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MRI REPORT

STUDY OF INDICIAL AERODYNAMIC FORCES ON MULTISTAGE SPACE VEHICLE SYSTEMS

VOLUME II

USER'S MANUAL FOR THE AERODYNAMICS COMPUTER PROGRAMS

FINAL REPORT
28 June 1967 - 27 September 1968

Contract No. NAS8-21167
Control No. DCN 1-7-20085 S2(1F)

MRI Project No. 3089-P

For

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

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ON MULTISTAGE SPACE VEHICLE SYSTEMS

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by

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PREFACE

This manual was prepared by Midwest Research Institute under Contract No. NAS8-21167, "Study of Indicial Aerodynamic Forces on Multistage Space Vehicle Systems," for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under the technical direction of the Aero-Astrodynamics Laboratory, George C. Marshall Space Flight Center, with Mr. Richard Beranek acting as Contracting Officer's Representative.

The authors wish to acknowledge the assistance of their co-workers, Mr. R. R. Blackburn and Mr. W. Chauncey in parts of the analysis and programming. Also, the authors thank Mr. Donald Stout and the staff of the Computation Laboratory at the Marshall Space Flight Center who helped with the debugging and adapting of the programs to their data processing system.

Approved for:

MIDWEST RESEARCH INSTITUTE

Sheldon L. Levy, Director
Mathematics and Physics Division

27 September 1968

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I. INTRODUCTION

Midwest Research Institute, under a previous contract NAS8-11012, has developed a theory of accurately predicting unsteady indicial aerodynamic forces on a body of revolution. By indicial, we mean the forces resulting when the vehicle encounters a side gust in the form of a step function. Since this theory is linear, it can be used with an integral or convolution approach to calculate aerodynamic forces associated with arbitrary side winds.

The object of the current contract is to apply the integral approach by developing the necessary computer programs and then using the programs to study several selected problems. This manual contains the information and instructions for users of these computer programs.

The programs required to compute the indicial aerodynamic forces have been previously documented.1/ However, because some improvements and modifications have been made since that report was issued, and for completeness, the documentation of these programs is repeated in this manual, together with the documentation of the completely new programs. It is assumed that the user is familiar with the basic theory and notation2/ and, to a lesser degree, the "equivalent body concept"3/ and the Duhamel integral approach.4/

The principal type of side wind considered in the study was sinusoidal in profile, hence, the programs were designed to handle this wind shape readily to generate frequency response data. However, it is also possible to obtain responses to arbitrary winds by utilizing an alternate set of routines and specifying the wind as a function of altitude.

There are three different programs, or deck setups described in this manual. Program I (main program COMTAR) contains all of the routines necessary to calculate indicial responses and then to use these to obtain frequency response data. This program is recommended for use in studying relatively simple body shapes which can be described by a reasonably small (say, less than 40) number of aerodynamic sources. It is recommended also for one-time calculations wherein the user is fairly certain he will not want to obtain additional frequency response data for the same geometry (and same Mach number) at a future date.

Since the calculation of the indicial responses is fairly time-consuming (indeed, often the major portion of a complete computer run of Program I) there are many situations in which the user might prefer to compute the indicial responses in a separate job, store these on magnetic tape, and subsequently use the tape as input to a wind-response program. Program II (main program TAPRES) may be used to calculate and store indicial responses on magnetic tape. Program III (main program RESINP) uses the tape(s) to compute frequency response data or optionally, with additional input data, responses to specified arbitrary winds. If responses to arbitrary winds are desired the sequence Program II, Program III must be used; Program I does not contain this option.

The programs are written exclusively in FORTRAN IV and utilize a great deal of double precision arithmetic. They have been compiled and executed on an IBM 7094-II and, with minor changes, should be acceptable to most other large-scale computers.

This manual presents, first, a discussion of the overall structure of the programs. Next a complete presentation of input data is given, with examples. A discussion of the output to be expected, its interpretation, units, etc., is given next, followed by a brief discussion of each of the subroutines. Then deck setup, operating instructions, timing, and the like are presented. Appendices contain selected flow diagrams and complete FORTRAN listings of all of the routines.

II. PROGRAM ORGANIZATION

Program I consists of a main control routine, COMTAR, and four major subroutines: MAIN1, MAIN2, MAIN3, and RESINP. (The deck names for these four are MAN1, MAN2, MAN3, and COMRES, respectively.) Control passes back and forth between these subroutines, at the user's command, via COMTAR. It is necessary that MAIN1 be called upon before either MAIN2 or MAIN3 is used. Furthermore, MAIN2 and/or MAIN3 must be called upon before RESINP is used.

Subroutine MAIN1 does most of the basic data input functions. In addition, it computes basic coefficients which are required by the other routines. The computational phase of MAIN1 can be bypassed when geometrical and velocity data are identical to those of a previous run. The punched card output of the previous MAIN1 run is used as input to MAIN1.

MAIN2 is used for computing local indicial normal force coefficients and related local quantities. MAIN3, on the other hand, is used for computing total indicial force coefficients, center of pressure location, and other integrated effects. Each of these routines may store its results on "scratch" or working tapes as well as providing printed output. Separate tapes are used, one for MAIN2 and one for MAIN3.

Subroutine RESINP utilizes the results on scratch tapes, prepared by MAIN2 and/or MAIN3, to compute aerodynamic forces associated with sinusoidal winds--that is, it computes frequency response data.

Program I may be used for computing only indicial responses, and the working tapes may be saved for subsequent use. Alternately, Program II may be used, resulting in moderate deck-handling simplifications. It consists of a main routine, TAPRES, and the three major subroutines MAIN1, MAIN2, and MAIN3 (identical to those used with Program I). Data preparation is identical for the two programs, except that with Program II the packet of data used by RESINP is not included.

Program III is a separate program which reads indicial data from magnetic tapes and computes aerodynamic responses to sinusoidal winds or to arbitrary, specified winds. Its main routine is RESINP, not to be confused with the subroutine of the same name but with the deck name COMRES. The deck, RESINP, is a greatly expanded version of the deck, COMRES, and is a main routine as opposed to a subroutine.

In addition to the seven major routines and subroutines mentioned above, there are sixteen other supporting routines. Table I shows the routines required for each of the three programs. All of these routines are listed in Appendix II, and additional documentation is given in other sections of this report.

All dimensional quantities referred to in this manual are in the metric system (K-M-S). The user may, however, use other units as long as he is consistent. (For example, feet and miles cannot be used simultaneously.) The only exception to this is in the use of the wind data in Program III, where the program explicitly utilizes the metric system of units in making altitude-flight time transformations. This would have to be modified for use with other units.

TABLE I

SUBROUTINES REQUIRED FOR AERODYNAMICS COMPUTER PROGRAMS

Program I		Program II		Program III	
Program Name	Deck Name	Program Name	Deck Name	Program Name	Deck Name
(Main)	COMTAR	(Main)	TAPRES	(Main)	RESINP
MAIN1	MAN1	MAIN1	MAN1	LNCNT	LNCNT
MAIN2	MAN2	MAIN2	MAN2	FINTAP	FINTAP
MAIN3	MAN3	MAIN3	MAN3	CONVOL	CONVOL
BINTAP	BINTAP	BINTAP	BINTAP	QUATAN	QUATAN
INTGRL	INTGRL	INTGRL	INTGRL	SHEARS	SHEARS
UTANVT	UTANVT	UTANVT	UTANVT	DWVDT	DWVDT
UANDV	UANDV	UANDV	UANDV		
POINTS	POINTS	POINTS	POINTS		
LNCNT	LNCNT	LNCNT	LNCNT		
COMELL	COMELL	COMELL	COMELL		
INCELL	INCELL	INCELL	INCELL		
ARCOSH	ARCOSH	ARCOSH	ARCOSH		
ERROR	ERROR	ERROR	ERROR		
RESINP	COMRES				
FINTAP	FINTAP				
DUHINT	DUHINT				
QUATAN	QUATAN				

III. INPUT DATA

A. Program I (COMTAR)

The input data consist of one or more cases. Each case (that is, a specified geometry and Mach number) contains a pack of data read by MAIN1, packs of data read by MAIN2 and/or MAIN3, and a pack of data read by RESINP. If MAIN2 (or MAIN3 or RESINP) is not to be called, there should be no data for MAIN2 (or MAIN3 or RESINP). Each pack of data is preceded by a program control card, which is read by the main program, COMTAR, and serves to call the required major subroutine.*

Figure 1 illustrates a typical deck arrangement. The program decks are source, object, or a mixture of the two, as given in Table I. Following the $DATA card are two sets of data. The first set causes various aerodynamic

* The supporting subroutines are called automatically as needed; the user need not concern himself with them during data preparation.

