63 , 29.40 , 29.09 /           AIRWTBL    77
C  *                                                                      AIRWTBL    78
C  ***    TABLE 1B. VX AT VSS = 20 KT AND SIS = 50 DEG.                   AIRWTBL    79
C  *                                                                      AIRWTBL    80
      DATA TAB1B/                                                         AIRWTBL    81
275   C                                                                   AIRWTBL    82
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL    83
C                                                                         AIRWTBL    84
      -18.75            29.89 , 24.68 , 12.64 , 10.29 , 10.92 ,           AIRWTBL    85
        0.0             10.85 ,  3.73 ,  6.71 ,  8.01 , 11.30 ,           AIRWTBL    86
280    18.75            -1.66 ,  4.45 ,  7.28 ,  6.32 ,  9.92 ,           AIRWTBL    87
       54.0             7.54 ,  6.66 ,  6.86 ,  2.72 , 10.10 ,            AIRWTBL    88
      104.0             3.81 ,  5.06 ,  6.68 ,  6.48 , 19.56 ,            AIRWTBL    89
C                                                                         AIRWTBL    90
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL    91
285   C                                                                   AIRWTBL    92
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                -18.75          30.68 , 26.80 , 19.48 , 14.14 , 19.39 ,                 AIRWTBL    93
                  0.0           23.90 ,  9.42 , 11.86 ,  9.19 , 15.18 ,                 AIRWTBL    94
                 18.75           7.47 , 10.86 , 12.24 ,  9.71 , 13.08 ,                 AIRWTBL    95
                 54.0           28.40 , 19.54 , 15.27 , 12.05 , 17.36 ,                 AIRWTBL    96
290             104.0           16.12 , 14.08 , 11.10 , 10.21 , 16.89 ,                 AIRWTBL    97
C                                                                                        AIRWTBL    98
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44               AIRWTBL    99
C                                                                                        AIRWTBL   100
                -18.75          33.36 , 34.62 , 31.50 , 27.16 , 22.43 ,                 AIRWTBL   101
295               0.0           33.49 , 31.27 , 21.88 , 20.71 , 17.95 ,                 AIRWTBL   102
                 18.75          34.22 , 29.48 , 20.99 , 20.95 , 12.34 ,                 AIRWTBL   103
                 54.0           36.01 , 35.78 , 32.39 , 30.50 , 24.34 ,                 AIRWTBL   104
                104.0            8.07 , 16.89 , 23.95 , 23.73 , 28.99 /                 AIRWTBL   105
C  *                                                                                     AIRWTBL   106
300 C  ***    TABLE IC. VX AT VSS = 35 KT AND SIS = 30 DEG.                              AIRWTBL   107
C  *                                                                                     AIRWTBL   108
        DATA TARIC/                                                                      AIRWTBL   109
C                                                                                        AIRWTBL   110
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14               AIRWTBL   111
305 C                                                                                    AIRWTBL   112
                -18.75          48.91 , 25.18 , 28.91 , 28.69 , 28.15 ,                 AIRWTBL   113
                  0.0           9.08 , 23.43 , 31.62 , 31.60 , 31.56 ,                  AIRWTBL   114
                 18.75          38.91 , 34.75 , 34.44 , 35.42 , 39.84 ,                 AIRWTBL   115
                 54.0           31.35 , 29.94 , 30.48 , 37.30 , 51.71 ,                 AIRWTBL   116
310              104.0          24.54 , 32.14 , 45.88 , 51.11 , 53.68 ,                 AIRWTBL   117
C                                                                                        AIRWTBL   118
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25               AIRWTBL   119
C                                                                                        AIRWTBL   120
                -18.75          51.67 , 48.67 , 29.34 , 30.90 , 30.72 ,                 AIRWTBL   121
315               0.0           31.62 , 35.13 , 32.07 , 30.55 , 31.15 ,                 AIRWTBL   122
                 18.75          52.77 , 46.36 , 43.06 , 45.71 , 39.39 ,                 AIRWTBL   123
                 54.0           40.17 , 38.47 , 39.14 , 45.49 , 55.78 ,                 AIRWTBL   124
                104.0           31.42 , 39.33 , 46.56 , 50.91 , 52.85 ,                 AIRWTBL   125
C                                                                                        AIRWTBL   126
320 C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44               AIRWTBL   127
C                                                                                        AIRWTBL   128
                -18.75          59.61 , 59.29 , 54.97 , 45.56 , 46.16 ,                 AIRWTBL   129
                  0.0           59.61 , 59.66 , 55.08 , 44.86 , 37.93 ,                 AIRWTBL   130
                 18.75          58.53 , 58.68 , 56.29 , 54.85 , 27.39 ,                 AIRWTBL   131
325              54.0           58.18 , 57.34 , 57.06 , 58.34 , 37.06 ,                 AIRWTBL   132
                104.0           45.92 , 49.34 , 51.94 , 53.73 , 45.59 /                 AIRWTBL   133
C  *                                                                                     AIRWTBL   134
C  ***    TABLE ID. VX AT VSS = 35 KT AND SIS = 50 DEG.                                 AIRWTBL   135
C  *                                                                                     AIRWTBL   136
330     DATA TABID/                                                                      AIRWTBL   137
C                                                                                        AIRWTBL   138
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14               AIRWTBL   139
C                                                                                        AIRWTBL   140
                -18.75          54.65 , 48.77 , 25.67 , 23.25 , 22.69 ,                 AIRWTBL   141
335               0.0           24.42 ,  7.12 , 13.05 , 14.17 , 19.99 ,                 AIRWTBL   142
                 18.75          -5.40 ,  2.97 , 12.64 , 11.81 , 15.93 ,                 AIRWTBL   143
                 54.0           16.30 , 12.25 , 11.29 ,  7.00 , 16.64 ,                 AIRWTBL   144
                104.0           10.78 , 10.41 ,  8.16 , 15.68 , 31.59 ,                 AIRWTBL   145
C                                                                                        AIRWTBL   146
340 C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25               AIRWTBL   147
C                                                                                        AIRWTBL   148
                -18.75          56.32 , 56.52 , 37.52 , 34.10 , 30.83 ,                 AIRWTBL   149
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      0.0              46.67 , 23.07 , 20.92 , 18.69 , 24.76 ,                AIRWTBL   150
     18.75             10.75 , 11.55 , 22.53 , 18.32 , 20.50 ,                AIRWTBL   151
     54.0              52.43 , 34.79 , 24.41 , 20.20 , 25.11 ,                AIRWTBL   152
    104.0              23.67 , 25.59 , 17.43 , 22.29 , 33.68 ,                AIRWTBL   153
C                                                                             AIRWTBL   154
C  Y          X =     0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL   155
C                                                                             AIRWTBL   156
   -18.75             61.99 , 65.63 , 61.99 , 55.57 , 33.10 ,                AIRWTBL   157
      0.0             61.21 , 60.72 , 47.69 , 40.10 , 27.52 ,                AIRWTBL   158
     18.75            62.41 , 51.42 , 38.42 , 32.00 , 18.34 ,                AIRWTBL   159
     54.0             67.22 , 68.20 , 54.67 , 48.81 , 13.46 ,                AIRWTBL   160
    104.0             16.26 , 29.72 , 37.37 , 33.75 , 22.15 /                AIRWTBL   161
C  *                                                                          AIRWTBL   162
C  ***    TABLE IF. VX AT VSS = 45 KT AND SIS = 30 DEG.                      AIRWTBL   163
C  *                                                                          AIRWTBL   164
      DATA TABIF/                                                             AIRWTBL   165
C                                                                             AIRWTBL   166
C  Y          X =     0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL   167
C                                                                             AIRWTBL   168
   -18.75             65.36 , 33.66 , 35.41 , 34.61 , 32.46 ,                AIRWTBL   169
      0.0             12.27 , 31.36 , 38.95 , 33.99 , 33.55 ,                AIRWTBL   170
     18.75            45.97 , 41.83 , 40.11 , 39.03 , 42.87 ,                AIRWTBL   171
     54.0             40.22 , 40.03 , 38.33 , 43.60 , 67.00 ,                AIRWTBL   172
    104.0             32.56 , 44.81 , 57.46 , 64.04 , 69.07 ,                AIRWTBL   173
C                                                                             AIRWTBL   174
C  Y          X =     0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL   175
C                                                                             AIRWTBL   176
   -18.75             72.02 , 66.73 , 37.43 , 37.71 , 38.85 ,                AIRWTBL   177
      0.0             43.95 , 45.81 , 40.88 , 39.28 , 36.41 ,                AIRWTBL   178
     18.75            65.01 , 53.49 , 50.36 , 48.92 , 45.46 ,                AIRWTBL   179
     54.0             41.44 , 46.77 , 46.89 , 56.65 , 70.43 ,                AIRWTBL   180
    104.0             40.64 , 50.32 , 59.79 , 63.50 , 68.02 ,                AIRWTBL   181
C                                                                             AIRWTBL   182
C  Y          X =     0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL   183
C                                                                             AIRWTBL   184
   -18.75             75.23 , 75.44 , 70.54 , 57.54 , 49.01 ,                AIRWTBL   185
      0.0             74.93 , 76.11 , 71.34 , 58.65 , 49.12 ,                AIRWTBL   186
     18.75            73.69 , 74.71 , 72.11 , 69.90 , 52.98 ,                AIRWTBL   187
     54.0             73.06 , 70.38 , 70.67 , 74.38 , 74.42 ,                AIRWTBL   188
    104.0             57.45 , 61.85 , 65.49 , 65.56 , 69.06 /                AIRWTBL   189
C  *                                                                          AIRWTBL   190
C  ***    TABLE IF. VX AT VSS = 45 KT AND SIS = 50 DEG.                      AIRWTBL   191
C  *                                                                          AIRWTBL   192
      DATA TABIF/                                                             AIRWTBL   193
C                                                                             AIRWTBL   194
C  Y          X =     0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL   195
C                                                                             AIRWTBL   196
   -18.75             75.52 , 71.69 , 39.59 , 29.08 , 26.57 ,                AIRWTBL   197
      0.0             39.33 , 11.80 , 13.82 , 20.84 , 22.95 ,                AIRWTBL   198
     18.75            -9.08 ,  3.87 , 10.68 , 17.09 , 20.65 ,                AIRWTBL   199
     54.0             19.08 , 14.04 , 14.66 , 12.93 , 21.55 ,                AIRWTBL   200
    104.0             11.57 ,  9.25 ,  6.33 , 14.21 , 38.44 ,                AIRWTBL   201
C                                                                             AIRWTBL   202
C  Y          X =     0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL   203
C                                                                             AIRWTBL   204
   -18.75             77.68 , 80.95 , 56.43 , 41.51 , 36.76 ,                AIRWTBL   205
      0.0             65.99 , 32.81 , 26.38 , 30.50 , 30.51 ,                AIRWTBL   206
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```
      18.75              10.49 , 17.44 , 20.76 , 27.28 , 26.38 ,                AIRWTBL  207
       54.0              63.90 , 35.23 , 28.17 , 24.18 , 27.88 ,                AIRWTBL  208
      104.0              37.50 , 24.73 , 18.87 , 21.71 , 40.96 ,                AIRWTBL  209
C                                                                               AIRWTBL  210
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44       AIRWTBL  211
C                                                                               AIRWTBL  212
-18.75               79.97 , 82.79 , 77.67 , 69.34 , 57.35 ,                   AIRWTBL  213
   0.0               78.49 , 75.16 , 56.57 , 53.56 , 51.35 ,                   AIRWTBL  214
 18.75               79.76 , 56.22 , 41.59 , 40.91 , 43.69 ,                   AIRWTBL  215
  54.0               85.52 , 86.19 , 71.83 , 61.04 , 55.71 ,                   AIRWTBL  216
 104.0               17.65 , 35.79 , 47.24 , 46.83 , 54.48 /                   AIRWTBL  217
C  *                                                                            AIRWTBL  218
C  ***    TABLE IIA. VY AT VSS = 20 KT AND SIS = 30 DEG.                       AIRWTBL  219
C  *                                                                            AIRWTBL  220
      DATA TABIIA/                                                              AIRWTBL  221
C                                                                               AIRWTBL  222
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14       AIRWTBL  223
C                                                                               AIRWTBL  224
-18.75               -0.41 ,  0.17 , -5.56 , -2.65 , -0.02 ,                   AIRWTBL  225
   0.0                3.75 , -5.10 , -4.32 , -2.04 , -1.18 ,                   AIRWTBL  226
 18.75               -1.96 , -4.10 , -1.57 , -0.98 , -1.13 ,                   AIRWTBL  227
  54.0               -2.35 , -0.59 ,  0.27 , -0.08 , -2.01 ,                   AIRWTBL  228
 104.0                0.85 , -1.92 , -3.71 , -4.16 , -2.56 ,                   AIRWTBL  229
C                                                                               AIRWTBL  230
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25       AIRWTBL  231
C                                                                               AIRWTBL  232
-18.75               2.84 ,  4.65 ,  0.48 ,  0.99 ,  3.20 ,                    AIRWTBL  233
   0.0               6.45 ,  4.52 , -0.33 , -0.99 ,  0.52 ,                    AIRWTBL  234
 18.75               3.80 ,  1.08 ,  1.31 ,  1.50 ,  1.70 ,                    AIRWTBL  235
  54.0               0.72 ,  1.57 ,  2.88 ,  1.00 ,  0.65 ,                    AIRWTBL  236
 104.0               0.90 , -3.41 , -2.41 , -2.92 , -2.38 ,                    AIRWTBL  237
C                                                                               AIRWTBL  238
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44       AIRWTBL  239
C                                                                               AIRWTBL  240
-18.75               3.07 ,  4.36 ,  6.84 ,  5.38 ,  5.10 ,                    AIRWTBL  241
   0.0               1.65 ,  2.47 ,  4.95 ,  3.87 ,  3.33 ,                    AIRWTBL  242
 18.75               4.11 ,  3.88 ,  8.26 ,  6.94 , -0.39 ,                    AIRWTBL  243
  54.0               3.67 ,  4.24 ,  5.61 ,  5.35 ,  3.66 ,                    AIRWTBL  244
 104.0               3.09 ,  2.80 ,  2.02 ,  1.03 ,  0.91 /                    AIRWTBL  245
C  *                                                                            AIRWTBL  246
C  ***    TABLE IIIA. VZ AT VSS = 20 KT AND SIS = 30 DEG.                      AIRWTBL  247
C  *                                                                            AIRWTBL  248
C  *                                                                            AIRWTBL  249
C  ***    TABLE IIB. VY AT VSS = 20 KT AND SIS = 50 DEG.                       AIRWTBL  250
C  *                                                                            AIRWTBL  251
      DATA TABIIB/                                                              AIRWTBL  252
C                                                                               AIRWTBL  253
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14       AIRWTBL  254
C                                                                               AIRWTBL  255
-18.75               -1.43 , -4.90 , -3.30 , -0.05 ,  2.46 ,                   AIRWTBL  256
   0.0                3.89 , -5.44 , -3.33 ,  0.06 ,  3.35 ,                   AIRWTBL  257
 18.75               -7.14 , -6.36 , -2.64 , -0.26 ,  0.80 ,                   AIRWTBL  258
  54.0               -3.00 , -1.63 ,  0.91 ,  4.96 ,  1.46 ,                   AIRWTBL  259
 104.0                2.39 ,  3.77 ,  2.17 , -0.19 , -3.18 ,                   AIRWTBL  260
C                                                                               AIRWTBL  261
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25       AIRWTBL  262
C                                                                               AIRWTBL  263
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     -18.75              1.34 , -2.35 , -1.13 , -0.02 ,  6.19 ,                AIRWTBL  264
        0.0              5.65 , -2.05 , -1.84 , -0.86 ,  4.59 ,                AIRWTBL  265
      18.75              3.35 , -3.37 , -0.53 ,  1.39 ,  3.39 ,                AIRWTBL  266
460   54.0               1.80 ,  0.75 ,  3.78 ,  5.71 ,  1.65 ,                AIRWTBL  267
     104.0               7.33 ,  6.44 ,  3.16 ,  0.79 , -2.29 ,                AIRWTBL  268
C                                                                              AIRWTBL  269
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44      AIRWTBL  270
C                                                                              AIRWTBL  271
465  -18.75              0.49 ,  0.37 ,  3.34 ,  2.25 ,  4.80 ,                AIRWTBL  272
        0.0             -1.68 , -0.26 ,  0.05 , -0.53 ,  2.05 ,                AIRWTBL  273
      18.75              2.68 ,  1.39 ,  0.52 , -0.19 , -0.69 ,                AIRWTBL  274
      54.0               2.08 ,  1.94 ,  2.00 ,  2.32 ,  1.80 ,                AIRWTBL  275
     104.0               3.24 ,  6.99 ,  5.31 ,  3.00 ,  3.09 /                AIRWTBL  276
470  C  *                                                                      AIRWTBL  277
     C  ***    TABLE IIC. VY AT VSS = 35 KT AND SIS = 30 DEG.                  AIRWTBL  278
     C  *                                                                      AIRWTBL  279
          DATA TABIIC/                                                         AIRWTBL  280
     C                                                                         AIRWTBL  281
475  C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  282
     C                                                                         AIRWTBL  283
     -18.75             -0.13 ,  0.21 , -9.44 , -6.94 , -0.25 ,                AIRWTBL  284
        0.0              8.50 , -8.52 , -7.84 , -3.88 , -1.87 ,                AIRWTBL  285
      18.75             -5.74 , -6.78 , -3.96 , -1.57 , -3.02 ,                AIRWTBL  286
480   54.0              -4.45 , -0.35 ,  1.34 , -3.06 , -2.13 ,                AIRWTBL  287
     104.0               2.25 , -1.19 , -7.95 ,-10.04 , -5.56 ,                AIRWTBL  288
     C                                                                         AIRWTBL  289
     C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  290
     C                                                                         AIRWTBL  291
485  -18.75              6.61 , 10.81 ,  2.21 , -0.61 ,  3.92 ,                AIRWTBL  292
        0.0             12.80 , 11.08 ,  2.19 ,  0.08 ,  1.65 ,                AIRWTBL  293
      18.75              9.07 , 13.60 ,  5.27 ,  4.42 ,  1.61 ,                AIRWTBL  294
      54.0               2.20 ,  3.91 ,  6.87 ,  2.34 , -0.09 ,                AIRWTBL  295
     104.0               3.16 , -2.66 , -4.48 , -5.90 , -4.96 ,                AIRWTBL  296
490  C                                                                         AIRWTBL  297
     C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  298
     C                                                                         AIRWTBL  299
     -18.75              4.55 ,  7.29 , 13.31 , 10.40 , 12.32 ,                AIRWTBL  300
        0.0              3.58 ,  5.71 , 11.17 ,  7.77 ,  7.35 ,                AIRWTBL  301
495   18.75             10.87 ,  9.93 , 15.92 , 15.55 ,  4.18 ,                AIRWTBL  302
      54.0              11.78 , 12.12 , 13.84 , 10.73 ,  5.86 ,                AIRWTBL  303
     104.0               7.53 ,  5.85 ,  6.81 ,  3.40 ,  3.82 /                AIRWTBL  304
     C  *                                                                      AIRWTBL  305
     C  ***    TABLE IID. VY AT VSS = 35 KT AND SIS = 50 DEG.                  AIRWTBL  306
500  C  *                                                                      AIRWTBL  307
          DATA TABIID/                                                         AIRWTBL  308
     C                                                                         AIRWTBL  309
     C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  310
     C                                                                         AIRWTBL  311
505  -18.75             -3.66 , -7.13 , -3.73 ,  2.09 ,  3.41 ,                AIRWTBL  312
        0.0              3.74 , -4.95 , -3.97 ,  1.31 ,  2.38 ,                AIRWTBL  313
      18.75             -9.64 ,-10.33 , -7.90 , -0.16 , -0.55 ,                AIRWTBL  314
      54.0               0.93 , -4.11 , -1.64 ,  5.05 , -2.81 ,                AIRWTBL  315
     104.0               6.03 , 10.44 ,  3.57 ,  0.99 , -6.71 ,                AIRWTBL  316
510  C                                                                         AIRWTBL  317
     C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  318
     C                                                                         AIRWTBL  319
     -18.75              0.87 , -2.99 ,  0.70 ,  3.88 ,  7.51 ,                AIRWTBL  320
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                .0.0          1.47 , -1.48 , -2.50 ,  1.56 ,  4.98 ,                AIRWTBL   321
515           18.75           3.81 , -3.47 , -4.46 ,  3.35 ,  3.63 ,                AIRWTBL   322
               54.0          -1.44 , -0.48 ,  8.26 ,  9.36 ,  2.20 ,                AIRWTBL   323
              104.0           9.49 ,  9.96 ,  4.95 ,  3.22 , -4.05 ,                AIRWTBL   324
                C                                                                    AIRWTBL   325
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL   326
520             C                                                                    AIRWTBL   327
              -18.75           1.57 ,  2.52 ,  5.48 ,  4.68 ,  1.79 ,                AIRWTBL   328
                0.0           -1.34 ,  1.27 ,  1.95 ,  2.05 , -3.71 ,                AIRWTBL   329
               18.75           8.86 ,  7.28 ,  4.24 ,  1.13 , -3.79 ,                AIRWTBL   330
               54.0            4.57 ,  5.31 ,  6.58 ,  8.41 , -5.12 ,                AIRWTBL   331
525            104.0           6.75 , 10.10 ,  9.62 ,  8.44 , -0.46 /                AIRWTBL   332
                C  *                                                                 AIRWTBL   333
                C  ***    TABLE IIE. VY AT VSS = 45 KT AND SIS = 30 DEG.             AIRWTBL   334
                C  *                                                                 AIRWTBL   335
                     DATA TABIIE/                                                    AIRWTBL   336
530             C                                                                    AIRWTBL   337
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL   338
                C                                                                    AIRWTBL   339
              -18.75          -3.97 , -1.94 ,-12.87 , -5.98 ,  1.19 ,                AIRWTBL   340
                0.0           12.83 ,-16.82 , -9.13 , -2.18 , -0.06 ,                AIRWTBL   341
535            18.75          -10.93 ,-12.36 , -3.26 , -1.71 , -3.27 ,               AIRWTBL   342
               54.0           -10.14 , -1.21 ,  1.86 ,  0.67 , -2.67 ,               AIRWTBL   343
              104.0            4.89 , -4.28 ,-12.30 ,-13.19 , -6.90 ,                AIRWTBL   344
                C                                                                    AIRWTBL   345
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL   346
540             C                                                                    AIRWTBL   347
              -18.75           6.86 , 11.91 ,  2.52 ,  0.13 ,  8.44 ,                AIRWTBL   348
                0.0           21.23 , 16.36 ,  1.53 ,  0.11 ,  3.69 ,                AIRWTBL   349
               18.75          10.03 ,  2.27 ,  4.28 ,  7.09 ,  2.42 ,                AIRWTBL   350
               54.0            2.80 ,  6.50 ,  8.80 ,  5.15 ,  0.24 ,                AIRWTBL   351
545            104.0           4.67 , -1.73 , -6.05 , -6.88 , -7.30 ,                AIRWTBL   352
                C                                                                    AIRWTBL   353
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL   354
                C                                                                    AIRWTBL   355
              -18.75           6.23 ,  8.70 , 15.06 , 14.61 , 15.17 ,                AIRWTBL   356
550             0.0            3.98 ,  6.67 , 13.81 ,  9.86 ,  9.33 ,                AIRWTBL   357
               18.75          13.66 , 12.94 , 21.41 , 19.74 , 10.03 ,                AIRWTBL   358
               54.0           15.87 , 15.27 , 19.13 , 14.82 ,  6.45 ,                AIRWTBL   359
              104.0            9.20 ,  7.40 ,  8.66 ,  4.28 , -1.66 /                AIRWTBL   360
                C  *                                                                 AIRWTBL   361
555             C  ***    TABLE IIF. VY AT VSS = 45 KT AND SIS = 50 DEG.             AIRWTBL   362
                C  *                                                                 AIRWTBL   363
                     DATA TABIIF/                                                    AIRWTBL   364
                C                                                                    AIRWTBL   365
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL   366
560             C                                                                    AIRWTBL   367
              -18.75           -4.95 ,-11.73 ,  0.73 , -2.89 ,  3.65 ,                AIRWTBL   368
                0.0            5.18 , -7.20 , -0.07 , -0.23 ,  2.48 ,                AIRWTBL   369
               18.75          -15.63 ,-15.71 , -4.81 ,  0.60 ,  0.83 ,               AIRWTBL   370
               54.0            -1.15 , -8.26 ,  1.33 ,  3.27 , -1.58 ,               AIRWTBL   371
565            104.0           5.52 , 12.74 ,  7.59 ,  3.84 , -9.16 ,                AIRWTBL   372
                C                                                                    AIRWTBL   373
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL   374
                C                                                                    AIRWTBL   375
              -18.75           -0.79 , -3.53 , -0.71 ,  1.23 ,  9.90 ,                AIRWTBL   376
570             0.0            -5.20 , -1.30 , -0.93 , -0.07 ,  6.83 ,                AIRWTBL   377
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                18.75              1.90 , -7.26 , -3.00 ,  4.42 ,  5.70 ,                AIRWTBL   378
                 54.0             -0.87 ,  3.10 ,  9.11 ,  9.00 ,  1.11 ,                AIRWTBL   379
                104.0             16.61 , 13.55 ,  8.07 ,  5.33 , -5.58 ,                AIRWTBL   380
               C                                                                         AIRWTBL   381
575            C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -44 AIRWTBL   382
               C                                                                         AIRWTBL   383
               -18.75             1.80 ,  2.92 ,  6.04 ,  8.00 , 14.94 ,                AIRWTBL   384
                  0.0            -5.24 ,  2.19 ,  4.77 ,  3.07 ,  8.66 ,                AIRWTBL   385
                18.75             8.19 , 11.74 ,  3.59 ,  2.46 ,  7.81 ,                AIRWTBL   386
580              54.0             4.24 ,  4.32 ,  9.80 , 10.13 ,  7.60 ,                AIRWTBL   387
                104.0             6.36 , 10.59 , 14.86 ,  8.28 ,  6.28 /                AIRWTBL   388
                     DATA TAB1111A/                                                      AIRWTBL   389
               C                                                                         AIRWTBL   390
               C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -14 AIRWTBL   391
585            C                                                                         AIRWTBL   392
               -18.75            -7.73 , -3.15 , -3.57 , -3.85 ,  0.45 ,                AIRWTBL   393
                  0.0            -1.26 , -3.66 , -3.26 , -2.48 ,  1.13 ,                AIRWTBL   394
                18.75             2.24 , -1.10 , -1.40 ,  0.19 ,  2.49 ,                AIRWTBL   395
                 54.0            -2.41 , -1.35 ,  2.20 ,  3.83 ,  5.69 ,                AIRWTBL   396
590             104.0             6.85 ,  6.31 ,  8.00 ,  6.47 ,  3.23 ,                AIRWTBL   397
               C                                                                         AIRWTBL   398
               C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -25 AIRWTBL   399
               C                                                                         AIRWTBL   400
               -18.75            -6.44 , -7.41 , -5.49 , -5.46 , -0.93 ,                AIRWTBL   401
595               0.0           -3.76 , -3.17 , -2.57 , -1.32 ,  2.34 ,                AIRWTBL   402
                18.75            -0.14 ,  0.76 ,  1.23 ,  3.37 ,  4.00 ,                AIRWTBL   403
                 54.0            -0.93 , -0.002 ,  3.00 ,  3.50 ,  5.86 ,               AIRWTBL   404
                104.0             9.79 , 12.37 , 10.17 ,  8.09 ,  4.35 ,                AIRWTBL   405
               C                                                                         AIRWTBL   406
600            C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -44 AIRWTBL   407
               C                                                                         AIRWTBL   408
               -18.75            -7.13 , -6.72 , -7.59 , -5.40 , -2.37 ,                AIRWTBL   409
                  0.0            -7.22 , -3.84 , -4.71 , -3.06 , -0.19 ,                AIRWTBL   410
                18.75            -3.91 , -1.05 , -0.70 ,  5.26 , 10.79 ,                AIRWTBL   411
605              54.0            -3.86 , -2.35 , -0.50 ,  0.81 ,  3.52 ,                AIRWTBL   412
                104.0             3.81 ,  5.54 ,  5.17 ,  4.40 ,  1.52 /                AIRWTBL   413
               C  *                                                                      AIRWTBL   414
               C  ***    TABLE IIIP. VZ AT VSS = 20 KT AND SIS = 50 DEG.                 AIRWTBL   415
               C  *                                                                      AIRWTBL   416
610                  DATA TAB1111P/                                                      AIRWTBL   417
               C                                                                         AIRWTBL   418
               C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -14 AIRWTBL   419
               C                                                                         AIRWTBL   420
               -18.75            -7.99 , -0.95 , -0.81 , -3.09 , -0.18 ,                AIRWTBL   421
615               0.0           -3.98 , -2.17 , -5.13 , -4.28 ,  1.78 ,                AIRWTBL   422
                18.75            -1.60 , -2.40 , -3.31 , -3.40 ,  2.15 ,                AIRWTBL   423
                 54.0             0.34 , -3.24 , -3.12 ,  0.13 ,  2.37 ,                AIRWTBL   424
                104.0            -5.96 , -2.26 ,  1.41 ,  2.22 ,  4.15 ,                AIRWTBL   425
               C                                                                         AIRWTBL   426
620            C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -25 AIRWTBL   427
               C                                                                         AIRWTBL   428
               -18.75            -7.08 , -4.15 , -2.05 , -3.62 ,  0.20 ,                AIRWTBL   429
                  0.0            -7.44 , -3.20 , -3.94 , -3.25 ,  1.16 ,                AIRWTBL   430
                18.75            -0.90 , -2.35 , -1.55 , -2.22 ,  2.36 ,                AIRWTBL   431
625              54.0            -1.11 , -1.92 , -1.41 ,  0.46 ,  4.79 ,                AIRWTBL   432
                104.0            -6.56 , -0.41 ,  2.54 ,  4.93 ,  7.78 ,                AIRWTBL   433
               C                                                                         AIRWTBL   434
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                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  435
                C                                                                      AIRWTBL  436
          630   -18.75              -7.79 , -7.18 , -6.26 , -3.67 , -1.90 ,            AIRWTBL  437
                  0.0               -8.54 , -5.58 , -2.35 , -0.80 , -0.10 ,            AIRWTBL  438
                 18.75              -6.10 , -0.12 , -0.60 ,  4.35 ,  8.32 ,            AIRWTBL  439
                 54.0               -5.34 , -3.92 , -2.20 ,  0.07 ,  4.48 ,            AIRWTBL  440
                104.0               -4.39 , -2.62 ,  1.33 ,  1.39 ,  4.17 /            AIRWTBL  441
          635   C  *                                                                   AIRWTBL  442
                C  ***    TABLE IIIC. VZ AT VSS = 35 KT AND SIS = 30 DEG.              AIRWTBL  443
                C  *                                                                   AIRWTBL  444
                     DATA TABIIIC/                                                     AIRWTBL  445
                C                                                                      AIRWTBL  446
          640   C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  447
                C                                                                      AIRWTBL  448
                -18.75             -20.55 , -6.90 , -9.55 , -8.56 ,  0.99 ,            AIRWTBL  449
                  0.0               -3.96 , -4.32 , -7.82 , -3.80 ,  4.66 ,            AIRWTBL  450
                 18.75               7.73 , -0.19 , -0.85 ,  1.52 ,  8.42 ,            AIRWTBL  451
          645    54.0               -3.31 , -0.48 ,  4.55 , 10.41 , 12.51 ,            AIRWTBL  452
                104.0               13.32 , 15.00 , 20.61 , 15.67 ,  7.18 ,            AIRWTBL  453
                C                                                                      AIRWTBL  454
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  455
                C                                                                      AIRWTBL  456
          650   -18.75             -14.69 ,-16.63 ,-11.50 , -8.37 , -0.33 ,            AIRWTBL  457
                  0.0               -6.59 , -3.82 , -6.24 , -5.46 ,  5.24 ,            AIRWTBL  458
                 18.75              -1.03 ,  0.43 ,  3.06 ,  4.66 , 11.22 ,            AIRWTBL  459
                 54.0               -4.65 ,  0.38 ,  6.12 ,  8.72 , 12.00 ,            AIRWTBL  460
                104.0               15.72 , 20.68 , 22.37 , 17.10 ,  7.96 ,            AIRWTBL  461
          655   C                                                                      AIRWTBL  462
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  463
                C                                                                      AIRWTBL  464
                -18.75             -13.01 ,-12.41 ,-14.71 ,-10.58 , -2.76 ,            AIRWTBL  465
                  0.0              -13.06 , -8.93 , -7.62 , -5.73 ,  0.01 ,            AIPWTBL  466
          660    18.75              -6.91 , -4.07 ,  0.95 ,  3.37 ,  8.53 ,            AIRWTEL  467
                 54.0               -8.24 , -4.15 , -0.70 ,  3.25 ,  7.31 ,            AIRWTBL  468
                104.0               9.74 , 11.65 , 10.93 ,  9.72 ,  8.09 /             AIRWTBL  469
                C  *                                                                   AIRWTBL  470
                C  ***    TABLE IIID. VZ AT VSS = 35 KT AND SIS = 50 DEG.              AIRWTBL  471
          665   C  *                                                                   AIRWTBL  472
                     DATA TABIIID/                                                     AIRWTBL  473
                C                                                                      AIRWTBL  474
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  475
                C                                                                      AIRWTBL  476
          670   -18.75             -16.44 , -4.29 , -0.87 , -3.49 ,  1.42 ,            AIRWTBL  477
                  0.0               -8.85 , -0.92 , -7.29 , -6.59 ,  5.62 ,            AIRWTBL  478
                 18.75              -4.27 , -4.46 , -5.11 , -2.91 ,  5.21 ,            AIRWTBL  479
                 54.0               -0.10 , -4.43 , -5.82 , -1.96 ,  5.71 ,            AIRWTBL  480
                104.0               -12.31 , -4.81 ,  3.46 ,  8.96 , 11.97 ,           AIRWTBL  481
          675   C                                                                      AIRWTBL  482
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  483
                C                                                                      AIRWTBL  484
                -18.75             -14.70 , -9.35 , -5.61 , -3.60 , -0.44 ,            AIRWTBL  485
                  0.0              -10.39 , -5.63 , -5.55 , -3.26 ,  4.65 ,            AIRWTBL  486
          680    18.75              -3.12 , -3.41 , -3.72 , -2.04 ,  4.84 ,            AIRWTBL  487
                 54.0               -2.44 , -2.64 , -4.71 , -0.33 ,  7.73 ,            AIRWTBL  488
                104.0               -12.96 , -2.12 ,  6.39 , 10.86 , 14.09 ,           AIRWTBL  489
                C                                                                      AIRWTBL  490
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  491
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C                                                                                AIRWTBL  492
-18.75          -15.59 ,-12.78 ,-10.27 , -6.63 ,  6.11 ,                         AIRWTBL  493
   0.0          -18.61 ,-12.92 , -3.89 , -2.26 ,  8.99 ,                         AIRWTBL  494
 18.75          -13.05 , -4.31 ,  1.94 ,  1.75 , 10.16 ,                         AIRWTBL  495
  54.0          -11.49 , -7.63 , -5.62 , -1.33 ,  2.05 ,                         AIRWTBL  496
 104.0          -10.52 , -2.74 ,  0.52 ,  3.35 ,  3.19 /                         AIRWTBL  497
C  *                                                                             AIRWTBL  498
C  ***    TABLE IIIF. VZ AT VSS = 45 KT AND SIS = 30 DEG.                        AIRWTBL  499
C  *                                                                             AIRWTBL  500
      DATA TABIIIF/                                                              AIRWTBL  501
C                                                                                AIRWTBL  502
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  503
C                                                                                AIRWTBL  504
-18.75          -31.11 , -7.50 ,-12.57 ,-12.04 ,  1.70 ,                         AIRWTBL  505
   0.0           -7.25 , -7.35 ,-10.22 , -7.05 ,  6.11 ,                         AIRWTBL  506
 18.75            7.88 , -3.06 , -3.44 ,  1.54 , 11.27 ,                         AIRWTBL  507
  54.0           -7.99 , -1.01 ,  8.31 , 12.76 , 19.52 ,                         AIRWTBL  508
 104.0           18.29 , 23.33 , 26.86 , 23.45 ,  8.29 ,                         AIRWTBL  509
C                                                                                AIRWTBL  510
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  511
C                                                                                AIRWTBL  512
-18.75          -19.44 ,-24.72 ,-13.77 ,-14.05 , -0.02 ,                         AIRWTBL  513
   0.0          -16.64 , -7.08 , -7.74 , -7.02 ,  5.76 ,                         AIRWTBL  514
 18.75           -0.62 ,  3.89 ,  1.88 ,  1.70 , 13.79 ,                         AIRWTBL  515
  54.0           -3.81 , -1.33 ,  6.59 , 11.90 , 16.00 ,                         AIRWTBL  516
 104.0           19.67 , 28.69 , 28.56 , 24.13 , 10.01 ,                         AIRWTBL  517
C                                                                                AIRWTBL  518
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  519
C                                                                                AIRWTBL  520
-18.75          -15.59 ,-16.00 ,-18.86 ,-13.57 , -5.32 ,                         AIRWTBL  521
   0.0          -15.49 ,-11.40 ,-11.19 , -7.62 ,  3.39 ,                         AIRWTBL  522
 18.75           -8.35 , -4.41 ,  0.91 ,  3.71 , 10.99 ,                         AIRWTBL  523
  54.0          -10.30 , -4.00 ,  0.54 ,  4.16 , 10.18 ,                         AIRWTBL  524
 104.0           12.07 , 14.93 , 15.77 , 12.17 ,  4.63 /                         AIRWTBL  525
C  *                                                                             AIRWTBL  526
C  ***    TABLE IIIF. VZ AT VSS = 45 KT AND SIS = 50 DEG.                        AIRWTBL  527
C  *                                                                             AIRWTBL  528
      DATA TABIIIF/                                                              AIRWTBL  529
C                                                                                AIRWTBL  530
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  531
C                                                                                AIRWTBL  532
-18.75          -24.54 , -1.09 , -0.05 , -2.22 , -0.77 ,                         AIRWTBL  533
   0.0          -10.45 ,  1.20 , -5.97 , -6.13 ,  2.19 ,                         AIRWTBL  534
 18.75           -4.25 , -5.27 , -6.56 , -4.14 ,  5.81 ,                         AIRWTBL  535
  54.0           -0.23 , -6.15 , -6.40 , -3.32 ,  7.16 ,                         AIRWTBL  536
 104.0          -12.95 , -2.81 ,  2.42 ,  6.74 , 12.87 ,                         AIRWTBL  537
C                                                                                AIRWTBL  538
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  539
C                                                                                AIRWTBL  540
-18.75          -21.37 ,-13.51 , -3.29 , -7.69 , -2.59 ,                         AIRWTBL  541
   0.0          -22.99 , -7.15 , -5.21 , -3.86 ,  3.17 ,                         AIRWTBL  542
 18.75           -5.65 , -6.19 , -4.56 , -3.03 ,  5.13 ,                         AIRWTBL  543
  54.0           -3.77 , -8.66 , -4.91 , -0.99 ,  9.51 ,                         AIRWTBL  544
 104.0          -13.57 , -1.05 ,  5.56 ,  9.98 , 18.29 ,                         AIRWTBL  545
C                                                                                AIRWTBL  546
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  547
C                                                                                AIRWTBL  548
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                -18.75          -17.25 ,-16.49 ,-15.28 , -8.78 , -2.43 ,                AIRWTBL  549
                   0.0          -23.82 ,-15.95 , -4.85 , -3.78 ,  0.61 ,                AIRWTBL  550
                 18.75          -18.37 , -6.60 ,  3.38 ,  4.07 , 11.51 ,                AIRWTBL  551
      745         54.0          -14.39 , -9.76 , -5.00 ,  1.12 , 10.49 ,                AIRWTBL  552
                 104.0           -9.70 , -2.54 ,  2.86 ,  6.68 , 10.82 /                AIRWTBL  553
                C  *                                                                     AIRWTBL  554
                C  ***    TABLE IVA. SIGMA VX AT VSS = 20 KT AND SIS = 30 DEG.          AIRWTBL  555
                C  *                                                                     AIRWTBL  556
      750           DATA T4BIVA/                                                         AIRWTBL  557
                C                                                                        AIRWTBL  558
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  559
                C                                                                        AIRWTBL  560
                -18.75                 1.62 ,  8.19 ,  4.53 ,  4.18 ,  3.23 ,          AIRWTBL  561
      755          0.0                 6.51 ,  5.30 ,  5.12 ,  4.94 ,  3.72 ,          AIRWTBL  562
                 18.75                 4.65 ,  4.74 ,  5.00 ,  4.85 ,  5.07 ,          AIRWTBL  563
                  54.0                 5.23 ,  4.47 ,  4.98 ,  5.39 ,  2.69 ,          AIRWTBL  564
                 104.0                 5.51 ,  4.47 ,  3.12 ,  2.05 ,  1.29 ,          AIRWTBL  565
                C                                                                        AIRWTBL  566
      760       C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  567
                C                                                                        AIRWTBL  568
                -18.75                 1.05 ,  4.31 ,  6.37 ,  5.79 ,  4.06 ,          AIRWTBL  569
                   0.0                 6.53 ,  6.75 ,  5.92 ,  5.23 ,  3.43 ,          AIRWTBL  570
                 18.75                 1.76 ,  6.09 ,  4.38 ,  4.33 ,  5.09 ,          AIRWTBL  571
      765         54.0                 5.03 ,  4.23 ,  3.78 ,  3.56 ,  1.97 ,          AIRWTBL  572
                 104.0                 6.35 ,  5.71 ,  3.64 ,  2.10 ,  1.18 ,          AIRWTBL  573
                C                                                                        AIRWTBL  574
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  575
                C                                                                        AIRWTBL  576
      770       -18.75                 0.80 ,  1.09 ,  5.23 ,  6.47 ,  3.46 ,          AIRWTBL  577
                   0.0                 0.88 ,  1.33 ,  4.49 ,  6.28 ,  4.10 ,          AIRWTBL  578
                 18.75                 0.88 ,  1.03 ,  3.62 ,  4.86 ,  8.44 ,          AIRWTBL  579
                  54.0                 4.20 ,  2.79 ,  2.80 ,  2.48 ,  1.58 ,          AIRWTBL  580
                 104.0                 5.49 ,  3.60 ,  1.82 ,  1.73 ,  0.88 /          AIRWTBL  581
      775       C  *                                                                     AIRWTBL  582
                C  ***    TABLE IVB. SIGMA VX AT VSS = 20 KT AND SIS = 50 DEG.          AIRWTBL  583
                C  *                                                                     AIRWTBL  584
                     DATA TABIVB/                                                        AIRWTBL  585
                C                                                                        AIRWTBL  586
      780       C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL  587
                C                                                                        AIRWTBL  588
                -18.75                 1.65 ,  8.74 ,  9.53 ,  7.99 ,  7.16 ,          AIRWTBL  589
                   0.0                11.01 ,  6.90 ,  6.38 ,  6.28 ,  6.18 ,          AIRWTBL  590
                 18.75                 5.52 ,  5.83 ,  5.50 ,  5.59 ,  6.97 ,          AIRWTBL  591
      785         54.0                 7.13 ,  4.93 ,  8.04 ,  6.29 ,  7.30 ,          AIRWTBL  592
                 104.0                 6.27 ,  5.86 ,  6.17 ,  7.43 ,  6.50 ,          AIRWTBL  593
                C                                                                        AIRWTBL  594
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL  595
                C                                                                        AIRWTBL  596
      790       -18.75                 1.10 ,  6.23 , 10.08 ,  9.20 ,  6.86 ,          AIRWTBL  597
                   0.0                8.83 ,  8.66 ,  8.47 ,  6.94 ,  7.39 ,          AIRWTBL  598
                 18.75                 8.55 ,  7.48 ,  8.05 ,  6.58 ,  7.15 ,          AIRWTBL  599
                  54.0                 4.65 ,  7.99 ,  9.07 ,  7.47 ,  6.72 ,          AIRWTBL  600
                 104.0                 8.62 ,  7.73 ,  6.92 ,  7.63 ,  6.20 ,          AIRWTBL  601
      795       C                                                                        AIRWTBL  602
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL  603
                C                                                                        AIRWTBL  604
                -18.75                 0.76 ,  1.77 ,  5.08 ,  6.72 ,  7.84 ;          AIRWTBL  605
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      0.0                 0.91 ,  5.95 ,  8.00 ,  8.97 ,  8.63 ,                AIRWTBL   606
   18.75                  1.28 ,  8.53 ,  8.47 ,  9.80 ,  8.82 ,                AIRWTBL   607
    54.0                  0.71 ,  2.15 ,  6.00 ,  5.57 ,  6.59 ,                AIRWTBL   608
   104.0                  6.45 ,  7.07 ,  5.54 ,  6.16 ,  4.14 /                AIRWTBL   609
C  *                                                                           AIRWTBL   610
C  ***    TABLE IVC. SIGMA VX AT VSS = 35 KT AND SIS = 30 DEG.                 AIRWTBL   611
C  *                                                                           AIRWTBL   612
      DATA TABIVC/                                                             AIRWTBL   613
C                                                                              AIRWTBL   614
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14      AIRWTBL   615
C                                                                              AIRWTBL   616
  -18.75                 3.74 , 13.05 ,  6.12 ,  4.99 ,  4.35 ,                AIRWTBL   617
      0.0               13.33 , 10.08 ,  7.78 ,  7.40 ,  5.29 ,                AIRWTBL   618
   18.75                 9.95 ,  8.33 ,  7.50 ,  7.16 ,  7.64 ,                AIRWTBL   619
    54.0                 7.73 ,  7.29 ,  7.73 ,  6.73 ,  5.89 ,                AIRWTBL   620
   104.0                 7.13 ,  6.27 ,  6.42 ,  5.44 ,  3.18 ,                AIRWTBL   621
C                                                                              AIRWTBL   622
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25      AIRWTBL   623
C                                                                              AIRWTBL   624
  -18.75                 2.09 ,  8.95 , 10.07 ,  6.71 ,  4.89 ,                AIRWTBL   625
      0.0               11.39 , 10.10 ,  8.62 ,  7.05 ,  5.85 ,                AIRWTBL   626
   18.75                 5.16 ,  9.28 ,  9.22 ,  8.43 ,  7.16 ,                AIRWTBL   627
    54.0                 7.35 ,  7.43 ,  7.87 ,  7.59 ,  2.69 ,                AIRWTBL   628
   104.0                 8.55 ,  7.84 ,  7.29 ,  5.75 ,  3.60 ,                AIRWTBL   629
C                                                                              AIRWTBL   630
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44      AIRWTBL   631
C                                                                              AIRWTBL   632
  -18.75                 0.89 ,  1.72 ,  6.91 , 10.03 , 12.61 ,                AIRWTBL   633
      0.0                1.17 ,  2.10 ,  7.35 , 10.04 , 13.17 ,                AIRWTBL   634
   18.75                 1.24 ,  1.91 ,  5.59 ,  7.38 , 13.70 ,                AIRWTBL   635
    54.0                 6.02 ,  6.20 ,  5.43 ,  3.98 , 12.41 ,                AIRWTBL   636
   104.0                 9.58 ,  7.81 ,  5.44 ,  3.90 ,  9.43 /                AIRWTBL   637
C  *                                                                           AIRWTBL   638
C  ***    TABLE IVD. SIGMA VX AT VSS = 35 KT AND SIS = 50 DEG.                 AIRWTBL   639
C  *                                                                           AIRWTBL   640
      DATA TABIVD/                                                             AIRWTBL   641
C                                                                              AIRWTBL   642
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14      AIRWTBL   643
C                                                                              AIRWTBL   644
  -18.75                 3.94 , 13.75 , 15.98 , 12.69 , 12.96 ,                AIRWTBL   645
      0.0               20.12 , 13.53 , 11.74 , 11.13 , 13.00 ,                AIRWTBL   646
   18.75                 8.96 , 10.00 , 12.10 , 11.14 , 11.71 ,                AIRWTBL   647
    54.0                12.15 , 11.52 , 13.68 , 11.25 , 11.99 ,                AIRWTBL   648
   104.0                10.55 , 10.93 , 10.67 , 11.67 , 10.86 ,                AIRWTBL   649
C                                                                              AIRWTBL   650
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25      AIRWTBL   651
C                                                                              AIRWTBL   652
  -18.75                 2.32 ,  8.42 , 17.09 , 15.06 , 12.98 ,                AIRWTBL   653
      0.0               13.13 , 15.09 , 14.02 , 11.59 , 13.79 ,                AIRWTBL   654
   18.75                15.15 , 13.79 , 13.13 , 13.31 , 11.18 ,                AIRWTBL   655
    54.0                 9.27 , 14.78 , 12.85 , 13.16 , 12.36 ,                AIRWTBL   656
   104.0                15.58 , 13.20 , 12.43 , 11.33 , 10.00 ,                AIRWTBL   657
C                                                                              AIRWTBL   658
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44      AIRWTBL   659
C                                                                              AIRWTBL   660
  -18.75                 1.22 ,  3.25 ,  8.45 , 11.13 , 17.73 ,                AIRWTBL   661
      0.0                2.56 , 10.31 , 14.31 , 13.23 , 16.21 ,                AIRWTBL   662
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                18.75              2.96 , 15.10 , 17.30 , 15.75 , 15.85 ,                AIRWTBL   663
                 54.0              1.42 ,  2.99 , 13.60 , 13.14 , 16.92 ,                AIRWTBL   664
                104.0             11.50 , 13.42 , 10.31 , 12.36 , 17.20 /                AIRWTBL   665
               C  *                                                                       AIRWTBL   666
  860          C  ***    TABLE IVE. SIGMA VX AT VSS = 35 KT45ND SIS = 30 DEG.            AIRWTBL   667
               C  *                                                                       AIRWTBL   668
                    DATA TABIVE/                                                          AIRWTBL   669
               C                                                                          AIRWTBL   670
               C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14  AIRWTBL   671
  865          C                                                                         AIRWTBL   672
               -18.75             3.68 , 17.72 ,  7.19 ,  7.41 ,  6.15 ,                AIRWTBL   673
                  0.0            19.52 , 14.60 ,  9.73 ,  9.30 ,  6.77 ,                AIRWTBL   674
                16.75            14.42 , 10.69 , 11.02 , 10.53 ,  9.03 ,                AIRWTBL   675
                 54.0            10.87 , 10.08 ,  9.71 , 10.40 ,  7.44 ,                AIRWTBL   676
  870           104.0            10.43 , 11.36 ,  7.75 ,  6.89 ,  3.92 ,                AIRWTBL   677
               C                                                                          AIRWTBL   678
               C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25  AIRWTBL   679
               C                                                                          AIRWTBL   680
               -18.75             1.57 , 15.21 , 13.41 ,  9.54 ,  7.50 ,                AIRWTBL   681
  875             0.0            13.18 , 16.02 , 10.63 ,  9.06 ,  7.52 ,                AIRWTBL   682
                18.75            13.81 , 13.76 , 12.52 , 11.04 ,  9.08 ,                AIRWTBL   683
                 54.0            11.44 , 11.04 ,  9.65 ,  9.31 ,  4.51 ,                AIRWTBL   684
                104.0            10.02 , 11.43 ,  8.05 ,  7.53 ,  4.28 ,                AIRWTBL   685
               C                                                                          AIRWTBL   686
  880          C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44  AIRWTBL   687
               C                                                                          AIRWTBL   688
               -18.75             0.77 ,  1.45 , 10.27 , 12.69 , 10.43 ,                AIRWTBL   689
                  0.0             1.18 ,  2.86 ,  9.93 , 12.19 , 10.07 ,                AIRWTBL   690
                18.75             1.08 ,  3.42 ,  5.76 ,  8.43 , 11.55 ,                AIRWTBL   691
  885            54.0             7.69 ,  8.94 ,  8.30 ,  5.84 ,  2.68 ,                AIRWTBL   692
                104.0            11.74 , 10.56 ,  6.40 ,  6.04 ,  3.45 /                AIRWTBL   693
               C  *                                                                       AIRWTBL   694
               C  ***    TABLE IVF. SIGMA VX AT VSS = 35 KT45ND SIS = 50 DEG.            AIRWTBL   695
               C  *                                                                       AIRWTBL   696
  890               DATA TABIVF/                                                         AIRWTBL   697
               C                                                                          AIRWTBL   698
               C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14  AIRWTBL   699
               C                                                                          AIRWTBL   700
               -18.75             5.45 , 18.22 , 19.45 , 16.98 , 17.07 ,                AIRWTBL   701
  895             0.0            23.31 , 20.14 , 14.66 , 15.20 , 16.16 ,                AIRWTBL   702
                18.75            12.84 , 14.31 , 12.83 , 12.32 , 14.17 ,                AIRWTBL   703
                 54.0            16.43 , 15.70 , 14.42 , 15.95 , 14.40 ,                AIRWTBL   704
                104.0            15.95 , 12.36 , 12.39 , 13.91 , 12.95 ,                AIRWTBL   705
               C                                                                          AIRWTBL   706
  900          C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25  AIRWTBL   707
               C                                                                          AIRWTBL   708
               -18.75             2.86 , 11.79 , 19.77 , 18.26 , 20.64 ,                AIRWTBL   709
                  0.0            16.91 , 20.76 , 18.35 , 15.91 , 18.57 ,                AIRWTBL   710
                18.75            20.61 , 18.79 , 17.00 , 14.67 , 14.85 ,                AIRWTBL   711
  905             54.0            17.50 , 18.49 , 18.86 , 17.57 , 16.76 ,                AIRWTBL   712
                104.0            19.21 , 16.25 , 15.12 , 14.96 , 13.61 ,                AIRWTBL   713
               C                                                                          AIRWTBL   714
               C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44  AIRWTBL   715
               C                                                                          AIRWTBL   716
  910          -18.75             1.05 ,  3.72 , 12.02 , 16.17 , 16.40 ,                AIRWTBL   717
                  0.0             2.56 , 13.73 , 19.33 , 17.11 , 15.11 ,                AIRWTBL   718
                18.75             4.22 , 20.34 , 23.52 , 19.86 , 14.93 ,                AIRWTBL   719
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      54.0              2.06 ,  4.75 , 15.93 , 17.07 , 16.18 ,                AIRWTBL  720
     104.0             15.19 , 16.43 , 14.13 , 13.59 , 13.23 /                AIRWTBL  721
C  *                                                                          AIRWTBL  722
C  ***    TABLE VA. SIGMA VY AT VSS = 20 KT AND SIS = 30 DEG.                 AIRWTBL  723
C  *                                                                          AIRWTBL  724
      DATA TABVA/                                                            AIRWTBL  725
C                                                                            AIRWTBL  726
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14    AIRWTBL  727
C                                                                            AIRWTBL  728
-18.75            2.03 ,  8.37 ,  3.59 ,  3.78 ,  3.90 ,                    AIRWTBL  729
   0.0            6.21 ,  5.90 ,  4.87 ,  4.22 ,  4.12 ,                    AIRWTBL  730
  18.75           5.18 ,  4.10 ,  4.11 ,  3.88 ,  4.43 ,                    AIRWTBL  731
  54.0            4.21 ,  4.10 ,  5.43 ,  6.59 ,  3.07 ,                    AIRWTBL  732
 104.0            5.27 ,  4.05 ,  4.21 ,  2.63 ,  1.76 ,                    AIRWTBL  733
C                                                                            AIRWTBL  734
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25    AIRWTBL  735
C                                                                            AIRWTBL  736
-18.75            1.39 ,  4.74 ,  6.85 ,  5.61 ,  4.20 ,                    AIRWTBL  737
   0.0            6.58 ,  7.21 ,  6.18 ,  4.71 ,  3.86 ,                    AIRWTBL  738
  18.75           2.97 ,  6.22 ,  5.79 ,  5.87 ,  4.84 ,                    AIRWTBL  739
  54.0            4.95 ,  3.81 ,  4.87 ,  4.15 ,  2.71 ,                    AIRWTBL  740
 104.0            6.83 ,  5.53 ,  4.32 ,  2.66 ,  1.75 ,                    AIRWTBL  741
C                                                                            AIRWTBL  742
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44    AIRWTBL  743
C                                                                            AIRWTBL  744
-18.75            1.24 ,  1.26 ,  6.04 ,  5.80 ,  3.82 ,                    AIRWTBL  745
   0.0            1.20 ,  1.62 ,  5.31 ,  4.89 ,  3.75 ,                    AIRWTBL  746
  18.75           1.25 ,  1.45 ,  5.37 ,  6.24 ,  7.39 ,                    AIRWTBL  747
  54.0            4.74 ,  3.84 ,  4.00 ,  3.51 ,  2.38 ,                    AIRWTBL  748
 104.0            6.12 ,  3.95 ,  2.54 ,  2.50 ,  1.69 /                    AIRWTBL  749
C  *                                                                         AIRWTBL  750
C  ***    TABLE VB. SIGMA VY AT VSS = 20 KT AND SIS = 50 DEG.                 AIRWTBL  751
C  *                                                                         AIRWTBL  752
      DATA TABVB/                                                            AIRWTBL  753
C                                                                            AIRWTBL  754
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14    AIRWTBL  755
C                                                                            AIRWTBL  756
-18.75            3.13 ,  7.87 ,  9.27 ,  6.86 ,  5.85 ,                    AIRWTBL  757
   0.0            9.29 ,  7.31 ,  6.11 ,  5.74 ,  6.58 ,                    AIRWTBL  758
  18.75           5.01 ,  5.54 ,  5.33 ,  5.33 ,  6.53 ,                    AIRWTBL  759
  54.0            7.30 ,  5.76 ,  5.96 ,  7.07 ,  8.33 ,                    AIRWTBL  760
 104.0            4.48 ,  4.61 ,  4.85 ,  6.11 ,  6.22 ,                    AIRWTBL  761
C                                                                            AIRWTBL  762
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25    AIRWTBL  763
C                                                                            AIRWTBL  764
-18.75            1.82 ,  6.45 ,  8.75 ,  7.22 ,  6.75 ,                    AIRWTBL  765
   0.0            7.90 ,  8.28 ,  8.41 ,  6.22 ,  6.32 ,                    AIRWTBL  766
  18.75           9.34 ,  8.06 ,  7.59 ,  5.39 ,  6.83 ,                    AIRWTBL  767
  54.0            4.63 ,  5.56 ,  6.79 ,  7.10 ,  7.35 ,                    AIRWTBL  768
 104.0            6.14 ,  6.91 ,  6.23 ,  7.97 ,  7.08 ,                    AIRWTBL  769
C                                                                            AIRWTBL  770
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44    AIRWTBL  771
C                                                                            AIRWTBL  772
-18.75            1.16 ,  1.74 ,  6.74 ,  6.94 ,  6.79 ,                    AIRWTBL  773
   0.0            1.04 ,  4.96 ,  8.53 ,  8.39 ,  5.35 ,                    AIRWTBL  774
  18.75           1.45 ,  7.27 , 10.00 , 11.13 ,  8.85 ,                    AIRWTBL  775
  54.0            0.92 ,  2.05 ,  5.58 ,  5.70 ,  6.43 /                    AIRWTBL  776
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      104.0              7.41 ,  7.94 ,  7.11 ,  7.38 ,  4.23 /                AIRWTBL   777
C  *                                                                           AIRWTBL   778
C  ***    TABLE VC. SIGMA VY AT VSS = 35 KT AND SIS = 30 DEG.                  AIRWTBL   779
C  *                                                                           AIRWTBL   780
      DATA TABVC/                                                             AIRWTBL   781
C                                                                             AIRWTBL   782
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14     AIRWTBL   783
C                                                                             AIRWTBL   784
-18.75             4.38 , 15.75 ,  9.24 ,  6.89 ,  6.89 ,                     AIRWTBL   785
   0.0            12.89 , 13.57 ,  9.27 ,  8.24 ,  8.54 ,                     AIRWTBL   786
 18.75            12.28 , 10.12 ,  8.41 ,  6.89 ,  7.69 ,                     AIRWTBL   787
  54.0             8.71 ,  8.92 , 10.47 ,  9.74 ,  5.91 ,                     AIRWTBL   788
 104.0            10.37 , 10.46 , 10.15 ,  6.14 ,  4.88 ,                     AIRWTBL   789
C                                                                             AIRWTBL   790
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25     AIRWTBL   791
C                                                                             AIRWTBL   792
-18.75             2.42 ,  9.10 , 13.35 ,  9.80 ,  7.94 ,                     AIRWTBL   793
   0.0            14.28 , 14.48 , 12.61 , 10.24 ,  8.31 ,                     AIRWTBL   794
 18.75             8.41 , 11.36 , 14.52 , 12.33 , 10.03 ,                     AIRWTBL   795
  54.0            10.95 ,  9.93 , 10.79 , 10.46 ,  4.58 ,                     AIRWTBL   796
 104.0            11.90 , 11.86 ,  9.94 ,  6.23 ,  4.63 ,                     AIRWTBL   797
C                                                                             AIRWTBL   798
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44     AIRWTBL   799
C                                                                             AIRWTBL   800
-18.75             1.31 ,  1.30 ,  8.32 , 12.15 , 12.68 ,                     AIRWTBL   801
   0.0             1.07 ,  2.47 ,  8.76 , 11.42 , 12.66 ,                     AIRWTBL   802
 18.75             1.48 ,  1.84 ,  8.64 ,  9.27 , 14.32 ,                     AIRWTBL   803
  54.0             8.82 ,  8.02 ,  7.57 ,  6.18 , 14.43 ,                     AIRWTBL   804
 104.0            13.06 , 10.25 ,  8.79 ,  5.66 , 10.44 /                     AIRWTBL   805
C  *                                                                          AIRWTBL   806
C  ***    TABLE VD. SIGMA VY AT VSS = 35 KT AND SIS = 50 DEG.                  AIRWTBL   807
C  *                                                                          AIRWTBL   808
      DATA TABVD/                                                             AIRWTBL   809
C                                                                             AIRWTBL   810
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14     AIRWTBL   811
C                                                                             AIRWTBL   812
-18.75             6.01 , 13.75 , 17.04 , 13.54 , 13.51 ,                     AIRWTBL   813
   0.0            17.96 , 13.38 , 14.25 , 11.57 , 13.17 ,                     AIRWTBL   814
 18.75             9.45 , 11.77 , 11.39 , 11.31 , 11.90 ,                     AIRWTBL   815
  54.0            13.75 , 11.20 , 12.70 , 11.83 , 15.07 ,                     AIRWTBL   816
 104.0             9.34 ,  8.96 ,  9.71 , 12.52 , 13.54 ,                     AIRWTBL   817
C                                                                             AIRWTBL   818
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25     AIRWTBL   819
C                                                                             AIRWTBL   820
-18.75             3.41 , 10.49 , 17.78 , 15.39 , 13.14 ,                     AIRWTBL   821
   0.0            12.86 , 16.87 , 15.53 , 13.53 , 12.53 ,                     AIRWTBL   822
 18.75            16.41 , 14.31 , 15.11 , 12.56 , 12.70 ,                     AIRWTBL   823
  54.0            10.20 , 12.57 , 14.11 , 14.16 , 12.75 ,                     AIRWTBL   824
 104.0            15.00 , 12.81 , 11.09 , 13.05 , 13.06 ,                     AIRWTBL   825
C                                                                             AIRWTBL   826
C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44     AIRWTBL   827
C                                                                             AIRWTBL   828
-18.75             1.37 ,  2.82 , 10.59 , 11.89 , 17.13 ,                     AIRWTBL   829
   0.0             2.40 , 10.42 , 14.75 , 15.72 , 16.43 ,                     AIRWTBL   830
 18.75             2.26 , 17.06 , 18.72 , 18.64 , 16.91 ,                     AIRWTBL   831
  54.0             2.16 ,  4.63 , 15.03 , 15.62 , 16.73 ,                     AIRWTBL   832
 104.0            14.58 , 14.67 , 15.33 , 14.93 , 17.08 /                     AIRWTBL   833
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C  *                                                                    AIRWTBL   834
C  ***    TABLE VF. SIGMA VY AT VSS = 45 KT AND SIS = 30 DEG.          AIRWTBL   835
C  *                                                                    AIRWTBL   836
      DATA TABVE/                                                       AIRWTBL   837
C                                                                       AIRWTBL   838
C  Y          X =    0.00    37.00    90.00    125.0    250.0    ZTAB = -14 AIRWTBL   839
C                                                                       AIRWTBL   840
-18.75              5.18 , 24.29 , 10.90 , 10.86 , 11.39 ,              AIRWTBL   841
   0.0             16.50 , 17.97 , 11.51 , 11.34 , 10.58 ,              AIRWTBL   842
 18.75             16.93 , 13.31 , 12.08 , 10.97 , 12.32 ,              AIRWTBL   843
  54.0             11.98 , 13.76 , 14.33 , 15.63 ,  9.64 ,              AIRWTBL   844
 104.0             13.49 , 16.83 , 12.93 ,  7.89 ,  5.39 ,              AIRWTBL   845
C                                                                       AIRWTBL   846
C  Y          X =    0.00    37.00    90.00    125.0    250.0    ZTAB = -25 AIRWTBL   847
C                                                                       AIRWTBL   848
-18.75              2.07 , 15.23 , 16.60 , 13.42 , 11.70 ,              AIRWTBL   849
   0.0             18.06 , 22.53 , 17.00 , 13.17 , 11.71 ,              AIRWTBL   850
 18.75             17.60 , 19.36 , 18.50 , 16.56 , 13.70 ,              AIRWTBL   851
  54.0             17.45 , 16.06 , 15.83 , 15.73 ,  5.88 ,              AIRWTBL   852
 104.0             15.28 , 16.56 , 13.89 , 10.44 ,  5.60 ,              AIRWTBL   853
C                                                                       AIRWTBL   854
C  Y          X =    0.00    37.00    90.00    125.0    250.0    ZTAB = -44 AIRWTBL   855
C                                                                       AIRWTBL   856
-18.75              1.08 ,  1.13 , 12.18 , 16.03 , 14.61 ,              AIRWTBL   857
   0.0              1.14 ,  4.09 , 12.59 , 14.38 , 13.76 ,              AIRWTBL   858
 18.75              1.27 ,  4.30 , 11.14 , 13.95 , 16.03 ,              AIRWTBL   859
  54.0             11.69 , 12.35 , 12.59 ,  7.63 ,  3.40 ,              AIRWTBL   860
 104.0             15.37 , 13.90 , 12.45 , 10.53 ,  3.83 /              AIRWTBL   861
C  *                                                                    AIRWTBL   862
C  ***    TABLE VF. SIGMA VY AT VSS = 45 KT AND SIS = 50 DEG.          AIRWTBL   863
C  *                                                                    AIRWTBL   864
      DATA TABVF/                                                       AIRWTBL   865
C                                                                       AIRWTBL   866
C  Y          X =    0.00    37.00    90.00    125.0    250.0    ZTAB = -14 AIRWTBL   867
C                                                                       AIRWTBL   868
-18.75              7.10 , 20.67 , 22.41 , 18.59 , 17.69 ,              AIRWTBL   869
   0.0             26.10 , 20.57 , 17.02 , 15.81 , 15.73 ,              AIRWTBL   870
 18.75             11.93 , 15.96 , 14.03 , 15.45 , 16.90 ,              AIRWTBL   871
  54.0             18.06 , 16.48 , 15.96 , 17.73 , 17.88 ,              AIRWTBL   872
 104.0             14.55 , 11.01 , 10.66 , 15.68 , 16.77 ,              AIRWTBL   873
C                                                                       AIRWTBL   874
C  Y          X =    0.00    37.00    90.00    125.0    250.0    ZTAB = -25 AIRWTBL   875
C                                                                       AIRWTBL   876
-18.75              4.70 , 13.77 , 21.29 , 20.51 , 18.33 ,              AIRWTBL   877
   0.0             20.41 , 25.70 , 19.81 , 19.08 , 16.57 ,              AIRWTBL   878
 18.75             21.24 , 23.84 , 18.68 , 18.31 , 16.44 ,              AIRWTBL   879
  54.0             17.20 , 17.05 , 18.84 , 15.89 , 18.31 ,              AIRWTBL   880
 104.0             19.50 , 13.98 , 14.47 , 17.16 , 17.68 ,              AIRWTBL   881
C                                                                       AIRWTBL   882
C  Y          X =    0.00    37.00    90.00    125.0    250.0    ZTAB = -44 AIRWTBL   883
C                                                                       AIRWTBL   884
-18.75              1.19 ,  4.28 , 14.92 , 17.18 , 17.58 ,              AIRWTBL   885
   0.0              2.63 , 14.33 , 21.28 , 20.95 , 16.31 ,              AIRWTBL   886
 18.75              3.50 , 21.63 , 27.21 , 24.25 , 19.59 ,              AIRWTBL   887
  54.0              2.58 ,  5.82 , 18.01 , 20.32 , 16.61 ,              AIRWTBL   888
 104.0             16.77 , 19.74 , 18.93 , 18.45 , 15.37 /              AIRWTBL   889
C  *                                                                    AIRWTBL   890
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                C  ***    TABLE VIA. SIGMA VZ AT VSS = 20 KT AND SIS = 30 DEG.          AIRWTBL   891
1085            C  *                                                                    AIRWTBL   892
                     DATA TABVIA/                                                       AIRWTBL   893
                C                                                                       AIRWTBL   894
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL   895
                C                                                                       AIRWTBL   896
1090            -18.75              2.11 ,  5.73 ,  4.13 ,  3.24 ,  3.18 ,             AIRWTBL   897
                   0.0              5.55 ,  6.43 ,  5.76 ,  5.08 ,  3.60 ,             AIRWTBL   898
                 18.75              4.41 ,  5.04 ,  5.05 ,  4.76 ,  4.12 ,             AIRWTBL   899
                  54.0              4.98 ,  4.65 ,  4.16 ,  4.10 ,  3.39 ,             AIRWTBL   900
                 104.0              5.40 ,  4.30 ,  4.66 ,  3.07 ,  1.97 ,             AIRWTBL   901
1095            C                                                                       AIRWTBL   902
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL   903
                C                                                                       AIRWTBL   904
                -18.75              1.05 ,  4.93 ,  7.05 ,  4.92 ,  3.28 ,             AIRWTBL   905
                   0.0              5.80 ,  5.70 ,  6.08 ,  6.00 ,  4.21 ,             AIRWTBL   906
1100             18.75              2.08 ,  5.05 ,  5.31 ,  5.87 ,  3.59 ,             AIRWTBL   907
                  54.0              4.40 ,  3.93 ,  4.39 ,  4.08 ,  2.34 ,             AIRWTBL   908
                 104.0              7.45 ,  6.54 ,  4.87 ,  3.08 ,  1.53 ,             AIRWTBL   909
                C                                                                       AIRWTBL   910
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL   911
1105            C                                                                       AIRWTBL   912
                -18.75              0.89 ,  1.43 ,  5.05 ,  6.35 ,  4.46 ,             AIRWTBL   913
                   0.0              1.21 ,  1.99 ,  5.99 ,  5.02 ,  3.93 ,             AIRWTBL   914
                 18.75              1.16 ,  1.04 ,  3.71 ,  4.94 ,  8.86 ,             AIRWTBL   915
                  54.0              4.46 ,  3.22 ,  3.71 ,  2.82 ,  1.41 ,             AIRWTBL   916
1110             104.0              5.78 ,  4.15 ,  2.10 ,  1.96 ,  1.24 /             AIRWTBL   917
                C  *                                                                    AIRWTBL   918
                C  ***    TABLE VIB. SIGMA VZ AT VSS = 20 KT AND SIS = 50 DEG.          AIRWTBL   919
                C  *                                                                    AIRWTBL   920
                     DATA TABVIB/                                                       AIRWTBL   921
1115            C                                                                       AIRWTBL   922
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -14 AIRWTBL   923
                C                                                                       AIRWTBL   924
                -18.75              2.36 ,  5.79 ,  6.79 ,  6.28 ,  5.59 ,             AIRWTBL   925
                   0.0              7.85 ,  7.22 ,  7.76 ,  6.77 ,  5.86 ,             AIRWTBL   926
1120             18.75              5.45 ,  5.36 ,  6.19 ,  6.15 ,  4.93 ,             AIRWTBL   927
                  54.0              6.07 ,  5.94 ,  5.35 ,  6.01 ,  6.19 ,             AIRWTBL   928
                 104.0              5.33 ,  5.22 ,  5.44 ,  6.33 ,  6.03 ,             AIRWTBL   929
                C                                                                       AIRWTBL   930
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -25 AIRWTBL   931
1125            C                                                                       AIRWTBL   932
                -18.75              1.31 ,  5.64 ,  7.93 ,  7.68 ,  6.57 ,             AIRWTBL   933
                   0.0              7.47 ,  7.26 ,  7.41 ,  6.34 ,  6.22 ,             AIRWTBL   934
                 18.75              8.01 ,  7.82 ,  7.41 ,  7.05 ,  5.11 ,             AIRWTBL   935
                  54.0              4.42 ,  5.93 ,  7.49 ,  6.53 ,  6.03 ,             AIRWTBL   936
1130             104.0              7.07 ,  7.39 ,  5.72 ,  6.53 ,  6.85 ,             AIRWTBL   937
                C                                                                       AIRWTBL   938
                C  Y          X =    0.00   37.00   90.00   125.0   250.0     ZTAB = -44 AIRWTBL   939
                C                                                                       AIRWTBL   940
                -18.75              0.85 ,  2.14 ,  5.12 ,  7.10 ,  6.57 ,             AIRWTBL   941
1135               0.0              1.28 ,  6.88 ,  7.92 ,  7.59 ,  7.26 ,             AIRWTBL   942
                 18.75              1.72 ,  8.77 ,  9.18 , 11.00 , 10.25 ,             AIRWTBL   943
                  54.0              1.00 ,  2.16 ,  5.55 ,  6.12 ,  6.43 ,             AIRWTBL   944
                 104.0              7.06 ,  7.76 ,  6.50 ,  5.67 ,  3.69 /             AIRWTBL   945
                C  *                                                                    AIRWTBL   946
1140            C  ***    TABLE VIC. SIGMA VZ AT VSS = 35 KT AND SIS = 30 DEG.          AIRWTBL   947
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      C  *                                                                  AIRWTBL   948
           DATA TABVIC/                                                     AIRWTBL   949
      C                                                                     AIRWTBL   950
      C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -14 AIRWTBL   951
 1145 C                                                                     AIRWTBL   952
          -18.75             3.99 ,  12.17 ,   8.50 ,   7.49 ,   6.56 ,          AIRWTBL   953
             0.0            12.09 ,  13.00 ,  11.14 ,   9.96 ,   8.01 ,          AIRWTBL   954
           18.75            11.10 ,  11.53 ,  10.72 ,  10.90 ,  10.33 ,          AIRWTBL   955
            54.0            12.43 ,  10.51 ,   9.08 ,   9.02 ,   6.89 ,          AIRWTBL   956
 1150      104.0             8.12 ,   8.91 ,   9.63 ,   7.33 ,   4.27 ,          AIRWTBL   957
      C                                                                     AIRWTBL   958
      C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -25 AIRWTBL   959
      C                                                                     AIRWTBL   960
          -18.75             2.05 ,   9.18 ,  12.77 ,   9.99 ,   6.55 ,          AIRWTBL   961
 1155        0.0            12.14 ,  11.18 ,  10.99 ,  11.40 ,   7.46 ,          AIRWTBL   962
           18.75             4.91 ,  10.40 ,  11.84 ,   9.92 ,   9.43 ,          AIRWTBL   963
            54.0            10.50 ,  10.43 ,  10.25 ,   8.78 ,   3.83 ,          AIRWTBL   964
           104.0            11.05 ,  10.61 ,   9.14 ,   6.60 ,   3.31 ,          AIRWTBL   965
      C                                                                     AIRWTBL   966
 1160 C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -44 AIRWTBL   967
      C                                                                     AIRWTBL   968
          -18.75             1.06 ,   1.95 ,   8.16 ,  11.81 ,  10.46 ,          AIRWTBL   969
             0.0             1.56 ,   3.30 ,   8.56 ,  11.93 ,  12.85 ,          AIRWTBL   970
           18.75             1.24 ,   2.84 ,   4.19 ,   6.60 ,  15.10 ,          AIRWTBL   971
 1165       54.0             6.65 ,   6.33 ,   6.34 ,   5.23 ,  12.23 ,          AIRWTBL   972
           104.0            11.54 ,   8.52 ,   5.79 ,   3.91 ,   9.85 /          AIRWTBL   973
      C  *                                                                  AIRWTBL   974
      C  ***    TABLE VID. SIGMA VZ AT VSS = 35 KT AND SIS = 50 DEG.        AIRWTBL   975
      C  *                                                                  AIRWTBL   976
 1170      DATA TABVID/                                                     AIRWTBL   977
      C                                                                     AIRWTBL   978
      C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -14 AIRWTBL   979
      C                                                                     AIRWTBL   980
          -18.75             4.62 ,  11.59 ,  13.94 ,  12.46 ,  11.64 ,          AIRWTBL   981
 1175        0.0            17.21 ,  12.85 ,  14.52 ,  12.37 ,  11.29 ,          AIRWTBL   982
           18.75            10.92 ,  10.50 ,  13.39 ,  12.17 ,  11.03 ,          AIRWTBL   983
            54.0            11.56 ,  11.41 ,  12.93 ,  11.79 ,  11.53 ,          AIRWTBL   984
           104.0            10.55 ,   9.78 ,   8.97 ,  11.25 ,  11.74 ,          AIRWTBL   985
      C                                                                     AIRWTBL   986
 1180 C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -25 AIRWTBL   987
      C                                                                     AIRWTBL   988
          -18.75             2.71 ,   8.82 ,  14.05 ,  13.83 ,  13.21 ,          AIRWTBL   989
             0.0            13.35 ,  13.63 ,  14.80 ,  12.83 ,  10.51 ,          AIRWTBL   990
           18.75            14.83 ,  12.99 ,  14.25 ,  13.96 ,  11.03 ,          AIRWTBL   991
 1185       54.0            11.61 ,  12.63 ,  14.82 ,  13.12 ,  11.27 ,          AIRWTBL   992
           104.0            14.17 ,  11.87 ,  10.85 ,  10.80 ,  10.92 ,          AIRWTBL   993
      C                                                                     AIRWTBL   994
      C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -44 AIRWTBL   995
      C                                                                     AIRWTBL   996
 1190     -18.75              1.39 ,   3.00 ,   9.07 ,  12.35 ,  16.21 ,          AIRWTBL   997
             0.0             3.79 ,  11.59 ,  15.66 ,  14.01 ,  15.67 ,          AIRWTBL   998
           18.75             4.25 ,  15.53 ,  17.52 ,  17.56 ,  17.93 ,          AIRWTBL   999
            54.0             1.90 ,   4.28 ,  12.21 ,  13.46 ,  17.11 ,          AIRWTBL  1000
           104.0            14.39 ,  15.05 ,  12.84 ,  12.78 ,  15.87 /          AIRWTBL  1001
 1195 C  *                                                                  AIRWTBL  1002
      C  ***    TABLE VIE. SIGMA VZ AT VSS = 45 KT AND SIS = 30 DEG.        AIRWTBL  1003
      C  *                                                                  AIRWTBL  1004
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                      DATA TABVIE/                                                                  AIRWTBL  1005
                     C                                                                              AIRWTBL  1006
                     C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -14  AIRWTBL  1007
                     C                                                                              AIRWTBL  1008
                     -18.75              5.93 ,  15.74 ,  10.25 ,   9.73 ,   8.59 ,                 AIRWTBL  1009
                        0.0             16.06 ,  18.09 ,  13.89 ,  11.81 ,   9.50 ,                 AIRWTBL  1010
                      18.75             16.15 ,  16.73 ,  13.95 ,  14.28 ,  13.72 ,                 AIRWTBL  1011
                       54.0             16.65 ,  15.87 ,  11.60 ,  11.64 ,   8.86 ,                 AIRWTBL  1012
                      104.0             10.75 ,  14.76 ,  11.24 ,   9.59 ,   6.52 ,                 AIRWTBL  1013
                     C                                                                              AIRWTBL  1014
                     C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -25  AIRWTBL  1015
                     C                                                                              AIRWTBL  1016
                     -18.75              1.79 ,  14.19 ,  15.60 ,  13.16 ,   9.24 ,                 AIRWTBL  1017
                        0.0             14.15 ,  15.01 ,  16.36 ,  14.66 ,   9.68 ,                 AIRWTBL  1018
                      18.75             14.49 ,  17.16 ,  16.26 ,  15.32 ,  13.62 ,                 AIRWTBL  1019
                       54.0             15.08 ,  16.05 ,  13.56 ,  12.22 ,   5.64 ,                 AIRWTBL  1020
                      104.0             13.45 ,  15.69 ,  11.26 ,   8.90 ,   4.97 ,                 AIRWTBL  1021
                     C                                                                              AIRWTBL  1022
                     C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -44  AIRWTBL  1023
                     C                                                                              AIRWTBL  1024
                     -18.75              0.98 ,   1.61 ,  11.60 ,  16.47 ,  11.90 ,                 AIRWTBL  1025
                        0.0              1.58 ,   3.97 ,  12.29 ,  16.01 ,  12.19 ,                 AIRWTBL  1026
                      18.75              1.15 ,   2.98 ,   5.91 ,   9.36 ,  12.60 ,                 AIRWTBL  1027
                       54.0             10.15 ,  10.48 ,   9.45 ,   5.20 ,   2.36 ,                 AIRWTBL  1028
                      104.0             13.03 ,  11.39 ,   8.13 ,   6.83 ,   3.88 /                 AIRWTBL  1029
                     C  *                                                                           AIRWTBL  1030
                     C  ***    TABLE VIF. SIGMA VZ AT VSS = 45 KT AND SIS = 50 DEG.                 AIRWTBL  1031
                     C  *                                                                           AIRWTBL  1032
                          DATA TABVIF/                                                              AIRWTBL  1033
                     C                                                                              AIRWTBL  1034
                     C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -14  AIRWTBL  1035
                     C                                                                              AIRWTBL  1036
                     -18.75              8.11 ,  17.01 ,  17.54 ,  17.60 ,  15.57 ,                 AIRWTBL  1037
                        0.0             20.48 ,  19.33 ,  16.36 ,  15.74 ,  14.31 ,                 AIRWTBL  1038
                      18.75             12.41 ,  14.11 ,  13.04 ,  14.33 ,  13.47 ,                 AIRWTBL  1039
                       54.0             16.76 ,  15.38 ,  14.29 ,  16.47 ,  14.92 ,                 AIRWTBL  1040
                      104.0             14.25 ,  13.52 ,  11.15 ,  11.50 ,  16.63 ,                 AIRWTBL  1041
                     C                                                                              AIRWTBL  1042
                     C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -25  AIRWTBL  1043
                     C                                                                              AIRWTBL  1044
                     -18.75              5.09 ,  12.43 ,  19.53 ,  18.96 ,  16.70 ,                 AIRWTBL  1045
                        0.0             18.46 ,  19.58 ,  17.42 ,  15.40 ,  14.12 ,                 AIRWTBL  1046
                      18.75             19.50 ,  17.39 ,  17.83 ,  16.09 ,  14.11 ,                 AIRWTBL  1047
                       54.0             14.84 ,  19.87 ,  20.11 ,  16.29 ,  16.56 ,                 AIRWTBL  1048
                      104.0             17.15 ,  14.66 ,  13.98 ,  13.86 ,  14.68 ,                 AIRWTBL  1049
                     C                                                                              AIRWTBL  1050
                     C  Y          X =    0.00    37.00    90.00    125.0    250.0     ZTAB = -44  AIRWTBL  1051
                     C                                                                              AIRWTBL  1052
                     -18.75              1.42 ,   3.89 ,  13.32 ,  15.39 ,  15.34 ,                 AIRWTBL  1053
                        0.0              4.41 ,  16.07 ,  20.94 ,  20.21 ,  15.50 ,                 AIRWTBL  1054
                      18.75              5.99 ,  20.17 ,  26.03 ,  21.22 ,  18.23 ,                 AIRWTBL  1055
                       54.0              2.21 ,   5.90 ,  15.69 ,  17.49 ,  14.31 ,                 AIRWTBL  1056
                      104.0             18.39 ,  19.33 ,  17.83 ,  16.77 ,  12.77 /                 AIRWTBL  1057
                     C                                                                              AIRWTBL  1058
                          DATA TABWOD / 20.0 , 35.0 , 45.0 /                                        AIRWTBL  1059
                     C  *                                                                           AIRWTBL  1060
                     C  ***                30.0             50.0                                    AIRWTBL  1061
```