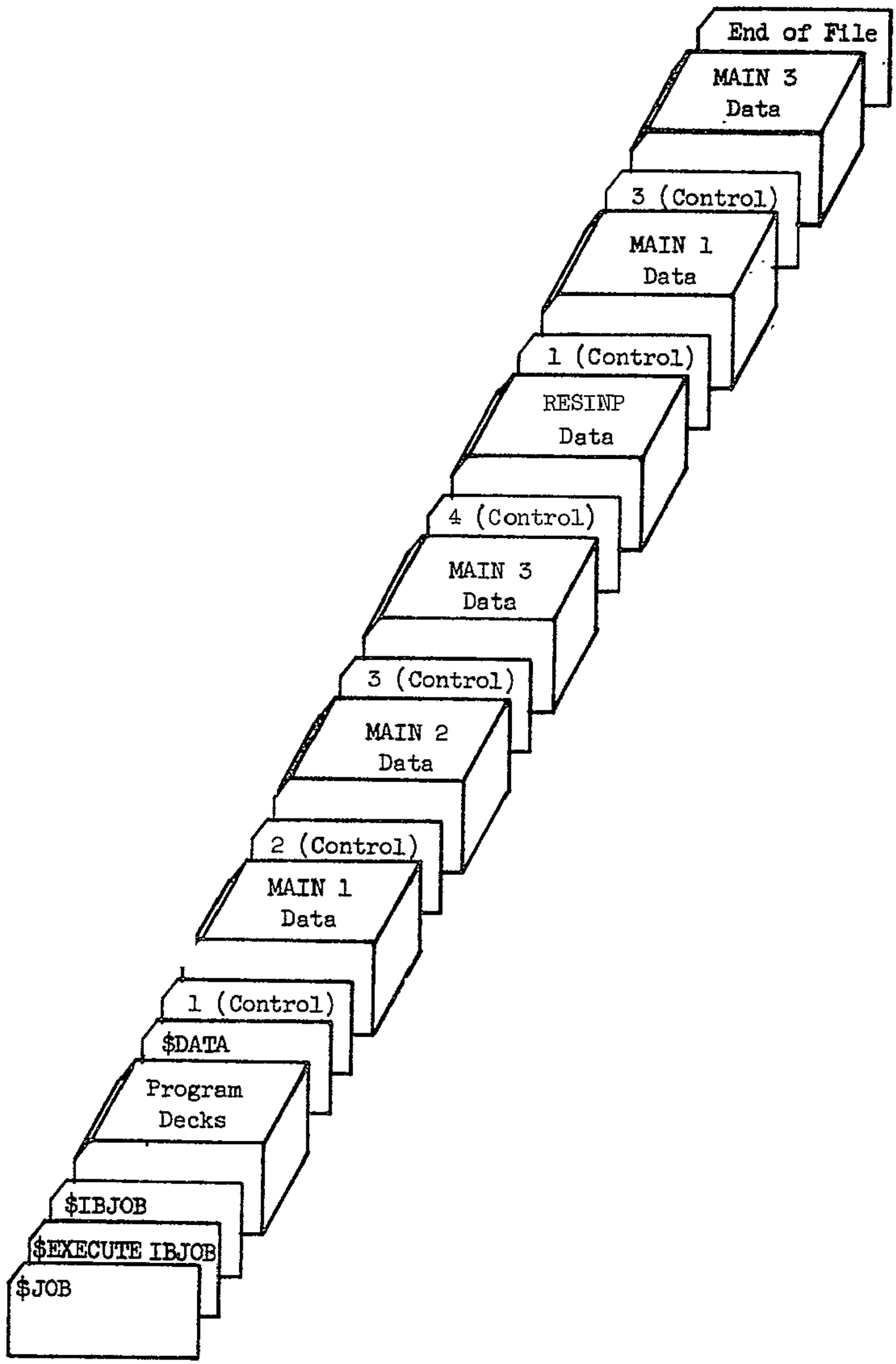

Figure 1 - Sample Deck Setup

coefficients to be calculated (MAIN1), some indicial local forces to be calculated and stored on a working tape (MAIN2), some indicial total forces to be calculated and stored on a working tape (MAIN3), and some frequency response data to be calculated (RESINP). The second set causes various aerodynamic coefficients to be calculated (presumably for a different geometry and/or Mach number), and indicial total forces to be calculated. Depending on the user's needs, the latter forces could be preserved by saving the magnetic tape; or, alternatively, the user may be interested only in the printout of these forces. To illustrate further the program capabilities, the data packs for MAIN2 and MAIN3 for the first set (including the control cards) could be interchanged without affecting the end results or the computer time. This is because MAIN2 and MAIN3 are independent routines which share only the data prepared by MAIN1. Moreover, by dividing up the data pack associated with RESINP and making slight data changes, the data for the first set could be arranged in the order: MAIN1, MAIN2, RESINP, MAIN3, RESINP. In this instance, identical results would be obtained at a slight loss in efficiency. This arrangement is not necessarily recommended, but is mentioned only to further illustrate data preparation procedures.

The details of the data cards for Program I are given below.

1. COMTAR data: Only a single card is read by this routine. This "program control" card indicates which major subroutine is to be called next. (Upon return to COMTAR, another "program control" card is read.) Table II shows the card format.

TABLE II

DATA FOR PROGRAM COMTAR

Card	Columns	Format	Quantity	Remarks
1	1-2	I2	I	Integer 1, 2, 3 or 4 to indicate which data pack follows (i.e., MAIN1, MAIN2, MAIN3 or RESINP data pack).

2. MAIN1 data: Two different sequences are possible. Sequence A is the set which must be used initially. On subsequent runs using the same configuration and speed, Sequence B may be used to bypass the computational portion of MAIN1. The input Sequence B contains previously computed information, and, with the exception of cards 1 and 2, was punched out by a previous run which used the Sequence A.* See Tables III and IV for the data descriptions. The user should refer to reference 2, Appendix V, for help in selecting the control point locations needed for cards 3...n.

* A "Card 2" is also punched out by the previous run. But, due to number base conversions from base 10 to base 2 and back again, the punched card does not always agree with the card read. It should be destroyed and replaced by a correct Card 2, to avoid possible program difficulties.

TABLE III

DATA FOR PROGRAM MAIN1, SEQUENCE A

Card	Columns	Format	Quantity	Remarks
1	1-72	18A4	HEADING	Seventy-two character page heading. May include date and other identification data.
2	1-13	F13.8	EM	Mach number.
	14-26	F13.8	UPSTRM	Upstream velocity, U (m/sec).
	27-39	F13.8	VZERO	Downwash velocity, v_o (m/sec).
	40-42	I3	NLAST	Number of control points, excluding the origin.
	43-55	F13.8	EPS	Small number used to offset Mach lines, e.g., 0.0000001.
	56-61	F6.0	DCOE	Control code. If Sequence A data are being used, DCOE $\neq$ 0.0.
	62-67	F6.0	WEIGHT	Factor used with equivalent body concept. Normally = 1. Program sets WEIGHT = 1. if input is 0. or blank.
	68-80	F13.8	RBASE	Radius at the base of the vehicle, used for nondimensionalizing.
3	1-10	F10.0	X	x-coordinate of first control point* on body surface (meters).
	11-20	F10.0	R	r-coordinate of first control point* on body surface (meters).
	21-30	F10.0	RP	Downstream slope. (Upstream slope for KTYPE = 1.)
	31-35	I5	KTYPE	Type of solution used; i.e., 0-linear, 1-corner and 2-quadratic. (See UANDV.)

TABLE III (Concluded)

Card	Columns	Format	Quantity	Remarks
3	36-45 46-55 56-65 66-70			Similar information as in columns 1-35 of this card for second control point on body surface.
4-n	1-10 ⋮ 66-70			Additional cards in same format as card 3. The n^{th} card need not contain two control points.

* Other than the origin, which is automatically included by program.

TABLE IV

DATA FOR PROGRAM MAIN1, SEQUENCE B

Card	Columns	Format	Quantity	Remarks
1				See Table III.
2				See Table III. Note, DCOE must be zero or blank.
3	1-5	I5	I	Control point number.
	6-30	E25.8	X(I)	x-coordinate of i^{th} control point (meters).
	31-55	E25.8	R(I)	r-coordinate of i^{th} control point (meters).
	56-80	E25.8	RP(I)	Slope at i^{th} control point.
4	1-5	I5	KTYPE(I)	Type of solution, i.e., 0-linear, 1-corner, 2-quadratic used at i^{th} control point.
	6-30	E25.8	XI(I)	Source location, ξ_i (meters).
	31-55	E25.8	A(I)	Axial coefficient at i^{th} control point.
	56-80	E25.8	C(I)	Cross flow coefficient at i^{th} control point.
5,6,..., m, m+1	1-5 . . . 56-80			Additional cards in same format as cards 3 and 4, respectively. Two such cards are needed for each control point.