```
1255          C  *                                                                  AIRWTBL  1062
                 DATA THIRTY , FIFTY / .52359878 , .87266463 /                      AIRWTBL  1063
              C  *                                                                  AIRWTBL  1064
              C  ***    FIND SECTION OF TABLE TO BE INTERPOLATED                    AIRWTBL  1065
              C  *                                                                  AIRWTBL  1066
1260             WOD              = VWOD/1.69                                       AIRWTBL  1067
                 RATPSI           = 1.0                                             AIRWTBL  1068
                 IF(PSIS.GE.FIFTY) RATPSI = 0.0                                     AIRWTBL  1069
                 IF(PSIS.GT.THIRTY .AND. PSIS.LT.FIFTY)                             AIRWTBL  1070
                1 RATPSI          = (FIFTY - PSIS)/(FIFTY - THIRTY)                 AIRWTBL  1071
1265             I                = 2                                               AIRWTBL  1072
                 RATWOD           = 1.0                                             AIRWTBL  1073
                 IF(WOD.LE.TABWOD(1)) GO TO 20                                      AIRWTBL  1074
                 DO 10 I=2,3                                                        AIRWTBL  1075
                 IF(WOD.GT.TABWOD(I)) GO TO 10                                      AIRWTBL  1076
1270             RATWOD           = (TABWOD(I) - WOD)/(TABWOD(I) - TABWOD(I-1))     AIRWTBL  1077
                 GO TO 20                                                           AIRWTBL  1078
              C                                                                     AIRWTBL  1079
                10 CONTINUE                                                         AIRWTBL  1080
                 I                = 3                                               AIRWTBL  1081
1275             RATWOD           = 0.0                                             AIRWTBL  1082
              C  *                                                                  AIRWTBL  1083
              C  ***    INTERPOLATE                                                 AIRWTBL  1084
              C  *                                                                  AIRWTBL  1085
                20 CONTINUE                                                         AIRWTBL  1086
1280             DO 60 I3=1,18                                                      AIRWTBL  1087
                 KK               = 6*((I3 + 2)/3 - 1)                              AIRWTBL  1088
                 KK               = 3*KK + I3 - 3*((I3 - 1)/3) - 3                  AIRWTBL  1089
                 DO 50 I2=1,5                                                       AIRWTBL  1090
                 DO 40 I1=1,5                                                       AIRWTBL  1091
1285             II               = I                                               AIRWTBL  1092
                 DO 30 JJ=1,2                                                       AIRWTBL  1093
                 LL               = KK + 6*II                                       AIRWTBL  1094
                 XDUM1            = TAB1(I1,I2,LL) - RATPSI*(TAB1(I1,I2,LL) -       AIRWTBL  1095
                1                   TAB1(I1,I2,LL-3))                               AIRWTBL  1096
1290             IF(JJ.EQ.1) XDUM2 = XDUM1                                          AIRWTBL  1097
                 II               = II - 1                                          AIRWTBL  1098
                30 CONTINUE                                                         AIRWTBL  1099
                 TAB2(I1,I2,I3) = XDUM2 - RATWOD*(XDUM2 - XDUM1)                    AIRWTBL  1100
                40 CONTINUE                                                         AIRWTBL  1101
1295            50 CONTINUE                                                         AIRWTBL  1102
                60 CONTINUE                                                         AIRWTBL  1103
                 RETURN                                                             AIRWTBL  1104
                 END                                                                AIRWTBL  1105
```

```
      SUBROUTINE AXIS(XPAGE,YPAGE,IBCD,NCHAR,AXLEN,ANGLE,FIRSTV,DELTAV)  AXIS
C*********************************************************************** AXIS
C*                                                                     * AXIS
C*        ROUTINE TO DRAW AN AXIS LINE ON THE CALCOMP PLOTTER.         * AXIS
C*                                                                     * AXIS
C*   INPUT ARGUMENTS                                                   * AXIS
C*        XPAGE     CALCOMP X COORDINATE OF START OF AXIS LINE.        * AXIS
C*        YPAGE     CALCOMP Y COORDINATE OF START OF AXIS LINE.        * AXIS
C*        IBCD      TITLE TO BE CENTERED AND PLACED PARALLEL TO LINE.  * AXIS
C*        NCHAR     IABS(NCHAR)=NUMBER OF CHARACTERS IN TITLE.         * AXIS
C*                  SIGN(NCHAR)=0,ANNOTATION ON POSITIVE SIDE OF LINE. * AXIS
C*                  SIGN(NCHAR)=1,ANNOTATION ON NEGATIVE SIDE OF LINE. * AXIS
C*        AXLEN     AXIS LENGTH (INCHES).                              * AXIS
C*        ANGLE     LINE ROTATION ANGLE (DEGREES).                     * AXIS
C*        FIRSTV    STARTING VALUE TO BE PLACED ON AXIS.               * AXIS
C*        DELTAV    INCREMENT PER INCH ON LINE.                        * AXIS
C*                                                                     * AXIS
C*********************************************************************** AXIS
      XP      = ANGLE/57.29579                                           AXIS
      SINE    = SIN(XP)                                                  AXIS
      COSINE  = COS(XP)                                                  AXIS
      XP      = XPAGE                                                    AXIS
      YP      = YPAGE                                                    AXIS
      CALL PLOT(XP,YP,3)                                                 AXIS
C                                                                      C AXIS
C**************FIND THE NUMBER OF DECIMALS TO BE PRINTED **************C AXIS
C                                                                      C AXIS
      DELN    = 0.2                                                      AXIS
      IF(NCHAR.LT.0) DELN = -0.2                                         AXIS
      FPN     = ABS(FIRSTV + DELTAV*AXLEN)                               AXIS
      IF(ABS(FIRSTV).GT.FPN) FPN = ABS(FIRSTV)                           AXIS
      NDEC    = 2                                                        AXIS
      IF(FPN.EQ.0.0.OR.FPN.EQ.1.0) GO TO 10                              AXIS
      NDEC    = IFIX(ALOG10(FPN))                                        AXIS
      IF(FPN.GT.1.0.AND.FPN.GT.(10.0**NDEC)) NDEC = NDEC + 1             AXIS
      NDEC    = 2 - NDEC                                                 AXIS
   10 DEL     = -0.1*FLOAT((NDEC+1)/2)                                   AXIS
      IF(NDEC.LT.2) DEL  =-0.2                                           AXIS
      IF(NDEC.GT.8) NDEC = 8                                             AXIS
      IF(NDEC.LT.0) NDEC =-1                                             AXIS
C                                                                      C AXIS
C**************              PLOT AXIS LINE              **************C AXIS
C                                                                      C AXIS
      FPN     = FIRSTV                                                   AXIS
      N       = AXLEN + 1.0                                              AXIS
      DO 30 I=1,N                                                        AXIS
      CALL SYMBOL(XP,YP,0.1,13,ANGLE,-1)                                 AXIS
      X       = XP - DELN*SINE                                           AXIS
      Y       = YP + DELN*COSINE                                         AXIS
      IF(ABS(FPN).LE.1.0E-07) GO TO 20                                   AXIS
      X       = XP + DEL*COSINE - DELN*SINE                              AXIS
      Y       = YP + DEL*SINE + DELN*COSINE                              AXIS
   20 CALL NUMBER(X,Y,0.1,FPN,ANGLE,NDEC)                                AXIS
      IF(I.EQ.N) GO TO 30                                                AXIS
      CALL PLOT(XP,YP,3)                                                 AXIS
      XP      = XP + COSINE                                              AXIS
      YP      = YP + SINE                                                AXIS
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                CALL PLOT(XP,YP,2)                                          AXIS      59
                FPN     = FPN + DELTAV                                      AXIS      60
      30        CONTINUE                                                    AXIS      61
                DEL     = 0.5*AXLEN - ABS(0.05*FLOAT(NCHAR))                AXIS      62
                DELN    = 0.4                                               AXIS      63
                IF(NCHAR.LT.0) DELN = -0.4                                  AXIS      64
                X       = DEL*COSINE - DELN*SINE                            AXIS      65
                Y       = DEL*SINE + DELN*COSINE                            AXIS      66
                CALL SYMBOL(X,Y,0.1,IBCD,ANGLE,IABS(NCHAR))                 AXIS      67
                RETURN                                                      AXIS      68
                END                                                         AXIS      69
```

```
      SUBROUTINE CALPLT(ROW,NLIST,NPRNT)                                CALPLT
C*********************************************************************** CALPLT
C*                                                                     * CALPLT
C*        GENERALIZED CALCOMP PLOT ROUTINE.                            * CALPLT
C*                                                                     * CALPLT
C*   INPUT ARGUMENTS                                                   * CALPLT
C*        ROW(1)     SCRATCH ARRAY TO BE USED WHEN READING DATA FILE.  * CALPLT
C*        NLIST      FILE CONTAINING INPUT INSTRUCTIONS.               * CALPLT
C*        NPRNT      =0 IF INPUT INSTRUCTIONS ARE NOT TO BE PLAYED BACK * CALPLT
C*                   ON THE OUTPUT FILE.                               * CALPLT
C*                                                                     * CALPLT
C*   DEFINITIONS                                                       * CALPLT
C*        I          =4HC.M. IF PLOTTING ON CENTIMETER PAPER.          * CALPLT
C*        MPLOTS     NUMBER OF PLOTS TO BE PRODUCED.                   * CALPLT
C*                                                                     * CALPLT
C*   DEFINITIONS FOR PLOT DATA                                         * CALPLT
C*        ANGLE      PLOT ROTATION ANGLE (DEGREES).                    * CALPLT
C*        DELX       INCREMENT PER INCH ON X AXIS.                     * CALPLT
C*        DELY       INCREMENT PER INCH ON Y AXIS.                     * CALPLT
C*        ISOPT      BIT ARRAY FOR SPECIAL OPTIONS.                    * CALPLT
C*                   BIT(0)=1 READ TITLE TO BE CENTERED OVER PLOT.     * CALPLT
C*                   BIT(1)=1 READ X AXIS LABEL.                       * CALPLT
C*                   BIT(2)=1 READ Y AXIS LABEL.                       * CALPLT
C*                   BIT(3)=1 READ LEGEND TITLE.                       * CALPLT
C*                   BIT(4)=1 READ TITLE AND COORDINATES.              * CALPLT
C*        LABELX     X AXIS LABEL.                                     * CALPLT
C*        LABELY     Y AXIS LABEL.                                     * CALPLT
C*        LNGTHX     LENGTH OF X AXIS (INCHES).                        * CALPLT
C*        LNGTHY     LENGTH OF Y AXIS (INCHES).                        * CALPLT
C*        NCURVS     NUMBER OF CURVES APPEARING ON THIS PLOT.          * CALPLT
C*        STARTX     INITIAL X VALUE.                                  * CALPLT
C*        STARTY     INITIAL Y VALUE.                                  * CALPLT
C*        XEXIT      FINAL HORIZONTAL PEN MOVEMENT (INCHES).           * CALPLT
C*        XLEGND     X COORDINATE (REL TO XPLOT) OF PLOT LEGEND (INCHES)* CALPLT
C*        XORG       X VALUE AT WHICH AXES INTERCEPT (DEFAULT=0.0).    * CALPLT
C*        XPLOT      INITIAL HORIZONTAL PEN MOVEMENT (INCHES).         * CALPLT
C*        YEXIT      FINAL VERTICAL PEN MOVEMENT (INCHES).             * CALPLT
C*        YLEGND     Y COORDINATE (REL TO YPLOT) OF PLOT LEGEND (INCHES)* CALPLT
C*        YORG       Y VALUE AT WHICH AXES INTERCEPT (DEFAULT=0.0).    * CALPLT
C*        YPLOT      INITIAL VERTICAL PEN MOVEMENT (INCHES).           * CALPLT
C*                                                                     * CALPLT
C*   DEFINITIONS FOR CURVE DATA                                        * CALPLT
C*        DASH       LENGTH OF PLOTTING SEGMENTS IN DASH PLOT (INCHES). * CALPLT
C*        LINTYP     LINE TYPE.                                        * CALPLT
C*                   =0 IF NO SYMBOLS (LINE ONLY).                     * CALPLT
C*                   =- IF NO LINE    (SYMBOLS ONLY).                  * CALPLT
C*                   =+ IF BOTH LINE AND SYMBOLS ARE TO BE PRODUCED.   * CALPLT
C*        LSTYLE     LINE STYLE.                                       * CALPLT
C*        NCOLX      COLUMN ON DATA FILE WHERE X DATA RESIDES.         * CALPLT
C*        NCOLY      COLUMN ON DATA FILE WHERE Y DATA RESIDES.         * CALPLT
C*        NCX        COLUMN WHERE X ELLIPTICAL AXIS DATA RESIDES.      * CALPLT
C*        NCY        COLUMN WHERE Y ELLIPTICAL AXIS DATA RESIDES.      * CALPLT
C*        NCXY       COLUMN WHERE XY CROSS CORRELATION DATA RESIDES    * CALPLT
C*        NDATA      FILE WHERE DATA RESIDES.                          * CALPLT
C*        NSYM       CALCOMP SYMBOL CODE (99 IF ELLIPSE).              * CALPLT
C*        SCALEX     SCALE FACTOR TO BE APPLIED TO X DATA.             * CALPLT
C*        SCALEY     SCALE FACTOR TO BE APPLIED TO Y DATA.             * CALPLT
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C*        SCALXX    SCALE FACTOR FOR X ELLIPTICAL AXIS (DEFAULT=SCALEX)*
C*        SCALYY    SCALE FACTOR FOR Y ELLIPTICAL AXIS (DEFAULT=SCALEY)*
C*                                                                     *
C***********************************************************************
      DIMENSION KOW(1),TITLE(32),LABELX(4),LABELY(4)
      REAL      LNGTHX,LNGTHY
      NAMELIST/PLOTD/ NCURVS,ANGLE,XPLOT,YPLOT,XEXIT,YEXIT,XLEGND,
     A                YLEGND,XORG,YORG,LNGTHX,LNGTHY,STARTX,STARTY,
     B                DELX,DELY,ISOPT
      NAMELIST/CURVE/ NDATA,NCOLX,NCOLY,NCX,NCY,NCXY,LINTYP,DASH,NSYM,
     *                SCALEX,SCALEY,SCALXX,SCALYY
      DATA BLANK,LSMAX/ 10H          , 1777778 /
C                                                                     C
C***************          SET UP PLOTTING LOOP          ***************C
C                                                                     C
      IF(NLIST.NE.5) REWIND NLIST
      READ(NLIST,1000) NPLOTS,I
1000  FORMAT(I5,5X,A4)
      IF(NPRNT.GT.0) WRITE(6,2000) NPLOTS
2000  FORMAT(//5X,I5)
      IF(I.EQ.4HC.P.) CALL FACTOR(0.7874015748)
      DO 310 I=1,NPLOTS
      READ(NLIST,PLOTD)
      CALL PLOT(XPLOT,YPLOT,-3)
      IF(ANGLE.NE.0.0) ANGLE = 90.0
C                                                                     C
C***************          READ SPECIAL OPTIONS          ***************C
C                                                                     C
      DO 140 J=1,5
      K       = ISOPT.AND.SHIFT(MASK(1),J)
      IF(K.EQ.0) GO TO 140
      GO TO (10,20,30,40,50),J
C  *
C  ***    READ AND PRODUCE A CENTERED PLOT TITLE.
C  *
10    READ(NLIST,1010) TITLE
1010  FORMAT(8A10)
      IF(NPRNT.GT.0) WRITE(6,2010) TITLE
2010  FORMAT(5X,8A10)
      NC      = 80
      NL      = 4
      X       = 0.5*LNGTHX - 4.0
      Y       = LNGTHY + 1.0
      GO TO 110
C  *
C  ***    READ X-AXIS LABEL.
C  *
20    READ(NLIST,1010) LABELX
      GO TO 140
C  *
C  ***    READ Y-AXIS LABEL.
C  *
30    READ(NLIST,1010) LABELY
      GO TO 140
C  *
C  ***    READ LEGEND TITLE.
C  *
```

```
      40    READ(NLIST,1010) (TITLE(K),K=1,4)                                CALPLT
            IF(NPRNT.GT.0) WRITE(6,2010) (TITLE(K),K=1,4)                    CALPLT
            NC       = 40                                                    CALPLT
            NL       = 1                                                     CALPLT
            X        = XLEGND                                                CALPLT
            Y        = YLEGND                                                CALPLT
            YLEGND   = YLEGND - 0.25                                         CALPLT
            GO TO 110                                                        CALPLT
      C  *                                                                   CALPLT
      C  ***    READ AND PRODUCE PAGE TITLE.                                 CALPLT
      C  *                                                                   CALPLT
      50    READ(NLIST,1020) X,Y                                             CALPLT
      1020  FORMAT(2F10.0)                                                   CALPLT
            READ(NLIST,1010) TITLE                                           CALPLT
            NC       = 80                                                    CALPLT
            NL       = 4                                                     CALPLT
            IF(NPRNT.LE.0) GO TO 110                                         CALPLT
            WRITE(6,2020) X,Y                                                CALPLT
      2020  FORMAT(5X,2F10.4)                                                CALPLT
            WRITE(6,2010) TITLE                                              CALPLT
      C  *                                                                   CALPLT
      C  ***    PRODUCE TITLES ON CALCOMP PLOTTER.                           CALPLT
      C  *                                                                   CALPLT
      110   Y        = Y + 0.25                                              CALPLT
            DO 130 K=1,NL                                                    CALPLT
            Y        = Y - 0.25                                              CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                  CALPLT
      120   L        = 8*(K - 1) + 1                                         CALPLT
            CALL SYMBOL(XR,YR,0.1,TITLE(L),ANGLE,NC)                         CALPLT
      130   CONTINUE                                                         CALPLT
      140   CONTINUE                                                         CALPLT
            IF(NPRNT.LE.0) GO TO 150                                         CALPLT
      C  *                                                                   CALPLT
      C  ***    PRODUCE REQUESTED PRINT.                                     CALPLT
      C  *                                                                   CALPLT
            WRITE(6,2030) NCURVS,XPLOT,YPLOT,XLEGND,YLEGND,ANGLE             CALPLT
      2030  FORMAT(5X,I5,5X,5F10.4)                                          CALPLT
            WRITE(6,2040) LABELX,LNGTHX,STARTX,DELX,XORG                     CALPLT
      2040  FORMAT(5X,4A10,4F10.4)                                           CALPLT
            WRITE(6,2040) LABELY,LNGTHY,STARTY,DELY,YORG                     CALPLT
      C                                                                    C CALPLT
      C**************          DRAW AND LABEL X AXIS          **************C CALPLT
      C                                                                    C CALPLT
      150   Y        = -(STARTY - YORG)/DELY                                 CALPLT
            XDUM     = STARTY + DELY*LNGTHY                                  CALPLT
            IF(STARTY.LT.YORG.AND.XDUM.LT.YORG) Y = 0.0                      CALPLT
            IF(STARTY.GT.YORG.AND.XDUM.GT.YORG) Y = 0.0                      CALPLT
            NC       = -4                                                    CALPLT
            XDUM     = 0.5*LNGTHY                                            CALPLT
            IF(Y.GT.XDUM) NC = 4                                             CALPLT
            X        = 0.0                                                   CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                  CALPLT
            CALL AXIS(XR,YR,BLANK,NC,LNGTHX,ANGLE,STARTX,DELX)               CALPLT
            X        = 0.5*LNGTHX - 2.0                                      CALPLT
            Y        = -0.4                                                  CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                  CALPLT
            CALL SYMBOL(XR,YR,0.1,LABELX,ANGLE,40)                           CALPLT
```

```
      C                                                                      C CALPLT
      C**************          DRAW AND LABEL Y AXIS          **************C CALPLT
      C                                                                      C CALPLT
            X       = -(STARTX - XORG)/DELX                                    CALPLT
            XDUM    = STARTX + DELX*LNGTHX                                     CALPLT
            IF(STARTX.LT.XORG.AND.XDUM.LT.XORG) X = 0.0                        CALPLT
            IF(STARTX.GT.XORG.AND.XDUM.GT.XORG) X = 0.0                        CALPLT
            NC      = 40                                                       CALPLT
            XDUM    = 0.5*LNGTHX                                               CALPLT
            IF(X.GT.XDUM) NC = -40                                             CALPLT
            Y       = 0.0                                                      CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                    CALPLT
            CALL AXIS(XR,YR,LABELY,NC,LNGTHY,ANGLE+90.0,STARTY,DELY)           CALPLT
      C                                                                      C CALPLT
      C**************    BEGIN LOOP FOR EACH CURVE ON PLOT    **************C CALPLT
      C                                                                      C CALPLT
            DO 300 J=1,NCURVS                                                  CALPLT
            READ(NLIST,CURVE)                                                  CALPLT
            READ(NLIST,1030) LSTYLE,(TITLE(K),K=1,4)                           CALPLT
      1030  FORMAT(O6,4X,4A10)                                                 CALPLT
            IF(NPRNT.GT.0) WRITE(6,2050) (TITLE(K),K=1,4),NDATA,NCOLX,NCOLY,   CALPLT
           1                              NSYM,LINTYP,DASH,SCALEX,SCALEY,LSTYLE CALPLT
      2050  FORMAT(5X,4A10,5I3,F5.3,2F7.4,O6)                                  CALPLT
            DO 190 K=1,4                                                       CALPLT
            IF(TITLE(K).NE.BLANK) GO TO 200                                    CALPLT
      190   CONTINUE                                                           CALPLT
            GO TO 240                                                          CALPLT
      200   IF(LINTYP.LT.0) GO TO 220                                          CALPLT
      C  *                                                                     CALPLT
      C  ***    DRAW LINE FOR LEGEND.                                          CALPLT
      C  *                                                                     CALPLT
            X       = XLEGND                                                   CALPLT
            XX      = X + 1.0                                                  CALPLT
            Y       = YLEGND + 0.05                                            CALPLT
            YY      = Y                                                        CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                    CALPLT
            CALL PLOT(XR,YR,3)                                                 CALPLT
            CALL ROTATE(XX,YY,ANGLE,-1,XR,YR)                                  CALPLT
            IF(LSTYLE.GE.LSMAX.OR.LSTYLE.LE.0) CALL PLOT(XR,YR,2)              CALPLT
            IF(LSTYLE.LT.LSMAX.AND.LSTYLE.GT.0) CALL DASPLT(XR,YR,DASH,LSTYLE) CALPLT
      220   IF(LINTYP.EQ.0.OR.NSYM.EQ.99) GO TO 230                            CALPLT
      C  *                                                                     CALPLT
      C  ***    DRAW SYMBOL FOR LEGEND.                                        CALPLT
      C  *                                                                     CALPLT
            X       = XLEGND + 0.5                                             CALPLT
            Y       = YLEGND + 0.05                                            CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                    CALPLT
            CALL SYMBOL(XR,YR,0.1,NSYM,ANGLE,-1)                               CALPLT
      C  *                                                                     CALPLT
      C  ***    WRITE LEGEND NOTATION.                                         CALPLT
      C  *                                                                     CALPLT
      230   X       = XLEGND + 1.1                                             CALPLT
            Y       = YLEGND                                                   CALPLT
            CALL ROTATE(X,Y,ANGLE,-1,XR,YR)                                    CALPLT
            CALL SYMBOL(XR,YR,0.1,TITLE,ANGLE,40)                              CALPLT
            YLEGND  = YLEGND - 0.25                                            CALPLT
      C  *                                                                     CALPLT
```

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                C  ***    READ AND PLOT DATA.                                          CALPLT   230
230             C  *                                                                   CALPLT   231
                240   REWIND NDATA                                                     CALPLT   232
                      READ(NDATA) K,NCOL,L                                             CALPLT   233
                      IF(L.EQ.0) GO TO 250                                             CALPLT   234
                      READ(NDATA) (ROW(L),L=1,NCOL)                                    CALPLT   235
235                   K       = IFIX(ROW(NCOLX) + 0.001)                               CALPLT   236
                250   IF(SCALEX.EQ.C.0) SCALEX = 1.C                                   CALPLT   237
                      IF(SCALEY.EQ.0.0) SCALEY = 1.C                                   CALPLT   238
                      IF(SCALXX.EQ.0.0) SCALXX = SCALEX                                CALPLT   239
                      IF(SCALYY.EQ.0.0) SCALYY = SCALEY                                CALPLT   240
240                   NN      = IABS(LINTYP)                                           CALPLT   241
                      DO 300 L=1,K                                                     CALPLT   242
                      READ(NDATA) (ROW(LL),LL=1,NCOL)                                  CALPLT   243
                      NN      = NN + 1                                                 CALPLT   244
                      IF(NN.LT.IABS(LINTYP).AND.LINTYP.LT.0) GO TO 300                 CALPLT   245
245                   X       = SCALEX*ROW(NCOLX)                                      CALPLT   246
                      Y       = SCALEY*ROW(NCOLY)                                      CALPLT   247
                      XX      = (X - STARTX)/DELX                                      CALPLT   248
                      YY      = (Y - STARTY)/DELY                                      CALPLT   249
                      CALL ROTATE(XX,YY,ANGLE,-1,XR,YR)                                CALPLT   250
250             260   IF(LINTYP.LT.0) GO TO 270                                        CALPLT   251
                      IF(L.EQ.1.AND.LINTYP.GT.0) GO TO 270                             CALPLT   252
                      IF(L.EQ.1.AND.LINTYP.EQ.0) GO TO 290                             CALPLT   253
                C  ***    PRODUCE LINE SEGMENT.                                        CALPLT   254
                      IF(LSTYLE.GE.LSMAX.OR.LSTYLE.LE.0) CALL PLOT(XR,YR,2)            CALPLT   255
255                   IF(LSTYLE.LT.LSMAX.AND.LSTYLE.GT.0) CALL DASPLT(XR,YR,DASH,LSTYLE) CALPLT 256
                      IF(LINTYP.EQ.0.OR.NN.LT.IABS(LINTYP)) GO TO 300                  CALPLT   257
                C  ***    PRODUCE SYMBOL.                                              CALPLT   258
                270   IF(NSYM.EQ.99) GO TO 280                                         CALPLT   259
                      CALL SYMBOL(XR,YR,0.1,NSYM,ANGLE,-1)                             CALPLT   260
260                   GO TO 290                                                        CALPLT   261
                280   CONTINUE                                                         CALPLT   262
                      CALL ELLIPSE(X,Y,ROW(NCX),ROW(NCY),ROW(NCXY),ANGLE,STARTX,DELX,  CALPLT   263
                     *             STARTY,DELY,SCALXX,SCALYY)                          CALPLT   264
                290   CALL PLOT(XR,YR,3)                                             CALPLT   265
265                   NN      = 0                                                      CALPLT   266
                300   CONTINUE                                                         CALPLT   267
                      WRITE(6,2060) I                                                  CALPLT   268
                2060  FORMAT(5X,21HCOMPLETED PLOT NUMBER,I5)                          CALPLT   269
                310   CONTINUE                                                         CALPLT   270
270                   CALL PLOT(XEXIT,YEXIT,999)                                       CALPLT   271
                      RETURN                                                           CALPLT   272
                      END                                                              CALPLT   273
```