If, over a portion of the body, the configuration is not axially symmetric the "equivalent body concept"[3] may be utilized. For this portion of the body, the meaning of some of the input data is changed, as follows:

R - artificial value of -1., indicating that equivalent radius is not known and must be calculated;

RP - dimensionless slope of the local normal force coefficient downstream (upstream if KTYPE = 1) of the control point. (This is $dC_{N_\alpha}/d(x/D)$.)

Moreover, if normal force discontinuities are desired, a "corner" must be introduced. This is done by specifying a corner solution (KTYPE = 1) with the upstream radius, if known. (If unknown because an equivalent body is upstream, the upstream $dC_{N_\alpha}/d(x/D)$ is given.) The corner solution is followed by a quadratic solution at the same location (as is normally done--see reference 2) but with an estimated body slope.* The estimate may be the result of trial and error. It is stated as the decimal fraction of the difference between the upstream slope and the slope of the Mach lines; i.e., if RP is given as 0., the upstream slope is used. If given as 1., the Mach angle is used. If the upstream slope is 0.1, the slope of the Mach lines is 0.5, and RP is stated as 0.75, a slope of 0.4 (0.1 + 0.75 (0.5-0.1)) will be used. Following these would be a sequence of x-coordinate values with $dC_{N_\alpha}/d(x/D)$ being given.

3. MAIN2 data: This major subroutine computes indicial local aerodynamic forces. A single data card indicates whether a tape is to be written, and information regarding station location and/or time after gust penetration at which the forces are required. It is possible to index either the location or the time through a sequence of values, using a single data card. If, as often is the case, the user wishes to use unequal time intervals, one or more cards designated as card 1' may be used with card 1. Automatic indexing on station location is not possible if a tape is to be written. This is because the program indexes x first, then t . Table V gives the data format for MAIN2 data.

Examples of MAIN2 data:

(a) It is desired to compute local forces at a series of equally spaced locations at a specified time, without the need for writing on tape. A single card 1 will suffice, with ITAPE = 0, KODE = -1 (assuming return to main program is desired next), KCODET = 0, NT = 1, and DT arbitrary.

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* Earlier versions of the program allowed $dC_{N_\alpha}/d(x/D)$ to be specified ahead of, and behind, the discontinuity. It was often found, however, that an axially symmetric body could not generate large enough discontinuities to satisfy the input data, and maintain body slopes less than the Mach line slope--a necessity in potential theory. Thus, the user must accept a smaller discontinuity followed, perhaps, by a rapid change in $dC_{N_\alpha}/d(x/D)$ as an approximation.

TABLE V

DATA FOR PROGRAM MAIN2

Card	Columns	Format	Quantity	Remarks
1	1-5	I5	ITAPE	ITAPE = 0 denotes no tape while ITAPE $\neq$ 0 indicates a binary tape of local forces is being created.
	6-9	A4	IDBODY	Four-character identification of vehicle configuration written on the binary tape (1st record).
	10	1X		This column ignored.
	11-20	F10.0	XF	First x value at which the integrand (local force) is computed.
	21-30	F10.0	DX	Interval for x values (ignored if ITAPE $\neq$ 0).
	31-40	F10.0	XL	Last x value (ignored if ITAPE $\neq$ 0).
	41-45	I5	KODE	Control code. If KODE $<$ 0, control is returned to main program after these calculations. If KODE = 0, an EOF is written on tape (ITAPE $\neq$ 0), tape is rewound, and then control is returned to main program. If KODE $>$ 0, another card 1 (another set of x values) is expected before returning to main program.

TABLE V (Concluded)

Card	Columns	Format	Quantity	Remarks
1	46-50	I5	KCODET	If KCODET is not equal to zero, additional time values will be read in. (See card type 1'.)
	51-60	F10.0	TF	First time value.
	61-70	F10.0	DT	Increment for time values.
	71-75	I5	NT	Number of time points. (The last time value, TL, is equal to TF + DT(NT-1).)
	76-80	I5	L1	If L1 $\neq$ 0, optional output from UTANVT is printed. If L1 = 0, no output from UTANVT is given (normal).
1'	1-45	45X		These columns ignored.
	46-50	I5	KCODET	Same type of format and definition as on card type 1.
	51-60 61-70 71-75	F10.0 F10.0 I5	TF DT NT	Same type of format as card 1, but with new set of time values.*
	76-80	I5	L1	Same type of format and definition as card 1.

* The new set of time values is used along with the same x values as previously read in on card 1 as well as the same KODE value indicated on the previous card 1.

(b) Same as (a) except the forces are desired at a sequence of equally spaced times, as well as locations. Again, a single card 1 suffices. It is the same as case (a) except that NT and DT should reflect the time sequence desired. Local forces will first be computed at time TF, at all locations; then at TF + DT at all locations, etc.

(c) The forces at x = 7.5 are desired, on tape, at t = 0.1, 0.2, and 0.5, and more MAIN2 data follow. Two cards are required here, since the times are not equally spaced. A possible arrangement is a card 1 with ITAPE = 1, XF = 7.5, DX = XL = 0., KODE = 1, KCODET = 1, TF = 0.1, DT = 0.1, NT = 2 followed by a card 1' with KCODET = 0, TF = 0.5, NT = 1.

(d) The forces at x = 7.5, 15.0, and 22.5 are desired, on tape, at t = 0.1, 0.2, and 0.5, with data for another routine following. Since the times are not equally spaced, cards of type 1' will again be required. The automatic sequencing of x-values is not possible since a tape is to be written. Therefore, six cards are required. The first two are identical with case (c) above. The fourth and sixth are copies of card 1' in (c), while the third and fifth are similar to card 1 in (c). They will differ in that the third card will have XF = 15.0 and the fifth card will have XF = 22.5. Moreover, the fifth card will have KODE = 0, unless it is desired to put more local forces on the same tape later in the run (perhaps for a different Mach number). In that case, KODE should be -1 except for the last time, when KODE = 0.

4. <u>MAIN3 data</u>: This major subroutine computes indicial total aerodynamic forces. A single data card indicates whether a tape is to be written, the type of aerodynamic theory to be used (full indicial theory or quasi-steady theory) and the time intervals at which the results are desired. If unequal time intervals are desired, one or more cards designated as card 1' may be used with card 1. The programs which read the tapes expect that the quasi-steady theory (KK = 3) has been used prior to using the full theory (KK = 5). Table VI gives the data format for MAIN3 data.

<u>Examples of MAIN3 data</u>:

(a) It is desired to compute total forces at equally spaced time intervals for both the quasi-steady and the full indicial theory. No tape is to be written and a return to the main program is desired. Two cards of type 1 are required. The first should have ITAPE = 0, KK = 3, KCODE = 1, and MORET = 0. The second should have ITAPE = 0, KK = 5, KCODE = -1, and MORET = 0. Both cards should include the required time intervals, but they need not be the same.

TABLE VI

DATA FOR PROGRAM MAIN3

Card	Columns	Format	Quantity	Remarks
1	1-5	I5	ITAPE	ITAPE $\neq$ 0 denotes a binary tape of total forces being created while ITAPE = 0 indicates no tape shall be written.
	6-9	A4	IDBODY	Identification of vehicle configuration written in first record of the binary tape.
	10	1X		This column ignored.
	11-20	F10.0	TF	First time value.
	21-30	F10.0	DT	Increment for time values.
	31-35	I5	NT	Number of time points (the last time value would be equal to TF + DT(NT-1).)
	36-40	I5	KK	Type of aerodynamics, i.e., 1 - instantaneous immersion (steady state value only); 3 - pure penetration (quasi-steady); and 5 - penetration with lift growth (full indicial theory).
	41-45	I5	KCODE	Control code. If KCODE < 0, control is returned to main program after these calculations. If KCODE = 0, an EOF is written on tape (ITAPE $\neq$ 0), tape is rewound, and then control is returned to the main program. If KCODE > 0, another card 1 is expected before returning to main program.

TABLE VI (Concluded)

Card	Columns	Format	Quantity	Remarks
1	46-50	I5	MORET	If MORET $\neq 0$, more time values will be read in (see card type 1'). If MORET is equal to zero, this is the last set of time values. (If ITAPE $\neq 0$ and MORET = 0, program calculates the KK = 3 case and then the KK = 5 case using only the <u>one</u> data card.)
	51-55	I5	L2	If L2 $\neq 0$, optional output of the integrand at each step is printed; otherwise, L2 = 0 for the omission of this output (normal).
	56-60	I5	L3	If L3 $\neq 0$, optional output of special values of x from POINTS are printed. If L3 = 0, this output is omitted (normal).
1'	1-10	10X		These columns ignored.
	11-20	F10.0	TF	Same type of format as card 1, but with a new set of time values.*
	21-30	F10.0	DT	
	31-35	I5	NT	
	36-45	10X		These columns ignored.
	46-50	I5	MORET	Same type of format and identification as card 1.
	51-55	I5	L2	Codes for optional output. Same format as card 1.
	56-60	I5	L3	

* The new set of time values is used with the <u>same KK value</u> and the <u>same KCODE value</u> as previously read in on card 1.