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      SUBROUTINE DASPLT(XPAGE,YPAGE,DASH,ISTYLE)                        DASPLT     2
C     ORIGINAL ROUTINE BY CANTRELL AND FRENCH FOR USE ON CDC3300        DASPLT     3
C     MODIFIED TO 360 VERSION WITH HEXADECIMAL INPUT BY                 DASPLT     4
C     E. E. SHAPT, AERODYNAMICS ENGINEER                                DASPLT     5
C     3-2-72                                                            DASPLT     6
C* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * DASPLT     7
C*                                                                      * DASPLT     8
C*       DASHPLOT PLOTS A LINE FROM THE PRESENT PEN POSITION TO         * DASPLT     9
C*       THE LOCATION DEFINED BY THE FIRST AND SECOND ARGUMENTS         * DASPLT    10
C*       WITH PEN UP AND DOWN COMMANDS CONTROLLED BY THE VALUES         * DASPLT    11
C*       OF THE THIRD AND FOURTH ARGUMENTS.                             * DASPLT    12
C*                                                                      * DASPLT    13
C*       CALLING ARGUMENTS                                              * DASPLT    14
C*                                                                      * DASPLT    15
C*         XPAGE,    = X,Y COORDINATES OF THE TERMINAL POSI-           * DASPLT    16
C*         YPAGE       TION TO WHICH THE PEN IS MOVED, IN              * DASPLT    17
C*                     INCHES FROM THE CURRENT ORIGIN (INPUT)          * DASPLT    18
C*                                                                     * DASPLT    19
C*         DASHSIZE  = BASIC PLOTTING INCREMENT IN INCHES. A           * DASPLT    20
C*                     VALUE OF ZERO IS DEFAULTED TO 0.1               * DASPLT    21
C*                     INCH. A VALUE OF LESS THAN ZERO                 * DASPLT    22
C*                     CAUSES RESIDUE FROM A PREVIOUS                  * DASPLT    23
C*                     CALL (SEE BELOW) TO BE IGNORED                  * DASPLT    24
C*                     AND THE ABSOLUTE VALUE IS RE-                   * DASPLT    25
C*                     TURNED TO THE CALLING PROGRAM.                  * DASPLT    26
C*                     (INPUT/OUTPUT)                                  * DASPLT    27
C*                                                                     * DASPLT    28
C*         ISTYLE    = BIT PATTERN CONTROLLING PEN UP AND DOWN        * DASPLT    29
C*                     COMMANDS. IF THE HIGH ORDER BIT IS SET,         * DASPLT    30
C*                     THE PEN IS DOWN FOR THE PLOTTING OF THE         * DASPLT    31
C*                     NEXT INCREMENT. IF THE HIGH ORDER BIT           * DASPLT    32
C*                     IS NOT SET, THE PEN IS UP FOR THE PLOT-         * DASPLT    33
C*                     TING OF THE NEXT INCREMENT. FOLLOWING           * DASPLT    34
C*                     THE PLOTTING OF EACH INCREMENT, THE BIT         * DASPLT    35
C*                     PATTERN IS SHIFTED LEFT (END AROUND) TO         * DASPLT    36
C*                     POSITION THE NEXT BIT FOR CONTROLLING           * DASPLT    37
C*                     THE PEN. THE CURRENT CONFIGURATION OF           * DASPLT    38
C*                     THE PATTERN IS RETURNED TO THE CALLING          * DASPLT    39
C*                     PROGRAM. A VALUE OF ZERO IS HANDLED AS          * DASPLT    40
C*                     IF ALL BITS WERE SET. (INPUT/OUTPUT)            * DASPLT    41
C*                                                                     * DASPLT    42
C*                                                                     * DASPLT    43
C*       WHEN THE PLOTTING OF THE LINE HAS BEEN COMPLETED, IF A        * DASPLT    44
C*       PORTION OF AN INCREMENT REMAINS TO BE PLOTTED, THE RES-       * DASPLT    45
C*       IDUE IS SAVED. IF THE NEXT CALL TO DASHPLOT HAS THE           * DASPLT    46
C*       SAME VALUE OF ISTYLE AS THAT RETURNED TO THE CALLING          * DASPLT    47
C*       PROGRAM, THE LENGTH OF THE RESIDUE IS FIRST PLOTTED BE-       * DASPLT    48
C*       FORE PLOTTING OF COMPLETE INTERVALS RESUMES. THUS, A          * DASPLT    49
C*       LINE PATTERN MAY BE MAINTAINED ACROSS A SERIES OF LINE        * DASPLT    50
C*       SEGMENTS.                                                     * DASPLT    51
C*                                                                     * DASPLT    52
C*       IF THE IAPRT PARAMETER IS USED IN THE CALL TO PLOTS,          * DASPLT    53
C*       THE NEGATIVE FRAME NUMBER IS RETURNED IN THE A-REGISTER       * DASPLT    54
C*       WHEN THE FILE IS FULL. IF THE FILE IS NOT FULL, A POSI-       * DASPLT    55
C*       TIVE NUMBER IS RETURNED.                                      * DASPLT    56
C*                                                                     * DASPLT    57
C*       CAUTION SHOULD BE EXERCISED IN THE USE OF THE DASHSIZE        * DASPLT    58
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C*.       AND ISTYLE ARGUMENTS. NUMERIC CONSTANTS SHOULD NOT BE          * DASPLT     59
C*        USED SINCE THE VALUES MAY BE CHANGED BEFORE THE RETURN         * DASPLT     60
C*        IS MADE.                                                       * DASPLT     61
C*                                                                       * DASPLT     62
C* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * DASPLT     63
      INTEGER PNTEST,SHIFT                                               DASPLT     64
      DATA(PNTEST=1000000B),(SHIFT=1777778)                              DASPLT     65
C                                                                        DASPLT     66
C FIRST EXECUTABLE STATEMENT                                             DASPLT     67
C                                                                        DASPLT     68
C SET DEFAULT VALUE FOR INCREMENT SIZE IF NECESSARY                      DASPLT     69
C                                                                        DASPLT     70
    1 SIZE=DASH                                                          DASPLT     71
      IF(SIZE) 5,10,20                                                   DASPLT     72
C                                                                        DASPLT     73
C   INHIBIT RESIDUE PLOTTING                                             DASPLT     74
C                                                                        DASPLT     75
    5 DASH = -SIZE                                                       DASPLT     76
      JSTYLE=0                                                           DASPLT     77
      GO TO 1                                                            DASPLT     78
   10 SIZE=.1                                                            DASPLT     79
C                                                                        DASPLT     80
C DETERMINE IF A PREVIOUS BIT PATTERN IS TO BE CONTINUED                 DASPLT     81
C                                                                        DASPLT     82
   20 IF(ISTYLE-JSTYLE) 30,40,30                                         DASPLT     83
C                                                                        DASPLT     84
C START A NEW BIT PATTERN                                                DASPLT     85
C                                                                        DASPLT     86
   30 JSTYLE=ISTYLE                                                      DASPLT     87
      GO TO 50                                                           DASPLT     88
C                                                                        DASPLT     89
C CONTINUE A BIT PATTERN, DETERMINE IF THE PREVIOUS PLOTTING LEFT A POR- DASPLT     90
C TION OF AN INTERVAL REMAINING TO BE PLOTTED                            DASPLT     91
C                                                                        DASPLT     92
   40 IF(RESIDU ) 60,50,60                                               DASPLT     93
C                                                                        DASPLT     94
C SET THE RESIDUE TO A FULL PLOTTING INTERVAL                            DASPLT     95
C                                                                        DASPLT     96
   50 RESIDU =SIZE                                                       DASPLT     97
C                                                                        DASPLT     98
C FIND THE PRESENT PEN LOCATION                                          DASPLT     99
C                                                                        DASPLT    100
   60 CALL WHERE(X,Y,XDIFF)                                              DASPLT    101
C                                                                        DASPLT    102
C FIND THE OVERALL DISTANCES REQUESTED FOR PLOTTING                      DASPLT    103
C                                                                        DASPLT    104
C   HORIZONTAL                                                           DASPLT    105
C                                                                        DASPLT    106
      XDIFF=XPAGE-X                                                      DASPLT    107
C                                                                        DASPLT    108
C   VERTICAL                                                             DASPLT    109
C                                                                        DASPLT    110
      YDIFF=YPAGE-Y                                                      DASPLT    111
C                                                                        DASPLT    112
C   SLANT                                                                DASPLT    113
C                                                                        DASPLT    114
      TOTAL=SQRT(XDIFF*XDIFF+YDIFF*YDIFF)                                DASPLT    115
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      C                                                                 DASPLT  116
      C   ELIMINATE NULL LINE REQUESTS                                 DASPLT  117
      C                                                                 DASPLT  118
            IF(TOTAL) 180,180,70                                        DASPLT  119
      C                                                                 DASPLT  120
      C CALCULATE ANGLE FUNCTIONS                                       DASPLT  121
      C                                                                 DASPLT  122
         70 COSINE=XDIFF/TOTAL                                          DASPLT  123
            SINE=YDIFF/TOTAL                                            DASPLT  124
      C                                                                 DASPLT  125
      C CALCULATE COORDINATE DISTANCES EQUIVALENT TO THE INCREMENT DISTANCE DASPLT 126
      C ALONG THE LINE                                                  DASPLT  127
      C                                                                 DASPLT  128
      C   HORIZONTAL                                                    DASPLT  129
      C                                                                 DASPLT  130
            DELX=SIZE*COSINE                                            DASPLT  131
      C                                                                 DASPLT  132
      C   VERTICAL                                                      DASPLT  133
      C                                                                 DASPLT  134
            DELY=SIZE*SINE                                              DASPLT  135
      C                                                                 DASPLT  136
      C DETERMINE THE PEN SETTING                                       DASPLT  137
      C                                                                 DASPLT  138
        80   CONTINUE                                                   DASPLT  139
            IPEN = 3                                                    DASPLT  140
            IF(JSTYLE.GE.PNTEST) IPEN = 2                               DASPLT  141
      C DETERMINE IF THE FULL LENGTH OF THE RESIDUE MAY BE PLOTTED      DASPLT  142
      C                                                                 DASPLT  143
        110 IF(RESIDU -TOTAL) 120,160,170                               DASPLT  144
      C                                                                 DASPLT  145
      C THE ENTIRE RESIDUE MAY BE PLOTTED, DISTINGUISH BETWEEN A FULL SIZE IN- DASPLT 146
      C CREMENT AND RESIDUE FROM A PREVIOUS CALL                        DASPLT  147
      C                                                                 DASPLT  148
        120 IF(RESIDU -SIZE) 130,140,140                                DASPLT  149
      C                                                                 DASPLT  150
      C PLOT THE RESIDUE FROM A PREVIOUS CALL                           DASPLT  151
      C                                                                 DASPLT  152
      C   CALCULATE THE NEW PEN POSITION                                DASPLT  153
      C                                                                 DASPLT  154
      C     HORIZONTAL                                                  DASPLT  155
        130 X=X+RESIDU *COSINE                                          DASPLT  156
      C                                                                 DASPLT  157
      C                                                                 DASPLT  158
      C                                                                 DASPLT  159
      C     VERTICAL                                                    DASPLT  160
            Y=Y+RESIDU *SINE                                            DASPLT  161
      C                                                                 DASPLT  162
      C   CALCULATE THE DISTANCE REMAINING TO BE PLOTTED                DASPLT  163
      C                                                                 DASPLT  164
            TOTAL=TOTAL-RESIDU                                          DASPLT  165
      C                                                                 DASPLT  166
      C   ENABLE FUTURE PLOTTING OF THE FULL INCREMENT LENGTH           DASPLT  167
      C                                                                 DASPLT  168
            RESIDU =SIZE                                                DASPLT  169
            GO TO 150                                                   DASPLT  170
      C                                                                 DASPLT  171
      C PLOT A FULL INCREMENT LENGTH                                    DASPLT  172
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C                                                                       DASPLT
C   CALCULATE THE NEW PEN POSITION                                      DASPLT
C                                                                       DASPLT
C      HORIZONTAL                                                       DASPLT
C                                                                       DASPLT
  140 X=X+DELX                                                          DASPLT
C                                                                       DASPLT
C      VERTICAL                                                         DASPLT
C                                                                       DASPLT
      Y=Y+DELY                                                          DASPLT
C                                                                       DASPLT
C   CALCULATE THE DISTANCE REMAINING TO BE PLOTTED                      DASPLT
C                                                                       DASPLT
      TOTAL=TOTAL-RESIDU                                                DASPLT
C                                                                       DASPLT
C MOVE THE NEXT BIT IN THE PATTERN INTO CONTROL POSITION                DASPLT
C                                                                       DASPLT
  150 JSTYLE = JSTYLE * 2                                               DASPLT
      IF(JSTYLE.GT.SHIFT ) JSTYLE = JSTYLE - SHIFT                      DASPLT
C                                                                       DASPLT
C PLOT THE NEXT SEGMENT                                                 DASPLT
C                                                                       DASPLT
      CALL PLOT(X,Y,IPEN)                                               DASPLT
      GO TO 80                                                          DASPLT
C                                                                       DASPLT
C EXACTLY ONE INCREMENT REMAINS TO BE PLOTTED, MOVE THE NEXT BIT IN THE DASPLT
C PATTERN INTO CONTROL POSITION                                         DASPLT
C                                                                       DASPLT
  160 JSTYLE = JSTYLE * 2                                               DASPLT
      IF(JSTYLE.GT.SHIFT ) JSTYLE = JSTYLE - SHIFT                      DASPLT
C                                                                       DASPLT
C THE LAST SEGMENT OF THE LINE IS TO BE PLOTTED, CALCULATE THE RESIDUE  DASPLT
C                                                                       DASPLT
  170 RESIDU =RESIDU -TOTAL                                             DASPLT
C                                                                       DASPLT
C PLOT THE FINAL SEGMENT AND SET THE FUNCTION VALUE                     DASPLT
C                                                                       DASPLT
      CALL PLOT(XPAGE,YPAGE,IPEN  )                                     DASPLT
C                                                                       DASPLT
C RETURN THE CURRENT BIT PATTERN TO THE CALLER                          DASPLT
C                                                                       DASPLT
      ISTYLE=JSTYLE                                                     DASPLT
C                                                                       DASPLT
C RETURN                                                                DASPLT
C                                                                       DASPLT
  180 RETURN                                                            DASPLT
      END                                                               DASPLT
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      SUBROUTINE DEQU                                                   DEQU
C     ******************************************************************* DEQU
C     ***                                                                 DEQU
C     ***    ROUTINE TO HANDLE SYSTEM DIFFERENTIAL EQUATIONS FOR MEANS.   DEQU
C     ***                                                                 DEQU
C     ******************************************************************* DEQU
C     *                                                                   R
C     ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                   R
C     *                                                                   R
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                              R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 2 - DERIVATIVES.                             R
C     *                                                                   R
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,           R
     A       ZSPDOT,TSPDOT,                                               R
     B       VDOT,PBDOT,RBDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT                R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                         R
C     *                                                                   R
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,               R
     A        VB,PB,RB,YAPP,PHI,PSI,YSP                                  R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.     R
C     *                                                                   R
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,      R
     A       THETAAO,PSIAO,PHIAO,RCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,     R
     B       NO,VBASO                                                     R
      REAL   MO,LO,NO                                                     R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                R
C     *                                                                   R
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,             R
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN                 R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 6 - GEOMETRY.                                R
C     *                                                                   R
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                     R
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                               R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 7 - CONSTANTS.                               R
C     *                                                                   R
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,          R
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,             R
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,             R
     3       OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                        R
      REAL  KU,KW,KFRPM,KCDN,                                             R
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,               R
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,               R
     3       K1,K2,KY,KV                                                  R
C     *                                                                   R
C     ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.    R
C     *                                                                   R
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X1DWS,  R
     A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP,  R
     B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,       R
     C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,     R
     D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSE,PSISS,PSISC,PSIST,TS1,  R
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      E        TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,
      F        ZBIASP
C  *
C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.
C  *
      COMMON THETAC,DFRPMOL,DCDNOL,DEOL,GAMMAGS,RANGE,VAIRC,
     1       DAOL,DROL
C  *
C  ***    R ARRAY SEGMENT 10 - AERO DATA.
C  *
      COMMON XU,XW,XQ,XFRPM,XCDN,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCDN,ZPDIGV,
     A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE,
     B        YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,
     C        NDA,NDR
      REAL   MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE
      REAL  LV,LP,LR,LDA,LDR,NV,NP,NR,NDA,NDR
C  *
C  ***    R ARRAY SEGMENT 11
C  *
      COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERPW, ETHETA,
     1        ERY,ERPHI,ERPSI,YCOM,PHICOM,PSICOM
C  *
C  ***    R ARRAY SEGMENT 12 - CONTROLS.
C  *
      COMMON  DE,DT,DCDN,DED,DTD,DCDND,
     1        DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D
C  *
C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.
C  *
      COMMON TABV1(6)
C  *
C  ***    R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE L
C  *
      COMMON TABV2(10)
C  *
C  ***    R ARRAY SEGMENT 15 - UNUSED
C  *
C  *
C  ***    R ARRAY SEGMENT 16 - GDF RELATED STUFF
C  *
      COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR
C  *
C  ***    R ARRAY SEGMENT 17 - SHIP MOTION
C  *
      COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,
     1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT
      REAL KXS,KZS,KTS,KYS,KRS,KPS
C  *
C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.
C  *
      COMMON TABTC(10)
      COMMON TRPMOL(10)
      COMMON TCDNOL(10)
      COMMON TDEOL(10)
C  *
C  ***    R ARRAY SEGMENTS 24-25
C  *
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      COMMON TABR(10)
      COMMON TABRDOT(10)
C  *
C  ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AERO DATA TABLES
C  *
      COMMON TXU(6)
      COMMON TXW(6)
      COMMON TXQ(6)
      COMMON TXRPM(6)
      COMMON TXCDN(6)
      COMMON TXPIGV(6)
      COMMON TXDE(6)
      COMMON TZU(6)
      COMMON TZW(6)
      COMMON TZQ(6)
      COMMON TZRPM(6)
      COMMON TZCDN(6)
      COMMON TZPIGV(6)
      COMMON TZDE(6)
      COMMON TMU(6)
      COMMON TMW(6)
      COMMON TMWD(6)
      COMMON TMQ(6)
      COMMON TMRPM(6)
      COMMON TMCDN(6)
      COMMON TMPIGV(6)
      COMMON TMDE(6)
C  *
C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIME
C  *
      COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)
C  *
C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.
C  *
      COMMON SIGMA(50)
      COMMON SIGMAXY(50)
C  *
C  ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES
C  *
      COMMON VXX(5,5,3)
      COMMON VYY(5,5,3)
      COMMON VZZ(5,5,3)
      COMMON SVXX(5,5,3)
      COMMON SVYY(5,5,3)
      COMMON SVZZ(5,5,3)
C  *
C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS
C  *
      COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),
     1        TKDEZ(6), TKDEN(6), TKDEDE(6), TKDEDT(6),
     2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),
     3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)
C  *
C  ***    R ARRAY SEGMENTS 81-106
C  *
      COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),
     1       H(1,1),D(1,1),C(4,6),RL(4,4),W(1,1),VU(1,1),VY(1,1),
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     2       VYI(1,1),S(1,1),FE(1,1),CE(1,1),PE(1,1),PFO(1,1),          R       167
     3       KG(1,1),FXHAT(1,1),PXHAT(1,1),PXHATD(1,1),PX(1,1),         R       168
     4       CS(1,1)                                                    R       169
175       REAL M1,M2,KG                                                R       170
C  *                                                                     R       171
C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE REL R       172
C  *                                                                     R       173
      COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                      R       174
180   1       DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                       R       175
C  *                                                                     R       176
C  ***    R ARRAY SEGMENTS 108-119                                      R       177
C  *                                                                     R       178
      COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),         R       179
185   1       TDEVZD(6), TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),        R       180
      2       TDTVZ(6), TDTVZD(6)                                        R       181
C *                                                                     R       182
C ***    R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES            R       183
C *                                                                     R       184
190   COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),                  R       185
      1       TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),                  R       186
      2       TNV(6), TNP(6), TNR(6), TNDA(6), TNDR(6)                   R       187
C *                                                                     R       188
C ***    R ARRAY SEGMENTS 135-139 - LONG. TERMS RECD FOR LAT/DIR CASE   R       189
195   C *                                                               R       190
      COMMON  TABUB(10),TABWB(10),TXAPP(10),TZAPP(10),TXSP(10)          R       191
C  *                                                                    R       192
C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS      R       193
C  *                                                                    R       194
200   COMMON TDAIN(4), TDAOUT(4), TDRIN(4),TDROUT(4)                    R       195
C  ********************************************************************* C R     196
C  *                                                                    I       2
C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                        I       3
C  *                                                                    I       4
205   COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NOM,NGM,NPE,NPX,NOAW,NOINIT I       5
C  *                                                                    I       6
C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                       I       7
C  *                                                                    I       8
      COMMON/INTEGER/ INDX1(14)                                         I       9
210   C  *                                                              I       10
C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                            I       11
C  *                                                                    I       12
      COMMON/INTEGER/ INDX2(14)                                         I       13
C  *                                                                    I       14
215   C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                    I       15
C  *                                                                    I       16
      COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX        I       17
C   ********************************************************************  C I   18
C *                                                                     DEQU    10
220   C ***    DIMENSION STATEMENTS                                     DEQU    11
C *                                                                     DEQU    12
      DIMENSION  CA(17)                                                 DEQU    13
C *                                                                     DEQU    14
C ***    DATA STATEMENTS                                                DEQU    15
225   C *                                                               DEQU    16
C                                                                       DEQU    17
C  *****************        DIFFERENTIAL EQUATIONS        ************** DEQU    18
C                                                                       DEQU    19
                                                                        DEQU    20
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C *                                                                    DEQU
C ***     LOOK UP VALUES OF REQUIRED LONGITUDINAL PARAMETERS           DEQU
C *                                                                    DEQU
      IF(NOINIT .LT. 0 .AND. TIME .GT. 0.0) GO TO 5                    DEQU
      CALL TLU(TIME,TABV2,10,TABUB,2,UB)                               DEQU
      CALL TLU(TIME,TABV2,10,TABTC,1,THETAC)                           DEQU
      CALL TLU(TIME,TABV2,10,TXAPP,2,XAPP)                             DEQU
      CALL TLU(TIME,TABV2,10,TXSP,1,XSP)                               DEQU
    5 CONTINUE                                                         DEQU
C *                                                                    DEQU
C ***     MISCELLANEOUS CALCULATIONS                                   DEQU
C *                                                                    DEQU
      THETA =  THETAC                                                  DEQU
      ZSP =  0.                                                        DEQU
      PP =  PB - PO                                                    DEQU
      RP =  RB - RO                                                    DEQU
      SINT     = SIN(THETA)                                            DEQU
      COST     = COS(THETA)                                            DEQU
      TANT     = TAN(THETA)                                            DEQU
      SECT     = 1./COS(THETA)                                         DEQU
      SPHI     = SIN(PHI)                                              DEQU
      CPHI     = COS(PHI)                                              DEQU
      SPSI     = SIN(PSI)                                              DEQU
      CPSI     = COS(PSI)                                              DEQU
C *                                                                    DEQU
C ***     ALTITUDE.                                                    DEQU
C *                                                                    DEQU
      ALT = -ZAPP                                                      DEQU
C *                                                                    DEQU
C ***     AIRPLANE W.R.T. SHIP, EARTH AXIS.                            DEQU
C *                                                                    DEQU
      DX45     = XAPP - XSP                                            DEQU
      DY45     = YAPP - YSP                                            DEQU
      DZ45     = ZAPP - ZSP                                            DEQU
C *                                                                    DEQU
C ***     AIRPLANE W.R.T. SHIP, SHIP WIND AXIS.                        DEQU
C *                                                                    DEQU
      XM       = DXM145*DX45 + DXM245*DY45                             DEQU
      YM       = DYM145*DX45 + DYM245*DY45                             DEQU
      ZM       = DZ45                                                  DEQU
C *                                                                    DEQU
C ***     EULER ANGLES FOR AIRWAKE MODEL.                              DEQU
C *                                                                    DEQU
      PSIA     = ASIN(SIN(PSI)*COS(PSI3) - COS(PSI)*SIN(PSI3))         DEQU
      THETAA   = THETA                                                 DEQU
      PHIA     = PHI                                                   DEQU
C *                                                                    DEQU
C ***     SHIP AIRWAKE.                                                DEQU
C *                                                                    DEQU
      IF(NOAW.EQ.0) CALL AIRWAKE                                       DEQU
C *                                                                    DEQU
C ***     AIRPLANE BODY AXIS COMPONENTS OF AMBIENT WIND.               DEQU
C *                                                                    DEQU
      UMEAN    = X1DWA*COST*CPSI + Y1DWA*COST*SPSI - Z1DWA*SINT        DEQU
      VMEAN    = X1DWA*(SPHI*SINT*CPSI - CPHI*SPSI) +                  DEQU
     1           Y1DWA*(SPHI*SINT*SPSI + CPHI*CPSI) +                  DEQU
     2           Z1DWA*SPHI*COST                                       DEQU
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                  WMEAN   = X1DWA*(CPHI*SINT*CPSI + SPHI*SPSI) +                    DEQU       77
                 1          Y1DWA*(CPHI*SINT*SPSI - SPHI*CPSI) +                   DEQU       78
                 2          Z1DWA*CPHI*COST                                        DEQU       79
               C  *                                                                DEQU       80
290            C  ***    WIND.                                                     DEQU       81
               C  *                                                                DEQU       82
                  UWIND   = UMEAN + UAW                                            DEQU       83
                  VWIND   = VMEAN + VAW                                            DEQU       84
                  WWIND   =  WMEAN + WAW                                           DEQU       85
295            C   INITIALIZE INERTIAL SPEEDS FROM AIRSPEEDS, ONE TIME ONLY.       DEQU       86
                  IF(ICEFS.EQ.1) UB = UBAS + UWIND                                 DEQU       87
                  IF(ICEES.EQ.1) VB = VBAS + VWIND                                 DEQU       88
                  IF(ICEES.EQ.1) WB = WBAS + WWIND                                 DEQU       89
               C  *                                                                DEQU       90
300            C  ***    AIRSPEED.                                                 DEQU       91
               C  *                                                                DEQU       92
                  UPAS  = UB - UWIND                                               DEQU       93
                  UAS   = UBAS - UBASO                                             DEQU       94
                  VBAS  = VB - VWIND                                               DEQU       95
305               VAS   = VBAS - VBASO                                             DEQU       96
                  WBAS  = WB - WWIND                                               DEQU       97
                  WAS   = WBAS - WBASO                                             DEQU       98
                  VAIR  = SQRT(UBAS*UBAS + VBAS*VBAS + WBAS*WBAS)                  DEQU       99
                  ALPHA = ATAN2(WBAS,UBAS)                                         DEQU      100
310               BETA  = ASIN(VBAS/VAIR)                                          DEQU      101
               C  *                                                                DEQU      102
               C  ***    LOOK UP AERO AND OPEN LOOP PARAMETERS.                    DEQU      103
               C  *                                                                DEQU      104
                  CALL TLU(VAIR,TABV1,6,TYV,15,YV)                                 DEQU      105
315               DADL =  0.                                                       DEQU      106
                  DRDL =  0.                                                       DEQU      107
               C  *                                                                DEQU      108
               C  ***    RANGE FROM SHIP.                                          DEQU      109
               C  *                                                                DEQU      110
320               RANGE   = XSP - XAPP                                             DEQU      111
               C  *                                                                DEQU      112
               C  ***    LATERAL POSITION ERROR                                    DEQU      113
               C  *                                                                DEQU      114
                  YCOM = YSP                                                       DEQU      115
325               ERY =  YCOM - YAPP                                               DEQU      116
               C  *                                                                DEQU      117
               C  ***    ROLL ATTITUDE ERROR                                       DEQU      118
               C  *                                                                DEQU      119
                  PHICOM = KY * ERY                                                DEQU      120
330            C   ERPHI BIASED BY PHI (TIME=0)                                    DEQU      121
                  IF(TIME .EQ. 0.0) PHIBIAS = PHI                                  DEQU      122
                  ERPHI = PHICOM - PHI + PHIBIAS                                   DEQU      123
               C  *                                                                DEQU      124
               C  ***    HEADING ERROR                                             DEQU      125
335            C  *                                                                DEQU      126
                  PSICOM =  0.                                                     DEQU      127
                  ERPSI  =  PSICOM - PSI                                           DEQU      128
               C  *                                                                DEQU      129
               C  ***    ROLL CONTROL                                              DEQU      130
340            C  *                                                                DEQU      131
                  DA1D =  -(2./TALD)*DA1 + ERPHI                                   DEQU      132
                  DA2D =  (4.**)/(TAUD*TALA))*DA1 - (1./TALA)*DA2                  DEQU      133
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     1        -(K1/TAUA)*ERPHI                                          DEQU
      DAP  =  (4.*TL1*K1/(TAUD*TAUA))*DA1 + (B1-TL1/TAUA)*DA2          DEQU
     1        -(K1*TL1/TAUA)*ERPHI                                      DEQU
C   CALCULATE SIGMA OF ROLL CONTROL.                                   DEQU
      DO 11  I=1,17                                                    DEQU
   11 CA(I)= 0.                                                        DEQU
      CA(4) = K1*TL1/TAUA                                              DEQU
      CA(6) = K1*KY*TL1/TAUA                                           DEQU
      CA(14)= (4.*K1*TL1)/(TAUD*TAUA)                                  DEQU
      CA(15)= B1 - TL1/TAUA                                            DEQU
      VAR =  0.                                                        DEQU
      DO 12  I=1,17                                                    DEQU
      DO 12  J=1,17                                                    DEQU
   12 VAR =  VAR  +  CA(I)*CA(J)*P(I,J)                                DEQU
      SIGDAP=  SQRT(VAR)                                               DEQU
C   GDF FOR ROLL CONTROL LIMITER                                       DEQU
      CALL DESCRIB(1,DAP,SIGDAP,DA,VAR,GAINDA)                         DEQU
      SIGDA =  SQRT(VAR)                                               DEQU
C *                                                                    DEQU
C ***     YAW CONTROL                                                  DEQU
C *                                                                    DEQU
      DR1D =  -(2./TAUD)*DR1 + ERPSI                                   DEQU
      DR2D =  (4.*K2/(TAUD*TAUA))*DR1 - (1./TAUA)*DR2                  DEQU
     1        -(K2/TAUA)*ERPSI                                          DEQU
      DRP  =  (4.*TL2*K2/(TAUD*TAUA))*DR1 + (B2-TL2/TAUA)*DR2          DEQU
     1        -(K2*TL2/TAUA)*ERPSI                                      DEQU
C   CALCULATE SIGMA OF YAW CONTROL.                                    DEQU
      DO 21  I=1,17                                                    DEQU
   21 CA(I)= 0.                                                        DEQU
      CA(5) = K2*TL2/TAUA                                              DEQU
      CA(16)= (4.*K2*TL2)/(TAUD*TAUA)                                  DEQU
      CA(17)= B2 - TL2/TAUA                                            DEQU
      VAR =  0.                                                        DEQU
      DO 22  I=1,17                                                    DEQU
      DO 22  J=1,17                                                    DEQU
   22 VAR =  VAR  +  CA(I)*CA(J)*P(I,J)                                DEQU
      SIGDRP=  SQRT(VAR)                                               DEQU
C   GDF FOR YAW CONTROL LIMITER                                        DEQU
      CALL DESCRIB(2,DRP,SIGDRP,DR,VAR,GAINDR)                         DEQU
      SIGDR =  SQRT(VAR)                                               DEQU
      IF(NOINIT .LT. 0) GO TO 200                                      DEQU
C  *                                                                   DEQU
C  ***    SHIP.                                                        DEQU
C  *                                                                   DEQU
      YSPDOT =  V5*SIN(PSI5)                                           DEQU
C  *                                                                   DEQU
C  ***    AIRFRAME.                                                    DEQU
C  *                                                                   DEQU
      YAPPDOT =  UB*COST*SPSI + VB*(SPHI*SINT*SPSI+CPHI*CPSI)          DEQU
     1           + WB*(CPHI*SINT*SPSI-SPHI*CPSI)                       DEQU
      D4       = DA + DAOL                                             DEQU
      D5       = DR + DROL                                             DEQU
      DFY      = YV*VAS + YP*PP + YR*RP                                DEQU
      DL       = LV*VAS + LP*PP + LR*RP                                DEQU
      DN       = NV*VAS + NP*PP + NR*RP                                DEQU
      SUMFY    = YO + DFY + YDA*D4 + YDR*D5                            DEQU
      SUML     = LO + DL  + LDA*D4 + LDR*D5                            DEQU
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      SUMN    = NO + DN  + NDA*D4 + NDR*D5                                  DEQU      191
      VDOT    = SUMFY + G*COST*SPHI - RP*UB + PB*WB                         DEQU      192
      PBDOT   = SUML                                                        DEQU      193
      RBDOT   = SUMN                                                        DEQU      194
      PHIDOT  = PB + QB*SPHI*TANT + RB*CPHI*TANT                            DEQU      195
      PSIDOT  = (QB*SPHI+RB*CPHI)*SECT                                      DEQU      196
  200 CONTINUE                                                              DEQU      197
C                                                                           C DEQU      198
C***************          UPDATE SUB 0 VALUES          ***************C DEQU      199
C                                                                           C DEQU      200
      IF(ICEES.EQ.2) GO TO 10                                               DEQU      201
      UO      = UB                                                          DEQU      202
      VO      = VB                                                          DEQU      203
      WO      = WB                                                          DEQU      204
      PO      = PB                                                          DEQU      205
      RO      = RB                                                          DEQU      206
      PSIO    = PSI                                                         DEQU      207
      THETAO  = THETA                                                       DEQU      208
      PHIO    = PHI                                                         DEQU      209
      XAPPO   = XAPP                                                        DEQU      210
      YAPPO   = YAPP                                                        DEQU      211
      ZAPPO   = ZAPP                                                        DEQU      212
      UBASO   = UBAS                                                        DEQU      213
      VBASO   = VBAS                                                        DEQU      214
      WBASO   = WBAS                                                        DEQU      215
      YO      = YO + DFY                                                    DEQU      216
      LO      = LO + DL                                                     DEQU      217
      NO      = NO + DN                                                     DEQU      218
      THETAAO = THETAA                                                      DEQU      219
      PSIAO   = PSIA                                                        DEQU      220
      PHIAO   = PHIA                                                        DEQU      221
10    RETURN                                                                DEQU      222
      END                                                                   DEQU      223
```

```
      SUBROUTINE DESCRIB(ITAB,BIAS,SIGMA,OMEAN,OVAR,REPRO)                DESCRIB    2
C     ******************************************************************** DESCRIB    3
C     ***                                                                  DESCRIB    4
C     ***    ROUTINE TO CALCULATE COMPONENTS OF THE DESCRIBING FUNCTION.   DESCRIB    5
C     ***                                                                  DESCRIB    6
C     ***    ITAB  - IN  - TABLE NUMBER FOR WHICH D.F. IS TO BE GENERATED. DESCRIB    7
C     ***                  TABLE NUMBER IS ESTABLISHED BY THE ORDER OF THE DESCRIB    8
C     ***                  CALLS TO TABRD.  THE FIRST NONLINEARITY WORKED  DESCRIB    9
C     ***                  ON BY TABRD IS NUMBER ONE, SECOND IS NUMBER TWO, DESCRIB   10
C     ***                  ETC.                                            DESCRIB   11
C     ***    BIAS  - IN  - INPUT BIAS (MEAN VALUE).                        DESCRIB   12
C     ***    SIGMA - IN  - INPUT SIGMA.                                    DESCRIB   13
C     ***    REPRO - OUT - GAIN ON RANDOM COMPONENT.                       DESCRIB   14
C     ***    OMEAN - OUT - OUTPUT MEAN.                                    DESCRIB   15
C     ***    OVAR  - OUT - OUTPUT VARIANCE.                                DESCRIB   16
C     ***    REPRO - OUT - GAIN ON RANDOM COMPONENT                        DESCRIB   17
C     ***                                                                  DESCRIB   18
C     ******************************************************************** DESCRIB   19
C     *                                                                    GDF        2
C     ***    TABLES DECOMPOSED INTO DESCRIBING FUNCTION ELEMENTS.          GDF        3
C     ***    DIMENSION ON INDEX - 4*(NUMBER OF CALLS TO TABRD)             GDF        4
C     ***    DIMENSION ON TABLE - (4*(NO. OF IND. VAR.)+3)*(NO. OF CALLS TO GDF        5
C     *                                                                    GDF        6
      COMMON/GDF/NTABLE,INDEX(20),TABLE(200)                              GDF        7
      DATA XPMIN /-675.81/                                                DESCRIB   21
      M            = 3*(ITAB - 1) + 1                                     DESCRIB   22
      RATIO        = 0.0                                                  DESCRIB   23
C     *                                                                    DESCRIB   24
C     ***    SET UP CALCULATION LOOP.                                      DESCRIB   25
C     *                                                                    DESCRIB   26
      J            = INDEX(M) + INDEX(M+1) + INDEX(M+2) + 1               DESCRIB   27
      K            = INDEX(M+2) - 1                                       DESCRIB   28
      YO           = TABLE(J) + RATIO*(TABLE(J+1) - TABLE(J))             DESCRIB   29
      I1           = INDEX(M) + 2*INDEX(M+1) + INDEX(M+2)                 DESCRIB   30
      I2           = I1 + K                                               DESCRIB   31
      SO           = TABLE(I1+1) + RATIO*(TABLE(I1+2*K+1) - TABLE(I1+1))  DESCRIB   32
      XX1          = TABLE(I2) + RATIO*(TABLE(I2+2*K) - TABLE(I2))        DESCRIB   33
      SE           = 0.0                                                  DESCRIB   34
      BE           = 0.0                                                  DESCRIB   35
      RE           = 0.0                                                  DESCRIB   36
      BO           = 0.0                                                  DESCRIB   37
      IF(BIAS.NE.0.0) BO = 2.0*XX1 - SO                                   DESCRIB   38
      RO           = 2.0*XX1 - SO                                         DESCRIB   39
      J            = INDEX(M) + INDEX(M+1)                                DESCRIB   40
C     *                                                                    DESCRIB   41
C     ***    DESCRIBING FUNCTION CALCULATION LOOP.                         DESCRIB   42
C     *                                                                    DESCRIB   43
      DO 70 I=1,K                                                         DESCRIB   44
      XX1          = TABLE(J+I) + BIAS                                    DESCRIB   45
      XX2          = TABLE(J+I) - BIAS                                    DESCRIB   46
      PI1          = 1.0                                                  DESCRIB   47
      PI2          = 1.0                                                  DESCRIB   48
      IF(XX1 .LT. 0.0) PI1 = 0.0                                          DESCRIB   49
      IF(XX2 .LT. 0.0) PI2 = 0.0                                          DESCRIB   50
      IF(SIGMA .EQ. 0.0) GO TO 65                                         DESCRIB   51
      XX1          = XX1/SIGMA                                            DESCRIB   52
      XX2          = XX2/SIGMA                                            DESCRIB   53
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                PI1          = 0.5*(1.0 + ERF(0.70710678*XX1))                          DESCRIB    54
                PI2          = 0.5*(1.0 + ERF(0.70710678*XX2))                          DESCRIB    55
60              XP1          = -0.5*XX1*XX1                                             DESCRIB    56
                XP2          = -0.5*XX2*XX2                                             DESCRIB    57
                IF(XP1 .LT. XPMIN) XP1 = XPMIN                                          DESCRIB    58
                IF(XP2 .LT. XPMIN) XP2 = XPMIN                                          DESCRIB    59
                G1           = XX1*PI1 + 0.39894228*EXP(XP1)                            DESCRIB    60
65              G2           = XX2*PI2 + 0.39894228*EXP(XP2)                            DESCRIB    61
             65 CONTINUE                                                               DESCRIB    62
             C  ***    EVEN COMPONENT CALCULATIONS.                                    DESCRIB    63
                XX1          = TABLE(I2+I) + RATIO*(TABLE(I2+2*K+I) - TABLE(I2+I))      DESCRIB    64
                XX2          = XX1 - SE                                                 DESCRIB    65
70              SE           = XX1                                                      DESCRIB    66
                IF(BIAS.NE.0.0) BE = BE - 2.0*XX2*TABLE(J+I)/BIAS + XX2*SIGMA*(        DESCRIB    67
               1                      G1 + G2)/BIAS                                   DESCRIB    68
                FE           = BE + XX2*(PI1 - PI2)                                     DESCRIB    69
                IF(I.EQ.1) GO TO 70                                                     DESCRIB    70
75           C  ***    ODD COMPONENT CALCULATIONS.                                     DESCRIB    71
                XX1          = TABLE(I1+I) + RATIO*(TABLE(I1+2*K+I) - TABLE(I1+I))      DESCRIB    72
                XX2          = SO - XX1                                                 DESCRIB    73
                SO           = XX1                                                      DESCRIB    74
                IF(BIAS.NE.0.0) BO = BO + XX2*SIGMA*(G1 - G2)/BIAS                      DESCRIB    75
80              PO           = PO + XX2*(PI1 + PI2)                                     DESCRIB    76
             70 CONTINUE                                                               DESCRIB    77
             C                                                                          DESCRIB    78
             C  ******************   CALCULATE OUTPUT MEAN AND VARIANCE   *************  DESCRIB    79
             C                                                                          DESCRIB    80
85              OMEAN        = BIAS*(BE + BO) + YO                                      DESCRIB    81
                OVAR         = SIGMA*(BE + BO)                                          DESCRIB    82
                OVAR         = OVAR*OVAR                                                DESCRIB    83
                REPRO        = BE + BO                                                  DESCRIB    84
                RETURN                                                                  DESCRIB    85
90              END                                                                     DESCRIB    86
```

```
      SUBROUTINE ELLIPSE(XP,YP,DXP,DYP,DXYP,ANGLE,STARTX,DELX,STARTY,
     *                   DELY,SCALXX,SCALYY)
C*****************************************************************************
C*                                                                           *
C*        ROUTINE TO PLACE AN ELLIPSE ON A CALCOMP PLOT.                     *
C*                                                                           *
C*   INPUT ARGUMENTS                                                         *
C*        XP         X COORDINATE OF CENTER OF ELLIPSE.                     *
C*        YP         Y COORDINATE OF CENTER OF ELLIPSE.                     *
C*        DX         ONE-HALF LENGTH OF X ELLIPTICAL AXIS.                  *
C*        DXP        ONE-HALF LENGTH OF X ELLIPTICAL AXIS (SIGMA X)         *
C*        DYP        ONE-HALF LENGTH OF Y ELLIPTICAL AXIS (SIGMA Y)         *
C*        DXYP       CROSS CORRELATION TERM (SIGMA XY)                      *
C*        DY         ONE-HALF LENGTH OF Y ELLIPTICAL AXIS.                  *
C*        ANGLE      PLOT ROTATION ANGLE.                                   *
C*        STARTX     INITIAL X VALUE.                                       *
C*        DELX       INCREMENT PER INCH ON X AXIS.                          *
C*        STARTY     INITIAL Y VALUE.                                       *
C*        DELY       INCREMENT PER INCH ON Y AXIS.                          *
C*        SCALXX     SCALE FACTOR FOR X ELLIPTICAL AXIS                     *
C*        SCALYY     SCALE FACTOR FOR Y ELLIPTICAL AXIS                     *
C*                                                                           *
C*****************************************************************************
C                                                                           C
C***************        CALCULATE ANGLE OF ROTATION        ***************C
C***************          DUE TO CROSS CORRELATION         ***************C
C                                                                           C
      IF(DXP .EQ. 0.0 .AND. DYP .EQ. 0.0) RETURN
      DXP2    = DXP*DXP
      DYP2    = DYP*DYP
      DELTA   = DXP2*DYP2 - DXYP*DXYP
      IF(DELTA .NE. 0.0) GO TO 10
      ANG     = 1.5707963
      GO TO 20
10    CONTINUE
      A11     = DYP2/DELTA
      A12     = -DXYP/DELTA
      A22     = DXP2/DELTA
      ANG     = 0.5*ATAN(-2.0*A12/(A22 - A11))
20    CONTINUE
      SIN2A   = SIN(2.0*ANG)
      SINA2   = SIN(ANG)**2
      COSA2   = COS(ANG)**2
      B11     = A11*COSA2 + A12*SIN2A + A22*SINA2
      B22     = A11*SINA2 - A12*SIN2A + A22*COSA2
      DX      = SQRT(1.3863/B11) * SCALXX
      DY      = SQRT(1.3863/B22) * SCALYY
      X       = (XP - STARTX)/DELX
      Y       = (YP - STARTY)/DELY
      CALL ROTATE(X,Y,ANGLE,-1,XR,YR)
      ANG     = ANG*57.29578
      X       = XR
      Y       = YR
      CALL ROTATE(X,Y,ANG,0,XR,YR)
      ANG     = ANG + ANGLE
C                                                                           C
C***************        CALCULATE SPLINING PARAMETERS      ***************C
```

```
      C                                                                  C ELLIPSE    59
            DXX     = ABS(DX)                                              ELLIPSE    60
   60       DYY     = ABS(DY)                                              ELLIPSE    61
            X       = XP - DXX                                             ELLIPSE    62
            Y       = YP                                                   ELLIPSE    63
            XX      = (X - STARTX)/DELX                                    ELLIPSE    64
            YY      = (Y - STARTY)/DELY                                    ELLIPSE    65
   65       CALL ROTATE(XX,YY,ANG,1,XR,YR)                                 ELLIPSE    66
            CALL PLOT(XR,YR,3)                                             ELLIPSE    67
            XX      = ABS(DXX/DELX)                                        ELLIPSE    68
            YY      = ABS(DYY/DELY)                                        ELLIPSE    69
            XDUM1   = SQRT(XX*XX + YY*YY)                                  ELLIPSE    70
   70       IF(XX.LT.0.025.OR.YY.LT.0.025.OR.XDUM1.LT.0.025) GO TO 60      ELLIPSE    71
            INUM    = IFIX(10.0*XDUM1 + 0.5)                               ELLIPSE    72
            IF(XDUM1.LT.1.0) INUM = IFIX(20.0*XDUM1 + 0.5)                 ELLIPSE    73
            IF(INUM.LT.3) INUM = 3                                         ELLIPSE    74
            XDUM1   = DXX/FLOAT(INUM)                                      ELLIPSE    75
   75       XDUM2   = DYY*DYY/(DXX*DXX)                                    ELLIPSE    76
            SIGN    = 1.0                                                  ELLIPSE    77
      C                                                                  C ELLIPSE    78
      C***************          PLOT THE ELLIPSE          ***************C ELLIPSE    79
      C                                                                  C ELLIPSE    80
   80       DO 40 I=1,4                                                    ELLIPSE    81
            DO 30 K=1,INUM                                                 ELLIPSE    82
            X       = X + SIGN*XDUM1                                       ELLIPSE    83
            XDUM3   = DYY*DYY - (X - XP)*(X - XP)*XDUM2                    ELLIPSE    84
            Y       = YP                                                   ELLIPSE    85
   85       IF(XDUM3.GT.0.0) Y = YP + SIGN*SQRT(XDUM3)                     ELLIPSE    86
            XX      = (X - STARTX)/DELX                                    ELLIPSE    87
            YY      = (Y - STARTY)/DELY                                    ELLIPSE    88
            CALL ROTATE(XX,YY,ANG,1,XR,YR)                                 ELLIPSE    89
            CALL PLOT(XR,YR,2)                                             ELLIPSE    90
   90   30  CONTINUE                                                       ELLIPSE    91
            X       = XP                                                   ELLIPSE    92
            IF(I.NE.2) GO TO 40                                            ELLIPSE    93
            X       = XP + DXX                                             ELLIPSE    94
            SIGN    =-1.0                                                  ELLIPSE    95
   95   40  CONTINUE                                                       ELLIPSE    96
            XX      = (XP - DXX - STARTX)/DELX                             ELLIPSE    97
            YY      = (YP - STARTY)/DELY                                   ELLIPSE    98
            CALL ROTATE(XX,YY,ANG,1,XR,YR)                                 ELLIPSE    99
            CALL PLOT(XR,YR,2)                                             ELLIPSE   100
  100       C                                                            C ELLIPSE   101
            C***************       PLOT ELLIPTICAL AXES         ***************C ELLIPSE   102
            C                                                            C ELLIPSE   103
            60  XX      = (XP + DXX - STARTX)/DELX                         ELLIPSE   104
            YY      = (YP - STARTY)/DELY                                   ELLIPSE   105
  105       CALL ROTATE(XX,YY,ANG,1,XR,YR)                                 ELLIPSE   106
            CALL PLOT(XR,YR,2)                                             ELLIPSE   107
            XX      = (XP - STARTX)/DELX                                   ELLIPSE   108
            YY      = (YP + DYY - STARTY)/DELY                             ELLIPSE   109
            CALL ROTATE(XX,YY,ANG,1,XR,YR)                                 ELLIPSE   110
  110       CALL PLOT(XR,YR,3)                                             ELLIPSE   111
            XX      = (XP - STARTX)/DELX                                   ELLIPSE   112
            YY      = (YP - DYY - STARTY)/DELY                             ELLIPSE   113
            CALL ROTATE(XX,YY,ANG,1,XR,YR)                                 ELLIPSE   114
            CALL PLOT(XR,YR,2)                                             ELLIPSE   115
```

```
115          RETURN                                          ELLIPSE  116
             END                                             ELLIPSE  117
```

```
      FUNCTION ERF(XX)
C  ******************************************************************
C  ***
C  ***    ROUTINE TO EVALUATE ERROR FUNCTION ASSOC. WITH NORMAL CURVE.
C  ***
C  ***    XX - IN - INPUT ARGUMENT.
C  ***
C  ******************************************************************
      DIMENSION P(5),Q(3),P1(6),Q1(7),P2(5),Q2(4)
C  *
C  ***    COEFFICIENTS FOR 0.0 .LE. ABS(XX) .LT. .477.
C  *
      DATA  P/ -0.44422647396874E+00 ,  0.10731707253648E+02 ,
     A          0.15915606197771E+02 ,  0.37481624081284E+03 ,
     B          0.25612422994823E-01 /
      DATA  Q/  0.17903143558843E+02 ,  0.12482892031581E+03 ,
     A          0.33217224470532E+03 /
C  *
C  ***    COEFFICIENTS FOR .477 .LE. ABS(XX) .LE. 4.0.
C  *
      DATA P1/  0.72117582508831E+01 ,  0.10731707253648E+02 ,
     A          0.15298928504694E+03 ,  0.33932081673434E+03 ,
     B          0.45191895371187E+03 ,  0.30045926102016E+03 ,
     C         -0.13686485738272E-06 ,  0.56419551747897E+00 /
      DATA Q1/  0.77000152935229E+02 ,  0.27758544474399E+03 ,
     A          0.63898026446563E+03 ,  0.93135409485061E+03 ,
     B          0.79095092532790E+03 ,  0.30045926095698E+03 ,
     C          0.12782727319629E+02 /
C  *
C  ***    COEFFICIENTS FOR 4.0 .LT. ABS(XX) .LE. 5.6875.
C  *
      DATA P2/ -0.22695659353969E+00 , -0.49473091062325E-01 ,
     A         -0.29961070770354E-02 , -0.22319245973418E-01 ,
     B         -0.27866130860965E+00 /
      DATA Q2/  0.10516751070679E+01 ,  0.19130892610783E+00 ,
     A          0.10620923052847E-01 ,  0.19873320181714E+01 /
C  *
C  ***    CONSTANTS.
C  *
      DATA    XMIN , XLARGE ,            SSQPI /
     A     1.0E-08 , 5.6875 , 0.56418958354776 /
      DATA XPMIN /-675.81/
      SIGN = 1.0
      IF(XX.LT.0.0) SIGN = -1.0
      X    = SIGN*XX
      XSQ  = X*X
      IF(X.GE.0.4770) GO TO 20
C  *
C  ***    EVALUATE ERF FOR 0.0 .LE. ABS(XX) .LT. 0.4770.
C  *
      ERF = SIGN*X*P(4)/Q(3)
      IF(X.LT.XMIN) GO TO 70
      ERF = P(5)
      DO 10 I=1,4
      ERF = ERF*XSQ + P(I)
   10 CONTINUE
      ERF = SIGN*X*ERF/(((Q(1) + XSQ)*XSQ + Q(2))*XSQ + Q(3))
```

```
      GO TO 70                                                          ERF
   20 IF(X.GT.4.0) GO TO 40                                             ERF
C  *                                                                    ERF
C  ***    EVALUATE ERF FOR 0.4770 .LE. ABS(XX) .LE. 4.0.                ERF
C  *                                                                    ERF
      ERF = P1(7)*X + P1(8)                                             ERF
      DUM = X + Q1(7)                                                   ERF
      DO 30 I=1,6                                                       ERF
      ERF = ERF*X + P1(I)                                               ERF
      DUM = DUM*X + Q1(I)                                               ERF
   30 CONTINUE                                                          ERF
      XP = -XSQ                                                         ERF
      IF(XP .LT. XPMIN) XP = XPMIN                                      ERF
      ERF = SIGN*(1.0 - ERF*EXP(XP)/DUM)                                ERF
      GO TO 70                                                          ERF
   40 IF(X.GT.XLARGE) GO TO 60                                          ERF
C  *                                                                    ERF
C  ***    EVALUATE ERF FOR 4.0 .LT. ABS(XX) .LE. 5.6875.                ERF
C  *                                                                    ERF
      XSQ = 1.0/XSQ                                                     ERF
      ERF = P2(4)*XSQ + P2(5)                                           ERF
      DUM = XSQ + Q2(4)                                                 ERF
      DO 50 I=1,3                                                       ERF
      ERF = ERF*XSQ + P2(I)                                             ERF
      DUM = DUM*XSQ + Q2(I)                                             ERF
   50 CONTINUE                                                          ERF
      XP = -1.0/XSQ                                                     ERF
      IF(XP .LT. XPMIN) XP = XPMIN                                      ERF
      ERF = SIGN*(1.0 - EXP(XP)*((SSQPI + XSQ*ERF/DUM)/X))              ERF
      GO TO 70                                                          ERF
C  *                                                                    ERF
C  ***    EVALUATE ERF FOR ABS(XX) .GT. 5.6875.                         ERF
C  *                                                                    ERF
   60 ERF = SIGN                                                        ERF
   70 RETURN                                                            ERF
      END                                                               ERF
```

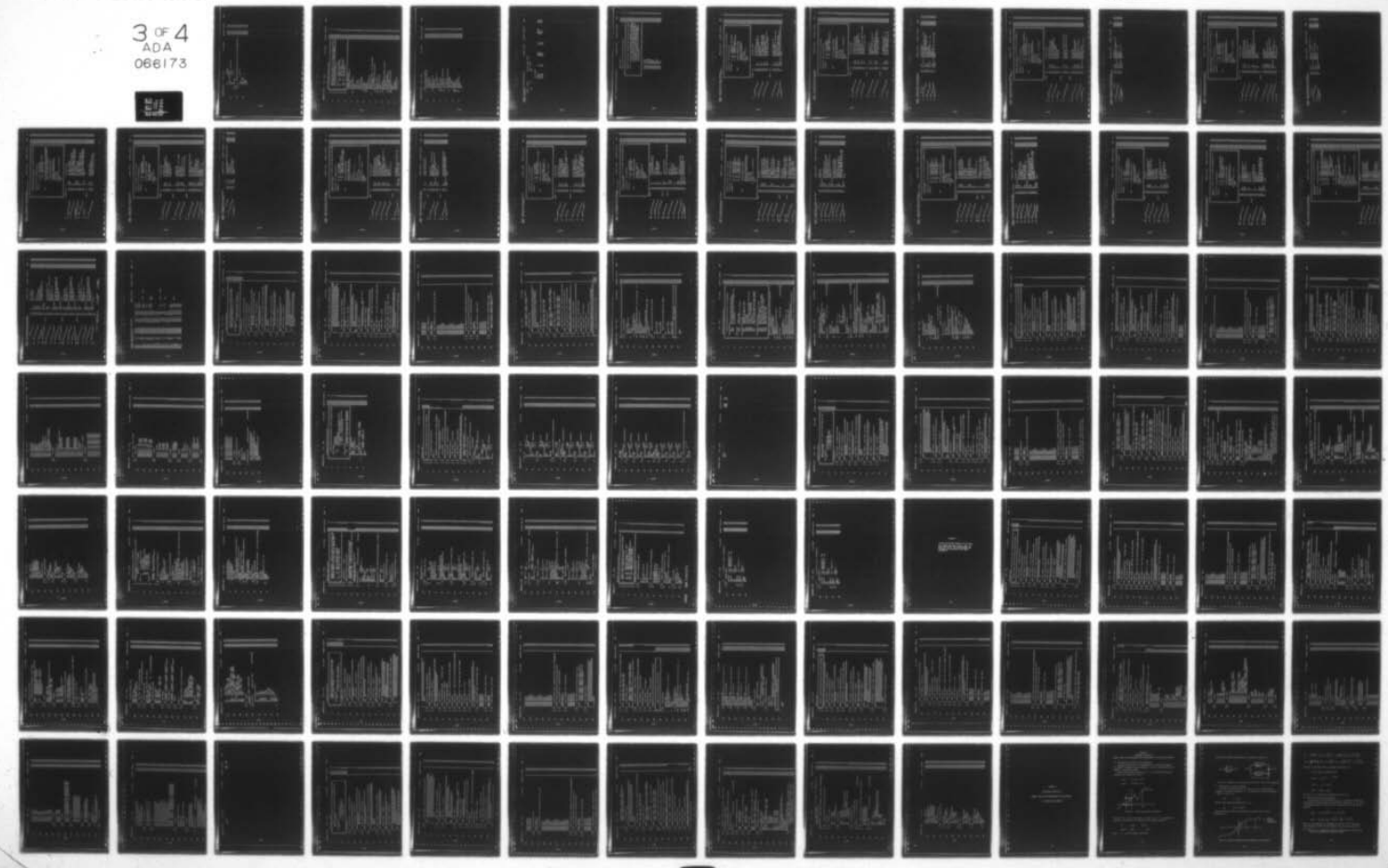
```
      SUBROUTINE KUTTA                                                  KUTTA
C     ******************************************************************* KUTTA
C     ***                                                               KUTTA
C     ***    ROUTINE TO PERFORM THIRD ORDER RUNGE-KUTTA INTEGRATION.    KUTTA
C     ***                                                               KUTTA
C     ******************************************************************* KUTTA
C     *                                                                 R2
C     ***    REAL VARIABLES (PROBLEM DEPENDENT).                        R2
C     *                                                                 R2
      COMMON R(6)                                                       R2
C     *                                                                 R2
C     ***    INTEGRATION VARIABLES (LOCATIONS ARE PROBLEM DEPENDENT).   R2
C     *                                                                 R2
      EQUIVALENCE (TI,R(1)),(TO,R(2)),(DT,R(3)),(DTOUT,R(4)),           R2
     A            (DTOUT2,R(5)),(TMAX,R(6))                             R2
C     *                                                                 I
C     ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                     I
C     *                                                                 I
      COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NOM,NGM,NPE,NPX,NOAW,NOINIT I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                    I
C     *                                                                 I
      COMMON/INTEGER/ INDX1(14)                                         I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 5 - STATE INDICES.                         I
C     *                                                                 I
      COMMON/INTEGER/ INDX2(14)                                         I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                       I
C     *                                                                 I
      COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX        I
C     ***************************************************************  C I
C     *                                                                 INTEG
C     ***    TEMPORARY INTEGRATION STORAGE.                             INTEG
C     ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2      INTEG
C     *                                                                 INTEG
      COMMON/INTEG/ RI(2187),RT(2187)                                   INTEG
C     *                                                                 KUTTA
C     ***    COMPLETE FIRST STAGE AT THIS INTEGRATION STEP.             KUTTA
C     *                                                                 KUTTA
C     ***    STATES.                                                    KUTTA
      DO 10 I=1,NSTATES                                                 KUTTA
      RI(I)        = R(INDX2(I))                                        KUTTA
      RT(I)        = DT*R(INDX1(I))                                     KUTTA
      R(INDX2(I)) = RI(I) + 0.5*RT(I)                                   KUTTA
   10 CONTINUE                                                          KUTTA
C     ***    P.                                                         KUTTA
      NL1 = NSTATES + 1                                                 KUTTA
      NU1 = NSTATES + NPA * NPA                                         KUTTA
      I1           = INDXPD                                             KUTTA
      I2           = INDXP                                              KUTTA
      DO 20 I=NL1,NU1                                                   KUTTA
      RI(I)        = R(I2)                                              KUTTA
      RT(I)        = DT*R(I1)                                           KUTTA
      R(I2)        = RI(I) + 0.5*RT(I)                                  KUTTA
      I1           = I1 + 1                                             KUTTA
      I2           = I2 + 1                                             KUTTA
```

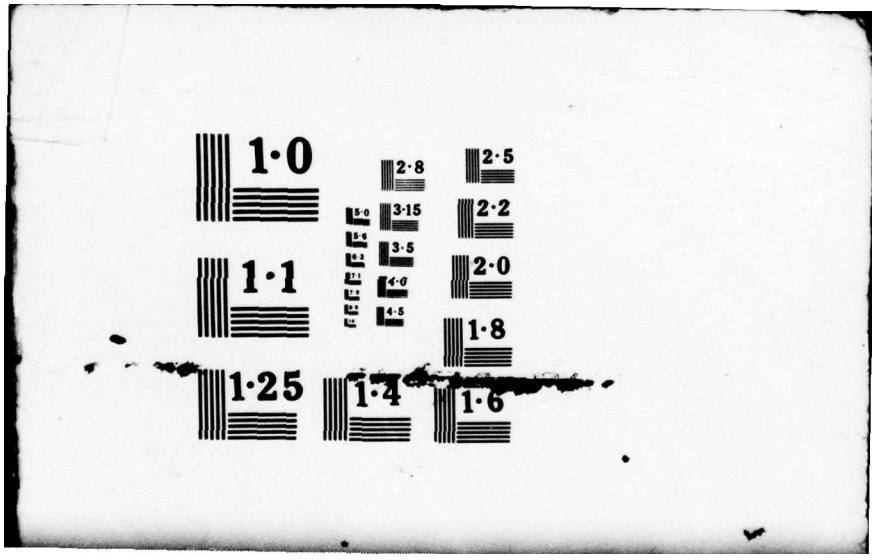
```
      20    CONTINUE                                                    KUTTA
      C  ***    PE.                                                     KUTTA
            NL2          = NU1 + 1                                      KUTTA
            NU2          = NU1 + NPE * NPE                              KUTTA
            I1           = INDXPED                                      KUTTA
            I2           = INDXPE                                       KUTTA
            DO 21 I=NL2,NU2                                             KUTTA
            RI(I)        = R(I2)                                        KUTTA
            RT(I)        = DT*R(I1)                                     KUTTA
            R(I2)        = RI(I) + 0.5*RT(I)                            KUTTA
            I1           = I1 + 1                                       KUTTA
            I2           = I2 + 1                                       KUTTA
      21    CONTINUE                                                    KUTTA
      C  ***    PX.                                                     KUTTA
            NL3          = NU2 + 1                                      KUTTA
            NEQU         = NU2 + NPX * NPX                              KUTTA
            I1           = INDXPXD                                      KUTTA
            I2           = INDXPX                                       KUTTA
            DO 22 I=NL3,NEQU                                            KUTTA
            RI(I)        = R(I2)                                        KUTTA
            RT(I)        = DT*R(I1)                                     KUTTA
            R(I2)        = RI(I) + 0.5*RT(I)                            KUTTA
            I1           = I1 + 1                                       KUTTA
            I2           = I2 + 1                                       KUTTA
      22    CONTINUE                                                    KUTTA
      C  *                                                              KUTTA
      C  ***    SECOND STAGE.                                           KUTTA
      C  *                                                              KUTTA
            TI           = TO + 0.5*DT                                  KUTTA
            CALL DEQU                                                   KUTTA
            CALL PROP                                                   KUTTA
            TEMP1        = 2.0*DT                                       KUTTA
            TEMP2        = TEMP1/3.0                                    KUTTA
            TEMP3        = 0.166666666667                               KUTTA
      C  ***    STATES.                                                 KUTTA
            DO 30 I=1,NSTATES                                           KUTTA
            R(INDX2(I)) = RI(I) + TEMP1*R(INDX1(I)) - RT(I)             KUTTA
      30    CONTINUE                                                    KUTTA
            DO 40 I=1,NSTATES                                           KUTTA
            RT(I)        = RI(I) + TEMP2*R(INDX1(I)) + TEMP3*RT(I)      KUTTA
      40    CONTINUE                                                    KUTTA
      C  ***    P.                                                      KUTTA
            I1           = INDXPD                                       KUTTA
            I2           = INDXP                                        KUTTA
            DO 50 I=NL1,NU1                                             KUTTA
            R(I2)        = RI(I) + TEMP1*R(I1) - RT(I)                  KUTTA
            I1           = I1 + 1                                       KUTTA
            I2           = I2 + 1                                       KUTTA
      50    CONTINUE                                                    KUTTA
            I1           = INDXPD                                       KUTTA
            I2           = INDXP                                        KUTTA
            DO 60 I=NL1,NU1                                             KUTTA
            RT(I)        = RI(I) + TEMP2*R(I1) + TEMP3*RT(I)            KUTTA
            I1           = I1 + 1                                       KUTTA
            I2           = I2 + 1                                       KUTTA
      60    CONTINUE                                                    KUTTA
      C  ***    PE.                                                     KUTTA
```

```
      I1          = INDXPED                                          KUTTA
      I2          = INDXPE                                           KUTTA
      DO 61 I=NL2,NL2                                                KUTTA
      R(I2)       = RI(I) + TEMP1*R(I1) - RT(I)                      KUTTA
      I1          = I1 + 1                                           KUTTA
      I2          = I2 + 1                                           KUTTA
   61 CONTINUE                                                       KUTTA
      I1          = INDXPED                                          KUTTA
      I2          = INDXPE                                           KUTTA
      DO 62 I=NL2,NU2                                                KUTTA
      RT(I)       = RI(I) + TEMP2*R(I1) + TEMP3*RT(1)                KUTTA
      I1          = I1 + 1                                           KUTTA
      I2          = I2 + 1                                           KUTTA
   62 CONTINUE                                                       KUTTA
C  ***    PX.                                                        KUTTA
      I1          = INDXPXD                                          KUTTA
      I2          = INDXPX                                           KUTTA
      DO 63 I=NL3,NEQU                                               KUTTA
      R(I2)       = RI(I) + TEMP1*R(I1) - RT(I)                      KUTTA
      I1          = I1 + 1                                           KUTTA
      I2          = I2 + 1                                           KUTTA
   63 CONTINUE                                                       KUTTA
      I1          = INDXPXD                                          KUTTA
      I2          = INDXPX                                           KUTTA
      DO 64 I=NL3,NEQU                                               KUTTA
      RT(I)       = RI(I) + TEMP2*R(I1) + TEMP3*RT(I)                KUTTA
      I1          = I1 + 1                                           KUTTA
      I2          = I2 + 1                                           KUTTA
   64 CONTINUE                                                       KUTTA
C  *                                                                 KUTTA
C  ***    THIRD STAGE.                                               KUTTA
C  *                                                                 KUTTA
      TI          = TO + DT                                          KUTTA
      CALL DECU                                                      KUTTA
      CALL PROP                                                      KUTTA
      TEMP1       = DT/6.0                                           KUTTA
C  ***    STATES.                                                    KUTTA
      DO 70 I=1,NSTATES                                              KUTTA
      R(INDX2(I)) = RT(I) + TEMP1*R(INDX1(I))                        KUTTA
   70 CONTINUE                                                       KUTTA
C  ***    P.                                                         KUTTA
      I1          = INDXPD                                           KUTTA
      I2          = INDXP                                            KUTTA
      DO 80 I=NL1,NU1                                                KUTTA
      R(I2)       = RT(I) + TEMP1*R(I1)                              KUTTA
      I1          = I1 + 1                                           KUTTA
      I2          = I2 + 1                                           KUTTA
   80 CONTINUE                                                       KUTTA
C  ***    PE.                                                        KUTTA
      I1          = INDXPED                                          KUTTA
      I2          = INDXPE                                           KUTTA
      DO 90 I=NL2,NU2                                                KUTTA
      R(I2)       = RT(I) + TEMP1*R(I1)                              KUTTA
      I1          = I1 + 1                                           KUTTA
      I2          = I2 + 1                                           KUTTA
   90 CONTINUE                                                       KUTTA
C  ***    PX.                                                        KUTTA
```

AD-A066 173 VOUGHT CORP DALLAS TEX F/G 1/2
VOLAR: A DIGITAL COMPUTER PROGRAM FOR SIMULATING VSTOL AIRCRAFT--ETC(U)
DEC 78 J WOLKOVITCH, B B BRASSELL N62269-77-R-0389
UNCLASSIFIED 2-32000/8R-51672-VOL-2 NADC-77123-30-VOL-2 NL

3 OF 4
ADA
066173




1·0
1·1
1·25
2·8
3·15
3·5
4·0
4·5
5·0
1·4
2·5
2·2
2·0
1·8
1·6

```
                I1          = INDXPXD                                          KUTTA   145
                I2          = INDXPX                                           KUTTA   146
                DO 100 I=NL3,NEQU                                              KUTTA   147
175             R(I2)       = RT(I) + TEMP1*R(I1)                              KUTTA   148
                I1          = I1 + 1                                           KUTTA   149
                I2          = I2 + 1                                           KUTTA   150
            100 CONTINUE                                                       KUTTA   151
            C  *                                                               KUTTA   152
180         C  ***    GENERATE DERIVATIVES AND STATES FOR NEXT INTEGRATION STEP. KUTTA   153
            C  *                                                               KUTTA   154
                TO          = TO + DT                                          KUTTA   155
                ICFES       = 0                                                KUTTA   156
                CALL DEQU                                                      KUTTA   157
185             CALL PROP                                                      KUTTA   158
                ICFES       = 2                                                KUTTA   159
                RETURN                                                         KUTTA   160
                END                                                            KUTTA   161
```

```
      SUBROUTINE MATINV (TEMP,N,DET,NDIM)                                MATINV
C  ************************************************************************* MATINV
C  ***                                                                    MATINV
C  ***    ROUTINE TO INVERT A MATRIX.  THE INVERSE IS FOUND BY ITERATION MATINV
C  ***    ON AN INVERSE DETERMINED BY USING A MODIFIED GAUSSIAN          MATINV
C  ***    ELIMINATION AND CONDITIONING.  TWO WORKING MATRICIES DIMENSION MATINV
C  ***    N BY 2*N AND 2*N ARE NECESSARY.                                MATINV
C  ***                                                                    MATINV
C  ***    TEMP - IN  - MATRIX TO BE INVERTED.                            MATINV
C  ***    N    - IN  - NUMBER OF ROWS IN TEMP.                           MATINV
C  ***    DET  - OUT - SINGULAR FLAG.                                    MATINV
C  ***                 DET = 0, SINGULAR MATRIX.                         MATINV
C  ***    NDIM - IN  - ROW DIMENSION OF TEMP.                            MATINV
C  ***    TEMP - OUT - INVERTED MATRIX.                                  MATINV
C  ***                                                                    MATINV
C  ************************************************************************* MATINV
      DIMENSION TEMP(NDIM,1)                                             MATINV
      DIMENSION A(17,34),ICOL(34)                                        MATINV
      DO 255 I=1,N                                                       MATINV
      DO 255 J=1,N                                                       MATINV
  255 A(I,J)= TEMP(I,J)                                                  MATINV
      N20=2*N                                                            MATINV
      N2=N+1                                                             MATINV
      DO 200 I=1,N                                                       MATINV
      DO 200 J=1,N                                                       MATINV
      NK=N+J                                                             MATINV
      A(I,NK)=A(I,J)                                                     MATINV
      IF (I-J) 60,50,60                                                  MATINV
   50 A(I,J)=1.                                                          MATINV
      GO TO 200                                                          MATINV
   60 A(I,J)=0.                                                          MATINV
  200 CONTINUE                                                           MATINV
      DO 600 K=1,N                                                       MATINV
      AMAX= ABS (A(K,N2))                                                MATINV
      IMAX=N2                                                            MATINV
C     LOCATE MAXIMUM ELEMENT.  FILE COLUMN NUMBER                        MATINV
      DO 560 J=N2,N20                                                    MATINV
      IF ( ABS (A(K,J))-AMAX) 560,560,555                                MATINV
  555 IMAX=J                                                             MATINV
      AMAX= ABS (A(K,J))                                                 MATINV
  560 CONTINUE                                                           MATINV
      IF(AMAX) 562,561,562                                               MATINV
  561 DET=0.                                                             MATINV
      GO TO 950                                                          MATINV
  562 ICOL(K)=IMAX                                                       MATINV
C     ZERO OFF REMAINING ELEMENTS IN COLUMN                              MATINV
      DO 600 I=1,N                                                       MATINV
      IF (I-K) 570,600,570                                               MATINV
  570 ATEMP=A(I,IMAX)/A(K,IMAX)                                          MATINV
      DO 599 J=1,N20                                                     MATINV
  599 A(I,J)=A(I,J)-A(K,J)*ATEMP                                         MATINV
  600 CONTINUE                                                           MATINV
      DET=1.                                                             MATINV
      DO 650 I=1,N                                                       MATINV
      IMAX=ICOL(I)                                                       MATINV
      DET=DET*A(I,IMAX)                                                  MATINV
      DO 650 J=1,N                                                       MATINV
```

```
      650 A(I,J)=A(I,J)/A(I,IMAX)                                    MATINV     59
C         SHIFT RIGHT AND REARRANGE                                   MATINV     60
   60     DO 700 I=1,N                                                MATINV     61
          IMAX=ICOL(I)-N                                              MATINV     62
          DO 700 J=1,N                                                MATINV     63
          NK=J+N                                                      MATINV     64
      700 A(IMAX,NK)=A(I,J)                                           MATINV     65
   65 C   SHIFT LEFT                                                  MATINV     66
          DO 750 I=1,N                                                MATINV     67
          ICOL(I) = ICOL(I) - N                                       MATINV     68
          DO 750 J=1,N                                                MATINV     69
          NK=J+N                                                      MATINV     70
   70     750 A(I,J)=A(I,NK)                                          MATINV     71
      800 DO 900 I=1,N                                                MATINV     72
          IF (ICOL(I)-I) 848,900,848                                  MATINV     73
      848 NTEMP=ICOL(I)                                               MATINV     74
          KJ= I+1                                                     MATINV     75
   75     DO 850 J=KJ,N                                               MATINV     76
          IF (ICOL(J)-I) 850,849,850                                  MATINV     77
      849 ICOL(I)=ICOL(J)                                             MATINV     78
          ICOL(J)= NTEMP                                              MATINV     79
          DET= -DET                                                   MATINV     80
   80     GO TO 900                                                   MATINV     81
      850 CONTINUE                                                    MATINV     82
      900 CONTINUE                                                    MATINV     83
      950 DO 256 I=1,N                                                MATINV     84
          DO 256 J=1,N                                                MATINV     85
   85 256 TEMP(I,J)= A(I,J)                                           MATINV     86
          RETURN                                                      MATINV     87
          END                                                         MATINV     88
```

STORAGE ALLOCATION.

ADDRESS	LENGTH	BINARY CONTROL CARDS.
0	235	IDENT MATRIX
235		END

ENTRY POINTS.

MULTNR	0+	TRANNN	62+	MULTABT	152+
MULTNN	7+	ADDNM	75+	MULTC	171+
MULTNT	23+	ADDNN	110+	SUB	200+
MULTTN	36+	ADDTR	117+	LAYIN	210+
MULTNNA	52+	MULT	131+		

```
                IDENT  MATRIX                                                    MATRIX      2
                                                                                MATRIX      4
                COMMENT MISCELLANEOUS MATRIX OPERATIONS.                        MATRIX      5
                                                                                MATRIX      6
      ********************************************************************      MATRIX      7
      **                                                                        MATRIX      8
      **        ROUTINE TO PERFORM ALL REQUIRED MATRIX OPERATIONS IN THE STACK  MATRIX      9
      **                                                                        MATRIX     10
      **        NOTES : 1) AN OUTPUT MATRIX CANNOT BE EQUIVALENT TO AN INPUT    MATRIX     11
      **                   MATRIX IN ANY ROUTINE WHICH INVOLVES MULTIPLICATION  MATRIX     12
      **                   OF TWO MATRICIES. IT IS ALLOWED IN ALL OTHER ROUTIN  MATRIX     13
      **                2) THESE ROUTINES ASSUME THAT SQUARE MATRICIES ARE       MATRIX     14
      **                   DIMENSIONED N BY N. OVER DIMENSIONING IS ALLOWED IF  MATRIX     15
      **                   THE MATRIX IS TREATED AS A SINGLE-DIMENSIONED        MATRIX     16
      **                   ARRAY. THE EQUIVALENT OF A(I,J) MAY BE ADDRESSED     MATRIX     17
      **                   AS A(J*(N-1)+I).                                     MATRIX     18
      **                                                                        MATRIX     19
      ********************************************************************      MATRIX     20
                                                                                MATRIX     21
                ENTRY  MULTNR                                                   MATRIX     22
                ENTRY  MULTNN                                                   MATRIX     23
                ENTRY  MULTNT                                                   MATRIX     24
                ENTRY  MULTTN                                                   MATRIX     25
                ENTRY  MULTNNA                                                  MATRIX     26
                ENTRY  TRANNN                                                   MATRIX     27
                ENTRY  ADDNM                                                    MATRIX     28
                ENTRY  ADDNN                                                    MATRIX     29
                ENTRY  ADDTR                                                    MATRIX     30
                ENTRY  MULT                                                     MATRIX     31
                ENTRY  MULTABT                                                  MATRIX     32
                ENTRY  MULTC                                                    MATRIX     33
                ENTRY  SUB                                                      MATRIX     34
                ENTRY  LAYIN                                                    MATRIX     35
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY AN N BY N MATRIX BY A CONSTANT.         ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ : CALL MULTNR(A,R,B,N)                          ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   : A - IN  - MATRIX TO BE MULTIPLIED.            ** MATRIX
                                  **                      R - IN  - CONSTANT.                           ** MATRIX
                                  **                      B - OUT - RESULTANT MATRIX.                  ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN MATRIX.          ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE MULTNR(A,R,B,N)                    ** MATRIX
                                  **                      DIMENSION A(N,N),B(N,N)                       ** MATRIX
                                  **                      DO 10 J=1,N                                   ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                   10 P(I,J) = R*A(I,J)                             ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
                                                                                                          MATRIX
0                        1     MULTNR   BSS    1            ENTRY/EXIT POINT                             MATRIX
                                                                                                          MATRIX
1  6110000001                          SB1    1            SET REG B1 TO 1                              MATRIX
             63210                     SB2    X1           SET REG B2 TO FWA OF *A*                     MATRIX
                  54111                SA1    A1+B1        SET REG X1 TO ADDRESS OF *R*                 MATRIX
2  53210                               SA2    X1           GET CONTENTS OF *R*                          MATRIX
        24202                          NX2    X2           NORMALIZE *R*                                MATRIX
             54111                     SA1    A1+B1        SET REG X1 TO ADDRESS OF *B*                 MATRIX
                  63310                SB3    X1           MOVE ADDRESS OF *B* TO REG B3                MATRIX
3  54111                               SA1    A1+B1        SET REG X1 TO ADDRESS OF *N*                 MATRIX
        53310                          SA3    X1           GET CONTENTS OF *N*                          MATRIX
             42333                     IX3    X3*X3        COMPUTE NUMBER OF ELEMENTS IN *B*            MATRIX
                  63433                SB4    B3+X3        SET REG B4 TO LWA+1 OF *B*                   MATRIX
                                                                                                          MATRIX
4                             LOOP.1   BSS    0                                                         MATRIX
                                                                                                          MATRIX
4  56320                               SA3    B2           GET NEXT ELEMENT OF *A*                      MATRIX
        24303                          NX3    X3           NORMALIZE ELEMENT                            MATRIX
             66221                     SB2    B2+B1        COMPUTE NEXT ELEMENT ADDRESS IN *A*          MATRIX
                  40623                FX6    X2*X3        MULTIPLY BY *R*                              MATRIX
5  56630                               SA6    B3           STORE IN NEXT ELEMENT OF *B*                 MATRIX
        66331                          SB3    B3+B1        COMPUTE NEXT ELEMENT ADDRESS IN *B*          MATRIX
             0734000004 +              LT     B3,B4,LOOP.1 CONTINUE LOOP UNTIL ALL ELEMENTS MULTIPLIE MATRIX
6  0400000000 +                        EQ     MULTNR       RETURN                                       MATRIX
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY TWO N BY N MATRICIES.                   ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ : CALL MULTNN(A,B,C,N)                          ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      B - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      C - OUT - RESULTANT MATRIX.                   ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN MATRIX.           ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE MULTNN(A,B,C,N)                    ** MATRIX
                                  **                      DIMENSION A(N,N),B(N,N),C(N,N)                ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                      DO 10 J=1,N                                   ** MATRIX
                                  **                      C(I,J) = 0.0                                  ** MATRIX
                                  **                      DO 10 K=1,N                                   ** MATRIX
                                  **                   10 C(I,J)= C(I,J) + A(I,K)*B(K,J)                ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
                                                                                                          MATRIX
  7                        1     MULTNN   BSS    1            ENTRY/EXIT POINT                           MATRIX
                                                                                                          MATRIX
 10  6110000001                           SB1    1            SET REG B1 TO 1                            MATRIX
                54211                     SA2    A1+B1        SET REG X2 TO FWA OF *B*                   MATRIX
                      54321               SA3    A2+B1        SET REG X3 TO FWA OF *C*                   MATRIX
 11  63230                                SB2    X3           MOVE FWA OF *C* TO REG B2                  MATRIX
          54331                           SA3    A3+B1        SET REG X3 TO ADDRESS OF *N*               MATRIX
                53330                     SA3    X3           GET CONTENTS OF *N*                        MATRIX
                      43000               MX0    0            CLEAR REG X0                               MATRIX
 12  42433                                IX4    X3*X3        CALCULATE NUMBER OF ELEMENTS IN MATRIX     MATRIX
          43700                           MX7    0            CLEAR REG X7                               MATRIX
                63342                     SB3    B2+X4        SET REG B3 TO LWA+1 OF *C*                 MATRIX
                                                                                                          MATRIX
 13                             LOOP.2    BSS    0                                                       MATRIX
                                                                                                          MATRIX
 13  42437                                IX4    X3*X7        CALCULATE N*(J-1)                          MATRIX
          43600                           MX6    0            CLEAR REG X6                               MATRIX
                36442                     IX4    X4+X2        CALCULATE ADDRESS OF *B(1,J)*              MATRIX
                      46000               NC                  NO-OP                                      MATRIX
 14  63440                                SB4    X4           STORE ADDRESS IN REG B4                    MATRIX
          36401                           IX4    X0+X1        CALCULATE ADDRESS OF *A(I,1)*              MATRIX
                63534                     SB5    B4+X3        SET REG B5 TO ADDRESS OF *B(N,J)*          MATRIX
                      63640               SB6    X4           STORE ADDRESS IN REG B6                    MATRIX
                                                                                                          MATRIX
 15                             LOOP.3    BSS    0                                                       MATRIX
                                                                                                          MATRIX
 15  56440                                SA4    B4           GET CONTENTS OF *B(K,J)*                   MATRIX
          56560                           SA5    B6           GET CONTENTS OF *A(I,K)*                   MATRIX
                66441                     SB4    B4+B1        GET NEXT ELEMENT ADDRESS OF *B*            MATRIX
                      40445               FX4    X4*X5        COMPUTE A(I,K)*B(K,J)                      MATRIX
 16  63636                                SB6    B6+X3        GET NEXT ELEMENT ADDRESS OF *A*            MATRIX
```

```
          30664                    FX6    X6+X4         SUM INTO *C(I,J)*                          MATRIX   142
               24606               NX6    X6            NORMALIZE RESULT                           MATRIX   143
   17  0745000015 +                LT     B4,B5,LOOP.3  CONTINUE LOOP UNTIL *B(N,J)* FOUND         MATRIX   144
               56620               SA6    B2            STORE SUMMATION INTO *C(I,J)*              MATRIX   145
                    66221          SB2    B2+B1         GET NEXT ELEMENT ADDRESS OF *C*            MATRIX   146
   20  73001                       SX0    X0+B1         INCREMENT *I*                              MATRIX   147
          37503                    IX5    X0-X3         COMPARE WITH *N*                           MATRIX   148
               0315000013 +        NZ     X5,LOOP.2     CONTINUE LOOP UNTIL *I* = *N*              MATRIX   149
   21  43000                       MX0    0             CLEAR *I*                                  MATRIX   150
          73771                    SX7    X7+B1         INCREMENT *J*                              MATRIX   151
               0723000013 +        LT     B2,B3,LOOP.2  CONTINUE LOOP UNTIL *C(N,N)* FOUND         MATRIX   152
   22  0400000007 +                EQ     MULTNN        RETURN                                     MATRIX   153
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY AN N BY N MATRIX BY THE TRANSPOSE OF    ** MATRIX
                                  **        ANOTHER N BY N MATRIX.                                      ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ : CALL MULTNT(A,B,C,N)                          ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      B - IN  - N BY N MATRIX TO BE TRANSPOSED.     ** MATRIX
                                  **                      C - OUT - RESULTANT MATRIX.                   ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN MATRIX.           ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE MULTNT(A,B,C,N)                    ** MATRIX
                                  **                      DIMENSION A(N,N),B(N,N),C(N,N)                ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                      DO 10 J=1,N                                   ** MATRIX
                                  **                      C(I,J) = 0.0                                  ** MATRIX
                                  **                      DO 10 K=1,N                                   ** MATRIX
                                  **                   10 C(I,J) = C(I,J + A(I,K)*B(J,K)                ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
                                                                                                          MATRIX
23                          1     MULTNT   BSS    1            ENTRY/EXIT POINT                          MATRIX
                                                                                                          MATRIX
24  6110000001                           SB1    1            SET REG B1 TO 1                           MATRIX
                54211                    SA2    A1+B1        SET REG X2 TO FWA OF *B*                  MATRIX
                      54321              SA3    A2+B1        SET REG X3 TO FWA OF *C*                  MATRIX
25  63230                                SB2    X3           MOVE FWA OF *C* TO REG B2                 MATRIX
          54331                          SA3    A3+B1        SET REG X3 TO ADDRESS OF *N*              MATRIX
                53330                    SA3    X3           SET REG X3 TO *N*                         MATRIX
                      63330              SB3    X3           MOVE *N* TO REG B3                        MATRIX
26  66400                                SB4    B0           CLEAR REG B4                              MATRIX
          66500                          SB5    B0           CLEAR REG B5                              MATRIX
                                                                                                          MATRIX
27                              LOOP.4   BSS    0                                                      MATRIX
                                                                                                          MATRIX
27  73014                                SX0    X1+B4        SET REG X0 TO ADDRESS OF *A(I,1)*         MATRIX
          43600                          MX6    0            CLEAR REG X6                              MATRIX
                73725                    SX7    X2+B5        SET REG X7 TO ADDRESS OF *B(J,1)*         MATRIX
                      66600              SB6    B0           CLEAR REG B6                              MATRIX
                                                                                                          MATRIX
30                              LOOP.5   BSS    0                                                      MATRIX
                                                                                                          MATRIX
30  53400                                SA4    X0           LOAD *A(I,K)*                             MATRIX
          53570                          SA5    X7           LOAD *B(J,K)*                             MATRIX
                36003                    IX0    X0+X3        CALCULATE NEXT *A* ADDRESS                MATRIX
                      40445              FX4    X4*X5        COMPUTE A(I,K)*B(J,K)                     MATRIX
31  66661                                SB6    B6+B1        INCREMENT K                               MATRIX
          36773                          IX7    X7+X3        CALCULATE NEXT *B* ADDRESS                MATRIX
                30664                    FX6    X6+X4        SUM RESULT                                MATRIX
                      24606              NX6    X6           NORMALIZE RESULT                          MATRIX
32  0763000030 +                         LT     B6,B3,LOOP.5 LOOP UNTIL K = *N*                        MATRIX
                56620                    SA6    B2           STORE SUMMATION INTO *C(I,J)*             MATRIX
```

```
                    66441          SB4    B4+B1        INCREMENT I                                MATRIX   212
   33  66221                       SB2    B2+B1        CALCULATE NEXT ADDRESS OF *C*              MATRIX   213
           074300C027 +            LT     B4,B3,LOOP.4 LOOP UNTIL I = *N*                         MATRIX   214
                    664C0          SB4    B0           CLEAR I                                    MATRIX   215
   34  66551                       SB5    B5+B1        INCREMENT J                                MATRIX   216
           075300C027 +            LT     B5,B3,LOOP.4 LOOP UNTIL J = *N*                         MATRIX   217
   35  0400000023 +                EQ     MULTNT       RETURN                                     MATRIX   218
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY THE TRANSPOSE OF AN N BY N MATRIX BY    ** MATRIX
                                  **        ANOTHER N BY N MATRIX.                                      ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ : CALL MULTTN(A,B,C,N)                          ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX TO BE TRANSPOSED.     ** MATRIX
                                  **                      B - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      C - OUT - RESULTANT MATRIX.                   ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS.                     ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE MULTTN(A,B,C,N)                    ** MATRIX
                                  **                      DIMENSION A(N,N),B(N,N),C(N,N)                ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                      DO 10 J=1,N                                   ** MATRIX
                                  **                      C(I,J) = 0.0                                  ** MATRIX
                                  **                      DO 10 K=1,N                                   ** MATRIX
                                  **                   10 C(I,J) = C(I,J) + A(K,I)*B(K,J)               ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
                                                                                                          MATRIX
36                          1     MULTTN   BSS    1            ENTRY/EXIT POINT                          MATRIX
                                                                                                          MATRIX
37  6110000001                           SB1    1            SET REG B1 TO 1                           MATRIX
                54211                    SA2    A1+B1        SET REG X2 TO FWA OF *B*                  MATRIX
                      54321              SA3    A2+B1        SET REG X3 TO FWA OF *C*                  MATRIX
40  43600                                MX6    0            CLEAR REG X6                              MATRIX
          63230                          SB2    X3           MOVE FWA OF *C* TO REG B2                 MATRIX
                54331                    SA3    A3+B1        GET ADDRESS OF *N*                        MATRIX
                      43700              MX7    0            CLEAR REG X7                              MATRIX
41  53330                                SA3    X3           GET CONTENTS OF *N*                       MATRIX
          63330                          SB3    X3           MOVE *N* TO REG B3                        MATRIX
                42433                    IX4    X3*X3        CALCULATE NUMBER OF ELEMENTS IN MATRIX    MATRIX
                      63440              SB4    X4           MOVE RESULT TO REG B4                     MATRIX
42  66500                                SB5    B0           CLEAR I                                   MATRIX
          66600                          SB6    B0           CLEAR J                                   MATRIX
                66700                    SB7    B0           CLEAR K                                   MATRIX
                                                                                                          MATRIX
43                          LOOP.6       BSS    0                                                      MATRIX
                                                                                                          MATRIX
43  53415                                SA4    X1+B5        LOAD *A(K,I)*                             MATRIX
          53526                          SA5    X2+B6        LOAD *B(K,J)*                             MATRIX
                66771                    SB7    B7+B1        INCREMENT K                               MATRIX
                      40445              FX4    X4*X5        CALCULATE A(K,I)*B(K,J)                   MATRIX
44  66551                                SB5    B5+B1        INCREMENT I                               MATRIX
          30664                          FX6    X6+X4        SUM RESULT INTO ACCUMULATOR               MATRIX
                24606                    NX6    X6           NORMALIZE RESULT                          MATRIX
                      66661              SB6    B6+B1        INCREMENT J                               MATRIX
45  0773000043 +                         LT     B7,B3,LOOP.6 LOOP UNTIL K = *N*                        MATRIX
                56620                    SA6    B2           STORE RESULT INTO *C(I,J)*                MATRIX
                      63670              SB6    X7           RESET J                                   MATRIX
46  43600                                MX6    0            CLEAR ACCUMULATOR                         MATRIX
```

```
                66221                   SB2     B2+B1           CALCULATE NEXT ADDRESS OF *C*           MATRIX  277
                    66700               SB7     B0              CLEAR K                                 MATRIX  278
     47  0754000043 +                   LT      B5,B4,LOOP.6    LOOP UNTIL I = N*N                      MATRIX  279
                    66500               SB5     B0              CLEAR I                                 MATRIX  280
                        73773           SX7     X7+B3           INCREMENT J RESET VALUE                 MATRIX  281
     50  63670                          SB6     X7              RESET J                                 MATRIX  282
             0764000043 +               LT      B6,B4,LOOP.6    LOOP UNTIL J = N*N                      MATRIX  283
     51  0400000036 +                   EQ      MULTTN                                                  MATRIX  284
```

```
                                  ************************************************************************
                                  **                                                                    **
                                  **        ROUTINE TO MULTIPLY TWO N BY N MATRICIES AND SUM THE RESULT **
                                  **        INTO A THIRD N BY N MATRIX.                                 **
                                  **                                                                    **
                                  **        CALLING SEQ : CALL MULTNNA(A,B,C,N)                         **
                                  **                                                                    **
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX.                      **
                                  **                      B - IN  - N BY N MATRIX.                      **
                                  **                      C - I/O - RESULTANT N BY N MATRIX.            **
                                  **                      N - IN  - NUMBER OF ROWS.                     **
                                  **                                                                    **
                                  **        NOTE        : THIS IS DONE BY REPLACING THE WORD FOLLOWING  **
                                  **                      *LOOP.2* IN ROUTINE *MULTNN* BY THE WORD AT   **
                                  **                      *CODE.1* THEN CALLING *MULTNN*.               **
                                  **                                                                    **
                                  **                    : FORTRAN EQUIVALENT ROUTINE                    **
                                  **                                                                    **
                                  **                      SUBROUTINE MULTNNA(A,B,C,N)                   **
                                  **                      DIMENSION A(N,N),B(N,N),C(N,N)                **
                                  **                      DO 10 I=1,N                                   **
                                  **                      DO 10 J=1,N                                   **
                                  **                      DO 10 K=1,N                                   **
                                  **                   10 C(I,J) = C(I,J) + A(I,K)*B(K,J)               **
                                  **                      RETURN                                        **
                                  **                      END                                           **
                                  **                                                                    **
                                  ************************************************************************

52                        1     MULTNNA  BSS    1            ENTRY/EXIT POINT

53  5120000013 +                         SA2    LOOP.2       GET WORD AT *LOOP.2*
                5130000061 +             SA3    CODE.1       GET WORD AT *CODE.1*
54  10622                                BX6    X2           MOVE WORD AT *LOOP.2* TO REG X6
          10733                          BX7    X3           MOVE WORD AT *CODE.1* TO REG X7
                54630                    SA6    A3           STORE WORD AT *LOOP.2* INTO *CODE.1*
                      54720              SA7    A2           STORE WORD AT *CODE.1* INTO *LOOP.2*
55  0100000007 +                         RJ     MULTNN       CALL *MULTNN*
56  5120000013 +                         SA2    LOOP.2       GET WORD AT *LOOP.2*
                5130000061 +             SA3    CODE.1       GET WORD AT *CODE.1*
57  10622                                BX6    X2           MOVE WORD AT *LOOP.2* TO REG X6
          10733                          BX7    X3           MOVE WORD AT *CODE.1* TO REG X7
                54630                    SA6    A3           STORE WORD AT *LOOP.2* INTO *CODE.1*
                      54720              SA7    A2           STORE WORD AT *CODE.1* INTO *LOOP.2*
60  0400000052 +                         EQ     MULTNNA      RETURN

61                              CODE.1   BSS    0

61  42437                                IX4    X3*X7        CALCULATE N*(J-1)
          56520                          SA5    B2           GET VALUE OF *C(I,J)*
                36442                    IX4    X4+X2        CALCULATE ADDRESS OF *B(1,J)*
                      10655              BX6    X5           MOVE VALUE OF *C(I,J)* TO REG X6
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO TRANSPOSE AN N BY N MATRIX.                      ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ : CALL TRANNN(A,B,N)                            ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      B - OUT - RESULTANT MATRIX.                   ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN MATRIX.           ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE TRANNN(A,B,N)                      ** MATRIX
                                  **                      DIMENSION A(N,N),B(N,N)                       ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                      DO 10 J=1,N                                   ** MATRIX
                                  **                   10 B(J,I) = A(I,J)                               ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
                                                                                                          MATRIX
62                        1     TRANNN  BSS    1            ENTRY/EXIT POINT                             MATRIX
                                                                                                          MATRIX
63  6110000001                        SB1    1            SET REG B1 TO 1                              MATRIX
              54211                   SA2    A1+B1        SET REG X2 TO FWA OF *B*                     MATRIX
                    54321             SA3    A2+B1        SET REG B3 TO ADDRESS OF *N*                 MATRIX
64  53330                             SA3    X3           GET CONTENTS OF *N*                          MATRIX
        63230                         SB2    X3           SET REG B2 TO *N*                            MATRIX
              67321                   SB3    B2-B1        SET REG B3 TO *N* - 1                        MATRIX
                    66400             SB4    B0           CLEAR REG B4                                 MATRIX
                                                                                                          MATRIX
65                              LOOP.7  BSS    0                                                         MATRIX
                                                                                                          MATRIX
65  76440                             SX4    B4           SET REG X4 TO I                              MATRIX
        42434                         IX4    X3*X4        CALCULATE I*N                                MATRIX
              63644                   SB6    X4+B4        GET OFFSET FOR *(I,I)* ELEMENT               MATRIX
                    53516             SA5    X1+B6        GET *A(I,I)*                                 MATRIX
66  10655                             BX6    X5           MOVE TO REG X6                               MATRIX
        53626                         SA6    X2+B6        STORE *A(I,I)* IN *B(I,I)*                   MATRIX
              66541                   SB5    B4+B1        SET J TO I+1                                 MATRIX
                    66760             SB7    B6           SET REG B7 TO *(I,I)* OFFSET                 MATRIX
                                                                                                          MATRIX
67                              LOOP.8  BSS    0                                                         MATRIX
                                                                                                          MATRIX
67  66661                             SB6    B6+B1        GET OFFSET FOR *(J,I)* ELEMENT               MATRIX
        66772                         SB7    B7+B2        GET OFFSET FOR *(I,J)*                       MATRIX
              53416                   SA4    X1+B6        GET *A(J,I)*                                 MATRIX
                    53517             SA5    X1+B7        GET *A(I,J)*                                 MATRIX
70  10644                             BX6    X4           MOVE REG X4 TO X6                            MATRIX
        53627                         SA6    X2+B7        SET *B(I,J)* TO *A(J,I)*                     MATRIX
              10755                   BX7    X5           MOVE REG X5 TO REG X7                        MATRIX
                    53726             SA7    X2+B6        SET *B(J,I)* TO *A(I,J)*                     MATRIX
71  66551                             SB5    B5+B1        INCREMENT J                                  MATRIX
        0752000067 +                  LT     B5,B2,LOOP.8 LOOP UNTIL J = *N*                           MATRIX
                    66441             SB4    B4+B1        INCREMENT I                                  MATRIX
72  0743000065 +                      LT     B4,B3,LOOP.7 LOOP UNTIL I = *N* - 1                       MATRIX
```

```
                42433                IX4    X3*X3     CALCULATE NUMBER OF ELEMENTS IN MATRIX    MATRIX   396
                     63240           SB2    X4        STORE IN REG B2                           MATRIX   397
   73  67221                         SB2    B2-B1     SUBTRACT 1                                MATRIX   398
           53512                     SA5    X1+B2     GET *A(N,N)*                              MATRIX   399
                10655                BX6    X5        MOVE REG X5 TO REG X6                     MATRIX   400
                     53622           SA6    X2+B2     STORE INTO *B(N,N)*                       MATRIX   401
   74  0400000062 +                  EQ     TRANNN    RETURN                                    MATRIX   402
```

```
                                  ************************************************************************
                                  **                                                                    **
                                  **        ROUTINE TO ADD AN M BY M MATRIX TO THE LOWER RIGHT HAND CORNER
                                  **        OF AN N BY N MATRIX.                                        **
                                  **                                                                    **
                                  **        CALLING SEQ : CALL ADDNM(A,B,C,N,M)                         **
                                  **                                                                    **
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX.                      **
                                  **                      B - IN  - M BY M MATRIX.                      **
                                  **                      C - OUT - RESULTANT N BY N MATRIX.            **
                                  **                      N - IN  - NUMBER OF ROWS IN N BY N MATRIX.    **
                                  **                      M - IN  - NUMBER OF ROWS IN M BY M MATRIX.    **
                                  **                                                                    **
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    **
                                  **                                                                    **
                                  **                      SUBROUTINE ADDNM(A,B,C,N,M)                   **
                                  **                      DIMENSION A(N,N),B(M,M),C(N,N)                **
                                  **                      K = N - M                                     **
                                  **                      L1 = 0                                        **
                                  **                      DO 10 I=1,N                                   **
                                  **                      IF(I .GT. K) L1 = L1 + 1                      **
                                  **                      L2 = 0                                        **
                                  **                      DO 10 J=1,N                                   **
                                  **                      C(I,J) = A(I,J)                               **
                                  **                      IF(I .LE. K .OR. J .LE. K) GO TO 10           **
                                  **                      L2 = L2 + 1                                   **
                                  **                      C(I,J) = C(I,J) + B(L1,L2)                    **
                                  **                   10 CONTINUE                                      **
                                  **                      RETURN                                        **
                                  **                      END                                           **
                                  **                                                                    **
                                  ************************************************************************

 75                        1     ADDNM    BSS     1            ENTRY/EXIT POINT
                                                                                                        MATRIX
 76  6110000001                           SB1     1            SET REG B1 TO 1
                 54211                    SA2     A1+B1        SET REG X2 TO FWA OF *B*
                       54321              SA3     A2+B1        SET REG X3 TO FWA OF *C*
 77  63230                                SB2     X3           STORE FWA OF *C* IN REG B2
          54431                           SA4     A3+B1        SET REG X4 TO ADDRESS OF *N*
                 54541                    SA5     A4+B1        SET REG X5 TO ADDRESS OF *M*
                       53440              SA4     X4           GET CONTENTS OF *N*
100  63740                                SB7     X4           STORE IN REG B7
          42644                           IX6     X4*X4        CALCULATE NUMBER OF ELEMENTS IN *C*
                 63362                    SB3     X6+B2        SET REG B3 TO LWA+1 OF *C*
                       53550              SA5     X5           GET VALUE OF *M*
101  66400                                SB4     B0           CLEAR *I*
          37545                           IX5     X4-X5        CALCULATE *K*
                 66500                    SB5     B0           CLEAR *J*
                       63650              SB6     X5           STORE *K* IN REG B6
                                                                                                        MATRIX
102                              LOOP.9   BSS     0
                                                                                                        MATRIX
102  43400                                MX4     0            CLEAR REG X4
          53510                           SA5     X1           GET CONTENTS OF NEXT ELEMENT OF *A*
                 0756000104 +             LT      B5,B6,JMP.1  JUMP IF *J* LT *K*
103  0746000104 +                         LT      B4,B6,JMP.1  JUMP IF *I* LT *K*
```

```
                53420                  SA4    X2          GET NEXT ELEMENT OF *B*                  MATRIX
                    73221              SX2    X2+B1       INCREMENT INDEX INTO *B*                 MATRIX
                                                                                                    MATRIX
104                          JMP.1     BSS    0                                                    MATRIX
                                                                                                    MATRIX
104  66441                             SB4    B4+B1       INCREMENT *I*                            MATRIX
          30645                        FX6    X4+X5       COMPUTE *A(I,J) + B(I-N+M,J-N+M)*        MATRIX
                24606                  NX6    X6          NORMALIZE RESULT                         MATRIX
                    73111              SX1    X1+B1       GET NEXT ELEMENT ADDRESS IN *A*          MATRIX
105  0747000106 +                      LT     B4,B7,JMP.2 JUMP IF *I* LT *N*                       MATRIX
                66400                  SB4    B0          CLEAR *I*                                MATRIX
                    66551              SB5    B5+B1       INCREMENT *J*                            MATRIX
                                                                                                    MATRIX
106                          JMP.2     BSS    0                                                    MATRIX
                                                                                                    MATRIX
106  56620                             SA6    B2          STORE SUM INTO NEXT ELEMENT OF *C*       MATRIX
          66221                        SB2    B2+B1       GET NEXT ELEMENT ADDRESS IN *C*          MATRIX
                0723000102 +           LT     B2,B3,LOOP.9 LOOP UNTIL *C(N,N)* FOUND               MATRIX
107  0400000075 +                      EQ     ADDNM       RETURN                                   MATRIX
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO ADD TWO N BY N MATRICIES.                        ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ : CALL ADDNN(A,B,C,N)                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   : A - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      B - IN  - N BY N MATRIX.                      ** MATRIX
                                  **                      C - OUT - RESULTANT MATRIX.                   ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN N BY N MATRIX.    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        : FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE ADDNN(A,B,C,N)                     ** MATRIX
                                  **                      DIMENSION A(N,N),B(N,N),C(N,N)                ** MATRIX
                                  **                      DO 10 J=1,N                                   ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                   10 C(I,J) = A(I,J) + B(I,J)                      ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
                                                                                                          MATRIX
110                        1     ADDNN    BSS    1            ENTRY/EXIT POINT                           MATRIX
                                                                                                          MATRIX
111  6110000001                          SB1    1            SET REG B1 TO 1                            MATRIX
                 54211                   SA2    A1+B1        SET REG X2 TO FWA OF *B*                   MATRIX
                      54321              SA3    A2+B1        SET REG X3 TO FWA OF *C*                   MATRIX
112  63230                               SB2    X3           MOVE FWA OF *C* TO REG B2                  MATRIX
           54331                         SA3    A3+B1        GET ADDRESS OF *N*                         MATRIX
                 53330                   SA3    X3           GET CONTENTS OF *N*                        MATRIX
                      42333              IX3    X3*X3        CALCULATE NUMBER OF ELEMENTS IN *C*        MATRIX
113  63332                               SB3    B2+X3        SET REG B3 TO LWA+1 OF *C*                 MATRIX
           76510                         SX5    B1           SET REG X5 TO 1                            MATRIX
                                                                                                          MATRIX
114                             LOOP.10  BSS    0                                                       MATRIX
                                                                                                          MATRIX
114  53310                               SA3    X1           GET NEXT ELEMENT OF *A*                    MATRIX
           53420                         SA4    X2           GET NEXT ELEMENT OF *B*                    MATRIX
                 36115                   IX1    X1+X5        GET NEXT ELEMENT ADDRESS IN *A*            MATRIX
                      30634              FX6    X3+X4        COMPUTE *A(I,J) + B(I,J)*                  MATRIX
115  24606                               NX6    X6           NORMALIZE RESULT                           MATRIX
           36225                         IX2    X2+X5        GET NEXT ELEMENT ADDRESS IN *B*            MATRIX
                 56620                   SA6    B2           STORE IN NEXT ELEMENT OF *C*               MATRIX
                      66221              SB2    B2+B1        COMPUTE NEXT ELEMENT ADDRESS OF *C*        MATRIX
116  0723000114 +                        LT     B2,B3,LOOP.10 LOOP UNTIL *C(N,N)* FOUND                 MATRIX
                 0400000110 +            EQ     ADDNN        RETURN                                     MATRIX
                                                                                                          MATRIX
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO TRANSPOSE AN N BY N MATRIX AND ADD THE RESULT TO ** MATRIX
                                  **        THE INITIAL MATRIX.                                         ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ :  CALL ADDTR(A,N)                              ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   :  A - IN  - N BY N MATRIX                      ** MATRIX
                                  **                       A - OUT - RESULTANT MATRIX                   ** MATRIX
                                  **                       N - IN  - NUMBER OF ROWS                     ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        :  FORTRAN EQUIVALENT ROUTINE                   ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                       SUBROUTINE ADDTR(A,N)                        ** MATRIX
                                  **                       DIMENSION A(N,N)                             ** MATRIX
                                  **                       DO 11 J=1,N                                  ** MATRIX
                                  **                       DO 11 I=J,N                                  ** MATRIX
                                  **                       A(I,J)=A(I,J)+A(J,I)                         ** MATRIX
                                  **                       A(J,I)=A(I,J)                                ** MATRIX
                                  **                    11 CONTINUE                                     ** MATRIX
                                  **                       RETURN                                       ** MATRIX
                                  **                       END                                          ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
117                          1    ADDTR    BSS    1            ENTRY/EXIT POINT                          MATRIX
120  5021000001                          SA2    A1+1         SET X2 TO ADDRESS OF *N*                  MATRIX
                53220                    SA2    X2           GET CONTENTS OF *N* IN X2                 MATRIX
                     63120               SB1    X2           *N*                                       MATRIX
121  6120000001                          SB2    B0+1         *1* IN B2                                 MATRIX
                66300                    SB3    B0           OUTER LOOP COUNTER                        MATRIX
                     66400               SB4    B0           INNER LOOP COUNTER                        MATRIX
122  6252777776                          SB5    X2-1         SET B5 TO *N-1*                           MATRIX
                66600                    SB6    B0           *I*                                       MATRIX
                     66700               SB7    B0           *J*                                       MATRIX
123                          LOOP.12     BSS    0                                                      MATRIX
123  66663                               SB6    B6+B3        I=I+OUTER LOOP COUNT                      MATRIX
          66760                          SB7    B6           J = I                                     MATRIX
                66430                    SB4    B3           INNER LOOP STARTS AT VALUE OF OUTER LOOP  MATRIX
124                          LOOP.11     BSS    0                                                      MATRIX
124  53316                               SA3    X1+B6        GET A(I)                                  MATRIX
          53417                          SA4    X1+B7        GET A(J)                                  MATRIX
                30634                    FX6    X3+X4        ADD A(I) TO A(J)                          MATRIX
                     24606               NX6                 NORMALIZE X6                              MATRIX
125  10766                               BX7    X6           COPY X6 INTO X7                           MATRIX
          54630                          SA6    A3           STORE A(I)                                MATRIX
                54740                    SA7    A4           STORE A(J)                                MATRIX
                     66662               SB6    B6+B2        I = I + 1                                 MATRIX
126  66771                               SB7    B7+B1        J = J + N                                 MATRIX
          66442                          SB4    B4+B2        INCREMENT INNER LOOP COUNT                MATRIX
                0741000124 +             LT     B4,B1,LOOP.11 END OF INNER LOOP                        MATRIX
127  66332                               SB3    B3+B2        INCREMENT OUTER LOOP COUNT                MATRIX
          0731000123 +                   LT     B3,B1,LOOP.12 END OF OUTER LOOP                        MATRIX
130  0400000117 +                        EQ     ADDTR                                                  MATRIX
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY TWO N BY M MATRICIES.                   ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ:  CALL MULT(A,N1,N2,B,M1,M2,C)                  ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS  :  A  - IN  - N1 BY N2 MATRIX                    ** MATRIX
                                  **                      N1 - IN  - NUMBER OF ROWS IN A                ** MATRIX
                                  **                      N2 - IN  - NUMBER OF COLUMNS IN A             ** MATRIX
                                  **                      B  - IN  - M1 BY M2 MATRIX                    ** MATRIX
                                  **                      M1 - IN  - NUMBER OF ROWS IN B                ** MATRIX
                                  **                      M2 - IN  - NUMBER OF COLUMNS IN B             ** MATRIX
                                  **                      C  - OUT - N1 BY M2 MATRIX                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE       :  FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE MULT(A,N1,N2,B,M1,M2,C)            ** MATRIX
                                  **                      DIMENSION A(N1,N2),B(M1,M2),C(N1,M2)          ** MATRIX
                                  **                      DO 10 I=1,N1                                  ** MATRIX
                                  **                      DO 10 J=1,M2                                  ** MATRIX
                                  **                      C(I,J) = 0.0                                  ** MATRIX
                                  **                      DO 10 K=1,N2                                  ** MATRIX
                                  **                   10 C(I,J) = C(I,J) + A(I,K)*B(K,J)               ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
131                        1     MULT     BSS    1          ENTRY/EXIT                                  MATRIX
132  6110000001                           SB1    1                                                      MATRIX
                54211                     SA2    A1+B1      PUT ADDRESS OF N1 INTO X2                   MATRIX
                      54321               SA3    A2+B1      PUT ADDRESS OF N2 INTO X3                   MATRIX
133  54431                                SA4    A3+B1      PUT ADDRESS OF B(1,1) INTO X4               MATRIX
          54541                           SA5    A4+B1      PUT ADDRESS OF M1 INTO X5                   MATRIX
                53220                     SA2    X2         PUT CONTENTS OF N1 INTO X2                  MATRIX
                      53330               SA3    X3         PUT CONTENTS OF N2 INTO X3                  MATRIX
134  63220                                SB2    X2         MOVE N1 TO B2                               MATRIX
          63330                           SB3    X3         MOVE N2 TO B3                               MATRIX
                54251                     SA2    A5+B1      PUT ADDRESS OF M2 INTO X2                   MATRIX
                      54321               SA3    A2+B1      PUT ADDRESS OF C(1,1) INTO X3               MATRIX
135  53220                                SA2    X2         PUT CONTENTS OF M2 INTO X2                  MATRIX
          63420                           SB4    X2         MOVE M2 TO B4                               MATRIX
                76020                     SX0    B2         MOVE N1 TO X0                               MATRIX
                      66700               SB7    B0         COLUMN INCREMENT FOR *B*                    MATRIX
136  66500                                SB5    B0         COLUMN INCREMENT FOR *C*                    MATRIX
137                             LOOP.A    BSS    0                                                      MATRIX
137  76770                                SX7    B7         MOVE J TO X7                                MATRIX
          43600                           MX6    0          SET X6 TO ZERO                              MATRIX
                36747                     IX7    X4+X7      PUT ADDRESS OF B(1,J) INTO X7               MATRIX
                      63670               SB6    X7         MOVE ADDRESS OF B(1,J) TO B6                MATRIX
140  73710                                SX7    X1         PUT ADDRESS OF A(I,1) INTO X7               MATRIX
141                             LOOP.B    BSS    0                                                      MATRIX
141  56260                                SA2    B6         PUT CONTENTS OF B(K,J) INTO X2              MATRIX
          53570                           SA5    X7         PUT CONTENTS OF A(I,K) INTO X5              MATRIX
                40552                     FX5    X5*X2      PUT A(I,K)*B(K,J) INTO X5                   MATRIX
                      66661               SB6    B6+B1      GET NEXT ELEMENT OF *B*                     MATRIX
142  73772                                SX7    X7+B2      GET NEXT ELEMENT OF *A*                     MATRIX
          30665                           FX6    X6+X5      SUM INTO C(I,J)                             MATRIX
```

```
                24606                NX6                NORMALIZE X6                                  MATRIX   641
                     67331           SB3     B3-B1      DECREMENT N2                                  MATRIX   642
  143  0703000141 +                  GT      B3,BC,LOOP.B                                             MATRIX   643
                53635                SA6     X3+B5      STORE C(I,J)                                  MATRIX   644
                     66552           SB5     B5+B2      GET NEXT ELEMENT OF *C*                       MATRIX   645
  144  5021000002                    SA2     A1+2       PUT ADDRESS OF N2 INTO X2 AGAIN               MATRIX   646
                53220                SA2     X2         PUT CONTENTS OF N2 X2 AGAIN                   MATRIX   647
                     63320           SB3     X2         MOVE N2 INTO B3 AGAIN                         MATRIX   648
  145  66773                         SB7     B7+B3      INCREMENT FOR NEXT COLUMN OF *B*              MATRIX   649
            67441                    SB4     B4-B1      DECREMENT M2                                  MATRIX   650
                0704000137 +         GT      B4,BC,LOOP.A                                             MATRIX   651
  146  5021000005                    SA2     A1+5       PUT ADDRESS OF M2 INTO X2                     MATRIX   652
                53220                SA2     X2         PUT CONTENTS OF M2 INTO X2                    MATRIX   653
                     63420           SB4     X2         PUT M2 BACK INTO B4 AGAIN                     MATRIX   654
  147  7200777776                    SX0     X0-1       DECREMENT N1                                  MATRIX   655
                73111                SX1     X1+B1      INCREMENT FOR NEXT ROW OF *A*                 MATRIX   656
                     73331           SX3     X3+B1      INCREMENT FOR NEXT ROW OF *C*                 MATRIX   657
  150  66500                         SB5     B0         RESET COLUMN INCREMENT FOR *C* TO ZERO        MATRIX   658
            66700                    SB7     B0         RESET COLUMN INCREMENT FOR *B* TO ZERO        MATRIX   659
                0310000137 +         NZ      X0,LOOP.A                                                MATRIX   660
  151  0400000131 +                  EQ      MULT       RETURN                                        MATRIX   661
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY AN N BY M MATRIX BY THE TRANSPOSE OF AN ** MATRIX
                                  **        L BY M MATRIX.                                              ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ:  CALL MULTABT(A,N1,N2,B,M1,M2,C)               ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS   :  A  - IN  - N1 BY N2 MATRIX                   ** MATRIX
                                  **                       N1 - IN  - NUMBER OF ROWS IN A               ** MATRIX
                                  **                       N2 - IN  - NUMBER OF COLUMNS IN B            ** MATRIX
                                  **                       B  - IN  - M1 BY M2 MARIX                    ** MATRIX
                                  **                       M1 - IN  - NUMBER OF ROWS IN B               ** MATRIX
                                  **                       M2 - IN  - NUMBER OF COLUMNS IN B            ** MATRIX
                                  **                       C  - OUT - N1 BY M1 MATRIX                   ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE        :  FORTRAN EQUIVALENT ROUTINE                   ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                       SUBROUTINE MULTABT(A,N1,N2,B,M1,M2,C)        ** MATRIX
                                  **                       DIMENSION A(N1,N2),B(M1,M2),C(N1,M1)         ** MATRIX
                                  **                       DO 10 I=1,N1                                 ** MATRIX
                                  **                       DO 10 J=1,M1                                 ** MATRIX
                                  **                       C(I,J) = 0.0                                 ** MATRIX
                                  **                       DO 10 K=1,M2                                 ** MATRIX
                                  **                    10 C(I,J) = C(I,J) + A(I,K)*B(J,K)              ** MATRIX
                                  **                       RETURN                                       ** MATRIX
                                  **                       END                                          ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
152                          1    MULTABT  BSS    1           ENTRY/EXIT                                 MATRIX
153  6110000001                           SB1    1                                                      MATRIX
                54211                     SA2    A1+B1       PUT ADDRESS OF N1 INTO X2                  MATRIX
                      54321               SA3    A2+B1       PUT ADDRESS OF N2 INTO X3                  MATRIX
154  54431                                SA4    A3+B1       PUT ADDRESS OF B(1,1) INTO X4              MATRIX
          54541                           SA5    A4+B1       PUT ADDRESS OF M1 INTO X5                  MATRIX
                53220                     SA2    X2          PUT N1 INTO X2                             MATRIX
                      63220               SB2    X2          PUT N1 INTO B2                             MATRIX
155  53350                                SA3    X5          PUT M1 INTO X3                             MATRIX
          63330                           SB3    X3          PUT M1 INTO B3                             MATRIX
                54351                     SA3    A5+B1       PUT ADDRESS OF M2 INTO X3                  MATRIX
                      54531               SA5    A3+B1       PUT ADDRESS OF C(1,1) INTO X5              MATRIX
156  53330                                SA3    X3          PUT M2 INTO X3                             MATRIX
          63430                           SB4    X3          PUT M2 INTO B4                             MATRIX
                76020                     SX0    B2          PUT N1 INTO X0                             MATRIX
                      66730               SB7    B3          LOOP COUNTER                               MATRIX
157  66500                                SB5    B0          COLUMN INCREMENT FOR *C*                   MATRIX
160                          LOOP.C      BSS    0                                                      MATRIX
160  43600                                MX6    0           ZERO X6                                    MATRIX
          63640                           SB6    X4          PUT ADDRESS OF B(J,1) INTO B6              MATRIX
                73710                     SX7    X1          PUT ADDRESS OF A(I,1) INTO X7              MATRIX
161                          LOOP.D      BSS    0                                                      MATRIX
161  56260                                SA2    B6          PUT CONTENTS OF B(J,K) INTO X2             MATRIX
          53370                           SA3    X7          PUT CONTENTS OF A(I,K) INTO X3             MATRIX
                40332                     FX3    X3*X2       PUT A(I,K)*B(J,K) INTO X3                  MATRIX
                      66663               SB6    B6+B3       GET NEXT ELEMENT OF *B*                    MATRIX
162  73772                                SX7    X7+B2       GET NEXT ELEMENT OF *A*                    MATRIX
          30663                           FX6    X6+X3       SUM INTO C(I,J)                            MATRIX
                24606                     NX6                NORMALIZE X6                               MATRIX
```

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                    67441          SB4    B4-B1       DECREMENT M2                                  MATRIX   720
163  0704000161 +                  GT     B4,B0,LOOP.D                                              MATRIX   721
                53655              SA6    X5+B5       STORE C(I,J)                                  MATRIX   722
                    66552          SB5    B5+B2       GET NEXT ELEMENT OF *C*                       MATRIX   723
164  5021000005                    SA2    A1+5        PUT ADDRESS OF M2 INTO X2                     MATRIX   724
                53220              SA2    X2          PUT M2 INTO X2                                MATRIX   725
                    63420          SB4    X2          PUT M2 INTO B4 AGAIN                          MATRIX   726
165  67771                         SB7    B7-B1       DECREMENT LOOP COUNT                          MATRIX   727
          73441                    SX4    X4+B1       GET NEXT ROW ELEMENT OF*B*                    MATRIX   728
                0707000160 +       GT     B7,B0,LOOP.C                                              MATRIX   729
166  5041000003                    SA4    A1+3        PUT ADDRESS OF B(1,1) INTO X4 AGAIN           MATRIX   730
                73111              SX1    X1+B1       INCREMENT FOR NEXT ROW OF *A*                 MATRIX   731
                    73551          SX5    X5+B1       INCREMENT FOR NEXT ROW OF *C*                 MATRIX   732
167  66500                         SB5    B0          RESET COLUMN INCREMENT FOR *C* TO ZERO        MATRIX   733
          66730                    SB7    B3          RESET COLUMN INCREMENT FOR *B* TO ZERO        MATRIX   734
                7200777776         SX0    X0-1        DECREMENT N1                                  MATRIX   735
170  0310000160 +                  NZ     X0,LOOP.C                                                 MATRIX   736
                0400000152 +       EQ     MULTABT     RETURN                                        MATRIX   737
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO MULTIPLY AN N BY M MATRIX BY A CONSTANT.         ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ:  CALL MULTC(A,B,N,M,C)                         ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS  :  A - IN  - SCALAR                              ** MATRIX
                                  **                      B - IN  - MATRIX                              ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN B                 ** MATRIX
                                  **                      M - IN  - NUMBER OF COLUMNS IN B              ** MATRIX
                                  **                      C - OUT - RESULTANT MATRIX OF A*B             ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE       :  FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE MULTC(A,B,N,M,C)                   ** MATRIX
                                  **                      DIMENSION B(N,M),C(N,M)                       ** MATRIX
                                  **                      DO 10 J=1,M                                   ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                   10 C(I,J) = A*B(I,J)                             ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
171                          1    MULTC    BSS    1           ENTRY/EXIT                                MATRIX
172  6110000001                           SB1    1                                                     MATRIX
                54211                     SA2    A1+B1       PUT ADDRESS OF B(1,1) INTO X2             MATRIX
                      54321               SA3    A2+B1       PUT ADDRESS OF N INTO X3                  MATRIX
173  54431                                SA4    A3+B1       PUT ADDRESS OF M INTO X4                  MATRIX
          54541                           SA5    A4+B1       PUT ADDRESS OF C(1,1) INTO X5             MATRIX
                53110                     SA1    X1          PUT A INTO X1                             MATRIX
                      53330               SA3    X3          PUT N INTO X3                             MATRIX
174  53440                                SA4    X4          PUT M INTO X4                             MATRIX
          42734                           IX7    X3*X4       PUT N*M INTO X7                           MATRIX
                63270                     SB2    X7          MOVE N*M TO B2                            MATRIX
175                          LOOP.H       BSS    0                                                     MATRIX
175  53320                                SA3    X2          PUT CONTENTS OF *B* INTO X3               MATRIX
          40613                           FX6    X1*X3       PUT A*B INTO X6                           MATRIX
                53650                     SA6    X5          STORE *C*                                 MATRIX
                      73221               SX2    X2+B1       GET NEXT ELEMENT OF *B*                   MATRIX
176  73551                                SX5    X5+B1       GET NEXT ELEMENT OF *C*                   MATRIX
          67221                           SB2    B2-B1       DECREMENT N*M                             MATRIX
                0520000175 +              NZ     B2,LOOP.H                                             MATRIX
177  0400000171 +                         EQ     MULTC       RETURN                                    MATRIX
```

```
                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO SUBTRACT AN N BY M MATRIX FROM ANOTHER N BY M    ** MATRIX
                                  **        MATRIX.                                                     ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ:  CALL SUB(A,B,N,M,C)                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS  :  A - IN  - MATRIX                              ** MATRIX
                                  **                      B - IN  - MATRIX TO BE SUBTRACTED FROM A      ** MATRIX
                                  **                      N - IN  - NUMBER OF ROWS IN A AND B           ** MATRIX
                                  **                      M - IN  - NUMBER OF COLUMNS IN A AND B        ** MATRIX
                                  **                      C - OUT - RESULTANT MATRIX                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE       :  FORTRAN EQUIVALENT ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE SUB(A,B,N,M,C)                     ** MATRIX
                                  **                      DIMENSION A(N,M),B(N,M),C(N,M)                ** MATRIX
                                  **                      DO 10 J=1,M                                   ** MATRIX
                                  **                      DO 10 I=1,N                                   ** MATRIX
                                  **                   10 C(I,J) = A(I,J) - B(I,J)                      ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
200                          1    SUB      BSS    1          ENTRY/EXIT                                  MATRIX
201  6110000001                           SB1    1                                                      MATRIX
                54211                     SA2    A1+B1      PUT ADDRESS OF B(1,1) IN X2                 MATRIX
                      54321               SA3    A2+B1      PUT ADDRESS OF N IN X3                      MATRIX
202  54431                                SA4    A3+B1      PUT ADDRESS OF M IN X4                      MATRIX
          54541                           SA5    A4+B1      PUT ADDRESS OF C(1,1) IN X5                 MATRIX
                53330                     SA3    X3         PUT N INTO X3                               MATRIX
                      53440               SA4    X4         PUT M INTO X4                               MATRIX
203  42734                                1X7    X3*X4      N*M IN X7                                   MATRIX
          63270                           SB2    X7         MOVE N*M TO B2                              MATRIX
204                               LOOP.I   BSS    0                                                      MATRIX
204  53310                                SA3    X1         GET NEXT ELEMENT OF *A*                     MATRIX
          53420                           SA4    X2         GET NEXT ELEMENT OF *B*                     MATRIX
                31634                     FX6    X3-X4      A-B INTO X6                                 MATRIX
                      24606               NX6               NORMALIZE X6                                MATRIX
205  53650                                SA6    X5         STORE *C*                                   MATRIX
          73111                           SX1    X1+B1      INCREMENT FOR NEXT ELEMENT OF *A*           MATRIX
                73221                     SX2    X2+B1      INCREMENT FOR NEXT ELEMENT OF *B*           MATRIX
                      73551               SX5    X5+B1      INCREMENT FOR NEXT ELEMENT OF *C*           MATRIX
206  67221                                SB2    B2-B1      DECREMENT N*M                               MATRIX
          0520000204 +                    NZ     B2,LOOP.I                                              MATRIX
207  0400000200 +                         EQ     SUB        RETURN                                      MATRIX
```

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                                  ************************************************************************ MATRIX
                                  **                                                                    ** MATRIX
                                  **        ROUTINE TO LAYIN A MATRIX INTO ANOTHER MATRIX AT A GIVEN ROW** MATRIX
                                  **        AND COLUMN.                                                 ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        CALLING SEQ:  CALL LAYIN(A,I,J,NRA,B,NR,NC,ITL)             ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        ARGUMENTS  :  A   - IN  - MATRIX                            ** MATRIX
                                  **                      I   - IN  - ROW IN A WHERE LAYIN IS TO BEGIN  ** MATRIX
                                  **                      J   - IN  - COLUMN IN A WHERE LAYIN IS TO BEGIN* MATRIX
                                  **                      NRA - IN  - NUMBER OF ROWS IN A               ** MATRIX
                                  **                      B   - IN  - MATRIX TO BE LAYED INTO A         ** MATRIX
                                  **                      NR  - IN  - NUMBER OF ROWS IN B               ** MATRIX
                                  **                      NC  - IN  - NUMBER OF COLUMNS IN B            ** MATRIX
                                  **                      ITL - IN  - TYPE OF LAYIN                     ** MATRIX
                                  **                                  NEGATIVE - SUBTRACT B FROM A      ** MATRIX
                                  **                                  ZERO     - OVERLAY B IN A         ** MATRIX
                                  **                                  POSITIVE - ADD B TO A             ** MATRIX
                                  **                      A   - OUT - NEW MATRIX                        ** MATRIX
                                  **                                                                    ** MATRIX
                                  **        NOTE       :  EQUIVALENT FORTRAN ROUTINE                    ** MATRIX
                                  **                                                                    ** MATRIX
                                  **                      SUBROUTINE LAYIN(A,I,J,NRA,B,NR,NC,ITL)       ** MATRIX
                                  **                      DIMENSION A(NRA,1),B(NR,NC)                   ** MATRIX
                                  **                      IF(ITL) 10,20,30                              ** MATRIX
                                  **                   10 DO 15 N=1,NC                                  ** MATRIX
                                  **                      DO 15 M=1,NR                                  ** MATRIX
                                  **                   15 A(I+M-1,J+N-1) = A(I+M-1,J+N-1) - B(M,N)      ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                   20 DO 25 N=1,NC                                  ** MATRIX
                                  **                      DO 25 M=1,NR                                  ** MATRIX
                                  **                   25 A(I+M-1,J+N-1) = B(M,N)                       ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                   30 DO 35 N=1,NC                                  ** MATRIX
                                  **                      DO 35 M=1,NR                                  ** MATRIX
                                  **                   35 A(I+M-1,J+N-1) = A(I+M-1,J+N-1) + B(M,N)      ** MATRIX
                                  **                      RETURN                                        ** MATRIX
                                  **                      END                                           ** MATRIX
                                  **                                                                    ** MATRIX
                                  ************************************************************************ MATRIX
210                        1     LAYIN    BSS    1          ENTRY/EXIT                                   MATRIX
211  6110000001                          SB1    1                                                       MATRIX
                63410                    SB4    X1         PUT ADDRESS OF A(1,1) IN B4                  MATRIX
                      54211              SA2    A1+B1      PUT ADDRESS OF I INTO X2                     MATRIX
212  54321                               SA3    A2+B1      PUT ADDRESS OF J INTO X3                     MATRIX
          54431                          SA4    A3+B1      PUT ADDRESS OF NRA INTO X4                   MATRIX
                54541                    SA5    A4+B1      PUT ADDRESS OF B(1,1) INTO X5                MATRIX
                      53220              SA2    X2         PUT I INTO X2                                MATRIX
213  63220                               SB2    X2         PUT I INTO B2                                MATRIX
          53330                          SA3    X3         PUT J INTO X3                                MATRIX
                63330                    SB3    X3         PUT J INTO B3                                MATRIX
                      53440              SA4    X4         PUT NRA INTO X4                              MATRIX
214  54151                               SA1    A5+B1      PUT ADDRESS OF NR INTO X1                    MATRIX
          54211                          SA2    A1+B1      PUT ADDRESS OF NC INTO X2                    MATRIX
                54321                    SA3    A2+B1      PUT ADDRESS OF ITL INTO X3                   MATRIX
                      53110              SA1    X1         PUT NR INTO X1                               MATRIX
215  63610                               SB6    X1         PUT NR INTO B6                               MATRIX
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          53220                          SA2    X2          PUT NC INTO X2                          MATRIX   887
               63720                     SP7    X2          PUT NC INTO B7                          MATRIX   888
                    53330                SA3    X3          PUT ITL INTO X3                         MATRIX   889
  216  77021                             SXC    B2-B1       I-1                                     MATRIX   890
          77731                          SX7    B3-B1       J-1                                     MATRIX   891
               42774                     IX7    X7*X4       (J-1)*NRA                               MATRIX   892
                    36007                IXC    X0+X7       (I-1)+(J-1)*NRA                         MATRIX   893
  217  73004                             SX0    X0+B4       PUT A(I,J) INTO X0                      MATRIX   894
          66400                          SB4    B0          ROW INCREMENT FOR *A*                   MATRIX   895
               63550                     SB5    X5          PUT ADDRESS OF B(1,1) IN B5             MATRIX   896
  220  0303000225 +                      ZR     X3,LOOP.F                                           MATRIX   897
               0333000231 +              NG     X3,LOOP.G                                           MATRIX   898
  221                          LOOP.E    BSS    0                                                   MATRIX   899
  221  53304                             SA3    X0+B4       PUT A(I+M-1,J+N-1) IN X3                MATRIX   900
          56554                          SA5    B5+B4       PUT B(M,N) IN X5                        MATRIX   901
               30635                     FX6    X3+X5       PUT A(I+M-1,J+N-1) + B(M,N) IN X6       MATRIX   902
                    24606                NX6                NORMALIZE X6                            MATRIX   903
  222  54630                             SA6    A3          STORE A(I+M-1,J+N-1)                    MATRIX   904
          66441                          SB4    B4+B1       INCREMENT M                             MATRIX   905
               0746000221 +              LT     B4,B6,LOOP.E                                        MATRIX   906
  223  36004                             IX0    X0+X4       INCREMENT FOR NEXT COLUMN OF *A*        MATRIX   907
          66556                          SB5    B5+B6       INCREMENT FOR NEXT COLUMN OF *B*        MATRIX   908
               66400                     SB4    B0          ZERO ROW INCREMENT                      MATRIX   909
                    67771                SB7    B7-B1       DECREMENT NC                            MATRIX   910
  224  0570000221 +                      NE     B7,B0,LOOP.E                                        MATRIX   911
               0400000210 +              EQ     LAYIN       RETURN                                  MATRIX   912
  225                          LOOP.F    BSS    0                                                   MATRIX   913
  225  56554                             SA5    B5+B4       PUT B(M,N) IN X5                        MATRIX   914
          10655                          BX6    X5          MOVE B(M,N) TO X6                       MATRIX   915
               53604                     SA6    X0+B4       STORE A(I+M-1,J+N-1)                    MATRIX   916
                    66441                SB4    B4+B1       INCREMENT M                             MATRIX   917
  226  0746000225 +                      LT     B4,B6,LOOP.F                                        MATRIX   918
               36004                     IXC    X0+X4       INCREMENT FOR NEXT COLUMN OF *A*        MATRIX   919
                    66556                SB5    B5+B6       INCREMENT FOR NEXT COLUMN OF *B*        MATRIX   920
  227  66400                             SB4    B0          ZERO ROW INCREMENT                      MATRIX   921
          67771                          SB7    B7-B1       DECREMENT NC                            MATRIX   922
               0570000225 +              NE     B7,B0,LOOP.F                                        MATRIX   923
  230  0400000210 +                      EQ     LAYIN       RETURN                                  MATRIX   924
  231                          LOOP.G    BSS    0                                                   MATRIX   925
  231  53304                             SA3    X0+B4       PUT A(I+M-1,J+N-1) IN X3                MATRIX   926
          56554                          SA5    B5+B4       PUT B(M,N) IN X5                        MATRIX   927
               31635                     FX6    X3-X5       PUT A(I+M-1,J+N-1) - B(M,N) IN X6       MATRIX   928
                    24606                NX6                NORMALIZE X6                            MATRIX   929
  232  54630                             SA6    A3          STORE A(I+M-1,J+N-1)                    MATRIX   930
          66441                          SB4    B4+B1       INCREMENT M                             MATRIX   931
               0746000231 +              LT     B4,B6,LOOP.G                                        MATRIX   932
  233  36004                             IX0    X0+X4       INCREMENT FOR NEXT COLUMN OF *A*        MATRIX   933
          66556                          SB5    B5+B6       INCREMENT FOR NEXT COLUMN OF *B*        MATRIX   934
               66400                     SB4    B0          ZERO ROW INCREMENT                      MATRIX   935
                    67771                SB7    B7-B1       DECREMENT NC                            MATRIX   936
  234  0570000231 +                      NE     B7,B0,LOOP.G                                        MATRIX   937
               0400000210 +              EQ     LAYIN       RETURN                                  MATRIX   938
  235                                    END                                                        MATRIX   939

                  50100B CM  STORAGE USED          938 STATEMENTS        38 SYMBOLS
                             MODEL 74 ASSEMBLY     2.401 SECONDS        108 REFERENCES
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SYMBOLIC REFERENCE TABLE.