(b) Same as (a) except a tape is to be written. If both aerodynamic theories will utilize the same time intervals, a single card 1 will do the job. It should have ITAPE $\neq$ 0 and MORET = 0. KK will be assigned automatically. KCODE should be either 0 or -1, depending on whether this is to conclude the tape. If the time intervals are to be different, three cards are required,* since in this case we do not want ITAPE $\neq$ 0 and MORET = 0. The first card, of type 1, should have ITAPE $\neq$ 0, KK = 3, MORET = 1, and KCODE = 1. A card 1' should follow with MORET = 0. The time intervals for the KK = 3 case should be split between these two cards (e.g., the last time value might be on card 1'). Then a card 1 with ITAPE $\neq$ 0, KK = 5, MORET = 0, and KCODE = 0 or -1 should follow.

5. RESINP (deck COMRES) data: This major subroutine computes frequency response data using user-supplied information and the magnetic tape produced by MAIN2 and/or the magnetic tape produced by MAIN3. (They are separate tapes.) The details of the data on the tapes are discussed in the next section. This integration routine takes advantage of the fact that the Duhamel integral approach can be considered as functionally independent of the data on which it operates. The two tapes are in the same format; the computations are data-independent; and only the final output distinguishes whether local or total responses have been found.

The user-supplied data specifies which tape is to be used--the local (MAIN2) tape or the total (MAIN3) tape. It also specifies which set of data on the tape is to be used. (There may be, for example, several geometries, Mach numbers, or even several locations for a given vehicle and Mach number, on the same tape.) The program searches the tape to locate the specified data. Finally, the user specifies the frequencies of interest.

The data consists of three card types. The first contains alphanumeric information which is used as a page heading for run identification. The second specifies the data set, from tape, to be used. The third type specifies the sinusoidal frequency or frequencies to be used. The data format is given in Table VII.

A single call to this subroutine will suffice for finding both local and total frequency responses, for several geometry-Mach number combinations. However, if the user wishes to change the heading, he simply returns to the main program by setting JCODE = 0, and then re-enters this subroutine with a program control card containing a "4."

It is most efficient to request data sets from the tapes in the same order they were computed and written. This minimizes the search time of the program.

* A simple program change could reduce this requirement to two cards.

TABLE VII

DATA FOR SUBROUTINE RESINP

Card	Columns	Format	Quantity	Remarks
1	1-72	18A4	HEADNG	Seventy-two character identification for page heading.
2	1-13	F13.8	EM	Mach number.*
	14-26	F13.8	UPSTRM	Upstream velocity, U (meters/sec).*
	27-39	F13.8	VZERO	Downwash velocity, v_o (this quantity is no longer used in the computations and may be ignored).
	40-44	I5	ITAPE	ITAPE = 1 denotes the tape of local forces is to be processed; ITAPE = 2 for processing the tape of total forces.
	45-48	A4	IDBODY	Identification of vehicle configuration. Input value here should agree with that on the tape being processed. See MAIN2 or MAIN3.
	49	1X		This column ignored.
	50-59	F10.0	XF	Station value (meters) at which local forces are desired (ignored if ITAPE = 2).
	60-64	I5	KK	Type of aerodynamics for which total forces are desired (3 or 5 ignored if ITAPE = 1).

TABLE VII (Continued)

Card	Columns	Format	Quantity	Remarks
2	65-69	I5	JCODE	Control code. If JCODE > 0, a card type 2' is to be read; i.e., a new value of XF or of KK. If JCODE < 0, a card type 2 is to be read; i.e., a new type of vehicle configuration or a different tape is to be processed or different Mach number data are being processed. If JCODE = 0, this is the last data set and control is to be returned to the main program.
2'	1-49	49X		These columns ignored.
	50-59	F10.0	XF	Same type of format and definition as on card type 2.
	60-64	I5	KK	Same definition and type of format as on card type 2.
	65-69	I5	JCODE	Same type of format and definition as on card type 2.
3	1-15	F15.0	AOMF	First frequency value.**
	16-30	F15.0	DAOM	Frequency increment.**
	31-45	F15.0	AOML	Last frequency value.**
	46-60	F15.0	VBAR	Half-amplitude of the sinusoidal cross wind. ($v = \overline{v} \cos \omega t$).
	61-70	F10.0	VLENTH	Length (meters) used to nondimensionalize frequency.**

TABLE VII (Concluded)

Card	Columns	Format	Quantity	Remarks
3	71-72	I2	MOREOM	If MOREOM > 0, a card type 3 is to be read next; otherwise control continues according to value of JCODE.
	73-74	I2	IOPT***	Optional printout from QUATAN is obtained if IOPT > 0.
	75-76	I2	OP1***	If OP1 > 0, optional output of intermediate results from the integration subroutine DUHINT is obtained.
	77-78	I2	OP2***	If OP2 > 0, optional printout of time, t , sin ωt and cos ωt used in DUHINT are obtained.
	79-80	I2	KOMEGA	Controls dimensions of AOMF, DAOM, and AOML input data: KOMEGA — data 1 — ω (rad/sec) 2 — $k = \omega L/U$ 3 — Strouhal No., $S = k/2\pi = fL/U$

* Must be identical to values used for MAIN1, which have been placed on magnetic tapes.

** See KOMEGA for units.

*** These should normally be zero or blank. The optional printout possible under IOPT, OP1 and OP2 should only be obtained when debugging is deemed necessary, due to the amount of paper generated.

Examples of data packs for subroutine RESINP:

(a) Find local frequency response at three vehicle stations and at four Mach numbers, assuming required indicial data are on magnetic tape. The data pack would consist of the following card types, in order given: 1, 2, 3, 2', 2', 2, 3, 2', 2', 2, 3, 2', 2', 2, 3, 2', 2'. The four cards of type 2 would have ITAPE = 1, JCODE = 1, and would contain different Mach numbers. The cards of type 3 would have MOREOM = 0. The cards of type 2' define the other vehicle stations, and make use of the card 3 read previously. The first of each pair of type 2' cards would have JCODE = 1, while the second would have JCODE = -1, except for the very last card which would have JCODE = 0.

(b) Find the total frequency response for the two aerodynamic types and for four Mach numbers. The data pack would be similar to that of (a), containing card types 1, 2, 3, 2', 2, 3, 2', 2, 3, 2', 2, 3, 2'. The code differences are that ITAPE = 2 and JCODE = -1 on all cards of type 2' except last on which JCODE = 0. The type 2 cards would have KK = 3 while the type 2' cards would have KK = 5.

(c) Find the total frequency response for ω = 0. (0.01)1.* and for ω = 1. (0.05)10. for the two aerodynamic types and for two Mach numbers. In this case, multiple card 3's are used, so card type 2' is not advisable. The pack arrangement would be 1, 2, 3, 3, 2, 3, 3, 2, 3, 3, 2, 3, 3. JCODE = -1 except for last card 2, where JCODE = 0. MOREOM = 1 on the first of each pair of card 3's, and is zero on the second of the pair.

6. Binary tape format: The binary tapes generated by MAIN2 and MAIN3 and used by RESINP have the same format. They consist of one or more sets of data, where a set is those data pertaining to a specific geometry and Mach number and, furthermore, to a specific vehicle station (for local responses) or to a specific aerodynamic type (for total responses). The sets are on the tapes in the order computed, which may be arbitrary. Again, there are two distinct tapes--the tape from MAIN2 and the tape from MAIN3.

Each data set contains an identification record followed by a variable number of data records. The data records each contain 240 binary words (120 double precision numbers) whereas the identification record contains 15 + 2(NTEST) binary words, where one of the words is NTEST, defined below.

The quantities which are in the identification record, and their definitions, are given in order below:

* This notation means all values of ω from 0. to 1. in steps of 0.01.

ITAPE - 1 if created in MAIN2 (local forces); 2 if created in MAIN3 (total forces). It is negative if the tape contains no more data; i.e., the record, in this case, is artificial and warns that an "end of file" follows. This is necessary since the FORTRAN language cannot properly recognize an end of file mark.

IDBODY - Four-character vehicle identification.

EM - Mach number (double precision variable).

UPSTRM - Free stream velocity in meters/sec (double precision variable).

XF - Station value (x-coordinate) at which the local forces are computed in MAIN2. An arbitrary value, XTEST (NTEST), is used in MAIN3 to keep the same form for the First Record in both subroutines (double precision variable).

KK - Aerodynamic type (3 for pure penetration and 5 for penetration with lift growth). An arbitrary value of KK = 5 is recorded on the tape in MAIN2 to keep the form of the First Record identical in both subroutines.

NTCOUN - Number of real time points in the following records (does not count the last artificial time point, t = 1,000.) (See below.)

(FSTEDY(I), I = 1,2) - The steady-state values of the local (or total) force and moment, respectively (double precision). (See below for units.)

NTEST - Number of "corners." Each conic section has two "corners," front and rear. The nose of the vehicle is <u>NOT</u> counted as a corner. If two conic sections adjoin, intersection is counted twice. Last "corner" is to be at the base of the vehicle. NTEST $\leq$ 20.

(XTEST(I), RTEST(I), I=1, NTEST) - Location of the corners in meters (double precision). Corners are numbered starting at nose and going aft (nose itself not counted).

The data records each contain 40 time values and the associated, computed aerodynamic quantities. All are in double precision and the aerodynamic quantities are dimensionless (time is in seconds). For the total forces tape, the aerodynamic quantities are C_{N_α} and C_{M_α}; for the local forces tape they are $dC_{N_\alpha}/d(x/D)$ and $dC_{M_\alpha}/d(x/D)$. The moments are taken about the vehicle nose, and are nondimensionalized by the base diameter, D, not the vehicle length. The order of the quantities is: t_1, $C_{N_\alpha}(1)$, $C_{M_\alpha}(1)$, t_2, $C_{N_\alpha}(2)$, $C_{M_\alpha}(2)$, t_3, etc. for the total forces tape with a corresponding arrangement for the local forces tape. The sequence is terminated by the artificial time value of 1,000. sec.; the remainder of the 240-word record is meaningless.

B. Program II (TAPRES)

Since this program is a subset of Program I, the data are nearly identical. There are but two differences: (a) there should be no program control card containing the integer 4, and (b) there should be no data pack for subroutine RESINP. This program contains no reference to RESINP; to include data for it will be erroneous. Other than these restrictions, the user should refer to Section III-A of this manual for data preparation details.

C. Program III (RESINP)

This main program is an expanded, stand-alone version of the subroutine RESINP used with Program I. It is capable of computing responses to sinusoidal winds or to arbitrary, specified wind profiles.

If this program is used to compute sinusoidal responses, data preparation is identical to that described in Section III-A-5 with the following three exceptions: (a) there is, of course, no "program control card," (b) card 2, columns 70-72 should be blank. They are read as the variable WINTYP (format F3.0) which signifies sinusoidal winds if zero or blank (the present case) or a specified wind profile if nonzero (see below), and (c) JCODE is interpreted somewhat differently on cards 2 and 2'. Recall (Section III-A-5) that with the subroutine RESINP, the value JCODE = 0 caused a return to the main program. Since, here, RESINP is the main program, the value JCODE = 0 causes the program to start at the beginning--i.e., to read another card of type 1.

The remainder of this section pertains to the use of RESINP for finding responses to arbitrary wind profiles. In this case, the data preparation is similar to that just discussed. There are basically three types of cards, in addition to those which define the wind profile. The cards of type 1 and 2 (and 2') are identical in format and use to those read by subroutine RESINP (except WINTYP, card 2, columns 70-72 should be 1.) and need not be discussed further.

Card type 3 is analogous to that described previously, but is in a different format and gives data relating to the wind profile rather than to frequency ranges. It specifies the altitude range and intervals (or flight-time range and intervals), nondimensionalizing quantities, and other control information. Its format is given in Table VIII.

The wind data proper are read whenever NSHR (card 3) is not zero.* The wind data consist of a header card and then a sequence of cards containing the wind velocity at 25 meter altitude increments, 10 increments per card. Table IX shows the format to be used. The number of wind cards after the header card is arbitrary, being given by NPRO/10 (truncated) + 1. The last card need not be filled. The wind values are to be arranged in order of increasing altitude.

The particular format used here for the winds was chosen for convenience in using with published data.[5] It should, of course, be possible for the user to modify the format and/or the programs to match other requirements.

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* The wind data are subsequently differentiated by the program since the wind shears are actually utilized in the Duhamel integration procedure.

TABLE VIII

CARD 3 DATA FOR PROGRAM III USING WIND PROFILES

Columns	Format	Quantity	Remarks
1-10	F10.0	FLYTIM	First flight time value (seconds) at which response to wind is desired.
11-20	F10.0	DFLYTM	Incremental flight time (seconds) at which response is desired.
21-30	F10.0	FLYTML	Last flight time (seconds) at which response is desired.
31-40	F10.0	Q	Nominal aerodynamic pressure (Kg/M^2) corresponding to Mach number, velocity, and flight path.
41-50	F10.0	RBASE	Base radius (meters) used in nondimensionalization.
51-60	F10.0	VLENTH	Vehicle length (meters).
61-70	10X		These columns ignored.
71-72	I2	MORETM	If > 0, another card of type 3 is to be read; otherwise control continues according to value of JCODE.
73-74	I2	NSHR	If $\neq 0$, a new wind profile is to be read next and wind shears computed. If $= 0$, previously read data are to be used. The first card 3 must specify NSHR $\neq 0$.
75-76	I2	OP1	If OP1 > 0, optional output of intermediate results from the integration subroutine CONVOL is obtained.

TABLE VIII (Concluded)

Columns	Format	Quantity	Remarks
77-78	I2	OP2	If OP2 > 0, optional print-out of time, t , sin ωt and cos ωt used in CONVOL are obtained.
79-80	I2	KTIME	If ≠ 0, the data read as FLYTIM, DFLYTM, and FLYTML are interpreted as altitudes (in meters) rather than flight times and are converted accordingly. If = 0, the above definitions stand.

TABLE IX

WIND DATA

Card	Columns	Format	Quantity	Remarks
Header	1-7	A4, A3	WORD1, WORD2	Seven characters which user specifies to identify the wind profile.
	8-13	I6	NPRO	Number of altitudes at which wind is given, at 25 meter intervals. (NPRO ≤ 750)
	14-19	I-6	INC	Number of increments per 25 meters to be used in check of wind differentiation. (INC ≤ 10. Does not affect end results.)
Wind cards	1-7	7X		These columns ignored.
	8-13	F6.0	CALT	Altitude (meters) of first wind velocity on this card.
	14	1X		This column ignored.
	15-20	F6.2	WV(J)	Wind velocity (meters/second) at altitude, CALT.
	21-26	F6.2	WV(J+1)	Wind velocity at CALT + 25.
	27-74			Eight more wind velocities at successive altitude intervals, each in format F6.2.

IV. OUTPUT

Each page of the printed output starts with the heading (See Table III, HEADING) and page number. Subroutine LNCNT accounts for a correct tabulation of page numbers which are printed automatically on output pages.

In MAIN1, if Sequence A of the input data is being used, the output is punched on cards for use in future runs. The following quantities are always printed (see Figure 2):

EM - Mach number.

UPSTRM - Speed, upstream velocity (meters/sec).

VZERO - Gust velocity, v_o (nondimensionalized by UPSTRM).

NLAST - Total number of control points (excludes the origin).

I, X(I), R(I) - Number of control point and the coordinates, x and r, at this point (r is the body radius).

RP(I) - Slope at the i^{th} control point.

KTYPE(I) - Type of solution (linear, corner or quadratic used at i^{th} control point).

XI(I) - ξ_i (source location) in meters.

T(I) - Starting times for sources in seconds.

A(I), C(I) - Axial coefficient and cross flow coefficient, respectively, at i^{th} control point.

The output from MAIN2 gives the components of the integrand appearing in the expression for the generalized force coefficient. These quantities are printed as follows (see Figure 3):

X, R - Coordinates, x and r, of computed components (r is the body radius corresponding to the x value, meters).

T - Time in seconds.

UA, VA, UC, VC - Velocity perturbations, equal to $(-\partial\phi a/\partial x)$, $(-\partial\phi a/\partial r)$, $(-\partial\phi c/\partial x)$ and $(-\partial\phi c/\partial r)$, respectively.