ADDMM	75	PROGRAM*	2/26 E	13/34 L	14/19			
ADDNN	110	PROGRAM*	2/27 E	15/24 L	15/47			
ADDTR	117	PROGRAM*	2/28 E	16/25 L	15/53			
CODE.1	61	PROGRAM*	10/33	10/40	10/47 L			
JMP.1	104	PROGRAM*	13/56	13/57	14/04 L			
JMP.2	106	PROGRAM*	14/10	14/14 L				
LAYIN	210	PROGRAM*	2/33 E	23/41 L	24/26	24/38	24/52	
LOOP.A	137	PROGRAM*	17/45 L	18/11	18/20			
LOOP.B	141	PROGRAM*	17/51 L	18/03				
LOOP.C	160	PROGRAM*	19/46 L	20/10	20/17			
LOOP.D	161	PROGRAM*	19/50 L	20/02				
LOOP.E	221	PROGRAM*	24/13 L	24/20	24/25			
LOOP.F	225	PROGRAM*	24/11	24/27 L	24/32	24/37		
LOOP.G	231	PROGRAM*	24/12	24/39 L	24/46	24/51		
LOOP.H	175	PROGRAM*	21/35 L	21/42				
LOOP.I	204	PROGRAM*	22/35 L	22/45				
LOOP.1	4	PROGRAM*	3/38 L	3/46				
LOOP.10	114	PROGRAM*	15/36 L	15/46				
LOOP.11	124	PROGRAM*	16/39 L	16/50				
LOOP.12	123	PROGRAM*	16/35 L	16/52				
LOOP.2	13	PROGRAM*	4/40 L	5/08	5/11	10/32	10/39	
LOOP.3	15	PROGRAM*	4/51 L	5/03				
LOOP.4	27	PROGRAM*	6/39 L	7/03	7/06			
LOOP.5	30	PROGRAM*	6/46 L	6/56				
LOOP.6	43	PROGRAM*	8/44 L	8/54	9/03	9/07		
LOOP.7	65	PROGRAM*	11/33 L	11/57				
LOOP.8	67	PROGRAM*	11/44 L	11/55				
LOOP.9	102	PROGRAM*	13/52 L	14/18				
MULT	131	PROGRAM*	2/29 E	17/28 L	18/21			
MULTART	152	PROGRAM*	2/30 E	19/29 L	20/16			
MULTC	171	PROGRAM*	2/31 E	21/24 L	21/43			
MULTNN	7	PROGRAM*	2/21 E	4/27 L	5/12	10/38		
MULTNNA	52	PROGRAM*	2/24 E	10/30 L	10/45			
MULTNR	0	PROGRAM*	2/20 E	3/24 L	3/47			
MULTNT	23	PROGRAM*	2/22 E	6/27 L	7/07			
MULTTN	36	PROGRAM*	2/23 E	8/27 L	9/08			
SUB	200	PROGRAM*	2/32 E	22/25 L	22/46			
TRANNN	62	PROGRAM*	2/25 E	11/23 L	12/07			

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      SUBROUTINE MISCAL(NPRNT)                                          MISCAL     2
C*****************************************************************     MISCAL     3
C*                                                                *     MISCAL     4
C*       SUBROUTINE FOR MISCELLANEOUS CALCULATIONS THAT DO NOT    *     MISCAL     5
C*       NATURALLY OCCUR ELSEWHERE BUT ARE DESIRED FOR OUTPUT,    *     MISCAL     6
C*       SUCH AS TABBING, PUNCHING, ETC., ETC.                    *     MISCAL     7
C*                                                                *     MISCAL     8
C*   INPUT ARGUMENTS                                              *     MISCAL     9
C*       NPRNT     COVARIANCE MATRIX PRINT INDICATOR.             *     MISCAL    10
C*                 0 = DO NOT PRINT MATRIX ON OUTPUT FILE.        *     MISCAL    11
C*                                                                *     MISCAL    12
C*****************************************************************     MISCAL    13
      DIMENSION CA(48)                                                  MISCAL    14
C  *                                                                    R         2
C  ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                    R         3
C  *                                                                    R         4
      COMMON TIME,TO,DTIME,DTCUT,DTOUT2,TMAX                            R         5
C  *                                                                    R         6
C  ***    R ARRAY SEGMENT 2 - DERIVATIVES.                              R         7
C  *                                                                    R         8
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,         R         9
     A       ZSPDOT,TSPDOT,                                             R        10
     P       VDOT,PDOT,RDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT                R        11
C  *                                                                    R        12
C  ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                          R        13
C  *                                                                    R        14
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,             R        15
     A       VB,PB,RB,YAPP,PHI,PSI,YSP                                  R        16
C  *                                                                    R        17
C  ***    R ARRAY SEGMENT 4 - PEF. VALUES FOR LOCAL LINEARIZATION.      R        18
C  *                                                                    R        19
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,    R        20
     A       THETAO,PSIAO,PHIAO,RCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,    R        21
     R       NO,VBASO                                                   R        22
      REAL   MO,LO,NO                                                   R        23
C  *                                                                    R        24
C  ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                 R        25
C  *                                                                    R        26
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,           R        27
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN               R        28
C  *                                                                    R        29
C  ***    R ARRAY SEGMENT 6 - GEOMETRY.                                 R        30
C  *                                                                    R        31
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                   R        32
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                             R        33
C  *                                                                    R        34
C  ***    R ARRAY SEGMENT 7 - CONSTANTS.                                R        35
C  *                                                                    R        36
      COMMON  OMEGAL,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,        R        37
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,           R        38
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,           R        39
     3       OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                      R        40
      REAL  KU,KW,KFRPM,KCDN,                                           R        41
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,            R        42
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,            R        43
     3       K1,K2,KY,KV                                               R        44
C  *                                                                    R        45
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      C  ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.      R          46
      C  *                                                                     R          47
   60       COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X1DWS,  R          48
     A             Y1DWS,VAMP,PSIAMP,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP,  R          49
     B             PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,       R          50
     C             SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,     R          51
     D             VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1,  R          52
   65        E      TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,        R          53
     F             ZRIASP                                                       R          54
      C  *                                                                     R          55
      C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                      R          56
      C  *                                                                     R          57
   70       COMMON THETAC,DFRFMOL,DCDNOL,DEOL,GAMMAGS,RANGE,VAIRC,              R          58
     1             DAOL,DROL                                                    R          59
      C  *                                                                     R          60
      C  ***    R ARRAY SEGMENT 10 - AERO DATA.                                R          61
      C  *                                                                     R          62
   75       COMMON XU,XW,XQ,XFRPM,XCDN,XPDIGV,XDE,ZU,ZW,ZC,ZFRPM,ZCDN,ZPDIGV,    R          63
     A             ZDE,MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE,                    R          64
     B              YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,                 R          65
     C              NDA,NDR                                                     R          66
        REAL   MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE                           R          67
   80   REAL  LV,LP,LR,LDA,LDR,NV,NP,NR,NDA,NDR                               R          68
      C  *                                                                     R          69
      C  ***    R ARRAY SEGMENT 11                                             R          70
      C  *                                                                     R          71
        COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA,               R          72
   85        1         ERY,ERPHI,ERPSI,YCOM,PHICOM,PSICOM                       R          73
      C  *                                                                     R          74
      C  ***    R ARRAY SEGMENT 12 - CONTROLS.                                 R          75
      C  *                                                                     R          76
        COMMON  DE,DT,DCDN,DED,DTD,DCDND,                                      R          77
   90        1         DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D       R          78
      C  *                                                                     R          79
      C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.       R          80
      C  *                                                                     R          81
        COMMON TABV1(6)                                                        R          82
   95   C  *                                                                   R          83
      C  ***    R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE L R          84
      C  *                                                                     R          85
        COMMON TABV2(10)                                                       R          86
      C  *                                                                     R          87
  100   C  ***    R ARRAY SEGMENT 15 - UNUSED                                  R          88
      C  *                                                                     R          89
      C  *                                                                     R          90
      C  ***    R ARRAY SEGMENT 16 - GDF RELATED STUFF                         R          91
      C  *                                                                     R          92
  105       COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR                R          93
      C  *                                                                     R          94
      C  ***    R ARRAY SEGMENT 17 - SHIP MOTION                               R          95
      C  *                                                                     R          96
        COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,                R          97
  110        1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT   R          98
        REAL KXS,KZS,KTS,KYS,KRS,KPS                                           R          99
      C  *                                                                     R         100
      C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.             R         101
      C  *                                                                     R         102
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      COMMON TABTC(10)                                                  R     103
      COMMON TRPMCL(10)                                                 R     104
      COMMON TCONOL(10)                                                 R     105
      COMMON TDENL(10)                                                  R     106
C     *                                                                 R     107
C     ***    R ARRAY SEGMENTS 24-25                                     R     108
C     *                                                                 R     109
      COMMON TABR(10)                                                   R     110
      COMMON TABRDOT(10)                                                R     111
C     *                                                                 R     112
C     ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AFRC DATA TABLES     R     113
C     *                                                                 R     114
      COMMON TXU(6)                                                     R     115
      COMMON TXW(6)                                                     R     116
      COMMON TXQ(6)                                                     R     117
      COMMON TXRPM(6)                                                   R     118
      COMMON TXCDN(6)                                                   R     119
      COMMON TXPIGV(6)                                                  R     120
      COMMON TXDE(6)                                                    R     121
      COMMON TZU(6)                                                     R     122
      COMMON TZW(6)                                                     R     123
      COMMON TZQ(6)                                                     R     124
      COMMON TZPPM(6)                                                   R     125
      COMMON TZCDN(6)                                                   R     126
      COMMON TZPIGV(6)                                                  R     127
      COMMON TZDE(6)                                                    R     128
      COMMON TMU(6)                                                     R     129
      COMMON TMW(6)                                                     R     130
      COMMON TMWD(6)                                                    R     131
      COMMON TMQ(6)                                                     R     132
      COMMON TMRPM(6)                                                   R     133
      COMMON TMCDN(6)                                                   R     134
      COMMON TMPIGV(6)                                                  R     135
      COMMON TMDE(6)                                                    R     136
C     *                                                                 R     137
C     ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIME R  138
C     *                                                                 R     139
      COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)            R     140
C     *                                                                 R     141
C     ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.              R     142
C     *                                                                 R     143
      COMMON SIGMA(50)                                                  R     144
      COMMON SIGMAXY(50)                                                R     145
C     *                                                                 R     146
C     ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES                    R     147
C     *                                                                 R     148
      COMMON VXX(5,5,3)                                                 R     149
      COMMON VYY(5,5,3)                                                 R     150
      COMMON VZZ(5,5,3)                                                 R     151
      COMMON SVXX(5,5,3)                                                R     152
      COMMON SVYY(5,5,3)                                                R     153
      COMMON SVZZ(5,5,3)                                                R     154
C     *                                                                 R     155
C     ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS          R     156
C     *                                                                 R     157
      COMMON  TKDEL(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),         R     158
     1        TKDEZ(6), TKDEM(6), TKDEDF(6), TKDEDT(6),                 R     159
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     2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),                R  160
     3        TKDTZ(6), TKDTA(6), TKDTDE(6), TKDTDT(6)                         R  161
C  *                                                                           R  162
C  ***    R ARRAY SEGMENTS 81-106                                             R  163
C  *                                                                           R  164
      COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),        R  165
     1       H(1,1),D(1,1),C(4,6),RL(4,4),VV(1,1),VU(1,1),VY(1,1),            R  166
     2       VYI(1,1),S(1,1),FE(1,1),QF(1,1),PE(1,1),PFD(1,1),                R  167
     3       KG(1,1),FXHAT(1,1),PXHAT(1,1),FXHATD(1,1),PX(1,1),               R  168
     4       CS(1,1)                                                          R  169
      REAL M1,M2,KG                                                           R  170
C  *                                                                           R  171
C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE REL      R  172
C  *                                                                           R  173
      COMMON  DFUR, DFWR, DFVX, DFVXD, DFVZ, DFVZD,                           R  174
     1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                            R  175
C  *                                                                           R  176
C  ***    R ARRAY SEGMENTS 108-119                                            R  177
C  *                                                                           R  178
      COMMON  TDFUR(6), TDFWR(6), TDFVX(6), TDFVXD(6), TDFVZ(6),              R  179
     1        TDFVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),            R  180
     2        TDTVZ(6), TDTVZD(6)                                             R  181
C *                                                                           R  182
C ***     R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES                 R  183
C *                                                                           R  184
      COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),                       R  185
     1        TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),                       R  186
     2        TNV(6), TNP(6), TNR(6), TNDA(6), TNDR(6)                        R  187
C *                                                                           R  188
C ***     R ARRAY SEGMENTS 135-139 - LONG. TERMS REQD FOR LAT/DIR CASE        R  189
C *                                                                           R  190
      COMMON  TAUB(10),TAWB(10),TXAPP(10),TZAPP(10),TXSP(10)                  R  191
C  *                                                                           R  192
C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS            R  193
C  *                                                                           R  194
      COMMON TDAIN(4), TDAOUT(4), TDRIN(4),TDROUT(4)                          R  195
C  ********************************************************************* C R  196
C  *                                                                           I    2
C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                              I    3
C  *                                                                           I    4
      COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NDAW,NDINIT       I    5
C  *                                                                           I    6
C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                             I    7
C  *                                                                           I    8
      COMMON/INTEGER/ INDX1(14)                                               I    9
C  *                                                                           I   10
C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                                  I   11
C  *                                                                           I   12
      COMMON/INTEGER/ INDX2(14)                                               I   13
C  *                                                                           I   14
C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                                I   15
C  *                                                                           I   16
      COMMON/INTEGER/ INDXPD,INDXF,INDXPEL,INDXPE,INDXPXD,INDXPX              I   17
C  ********************************************************************* C I   18
C*********************************************************************** MISCAL  17
C*                                                                       * MISCAL  18
C*       SIGMAS OF STATE VARIABLES AND OTHER TERMS.                      * MISCAL  19
```

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C*.                                                                    * MISCAL
C*********************************************************************** MISCAL
C  *                                                                     MISCAL
C  ***    STATE VARIABLES.                                              MISCAL
C  *                                                                     MISCAL
      DO 10 I=1,NPA                                                      MISCAL
      SIGMA(I)= SQRT(P(I,I))                                             MISCAL
      CA(I)   = 0.0                                                      MISCAL
10    CONTINUE                                                           MISCAL
      L = NPA                                                            MISCAL
      IF(NPRNT.EQ.0) GO TO 30                                            MISCAL
C  ***    PRODUCE REQUESTED PRINT.                                       MISCAL
      WRITE(6,2000) TIME                                                 MISCAL
2000  FORMAT(1H1,47X,27HCOVARIANCE MATRIX AT TIME =,F6.2,5H SEC.   //)   MISCAL
      DO 20 I=1,NPA                                                      MISCAL
      WRITE(6,2010) (P(I,J),J=1,NPA)                                     MISCAL
2010  FORMAT(1X,8E16.6)                                                  MISCAL
      WRITE(6,2020)                                                      MISCAL
2020  FORMAT(/)                                                          MISCAL
20    CONTINUE                                                           MISCAL
      WRITE(6,2030) (SIGMA(I),I=1,NPA)                                   MISCAL
2030  FORMAT(//35H SQUARE ROOT OF MAIN DIAGONAL TERMS   ,                MISCAL
     1      /(8E12.4))                                                   MISCAL
   30 CONTINUE                                                           MISCAL
C *                                                                      MISCAL
C ***     SIGMAS OF NON-LIMITED ROLL AND YAW CONTROL                     MISCAL
C *                                                                      MISCAL
C    ROLL                                                                MISCAL
      L       = L + 1                                                    MISCAL
      SIGMA(L)= SIGDAP                                                   MISCAL
C    YAW                                                                 MISCAL
      L       = L + 1                                                    MISCAL
      SIGMA(L)= SIGDRP                                                   MISCAL
C *                                                                      MISCAL
C ***     SIGMAS OF ROLL AND YAW CONTROL AFTER LIMITERS                  MISCAL
C *                                                                      MISCAL
C    ROLL                                                                MISCAL
      L       = L + 1                                                    MISCAL
      SIGMA(L) = SIGDA                                                   MISCAL
C    YAW                                                                 MISCAL
      L       = L + 1                                                    MISCAL
      SIGMA(L) = SIGDR                                                   MISCAL
C*********************************************************************** MISCAL
C*                        END OF SIGMA HACK                            * MISCAL
C*********************************************************************** MISCAL
C                                                                        MISCAL
C                                                                        MISCAL
      RETURN                                                             MISCAL
      END                                                                MISCAL
```

```
      SUBROUTINE PRNPLT(ROW,NLIST,NPRNT)                                PRNPLT
C*********************************************************************** PRNPLT
C*                                                                     * PRNPLT
C*        ROUTINE TO PRODUCE PLOT ON PRINTER (6600 DEPENDENT).         * PRNPLT
C*                                                                     * PRNPLT
C*   INPUT ARGUMENTS                                                   * PRNPLT
C*        ROW       SCRATCH ARRAY FOR READING DATA FILE.               * PRNPLT
C*        NLIST     FILE WHERE PLOTTING INSTRUCTIONS RESIDE.           * PRNPLT
C*        NPRNT     =0 IF INSTRUCTIONS ARE NOT TO BE PLAYED BACK ON    * PRNPLT
C*                  THE OUTPUT FILE.                                   * PRNPLT
C*                                                                     * PRNPLT
C*   DEFINITIONS                                                       * PRNPLT
C*        LINE      PLOTTING ARRAY.                                    * PRNPLT
C*        NPLOTS    NUMBER OF PLOTS TO BE PRODUCED.                    * PRNPLT
C*                                                                     * PRNPLT
C*   DEFINITIONS FOR PLOT DATA                                         * PRNPLT
C*        DELX      INCREMENTS PER INCH ON X AXIS.                     * PRNPLT
C*        DELY      INCREMENTS PER INCH ON Y AXIS.                     * PRNPLT
C*        LABELX    X AXIS LABEL.                                      * PRNPLT
C*        LABELY    Y AXIS LABEL.                                      * PRNPLT
C*        NCURVS    NUMBER OF CURVS TO BE PRODUCED ON THIS PLOT.       * PRNPLT
C*        STARTX    X VALUE AT AXIS INTERSECTION.                      * PRNPLT
C*        STARTY    Y VALUE AT AXIS INTERSECTION.                      * PRNPLT
C*        TITLE     PLOT TITLE.                                        * PRNPLT
C*        XORG      NUMBER OF INCHES FROM LEFT TO PLACE *STARTX*.      * PRNPLT
C*        YORG      NUMBER OF INCHES FROM TOP TO PLACE *STARTY*.       * PRNPLT
C*                                                                     * PRNPLT
C*   DEFINITIONS FOR CURVE DATA.                                       * PRNPLT
C*        ISYM      PLOTTING SYMBOL FOR THIS CURVE.                    * PRNPLT
C*        LEGEND    CURVE LEGEND NOTATION.                             * PRNPLT
C*        NCOLX     COLUMN ON DATA FILE WHERE X DATA RESIDE.           * PRNPLT
C*        NCOLY     COLUMN ON DATA FILE WHERE Y DATA RESIDE.           * PRNPLT
C*        NDATA     FILE WHERE DATA FOR X AND Y RESIDE.                * PRNPLT
C*        SCALEX    SCALE FACTOR FOR X DATA.                           * PRNPLT
C*        SCALEY    SCALE FACTOR FOR Y DATA.                           * PRNPLT
C*                                                                     * PRNPLT
C*********************************************************************** PRNPLT
      DIMENSION ROW(1),TITLE(24),LEGEND(4),LINE(7,36),LABELX(4),        PRNPLT
     A          LABELY(4),X(7)                                          PRNPLT
      IF(NLIST.NE.5) REWIND NLIST                                       PRNPLT
      READ(NLIST,1000) NPLOTS                                           PRNPLT
 1000 FORMAT(I5)                                                        PRNPLT
      IF(NPRNT.GT.0) WRITE(6,2000) NPLOTS                               PRNPLT
 2000 FORMAT(//5X,I5)                                                   PRNPLT
C                                                                     C PRNPLT
C**************              READ PLOT DATA              **************C PRNPLT
C                                                                     C PRNPLT
      DO 140 I=1,NPLOTS                                                 PRNPLT
      READ(NLIST,1010) TITLE                                            PRNPLT
 1010 FORMAT(8A10)                                                      PRNPLT
      IF(NPRNT.GT.0) WRITE(6,2010) TITLE                                PRNPLT
 2010 FORMAT(5X,8A10)                                                   PRNPLT
      IF(NPRNT.EQ.0) WRITE(6,30001)TITLE                                PRNPLT
30001 FORMAT(1H1////5X,8A10//5X,8A10//5X,8A10///)                       PRNPLT
      READ(NLIST,1020) NCURVS,XORG,YORG,DELX,DELY,STARTX,STARTY         PRNPLT
 1020 FORMAT(I5,5X,6E10.3)                                              PRNPLT
      IF(NPRNT.GT.0) WRITE(6,2020) NCURVS,XORG,YORG,DELX,DELY,STARTX,   PRNPLT
```

```
     1                                  STARTY
 2020 FORMAT(5X,I5,5X,6F10.4)
      READ(NLIST,1010) LABELX,LABELY
      IF(NPRNT.GT.0) WRITE(6,2010) LABELX,LABELY
      NLO          = IFIX(5.0*YORG) + 1
      NCO          = IFIX(10.0*XORG) + 1
C                                                                      C
C**************            PLOT X AND Y AXES            **************C
C                                                                      C
      DO 20 J=1,36
      DO 10 K=1,7
      LINE(K,J)    = 10H
 10   CONTINUE
 20   CONTINUE
      DO 30 K=1,7
      LINE(K,NLO) = 10H..........
 30   CONTINUE
      K            = (NCO + 9)/10
      L            = 10H
      J            = 10*K - NCO
      L            = L.AND.SHIFT(MASK(54),6*J)
      L            = L.OR.SHIFT(1R.,6*J)
      DO 40 J=1,36
      IF(J.NE.NLO) LINE(K,J) = L
 40   CONTINUE
C                                                                      C
C**************            READ AND PLOT CURVES         **************C
C                                                                      C
      DO 70 J=1,NCURVS
      READ(NLIST,1030) LEGEND,NDATA,NCOLX,NCOLY,ISYM,SCALEX,SCALEY
 1030 FORMAT(4A10,3I5,2X,R1,2X,2E10.3)
      IF(NPRNT.GT.0) WRITE(6,2030) LEGEND,NDATA,NCOLX,NCOLY,ISYM,SCALEX,
     1                                  SCALEY
 2030 FORMAT(5X,4A10,3I5,2X,R1,2X,2F12.5)
      IF(NPRNT.EQ.0) WRITE(6,30002) ISYM,LEGEND
 30002 FORMAT(60X,R1,5X,4A10)
      REWIND NDATA
      READ(NDATA) L,NCOL,K
      IF(K.EQ.0) GO TO 50
      READ(NDATA) (ROW(K),K=1,NCOL)
      L            = IFIX(ROW(NCOLX) + 0.001)
 50   XDUM1        = 10.0/DELX
      XDUM2        = 5.0/DELY
      IF(SCALEX.NE.0.0) XDUM1 = SCALEX*XDUM1
      IF(SCALEY.NE.0.0) XDUM2 = SCALEY*XDUM2
      DO 60 K=1,L
      READ(NDATA) (ROW(LL),LL=1,NCOL)
      NC           = NCO + IFIX(XDUM1*(ROW(NCOLX) - STARTX))
      NL           = NLO - IFIX(XDUM2*(ROW(NCOLY) - STARTY))
      IF(NC.LT.1.OR.NL.LT.1.OR.NC.GT.61.OR.NL.GT.36) GO TO 60
      LL           = (NC + 9)/10
      NC           = 10*LL - NC
      LINE(LL,NL) = LINE(LL,NL).AND.SHIFT(MASK(54),6*NC)
      LINE(LL,NL) = LINE(LL,NL).OR.SHIFT(ISYM,6*NC)
 60   CONTINUE
 70   CONTINUE
      IF(NPRNT.EQ.0) GO TO 100
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115             WRITE(6,30001) TITLE                                    PRNPLT   116
                DO 80 J=1,NCURVS                                        PRNPLT   117
                BACKSPACE NLIST                                         PRNPLT   118
80              CONTINUE                                                PRNPLT   119
                DO 90 J=1,NCURVS                                        PRNPLT   120
120             READ(NLIST,1040) LEGEND,ISYM                            PRNPLT   121
1040            FORMAT(4A10,17X,R1)                                     PRNPLT   122
                WRITE(6,30002) ISYM,LEGEND                              PRNPLT   123
90              CONTINUE                                                PRNPLT   124
100             WRITE(6,30003)                                          PRNPLT   125
125             30003 FORMAT(//)                                        PRNPLT   126
                C                                                     C PRNPLT   127
                C***************          PUT PLOT ON PRINTER          ***************C PRNPLT   128
                C                                                     C PRNPLT   129
                      Y           = STARTY + DELY*(YORG + 1.0)          PRNPLT   130
130                   K           = 0                                   PRNPLT   131
                      DO 120 J=1,36                                     PRNPLT   132
                      K           = K + 1                               PRNPLT   133
                      IF(K.GE.6) K = 1                                  PRNPLT   134
                       NC = 10H                                         PRNPLT   135
135                   IF(J.GE.14.AND.J.LE.17) NC = LABELY(J-13)         PRNPLT   136
                      IF(K.GT.1) GO TO 110                              PRNPLT   137
                      Y           = Y - DELY                            PRNPLT   138
                      WRITE(6,30004) NC,Y,(LINE(LL,J),LL=1,7)           PRNPLT   139
                30004 FORMAT(5X,A10,2X,F5.2,1X,6A10,A1)                 PRNPLT   140
140                   GO TO 120                                         PRNPLT   141
                110   WRITE(6,30005) NC,(LINE(LL,J),LL=1,7)             PRNPLT   142
                30005 FORMAT(5X,A10,8X,6A10,A1)                         PRNPLT   143
                120   CONTINUE                                          PRNPLT   144
                      X(1)        = STARTX - XORG*DELX                  PRNPLT   145
145                   DO 130 J=2,7                                      PRNPLT   146
                      X(J)        = X(J-1) + DELX                       PRNPLT   147
                130   CONTINUE                                          PRNPLT   148
                      WRITE(6,30006) X                                  PRNPLT   149
                30006 FORMAT(/21X,7(F4.1,6X)//)                         PRNPLT   150
150                   WRITE(6,30007) LABELX                             PRNPLT   151
                30007 FORMAT(34X,4A10)                                  PRNPLT   152
                      WRITE(6,30003)                                    PRNPLT   153
                140   CONTINUE                                          PRNPLT   154
                      RETURN                                            PRNPLT   155
155                   END                                               PRNPLT   156
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      SUBROUTINE PROP                                                   PROP
C  ******************************************************************** PROP
C  ***                                                                  PROP
C  ***    ROUTINE TO CALCULATE PERTUBATION EQNS AND PROPAGATE COVARIANCE PROP
C  ***                                                                  PROP
C  ******************************************************************** PROP
      DIMENSION  WK2(4,11), G2(11,11)                                   PROP
C  *                                                                    R
C  ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                    R
C  *                                                                    R
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                            R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 2 - DERIVATIVES.                              R
C  *                                                                    R
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,         R
     A       ZSPDOT,TSPDOT,                                             R
     B       VDOT,PBDOT,RBDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT              R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                          R
C  *                                                                    R
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,             R
     A        VB,PB,RB,YAPP,PHI,PSI,YSP                                 R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.      R
C  *                                                                    R
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,    R
     A       THETAAO,PSIAO,PHIAO,PCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,   R
     B       NO,VBASO                                                   R
      REAL   MO,LO,NO                                                   R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                 R
C  *                                                                    R
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,           R
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN               R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 6 - GEOMETRY.                                 R
C  *                                                                    R
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                   R
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                             R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 7 - CONSTANTS.                                R
C  *                                                                    R
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,        R
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,           R
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,           R
     3       OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                      R
      REAL  KU,KW,KFRPM,KCDN,                                           R
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,             R
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,             R
     3       K1,K2,KY,KV                                                R
C  *                                                                    R
C  ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.     R
C  *                                                                    R
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X1DWS, R
     A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWCD,PSIWOD,PSI3,PSISP, R
     B       PSI5,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,     R
     C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,   R
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      D       VMEAN,VP,VAW,WWIND,WMEAN,WP,WAW,WNSF,PSISS,PSISC,PSIST,TS1,   R        52
      F       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,         R        53
60    F       ZBIASP                                                        R        54
C     *                                                                     R        55
C     ***     R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                     R        56
C     *                                                                     R        57
      COMMON THETAC,QFRPMOL,QCONOL,QEOL,GAMMAGS,RANGE,VAIRC,                R        58
65   1        DAOL,DROL                                                     R        59
C     *                                                                     R        60
C     ***     R ARRAY SEGMENT 10 - AFPO DATA.                               R        61
C     *                                                                     R        62
      COMMON XU,XW,XQ,XFRPM,XCON,XPDIGV,XDE,ZU,ZW,ZC,ZFRPM,ZCON,ZPDIGV,      R        63
70   A        ZDE,MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE,                     R        64
     B         YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,                  R        65
     C         NDA,NDR                                                      R        66
      REAL    MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                         R        67
      REAL   LV,LP,LR,LDA,LDR,NV,NP,NR,NDA,NDR                             R        68
75    C     *                                                               R        69
C     ***     R ARRAY SEGMENT 11                                            R        70
C     *                                                                     R        71
      COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA,              R        72
     1         ERY,ERPHI,ERPS1,YCOM,PHICOM,PSICOM                           R        73
80    C     *                                                               R        74
C     ***     R ARRAY SEGMENT 12 - CONTROLS.                                R        75
C     *                                                                     R        76
      COMMON  DE,DT,DCON,DED,DTD,DCOND,                                     R        77
     1         DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D            R        78
85    C     *                                                               R        79
C     ***     R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.      R        80
C     *                                                                     R        81
      COMMON TABV1(6)                                                       R        82
C     *                                                                     R        83
90    C     ***     R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE L R 84
C     *                                                                     R        85
      COMMON TABV2(10)                                                      R        86
C     *                                                                     R        87
C     ***     R ARRAY SEGMENT 15 - UNUSED                                   R        88
95    C     *                                                               R        89
C     *                                                                     R        90
C     ***     R ARRAY SEGMENT 16 - GDF RELATED STUFF                        R        91
C     *                                                                     R        92
      COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR                   R        93
100   C     *                                                               R        94
C     ***     R ARRAY SEGMENT 17 - SHIP MOTION                              R        95
C     *                                                                     R        96
      COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,               R        97
     1        KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT        R        98
105    REAL KXS,KZS,KTS,KYS,KRS,KPS                                         R        99
C     *                                                                     R       100
C     ***     R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.            R       101
C     *                                                                     R       102
      COMMON TABTC(10)                                                      R       103
110   COMMON TRPMOL(10)                                                     R       104
      COMMON TCONOL(10)                                                     R       105
      COMMON TDEOL(10)                                                      R       106
C     *                                                                     R       107
C     ***     R ARRAY SEGMENTS 24-25                                        R       108
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C *
      COMMON TABR(10)
      COMMON TABRDOT(10)
C *
C ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AERO DATA TABLES
C *
      COMMON TXU(6)
      COMMON TXW(6)
      COMMON TXQ(6)
      COMMON TXRPM(6)
      COMMON TXCON(6)
      COMMON TXPIGV(6)
      COMMON TXDE(6)
      COMMON TZU(6)
      COMMON TZW(6)
      COMMON TZQ(6)
      COMMON TZRPM(6)
      COMMON TZCON(6)
      COMMON TZPIGV(6)
      COMMON TZDE(6)
      COMMON TMU(6)
      COMMON TMW(6)
      COMMON TMWD(6)
      COMMON TMQ(6)
      COMMON TMRPM(6)
      COMMON TMCON(6)
      COMMON TMPIGV(6)
      COMMON TMDE(6)
C *
C ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIME
C *
      COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)
C *
C ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.
C *
      COMMON SIGMA(50)
      COMMON SIGMAXY(50)
C *
C ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES
C *
      COMMON VXX(5,5,3)
      COMMON VYY(5,5,3)
      COMMON VZZ(5,5,3)
      COMMON SVXX(5,5,3)
      COMMON SVYY(5,5,3)
      COMMON SVZZ(5,5,3)
C *
C ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS
C *
      COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),
     1        TKDEZ(6), TKDEN(6), TKDEDE(6), TKDEDT(6),
     2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),
     3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)
C *
C ***    R ARRAY SEGMENTS 81-106
C *
      COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),
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                1       M(1,1),D(1,1),C(4,6),RL(4,4),W(1,1),VU(1,1),VY(1,1),          R         166
                2       VYI(1,1),S(1,1),FE(1,1),GE(1,1),PE(1,1),PED(1,1),             R         167
                3       KG(1,1),FXHAT(1,1),PXHAT(1,1),PXHATD(1,1),PX(1,1),            R         168
175             4       CS(1,1)                                                       R         169
                REAL M1,M2,KG                                                         R         170
          C  *                                                                        R         171
          C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE REL    R         172
          C  *                                                                        R         173
180             COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                         R         174
                1       DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                          R         175
          C  *                                                                        R         176
          C  ***    R ARRAY SEGMENTS 108-119                                          R         177
          C  *                                                                        R         178
185             COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),            R         179
                1       TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),          R         180
                2       TDTVZ(6), TDTVZD(6)                                           R         181
          C *                                                                         R         182
          C ***     R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES               R         183
190       C *                                                                         R         184
                COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),                     R         185
                1       TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),                     R         186
                2       TNV(6), TNP(6), TNR(6), TNDA(6), TNDR(6)                      R         187
          C *                                                                         R         188
195       C ***     R ARRAY SEGMENTS 135-139 - LONG. TERMS REQD FOR LAT/DIR CASE      R         189
          C *                                                                         R         190
                COMMON  TABUB(10),TABWB(10),TXAPP(10),TZAPP(10),TXSP(10)            R         191
          C  *                                                                        R         192
          C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS          R         193
200       C  *                                                                        R         194
                COMMON TDAIN(4), TDAOUT(4), TDRIN(4),TDROUT(4)                        R         195
          C  ********************************************************************* C R         196
          C  *                                                                       I           2
          C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                          I           3
205       C  *                                                                       I           4
                COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NOM,NGM,NPE,NPX,NOAW,NOINIT   I           5
          C  *                                                                       I           6
          C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                         I           7
          C  *                                                                       I           8
210             COMMON/INTEGER/ INDX1(14)                                           I           9
          C  *                                                                       I          10
          C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                              I          11
          C  *                                                                       I          12
                COMMON/INTEGER/ INDX2(14)                                           I          13
215       C  *                                                                       I          14
          C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                            I          15
          C  *                                                                       I          16
                COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX          I          17
          C   ********************************************************************* C I          18
220       C  *                                                                      INTEG       2
          C  ***    TEMPORARY INTEGRATION STORAGE.                                  INTEG       3
          C  ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2           INTEG       4
          C  *                                                                      INTEG       5
                COMMON/INTEG/ RI(2187),RT(2187)                                     INTEG       6
225       C  *                                                                      PROP       12
          C  ***    MISCELLANEOUS CALCULATIONS                                      PROP       13
          C  *                                                                      PROP       14
                COSTO = COS(THETA0)                                                 PROP       15
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      SINTO = SIN(THETAO)                                          PROP   16
      SINTA = SIN(THETAA)                                          PROP   17
      COSTA = COS(THETAA)                                          PROP   18
      SPHIA = SIN(PHIA)                                            PROP   19
      CPHIA = COS(PHIA)                                            PROP   20
      SPSIA = SIN(PSIA)                                            PROP   21
      CPSIA = COS(PSIA)                                            PROP   22
      TEMP1 = K1*TL1/TAUA                                          PROP   23
      TEMP2 = K2*TL2/TAUA                                          PROP   24
      TEMP3 = K1*KY*TL1/TAUA                                       PROP   25
      TEMP4 = 4.*K1*TL1/(TAUD*TAUA)                                PROP   26
      TEMP5 = B1 - TL1/TAUA                                        PROP   27
      TEMP6 = 4.*K2*TL2/(TAUD*TAUA)                                PROP   28
      TEMP7 = B2 - TL2/TAUA                                        PROP   29
      TEMP8 = SPHIA*SINTA*CPSIA - SPSIA*CPHIA                      PROP   30
      TEMP9 = SPSIA*SINTA*SPHIA + CPHIA*CPSIA                      PROP   31
      TEMPO = SPHIA*COSTA                                          PROP   32
C *                                                                PROP   33
C ***     F1 MATRIX                                                PROP   34
C *                                                                PROP   35
      F1(1,1) = YV                                                 PROP   36
      F1(1,2) = WO + YP                                            PROP   37
      F1(1,3) = YR - UO                                            PROP   38
      F1(1,4) = G*COSTO + YDA*TEMP1*GAINDA                         PROP   39
      F1(1,5) = YDR*TEMP2*GAINDR                                   PROP   40
      F1(1,6) = YDA*TEMP3*GAINDA                                   PROP   41
      F1(2,1) = LV                                                 PROP   42
      F1(2,2) = LP                                                 PROP   43
      F1(2,3) = LR                                                 PROP   44
      F1(2,4) = LDA*TEMP1*GAINDA                                   PROP   45
      F1(2,5) = LDR*TEMP2*GAINDR                                   PROP   46
      F1(2,6) = LDA*TEMP3*GAINDA                                   PROP   47
      F1(3,1) = NV                                                 PROP   48
      F1(3,2) = NP                                                 PROP   49
      F1(3,3) = NR                                                 PROP   50
      F1(3,4) = NDA*TEMP1*GAINDA                                   PROP   51
      F1(3,5) = NDR*TEMP2*GAINDR                                   PROP   52
      F1(3,6) = NDA*TEMP3*GAINDA                                   PROP   53
      F1(4,2) = 1.                                                 PROP   54
      F1(4,3) = TAN(THETAO)                                        PROP   55
      F1(5,3) = 1./COSTO                                           PROP   56
      F1(6,1) = 1.                                                 PROP   57
      F1(6,5) = UO*COSTO + WO*SINTO                                PROP   58
C *                                                                PROP   59
C ***     G1 MATRIX                                                PROP   60
C *                                                                PROP   61
      G1(1,1) =  YDA * TEMP4 * GAINDA                              PROP   62
      G1(1,2) =  YDA * TEMP5 * GAINDA                              PROP   63
      G1(1,3) =  YDR * TEMP6 * GAINDR                              PROP   64
      G1(1,4) =  YDR * TEMP7 * GAINDR                              PROP   65
      G1(2,1) =  LDA * TEMP4 * GAINDA                              PROP   66
      G1(2,2) =  LDA * TEMP5 * GAINDA                              PROP   67
      G1(2,3) =  LDR * TEMP6 * GAINDR                              PROP   68
      G1(2,4) =  LDR * TEMP7 * GAINDR                              PROP   69
      G1(3,1) =  NDA * TEMP4 * GAINDA                              PROP   70
      G1(3,2) =  NDA * TEMP5 * GAINDA                              PROP   71
      G1(3,3) =  NDR * TEMP6 * GAINDR                              PROP   72
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                G1(3,4) =  NDR * TEMP7 * GAINDR                          PROP      73
              C *                                                        PROP      74
              C ***     GAMMA MATRIX                                     PROP      75
              C *                                                        PROP      76
  290               GAMMA(1,1) =  -YV                                    PROP      77
                    GAMMA(1,2) =  -YV * TEMP8                            PROP      78
                    GAMMA(1,4) =  -YV * TEMP9                            PROP      79
                    GAMMA(1,6) =  -YV * TEMPO                            PROP      80
                    GAMMA(2,1) =  -LV                                    PROP      81
  295               GAMMA(2,2) =  -LV * TEMP8                            PROP      82
                    GAMMA(2,4) =  -LV * TEMP9                            PROP      83
                    GAMMA(2,6) =  -LV * TEMPO                            PROP      84
                    GAMMA(3,1) = -NV                                     PROP      85
                    GAMMA(3,2) = -NV * TEMP8                             PROP      86
  300               GAMMA(3,4) = -NV * TEMP9                             PROP      87
                    GAMMA(3,6) = -NV * TEMPO                             PROP      88
              C *                                                        PROP      89
              C ***     A MATRIX                                         PROP      90
              C *                                                        PROP      91
  305               A(1,1) =  -OMEGAV                                    PROP      92
                    A(2,3) =  1.                                         PROP      93
                    A(3,2) =  -WNSF*WNSF                                 PROP      94
                    A(3,3) =  -0.8*WNSF                                  PROP      95
                    A(4,5) =  1.                                         PROP      96
  310               A(5,4) =  -WNSF*WNSF                                 PROP      97
                    A(5,5) =  -0.8*WNSF                                  PROP      98
                    A(6,7) =  1.                                         PROP      99
                    A(7,6) =  -WNSF*WNSF                                 PROP     100
                    A(7,7) =  -0.8*WNSF                                  PROP     101
  315           C *                                                      PROP     102
              C ***     B MATRIX                                         PROP     103
              C *                                                        PROP     104
                    B(1,1) =  SQRT(KV)                                   PROP     105
                    B(3,2) =  TR1*SIGMAVX                                PROP     106
  320               B(5,3) =  TR1*SIGMAVY                                PROP     107
                    B(7,4) =  TR1*SIGMAVZ                                PROP     108
              C *                                                        PROP     109
              C ***     C MATRIX                                         PROP     110
              C *                                                        PROP     111
  325               C(1,4) = -1.                                         PROP     112
                    C(1,6) = -KY                                         PROP     113
                    C(2,4) =  K1/TAUA                                    PROP     114
                    C(2,6) =  K1*KY/TAUA                                 PROP     115
                    C(3,5) = -1.                                         PROP     116
  330               C(4,5) =  K2/TAUA                                    PROP     117
              C *                                                        PROP     118
              C ***     RL MATRIX                                        PROP     119
              C *                                                        PROP     120
                    RL(1,1) =  -2./TAUD                                  PROP     121
  335               RL(2,1) =  4.*K1/(TAUD*TAUA)                         PROP     122
                    RL(2,2) =  -1./TAUA                                  PROP     123
                    RL(3,3) =  -2./TAUD                                  PROP     124
                    RL(4,3) =  4.*K2/(TAUD*TAUA)                         PROP     125
                    RL(4,4) =  -1./TAUA                                  PROP     126
  340           C *                                                      PROP     127
              C ***     F MATRIX                                         PROP     128
              C *                                                        PROP     129
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                CALL LAYIN(F,1,1,NPA,F1,6,6,0)                                  PROP      130
                CALL LAYIN(F,1,7,NPA,GAMMA,6,7,0)                               PROP      131
345             CALL LAYIN(F,1,14,NPA,G1,6,4,0)                                 PROP      132
                CALL LAYIN(F,7,7,NPA,A,7,7,0)                                   PROP      133
                CALL LAYIN(F,14,1,NPA,C,4,6,0)                                  PROP      134
                CALL LAYIN(F,14,14,NPA,PL,4,4,0)                                PROP      135
              C *                                                               PROP      136
350           C ***     GM MATRIX                                               PROP      137
              C *                                                               PROP      138
                CALL LAYIN(GM,1,1,NGM,R,7,4,0)                                  PROP      139
              C *                                                               PROP      140
              C ***     GM MATRIX                                               PROP      141
355           C *                                                               PROP      142
                GM(1,1)= 1.33333                                                PROP      143
                GM(2,2)= 1.                                                     PROP      144
                GM(3,3)= 1.                                                     PROP      145
                GM(4,4)= 1.                                                     PROP      146
360           C                                                                 PROP      147
              C  ******************          PROPAGATE COVARIANCE          ************ PROP      148
              C                                                                 PROP      149
                CALL MULTABT(GM,NOM,NOM,GM,NGM,NOM,WK2)                         PROP      150
                CALL MULT(GM,NGM,NOM,WK2,NOM,NGM,G2)                            PROP      151
365             IF(ICEES.EQ.1.AND.NOINIT.EQ.0)                                  PROP      152
               *   CALL SOLVP(F,G2,NPA,NGM,P,PDOT,R1,RT)                        PROP      153
                CALL MULTNN(F,P,PDOT,NPA)                                       PROP      154
                CALL ADDTR(PDOT,NPA)                                            PROP      155
                CALL ADDNM(PDOT,G2,PDOT,NPA,NGM)                                PROP      156
370             RETURN                                                          PROP      157
                END                                                             PROP      158
```

```
      SUBROUTINE ROTATE(X,Y,ANG,IT,XR,YR)                                ROTATE
C*********************************************************************** ROTATE
C*                                                                     * ROTATE
C*        ROUTINE TO ROTATE AND TRANSFORM TO ANOTHER COORDINATE SYSTEM * ROTATE
C*                                                                     * ROTATE
C*    INPUT ARGUMENTS                                                  * ROTATE
C*        X      - X COORDINATE                                        * ROTATE
C*        Y      - Y COORDINATE                                        * ROTATE
C*        ANG    - ANGLE OF ROTATION                                   * ROTATE
C*        IT     - SWITCH FOR CALCULATING TRANSFORMATION DELTAS        * ROTATE
C*                 IT - NEGATIVE:  NO TRANSFORMATION                   * ROTATE
C*                 IT - ZERO:      CALCULATE TRANSFORMATION DELTAS     * ROTATE
C*                 IT - POSITIVE:  USE PREVIOUS DELTAS                 * ROTATE
C*                                                                     * ROTATE
C*    OUTPUT ARGUMENTS                                                 * ROTATE
C*        XR     - X COORDINATE AFTER ROTATION AND TRANSFORMATION      * ROTATE
C*        YR     - Y COORDINATE AFTER ROTATION AND TRANSFORMATION      * ROTATE
C*                                                                     * ROTATE
C*********************************************************************** ROTATE
      RAD     = ANG*0.01745329                                           ROTATE
      SINANG  = SIN(RAD)                                                 ROTATE
      COSANG  = COS(RAD)                                                 ROTATE
      IF (IT .GT. 0) GO TO 50                                            ROTATE
      DX      = 0.0                                                      ROTATE
      DY      = 0.0                                                      ROTATE
      IF (IT .EQ. 0) DX = X - (X*COSANG - Y*SINANG)                      ROTATE
      IF (IT .EQ. 0) DY = Y - (X*SINANG + Y*COSANG)                      ROTATE
   50 CONTINUE                                                           ROTATE
      XR      = X*COSANG - Y*SINANG + DX                                 ROTATE
      YR      = X*SINANG + Y*COSANG + DY                                 ROTATE
      RETURN                                                             ROTATE
      END                                                                ROTATE
```

```
      SUBROUTINE RUNGE                                                  RUNGE
C     ******************************************************************* RUNGE
C     ***                                                               RUNGE
C     ***    ROUTINE TO PERFORM FOURTH ORDER RUNGE-KUTTA INTEGRATION.   RUNGE
C     ***                                                               RUNGE
C     ******************************************************************* RUNGE
C     *                                                                 R2
C     ***    REAL VARIABLES (PROBLEM DEPENDENT).                        R2
C     *                                                                 R2
      COMMON R(6)                                                       R2
C     *                                                                 R2
C     ***    INTEGRATION VARIABLES (LOCATIONS ARE PROBLEM DEPENDENT).   R2
C     *                                                                 R2
      EQUIVALENCE (TI,R(1)),(TO,R(2)),(DT,R(3)),(DTOUT,R(4)),           R2
     A            (DTOUT2,R(5)),(TMAX,R(6))                             R2
C     *                                                                 I
C     ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                     I
C     *                                                                 I
      COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NOAW,NOINIT I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                    I
C     *                                                                 I
      COMMON/INTEGER/ INDX1(14)                                         I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 5 - STATE INDICES.                         I
C     *                                                                 I
      COMMON/INTEGER/ INDX2(14)                                         I
C     *                                                                 I
C     ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                       I
C     *                                                                 I
      COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX        I
C     ******************************************************************* C I
C     *                                                                 INTEG
C     ***    TEMPORARY INTEGRATION STORAGE.                             INTEG
C     ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2      INTEG
C     *                                                                 INTEG
      COMMON/INTEG/ RI(2187),RT(2187)                                   INTEG
C     *                                                                 RUNGE
C     ***    COMPLETE FIRST STAGE AT THIS INTEGRATION STEP.             RUNGE
C     *                                                                 RUNGE
      TEMP1       = 0.1666666667*DT                                     RUNGE
C     ***    STATES.                                                    RUNGE
      DO 10 I=1,NSTATES                                                 RUNGE
      RI(I)       = R(INDX2(I))                                         RUNGE
      RT(I)       = RI(I) + TEMP1*R(INDX1(I))                           RUNGE
   10 CONTINUE                                                          RUNGE
C     ***    P.                                                         RUNGE
      NL1 =  NSTATES + 1                                                RUNGE
      NU1 =  NSTATES + NPA * NPA                                        RUNGE
      I1          = INDXPD                                              RUNGE
      I2          = INDXP                                               RUNGE
      DO 20 I=NL1,NU1                                                   RUNGE
      RI(I)       = R(I2)                                               RUNGE
      RT(I)       = RI(I) + TEMP1*R(I1)                                 RUNGE
      I1          = I1 + 1                                              RUNGE
      I2          = I2 + 1                                              RUNGE
   20 CONTINUE                                                          RUNGE
```

```
      C  ***    PE.
            NL2          = NU1 + 1
            NU2          = NU1 + NPE * NPE
            I1           = INDXPED
            I2           = INDXPE
            DO 21 I=NL2,NU2
            RI(I)        = R(I2)
            RT(I)        = RI(I) + TEMP1*R(I1)
            I1           = I1 + 1
            I2           = I2 + 1
      21    CONTINUE
      C  ***    PX.
            NL3          = NU2 + 1
            NEQU         = NU2 + NPX * NPX
            I1           = INDXPXD
            I2           = INDXPX
            DO 22 I=NL3,NEQU
            RI(I)        = R(I2)
            RT(I)        = RI(I) + TEMP1*R(I1)
            I1           = I1 + 1
            I2           = I2 + 1
      22    CONTINUE
      C  *
      C  ***    COMPLETE INTEGRATION AT THIS INTEGRATION STEP.
      C  *
            TEMP1        = DT/3.0
            TEMP2        = 0.5*DT
            DO 70 IC=1,3
            TI           = TO + TEMP2
      C  ***    STATES.
            DO 30 I=1,NSTATES
            R(INDX2(I)) = RI(I) + TEMP2*R(INDX1(I))
      30    CONTINUE
      C  ***    P.
            I1           = INDXPD
            I2           = INDXP
            DO 40 I=NL1,NU1
            R(I2)        = RI(I) + TEMP2*R(I1)
            I1           = I1 + 1
            I2           = I2 + 1
      40    CONTINUE
      C  ***    PE.
            I1           = INDXPED
            I2           = INDXPE
            DO 41 I=NL2,NU2
            R(I2)        = RI(I) + TEMP2*R(I1)
            I1           = I1 + 1
            I2           = I2 + 1
      41    CONTINUE
      C  ***    PX.
            I1           = INDXPXD
            I2           = INDXPX
            DO 42 I=NL3,NEQU
            R(I2)        = RI(I) + TEMP2*R(I1)
            I1           = I1 + 1
            I2           = I2 + 1
      42    CONTINUE
```

```
      CALL DEQU                                                          RUNGE   88
      CALL PROP                                                          RUNGE   89
C ***    STATES.                                                         RUNGE   90
      DO 50 I=1,NSTATES                                                  RUNGE   91
      RT(I)        = RT(I) + TEMP1*R(INDX1(I))                           RUNGE   92
50    CONTINUE                                                           RUNGE   93
C ***    P.                                                              RUNGE   94
      I1           = INDXPD                                              RUNGE   95
      DO 60 I=NL1,NU1                                                    RUNGE   96
      RT(I)        = RT(I) + TEMP1*R(I1)                                 RUNGE   97
      I1           = I1 + 1                                              RUNGE   98
60    CONTINUE                                                           RUNGE   99
C ***    PE.                                                             RUNGE  100
      I1           = INDXPED                                             RUNGE  101
      DO 61 I=NL2,NU2                                                    RUNGE  102
      RT(I)        = RT(I) + TEMP1*R(I1)                                 RUNGE  103
      I1           = I1 + 1                                              RUNGE  104
61    CONTINUE                                                           RUNGE  105
C ***    PX.                                                             RUNGE  106
      I1           = INDXPXD                                             RUNGE  107
      DO 62 I=NL3,NEQU                                                   RUNGE  108
      RT(I)        = RT(I) + TEMP1*R(I1)                                 RUNGE  109
      I1           = I1 + 1                                              RUNGE  110
62    CONTINUE                                                           RUNGE  111
      IF(IC.NE.2) GO TO 70                                               RUNGE  112
      TEMP1        = DT/6.0                                              RUNGE  113
      TEMP2        = DT                                                  RUNGE  114
70    CONTINUE                                                           RUNGE  115
C ***    STATES.                                                         RUNGE  116
      DO 80 I=1,NSTATES                                                  RUNGE  117
      R(INDX2(I)) = RT(I)                                                RUNGE  118
80    CONTINUE                                                           RUNGE  119
C ***    P.                                                              RUNGE  120
      I2           = INDXP                                               RUNGE  121
      DO 90 I=NL1,NU1                                                    RUNGE  122
      R(I2)        = RT(I)                                               RUNGE  123
      I2           = I2 + 1                                              RUNGE  124
90    CONTINUE                                                           RUNGE  125
C ***    PE.                                                             RUNGE  126
      I2           = INDXPE                                              RUNGE  127
      DO 91 I=NL2,NU2                                                    RUNGE  128
      R(I2)        = RT(I)                                               RUNGE  129
      I2           = I2 + 1                                              RUNGE  130
91    CONTINUE                                                           RUNGE  131
C ***    PX.                                                             RUNGE  132
      I2           = INDXPX                                              RUNGE  133
      DO 92 I=NL3,NEQU                                                   RUNGE  134
      R(I2)        = RT(I)                                               RUNGE  135
      I2           = I2 + 1                                              RUNGE  136
92    CONTINUE                                                           RUNGE  137
C *                                                                      RUNGE  138
C ***    GENERATE DERIVATIVES AND STATES FOR NEXT INTEGRATION STEP.      RUNGE  139
C *                                                                      RUNGE  140
      TO           = TO + DT                                             RUNGE  141
      ICFES        = 0                                                   RUNGE  142
      CALL DEQU                                                          RUNGE  143
      CALL PROP                                                          RUNGE  144
```

```
      ICFFS      = 2                                          RUNGF    145
      RETURN                                                  RUNGE    146
      END                                                     RUNGE    147
```

```
      SUBROUTINE SETUP(INT)                                                SETUP
C*********************************************************************** SETUP
C*                                                                     * SETUP
C*        ROUTINE TO INITIALIZE THE INTEGRATORS AND PERFORM ONE TIME   * SETUP
C*        ONLY CALCULATIONS.                                           * SETUP
C*                                                                     * SETUP
C*   INPUT ARGUMENTS                                                   * SETUP
C*        INT        INTEGRATION OPTION.                                * SETUP
C*                   1 = 4 TH ORDER RUNGE-KUTTA.                       * SETUP
C*                   2 = 3 RD ORDER RUNGE-KUTTA.                       * SETUP
C*                   3 = 2 ND ORDER ADAMS.                             * SETUP
C*                                                                     * SETUP
C*********************************************************************** SETUP
      DIMENSION R(1)                                                     SETUP
C  *                                                                     R
C  ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                     R
C  *                                                                     R
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                             R
C  *                                                                     R
C  ***    R ARRAY SEGMENT 2 - DERIVATIVES.                               R
C  *                                                                     R
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,          R
     A       ZSPDOT,TSPDOT,                                              R
     B       VDOT,PBDOT,RBDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT               R
C  *                                                                     R
C  ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                           R
C  *                                                                     R
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,              R
     A        VB,PB,RB,YAPP,PHI,PSI,YSP                                  R
C  *                                                                     R
C  ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.       R
C  *                                                                     R
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,     R
     A       THETAAO,PSIAO,PHIAO,RCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,    R
     B       NO,VBASO                                                    R
      REAL   MO,LO,NO                                                    R
C  *                                                                     R
C  ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                  R
C  *                                                                     R
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,            R
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN                R
C  *                                                                     R
C  ***    R ARRAY SEGMENT 6 - GEOMETRY.                                  R
C  *                                                                     R
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                    R
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                              R
C  *                                                                     R
C  ***    R ARRAY SEGMENT 7 - CONSTANTS.                                 R
C  *                                                                     R
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,         R
     1        KDEU,KDEW,KDEC,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,            R
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,            R
     3       OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                       R
      REAL  KU,KW,KFRPM,KCDN,                                            R
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,              R
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,              R
     3       K1,K2,KY,KV                                                 R
```