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MACH NØ. 2.250, SPEED 768.096, GUST VEL. 0.001, USING 20 CØNTRØL PØINTS

NUMBR	X	R	SLØPE	TYPE	XI	T	A	C
1	0.0000000E-39	0.0000000E-39	1.8999994E-01	0	0.0000000E-39	0.0000000E-39	3.7872447E-02	-1.6315733E-04
2	5.0000000E-02	9.7499900E-03	1.8999994E-01	2	3.0348264E-02	3.9511029E-05	-1.1667089E-01	2.6115279E-04
3	1.0000000E-01	1.8999980E-02	1.7999989E-01	2	6.1704309E-02	8.0334110E-05	6.2680601E-02	-1.8047385E-04
4	1.5000000E-01	2.7749960E-02	1.6999990E-01	2	9.4068159E-02	1.2248927E-04	-1.4751929E-02	7.5438691E-05
5	2.0000000E-01	3.5999940E-02	1.5999997E-01	2	1.2743979E-01	1.6591648E-04	1.2340128E-02	-3.6675500E-05
6	2.5000000E-01	4.3749950E-02	1.4999998E-01	2	1.6181914E-01	2.1067567E-04	2.3114991E-03	7.0888590E-06
7	3.0000000E-01	5.0999930E-02	1.3999999E-01	2	1.9720634E-01	2.5674699E-04	5.3025332E-03	-9.1230980E-06
8	3.5000000E-01	5.7749920E-02	1.3000000E-01	2	2.3360129E-01	3.0413033E-04	3.8838034E-03	-2.8244186E-06
9	4.0000000E-01	6.3999890E-02	1.2000000E-01	2	2.7100407E-01	3.5282577E-04	4.0190548E-03	-4.8552541E-06
10	4.5000000E-01	6.9749890E-02	1.1000001E-01	2	3.0941457E-01	4.0283320E-04	3.6658688E-03	-3.8835689E-06
11	5.0000000E-01	7.4999870E-02	1.0000002E-01	2	3.4883289E-01	4.5415272E-04	3.5157511E-03	-4.0844555E-06
12	5.5000000E-01	7.9749880E-02	9.0000030E-02	2	3.8925894E-01	5.0678422E-04	3.3247137E-03	-3.8911919E-06
13	5.9999900E-01	8.3999810E-02	8.0000040E-02	2	4.3069193E-01	5.6072669E-04	3.1845242E-03	-3.9152940E-06
14	6.4999900E-01	8.7749840E-02	7.0000050E-02	2	4.7313350E-01	6.1598224E-04	3.0421100E-03	-3.9081309E-06
15	6.9999900E-01	9.0999840E-02	6.0000100E-02	2	5.1658291E-01	6.7254991E-04	2.9272148E-03	-3.9903988E-06
16	7.4999900E-01	9.3749820E-02	5.0000110E-02	2	5.6104014E-01	7.3042971E-04	2.8249656E-03	-4.1010027E-06
17	7.9999900E-01	9.5999780E-02	4.0000130E-02	2	6.0650519E-01	7.8962159E-04	2.7362818E-03	-4.2933984E-06
18	8.4999900E-01	9.7749830E-02	3.0000140E-02	2	6.5297785E-01	8.5012531E-04	2.6609114E-03	-4.4869489E-06
19	8.9999900E-01	9.8999860E-02	2.0000150E-02	2	7.0045833E-01	9.1194113E-04	2.5981407E-03	-4.8020525E-06
20	9.4999900E-01	9.9749800E-02	1.0000170E-02	2	7.4894677E-01	9.7506922E-04	2.5457023E-03	-5.2476254E-06
21	1.0000000E 00	1.0000000E-01	0.0000000E-39	2	7.9844347E-01	1.0395100E-03	3.3333333E 32	3.3333333E 32

Figure 2 - Sample Output from MAIN1

X	R	T	UA	VA	UC	VC	(1/L)PHIT	DCNDX	DCNAD(X/D)	DCMDX	DCMAD(X/D)
1.0000	0.10000	0.000900	1.5332E-02	-2.7105E-20	-0.0000E-39	-0.0000E-39	-0.0000E-39	0.0000E-39	0.0000000	0.0000E-39	0.0000E-39
1.0000	0.10000	0.000930	1.5332E-02	-2.7105E-20	2.3244E-06	6.2512E-07	3.3658E-06	2.3724E-05	0.00364445	1.1862E-04	1.8222E-02
1.0000	0.10000	0.000960	1.5332E-02	-2.7105E-20	8.4047E-06	1.1357E-06	1.1793E-05	7.8035E-05	0.01198761	3.9017E-04	5.9938E-02
1.0000	0.10000	0.000990	1.5332E-02	-2.7105E-20	1.6459E-05	4.7044E-07	2.2336E-05	1.3805E-04	0.02120657	6.9023E-04	1.0603E-01
1.0000	0.10000	0.001020	1.5332E-02	-2.7105E-20	2.7384E-05	-1.3694E-06	3.5974E-05	2.0591E-04	0.03163182	1.0296E-03	1.5816E-01
1.0000	0.10000	0.001050	1.5332E-02	-2.7105E-20	4.2539E-05	-4.2225E-06	5.4117E-05	2.8457E-04	0.04371507	1.4228E-03	2.1858E-01
1.0000	0.10000	0.001080	1.5332E-02	-2.7105E-20	6.4000E-05	-7.5424E-06	7.8923E-05	3.7818E-04	0.05809633	1.8909E-03	2.9048E-01
1.0000	0.10000	0.001110	1.5332E-02	-2.7105E-20	9.4943E-05	-9.9069E-06	1.1366E-04	4.9270E-04	0.07568882	2.4635E-03	3.7844E-01
1.0000	0.10000	0.001140	1.5332E-02	-2.7105E-20	1.4008E-04	-7.9910E-06	1.6318E-04	6.3647E-04	0.09777424	3.1824E-03	4.8887E-01
1.0000	0.10000	0.001170	1.5332E-02	-2.7105E-20	2.0576E-04	5.5055E-06	2.3396E-04	8.2022E-04	0.12600205	4.1011E-03	6.3001E-01
1.0000	0.10000	0.001200	1.5332E-02	-2.7105E-20	2.9842E-04	4.5266E-05	3.3256E-04	1.0545E-03	0.16199124	5.2725E-03	8.0996E-01
1.0000	0.10000	0.001230	1.5332E-02	-2.7105E-20	4.1809E-04	1.3651E-04	4.5903E-04	1.3397E-03	0.20580060	6.6984E-03	1.0290E 00
1.0000	0.10000	0.001260	1.5332E-02	-2.7105E-20	5.4433E-04	3.0928E-04	5.9268E-04	1.6450E-03	0.25270925	8.2252E-03	1.2635E 00
1.0000	0.10000	0.001290	1.5332E-02	-2.7105E-20	6.2705E-04	5.6968E-04	6.5269E-04	1.8940E-03	0.29096248	9.4702E-03	1.4548E 00
1.0000	0.10000	0.001320	1.5332E-02	-2.7105E-20	6.1647E-04	8.6540E-04	6.7835E-04	2.0055E-03	0.30808954	1.0028E-02	1.5404E 00
1.0000	0.10000	0.001350	1.5332E-02	-2.7105E-20	5.1829E-04	1.1128E-03	5.8468E-04	1.9736E-03	0.30317630	9.8678E-03	1.5159E 00
1.0000	0.10000	0.001380	1.5332E-02	-2.7105E-20	3.8634E-04	1.2700E-03	4.5558E-04	1.8661E-03	0.28667215	9.3306E-03	1.4334E 00
1.0000	0.10000	0.001410	1.5332E-02	-2.7105E-20	2.6625E-04	1.3495E-03	3.3714E-04	1.7495E-03	0.26876148	8.7476E-03	1.3438E 00
1.0000	0.10000	0.001440	1.5332E-02	-2.7105E-20	1.7407E-04	1.3815E-03	2.4590E-04	1.6535E-03	0.25400484	8.2673E-03	1.2700E 00
1.0000	0.10000	0.001470	1.5332E-02	-2.7105E-20	1.0821E-04	1.3893E-03	1.8060E-04	1.5826E-03	0.24311652	7.9130E-03	1.2156E 00
1.0000	0.10000	0.001500	1.5332E-02	-2.7105E-20	6.2155E-05	1.3862E-03	1.3491E-04	1.5326E-03	0.23543731	7.6630E-03	1.1772E 00
1.0000	0.10000	0.001530	1.5332E-02	-2.7105E-20	2.9833E-05	1.3789E-03	1.0288E-04	1.4981E-03	0.23013447	7.4904E-03	1.1507E 00
1.0000	0.10000	0.001560	1.5332E-02	-2.7105E-20	6.7941E-06	1.3704E-03	8.0095E-05	1.4745E-03	0.22651018	7.3725E-03	1.1326E 00
1.0000	0.10000	0.001590	1.5332E-02	-2.7105E-20	-9.9761E-06	1.3620E-03	6.3575E-05	1.4586E-03	0.22406843	7.2930E-03	1.1203E 00
1.0000	0.10000	0.001620	1.5332E-02	-2.7105E-20	-2.2462E-05	1.3542E-03	5.1345E-05	1.4481E-03	0.22246345	7.2407E-03	1.1123E 00
1.0000	0.10000	0.001650	1.5332E-02	-2.7105E-20	-3.1972E-05	1.3472E-03	4.2101E-05	1.4416E-03	0.22146000	7.2081E-03	1.1073E 00
1.0000	0.10000	0.001680	1.5332E-02	-2.7105E-20	-3.9374E-05	1.3410E-03	3.4975E-05	1.4379E-03	0.22089376	7.1896E-03	1.1045E 00
1.0000	0.10000	0.001710	1.5332E-02	-2.7105E-20	-4.5259E-05	1.3355E-03	2.9378E-05	1.4364E-03	0.22065264	7.1818E-03	1.1033E 00
1.0000	0.10000	0.001740	1.5332E-02	-2.7105E-20	-5.0027E-05	1.3308E-03	2.4908E-05	1.4364E-03	0.22065415	7.1819E-03	1.1033E 00
1.0000	0.10000	0.001770	1.5332E-02	-2.7105E-20	-5.3961E-05	1.3266E-03	2.1279E-05	1.4376E-03	0.22084169	7.1880E-03	1.1042E 00
1.0000	0.10000	0.001800	1.5332E-02	-2.7105E-20	-5.7262E-05	1.3229E-03	1.8292E-05	1.4397E-03	0.22117168	7.1987E-03	1.1059E 00
1.0000	0.10000	0.001830	1.5332E-02	-2.7105E-20	-6.0073E-05	1.3197E-03	1.5799E-05	1.4426E-03	0.22161287	7.2131E-03	1.1081E 00
1.0000	0.10000	0.001860	1.5332E-02	-2.7105E-20	-6.2502E-05	1.3169E-03	1.3693E-05	1.4461E-03	0.22214191	7.2303E-03	1.1107E 00
1.0000	0.10000	0.001890	1.5332E-02	-2.7105E-20	-6.4628E-05	1.3145E-03	1.1895E-05	1.4499E-03	0.22274002	7.2497E-03	1.1137E 00
1.0000	0.10000	0.001920	1.5332E-02	-2.7105E-20	-6.6511E-05	1.3123E-03	1.0342E-05	1.4542E-03	0.22339372	7.2710E-03	1.1170E 00
1.0000	0.10000	0.001950	1.5332E-02	-2.7105E-20	-6.8196E-05	1.3104E-03	8.9894E-06	1.4588E-03	0.22409231	7.2938E-03	1.1205E 00
1.0000	0.10000	0.001980	1.5332E-02	-2.7105E-20	-6.9719E-05	1.3088E-03	7.8000E-06	1.4635E-03	0.22482699	7.3177E-03	1.1241E 00
1.0000	0.10000	0.002010	1.5332E-02	-2.7105E-20	-7.1109E-05	1.3074E-03	6.7458E-06	1.4685E-03	0.22559135	7.3425E-03	1.1280E 00
1.0000	0.10000	0.002040	1.5332E-02	-2.7105E-20	-7.2387E-05	1.3062E-03	5.8041E-06	1.4736E-03	0.22638017	7.3682E-03	1.1319E 00
1.0000	0.10000	0.002070	1.5332E-02	-2.7105E-20	-7.3571E-05	1.3052E-03	4.9568E-06	1.4789E-03	0.22718934	7.3946E-03	1.1359E 00
1.0000	0.10000	0.002100	1.5332E-02	-2.7105E-20	-7.4676E-05	1.3043E-03	4.1895E-06	1.4843E-03	0.22801552	7.4214E-03	1.1401E 00
1.0000	0.10000	0.002130	1.5332E-02	-2.7105E-20	-7.5714E-05	1.3036E-03	3.4904E-06	1.4898E-03	0.22885558	7.4488E-03	1.1443E 00
1.0000	0.10000	0.002160	1.5332E-02	-2.7105E-20	-7.6694E-05	1.3030E-03	2.8487E-06	1.4953E-03	0.22970968	7.4766E-03	1.1485E 00
1.0000	0.10000	0.002190	1.5332E-02	-2.7105E-20	-7.7624E-05	1.3025E-03	2.2580E-06	1.5009E-03	0.23057234	7.5047E-03	1.1529E 00
1.0000	0.10000	0.002220	1.5332E-02	-2.7105E-20	-7.8512E-05	1.3022E-03	1.7094E-06	1.5066E-03	0.23144670	7.5331E-03	1.1572E 00
1.0000	0.10000	0.002250	1.5332E-02	-2.7105E-20	-7.9365E-05	1.3020E-03	1.1975E-06	1.5124E-03	0.23233167	7.5619E-03	1.1617E 00
1.0000	0.10000	0.002280	1.5332E-02	-2.7105E-20	-8.0175E-05	1.3019E-03	7.2442E-07	1.5181E-03	0.23321053	7.5905E-03	1.1661E 00
1.0000	0.10000	0.002310	1.5332E-02	-2.7105E-20	-8.0987E-05	1.3019E-03	2.6303E-07	1.5241E-03	0.23413332	7.6206E-03	1.1707E 00
1.0000	0.10000	0.002340	1.5332E-02	-2.7105E-20	-8.1460E-05	1.3019E-03	0.0000E-39	1.5277E-03	0.23468717	7.6386E-03	1.1734E 00