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      C  *                                                                  R          45
      C  ***    P ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.   R          46
   60 C  *                                                                  P          47
         COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X1DWS,  R          48
        A       Y1DWS,VAPB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP,  R          49
        B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,       R          50
        C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,     R          51
   65   D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1,  R          52
        E       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,        R          53
        F       Z8IASP                                                       R          54
      C  *                                                                  R          55
      C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                   R          56
   70 C  *                                                                  R          57
         COMMON THETAC,DFRPMOL,DCDNOL,DEOL,GAMMAGS,RANGE,VAIRC,             R          58
        1       DAOL,DROL                                                    R          59
      C  *                                                                  R          60
      C  ***    R ARRAY SEGMENT 10 - AERO DATA.                             R          61
   75 C  *                                                                  R          62
         COMMON XU,XW,XQ,XFRPM,XCDN,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCDN,ZPDIGV,   R          63
        A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE,                    R          64
        B        YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,                 R          65
        C        NDA,NDR                                                     R          66
         REAL   MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                        R          67
   80    REAL   LV,LP,LR,LDA,LDR,NV,NP,NR,NDA,NDR                           R          68
      C  *                                                                  R          69
      C  ***    R ARRAY SEGMENT 11                                          R          70
      C  *                                                                  R          71
         COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA,           R          72
   85   1        ERY,ERPHI,ERPSI,YCOM,PHICOM,PSICOM                         R          73
      C  *                                                                  R          74
      C  ***    R ARRAY SEGMENT 12 - CONTROLS.                              R          75
      C  *                                                                  R          76
         COMMON  DE,DT,DCDN,DED,DTD,DCDND,                                  R          77
   90   1        DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D          R          78
      C  *                                                                  R          79
      C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.    R          80
      C  *                                                                  P          81
   95    COMMON TABV1(6)                                                    R          82
      C  *                                                                  R          83
      C  ***    R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE L R       84
      C  *                                                                  R          85
         COMMON TABV2(10)                                                   R          86
  100 C  *                                                                  R          87
      C  ***    R ARRAY SEGMENT 15 - UNUSED                                 R          88
      C  *                                                                  R          89
      C  *                                                                  R          90
      C  ***    R ARRAY SEGMENT 16 - GDF RELATED STUFF                      R          91
  105 C  *                                                                  R          92
         COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR                R          93
      C  *                                                                  R          94
      C  ***    R ARRAY SEGMENT 17 - SHIP MOTION                            R          95
      C  *                                                                  R          96
  110    COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,            R          97
        1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT      R          98
         REAL KXS,KZS,KTS,KYS,KRS,KPS                                       R          99
      C  *                                                                  R         100
      C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.          R         101
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      C .*                                                              R     102
            COMMON TARTC(10)                                            R     103
            COMMON TRPPCL(10)                                           R     104
            COMMON TCONCL(10)                                           R     105
            COMMON TDEOL(10)                                            R     106
      C  *                                                              R     107
      C  ***    R ARRAY SEGMENTS 24-25                                  R     108
      C  *                                                              R     109
            COMMON TABR(10)                                             R     110
            COMMON TABRDGT(10)                                          R     111
      C  *                                                              R     112
      C  ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AERO DATA TABLES  R     113
      C  *                                                              R     114
            COMMON TXU(6)                                               R     115
            COMMON TXW(6)                                               R     116
            COMMON TXQ(6)                                               R     117
            COMMON TXPPM(6)                                             R     118
            COMMON TXCDN(6)                                             R     119
            COMMON TXPIGV(6)                                            R     120
            COMMON TXDE(6)                                              R     121
            COMMON TZU(6)                                               R     122
            COMMON TZW(6)                                               R     123
            COMMON TZQ(6)                                               R     124
            COMMON TZRPM(6)                                             R     125
            COMMON TZCDN(6)                                             R     126
            COMMON TZPIGV(6)                                            R     127
            COMMON TZDE(6)                                              R     128
            COMMON TMU(6)                                               R     129
            COMMON TMW(6)                                               R     130
            COMMON TMWD(6)                                              R     131
            COMMON TMQ(6)                                               R     132
            COMMON TMRPM(6)                                             R     133
            COMMON TMCDN(6)                                             R     134
            COMMON TMPIGV(6)                                            R     135
            COMMON TMDE(6)                                              R     136
      C  *                                                              R     137
      C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIME R     138
      C  *                                                              R     139
            COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)      R     140
      C  *                                                              R     141
      C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.           R     142
      C  *                                                              R     143
            COMMON SIGMA(50)                                            R     144
            COMMON SIGMAXY(50)                                          R     145
      C  *                                                              P     146
      C  ***    P ARRAY SEGMENTS 57-62 - AIRWAKE TABLES                 R     147
      C  *                                                              R     148
            COMMON VXX(5,5,3)                                           R     149
            COMMON VYY(5,5,3)                                           R     150
            COMMON VZZ(5,5,3)                                           R     151
            COMMON SVXX(5,5,3)                                          R     152
            COMMON SVYY(5,5,3)                                          R     153
            COMMON SVZZ(5,5,3)                                          R     154
      C  *                                                              R     155
      C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS       R     156
      C  *                                                              R     157
            COMMON TKDEL(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),    R     158
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                     1        TKDEZ(6), TKDEN(6), TKDEDF(6), TKDEDT(6),                    R        159
                     2        TKDTU(6), TKDTW(6), TKDTO(6), TKDTT(6), TKDTX(6),            R        160
                     3        TKDTZ(6), TKDTN(6), TKDIDE(6), TKDIDT(6)                     R        161
175            C  *                                                                        R        162
               C  ***    R ARRAY SEGMENTS 81-106                                           R        163
               C  *                                                                        R        164
                    COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),      R        165
                     1       H(1,1),D(1,1),C(4,6),RL(4,4),W(1,1),VU(1,1),VY(1,1),        R        166
180                  2       VYI(1,1),S(1,1),FE(1,1),QE(1,1),PE(1,1),PED(1,1),           R        167
                     3       KG(1,1),FXHAT(1,1),PXHAT(1,1),PXHATD(1,1),PX(1,1),          R        168
                     4       CS(1,1)                                                     R        169
                    REAL M1,M2,KG                                                        R        170
               C  *                                                                        R        171
185            C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE REL   R        172
               C  *                                                                        R        173
                    COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                        R        174
                     1       DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                        R        175
               C  *                                                                        R        176
190            C  ***    R ARRAY SEGMENTS 108-119                                        R        177
               C  *                                                                        R        178
                    COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),           R        179
                     1       TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),        R        180
                     2       TDTVZ(6), TDTVZD(6)                                         R        181
195            C  *                                                                        R        182
               C  ***    R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES              R        183
               C  *                                                                        R        184
                    COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),                    R        185
                     1       TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),                   R        186
200                  2       TNV(6), TNP(6), TNR(6), TNDA(6), TNDR(6)                    R        187
               C  *                                                                        R        188
               C  ***    R ARRAY SEGMENTS 135-139 - LONG. TERMS REQD FOR LAT/DIR CASE     R        189
               C  *                                                                        R        190
                    COMMON  TABUB(10),TABWB(10),TXAPP(10),TZAPP(10),TXSP(10)             R        191
205            C  *                                                                        R        192
               C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS        R        193
               C  *                                                                        R        194
                    COMMON TDAIN(4), TDAOUT(4), TDRIN(4),TDROUT(4)                       R        195
               C  ********************************************************************* C R        196
210            C  *                                                                        I          2
               C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                          I          3
               C  *                                                                        I          4
                    COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NDAW,NDINIT    I          5
               C  *                                                                        I          6
215            C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                         I          7
               C  *                                                                        I          8
                    COMMON/INTEGER/ INDX1(14)                                            I          9
               C  *                                                                        I         10
               C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                              I         11
220            C  *                                                                        I         12
                    COMMON/INTEGER/ INDX2(14)                                            I         13
               C  *                                                                        I         14
               C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                            I         15
               C  *                                                                        I         16
225                 COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX           I         17
               C  ********************************************************************* C I         18
               C  *                                                                      INTEG       2
               C  ***    TEMPORARY INTEGRATION STORAGE.                                  INTEG       3
```

```
      C  ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2          INTEG      4
230   C  *                                                                     INTEG      5
         COMMON/INTEG/ RI(2187),PT(2187)                                       INTEG      6
      C  *                                                                     SETUP     19
      C  ***    R ARRAY EQUIVALENCE STATEMENT (PROBLEM DEPENDENT).             SETUP     20
      C  *                                                                     SETUP     21
235      EQUIVALENCE (R(1),TIME)                                               SETUP     22
      C                                                                     C  SETUP     23
      C***************          WIND CALCULATIONS          ***************C  SETUP     24
      C                                                                     C  SETUP     25
      C  *                                                                     SETUP     26
240   C  ***    EARTH AXIS COMPONENTS OF AMBIENT WIND.                         SETUP     27
      C  *                                                                     SETUP     28
         X1DWA    = VAMB*COS(PSIAMB)                                           SETUP     29
         Y1DWA    = VAMB*SIN(PSIAMB)                                           SETUP     30
      C  *                                                                     SETUP     31
245   C  ***    EARTH AXIS COMPONENTS OF SHIP RELATIVE WIND.                   SETUP     32
      C  *                                                                     SETUP     33
         X1DWS    = V5*COS(PSI5 - 3.14159)                                     SETUP     34
         Y1DWS    = V5*SIN(PSI5 - 3.14159)                                     SETUP     35
      C  *                                                                     SETUP     36
250   C  ***    WIND OVER DECK.                                                SETUP     37
      C  *                                                                     SETUP     38
         VWOD     = SQRT((X1DWA + X1DWS)**2 + (Y1DWA + Y1DWS)**2)              SETUP     39
         PSIWOD   = 0.0                                                        SETUP     40
         XDUM     = X1DWA + X1DWS + Y1DWA + Y1DWS                              SETUP     41
255      IF(XDUM.NE.0.0) PSIWOD = ATAN2(Y1DWA+Y1DWS,X1DWA+X1DWS)               SETUP     42
      C  *                                                                     SETUP     43
      C  ***    ORIENTATION OF SHIP WIND AXIS SYSTEM.                          SETUP     44
      C  *                                                                     SETUP     45
         PSI3     = PSIWOD - 3.14159                                           SETUP     46
260   C  ***    TRANSFORMATION ANGLES.                                         SETUP     47
         PSISP    = PSI3 - PSI5                                                SETUP     48
         TWOPI = 2.0*3.14159                                                   SETUP     49
         IF(PSISP .LT. -TWOPI) PSISP = PSISP + TWOPI                           SETUP     50
         IF(PSISP .GT. TWOPI) PSISP = PSISP - TWOPI                            SETUP     51
265      PSIS     =-PSISP                                                      SETUP     52
         TS1      = COS(PSISP)                                                 SETUP     53
         TS2      = SIN(PSISP)                                                 SETUP     54
         TS3      = COS(PSI5)                                                  SETUP     55
         TS4      = SIN(PSI5)                                                  SETUP     56
270      DXM145   = TS1*TS3 - TS2*TS4                                          SETUP     57
         DXM245   = TS1*TS4 + TS2*TS3                                          SETUP     58
         DYM145   =-TS2*TS3 - TS1*TS4                                          SETUP     59
         DYM245   = TS1*TS3 - TS2*TS4                                          SETUP     60
         AWFLG = 0.0                                                           SETUP     61
275      IF(VWOD.LT.32.0.OR.VWOD.GT.78.0) AWFLG = 1.0                          SETUP     62
         IF(PSIS.LT.0.50611.OR.PSIS.GT.0.89005) AWFLG = 1.0                    SETUP     63
         IF(NOAW.EQ.1) GO TO 10                                                SETUP     64
         VEL = VWOD/1.688                                                      SETUP     65
         ANG = PSI5*57.3                                                       SETUP     66
280      IF(AWFLG.NE.0.0) WRITE(6,1000) VEL,ANG                                SETUP     67
      1000 FORMAT(1H1,/////  WARNING  ****  WARNING  ****  WARNING  *****// SETUP     68
     *        4X,*THE NO AIRWAKE FLAG (NOAW) HAS BEEN SET.* /                 SETUP     69
     *        1X,*VWOD OF *,F4.1,* KNOTS OR PSIS OF *,F4.1,* DEGREES*         SETUP     70
     *           *IS NOT IN THE AIRWAKE TABLE.* /                             SETUP     71
285  *        1X,*THEREFORE, THIS RUN DOES NOT HAVE AIRWAKE DATA.* //          SETUP     72
```

```
                  *       1X,*****  WARNING  ****  WARNING  ****  WARNING  *****)      SETUP      73
                    IF(AWFLG.NE.0.0) NOAW = 1                                         SETUP      74
                    IF(AWFLG.NE.0.0) GO TO 10                                         SETUP      75
                C                                                                   C SETUP      76
290             C***************  AIRWAKE MODEL PRELIMINARY CALCULATIONS  ***************C SETUP      77
                C                                                                   C SETUP      78
                C  *                                                                  SETUP      79
                C  ***    GENERATE AIRWAKE TABLES BASED ON VWOD AND PSIS.              SETUP      80
                C  *                                                                  SETUP      81
295                 CALL AIRWTBL                                                      SETUP      82
                C  *                                                                  SETUP      83
                C  ***    SCALING RELATIONS.                                          SETUP      84
                C  *                                                                  SETUP      85
                    XDUM    = 46.75/WM                                                SETUP      86
300                 LS      = LM*XDUM                                                 SETUP      87
                    LTDS    = LTDM*XDUM                                               SETUP      88
                    WNSF    = 1.9*XDUM*VWOD/59.15                                     SETUP      89
                C  *                                                                  SETUP      90
                C  ***    SHAPING TERMS.                                              SETUP      91
305             C  *                                                                  SETUP      92
                    PSISS   = SIN(PSIS)                                               SETUP      93
                    PSISC   = COS(PSIS)                                               SETUP      94
                    PSIST   = PSISS/PSISC                                             SETUP      95
                    TS1     = PSISS*LTDS - PSISS*LS - 23.375*PSISC                    SETUP      96
310                 TS2     = PSISS*LTDS + 23.375*PSISC                               SETUP      97
                    TS3     = PSISC*LTDS - PSISC*LS + 23.375*PSISS                    SETUP      98
                    TS4     = 23.375/PSISS                                            SETUP      99
                    TS5     = 23.375/PSISC                                            SETUP     100
                C  *                                                                  SETUP     101
315             C  ***    RANDOM COMPONENT TERM.                                      SETUP     102
                C  *                                                                  SETUP     103
                    TR1     = SQRT(1.6*WNSF*WNSF*WNSF)                                SETUP     104
                C                                                                     SETUP     105
                C***************       GDF INITIALIZATION              ***************C SETUP     106
320             C                                                                     SETUP     107
                C  *                                                                  SETUP     108
                C  ***    TABRD SETS UP TABLES FOR DESCRIBING FUNCTION SUBROUTINE     SETUP     109
                C  *                                                                  SETUP     110
                C    ROLL CONTROL NONLINEARITY                                        SETUP     111
325                  CALL TABRD(TDAIN,TDAOUT,4)                                       SETUP     112
                C    YAW CONTROL NONLINEARITY                                         SETUP     113
                     CALL TABRD(TDRIN,TDROUT,4)                                       SETUP     114
                C                                                                   C SETUP     115
                C***************           SET UP INTEGRATION          ***************C SETUP     116
330             C                                                                   C SETUP     117
                10  ICEES   = 1                                                      SETUP     118
                    TIME    = T0                                                      SETUP     119
                    XMASS   = WEIGHT/G                                                SETUP     120
                    YO      = SUMFYO/XMASS                                            SETUP     121
335                 LO      = (IZ*SUMLO+IXZ*SUMNO)/(IX*IZ-IXZ*IXZ)                    SETUP     122
                    NO      = (IX*SUMNO+IXZ*SUMLO)/(IX*IZ-IXZ*IXZ)                    SETUP     123
                    UBASO   = UBAS                                                    SETUP     124
                    VBASO   = VBAS                                                    SETUP     125
                    WBASO   = WBAS                                                    SETUP     126
340                 PO =  PB                                                          SETUP     127
                    RO =  RB                                                          SETUP     128
                    CALL DEQU                                                         SETUP     129
```

```
      XDUM    = WNSF*WNSF                                          SETUP     130
      P(7,7)  = 1.0                                                SETUP     131
      P(8,8)= SIGMAVX*SIGMAVX                                      SETUP     132
      P(9,9)= XDUM*P(8,8)                                          SETUP     133
      P(10,10)= SIGMAVY*SIGMAVY                                    SETUP     134
      P(11,11)= XDUM*P(10,10)                                      SETUP     135
      P(12,12)= SIGMAVZ*SIGMAVZ                                    SETUP     136
      P(13,13)= XDUM*P(12,12)                                      SETUP     137
      CALL PROP                                                    SETUP     138
      ICEES   = 2                                                  SETUP     139
      IF(INT.LT.3) GO TO 40                                        SETUP     140
C     *                                                            SETUP     141
C     ***    ADAMS INTEGRATION ONLY.                               SETUP     142
C     *                                                            SETUP     143
      ICEES   = 0                                                  SETUP     144
C     ***    STATES.                                               SETUP     145
      DO 20 I=1,NSTATES                                            SETUP     146
      RT(I)   = R(INDX1(I))                                        SETUP     147
20    CONTINUE                                                     SETUP     148
C     ***    P.                                                    SETUP     149
      NL1 = NSTATES + 1                                            SETUP     150
      NU1 = NSTATES + NPA*NPA                                      SETUP     151
      I1      = INDXPD                                             SETUP     152
      DO 30 I=NL1,NU1                                              SETUP     153
      RT(I)   = R(I1)                                              SETUP     154
      I1      = I1 + 1                                             SETUP     155
30    CONTINUE                                                     SETUP     156
C     *                                                            SETUP     157
C     ***    PE.                                                   SETUP     158
C     *                                                            SETUP     159
      NL2 = NU1 + 1                                                SETUP     160
      NU2 = NU1 + NPE*NPE                                          SETUP     161
      I1 = INDXPED                                                 SETUP     162
      DO 31 I=NL2,NU2                                              SETUP     163
      RT(I) = R(I1)                                                SETUP     164
      I1 = I1 + 1                                                  SETUP     165
31 CONTINUE                                                        SETUP     166
C     *                                                            SETUP     167
C     ***    PX.                                                   SETUP     168
      NL3 = NU2 + 1                                                SETUP     169
      NEQU = NU2 + NPX*NPX                                         SETUP     170
      I1 = INDXPXD                                                 SETUP     171
      DO 32 I=NL3,NEQU                                             SETUP     172
      RT(I) = R(I1)                                                SETUP     173
      I1 = I1 + 1                                                  SETUP     174
32 CONTINUE                                                        SETUP     175
40    RETURN                                                       SETUP     176
      END                                                          SETUP     177
```

```
      SUBROUTINE SOLVR(F,A,N,M,P,PSI,PHI,DELP)                          SOLVR      2
C                                                                       SOLVR      3
C   SUBROUTINE TO SOLVE FOR P IN THE MATRIX RICCATI EQUATION,           SOLVR      4
C      P * F TRANSPOSE  +  F * P  +  A  =  0                            SOLVR      5
C            WHERE A = G * Q * G TRANSPOSE                              SOLVR      6
C                                                                       SOLVR      7
C   INPUT... F      N X N  COEFFICIENT MATRIX                           SOLVR      8
C            A      M X M  MATRIX                                       SOLVR      9
C            N      SIZE OF MATRICES                                    SOLVR     10
C            IMAX   MAXIMUM NUMBER OF ITERATIONS                        SOLVR     11
C            PSI    N X N WORKING MATRIX                                SOLVR     12
C            PHI    N X N WORKING MATRIX                                SOLVR     13
C            DELP   N X N WORKING MATRIX                                SOLVR     14
C   OUTPUT.. P      N X N  SOLUTION MATRIX                              SOLVR     15
C                                                                       SOLVR     16
C                                                                       SOLVR     17
      DIMENSION  F(N,1), A(M,1), P(N,1)                                 SOLVR     18
      DIMENSION   PSI(N,1), PHI(N,1), DELP(N,1)                         SOLVR     19
C                                                                       SOLVR     20
C  *                                                                    SOLVR     21
C  ***    CALCULATE THE SCALAR FACTOR ALPHA                            SOLVR     22
C  *                                                                    SOLVR     23
      SUM= 0.0                                                          SOLVR     24
      DO 10  I=1,N                                                      SOLVR     25
   10 SUM= SUM + F(I,I)                                                 SOLVR     26
      ALPHA=  ABS( SUM ) / FLOAT(N)                                     SOLVR     27
      IF(ALPHA.GE.1.0) GO TO 11                                         SOLVR     28
      ALPHA= 1.1                                                        SOLVR     29
   11 CONTINUE                                                          SOLVR     30
C  *                                                                    SOLVR     31
C  ***    INITIALIZE FOR THE ITERATION LOOP                            SOLVR     32
C  *                                                                    SOLVR     33
      CALL TRANNN(F,PSI,N)                                              SOLVR     34
      DO 21 I=1,N                                                       SOLVR     35
   21 PSI(I,I)=  PSI(I,I) - ALPHA                                       SOLVR     36
      CALL MATINV(PSI,N,DET,N)                                          SOLVR     37
      IF(DET .EQ. 0.0) WRITE(6,1000)                                    SOLVR     38
 1000 FORMAT(/70H SOLVR CANNOT INVERT F MATRIX - ORIGINAL VALUES OF P WI SOLVR     39
     1LL BE RETAINED.)                                                  SOLVR     40
      IF(DET .EQ. 0.0) RETURN                                           SOLVR     41
      CALL ADDNM(PHI,A,PHI,N,M)                                         SOLVR     42
      CALL MULTNN(PHI,PSI,DELP,N)                                       SOLVR     43
C                                                                       SOLVR     44
      CALL MULTNR(PSI,2.*ALPHA,PHI,N)                                   SOLVR     45
      CALL MULTTN(PHI,DELP,P,N)                                         SOLVR     46
C                                                                       SOLVR     47
      DO 30  I=1,N                                                      SOLVR     48
   30 PHI(I,I)=  PHI(I,I) + 1.0                                         SOLVR     49
C  *                                                                    SOLVR     50
C  ***      P = 2*ALPHA*PSIT*A*PSI                                      SOLVR     51
C  ***    PHI = 2*ALPHA*PSI + I                                        SOLVR     52
C  *                                                                    SOLVR     53
C  *                                                                    SOLVR     54
C  ***    ITERATION LOOP  (SOLVE FOR P)                                SOLVR     55
C  *                                                                    SOLVR     56
      DO 40  LOOP=1,15                                                  SOLVR     57
C   CALCULATE CORRECTION TO PRESENT VALUE OF P.                         SOLVR     58
```

```
                  CALL MULTNN(P,PHI,PSI,N)                                          SOLVR      59
                  CALL MULTTN(PHI,PSI,DELP,N)                                       SOLVR      60
60          C   CALCULATE NEW VALUE OF P.                                           SOLVR      61
                  CALL ADDNN(P,DELP,P,N)                                            SOLVR      62
            C   CHECK FOR CONVERGENCE                                               SOLVR      63
                  DO 42 K=1,N                                                       SOLVR      64
                  DO 42 L=K,N                                                       SOLVR      65
65                IF(P(K,L).EQ.0.0.AND.ABS(DELP(K,L)).GE.1.0E-07) GO TO 43          SOLVR      66
                  IF(P(K,L) .EQ. 0.0) GO TO 42                                      SOLVR      67
                  IF(ABS(DELP(K,L)/P(K,L)) .GE. 0.01) GO TO 43                      SOLVR      68
               42 CONTINUE                                                          SOLVR      69
            C   CONVERGENCE.  RETURN TO CALLING PROGRAM.                           SOLVR      70
70                WRITE(6,1002) LOOP                                                SOLVR      71
            1002  FORMAT(/36H SOLVR CONVERGED ON ITERATION NUMBER,I3,1H.)           SOLVR      72
                  RETURN                                                            SOLVR      73
               43 CONTINUE                                                          SOLVR      74
            C   ITERATION HAS NOT CONVERGED.                                       SOLVR      75
75                CALL MULTNN(PHI,PHI,DELP,N)                                       SOLVR      76
                  DO 44 I=1,N                                                       SOLVR      77
                  DO 44 J=1,N                                                       SOLVR      78
               44 PHI(I,J)=  DELP(I,J)                                              SOLVR      79
               40 CONTINUE                                                          SOLVR      80
80          C  ***    END OF ITERATION LOOP                                       SOLVR      81
                  PRINT 1001                                                        SOLVR      82
            1001  FORMAT(/63H SOLVR FAILED TO CONVERGE - P WILL BE RESET TO ORIGINAL SOLVR      83
                 1 PATRIX.)                                                         SOLVR      84
                  K = N - M                                                         SOLVR      85
85                DO 46 I=1,N                                                       SOLVR      86
                  DO 45 J=1,N                                                       SOLVR      87
                  IF(I.LT.K.OR.I.NE.J) P(I,J) = 0.0                                 SOLVR      88
               45 CONTINUE                                                          SOLVR      89
               46 CONTINUE                                                          SOLVR      90
90                RETURN                                                            SOLVR      91
                  END                                                               SOLVR      92
```

```
      SUBROUTINE TABRD(X,Y,NPTS)                                        TABRD
C     ******************************************************************* TABRD
C     ***                                                                 TABRD
C     ***    ROUTINE TO DECOMPOSE A NONLINEAR FUNCTION INTO ELEMENTS OF ITS TABRD
C     ***    DESCRIBING FUNCTION.  THE ARRAY #TABLE# IS USED BY SUBROUTINE  TABRD
C     ***    DESCRIB TO COMPUTE THE GAUSSIAN DESCRIBING FUNCTION (GDF).    TABRD
C     ***                                                                 TABRD
C     ***    X    - IN - ARRAY OF INDEPENDENT VARIABLES.                  TABRD
C     ***    Y    - IN - ARRAY OF DEPENDENT VARIABLES.                    TABRD
C     ***    NPTS - IN - DIMENSION OF X AND Y ARRAYS.                     TABRD
C     ***                                                                 TABRD
C     ******************************************************************* TABRD
C     *                                                                   TABRD
C     ***    DIMENSION ON T     - 2*NPTS                                  TABRD
C     *                                                                   TABRD
      DIMENSION T(120),YY(2),X(NPTS),Y(NPTS)                            TABRD
C     *                                                                   GDF
C     ***    TABLES DECOMPOSED INTO DESCRIBING FUNCTION ELEMENTS.         GDF
C     ***    DIMENSION ON INDEX - 4*(NUMBER OF CALLS TO TABRD)            GDF
C     ***    DIMENSION ON TABLE - (4*(NO. OF IND. VAR.)+3)*(NO. OF CALLS TO GDF
C     *                                                                   GDF
      COMMON/GDF/NTABLE,INDEX(20),TABLE(200)                            GDF
      DATA NTABLE,NEXT,L2 /0,1,1/                                       TABRD
C                                                                       TABRD
C     *****************          STORE NON-LINEAR TABLES        ************ TABRD
C                                                                       TABRD
      NTABLE       = NTABLE + 1                                         TABRD
      L            = 3*(NTABLE - 1) + 1                                 TABRD
      INDEX(L)     = NEXT                                               TABRD
      INDEX(L+1)   = L2                                                 TABRD
      DO 30 K=1,NPTS                                                    TABRD
      T(K)         = X(K)                                               TABRD
      T(NPTS+K)    = Y(K)                                               TABRD
   30 CONTINUE                                                          TABRD
      NEXT         = NEXT + 1                                           TABRD
      TABLE(NEXT)  = 0.0                                                TABRD
      NEXT         = NEXT + 1                                           TABRD
      TABLE(NEXT)  = 0.0                                                TABRD
      L1           = NPTS                                               TABRD
C                                                                       TABRD
C     *****************  FIND DESCRIBING FUNCTION BREAKPOINTS  ************ TABRD
C                                                                       TABRD
      TABLE(NEXT)  = 0.0                                                TABRD
      NEXT         = NEXT + 1                                           TABRD
      NCX          = 1                                                  TABRD
      IF(T(1).LT.0.0) GO TO 40                                          TABRD
C     *                                                                   TABRD
C     ***    ALL BREAKPOINTS ON POSITIVE X AXIS.                          TABRD
C     *                                                                   TABRD
      I2           = 1                                                  TABRD
      IF(T(1).EQ.0.0) I2 = 2                                            TABRD
      GO TO 110                                                         TABRD
   40 IF(T(L1).GT.0.0) GO TO 50                                         TABRD
C     *                                                                   TABRD
C     ***    ALL BREAKPOINTS ON NEGATIVE X AXIS.                          TABRD
C     *                                                                   TABRD
      I1           = L1                                                 TABRD
```

```
                IF(T(L1).EQ.0.0) I1 = L1 - 1                                    TABRD      54
                GO TO 130                                                       TABRD      55
      60      C  *                                                              TABRD      56
              C  ***    BREAKPOINTS SPAN X AXIS.                                TABRD      57
              C  *                                                              TABRD      58
              50    I1          = 1                                             TABRD      59
                    I2          = L1                                            TABRD      60
      65      60    J           = (I1 + I2)/2                                   TABRD      61
                    IF(T(J).EQ.0.0) GO TO 70                                    TABRD      62
                    IF(T(J).GT.0.0) I2 = J                                      TABRD      63
                    IF(T(J).LT.0.0) I1 = J                                      TABRD      64
                    IF((I2-I1).EQ.1) GO TO 80                                   TABRD      65
      70            GO TO 60                                                    TABRD      66
              70    I1          = J - 1                                         TABRD      67
                    I2          = J + 1                                         TABRD      68
              80    IF(T(I2).EQ.ABS(T(I1))) GO TO 90                            TABRD      69
                    IF(T(I2).GT.ABS(T(I1))) GO TO 100                           TABRD      70
      75      C  ***    INSERT POINT FROM POSITIVE X AXIS.                      TABRD      71
                    TABLE(NEXT) = T(I2)                                         TABRD      72
                    NEXT        = NEXT + 1                                      TABRD      73
                    NCX         = NCX + 1                                       TABRD      74
                    I2          = I2 + 1                                        TABRD      75
      80            IF(I2.GT.L1) GO TO 130                                      TABRD      76
                    GO TO 80                                                    TABRD      77
              C  ***    INSERT POSITIVE PART OF SYMMETRIC POINT.                TABRD      78
              90    TABLE(NEXT) = T(I2)                                         TABRD      79
                    NEXT        = NEXT + 1                                      TABRD      80
      85            NCX         = NCX + 1                                       TABRD      81
                    I2          = I2 + 1                                        TABRD      82
                    I1          = I1 - 1                                        TABRD      83
                    IF(I1.GT.0.AND.I2.LE.L1) GO TO 90                           TABRD      84
                    IF(I1.GT.0) GO TO 130                                       TABRD      85
      90            IF(I2.LE.L1) GO TO 110                                      TABRD      86
                    GO TO 150                                                   TABRD      87
              C  ***    INSERT POINT FROM NEGATIVE X AXIS.                      TABRD      88
              100   TABLE(NEXT) = ABS(T(I1))                                    TABRD      89
                    NEXT        = NEXT + 1                                      TABRD      90
      95            NCX         = NCX + 1                                       TABRD      91
                    I1          = I1 - 1                                        TABRD      92
                    IF(I1.GT.0) GO TO 80                                        TABRD      93
              C  *                                                              TABRD      94
              C  ***    REMAINING POINTS ON POSITIVE X AXIS.                    TABRD      95
     100      C  *                                                              TABRD      96
              110   DO 120 I=I2,L1                                              TABRD      97
                    TABLE(NEXT) = T(I)                                          TABRD      98
                    NEXT        = NEXT + 1                                      TABRD      99
                    NCX         = NCX + 1                                       TABRD     100
     105      120   CONTINUE                                                    TABRD     101
                    GO TO 150                                                   TABRD     102
              C  *                                                              TABRD     103
              C  ***    REMAINING POINTS ON NEGATIVE X AXIS.                    TABRD     104
              C  *                                                              TABRD     105
     110      130   DO 140 I=1,I1                                               TABRD     106
                    TABLE(NEXT) = ABS(T(I1+1-I))                                TABRD     107
                    NEXT        = NEXT + 1                                      TABRD     108
                    NCX         = NCX + 1                                       TABRD     109
               140  CONTINUE                                                    TABRD     110
```

```
      150   INDEX(L+2)  = NCX                                                TABRD
            NCX         = NEXT + L2                                          TABRD
      C                                                                      TABRD
      C  ************     COMPUTE ELEMENTS OF DESCRIBING FUNCTIONS     *******TABRD
      C                                                                      TABRD
            INDX        = INDEX(L) + INDEX(L+1) + 2                          TABRD
            JNDX        = INDEX(L) + INDEX(L+1) + INDEX(L+2)                 TABRD
            DO 240 I=1,L2                                                    TABRD
            K           = L1*I                                               TABRD
      C  *                                                                   TABRD
      C  ***    COMPUTE Y-AXIS INTERCEPT.                                    TABRD
      C  *                                                                   TABRD
            I1          = 1                                                  TABRD
            I2          = 2                                                  TABRD
            IF(T(I1).GT.C.0) GO TO 170                                       TABRD
            I1          = L1 - 1                                             TABRD
            I2          = L1                                                 TABRD
            IF(T(I2).LT.0.0) GO TO 170                                       TABRD
            I1          = 1                                                  TABRD
      160   J           = (I1 + I2)/2                                        TABRD
            TABLE(NEXT) = T(K+J)                                             TABRD
            IF(T(J).EQ.0.0) GO TO 180                                        TABRD
            IF(T(J).GT.0.0) I2 = J                                           TABRD
            IF(T(J).LT.0.0) I1 = J                                           TABRD
            IF((I2-I1).GT.1) GO TO 160                                       TABRD
      170   TABLE(NEXT) = T(I1+K) - T(I1)*(T(I2+K) - T(I1+K))/(T(I2) - T(I1))TABRD
      180   NEXT        = NEXT + 1                                           TABRD
            YOL         = 0.0                                                TABRD
            YEL         = 0.0                                                TABRD
            XOL         = 0.0                                                TABRD
            DO 230 J=INDX,JNDX                                               TABRD
      C  *                                                                   TABRD
      C  ***    COMPUTE FUNCTION VALUES AT BREAKPCINTS.                      TABRD
      C  *                                                                   TABRD
            XX          = TABLE(J)                                           TABRD
            DO 220 M=1,2                                                     TABRD
            I1          = 1                                                  TABRD
            I2          = 2                                                  TABRD
            IF(T(I1).GT.XX) GO TO 200                                        TABRD
            I1          = L1 - 1                                             TABRD
            I2          = L1                                                 TABRD
            IF(T(I2).LT.XX) GO TO 200                                        TABRD
            I1          = 1                                                  TABRD
      190   N           = (I1 + I2)/2                                        TABRD
            YY(M)       = T(K+N)                                             TABRD
            IF(T(N).EQ.XX) GO TO 210                                         TABRD
            IF(T(N).GT.XX) I2 = N                                            TABRD
            IF(T(N).LT.XX) I1 = N                                            TABRD
            IF((I2-I1).GT.1) GO TO 190                                       TABRD
      200   YY(M)       = T(I1+K) + (XX - T(I1))*(T(I2+K) - T(I1+K))/(T(I2) -TABRD
           1              T(I1))                                             TABRD
      210   XX          = -XX                                                TABRD
      220   CONTINUE                                                         TABRD
      C  *                                                                   TABRD
      C  ***    COMPUTE EVEN AND ODD COMPONENTS.                             TABRD
      C  *                                                                   TABRD
            YO          = 0.5*(YY(1) - YY(2))                                TABRD
```

```
      SUBROUTINE TLU(X,TABX,NX,TABY,NDEP,Y)
C  ***********************************************************************
C  ***
C  ***    ROUTINE TO LOOK UP VALUES FOR A SET OF DEPENDENT VARIABLES
C  ***    BASED ON A SINGLE INDEPENDENT VARIABLE.
C  ***
C  ***    X    - IN  - INDEPENDENT VARIABLE (I.V.) VALUE.
C  ***    TABX - IN  - TABLE OF I.V. VALUES.
C  ***    NX   - IN  - NUMBER OF VALUES IN TABX ARRAY.
C  ***    TABY - IN  - TABLE OF VALUES FOR DEPENDENT VARIABLES.
C  ***    NDEP - IN  - NUMBER OF DEPENDENT VARIABLES.
C  ***    Y    - OUT - DEPENDENT VARIABLE VALUE ARRAY.
C  ***
C  ***********************************************************************
      DIMENSION TABX(1),TABY(1),Y(1)
C  *
C  ***    DETERMINE IF EXTRAPOLATION NEEDED.
C  *
      K1 = 1
      K2 = 2
      IF(X.LT.TABX(1)) GO TO 20
      K1 = NX - 1
      K2 = NX
      IF(X.GT.TABX(NX)) GO TO 20
      K1 = 1
C  *
C  ***    FIND SECTION OF TABLE TO BE INTERPOLATED.
C  *
10    K3 = (K1 + K2)/2
      IF(X.EQ.TABX(K3)) GO TO 40
      IF(X.GT.TABX(K3)) K1 = K3
      IF(X.LT.TABX(K3)) K2 = K3
      K3 = K2 - K1
      IF(K3.GT.1) GO TO 10
C  *
C  ***    LINEARLY INTERPOLATE OR EXTRAPOLATE.
C  *
20    XDUM = (X - TABX(K1))/(TABX(K2) - TABX(K1))
      DO 30 I=1,NDEP
      K3 = NX*(I - 1)
      Y(I) = TABY(K3+K1) + XDUM*(TABY(K3+K2) - TABY(K3+K1))
30    CONTINUE
      GO TO 60
C  *
C  ***    ENTRY IN TABLE.
C  *
40    DO 50 I=1,NDEP
      K2 = NX*(I - 1) + K3
      Y(I) = TABY(K2)
50    CONTINUE
60    RETURN
      END

***********    ANANIAN  //// END OF LIST ////
***********    ANANIAN  //// END OF LIST ////
```

```
                YE          = 0.5*(YY(1) + YY(2)) - TABLE(NEXT-1)                TABRD   168
      C  *                                                                       TABRD   169
      C  ***    COMPUTE SLOPES.                                                  TABRD   170
      C  *                                                                       TABRD   171
                TABLE(NCX)  = (YO - YOL)/(TABLE(J) - XOL)                        TABRD   172
                M           = NCX + INDEX(L+2) - 1                               TABRD   173
                TABLE(M)    = (YE - YEL)/(TABLE(J) - XOL)                        TABRD   174
                YOL         = YO                                                 TABRD   175
                YEL         = YE                                                 TABRD   176
                XOL         = TABLE(J)                                           TABRD   177
                NCX         = NCX + 1                                            TABRD   178
          230   CONTINUE                                                         TABRD   179
                NCX         = NCX + INDEX(L+2) - 1                               TABRD   180
          240   CONTINUE                                                         TABRD   181
                NEXT        = NCX                                                TABRD   182
          250   M           = 3*NTABLE + 1                                       TABRD   183
                INDEX(M)    = NEXT                                               TABRD   184
                RETURN                                                           TABRD   185
                END                                                              TABRD   186
```

```
      YE          = 0.5*(YY(1) + YY(2)) - TABLE(NEXT-1)
C  *
C  ***    COMPUTE SLOPES.
C  *
      TABLE(NCX)  = (YO - YOL)/(TABLE(J) - XOL)
      M           = NCX + INDEX(L+2) - 1
      TABLE(M)    = (YF - YEL)/(TABLE(J) - XOL)
      YOL         = YO
      YFL         = YE
      XCL         = TABLE(J)
      NCX         = NCX + 1
  230 CONTINUE
      NCX         = NCX + INDEX(L+2) - 1
  240 CONTINUE
      NEXT        = NCX
  250 M           = 3*NTABLE + 1
      INDEX(M)    = NEXT
      RETURN
      END
```

APPENDIX C

LISTING FOR OPTIMAL CONTROLLER PILOT MODEL

ONLY SUBROUTINES DEQU, MISCAL, PRØP, AND SETUP ARE LISTED, THE OTHER ROUTINES ARE THE SAME AS THE CLASSICAL PILOT MODEL (APPENDIX B)

```
      SUBROUTINE DEQU                                                   DEQU
C     ***********************************************************************  CDEQU
C     ***                                                               ***  CDEQU
C     ***    ROUTINE TO HANDLE SYSTEM DIFFERENTIAL EQUATIONS FOR MEANS.  ***  CDEQU
C     ***                                                               ***  CDEQU
C     ***********************************************************************  CDEQU
C     *                                                                     R
C     ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                     R
C     *                                                                     R
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                                R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 2 - DERIVATIVES.                               R
C     *                                                                     R
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,             R
     A       ZSPDOT,TSPDOT                                                  R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                           R
C     *                                                                     R
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS                  R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.       R
C     *                                                                     R
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,        R
     A       THETAAO,PSIAO,PHIAO,RCDO                                       R
      REAL   MO                                                             R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                  R
C     *                                                                     R
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM                R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 6 - GEOMETRY.                                  R
C     *                                                                     R
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTOM,LS,LTDS                       R
      REAL   G,IX,IY,IZ,IXZ,LM,LTOM,LS,LTDS                                 R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 7 - CONSTANTS.                                 R
C     *                                                                     R
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,            R
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,               R
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT                R
      REAL  KU,KW,KFRPM,KCDN,                                               R
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,                 R
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT                  R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.      R
C     *                                                                     R
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,PSI,PHI,V5,PSI5,X1DWS,      R
     A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP,    R
     B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,         R
     C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,       R
     D       VMEAN,VP,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1,    R
     E       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,          R
     F       ZBIASP                                                         R
C     *                                                                     R
C     ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                      R
C     *                                                                     R
      COMMON THETAC,DFRPMOL,DCDNOL,DEOL,GAMMAGS,RANGE,VAIRC                 R
```

```
                C  *                                                                  R       53
                C  ***    R ARRAY SEGMENT 10 - AERO DATA.                             R       54
           60   C  *                                                                  R       55
                     COMMON XU,XW,XQ,XFRPM,XCON,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCON,ZPDIGV,  R       56
                    &       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                    R       57
                     REAL   MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                       R       58
                C  *                                                                  R       59
           65   C  ***    R ARRAY SEGMENT 11                                          R       60
                C  *                                                                  R       61
                     COMMON  PC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA       R       62
                C  *                                                                  R       63
                C  ***    R ARRAY SEGMENT 12 - CONTROLS.                              R       64
           70   C  *                                                                  R       65
                     COMMON  DE,DT,DCON,DED,DTD,DCOND                                  R       66
                C  *                                                                  R       67
                C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.    R       68
                C  *                                                                  R       69
           75        COMMON TABV1(6)                                                  R       70
                C  *                                                                  R       71
                C  ***    R ARRAY SEGMENT 14 - SPEED TABLE FOR OPEN LOOP COMMAND TABLE LOOKUPS. R  72
                C  *                                                                  R       73
                     COMMON TABV2(10)                                                 R       74
           80   C  *                                                                  R       75
                C  ***    R ARRAY SEGMENT 15 - FLIGHT ABOVE SHIP TABLE FOR EZ LOOKUP. R       76
                C  *                                                                  R       77
                     COMMON TABEZP(7)                                                 R       78
                C  *                                                                  R       79
           85   C  ***    R ARRAY SEGMENT 16 - EZ TABLE.                              R       80
                C  *                                                                  R       81
                     COMMON TABEZ(7)                                                  R       82
                C  *                                                                  R       83
                C  ***    R ARRAY SEGMENT 17 - SHIP MOTION                            R       84
           90   C  *                                                                  R       85
                     COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,          R       86
                    1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT    R       87
                     REAL KXS,KZS,KTS,KYS,KRS,KPS                                     R       88
                C  *                                                                  R       89
           95   C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.          R       90
                C  *                                                                  R       91
                     COMMON TABTC(10)                                                 R       92
                     COMMON TRPMOL(10)                                                R       93
                     COMMON TCONOL(10)                                                R       94
          100        COMMON TDEOL(10)                                                 R       95
                C  *                                                                  R       96
                C  ***    R ARRAY SEGMENTS 24-25 - NOZZLE TABLES.                     R       97
                C  *                                                                  R       98
                     COMMON TABR(10)                                                  R       99
          105        COMMON TABRD(10)                                                 R      100
                C  *                                                                  R      101
                C  ***    R ARRAY SEGMENTS 27-48 - AERO TABLES.                       R      102
                C  *                                                                  R      103
                     COMMON TXU(6)                                                    R      104
          110        COMMON TXW(6)                                                    R      105
                     COMMON TXQ(6)                                                    R      106
                     COMMON TXRPM(6)                                                  R      107
                     COMMON TXCON(6)                                                  R      108
                     COMMON TXPIGV(6)                                                 R      109
```

```
      COMMON TXDE(6)                                                    R      110
      COMMON TZU(6)                                                     R      111
      COMMON TZW(6)                                                     R      112
      COMMON TZQ(6)                                                     R      113
      COMMON TZRPM(6)                                                   R      114
      COMMON TZCDN(6)                                                   R      115
      COMMON TZPIGV(6)                                                  R      116
      COMMON TZDE(6)                                                    R      117
      COMMON TMU(6)                                                     R      118
      COMMON TMW(6)                                                     R      119
      COMMON TMWD(6)                                                    R      120
      COMMON TMQ(6)                                                     R      121
      COMMON TMRPM(6)                                                   R      122
      COMMON TMCDN(6)                                                   R      123
      COMMON TMPIGV(6)                                                  R      124
      COMMON TMDE(6)                                                    R      125
C     *                                                                 R      126
C     ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIMENSION) R      127
C     *                                                                 R      128
      COMMON F(39,39),P(39,39),PDOT(39,39),GM(32,15),OM(15,15)          R      129
C     *                                                                 R      130
C     ***    P ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.              R      131
C     *                                                                 R      132
      COMMON SIGMA(50)                                                  R      133
      COMMON SIGMAXY(50)                                                R      134
C     *                                                                 R      135
C     ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES                    R      136
C     *                                                                 R      137
      COMMON VXX(5,5,3)                                                 R      138
      COMMON VYY(5,5,3)                                                 R      139
      COMMON VZZ(5,5,3)                                                 R      140
      COMMON SVXX(5,5,3)                                                R      141
      COMMON SVYY(5,5,3)                                                R      142
      COMMON SVZZ(5,5,3)                                                R      143
C     *                                                                 R      144
C     ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS          R      145
C     *                                                                 R      146
      COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),         R      147
     1        TKDEZ(6), TKDEN(6), TKDEDE(6), TKDEDT(6),                 R      148
     2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),         R      149
     3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)                  R      150
C     *                                                                 R      151
C     ***    R ARRAY SEGMENTS 81-106                                    R      152
C     *                                                                 R      153
      COMMON F1(7,7),G1(7,3),GAMMA(7,8),A(8,8),B(8,5),M1(6,6),M2(6,7),  R      154
     1       H(6,6),D(6,7),C(3,15),RL(3,3),W(5,5),VU(3,3),VY(6,6),      R      155
     2       VYI(6,6),S(3,3),FE(18,18),QE(18,18),PE(18,18),PED(18,18),  R      156
     3       KG(18,6),FXHAT(18,18),PXHAT(18,18),PXHATD(18,18),PX(18,18),R      157
     4       CS(3,3)                                                    R      158
      REAL M1,M2,KG                                                     R      159
C     *                                                                 R      160
C     ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE RELATED) R      161
C     *                                                                 R      162
      COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                     R      163
     1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                      R      164
C     *                                                                 R      165
C     ***    R ARRAY SEGMENTS 108-119                                   R      166
```

```
      C  *                                                                      R
            COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),          R
           1        TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),        R
           2        TDTVZ(6), TDTVZD(6)                                         R
      C  ******************************************************************  C  R
      C  *                                                                      I
      C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                          I
      C  *                                                                      I
            COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NOAW,NOINIT   I
      C  *                                                                      I
      C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                         I
      C  *                                                                      I
            COMMON/INTEGER/ INDX1(14)                                           I
      C  *                                                                      I
      C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                              I
      C  *                                                                      I
            COMMON/INTEGER/ INDX2(14)                                           I
      C  *                                                                      I
      C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                            I
      C  *                                                                      I
            COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX          I
      C                                                                        CI
            DATA  FLAG/0./                                                     DEQU
      C                                                                        DEQU
      C  *****************          DIFFERENTIAL EQUATIONS          *****************  CDEQU
      C                                                                        CDEQU
            Q = QB - QO                                                        DEQU
            SINT    = SIN(THETA)                                               DEQU
            COST    = COS(THETA)                                               DEQU
            SPHI    = SIN(PHI)                                                 DEQU
            CPHI    = COS(PHI)                                                 DEQU
            SPSI    = SIN(PSI)                                                 DEQU
            CPSI    = COS(PSI)                                                 DEQU
      C  *                                                                      DEQU
      C  ***    ALTITUDE.                                                       DEQU
      C  *                                                                      DEQU
            ALT = -ZAPP                                                        DEQU
      C  *                                                                      DEQU
      C  ***    AIRPLANE W.R.T. SHIP, EARTH AXIS.                               DEQU
      C  *                                                                      DEQU
            DX45    = XAPP - XSP                                               DEQU
            DZ45    = ZAPP - ZSP                                               DEQU
      C  *                                                                      DEQU
      C  ***    AIRPLANE W.R.T. SHIP, SHIP WIND AXIS.                           DEQU
      C  *                                                                      DEQU
            XM      = DXM145*DX45 + DXM245*DY45                                DEQU
            YM      = DYM145*DX45 + DYM245*DY45                                DEQU
            ZM      = DZ45                                                     DEQU
      C  *                                                                      DEQU
      C  ***    EULER ANGLES FOR AIRWAKE MODEL.                                 DEQU
      C  *                                                                      DEQU
            PSIA    = ASIN(SIN(PSI)*COS(PSI3) - COS(PSI)*SIN(PSI3))            DEQU
            THETAA  = THETA                                                    DEQU
            PHIA    = PHI                                                      DEQU
      C  *                                                                      DEQU
      C  ***    SHIP AIRWAKE.                                                   DEQU
      C  *                                                                      DEQU
```

```
      IF(NOAW.EQ.0) CALL AIRWAKE
C  *
C  ***    AIRPLANE BODY AXIS COMPONENTS OF AMBIENT WIND.
C  *
      UMEAN   = X1DWA*COST*CPSI + Y1DWA*COST*SPSI - Z1DWA*SINT
      VMEAN   = X1DWA*(SPHI*SINT*CPSI - CPHI*SPSI) +
     1          Y1DWA*(SPHI*SINT*SPSI + CPHI*CPSI) +
     2          Z1DWA*SPHI*COST
      UMEAN   = X1DWA*(CPHI*SINT*CPSI + SPHI*SPSI) +
     1          Y1DWA*(CPHI*SINT*SPSI - SPHI*CPSI) +
     2          Z1DWA*CPHI*COST
C  *
C  ***    WIND.
C  *
      UWIND   = UMEAN + UAW
       WWIND  =  WMEAN + WAW
C   INITIALIZE INERTIAL SPEEDS FROM AIRSPEEDS, ONE TIME ONLY.
      IF(ICEES.EQ.1) UB = UBAS + UWIND
      IF(ICEES.EQ.1) WB = WBAS + WWIND
C  *
C  ***    AIRSPEED.
C  *
      UBAS  = UB - UWIND
      UAS   = UBAS - UBASO
      WBAS  = WB - WWIND
      WAS   = WBAS - WBASO
      VAIR  = SQRT(UBAS*UBAS + WBAS*WBAS)
      ALPHA = ATAN2(WBAS,UBAS)
C  *
C  ***    LOOK UP AERO AND OPEN LOOP PARAMETERS.
C  *
      CALL TLU(VAIR,TABV1,6,TXU,22,XU)
      CALL TLU(TIME,TABV2,10,TABTC,4,THETAC)
      CALL TLU(VAIR,TABV1,6,TKDEU,18,KDEU)
C
C  NOINIT .LT. 0 INDICATES A RUN TO INITIALIZE P, VU AND VY ARRAYS BY
C  USE OF OPTION 28.  RCD MUST BE INPUT.
C
      IF(NOINIT .LT. 0) GO TO 200
C  *
C  ***    SHIP.
C  *
      XSPDOT = V5*COS(PSI5)
      ZSPDOT = 0.0
      TSPDOT = 0.0
C  *
C  ***    RANGE FROM SHIP.  RATE OF CLOSURE COMMANDS.
C  *
      RANGE   = XSP - XAPP
      RCD = -(37.28 - 2.33*TIME)
      IF(TIME .GE. 16.) RCD= 0.
      IF(TIME .GE. 16.) RC= 0.
C   SET A FLAG IF AIRPLANE OVERTAKES THE SHIP.
      IF(FLAG.EQ.0. .AND. XAPP.GE.XSP) FLAG=1.
      IF(FLAG.EQ.1.) RC= 0.
      IF(FLAG.EQ.1.) RCD= 0.
C  *
```