Figure 3 - Sample Output from MAIN2

(1/U) PHIT - Equals $(1/U)(\partial\phi/\partial t)$.

DCNDX, DCNAD(X/D) - $d(C_N)/d(x)$ and $d(C_{N_\alpha})/d(x/D)$, respectively.

DCMDX, DCMAD(X/D) - $d(C_M)/d(x)$ and $d(C_{M_\alpha})/d(x/D)$, respectively. Moments are nondimensionalized by the base diameter, not the vehicle length.

In MAIN3, the force coefficients and pertinent data are printed as follows (see Figure 4):

K - Aerodynamic type (1 or 2 for instantaneous immersion, 3 or 4 for pure penetration, 5 or 6 for penetration with lift growth).

TIME - Time (seconds).

XSTF, XSTL - Lower and upper limits for the additional steady-state portion of the integrations (meters).

XGUST - Ut, location of gust front (meters).

X2 - Upper limit of transient integrations when K = 5 (meters)

CNA - C_{N_α} , per radian.

CMA - C_{M_α} , per radian.

CENT. PRES. - Location of the center of pressure from nose, in diameters.

In RESINP (deck COMRES) the frequency response data are printed out. Each page contains the new heading read by this routine and a page number. Pagination restarts each time a card of type 2 is read. The other data are as follows (see Figure 5):

IDBODY - The four-character vehicle identification.

EM - Mach number.

UPSTRM - Vehicle speed, meters/sec.

VZERO - Value of VZERO read by this routine, nondimensionalized by UPSTRM.

NTEST - Number of "corners" defining the geometry, read from magnetic tape.

XTEST(I), RTEST (I) - Coordinates, x and r, of the corners.