```
C  ***    LONGITUDINAL POSITION ERROR.                                          DEQU  102
C  *                                                                            DEQU  103
      XAPCOM= XSP - RC                                                         DEQU  104
      ERRX=  XAPP - XAPCOM                                                     DEQU  105
290   XAPPDOT = UB*COST + WB*SINT                                              DEQU  106
      ERRXD= XAPPDOT - XSPDOT + RCD                                            DEQU  107
C  *                                                                            DEQU  108
C  ***    GLIDE SLOPE  (POSITION AT COMMANDED RANGE)                            DEQU  109
C  *                                                                            DEQU  110
295   ZGSP = ZSP - (    RC    )*TAN(0.01745329*GAMMAGS)+ZBIASP                   DEQU  111
C  *                                                                            DEQU  112
C  ***    VERTICAL POSITION ERROR                                               DEQU  113
C  *                                                                            DEQU  114
      IF(FLAG.EQ.1. .OR. TIME.GT.16.) ZGSP= ZBIASP                             DEQU  115
300   ERRZ=  ZAPP - ZGSP                                                       DEQU  116
      ZAPPDOT = WB*COST - UB*SINT                                              DEQU  117
      ERRZD= ZAPPDOT - ZSPDOT + (      RCD     )*TAN(.01745329*GAMMAGS)        DEQU  118
C  *                                                                            DEQU  119
C  ***    ATTITUDE AND SPEED ERRORS                                             DEQU  120
305   C  *                                                                      DEQU  121
      ETHETA= THETA - THETAC                                                   DEQU  122
      COST =  COS(THETA)                                                       DEQU  123
      SINT =  SIN(THETA)                                                       DEQU  124
      ERRU =  ERRXD * COST  -  ERRZD * SINT                                    DEQU  125
310   ERRW =  ERRXD * SINT  +  ERRZD * COST                                    DEQU  126
C  *                                                                            DEQU  127
C  ***    PITCH CONTROL.                                                        DEQU  128
C  *                                                                            DEQU  129
      DED= -KDEU*ERRU  - KDEW*ERRW  - KDE0*QB - KDET*ETHETA                    DEQU  130
315     1   - KDEX*ERRX - KDEZ*ERRZ - KDEN*DFRPM - KDEDE*DE - KDEDT*DT         DEQU  131
C  *                                                                            DEQU  132
C  ***    THRUST CONTROL.                                                       DEQU  133
C  *                                                                            DEQU  134
      DTD= -KDTU*ERRU  - KDTW*ERRW  - KDT0*QB - KDTT*ETHETA                    DEQU  135
320     1   - KDTX*ERRX - KDTZ*ERRZ - KDTN*DFRPM - KDTDE*DE - KDTDT*DT         DEQU  136
C  *                                                                            DEQU  137
C  ***    NOZZLE.                                                               DEQU  138
C  *                                                                            DEQU  139
C                                                                               DEQU  140
325   DCOND= 0.                                                                DEQU  141
C  *                                                                            DEQU  142
C  ***    COMMANDED AIRSPEED  (HACKED FOR REFERENCE ONLY)                       DEQU  143
C  *                                                                            DEQU  144
      RDCOM =  -RCD                                                            DEQU  145
330   SINTC   = SIN(THETAC)                                                    DEQU  146
      COSTC   = COS(THETAC)                                                    DEQU  147
      XDC     = RDCOM + XSPDOT                                                 DEQU  148
      ZDC     = XDC*TAN(.01745329*GAMMAGS)                                     DEQU  149
      UASC    = COSTC*XDC - SINTC*ZDC - UWIND                                  DEQU  150
335   WASC    = SINTC*XDC + COSTC*ZDC - WWIND                                  DEQU  151
      VAIRC   = SQRT(UASC*UASC + WASC*WASC)                                    DEQU  152
C  *                                                                            DEQU  153
C  ***    AIRFRAME.                                                             DEQU  154
C  *                                                                            DEQU  155
340   XAPPDOT = UB*COST + WB*SINT                                              DEQU  156
      ZAPPDOT = WB*COST - UB*SINT                                              DEQU  157
      D1      = DFRPM + DFRPMCL                                                DEQU  158
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      D2      = DE + DEOL                                                  DEQU  159
      D3      = DCDN + DCDNOL                                              DEQU  160
      DFX     = XU*UAS + XW*WAS + XQ*Q                                     DEQU  161
      DFZ     = ZU*UAS + ZW*WAS + ZQ*Q                                     DEQU  162
      DM      = MU*UAS + MW*WAS + MQ*Q                                     DEQU  163
      SUMFX   = XO + DFX + XFRPM*D1 + XDE*D2 + XCDN*D3                     DEQU  164
      SUMFZ   = ZO + DFZ + ZFRPM*D1 + ZDE*D2 + ZCDN*D3                     DEQU  165
      SUMM    = MO + DM + MFRPM*D1 + MDE*D2 + MCDN*D3                      DEQU  166
      WASD    = SUMFZ + G*COST +     QB*UB                                 DEQU  167
      IF(ICEES.EQ.1) WASDO = WASD                                          DEQU  168
      DM      = DM + MWDOT*(WASD - WASDO)                                  DEQU  169
      SUMM    = SUMM + MWDOT*(WASD - WASDO)                                DEQU  170
      UDOT    = SUMFX - G*SINT - QB*WB                                     DEQU  171
      WDOT    = SUMFZ + G*COST + QB*UB                                     DEQU  172
      QDOT    = SUMM                                                       DEQU  173
      TDOT    = QB                                                         DEQU  174
C  *                                                                       DEQU  175
C  ***    ENGINE.                                                          DEQU  176
C  *                                                                       DEQU  177
      DFRPMD = (KFRPM*DT - DFRPM)/TAUENG                                   DEQU  178
  200 CONTINUE                                                             DEQU  179
C                                                                     C    DEQU  180
C**************          UPDATE SUB O VALUES          **************C      DEQU  181
C                                                                     C    DEQU  182
      IF(ICEES.EQ.2) GO TO 10                                              DEQU  183
      UO      = UB                                                         DEQU  184
      WO      = WB                                                         DEQU  185
      QO      = QB                                                         DEQU  186
      THETAO  = THETA                                                      DEQU  187
      XAPPO   = XAPP                                                       DEQU  188
      ZAPPO   = ZAPP                                                       DEQU  189
      UBASO   = UBAS                                                       DEQU  190
      WBASO   = WBAS                                                       DEQU  191
      WASDO   =  WASD                                                      DEQU  192
      XO      = XO + DFX                                                   DEQU  193
      ZO      = ZO + DFZ                                                   DEQU  194
      MO      = MO + DM                                                    DEQU  195
      THETAAO = THETAA                                                     DEQU  196
      PSIAO   = PSIA                                                       DEQU  197
      PHIAO   = PHIA                                                       DEQU  198
      RCDO = RCD                                                           DEQU  199
   10 RETURN                                                               DEQU  200
      END                                                                  DEQU  201
```

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      SUBROUTINE MISCAL(NPRNT)                                          MISCAL   2
C*****************************************************************     MISCAL   3
C*                                                               *     MISCAL   4
C*       SUBROUTINE FOR MISCELLANEOUS CALCULATIONS THAT DO NOT   *     MISCAL   5
C*       NATURALLY OCCUR ELSEWHERE BUT ARE DESIRED FOR OUTPUT,   *     MISCAL   6
C*       SUCH AS TABBING, PUNCHING, ETC., ETC.                   *     MISCAL   7
C*                                                               *     MISCAL   8
C*   INPUT ARGUMENTS                                             *     MISCAL   9
C*       NPRNT     COVARIANCE MATRIX PRINT INDICATOR.            *     MISCAL  10
C*                 0 = DO NOT PRINT MATRIX ON OUTPUT FILE.       *     MISCAL  11
C*                                                               *     MISCAL  12
C*****************************************************************     MISCAL  13
      DIMENSION CA(48)                                                  MISCAL  14
C  *                                                                    P       2
C  ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                    R       3
C  *                                                                    R       4
      COMMON TIME,TC,DTIME,DTOUT,DTOUT2,TMAX                            R       5
C  *                                                                    R       6
C  ***    R ARRAY SEGMENT 2 - DERIVATIVES.                              R       7
C  *                                                                    R       8
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,         R       9
     A       ZSPDOT,TSPDOT                                              R      10
C  *                                                                    R      11
C  ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                          R      12
C  *                                                                    R      13
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS              R      14
C  *                                                                    R      15
C  ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.      R      16
C  *                                                                    R      17
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDG,    R      18
     A       THETAAO,PSIAO,PHIAO,RCDO                                   R      19
      REAL   MO                                                         R      20
C  *                                                                    R      21
C  ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                 R      22
C  *                                                                    R      23
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM            R      24
C  *                                                                    R      25
C  ***    R ARRAY SEGMENT 6 - GEOMETRY.                                 R      26
C  *                                                                    R      27
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                   R      28
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                             R      29
C  *                                                                    R      30
C  ***    R ARRAY SEGMENT 7 - CONSTANTS.                                R      31
C  *                                                                    R      32
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCON,TAUENG,TAUCON,TAUD,        R      33
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,           R      34
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT            R      35
      REAL  KU,KW,KFRPM,KCON,                                           R      36
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,             R      37
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT              R      38
C  *                                                                    R      39
C  ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.     R      40
C  *                                                                    R      41
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,PSI,PHI,V5,PSI5,X1DWS,  R      42
     A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP,R      43
     B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,     R      44
     C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,   R      45
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                     D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1,          R      46
                     E       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,               R      47
60                   F       ZBIASP                                                              R      48
                C  *                                                                             R      49
                C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                              R      50
                C  *                                                                             R      51
                     COMMON THETAC,OFRPMOL,DCONOL,DEOL,GAMMAGS,RANGE,VAIRC                       R      52
65              C  *                                                                             R      53
                C  ***    R ARRAY SEGMENT 10 - AERO DATA.                                        R      54
                C  *                                                                             R      55
                     COMMON XU,XW,XQ,XFRPM,XCON,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCON,ZPDIGV,            R      56
                    A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                             R      57
70                   REAL   MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                                 R      58
                C  *                                                                             R      59
                C  ***    R ARRAY SEGMENT 11                                                     R      60
                C  *                                                                             R      61
                     COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA                    R      62
75              C  *                                                                             R      63
                C  ***    R ARRAY SEGMENT 12 - CONTROLS.                                         R      64
                C  *                                                                             R      65
                     COMMON  DE,DT,DCDM,DED,DTD,DCDND                                            R      66
                C  *                                                                             R      67
80              C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.               R      68
                C  *                                                                             R      69
                     COMMON TABV1(6)                                                             R      70
                C  *                                                                             R      71
                C  ***    R ARRAY SEGMENT 14 - SPEED TABLE FOR OPEN LOOP COMMAND TABLE LOOKUPS.  R      72
85              C  *                                                                             R      73
                     COMMON TABV2(10)                                                            R      74
                C  *                                                                             R      75
                C  ***    R ARRAY SEGMENT 15 - FLIGHT ABOVE SHIP TABLE FOR EZ LOOKUP.            R      76
                C  *                                                                             R      77
90                   COMMON TABEZP(7)                                                            R      78
                C  *                                                                             R      79
                C  ***    R ARRAY SEGMENT 16 - EZ TABLE.                                         R      80
                C  *                                                                             R      81
                     COMMON TABEZ(7)                                                             R      82
95              C  *                                                                             R      83
                C  ***    R ARRAY SEGMENT 17 - SHIP MOTION                                       R      84
                C  *                                                                             R      85
                     COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,                     R      86
                    1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT               R      87
100                  REAL KXS,KZS,KTS,KYS,KRS,KPS                                                R      88
                C  *                                                                             R      89
                C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.                     R      90
                C  *                                                                             R      91
                     COMMON TABTC(10)                                                            R      92
105                  COMMON TRPMOL(10)                                                           R      93
                     COMMON TCONOL(10)                                                           R      94
                     COMMON TDEOL(10)                                                            R      95
                C  *                                                                             R      96
                C  ***    R ARRAY SEGMENTS 24-25 - NOZZLE TABLES.                                R      97
110             C  *                                                                             R      98
                     COMMON TABR(10)                                                             R      99
                     COMMON TABRD(10)                                                            R     100
                C  *                                                                             R     101
                C  ***    R ARRAY SEGMENTS 27-48 - AERO TABLES.                                  R     102
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      C  *                                                                  R      103
            COMMON TXU(6)                                                   R      104
            COMMON TXW(6)                                                   R      105
            COMMON TXQ(6)                                                   R      106
            COMMON TXRPM(6)                                                 R      107
            COMMON TXCON(6)                                                 R      108
            COMMON TXPIGV(6)                                                R      109
            COMMON TXDE(6)                                                  R      110
            COMMON TZU(6)                                                   R      111
            COMMON TZW(6)                                                   R      112
            COMMON TZQ(6)                                                   R      113
            COMMON TZRPM(6)                                                 R      114
            COMMON TZCON(6)                                                 R      115
            COMMON TZPIGV(6)                                                R      116
            COMMON TZDE(6)                                                  R      117
            COMMON TMU(6)                                                   R      118
            COMMON TMW(6)                                                   R      119
            COMMON TMWD(6)                                                  R      120
            COMMON TMQ(6)                                                   R      121
            COMMON TMRPM(6)                                                 R      122
            COMMON TMCON(6)                                                 R      123
            COMMON TMPIGV(6)                                                R      124
            COMMON TMDE(6)                                                  R      125
      C  *                                                                  R      126
      C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIMENSION)  R  127
      C  *                                                                  R      128
            COMMON F(39,39),P(39,39),PDOT(39,39),GM(32,15),QM(15,15)        R      129
      C  *                                                                  R      130
      C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.               R      131
      C  *                                                                  R      132
            COMMON SIGMA(50)                                                R      133
            COMMON SIGMAXY(50)                                              R      134
      C  *                                                                  R      135
      C  ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES                     R      136
      C  *                                                                  R      137
            COMMON VXX(5,5,3)                                               R      138
            COMMON VYY(5,5,3)                                               R      139
            COMMON VZZ(5,5,3)                                               R      140
            COMMON SVXX(5,5,3)                                              R      141
            COMMON SVYY(5,5,3)                                              R      142
            COMMON SVZZ(5,5,3)                                              R      143
      C  *                                                                  R      144
      C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS           R      145
      C  *                                                                  R      146
            COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),       R      147
           1        TKDEZ(6), TKDEN(6), TKDEDE(6), TKDEDT(6),               R      148
           2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),       R      149
           3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)                R      150
      C  *                                                                  R      151
      C  ***    R ARRAY SEGMENTS 81-106                                     R      152
      C  *                                                                  R      153
            COMMON F1(7,7),G1(7,3),GAMMA(7,8),A(8,8),B(8,5),M1(6,6),M2(6,7),R      154
           1       H(6,6),D(6,7),C(3,15),RL(3,3),W(5,5),VU(3,3),VY(6,6),    R      155
           2       VYI(6,6),S(3,3),FE(18,18),QE(18,18),PE(18,18),PED(18,18),R      156
           3       KG(18,6),FXHAT(18,18),PXHAT(18,18),PXHATD(18,18),PX(18,18),R    157
           4       CS(3,3)                                                  R      158
            REAL M1,M2,KG                                                   R      159
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C  *                                                                      R
C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE RELATED)  R
C  *                                                                      R
      COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                       R
     1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                        R
C  *                                                                      R
C  ***    R ARRAY SEGMENTS 108-119                                        R
C  *                                                                      R
      COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),          R
     1        TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),        R
     2        TDTVZ(6), TDTVZD(6)                                         R
C  ****************************************************************  C   R
C  *                                                                      I
C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                          I
C  *                                                                      I
      COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NOAW,NOINIT   I
C  *                                                                      I
C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                         I
C  *                                                                      I
      COMMON/INTEGER/ INDX1(14)                                           I
C  *                                                                      I
C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                              I
C  *                                                                      I
      COMMON/INTEGER/ INDX2(14)                                           I
C  *                                                                      I
C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                            I
C  *                                                                      I
      COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX          I
C                                                                        CI
C*********************************************************************  MISCAL
C*                                                                 *  MISCAL
C*        SIGMAS OF STATE VARIABLES AND OTHER TERMS.                *  MISCAL
C*                                                                 *  MISCAL
C*********************************************************************  MISCAL
C  *                                                                      MISCAL
C  ***    STATE VARIABLES.                                                MISCAL
C  *                                                                      MISCAL
      DO 10 I=1,NPA                                                       MISCAL
      SIGMA(I)= SQRT(P(I,I))                                              MISCAL
C    SAVE THE CROSS CORRELATION WITH X (STATE NO. 5)                      MISCAL
      SIGMAXY(I) = P(5,I)                                                 MISCAL
      CA(I)    = 0.0                                                      MISCAL
10    CONTINUE                                                            MISCAL
      L = NPA                                                             MISCAL
      IF(NPRNT.EQ.0) GO TO 30                                             MISCAL
C  ***    PRODUCE REQUESTED PRINT.                                        MISCAL
      WRITE(6,2000) TIME                                                  MISCAL
2000  FORMAT(1H1,47X,27HCOVARIANCE MATRIX AT TIME =,F6.2,5H SEC.   //)    MISCAL
      DO 20 I=1,NPA                                                       MISCAL
      WRITE(6,2010) (P(I,J),J=1,NPA)                                      MISCAL
2010  FORMAT(1X,8E16.6)                                                   MISCAL
      WRITE(6,2020)                                                       MISCAL
2020  FORMAT(/)                                                           MISCAL
20    CONTINUE                                                            MISCAL
      WRITE(6,2030) (SIGMA(I),I=1,NPA)                                    MISCAL
2030  FORMAT(//35H SQUARE ROOT OF MAIN DIAGONAL TERMS    ,                MISCAL
     1      /(8E12.4))                                                    MISCAL
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      WRITE(6,3000) TIME                                                    MISCAL  45
230   3000 FORMAT(1H1,47X,19HPE MATRIX AT TIME =,F6.2,5H SEC. //)           MISCAL  46
      DO 23 I=1,NPE                                                         MISCAL  47
      WRITE(6,2010) (PE(I,J),J=1,NPE)                                       MISCAL  48
      WRITE(6,2020)                                                         MISCAL  49
   23 CONTINUE                                                              MISCAL  50
235   WRITE(6,3500) TIME                                                    MISCAL  51
      3500 FORMAT(1H1,47X,#KG MATRIX AT TIME =#,F6.2,# SEC.# //)            MISCAL  52
      DO 25 I=1,NPE                                                         MISCAL  53
      WRITE(6,2010) (KG(I,J),J=1,6)                                         MISCAL  54
      WRITE(6,2020)                                                         MISCAL  55
240   25 CONTINUE                                                           MISCAL  56
      WRITE(6,3600) TIME                                                    MISCAL  57
      3600 FORMAT(1H1,47X,#VY MATRIX AT TIME =#,F6.2,# SEC.# //)            MISCAL  58
      DO 26 I=1,6                                                           MISCAL  59
      WRITE(6,2010) (VY(I,J),J=1,6)                                         MISCAL  60
245   WRITE(6,2020)                                                         MISCAL  61
   26 CONTINUE                                                              MISCAL  62
      WRITE(6,3700) TIME                                                    MISCAL  63
      3700 FORMAT(1H1,47X,#VU MATRIX AT TIME =#,F6.2,# SEC.# //)            MISCAL  64
      DO 27 I=1,3                                                           MISCAL  65
250   WRITE(6,2010) (VU(I,J),J=1,3)                                         MISCAL  66
      WRITE(6,2020)                                                         MISCAL  67
   27 CONTINUE                                                              MISCAL  68
   30 CONTINUE                                                              MISCAL  69
C  *                                                                        MISCAL  70
255 C  ***    GLIDE SLOPE ERROR                                            MISCAL  71
C  *                                                                        MISCAL  72
      CA(5)   =-TAN(0.01745329*GAMMAGS)                                     MISCAL  73
      CA(6)   = 1.0                                                         MISCAL  74
      L       = L + 1                                                       MISCAL  75
260   SIGMA(L)= SQRT(CA(5)*CA(5)*P(5,5) + CA(5)*CA(6)*P(5,6) +              MISCAL  76
     1               CA(6)*CA(5)*P(6,5) + CA(6)*CA(6)*P(6,6))               MISCAL  77
      SIGMAXY(L) = CA(5)*P(5,5) + CA(6)*P(5,6)                              MISCAL  78
C  *                                                                        MISCAL  79
C  ***    TOUCHDOWN DISPERSION, Z DIRECTION                               MISCAL  80
265 C  *                                                                    MISCAL  81
      CA(6) = 1.0                                                           MISCAL  82
      CA(38) = -KZS                                                         MISCAL  83
      L = L + 1                                                             MISCAL  84
      SIGMA(L) = SQRT(CA(6)*CA(6)*P(6,6) + CA(6)*CA(38)*P(6,38) +           MISCAL  85
     *          CA(38)*CA(6)*P(38,6) + CA(38)*CA(38)*P(38,38))              MISCAL  86
270   SIGMAXY(L) = CA(6)*P(5,6) + CA(38)*P(5,38)                            MISCAL  87
C*************************************************************************MISCAL  88
C*                        END OF SIGMA HACK                              *MISCAL  89
C*************************************************************************MISCAL  90
275 C                                                                       MISCAL  91
C                                                                           MISCAL  92
      RETURN                                                                MISCAL  93
      END                                                                   MISCAL  94
```

```
      SUBROUTINE PROP                                                   PROP
C     ******************************************************************** CPROP
C     ***                                                            *** CPROP
C     ***    ROUTINE TO CALCULATE PERTUBATION EQNS AND PROPAGATE COVARIANCE *** CPROP
C     ***                                                            *** CPROP
C     ******************************************************************** CPROP
      DIMENSION WK1(7,18),WK2(15,32),BWRT(8,8),DOO(6,18),G2(32,32)      PROP
C     *                                                                 R
C     ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                 R
C     *                                                                 R
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                            R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 2 - DERIVATIVES.                           R
C     *                                                                 R
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,         R
     A       ZSPDOT,TSPDOT                                              R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                       R
C     *                                                                 R
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS              R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.   R
C     *                                                                 R
      COMMON UC,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,    R
     A       THETAAO,PSIAO,PHIAO,PCDO                                   R
      REAL   MO                                                         R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.              R
C     *                                                                 R
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM            R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 6 - GEOMETRY.                              R
C     *                                                                 R
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                   R
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                             R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 7 - CONSTANTS.                             R
C     *                                                                 R
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,        R
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,           R
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT            R
      REAL  KU,KW,KFRPM,KCDN,                                           R
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,             R
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT              R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.  R
C     *                                                                 R
      COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,PSI,PHI,V5,PSI5,X1DWS,  R
     A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP, R
     B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,     R
     C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,   R
     D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1, R
     E       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,      R
     F       ZBIASP                                                     R
C     *                                                                 R
C     ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                  R
C     *                                                                 R
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      COMMON THETAC,DFRPMOL,DCDNOL,DECL,GAMMAGS,RANGE,VAIPC
C  *
C  ***    P ARRAY SEGMENT 10 - AERO DATA.
C  *
      COMMON XU,XW,XQ,XFRPM,XCDN,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCDN,ZPDIGV,
     A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE
      REAL   MU,MW,MWDOT,MQ,MFRPM,MCDN,MPDIGV,MDE
C  *
C  ***    R ARRAY SEGMENT 11
C  *
      COMMON  RC,RCD,XAPCOM,ERRX,ERPU,      ERRZ,ERRW, ETHETA
C  *
C  ***    R ARRAY SEGMENT 12 - CONTROLS.
C  *
      COMMON  DE,DT,DCDN,DED,DTD,DCDND
C  *
C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.
C  *
      COMMON TABV1(6)
C  *
C  ***    R ARRAY SEGMENT 14 - SPEED TABLE FOR OPEN LOOP COMMAND TABLE LOOKUPS.
C  *
      COMMON TABV2(10)
C  *
C  ***    R ARRAY SEGMENT 15 - FLIGHT ABOVE SHIP TABLE FOR EZ LOOKUP.
C  *
      COMMON TABEZP(7)
C  *
C  ***    R ARRAY SEGMENT 16 - EZ TABLE.
C  *
      COMMON TABEZ(7)
C  *
C  ***    R ARRAY SEGMENT 17 - SHIP MOTION
C  *
      COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,
     1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT
      REAL KXS,KZS,KTS,KYS,KRS,KPS
C  *
C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.
C  *
      COMMON TABTC(10)
      COMMON TPPMOL(10)
      COMMON TCDNOL(10)
      COMMON TDEOL(10)
C  *
C  ***    R ARRAY SEGMENTS 24-25 - NOZZLE TABLES.
C  *
      COMMON TABR(10)
      COMMON TABRD(10)
C  *
C  ***    R ARRAY SEGMENTS 27-48 - AERO TABLES.
C  *
      COMMON TXU(6)
      COMMON TXW(6)
      COMMON TXQ(6)
      COMMON TXRPM(6)
      COMMON TXCDN(6)
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      COMMON TXPIGV(6)
      COMMON TXDE(6)
      COMMON TZU(6)
      COMMON TZW(6)
      COMMON TZQ(6)
      COMMON TZRPM(6)
      COMMON TZCDN(6)
      COMMON TZPIGV(6)
      COMMON TZDE(6)
      COMMON TMU(6)
      COMMON TMW(6)
      COMMON TMWD(6)
      COMMON TMQ(6)
      COMMON TMRPM(6)
      COMMON TMCDN(6)
      COMMON TMPIGV(6)
      COMMON TMDE(6)
C  *
C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIMENSION)
C  *
      COMMON F(39,39),P(39,39),PDOT(39,39),GM(32,15),QM(15,15)
C  *
C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.
C  *
      COMMON SIGMA(50)
      COMMON SIGMAXY(50)
C  *
C  ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES
C  *
      COMMON VXX(5,5,3)
      COMMON VYY(5,5,3)
      COMMON VZZ(5,5,3)
      COMMON SVXX(5,5,3)
      COMMON SVYY(5,5,3)
      COMMON SVZZ(5,5,3)
C  *
C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS
C  *
      COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),
     1        TKDEZ(6), TKDEN(6), TKDEDE(6), TKDEDT(6),
     2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),
     3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)
C  *
C  ***    R ARRAY SEGMENTS 81-106
C  *
      COMMON F1(7,7),G1(7,3),GAMMA(7,8),A(8,8),B(8,5),M1(6,6),M2(6,7),
     1       H(6,6),D(6,7),C(3,15),RL(3,3),W(5,5),VU(3,3),VY(6,6),
     2       VYI(6,6),S(3,3),FE(18,18),QE(18,18),PE(18,18),PED(18,18),
     3       KG(18,6),FXHAT(18,18),PXHAT(18,18),PXHATD(18,18),PX(18,18),
     4       CS(3,3)
      REAL M1,M2,KG
C  *
C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE RELATED)
C  *
      COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,
     1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD
C  *
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C  ***    R ARRAY SEGMENTS 108-119                                          R
C  *                                                                        R
      COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),            R
     1        TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),           R
     2        TDTVZ(6), TDTVZD(6)                                            R
C  ***************************************************************  C       R
C  *                                                                        I
C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                            I
C  *                                                                        I
      COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NOAW,NOINIT     I
C  *                                                                        I
C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                           I
C  *                                                                        I
      COMMON/INTEGER/ INDX1(14)                                             I
C  *                                                                        I
C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                                I
C  *                                                                        I
      COMMON/INTEGER/ INDX2(14)                                             I
C  *                                                                        I
C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                              I
C  *                                                                        I
      COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX            I
C                                                                          CI
C  *                                                                        INTEG
C  ***    TEMPORARY INTEGRATION STORAGE.                                    INTEG
C  ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2             INTEG
C  *                                                                        INTEG
      COMMON/INTEG/ RI(2187),RT(2187)                                       INTEG
      COSTO = COS(THETAO)                                                   PROP
      SINTO = SIN(THETAO)                                                   PROP
      COSSIA = COS(PSIA)                                                    PROP
      SINSIA = SIN(PSIA)                                                    PROP
      COSTA = COS(THETAA)                                                   PROP
      SINTA = SIN(THETAA)                                                   PROP
      V5CS5 = V5*COS(PSI5) - RCDO                                           PROP
C *                                                                         PROP
C ***     F1 MATRIX                                                         PROP
C *                                                                         PROP
      F1(1,1) = XU                                                          PROP
      F1(1,2) = XW - QO                                                     PROP
      F1(1,3) = XQ - WO                                                     PROP
      F1(1,4) = -G*COSTO                                                    PROP
      F1(1,7) = XFRPM                                                       PROP
      F1(2,1) = QO + ZU                                                     PROP
      F1(2,2) = ZW                                                          PROP
      F1(2,3) = UO + ZQ                                                     PROP
      F1(2,4) = -G*SINTO                                                    PROP
      F1(2,7) = ZFRPM                                                       PROP
      F1(3,1) = MU + MWDOT*F1(2,1)                                          PROP
      F1(3,2) = MW + MWDOT*F1(2,2)                                          PROP
      F1(3,3) = MQ + MWDOT*F1(2,3)                                          PROP
      F1(3,4) =       MWDOT*F1(2,4)                                         PROP
      F1(3,7) = MFRPM + MWDOT*F1(2,7)                                       PROP
      F1(4,3) = 1.0                                                         PROP
      F1(5,1) = COSTO                                                       PROP
      F1(5,2) = SINTO                                                       PROP
      F1(5,4) = -UO*SINTO + WO*COSTO                                        PROP
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      F1(6,1) = -SINTO                                                  PROP    41
230   F1(6,2) = COSTO                                                   PROP    42
      F1(6,4) = -UO*COSTO - WO*SINTO                                    PROP    43
      F1(7,7) = -1.0/TAUENG                                             PROP    44
C *                                                                     PROP    45
C ***     G1 MATRIX                                                     PROP    46
235   C *                                                               PROP    47
      G1(1,1) = XDE                                                     PROP    48
      G1(1,3) = XCDN                                                    PROP    49
      G1(2,1) = ZDE                                                     PROP    50
      G1(2,3) = ZCDN                                                    PROP    51
240   G1(3,1) = MDE + MWDOT*G1(2,1)                                     PROP    52
      G1(3,3) = MCDN + MWDOT*G1(2,3)                                    PROP    53
      G1(7,2) = KFRPM/TAUENG                                            PROP    54
C *                                                                     PROP    55
C ***     GAMMA MATRIX                                                  PROP    56
245   C *                                                               PROP    57
      GAMMA(1,1) = -XU                                                  PROP    58
      GAMMA(1,2) = -XW                                                  PROP    59
      GAMMA(1,3) = -COSSIA*(XU*COSTA + XW*SINTA)                        PROP    60
      GAMMA(1,5) = -SINSIA*(XU*COSTA + XW*SINTA)                        PROP    61
250   GAMMA(1,7) = XU*SINTA - XW*COSTA                                  PROP    62
      GAMMA(2,1) = -ZU                                                  PROP    63
      GAMMA(2,2) = -ZW                                                  PROP    64
      GAMMA(2,3) = -COSSIA*(ZU*COSTA + ZW*SINTA)                        PROP    65
      GAMMA(2,5) = -SINSIA*(ZU*COSTA + ZW*SINTA)                        PROP    66
255   GAMMA(2,7) = ZU*SINTA - ZW*COSTA                                  PROP    67
      GAMMA(3,1) = -MU + MWDOT*GAMMA(2,1)                               PROP    68
      GAMMA(3,2) = -MW + MWDOT*GAMMA(2,2)                               PROP    69
      GAMMA(3,3) = -COSSIA*(MU*COSTA + MW*SINTA) + MWDOT*GAMMA(2,3)     PROP    70
      GAMMA(3,5) = -SINSIA*(MU*COSTA + MW*SINTA) + MWDOT*GAMMA(2,5)     PROP    71
260   GAMMA(3,7) = MU*SINTA - MW*COSTA + MWDOT*GAMMA(2,7)               PROP    72
C *                                                                     PROP    73
C ***     A MATRIX                                                      PROP    74
C *                                                                     PROP    75
      A(1,1) = -OMEGAU                                                  PROP    76
265   A(2,2) = -OMEGAW                                                  PROP    77
      A(3,4) = 1.0                                                      PROP    78
      A(4,3) = -WNSF*WNSF                                               PROP    79
      A(4,4) = -0.8*WNSF                                                PROP    80
      A(5,6) = 1.0                                                      PROP    81
270   A(6,5) = A(4,3)                                                   PROP    82
      A(6,6) = A(4,4)                                                   PROP    83
      A(7,8) = 1.0                                                      PROP    84
      A(8,7) = A(4,3)                                                   PROP    85
      A(8,8) = A(4,4)                                                   PROP    86
275   C *                                                               PROP    87
C ***     B MATRIX                                                      PROP    88
C *                                                                     PROP    89
      B(1,1) = SQRT(KU)                                                 PROP    90
      B(2,2) = SQRT(KW)                                                 PROP    91
280   B(4,3) = TR1*SIGMAVX                                              PROP    92
      B(6,4) = TR1*SIGMAVY                                              PROP    93
      B(8,5) = TR1*SIGMAVZ                                              PROP    94
C *                                                                     PROP    95
C ***     D MATRIX                                                      PROP    96
285   C *                                                               PROP    97
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                D(1,1) = COSTO                                                  PROP    98
                D(1,2) = SINTO                                                  PROP    99
                D(1,4) = -UO*SINTO + WO*COSTO                                   PROP   100
                D(2,1) = -SINTO                                                 PROP   101
290             D(2,2) = COSTO                                                  PROP   102
                D(2,4) = -UO*COSTO - WO*SINTO                                   PROP   103
                D(3,3) = 1.0                                                    PROP   104
                D(4,4) = 1.0                                                    PROP   105
                D(5,5) = 1.0                                                    PROP   106
295             D(6,6) = 1.0                                                    PROP   107
          C *                                                                   PROP   108
          C ***    PX MATRIX                                                    PROP   109
          C *                                                                   PROP   110
                CALL ADDNN(PXHAT,PE,PX,NPX)                                     PROP   111
300       C *                                                                   PROP   112
          C ***     D O O MATRIX (MEASUREMENT MATRIX)                           PROP   113
          C *                                                                   PROP   114
                CALL LAYIN(DOO,1,1,6,D,6,7,0)                                   PROP   115
          C *                                                                   PROP   116
305       C ***     VY MATRIX                                                   PROP   117
          C *                                                                   PROP   118
                CALL MULT(DOO,6,NPX,PX,NPX,NPX,WK1)                             PROP   119
                CALL MULTABT(WK1,6,NPX,DOO,6,NPX,VY)                            PROP   120
                DO 30 J=1,6                                                     PROP   121
310             DO 25 I=1,6                                                     PROP   122
                IF(I.NE.J) VY(I,J) = 0.0                                        PROP   123
                VY(I,J) = .031415927*VY(I,J)                                    PROP   124
             25 CONTINUE                                                        PROP   125
                IF(VY(J,J).LT..1E-5) VY(J,J) = .1E-5                            PROP   126
315          30 CONTINUE                                                        PROP   127
          C *                                                                   PROP   128
          C ***     VU MATRIX                                                   PROP   129
          C *                                                                   PROP   130
                DO 50 I=1,2                                                     PROP   131
320             VU(I,I) = .00942478*PX(NPX-3+I,NPX-3+I)                         PROP   132
                IF(VU(I,I).LT..3E-6) VU(I,I) = .3E-6                            PROP   133
             50 CONTINUE                                                        PROP   134
          C *                                                                   PROP   135
          C ***     FE MATRIX                                                   PROP   136
325       C *                                                                   PROP   137
                CALL LAYIN(FE,1,1,NPE,F1,7,7,0)                                 PROP   138
                CALL LAYIN(FE,1,8,NPE,GAMMA,7,8,0)                              PROP   139
                CALL LAYIN(FE,1,16,NPE,G1,7,3,0)                                PROP   140
                CALL LAYIN(FE,8,8,NPE,A,8,8,0)                                  PROP   141
330       C *                                                                   PROP   142
          C ***     C MATRIX                                                    PROP   143
          C *                                                                   PROP   144
                CALL  TLU(VAIR,TABV1,6,TDEUR,12,DEUR)                           PROP   145
                C(1,1) = -KDEU                                                  PROP   146
335             C(1,2) = -KDEW                                                  PROP   147
                C(1,3) = -KDEO                                                  PROP   148
                C(1,4) = -KDET                                                  PROP   149
                C(1,5) = -KDEX                                                  PROP   150
                C(1,6) = -KDEZ                                                  PROP   151
340             C(1,7) = -KDEN                                                  PROP   152
                C(1,8) = -DEUR                                                  PROP   153
                C(1,9) = -DEWR                                                  PROP   154
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                C(1,10) = -DEVX                                                  PROP  155
                C(1,11) = -DEVXD                                                 PROP  156
      345       C(1,14) = -DEVZ                                                  PROP  157
                C(1,15) = -DEVZD                                                 PROP  158
                C(2,1) = -KDTU                                                   PROP  159
                C(2,2) = -KDTW                                                   PROP  160
                C(2,3) = -KDTQ                                                   PROP  161
      350       C(2,4) = -KDTT                                                   PROP  162
                C(2,5) = -KDTX                                                   PROP  163
                C(2,6) = -KDTZ                                                   PROP  164
                C(2,7) = -KDTN                                                   PROP  165
                C(2,8)  = -DTUR                                                  PROP  166
      355       C(2,9)  = -DTWR                                                  PROP  167
                C(2,10) = -DTVX                                                  PROP  168
                C(2,11) = -DTVXD                                                 PROP  169
                C(2,14) = -DTVZ                                                  PROP  170
                C(2,15) = -DTVZD                                                 PROP  171
      360   C *                                                                  PROP  172
            C ***     RL MATRIX                                                  PROP  173
            C *                                                                  PROP  174
                RL(1,1) = -KDEDE                                                 PROP  175
                RL(1,2) = -KDEDT                                                 PROP  176
      365       RL(2,1) = -KDTDE                                                 PROP  177
                RL(2,2) = -KDTDT                                                 PROP  178
            C *                                                                  PROP  179
            C ***    CS MATRIX                                                   PROP  180
            C *                                                                  PROP  181
      370       CS(1,2) = -KDEU*SINTO*KZS/TAUPRT + KDEW*COSTO*KZS/TAUPRT         PROP  182
                CS(1,3) = KDEU*SINTO/TAUPRT - KDEW*COSTO/TAUPRT + KDEZ           PROP  183
                CS(2,2) = -KDTU*SINTO*KZS/TAUPRT + KDTW*COSTO*KZS/TAUPRT         PROP  184
                CS(2,3) = KDTU*SINTO/TAUPRT - KDTW*COSTO/TAUPRT + KDTZ           PROP  185
            C *                                                                  PROP  186
      375   C ***    FX HAT MATRIX                                               PROP  187
            C *                                                                  PROP  188
                CALL LAYIN(FXHAT,1,1,NPX,F1,7,7,0)                               PROP  189
                CALL LAYIN(FXHAT,1,8,NPX,GAMMA,7,6,0)                            PROP  190
                CALL LAYIN(FXHAT,1,16,NPX,G1,7,3,0)                              PROP  191
      380       CALL LAYIN(FXHAT,8,8,NPX,A,8,8,C)                                PROP  192
                CALL LAYIN(FXHAT,16,1,NPX,C,3,15,0)                              PROP  193
                CALL LAYIN(FXHAT,16,16,NPX,RL,3,3,0)                             PROP  194
            C *                                                                  PROP  195
            C ***     QE MATRIX                                                  PROP  196
      385   C *                                                                  PROP  197
                CALL MULT(B,8,5,W,5,5,WK1)                                       PROP  198
                CALL MULTABT(WK1,8,5,B,8,5,BWBT)                                 PROP  199
                CALL LAYIN(QE,8,8,NPE,BWBT,8,8,0)                                PROP  200
            C *                                                                  PROP  201
      390   C ***     KG MATRIX                                                  PROP  202
            C *                                                                  PROP  203
                DO 100 I=1,6                                                     PROP  204
                VYI(I,I) = 1.0/VY(I,I)                                           PROP  205
              100 CONTINUE                                                       PROP  206
      395       CALL MULTABT(PE,NPE,NPE,DOO,6,NPE,WK1)                           PROP  207
                CALL MULT(WK1,NPE,6,VYI,6,6,KG)                                  PROP  208
            C *                                                                  PROP  209
            * ***     PE DOT MATRIX                                              PROP  210
            C *                                                                  PROP  211
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      CALL MULT(DCC,S,NPE,PE,NPE,NPE,WK1)                                PROP  212
      CALL MULT(KG,NPE,6,WK1,6,NPE,WK2)                                  PROP  213
      CALL MULTNN(FE,PE,PED,NPE)                                         PROP  214
      CALL ADDTR(PED,NPE)                                                PROP  215
      CALL ADDNN(PED,QE,PED,NPE)                                         PROP  216
      CALL SUB(PED,WK2,NPE,NPE,PED)                                      PROP  217
C *                                                                      PROP  218
C ***    PX HAT DOT MATRIX                                               PROP  219
C *                                                                      PROP  220
      CALL MULTNN(PXHAT,PXHAT,PXHATD,NPX)                                PROP  221
      CALL ADDTR(PXHATD,NPX)                                             PROP  222
      CALL ADDNN(PXHATD,WK2,PXHATD,NPX)                                  PROP  223
C *                                                                      PROP  224
C ***     F MATRIX                                                       PROP  225
C *                                                                      PROP  226
      CALL LAYIN(F,1,1,NPA,FE,NPE,NPE,0)                                 PROP  227
      CALL LAYIN(F,16,19,NPA,C,3,15,0)                                   PROP  228
      CALL LAYIN(F,16,34,NPA,PL,3,3,0)                                   PROP  229
      CALL LAYIN(F,16,37,NPA,CS,3,3,0)                                   PROP  230
      CALL MULT(KG,NPE,6,D,6,7,WK1)                                      PROP  231
      CALL LAYIN(F,19,1,NPA,WK1,NPE,7,0)                                 PROP  232
      CALL LAYIN(F,19,19,NPA,FE,NPE,NPE,0)                               PROP  233
      CALL LAYIN(F,34,19,NPA,C,3,15,0)                                   PROP  234
      CALL LAYIN(F,19,19,NPA,WK1,NPE,7,-1)                               PROP  235
      CALL LAYIN(F,34,34,NPA,PL,3,3,0)                                   PROP  236
      CALL LAYIN(F,37,37,NPA,S,3,3,0)                                    PROP  237
      CALL LAYIN(F,34,37,NPA,CS,3,3,0)                                   PROP  238
      F(16,22) = F(16,22) - KDEU*V5CS5*SINTO + KDEW*V5CS5*COSTO          PROP  239
      F(17,22) = F(17,22) - KDTU*V5CS5*SINTO + KDTW*V5CS5*COSTO          PROP  240
      F(34,22) = F(34,22) - KDEU*V5CS5*SINTO + KDEW*V5CS5*COSTO          PROP  241
      F(35,22) = F(35,22) - KDTU*V5CS5*SINTO + KDTW*V5CS5*COSTO          PROP  242
C *                                                                      PROP  243
C ***     GM MATRIX                                                      PROP  244
C *                                                                      PROP  245
      CALL LAYIN(GM,1,10,NGM,8,8,5,0)                                    PROP  246
      GM( 9,7) = 1.0                                                     PROP  247
      GM(10,8) = 1.0                                                     PROP  248
      GM(11,9) = 1.0                                                     PROP  249
      CALL LAYIN(GM,12,1,NGM,KG,NPE,6,0)                                 PROP  250
      GM(31,15) = 1.0                                                    PROP  251
C *                                                                      PROP  252
C ***     QM MATRIX                                                      PROP  253
C *                                                                      PROP  254
      CALL LAYIN(QM,1,1,NQM,VV,6,6,0)                                    PROP  255
      CALL LAYIN(QM,7,7,NQM,VU,3,3,0)                                    PROP  256
      CALL LAYIN(QM,10,10,NQM,W,5,5,0)                                   PROP  257
      QM(15,15) = 1.0                                                    PROP  258
C                                                                        PROP  259
C  *****************          PROPAGATE COVARIANCE          ************  PROP  260
C                                                                        PROP  261
      CALL MULTART(QM,NQM,NQM,GM,NGM,NQM,WK2)                            PROP  262
      CALL MULT(GM,NGM,NQM,WK2,NQM,NGM,G2)                               PROP  263
      IF(ICEES.EQ.1.AND.NOINIT.EQ.0)                                     PROP  264
     *   CALL SOLVR(F,G2,NPA,NGM,P,PDOT,RI,RT)                           PROP  265
      CALL MULTNN(F,P,PDOT,NPA)                                          PROP  266
      CALL ADDTR(PDOT,NPA)                                               PROP  267
      CALL ADDNN(PDOT,G2,PDOT,NPA,NGM)                                   PROP  268
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      RETURN                                                    PROP  269
      END                                                       PROP  270
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```
      SUBROUTINE SETUP(INT)                                                 SETUP    2
C*********************************************************************      SETUP    3
C*                                                                   *      SETUP    4
C*        ROUTINE TO INITIALIZE THE INTEGRATORS AND PERFORM ONE TIME *      SETUP    5
C*        ONLY CALCULATIONS.                                         *      SETUP    6
C*                                                                   *      SETUP    7
C*   INPUT ARGUMENTS                                                 *      SETUP    8
C*        INT        INTEGRATION OPTION.                             *      SETUP    9
C*                   1 = 4 TH ORDER RUNGE-KUTTA.                     *      SETUP   10
C*                   2 = 3 RD ORDER RUNGE-KUTTA.                     *      SETUP   11
C*                   3 = 2 ND ORDER ADAMS.                           *      SETUP   12
C*                                                                   *      SETUP   13
C*********************************************************************      SETUP   14
      DIMENSION R(1)                                                        SETUP   15
C  *                                                                        R        2
C  ***    R ARRAY SEGMENT 1 - INTEGRATION VARIABLES.                        R        3
C  *                                                                        R        4
      COMMON TIME,TO,DTIME,DTOUT,DTOUT2,TMAX                                R        5
C  *                                                                        R        6
C  ***    R ARRAY SEGMENT 2 - DERIVATIVES.                                  R        7
C  *                                                                        R        8
      COMMON UDOT,WDOT,QDOT,TDOT,XAPPDOT,ZAPPDOT,DFRPMD,XSPDOT,             R        9
     A       ZSPDOT,TSPDOT,                                                 R       10
     B       VDOT,PBDOT,RBDOT,YAPPDOT,PHIDOT,PSIDOT,YSPDOT                  R       11
C  *                                                                        R       12
C  ***    R ARRAY SEGMENT 3 - STATE VARIABLES.                              R       13
C  *                                                                        R       14
      COMMON UB,WB,QB,THETA,XAPP,ZAPP,DFRPM,XSP,ZSP,THETAS,                 R       15
     A        VB,PB,RB,YAPP,PHI,PSI,YSP                                     R       16
C  *                                                                        R       17
C  ***    R ARRAY SEGMENT 4 - REF. VALUES FOR LOCAL LINEARIZATION.          R       18
C  *                                                                        R       19
      COMMON UO,WO,QO,THETAO,XAPPO,ZAPPO,XO,ZO,MO,UBASO,WBASO,WASDO,        R       20
     A       THETAAO,PSIAO,PHIAO,RCDO,VO,PO,RO,YAPPO,PHIO,PSIO,YO,LO,       R       21
     B       NO,VBASO                                                       R       22
      REAL   MO,LO,NO                                                       R       23
C  *                                                                        R       24
C  ***    R ARRAY SEGMENT 5 - INPUT FORCES AND MOMENTS.                     R       25
C  *                                                                        R       26
      COMMON SUMFXO,SUMFZO,SUMMO,SUMFX,DFX,SUMFZ,DFZ,SUMM,DM,               R       27
     A       SUMFYO,SUMLO,SUMNO,SUMFY,DFY,SUML,DL,SUMN,DN                   R       28
C  *                                                                        R       29
C  ***    R ARRAY SEGMENT 6 - GEOMETRY.                                     R       30
C  *                                                                        R       31
      COMMON WEIGHT,G,IX,IY,IZ,IXZ,LM,WM,LTDM,LS,LTDS                       R       32
      REAL   G,IX,IY,IZ,IXZ,LM,LTDM,LS,LTDS                                 R       33
C  *                                                                        R       34
C  ***    R ARRAY SEGMENT 7 - CONSTANTS.                                    R       35
C  *                                                                        R       36
      COMMON  OMEGAU,OMEGAW,KU,KW,KFRPM,KCDN,TAUENG,TAUCDN,TAUD,            R       37
     1        KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,               R       38
     2        KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,               R       39
     3       OMEGAV,KV,TAUA,K1,K2,KY,B1,B2,TL1,TL2                          R       40
      REAL  KU,KW,KFRPM,KCDN,                                               R       41
     1      KDEU,KDEW,KDEQ,KDET,KDEX,KDEZ,KDEN,KDEDE,KDEDT,                 R       42
     2      KDTU,KDTW,KDTQ,KDTT,KDTX,KDTZ,KDTN,KDTDE,KDTDT,                 R       43
     3       K1,K2,KY,KV                                                    R       44
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      C  *                                                                  R       45
      C  ***    R ARRAY SEGMENT 8 - WIND, ALTITUDE, AIRSPEED AND AIRWAKE.   R       46
   60 C  *                                                                  R       47
         COMMON ALT,VAIR,UBAS,VBAS,WBAS,ALPHA,BETA,DUM1,DUM2,V5,PSI5,X1DWS,  R       48
        A       Y1DWS,VAMB,PSIAMB,X1DWA,Y1DWA,Z1DWA,VWOD,PSIWOD,PSI3,PSISP,  R       49
        B       PSIS,DX45,DY45,DZ45,XM,YM,ZM,PSIA,THETAA,PHIA,SIGMAVX,       R       50
        C       SIGMAVY,SIGMAVZ,VXAW,VYAW,VZAW,UWIND,UMEAN,UR,UAW,VWIND,     R       51
   65   D       VMEAN,VR,VAW,WWIND,WMEAN,WR,WAW,WNSF,PSISS,PSISC,PSIST,TS1,  R       52
        E       TS2,TS3,TS4,TS5,TR1,DXM145,DXM245,DYM145,DYM245,ZGSP,        R       53
        F       ZRIASP                                                       R       54
      C  *                                                                  R       55
      C  ***    R ARRAY SEGMENT 9 - OPEN LOOP PARAMETERS.                   R       56
   70 C  *                                                                  R       57
         COMMON THETAC,DFRPMOL,DCONOL,DEOL,GAMMAGS,RANGE,VAIRC,             R       58
        1       DAOL,DROL                                                    R       59
      C  *                                                                  R       60
      C  ***    R ARRAY SEGMENT 10 - AERO DATA.                             R       61
   75 C  *                                                                  R       62
         COMMON XU,XW,XQ,XFRPM,XCON,XPDIGV,XDE,ZU,ZW,ZQ,ZFRPM,ZCON,ZPDIGV,   R       63
        A       ZDE,MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE,                    R       64
        B        YV,YP,YR,YDA,YDR,LV,LP,LR,LDA,LDR,NV,NP,NR,                 R       65
        C        NDA,NDR                                                     R       66
   80    REAL   MU,MW,MWDOT,MQ,MFRPM,MCON,MPDIGV,MDE                        R       67
         REAL  LV,LP,LR,LDA,LDR,NV,NP,NR,NDA,NDR                            R       68
      C  *                                                                  R       69
      C  ***    R ARRAY SEGMENT 11                                          R       70
      C  *                                                                  R       71
   85    COMMON  RC,RCD,XAPCOM,ERRX,ERRU,      ERRZ,ERRW, ETHETA,           R       72
        1        ERY,ERPHI,ERPSI,YCOM,PHICOM,PSICOM                          R       73
      C  *                                                                  R       74
      C  ***    R ARRAY SEGMENT 12 - CONTROLS.                              R       75
      C  *                                                                  R       76
   90    COMMON  DE,DT,DCON,DED,DTD,DCOND,                                  R       77
        1        DA,DR,DAP,DRP,DA1,DA2,DR1,DR2,DA1D,DA2D,DR1D,DR2D          R       78
      C  *                                                                  R       79
      C  ***    R ARRAY SEGMENT 13 - SPEED TABLE FOR AERO TABLE LOOKUPS.    R       80
      C  *                                                                  R       81
   95    COMMON TABV1(6)                                                    R       82
      C  *                                                                  R       83
      C  ***    R ARRAY SEGMENT 14 -  TIME TABLE FOR OPEN LOOP COMMAND TABLE LOOKUPS. R 84
      C  *                                                                  R       85
         COMMON TABV2(10)                                                   R       86
  100 C  *                                                                  R       87
      C  ***    R ARRAY SEGMENT 15 - UNUSED                                 R       88
      C  *                                                                  R       89
      C  *                                                                  R       90
      C  ***    R ARRAY SEGMENT 16 - GDF RELATED STUFF                      R       91
  105 C  *                                                                  R       92
         COMMON SIGDAP, SIGDRP, SIGDA, SIGDR, GAINDA, GAINDR                R       93
      C  *                                                                  R       94
      C  ***    R ARRAY SEGMENT 17 - SHIP MOTION                            R       95
      C  *                                                                  R       96
  110    COMMON KXS,ZETAXS,WNXS,KZS,ZETAZS,WNZS,KTS,ZETATS,WNTS,            R       97
        1       KYS,ZETAYS,WNYS,KRS,ZETARS,WNRS,KPS,ZETAPS,WNPS,TAUPRT      R       98
         REAL KXS,KZS,KTS,KYS,KRS,KPS                                       R       99
      C  *                                                                  R      100
      C  ***    R ARRAY SEGMENTS 20-23 - OPEN LOOP COMMAND TABLES.          R      101
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C  *
      COMMON TABTC(10)
      COMMON TRPMOL(10)
      COMMON TCDNOL(10)
      COMMON TDEOL(10)
C  *
C  ***    R ARRAY SEGMENTS 24-25
C  *
      COMMON TABR(10)
      COMMON TABRDOT(10)
C  *
C  ***    R ARRAY SEGMENTS 27-48 - LONGITUDINAL AERO DATA TABLES
C  *
      COMMON TXU(6)
      COMMON TXW(6)
      COMMON TXQ(6)
      COMMON TXRPM(6)
      COMMON TXCDN(6)
      COMMON TXPIGV(6)
      COMMON TXDE(6)
      COMMON TZU(6)
      COMMON TZW(6)
      COMMON TZQ(6)
      COMMON TZRPM(6)
      COMMON TZCDN(6)
      COMMON TZPIGV(6)
      COMMON TZDE(6)
      COMMON TMU(6)
      COMMON TMW(6)
      COMMON TMWD(6)
      COMMON TMQ(6)
      COMMON TMRPM(6)
      COMMON TMCDN(6)
      COMMON TMPIGV(6)
      COMMON TMDE(6)
C  *
C  ***    R ARRAY SEGMENTS 50-54 - COVARIANCE MATRICIES (DO NOT OVERDIMENSION)
C  *
      COMMON  F(17,17),P(17,17),PDOT(17,17),GM(11,4),QM(4,4)
C  *
C  ***    R ARRAY SEGMENTS 55-56 - STANDARD DEVIATIONS.
C  *
      COMMON SIGMA(50)
      COMMON SIGMAXY(50)
C  *
C  ***    R ARRAY SEGMENTS 57-62 - AIRWAKE TABLES
C  *
      COMMON VXX(5,5,3)
      COMMON VYY(5,5,3)
      COMMON VZZ(5,5,3)
      COMMON SVXX(5,5,3)
      COMMON SVYY(5,5,3)
      COMMON SVZZ(5,5,3)
C  *
C  ***    R ARRAY SEGMENTS 63-80 - OPTIMAL CONTROLLER GAINS
C  *
      COMMON  TKDEU(6), TKDEW(6), TKDEQ(6), TKDET(6), TKDEX(6),
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                1        TKDEZ(6), TKDEN(6), TKDFDE(6), TKDEDT(6),                          R      159
                2        TKDTU(6), TKDTW(6), TKDTQ(6), TKDTT(6), TKDTX(6),                  R      160
                3        TKDTZ(6), TKDTN(6), TKDTDE(6), TKDTDT(6)                           R      161
      175     C  *                                                                          R      162
              C  ***    R ARRAY SEGMENTS 81-106                                            R      163
              C  *                                                                          R      164
                 COMMON F1(6,6),G1(6,4),GAMMA(6,7),A(7,7),B(7,4),M1(1,1),M2(1,1),         R      165
                1       H(1,1),D(1,1),C(4,6),PL(4,4),W(1,1),VU(1,1),VY(1,1),              R      166
      180       2       VYI(1,1),S(1,1),FE(1,1),QE(1,1),PE(1,1),PED(1,1),                 R      167
                3       KG(1,1),FXHAT(1,1),PXHAT(1,1),PXHATD(1,1),PX(1,1),                R      168
                4       CS(1,1)                                                           R      169
                 REAL M1,M2,KG                                                            R      170
              C  *                                                                          R      171
      185     C  ***    R ARRAY SEGMENT 107 - MORE OPTIMAL CONTROLLER GAINS (NOISE RELATED) R      172
              C  *                                                                          R      173
                 COMMON  DEUR, DEWR, DEVX, DEVXD, DEVZ, DEVZD,                            R      174
                1        DTUR, DTWR, DTVX, DTVXD, DTVZ, DTVZD                             R      175
              C  *                                                                          P      176
      190     C  ***    R ARRAY SEGMENTS 108-119                                           R      177
              C  *                                                                          R      178
                 COMMON  TDEUR(6), TDEWR(6), TDEVX(6), TDEVXD(6), TDEVZ(6),               R      179
                1        TDEVZD(6),  TDTUR(6), TDTWR(6), TDTVX(6), TDTVXD(6),             R      180
                2        TDTVZ(6), TDTVZD(6)                                              R      181
      195     C  *                                                                          R      182
              C  ***    R ARRAY SEGMENTS 120-134 - LAT/DIR AERO DATA TABLES                R      183
              C  *                                                                          R      184
                 COMMON  TYV(6), TYP(6), TYR(6), TYDA(6), TYDR(6),                        R      185
                1        TLV(6), TLP(6), TLR(6), TLDA(6), TLDR(6),                        R      186
      200       2        TNV(6), TNP(6), TNP(6), TNDA(6), TNDR(6)                         R      187
              C  *                                                                          R      188
              C  ***    R ARRAY SEGMENTS 135-139 - LONG. TERMS REQD FOR LAT/DIR CASE       R      189
              C  *                                                                          R      190
                 COMMON  TABUB(10),TABWB(10),TXAPP(10),TZAPP(10),TXSP(10)                 R      191
      205     C  *                                                                          R      192
              C  ***    R ARRAY SEGMENTS 140-143 - TABLES OF NONLINEAR FUNCTIONS           R      193
              C  *                                                                          R      194
                 COMMON TDAIN(4), TDADUT(4), TDRIN(4),TDROUT(4)                           R      195
              C  ********************************************************************  C  R      196
      210     C  *                                                                          I        2
              C  ***    I ARRAY SEGMENT 1 - INTEGER VARIABLES.                             I        3
              C  *                                                                          I        4
                 COMMON/INTEGER/ICEES,NEQU,NSTATES,NPA,NQM,NGM,NPE,NPX,NOAW,NOINIT        I        5
              C  *                                                                          I        6
      215     C  ***    I ARRAY SEGMENT 4 - DERIVATIVE INDICES.                            I        7
              C  *                                                                          I        8
                 COMMON/INTEGER/ INDX1(14)                                                I        9
              C  *                                                                          I       10
              C  ***    I ARRAY SEGMENT 5 - STATE INDICES.                                 I       11
      220     C  *                                                                          I       12
                 COMMON/INTEGER/ INDX2(14)                                                I       13
              C  *                                                                          I       14
              C  ***    I ARRAY SEGMENT 6 - VARIOUS INDICES.                               I       15
              C  *                                                                          I       16
      225        COMMON/INTEGER/ INDXPD,INDXP,INDXPED,INDXPE,INDXPXD,INDXPX               I       17
              C  ********************************************************************  C  I       18
              C  *                                                                       INTEG    2
              C  ***    TEMPORARY INTEGRATION STORAGE.                                   INTEG    3
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C  ***    DIMENSION = NEQU = NSTATES + NPA**2 + NPX**2 + NPE**2                INTEG    4
C  *                                                                           INTEG    5
      COMMON/INTEG/ RI(2187),PT(2187)                                          INTEG    6
C  *                                                                           SETUP   19
C  ***    R ARRAY EQUIVALENCE STATEMENT (PROBLEM DEPENDENT).                   SETUP   20
C  *                                                                           SETUP   21
      EQUIVALENCE (R(1),TIME)                                                  SETUP   22
C                                                                      C       SETUP   23
C**************            WIND CALCULATIONS            **************C        SETUP   24
C                                                                      C       SETUP   25
C  *                                                                           SETUP   26
C  ***    EARTH AXIS COMPONENTS OF AMBIENT WIND.                               SETUP   27
C  *                                                                           SETUP   28
      X1DWA    = VAMB*COS(PSIAMB)                                              SETUP   29
      Y1DWA    = VAMB*SIN(PSIAMB)                                              SETUP   30
C  *                                                                           SETUP   31
C  ***    EARTH AXIS COMPONENTS OF SHIP RELATIVE WIND.                         SETUP   32
C  *                                                                           SETUP   33
      X1DWS    = V5*COS(PSI5 - 3.14159)                                        SETUP   34
      Y1DWS    = V5*SIN(PSI5 - 3.14159)                                        SETUP   35
C  *                                                                           SETUP   36
C  ***    WIND OVER DECK.                                                      SETUP   37
C  *                                                                           SETUP   38
      VWOD     = SQRT((X1DWA + X1DWS)**2 + (Y1DWA + Y1DWS)**2)                 SETUP   39
      PSIWOD   = 0.0                                                           SETUP   40
      XDUM     = X1DWA + X1DWS + Y1DWA + Y1DWS                                 SETUP   41
      IF(XDUM.NE.0.0) PSIWOD = ATAN2(Y1DWA+Y1DWS,X1DWA+X1DWS)                  SETUP   42
C  *                                                                           SETUP   43
C  ***    ORIENTATION OF SHIP WIND AXIS SYSTEM.                                SETUP   44
C  *                                                                           SETUP   45
      PSI3     = PSIWOD - 3.14159                                              SETUP   46
C  ***    TRANSFORMATION ANGLES.                                               SETUP   47
      PSISP    = PSI3 - PSI5                                                   SETUP   48
      TWOPI = 2.0*3.14159                                                      SETUP   49
      IF(PSISP .LT. -TWOPI) PSISP = PSISP + TWOPI                              SETUP   50
      IF(PSISP .GT. TWOPI) PSISP = PSISP - TWOPI                               SETUP   51
      PSIS     =-PSISP                                                         SETUP   52
      TS1      = COS(PSISP)                                                    SETUP   53
      TS2      = SIN(PSISP)                                                    SETUP   54
      TS3      = COS(PSI5)                                                     SETUP   55
      TS4      = SIN(PSI5)                                                     SETUP   56
      DXM145   = TS1*TS3 - TS2*TS4                                             SETUP   57
      DXM245   = TS1*TS4 + TS2*TS3                                             SETUP   58
      DYM145   =-TS2*TS3 - TS1*TS4                                             SETUP   59
      DYM245   = TS1*TS3 - TS2*TS4                                             SETUP   60
      AWFLG = 0.0                                                              SETUP   61
      IF(VWOD.LT.32.0.OR.VWOD.GT.78.0) AWFLG = 1.0                             SETUP   62
      IF(PSIS.LT.0.50611.OR.PSIS.GT.0.89005) AWFLG = 1.0                       SETUP   63
      IF(NOAW.EQ.1) GO TO 10                                                   SETUP   64
      VEL = VWOD/1.688                                                         SETUP   65
      ANG = PSIS*57.3                                                          SETUP   66
      IF(AWFLG.NE.0.0) WRITE(6,1000) VEL,ANG                                   SETUP   67
 1000 FORMAT(1H1,#****  WARNING  ****  WARNING  ****  WARNING  ****# //         SETUP   68
     *        4X,#THE NO AIRWAKE FLAG (NOAW) HAS BEEN SET.# /                  SETUP   69
     *        1X,#VWOD OF #,F4.1,# KNOTS OR PSIS OF #,F4.1,# DEGREES#          SETUP   70
     *           #IS NOT IN THE AIRWAKE TABLE.# /                              SETUP   71
     *        1X,#THEREFORE, THIS RUN DOES NOT HAVE AIRWAKE DATA.# //          SETUP   72
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                *       1X,*****  WARNING  ****  WARNING  ****  WARNING  *****)          SETUP  73
                 IF(AWFLG.NE.0.0) NOAW = 1                                              SETUP  74
                 IF(AWFLG.NE.0.0) GO TO 10                                              SETUP  75
               C                                                                C       SETUP  76
   290         C***************  AIRWAKE MODEL PRELIMINARY CALCULATIONS  ***************C SETUP  77
               C                                                                C       SETUP  78
               C  *                                                                    SETUP  79
               C  ***    GENERATE AIRWAKE TABLES BASED ON VWOD AND PSIS.               SETUP  80
               C  *                                                                    SETUP  81
   295            CALL AIRWTBL                                                        SETUP  82
               C  *                                                                    SETUP  83
               C  ***    SCALING RELATIONS.                                            SETUP  84
               C  *                                                                    SETUP  85
                  XDUM    = 46.75/WM                                                   SETUP  86
   300            LS      = LM*XDUM                                                    SETUP  87
                  LTDS    = LTDM*XDUM                                                  SETUP  88
                  WNSF    = 1.9*XDUM*VWOD/59.15                                        SETUP  89
               C  *                                                                    SETUP  90
               C  ***    SHAPING TERMS.                                                SETUP  91
   305         C  *                                                                    SETUP  92
                  PSISS   = SIN(PSIS)                                                  SETUP  93
                  PSISC   = COS(PSIS)                                                  SETUP  94
                  PSIST   = PSISS/PSISC                                                SETUP  95
                  TS1     = PSISS*LTDS - PSISS*LS - 23.375*PSISC                       SETUP  96
   310            TS2     = PSISS*LTDS + 23.375*PSISC                                  SETUP  97
                  TS3     = PSISC*LTDS - PSISC*LS + 23.375*PSISS                       SETUP  98
                  TS4     = 23.375/PSISS                                               SETUP  99
                  TS5     = 23.375/PSISC                                               SETUP 100
               C  *                                                                    SETUP 101
   315         C  ***    RANDOM COMPONENT TERM.                                        SETUP 102
               C  *                                                                    SETUP 103
                  TR1     = SQRT(1.6*WNSF*WNSF*WNSF)                                   SETUP 104
               C                                                                       SETUP 105
               C***************       GDF INITIALIZATION                ***************C SETUP 106
   320         C                                                                       SETUP 107
               C  *                                                                    SETUP 108
               C  ***    TABRD SETS UP TABLES FOR DESCRIBING FUNCTION SUBROUTINE       SETUP 109
               C  *                                                                    SETUP 110
               C    ROLL CONTROL NONLINEARITY                                          SETUP 111
   325          CALL TABRD(TDAIN,TDAOUT,4)                                           SETUP 112
               C    YAW CONTROL NONLINEARITY                                           SETUP 113
                CALL TABRD(TDRIN,TDROUT,4)                                          SETUP 114
               C                                                                C       SETUP 115
               C***************           SET UP INTEGRATION            ***************C SETUP 116
   330         C                                                                C       SETUP 117
               10    ICEES   = 1                                                       SETUP 118
                     TIME    = TO                                                      SETUP 119
                     XMASS   = WEIGHT/G                                                SETUP 120
                     YO      = SUMFYO/XMASS                                            SETUP 121
   335               LO      = (IZ*SUMLO+IXZ*SUMNO)/(IX*IZ-IXZ*IXZ)                   SETUP 122
                     NO      = (IX*SUMNO+IXZ*SUMLO)/(IX*IZ-IXZ*IXZ)                   SETUP 123
                     UBASO   = UBAS                                                    SETUP 124
                     VBASO   = VBAS                                                    SETUP 125
                     WBASO   = WBAS                                                    SETUP 126
   340               PO =  PB                                                          SETUP 127
                     RO =  RB                                                          SETUP 128
                     CALL DEQU                                                         SETUP 129
```

```
                XDUM    = WNSF*WNSF                                          SETUP  130
                P(7,7)  = 1.0                                                SETUP  131
      345       P(8,8)= SIGMAVX*SIGMAVX                                      SETUP  132
                P(9,9)= XDUM*P(8,8)                                          SETUP  133
                P(10,10)= SIGMAVY*SIGMAVY                                    SETUP  134
                P(11,11)= XDUM*P(10,10)                                      SETUP  135
                P(12,12)= SIGMAVZ*SIGMAVZ                                    SETUP  136
      350       P(13,13)= XDUM*P(12,12)                                      SETUP  137
                CALL PROP                                                    SETUP  138
                ICEES   = 2                                                  SETUP  139
                IF(INT.LT.3) GO TO 40                                        SETUP  140
              C *                                                            SETUP  141
      355     C ***     ADAMS INTEGRATION ONLY.                              SETUP  142
              C *                                                            SETUP  143
                ICEES   = 0                                                  SETUP  144
              C ***     STATES.                                            SETUP  145
                DO 20 I=1,NSTATES                                            SETUP  146
      360       RT(I)   = R(INDX1(I))                                        SETUP  147
              20  CONTINUE                                                   SETUP  148
              C ***     P.                                                 SETUP  149
                NL1 = NSTATES + 1                                            SETUP  150
                NU1 = NSTATES + NPA*NPA                                      SETUP  151
      365       I1      = INDXPD                                             SETUP  152
                DO 30 I=NL1,NU1                                              SETUP  153
                RT(I)   = R(I1)                                              SETUP  154
                I1      = I1 + 1                                             SETUP  155
              30  CONTINUE                                                   SETUP  156
      370     C *                                                            SETUP  157
              C ***     PE.                                                SETUP  158
              C *                                                            SETUP  159
                NL2 = NU1 + 1                                                SETUP  160
                NU2 = NU1 + NPE*NPE                                          SETUP  161
      375       I1 = INDXPED                                                 SETUP  162
                DO 31 I=NL2,NU2                                              SETUP  163
                RT(I) = R(I1)                                                SETUP  164
                I1 = I1 + 1                                                  SETUP  165
             31 CONTINUE                                                     SETUP  166
      380     C *                                                            SETUP  167
              C ***     PX.                                                SETUP  168
                NL3 = NU2 + 1                                                SETUP  169
                NEQU = NU2 + NPX*NPX                                         SETUP  170
                I1 = INDXPXD                                                 SETUP  171
      385       DO 32 I=NL3,NEQU                                             SETUP  172
                RT(I) = R(I1)                                                SETUP  173
                I1 = I1 + 1                                                  SETUP  174
             32 CONTINUE                                                     SETUP  175
              40  RETURN                                                     SETUP  176
      390       END                                                          SETUP  177
```

APPENDIX D

DESCRIBING FUNCTIONS OF

GENERAL SINGLE-VALUED NONLINEARITIES REPPESENTABLE

BY STRAIGHT-LINE SEGMENTS

APPENDIX D

DESCRIBING FUNCTIONS OF

GENERAL SINGLE-VALUED NONLINEARITIES REPRESENTABLE BY STRAIGHT-LINE SEGMENTS

D.1 Decomposition Into Odd and Even Components

The general nonlinearity is represented by N straight-line segments. The number of segments in the odd component is also N, and there are also N segments in the even component.

Denoting the general nonlinearity by $y = f(x)$: then the odd and even components are respectively given by

$$y_o(x) = 1/2\ y(x) - y(-x)$$

$$y_E(x) = 1/2\ y(x) + y(-x)$$

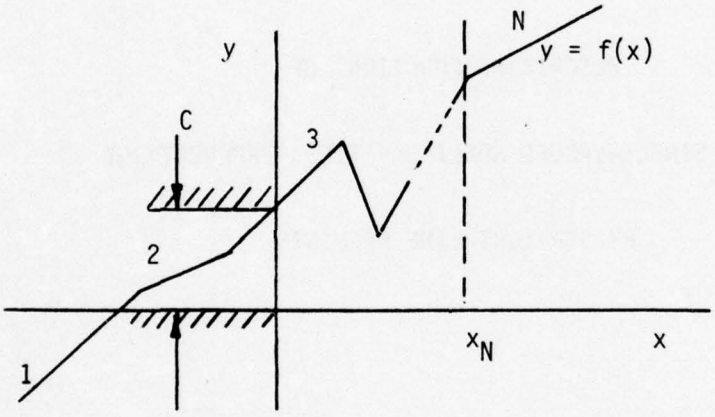

Figure D.1 General Nonlinearity Considered

Note that for x = 0 this gives $y_o(0) = 0$; $y_E(0) = y(0)$. It is convenient to separate out the offset C, as indicated by the following equations

$$y_o' = y_o(x) = f_o'(x)$$

$$y_E'(x) = y_E(x) - C = f_E'(x)$$

where C = y(0), as shown in Figure D.1.

We split the nonlinear characteristic as indicated in Figure D.2.

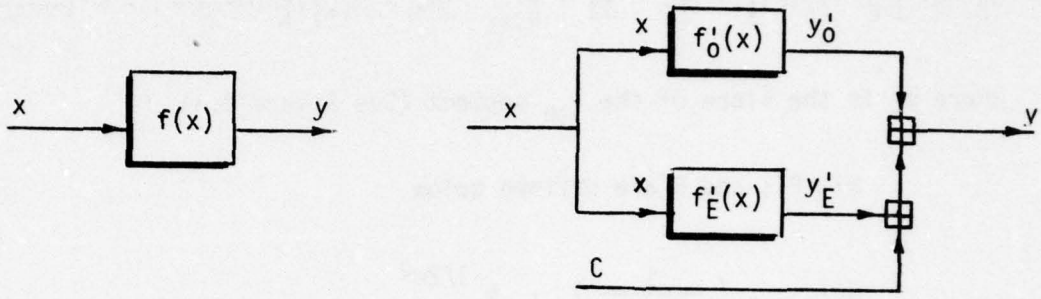

Figure D.2 Separation of the Nonlinearity Into Even, Odd, and Bias Components

D.2 Approximation to the Odd Component

The input is assumed to consist of a bias, B, plus a random Gaussian component of variance σ^2, denoted by x_R. The general form of the odd component is shown in Figure A.5.3.

$$x(t) = B + x_R(t)$$

The best least-squares approximation to y_o' is

$$y_{oA}' = N_B B + N_R x_R(t)$$

where N_B and N_R are given by the expressions overleaf (from p. 579 of Reference D.1).

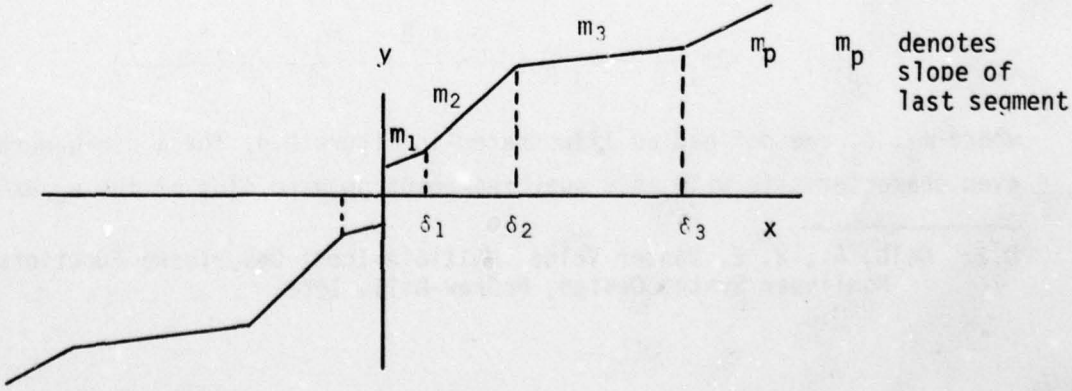

Figure D.3 General Piecewise-Linear Odd Memoryless Nonlinearity

$$N_R = 2\frac{D}{\sigma} PE(\frac{B}{\sigma}) + 2m_p - m_1 + \sum_{i=1}^{p-1} (m_i - m_{i+1})\left[PI(\frac{\delta_i + B}{\sigma}) + PI(\frac{\delta_i - B}{\sigma})\right]$$

$$N_B = \frac{D}{B}\left[2PI(\frac{B}{\sigma})-1\right] + 2m_p - m_1 + \frac{\sigma}{B}\sum_{i=1}^{p-1} (m_i - m_{i+1})\left[G(\frac{\delta_i + B}{\sigma}) - G(\frac{\delta_i - B}{\sigma})\right]$$

where m_i is the slope of the i_{th} segment (See Figure D.3)

PF, PI; and G are defined below

$$PF(w) = \left(\frac{1}{2\pi}\right) \cdot e^{-1/2w^2}$$

$$PI(w) = \int_{-\infty}^{w} PF(\Omega)\, d\Omega$$

$$G(w) = wPI(w) + PF(w)$$

Note that D = 0, because we have separated out the bias C.

D.3 Approximation to the Even Component

The best least-squares approximation to y_E' is obtained by subtracting two describing functions given on p 585 and 586 of Reference D.1. The results of subtracting describing function No. 55 from describing function No. 52 reduce to:

$$N_R(j) = m_j\, PI\,(\frac{\delta_j + B}{\sigma}) - m_j\, PI\,(\frac{\delta_j - B}{\sigma})$$

$$N_B(j) = -2m_j \frac{\delta_j}{B} + m_j \frac{\sigma}{B}\, G(\frac{\delta_j + B}{\sigma}) + \frac{m_j\, \sigma}{B}\, G\,(\frac{\delta_j - B}{\sigma})$$

where m_j, δ_j are defined as illustrated in Figure D.4, for a non-general even characteristic with only one breakpoint on each side of the y_E axis.

D.1. Gelb, A., W. E. Vander Velde, Multiple-Input Describing Functions and Nonlinear System Design, McGraw-Hill, 1968.

AD-A066 173 VOUGHT CORP DALLAS TEX F/G 1/2
VOLAR: A DIGITAL COMPUTER PROGRAM FOR SIMULATING VSTOL AIRCRAFT--ETC(U)
DEC 78 J WOLKOVITCH, B B BRASSELL N62269-77-R-0389
UNCLASSIFIED 2-32000/8R-51672-VOL-2 NADC-77123-30-VOL-2 NL

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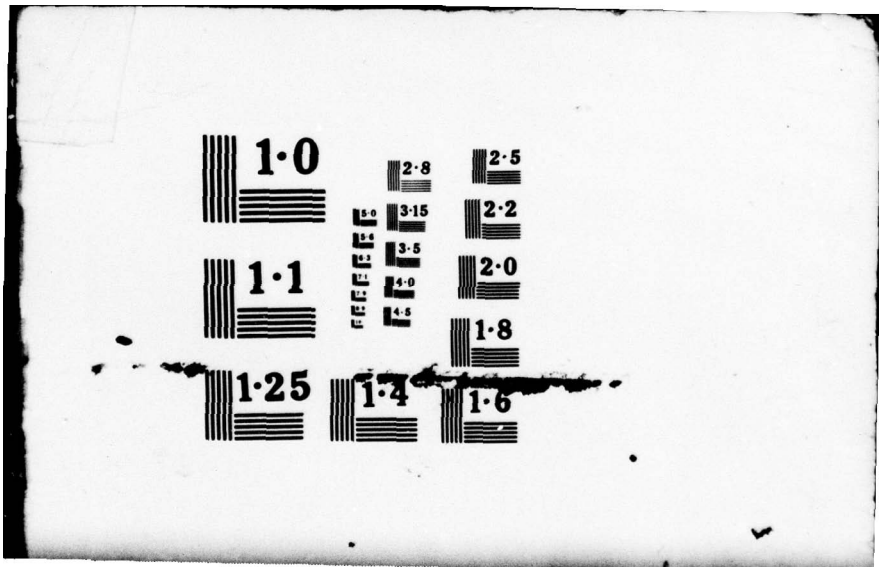
1·0
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4·5

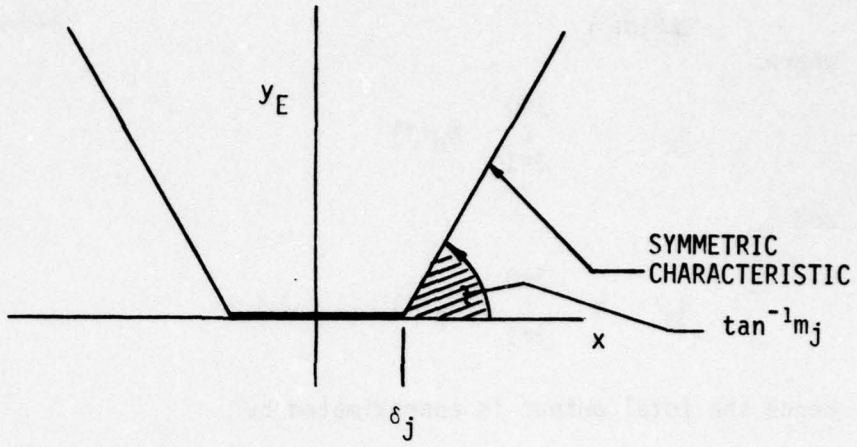


Figure D.4 Non-General Even Characteristic

In Figure D.4 δ_j is the only breakpoint. For the <u>general</u> even component there will be Q breakpoints as shown in Figure A.5, hence the overall approximation is:

$$y_{oA}' = N_B' \cdot B + N_R' \cdot x_R(t)$$

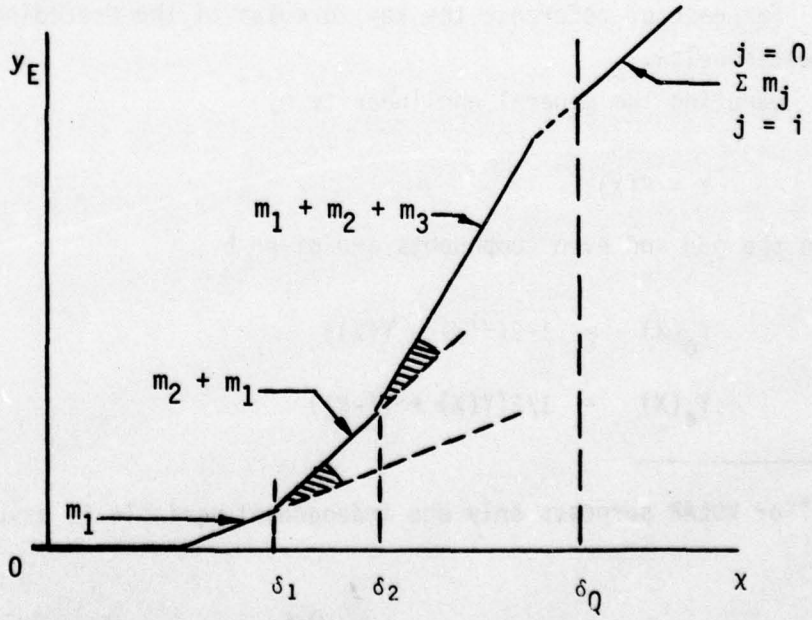


Figure D.5 General Even Characteristic with Zero Offset

where:

$$N_R' = \sum_{J=1}^{j=Q} N_R(j)$$

and

$$N_B' = \sum_{j=1}^{j=Q} N_B(j)$$

Hence the total output is approximated by:

$$y_A = B\,(N_B' + N_B) + x_R(t)(N_R' + N_R) + C$$

D.4 Routines for Computing Describing Functions of General Single-Valued Nonlinearities Represented by Straight-Line Segments

Three FORTRAN routines, TABRD, DESCRIB and ERF provide a capability for generating describing functions for general single-valued nonlinearities which can be expressed as functions of as many as three independent variables.* One COMMON block is required to transfer data between routines. The procedures for invoking the proper routines and initializing the COMMON block are described below.

Method

For ease of reference the key formulas of the preceding section are repeated below.

Denoting the general nonlinearity by

$$Y = F(X)$$

then the odd and even components are given by

$$Y_o(X) = 1/2(Y(X) - Y(X))$$

$$Y_e(X) = 1/2(Y(X) + Y(-X))$$

---

*For VOLAR purposes only one independent variable is assumed.

for X = 0, this yields

$$Y_o(0) = 0$$

$$Y_e(0) = Y(0)$$

It is convenient to separate out the offset yielding

$$Y'_o(X) = Y_o(X)$$

$$Y'_o(X) = Y_e(X) - Y(0)$$

Assuming the input consists of a bias, B, and a random Gaussian component of variance σ^2, denoted by X_r, the best linear least squares approximation to y'_o is:

$$Y'_{o_a} = N_b\, B + N_r\, X_r(t)$$

where:

$$N_b = 2M_p - M_1 + \frac{\sigma}{B} \sum_{i=1}^{P-1} (M_i - M_{i+1}) \left[G\left(\frac{\delta_i + B}{\sigma}\right) - G\left(\frac{\delta_i + B}{\sigma}\right) - G\left(\frac{\delta_i - B}{\sigma}\right) \right]$$

$$N_r = 2M_p - M_1 + \sum_{i=1}^{P-1} (M_i - M_{i+1}) \left[PI\left(\frac{\delta_i + B}{\sigma}\right) + PI\left(\frac{\delta_i - B}{\sigma}\right) \right]$$

M_i = Slope of the ith odd component segment

P = Index of last odd component linear segment

$G(W) = WPI(W) + PF(W)$

$PI(W) = \int_{-\infty}^{W} PF(\Omega)\, d\Omega$

$$PF(W) = \frac{1}{\sqrt{2\pi}}\, e^{-\frac{1}{2}W^2}$$

δ_i = Max value of the first independent variable associated with the ith odd component segment

NOTE: Only segments where $\delta_i > 0$ are considered.

The best linear least squares approximation to Y'_e is:

$$Y'_{e_a} = N'_b B + N'_r X_r(t)$$

where:

$$N'_r = \sum_{i=1}^{P-1} (M_{i+1} - M_i) \left[PI\left(\frac{\delta_i + B}{\sigma}\right) - PI\left(\frac{\delta_i - B}{\sigma}\right) \right]$$

$$N'_b = \sum_{i=1}^{P-1} (M_{i+1} - M_i) \left[\frac{-2\delta_i}{B} + \frac{\sigma}{B}\left(G\left(\frac{\delta_i + B}{\sigma}\right) + G\left(\frac{\delta_i - B}{\sigma}\right)\right) \right]$$

M_i = Slope of the ith even component segment

P = Index of last even component linear segment

G, PI, PF as defined above

δ_i = Min value of the first independent variable associated with the ith even component segment

NOTE: Only segments where $\delta_i \geq 0$ are considered.

The approximated output bias is given by

$$\overline{Y}_a = B(N_b + N'_b) + Y(0)$$

The approximated output variance is given by

$$\sigma_a^2 = \sigma^2 (N_r + N'_r)^2$$

D.5 Common Block Initialization

It can be seen from the discussion on methodology above that the data that must be preserved includes:

(1) Values of the second and third independent variables for interpolation purposes.*

(2) A subset of the first indepent variable. When generating the even and odd components of the nonlinearity, the x values are symetrically disposed around x = 0. Once generated, only the disposed values of $x \geq 0$ need be kept.

(3) Slopes of the even and odd components corresponding to the stored values of x.

(4) The offset that was separated out of the even components.

The method of data storage within the COMMON block is discussed below.

CØMMØN/GDF/NTABLE,INDEX(m),TABLE(n)

NTABLE - Number of tables that were read.

INDEX - Array holding pointers into TABLE (must be dimensioned at least 3*NTABLE+1).

INDEX(3*(I-1)+1) - Index into TABLE where data for table I begins.

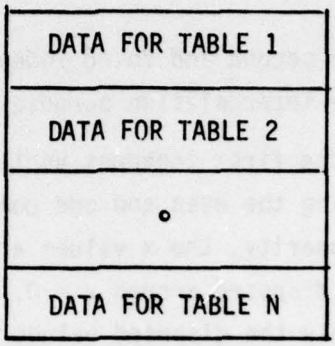
INDEX(3*(I-1)+2) - Number of values of 2nd independent variables in table I.

INDEX(3*I) - Number of saved values of x in table I.

---

*For VOLAR purposes only one independent variable is used. Zeros were input in the table for the second and third independent variables.

TABLE is arranged in the following manner:



X_3 VALUE (1 ENTRY)
X_2 VALUES (INDEX(3*(I-1)+2) ENTRIES)
SAVED X_1 VALUES (INDEX(3*I) ENTRIES)
OFFSET SEPAPATED FROM EVEN COMPONENTS (INDEX(3*(I-1)+2) ENTRIES)
ODD COMPONENT SLOPES FOR 1st Y VALUE(INDEX(3*I)-1 ENTRIES)
EVEN COMPONENT SLOPES FOR 1st Y VALUE(INDEX(3*I)-1 ENTRIES)
° °
ODD SLOPES FOR INDEX(3*(1-1)+2)th Y VALUE (INDEX(3*I)-1 ENTRIES)
EVEN SLOPES FOR INDEX(3*(I-1)+2)th Y VALUE(INDEX(3*I)-1 ENTRIES)

TABLE must be dimensioned large enough to hold required data generated from all input tables.

D.6 Routine Description

TABRD

This routine is responsible for calculating the even and odd components of the nonlinearity, calculating the component slopes and storing the data into the COMMON block. The calling statement is:

```
CALL   TABRD(X,Y,NPTS)
```

where:

X - Array of independent variables.
Y - Array of dependent variables.
NPTS - Number of elements in the X and Y arrays.

DESCRIB

This routine is responsible for calculating elements of the describing function. The calling statement is:

```
CALL   DESCRIB(ITAB,BIAS,SIGMA,ØBIAS,ØVAR,REPRØ)
```

where:

ITAB = Table number for which describing function is to be generated.
BIAS = Input BIAS.
SIGMA = Input SIGMA.
ØBIAS = Output BIAS.
ØVAR = Output variance.
REPRØ = Gain on output sigma.

ERF

This is an internal FUNCTION subroutine to evaluate the error function associated with the normal curve. The calling sequence is:

```
X = ERF(Y)
```

where:

Y = Upper limit of integration for the error function.

EXAMPLE: AV-8A NONLINEARITY FROM REFERENCE D.2

For checkout purposes, a describing function was generated for the CM vs ALPHA nonlinearity with DH = 6 deg, VJ/VØ = 5.4 and a 15 deg. nozzle. The following data were considered.

NOZZLE = 0 deg

ALPHA (deg)	CM
-5	-.14
0	-.165
5	-.190
10	-.24
12	-.27
15	-.32
20	0.39

NOZZLE = 30 deg

ALPHA (DEG)	CM
-5	-.055
0	-.024
5	-.03
8	-.034
10	-.038
12	-.042
15	-.036
20	-.018

The input, ALPHA, consisted of a bias of 10 deg. and a variance of 1 deg. The describing function yielded a mean for the output, CM, of -.139988 and a variance of 0.000052097. An alternate method of inputting 1000 Gaussian-distributed random numbers with a mean of 10 and a variance of 1 was checked yielding an output mean for CM of -.14 and a variance of 0.00005279.

D.2. Nave, R. L., "Progress Toward a Computerized VSTOL/Small Platform Landing Dynamics Investigation Model," NADC Report 77024-30, 1977.

REFERENCES

D.1. Gelb, A., and W. E. Vander Velde, Multiple-Input Describing Functions and Nonlinear System Design, McGraw-Hill, 1968.

D.2. Nave, R. L., "Progress Toward a Computerized VSTOL/Small Platform Landing Dynamics Investigation Model," NADC Report 77024-30, 1977.

APPENDIX E

THE I AND R ARRAYS

E.1 The I Array

I ARRAY SEGMENT	I ARRAY ELEMENT	VARIABLE NAME	DESCRIPTION
1	1	ICEES	An internal 'flag' to keep track of what stage the integration is in and to identify the very first pass through the program (ICEES = 1).
1	2	NEQU	Total number of differential equations to integrate.
1	3	NSTATES	Number of mean equations to integrate.
1	4	NPA	Order of the P matrix (NPA by NPA).
1	5	NQM	Order of the QM matrix (NQM by NQM).
1	6	NGM	Row dimension of GM matrix (NGM by NQM).
1	7	NPE	Order of the PE matrix (NPE by NPE).
1	8	NPX	Order of the PXHAT matrix (NPX by NPX).
1	9	NØAW	User specified control of airwake calculations. NØAW = 0, calculate airwake NØAW = 1, no airwake calculations desired
1	10	NØINIT	User specified control of program flow NØINIT = -1, fix means and integrate covariance matrices only NØINIT = 0, call SOLVR to calculate steady state value of P at the conditions defined by means NØINIT = 1, no special initialization calculations desired - run a normal time history

I ARRAY		VARIABLE	DESCRIPTION
SEGMENT	ELEMENT	NAME	
4	1-14	INDX1	R array locations of elements to be integrated. Setup by Option 6.
5	1-14	INDX2	R array locations of elements that are the outputs of integrators. Setup by Option 6.

I ARRAY SEGMENT	I ARRAY ELEMENT	VARIABLE NAME	DESCRIPTION
6	1	INDXPD	R array location of the first element of the PDØT matrix. Setup by Option 6.
6	2	INDXP	R array location of the first element of the P matrix. Setup by Option 6.
6	3	INDXPED	R array location of the first element of the PED matrix. Setup by Option 6.
6	4	INDXPE	R array location of the first element of the PE matrix. Setup by Option 6.
6	5	INDXPXD	R array location of the first element of the PXHATD matrix. Setup by Option 6.
6	6	INDXPX	R array location of the first element of the PXHAT matrix. Setup by Option 6.

E.2 The R Array

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
1	1	TIME	t	Time
1	2	TO	t	Initial time; time for which reference values are defined
1	3	DTIME	t	Integration interval
1	4	DTØUT	t	Output file written every DTØUT seconds
1	5	DTØUT2	t	Print interval for MISCAL output
1	6	TMAX	t	Upper integration limit

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
3	1	UB	l/t	Inertial speed along airplane X body axis
3	2	WB	l/t	Inertial speed along airplane Z body axis
3	3	QB	rad/t	Airplane pitch rate
3	4	THETA	rad	Airplane pitch attitude
3	5	XAPP	l	Airplane position, X earth axis
3	6	ZAPP	l	Airplane position, Z earth axis
3	7	DFRPM	rpm	Engine rpm
3	8	XSP	l	Ship position, X earth axis
3	9	THETAS	rad	Ship pitch attitude
3	10	VB	l/t	Inertial speed along airplane Y body axis
3	11	PB	rad/t	Airplane roll rate
3	12	RB	rad/t	Airplane yaw rate
3	13	YAPP	l	Airplane position, Y earth axis
3	14	PHI	rad	Airplane roll attitude
3	15	PSI	rad	Airplane heading
3	16	YSP	l	Ship position, Y earth axis

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
2	1	UDØT	$1/t^2$	Airplane acceleration along X body axis
2	2	WDØT	$1/t^2$	Airplane acceleration along Z body axis
2	3	QDØT	rad/t^2	Airplane pitch acceleration
2	4	TDØT	rad/t	Airplane pitch attitude rate-of-change
2	5	XAPPDØT	1/t	Airplane velocity along X earth axis
2	6	ZAPPDØT	1/t	Airplane velocity along Z earth axis
2	7	DFRPMD	rpm/t	Engine rpm rate-of-change
2	8	XSPDØT	1/t	Ship velocity along X earth axis
2	9	ZSPDØT	1/t	Ship velocity along Z earth axis
2	10	TSPDØT	rad/t	Ship pitch attitude rate-of-change

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
4	1	UO	l/t	Reference value of UB used for local linearization
4	2	WO	l/t	Reference value of WB used for local linearization
4	3	QO	rad/t	Reference value of QB used for local linearization
4	4	THETAO	rad	Reference value of THETA used for local linearization
4	5	XAPPO	l	Reference value of XAPP used for local linearization
4	6	ZAPPO	l	Reference value of ZAPP used for local linearization
4	7	XO	l/t^2	ΣF_x/mass
4	8	ZO	l/t^2	ΣF_z/mass
4	9	MO	rad/t^2	$\Sigma M_y/I_y$
4	10	UBASO	l/t	Reference value of UBAS
4	11	WBASO	l/t	Reference value of WBAS
4	12	WASDO	l/t^2	Reference value of WASD
4	13	THETAAO	rad	Reference value of THETAA
4	14	PSIAO	rad	Reference value of PSIA
4	15	PHIAO	rad	Reference value of PHIA
4	16	RCDO	l/t	Reference value of RCD
4	17	VO	l/t	Reference value of VB used for local linearization
4	18	PO	rad/t	Reference value of PB used for local linearization
4	19	RO	rad/t	Reference value of RB used for local linearization

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
4	20	YAPPO	1	Reference value of YAPP
4	21	PHIO	rad	Reference value of PHI
4	22	PSIO	rad	Reference value of PSI
4	23	YO	l/t^2	ΣF_y/mass
4	24	LO	rad/t^2	$\Sigma M'_x/I_x$
4	25	NO	rad/t^2	$\Sigma M'_z/I_z$
4	26	VBASO	l/t	Reference value of VBAS

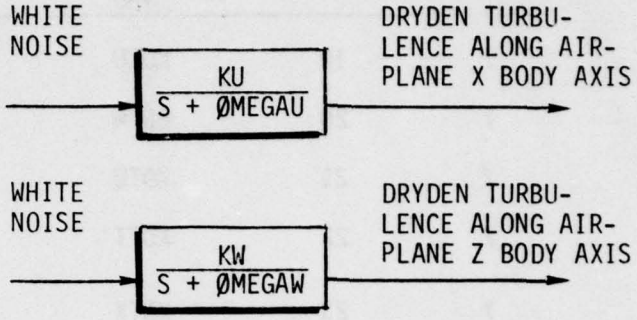
R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
5	1	SUMFXO	f	Initial summation of forces along the airplane body axis. Required input if means are propagated.
5	2	SUMFZO	f	Initial summation of forces along the airplane body axis. Required input if means are propagated.
5	3	SUMMO	fl	Initial summation of moments about the airplane body axis. Required input if means are propagated.
5	4	SUMFX	l/t^2	Summation of 'forces' along airplane X body axis.
5	5	DFX	l/t^2	Incremental 'force' due to airplane departure from reference trajectory.
5	6	SUMFZ	l/t^2	Summation of 'forces' along airplane Z body axis.
5	7	DFZ	l/t^2	Incremental 'force' due to airplane departure from reference trajectory.
5	8	SUMM	rad/t^2	Summation of 'moments' about airplane Y body axis.
5	9	DM	rad/t^2	Incremental pitching 'moment' due to airplane departure from reference trajectory.
5	10	SUMFYO	f	Initial summation of forces along the airplane Y body axis. Required input if means are propagated.
5	11	SUMLO	fl	Initial summation of moments about the airplane X body axis. Required input if means are propagated.

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
5	12	SUMNO	fl	Initial summation of moments about the airplane Z body axis. Required input if means are propagated.
5	13	SUMFY	l/t^2	Summation of 'forces' along airplane Y body axis.
5	14	DFY	l/t^2	Incremental 'force' due to airplane departure from reference trajectory.
5	15	SUML	rad/t^2	Summation of 'moments' that produce angular acceleration only about the airplane X body axis.
5	16	DL	rad/t^2	Incremental 'moment' due to airplane departure from reference trajectory.
5	17	SUMN	rad/t^2	Summation of 'moments' that produce angular acceleration only about the airplane Z body axis.
5	18	DN	rad/t^2	Incremental 'moment' due to airplane departure from reference trajectory.

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
6	1	WEIGHT	ml/t^2	Airplane weight
6	2	G	l/t^2	Gravitational constant
6	3	IX	ml^2	Airplane body axis inertia component
6	4	IY	ml^2	Airplane body axis inertia component
6	5	IZ	ml^2	Airplane body axis inertia component
6	6	IXZ	ml^2	Product of inertia
6	7	LM	l	Overall length of ship
6	8	WM	l	Maximum beam of ship
6	9	LTDM	l	Distance from bow to landing pad center measured along ship centerline
6	10	LS	l	Scaled ship length
6	11	LTDS	l	A scaled LTDM

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
7	1	ØMEGAU		
7	2	ØMEGAW		
7	3	KU		
7	4	KW		
7	5	KFRPM		Gain on input to engine model
7	6	KCDN		Gain on input to nozzle actuator
7	7	TAUENG	t	Engine time constant
7	8	TAUCDN	t	Nozzle actuator time constant
7	9	TAUD	t	Nozzle actuator time constant
7	10	KDEU	1/l	Longitudinal optimal pilot feedback gains on states into pitch control
7	11	KDEW	1/l	
7	12	KDEQ	1/rad	
7	13	KDET	$\frac{1}{t \text{ rad}}$	
7	14	KDEX	$\frac{1}{t \text{ l}}$	
7	15	KDEZ	$\frac{1}{t \text{ l}}$	
7	16	KDEN	$\frac{1}{t \text{ rpm}}$	
7	17	KDEDE	$\frac{1}{t}$	
7	18	KDEDT	$\frac{1}{t}$	



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R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
7	19	KDTU	1/l	Longitudinal optimal pilot feedback gains on states into thrust control
7	20	KDTW	1/l	
7	21	KDTQ	1/rad	
7	22	KDTT	$\frac{1}{t\ rad}$	
7	23	KDTX	$\frac{1}{t\ l}$	
7	24	KDTZ	$\frac{1}{t\ l}$	
7	25	KDTN	$\frac{1}{t\ rpm}$	
7	26	KDTDE	$\frac{1}{t}$	
7	27	KDTDT	1/t	
7	28	ØMEGAV		WHITE NOISE → $\frac{KV}{S + ØMEGAV}$ → DRYDEN TURBULENCE ALONG AIRPLANE Y BODY AXIS
7	29	KV		
7	30	TAUA	t	Actuator time constant
7	31	K1		ROLL CONTROL:
7	32	K2		
7	33	KY		ERPHI → $\frac{K1(TL1*S+B1)(-S+2/TAUD)}{(TAU*S+1)(S+2/TAUD)}$ → DAP
7	34	B1		
7	35	B2		YAW CONTROL:
7	36	TL1		ERPSI → $\frac{K2(TL2*S+B2)(-S+2/TAUD)}{(TAU*S+1)(S+2/TAUD)}$ → DRP
7	37	TL2		

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
8	1	ALT	l	Altitude
8	2	VAIR	l/t	Airspeed
8	3	UBAS	l/t	Airplane X body axis component of airspeed
8	4	VBAS	l/t	Airplane Y body axis component of airspeed
8	5	WBAS	l/t	Airplane Z body axis component of airspeed
8	6	ALPHA	rad	Angle-of-attack
8	7	BETA	rad	Sideslip angle
8	8	DUM1		Dummy variable, this location unused
8	9	DUM2		Dummy variable, this location unused
8	10	V5	l/t	Ship speed
8	11	PSI5	rad	Ship heading
8	12	X1DWS	l/t	Earth axis component of ship's relative wind
8	13	Y1DWS	l/t	Earth axis component of ship's relative wind
8	14	VAMB	l/t	Ambient wind speed
8	15	PSIAMB	rad	Ambient wind heading
8	16	X1DWA	l/t	Earth axis component of ambient wind
8	17	Y1DWA	l/t	Earth axis component of ambient wind
8	18	Z1DWA	l/t	Earth axis component of ambient wind

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
8	19	VWØD	l/t	Wind-over-deck speed
8	20	PSIWØD	rad	Wind-over-deck heading
8	21	PSI3	rad	Orientation of ship wing axis; angle of rotation about the Z earth axis to point ship X wind axis into the wind-over-deck
8	22	PSISP	rad	= PSI3 - PSI5
8	23	PSIS	rad	= -PSIP; this is the angle ψ_{ss} in the airwake math model of Reference 12
8	24	DX45	l	Earth axis distance between airplane and ship
8	25	DY45	l	Earth axis distance between airplane and ship
8	26	DZ45	l	Earth axis distance between airplane and ship
8	27	XM	l	Airplane position in space with respect to the ship wind axis system (i.e., the airwake model reference point)
8	28	YM	l	
8	29	ZM	l	
8	30	PSIA	rad	Euler type angles relating the airplane to the ship wind axis system. It is assumed that the ship wind axis does not pitch and/or roll.
8	31	THETAA	rad	
8	32	PHIA	rad	
8	33	SIGMAVX	l/t	Standard deviations of the airwake in the ship wind axis system
8	34	SIGMAVY	l/t	
8	35	SIGMAVZ	l/t	
8	36	VXAW	l/t	Mean components of the ship airwake in the ship wind axis system
8	37	VYAW	l/t	
8	38	VZAW	l/t	

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
8	39	UWIND	l/t	Total wind component along airplane X body axis; UWIND = UMEAN + UAW
8	40	UMEAN	l/t	Ambient wind component along airplane X body axis
8	41	UR		Random wind component; unused
8	42	UAW	l/t	Mean component of airwake disturbance along airplane X body axis
8	43	VWIND	l/t	Total wind component along airplane Y body axis; VWIND = VMEAN + VAW
8	44	VMEAN	l/t	Ambient wind component along airplane Y body axis
8	45	VR		Random wind component; unused
8	46	VAW	l/t	Mean component of airwake disturbance along airplane Y body axis
8	47	WWIND	l/t	Total wind component along airplane Z body axis; WWIND = WMEAN + WAW
8	48	WMEAN	l/t	Ambient wind component along airplane Z body axis
8	49	WR		Random wind component; unused
8	50	WAW	l/t	Mean component of airwake disturbance along airplane Z body axis
8	51	WNSF	rad/t	Natural frequency of second order shaping filter used in airwake model
8	52	PSISS		sin (PSIS)

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
8	53	PSISC		cos (PSIS)
8	54	PSIST		tan (PSIS)
8	55	TS1		Temporary storage for preliminary calculations involving wind-over-deck and airwake shaping functions
8	56	TS2		
8	57	TS3		
8	58	TS4		
8	59	TS5		
8	60	TR1		Scale factor on SIGMAVX, SIGMAVY, and SIGMAVZ
8	61	DXM145		= cos (PSISP)* cox (PSI5) - sin (PSIP)* sin (PSI5)
8	62	DXM245		= cos (PSIP)* sin (PSI5) + sin (PSIP)* cos (PSI5)
8	63	DYM145		= -sin (PSIP)* cos (PSI5) - cox (PSIP)* sin (PSI5)
8	64	DYM245		= cos (PSIP)* cos (PSI5) - sin (PSIP)* sin (PSI5)
8	65	ZGSP	1	Commanded $Z'_{A/P}$
8	66	ZBIASP	1	Bias term

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
9	1	THETAC	rad	Commanded airplane pitch attitude
9	2	DFRPMØL	rpm	Open loop rpm command
9	3	DCDNØL	rad	Open loop nozzle command
9	4	DEØL	units	Open loop pitch control command
9	5	GAMMAGS	deg	Commanded glide slope angle
9	6	RANGE	l	$\triangleq X'_S - X'_{A/P}$
9	7	VAIRC	l/t	Commanded airspeed
9	8	DAØL	units	Open loop roll control command
9	9	DRØL	units	Open loop yaw control command

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
10	1	XU	1/t	Airplane longitudinal dimensional derivatives; results of table look up
10	2	XW	1/t	
10	3	XQ	1/t	
10	4	XFRPM	$\frac{1}{t^2*rpm}$	
10	5	XCDN	$\frac{1}{t^2}$	
10	6	XPDIGV		Not used
10	7	XDE	$1/t^2$	
10	8	ZU	1/t	
10	9	ZW	1/t	
10	10	ZQ	1/t	
10	11	ZFRPM	$\frac{1}{t^2*rpm}$	
10	12	ZCDN	$\frac{1}{t^2}$	
10	13	ZPDIGV		Not used
10	14	ZDE	$1/t^2$	
10	15	MU	$\frac{1}{l\ t}$	
10	16	MW	$\frac{1}{l\ t}$	
10	17	MWDØT	$\frac{1}{l}$	
10	18	MQ	$\frac{1}{t}$	
10	19	MFRPM	$\frac{1}{t^2*rpm}$	
10	20	MCDN	$\frac{1}{t^2}$	

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
10	21	MPDIGV		Not used
10	22	MDE	$1/t^2$	
10	23	YV	$1/t$	Airplane lateral/directional dimensional derivatives; results of table look up
10	24	YP	$1/t$	
10	25	YR	$1/t$	
10	26	YDA	$1/t^2$	
10	27	YDR	$1/t$	
10	28	LV	$\frac{1}{l\ t}$	
10	29	LP	$\frac{1}{t}$	
10	30	LR	$1/t$	
10	31	LDA	$\frac{rad}{t^2}$	
10	32	LDR	$\frac{rad}{t^2}$	
10	33	NV	$\frac{1}{l\ t}$	
10	34	NP	$\frac{1}{t}$	
10	35	NR	$\frac{1}{t}$	
10	36	NDA	$\frac{rad}{t^2}$	
10	37	NDR	$\frac{rad}{t^2}$	

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
11	1	RC	l	Commanded range; range $\triangleq X'_S - X'_{A/P}$
11	2	RCD	l/t	Commanded range time rate-of-change
11	3	XAPCØM	l	Airplane commanded position along X earth axis
11	4	ERRX	l	= $X'_{A/P}$ - XAPCØM; longitudinal position error
11	5	ERRU	l/t	Airplane body axis component of error rate
11	6	ERRZ	l	= $Z'_{A/P}$ - ZGSP; vertical position error
11	7	ERRW	l/t	Airplane body axis component of error rate
11	8	ETHETA	rad	= THETA - THETAC; pitch altitude error
11	9	ERY	l	= YCØM - $Y'_{A/P}$; lateral position error
11	10	ERPHI	rad	= PHICØM - PHI; roll altitude error
11	11	ERPSI	rad	= PSICØM - PSI; heading error
11	12	YCØM	l	Airplane commanded Y earth axis position
11	13	PHICØM	rad	Airplane roll altitude command
11	14	PSICØM	rad	Airplane heading command

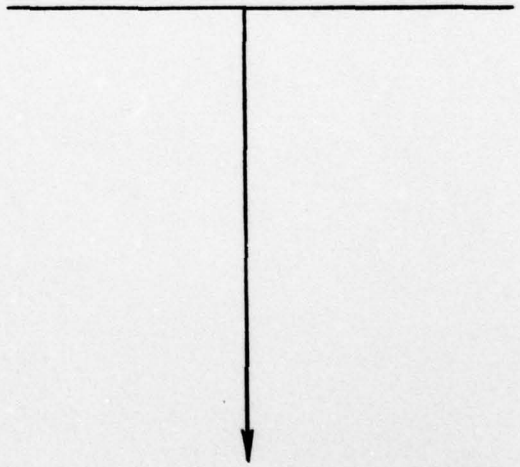
R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
12	1	DE	units	Pitch control displacemert
12	2	DT	units	Thrust control displacement
12	3	DCDN	rad	Nozzle position
12	4	DED	1/t	Pitch control rate
12	5	DTD	1/t	Thrust control rate
12	6	DCDND	rad/t	Nozzle angle rate
12	7	DA	units	Roll control displacement limited output value
12	8	DR	units	Yaw control displacement limited output value
12	9	DAP	units	Roll control displacement, input to limiter
12	10	DRP	units	Yaw control displacement, input to limiter
12	11	DA1	units	Intermediate variable used in calculation of roll control
12	12	DA2	units	Intermediate variable used in calculation of roll control
12	13	DR1	units	Intermediate variable used in calculation of yaw control
12	14	DR2	units	Intermediate variable used in calculation of yaw control
12	15	DA1D	1/t	Intermediate rate variable used in calculation of roll control
12	16	DA2D	1/t	Intermediate rate variable used in calculation of roll control
12	17	DR1D	1/t	Intermediate rate variable used in calculation of yaw control
12	18	DR2D	1/t	Intermediate rate variable used in calculation of yaw control

R ARRAY		VARIABLE	UNITS	DESCRIPTION
SEGMENT	ELEMENT	NAME		
13	1-6	TABV1	1/t	Independent variable table of airspeeds
14	1-10	TABV2	t	Independent variable table of time

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
16	1	SIGDAP	units	Standard deviation of roll control displacement at input to limiter
16	2	SIGDRP	units	Standard deviation of yaw control displacement at input to limiter
16	3	SIGDA	units	Standard deviation of roll control displacement after limiter
16	4	SIGDR	units	Standard deviation of yaw control displacement after limiter
16	5	GAINDA		Gain on random component of roll control, from describing function representation of limiter
16	5	GAINDR		Gain on random component of yaw control, from describing function representation of limiter

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
17	1	KXS	1	Gains, damping ratios, and natural frequency for the transfer functions which describe ship surge, heave, pitch, sway, roll, and yaw perturbations
17	2	ZETAXS		
17	3	WNXS	rad/t	
17	4	KZS	1	
17	5	ZETAZS		
17	6	WNZS	rad/t	
17	7	KTS	rad	
17	8	ZETATS		
17	9	WNTS	rad/t	
17	10	KYS	1	
17	11	ZETAYS		
17	12	WNYS	rad/t	
17	13	KRS	rad	
17	14	ZETARS		
17	15	WNRS	rad/t	
17	16	KPS	rad	
17	17	ZETAPS		
17	18	WNPS	rad/t	
17	19	TAUPRT	t	Time constant of first order lag. Output of this filter modifies pilots altitude command.

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
18	None	N/A	N/A	Open segment
19	None	N/A	N/A	Open segment
20	1-10	TABTC	rad	Dependent variable table of pitch altitude commands
21	1-10	TRPMØL	rpm	Dependent variable table of rpm open loop inputs
22	1-10	TCDNØL	deg	Dependent variable table of nozzle position open loop inputs
23	1-10	TDEØL	units	Dependent variable table of pitch control open loop inputs
24	1-10	TABR		Dependent variable table of range commands; not currently in use
25	1-10	TABRDØT		Dependent variable table of rate-of-closure; not currently in use
27	1-6	TXU		Dependent variable tables of longitudinal dimensional derivatives. Units are consistent with output values
28	1-6	TXW		
29	1-6	TXQ		
30	1-6	TXRPM		
31	1-6	TXCDN		
32	1-6	TXPIGV		
33	1-6	TXDE		
34	1-6	TZU		
35	1-6	TZW		



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R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
36	1-6	TZQ		
37	1-6	TZRPM		
38	1-6	TZCDN		
39	1-6	TZPIGV		
40	1-6	TZDE		
41	1-6	TMU		
42	1-6	TMW		
43	1-6	TMWD		
44	1-6	TMQ		
45	1-6	TMRPM		
46	1-6	TMCON		
47	1-6	TMPIGV		
48	1-6	TMDE		
49	None	None	N/A	Open segment

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
50	varies	F		Overall system matrix
51	varies	P		Covariance matrix
52	varies	PDØT		Covariance matrix time rate-of-change; $PDØT=F*P + P*F^T + GM*QM*GM^T$
53	varies	GM		Matrix relating external white noise disturbances to state equations
54	varies	QM		Covariance matrix of external white noise sources
55	1-50	SIGMA	varies	Array of standard deviations
56	1-50	SIGMAXY	varies	Array of cross correlations with a given element (used when plotting ellipses); see subroutine MISCAL
57	1-75	VXX	l/t	Table of mean components of airwake along x ship wind axis
58	1-75	VYY	l/t	Table of mean components of airwake along y ship wind axis
59	1-75	VZZ	l/t	Table of mean component of airwake along z ship wind axis
60	1-75	SVXX	l/t	Table of standard deviation components of airwake along X ship wind axis
61	1-75	SVYY	l/t	Table of standard deviation components of airwake along Y ship wind axis
62	1-75	SVZZ	l/t	Table of standard deviation components along Z ship wind axis

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
63	1-6	TKDEU		Dependent variable tables of pilot feedback gains. Units are consistent with previously defined output values.
64	1-6	TKDEW		
65	1-6	TKDEQ		
66	1-6	TKDET		
67	1-6	TKDEX		
68	1-6	TKDEZ		
69	1-6	TKDEN		
70	1-6	TKDEDE		
71	1-6	TKDEDT		
72	1-6	TKDTU		
73	1-6	TKDTW		
74	1-6	TKDTQ		
75	1-6	TKDTT		
76	1-6	TKDTX		
77	1-6	TKDTZ		
78	1-6	TKDTN		
79	1-6	TKDTDE		
80	1-6	TKDTDT		
81	varies	F1		Aircraft system matrix
82	varies	G1		Aircraft control matrix
83	varies	GAMMA		Matrix relating colored noise inputs to aircraft

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
84	varies	A		Colored noise shaping matrix
85	varies	B		Matrix relating white noise inputs to shaping filters
86	varies	M1		Not currently used
87	varies	M2		Not currently used
88	varies	H		Not currently used
89	varies	D		Measurement matrix
90	varies	C		Feedback matrix operating on states in control rate equation
91	varies	RL		Feedback matrix operating on controls in control rate equation
92	varies	W		Covariance matrix of white noise external disturbances
93	varies	VU		Covariance matrix of white neuromuscular noise
94	varies	VY		Covariance matrix of white measurement noise
95	varies	VYI		Inverse of matrix VY
96	varies	S		Ship motion system matrix
97	varies	FE		System matrix for estimator covariance calculation
98	varies	QE		Covariance matrix for driving estimator covariance calculation
99	varies	PE		Covariance matrix for estimator error
100	varies	PED		Time rate-of-change of estimator error covariance matrix
101	varies	KG		Kalman gain matrix

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
102	varies	FXHAT		System matrix for estimated state covariance calculations
103	varies	PXHAT		Estimated states covariance matrix
104	varies	PXHATD		Time rate-of-change of estimated states covariance matrix
105	varies	PX		State covariance matrix
106	varies	CS		A sub matrix in F related to the modified pilot altitude command due to ship motion

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
107	1	DEUR	$\frac{1}{1}$	These additional feedback gains in the optimal pilot model operate on the estimated colored noise disturbances; results of table look-up
107	2	DEWR	$\frac{1}{1}$	
107	3	DEVX	$\frac{1}{1}$	
107	4	DEVXD	$\frac{t}{1}$	
107	5	DEVZ	$\frac{1}{1}$	
107	6	DEVZD	$\frac{t}{1}$	
107	7	DTUR	$\frac{1}{1}$	
107	8	DTWR	$\frac{1}{1}$	
107	9	DTVX	$\frac{1}{1}$	
107	10	DTVXD	$\frac{t}{1}$	
107	11	DTVZ	$\frac{1}{1}$	
107	12	DTVZD	$\frac{t}{1}$	

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
108	1-6	TDEUR		Dependent variable tables for pilot feedback gains. Units are consistent with the output values.
109	1-6	TDEWR		
110	1-6	TDEVX		
111	1-6	TDEVXD		
112	1-6	TDEVZ		
113	1-6	TDEVZD		
114	1-6	TDTUR		
115	1-6	TDTWR		
116	1-6	TDTVX		
117	1-6	TDTVXD		
118	1-6	TDTVZ		
119	1-6	TDTVZD		
120	1-6	TYV		Dependent variable tables for lateral/directional dimensional derivatives. Units are consistent with output values.
121	1-6	TYP		
122	1-6	TYR		
123	1-6	TYDA		
124	1-6	TYDR		
125	1-6	TLV		
126	1-6	TLP		
127	1-6	TLR		

Cont'd

R ARRAY SEGMENT	R ARRAY ELEMENT	VARIABLE NAME	UNITS	DESCRIPTION
128	1-6	TLDA		
129	1-6	TLDR		
130	1-6	TNV		
131	1-6	TNP		
132	1-6	TNR		
133	1-6	TNDA		
134	1-6	TNDR		
135	1-10	TABUB	1/t	Dependent variable tables of longitudinal parameters required in a lateral/directional run.
136	1-10	TABWB	1/t	
137	1-10	TXAPP	1	
138	1-10	TZAPP	1	
139	1-10	TXSP	1	
140	1-4	TDAIN	units	Independent variable table for defining roll control limiter.
141	1-4	TDAØUT	units	Dependent variable table for defining roll control limiter.
142	1-4	TDRIN	units	Independent variable table for defining yaw control limiter.
143	1-4	TDRØUT	units	Dependent variable table for defining yaw control limiter.

APPENDIX F

LIST OF SYMBOLS

F.0 LIST OF SYMBOLS

Throughout the text several equations appear in vector-matrix format. In these equations lower case letters represent vectors and upper case letters are matrices. For scalar quantities, upper case letters are nominal or mean values and lower case letters represent perturbation values. The test clearly distinguishes between variables, as to whether they are matrices, vectors, or scalars, when they are used.

Symbols

C_i	Dimensional stability derivative (includes mass or inertia); C = X, Y, Z, L, M, and N; i = u, v, w, p, q, r, and δ_j.
E { }	Expected value operator.
g	Gravitational constant.
s	Laplace transform variable.
$X'_{A/P}$, $Y'_{A/P}$, $Z'_{A/P}$	Earth axis coordinates of the airplane.
X'_S, Y'_S, Z'_S	Earth axis coordinates of the ship.
W.O.D.	Wind over deck
T/W	Thrust to weight ratio
δ_j	Deflection of $j^{\underline{th}}$ controller.
δ_{ES}	AV-8 pitch control position.
δ_T	AV-8 throttle position.
δ_j	AV-8 nozzle angle.
δ_{as}	AV-8 roll control position
δ_{RP}	AV-8 yaw control position

σ	Standard deviation.
ψ, Θ, ϕ	Euler angles.
$(\dot{\ })$	Time derivative of ( ).
$(\bar{\ })$	Mean value of ( ).
$(\hat{\ })$	Expected value of ( ).

Subscripts

o	Denotes reference value or condition.
g	Gust.

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