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K	TIME	XSTF	XSTL	XGUST	X2	CNA	CMA	CENT. PRES.
3	0.000000	0.0000	0.0000	0.0000	1.0000	0.0000000E-39	0.0000000E-39	0.0000
3	0.000015	0.0000	0.0115	0.0115	1.0000	9.4830127E-04	5.4628981E-05	0.0576
3	0.000030	0.0115	0.0230	0.0230	1.0000	3.7932051E-03	3.2777389E-04	0.0864
3	0.000045	0.0230	0.0346	0.0346	1.0000	8.5347114E-03	1.0302473E-03	0.1207
3	0.000060	0.0346	0.0461	0.0461	1.0000	1.5172820E-02	2.3959718E-03	0.1579
3	0.000075	0.0461	0.0576	0.0576	1.0000	2.3794981E-02	4.6463711E-03	0.1953
3	0.000090	0.0576	0.0691	0.0691	1.0000	3.4233773E-02	7.9790235E-03	0.2331
3	0.000105	0.0691	0.0807	0.0807	1.0000	4.6389489E-02	1.2542743E-02	0.2704
3	0.000120	0.0807	0.0922	0.0922	1.0000	6.0175214E-02	1.8521921E-02	0.3078
3	0.000135	0.0922	0.1037	0.1037	1.0000	7.5437766E-02	2.6006515E-02	0.3447
3	0.000150	0.1037	0.1152	0.1152	1.0000	9.2152177E-02	3.5175223E-02	0.3817
3	0.000165	0.1152	0.1267	0.1267	1.0000	1.1035072E-01	4.6198935E-02	0.4187
3	0.000180	0.1267	0.1383	0.1383	1.0000	1.3001796E-01	5.9249167E-02	0.4557
3	0.000195	0.1383	0.1498	0.1498	1.0000	1.5113429E-01	7.4475540E-02	0.4928
3	0.000210	0.1498	0.1613	0.1613	1.0000	1.7351022E-01	9.1895574E-02	0.5296
3	0.000225	0.1613	0.1728	0.1728	1.0000	1.9719341E-01	1.1168820E-01	0.5664
3	0.000240	0.1728	0.1843	0.1843	1.0000	2.2210616E-01	1.3395421E-01	0.6031
3	0.000255	0.1843	0.1959	0.1959	1.0000	2.4822825E-01	1.5880071E-01	0.6397
3	0.000270	0.1959	0.2074	0.2074	1.0000	2.7539023E-01	1.8619124E-01	0.6761
3	0.000285	0.2074	0.2189	0.2189	1.0000	3.0360350E-01	2.1627435E-01	0.7124
3	0.000300	0.2189	0.2304	0.2304	1.0000	3.3236542E-01	2.4915291E-01	0.7485
3	0.000315	0.2304	0.2420	0.2420	1.0000	3.6314174E-01	2.8492207E-01	0.7846
3	0.000330	0.2420	0.2535	0.2535	1.0000	3.9431516E-01	3.2353873E-01	0.8205
3	0.000345	0.2535	0.2650	0.2650	1.0000	4.2634470E-01	3.6506676E-01	0.8563
3	0.000360	0.2650	0.2765	0.2765	1.0000	4.5922964E-01	4.0959471E-01	0.8919
3	0.000375	0.2765	0.2880	0.2880	1.0000	4.9293328E-01	4.5717477E-01	0.9275
3	0.000390	0.2880	0.2996	0.2996	1.0000	5.2742174E-01	5.0784882E-01	0.9629
3	0.000405	0.2996	0.3111	0.3111	1.0000	5.6250478E-01	5.6141523E-01	0.9981
3	0.000420	0.3111	0.3226	0.3226	1.0000	5.9825001E-01	6.1805214E-01	1.0331
3	0.000435	0.3226	0.3341	0.3341	1.0000	6.3463258E-01	6.7779121E-01	1.0680
3	0.000450	0.3341	0.3456	0.3456	1.0000	6.7161954E-01	7.4065580E-01	1.1028
3	0.000465	0.3456	0.3572	0.3572	1.0000	7.0906451E-01	8.0645057E-01	1.1373
3	0.000480	0.3572	0.3687	0.3687	1.0000	7.4697438E-01	8.7524964E-01	1.1717
3	0.000495	0.3687	0.3802	0.3802	1.0000	7.8534530E-01	9.4709223E-01	1.2060
3	0.000510	0.3802	0.3917	0.3917	1.0000	8.2414444E-01	1.0219744E 00	1.2400
3	0.000525	0.3917	0.4033	0.4033	1.0000	8.6325938E-01	1.0997152E 00	1.2739
3	0.000540	0.4033	0.4148	0.4148	1.0000	9.0265643E-01	1.1802887E 00	1.3076
3	0.000555	0.4148	0.4263	0.4263	1.0000	9.4234441E-01	1.2637424E 00	1.3411
3	0.000570	0.4263	0.4378	0.4378	1.0000	9.8229547E-01	1.3500511E 00	1.3744
3	0.000585	0.4378	0.4493	0.4493	1.0000	1.0224828E 00	1.4391848E 00	1.4075
3	0.000600	0.4493	0.4609	0.4609	1.0000	1.0627314E 00	1.5307717E 00	1.4404
3	0.000615	0.4609	0.4724	0.4724	1.0000	1.1031058E 00	1.6249705E 00	1.4731
3	0.000630	0.4724	0.4839	0.4839	1.0000	1.1435866E 00	1.7217488E 00	1.5056
3	0.000645	0.4839	0.4954	0.4954	1.0000	1.1841460E 00	1.8210514E 00	1.5379
3	0.000660	0.4954	0.5069	0.5069	1.0000	1.2246519E 00	1.9225551E 00	1.5699
3	0.000675	0.5069	0.5185	0.5185	1.0000	1.2651135E 00	2.0262787E 00	1.6017
3	0.000690	0.5185	0.5300	0.5300	1.0000	1.3055318E 00	2.1322198E 00	1.6332
3	0.000705	0.5300	0.5415	0.5415	1.0000	1.3458804E 00	2.2403020E 00	1.6646
3	0.000720	0.5415	0.5530	0.5530	1.0000	1.3860610E 00	2.3502475E 00	1.6956
3	0.000735	0.5530	0.5646	0.5646	1.0000	1.4260446E 00	2.4619571E 00	1.7264
3	0.000750	0.5646	0.5761	0.5761	1.0000	1.4658424E 00	2.5754404E 00	1.7570

Figure 4 - Sample Output from MAIN3

VEHICLE TYPE - SAT5, MACH NØ. 1.300, SPEED 395.382, GUST VEL. 0.003,
NØ. ØF CØRNERS 9, VALUES BELØW ARE LØCATED AT THE CØRNERS PLUS THE END ØF THE VEHICLE

X	R
1.239	0.332
9.414	0.332
11.915	1.956
16.415	1.956
24.949	3.299
37.955	3.299
43.734	5.029
98.519	5.029
106.484	10.684

L Ø C A L R E S P Ø N S E S

STEADY STATE CNA = 1.471048E 00
STEADY STATE CMA = 1.742792E 00

AERØDYNAMIC TYPE = 5
STATIØN (X) = 11.916

				C N A		C N A		C M A		C M A	
ØMEGA	K	(K/2PI)	VBAR	IN PHASE CØMPØNENT	ØUT PHASE CØMPØNENT	MAGNITUDE	ANGLE (DEG.)	IN PHASE CØMPØNENT	ØUT PHASE CØMPØNENT	MAGNITUDE	ANGLE (DEG.)
0.00	0.0000	0.0000	1.00	3.720570E-03	0.000000E-39	3.720570E-03	0.00	4.407865E-03	0.000000E-39	4.407865E-03	0.00
1.00	0.2693	0.0429	1.00	3.718215E-03	1.316750E-04	3.720546E-03	2.03	4.405075E-03	1.559991E-04	4.407837E-03	2.03
2.00	0.5386	0.0857	1.00	3.711154E-03	2.631796E-04	3.720474E-03	4.06	4.396710E-03	3.117964E-04	4.407752E-03	4.06
3.00	0.8080	0.1286	1.00	3.699396E-03	3.943438E-04	3.720354E-03	6.08	4.382780E-03	4.671904E-04	4.407610E-03	6.08
4.00	1.0773	0.1715	1.00	3.682956E-03	5.249978E-04	3.720187E-03	8.11	4.363303E-03	6.219800E-04	4.407411E-03	8.11
5.00	1.3466	0.2143	1.00	3.661857E-03	6.549728E-04	3.719971E-03	10.14	4.338307E-03	7.759650E-04	4.407156E-03	10.14
6.00	1.6159	0.2572	1.00	3.636126E-03	7.841007E-04	3.719708E-03	12.17	4.307823E-03	9.289466E-04	4.406845E-03	12.17
7.00	1.8852	0.3001	1.00	3.605798E-03	9.122148E-04	3.719398E-03	14.20	4.271892E-03	1.080727E-03	4.406477E-03	14.20
8.00	2.1546	0.3429	1.00	3.570913E-03	1.039150E-03	3.719039E-03	16.23	4.230563E-03	1.231110E-03	4.406052E-03	16.23
9.00	2.4239	0.3858	1.00	3.531518E-03	1.164741E-03	3.718634E-03	18.25	4.183890E-03	1.379902E-03	4.405572E-03	18.25
10.00	2.6932	0.4286	1.00	3.487663E-03	1.288828E-03	3.718181E-03	20.28	4.131934E-03	1.526911E-03	4.405036E-03	20.28
11.00	2.9625	0.4715	1.00	3.439409E-03	1.411250E-03	3.717682E-03	22.31	4.074766E-03	1.671948E-03	4.404444E-03	22.31
12.00	3.2318	0.5144	1.00	3.386817E-03	1.531849E-03	3.717135E-03	24.34	4.012459E-03	1.814825E-03	4.403796E-03	24.34
13.00	3.5011	0.5572	1.00	3.329959E-03	1.650471E-03	3.716542E-03	26.36	3.945098E-03	1.955360E-03	4.403093E-03	26.36
14.00	3.7705	0.6001	1.00	3.268910E-03	1.766963E-03	3.715902E-03	28.39	3.872771E-03	2.093371E-03	4.402335E-03	28.39
15.00	4.0398	0.6430	1.00	3.203749E-03	1.881176E-03	3.715216E-03	30.42	3.795573E-03	2.228683E-03	4.401522E-03	30.42
16.00	4.3091	0.6858	1.00	3.134563E-03	1.992963E-03	3.714483E-03	32.45	3.713607E-03	2.361120E-03	4.400655E-03	32.45
17.00	4.5784	0.7287	1.00	3.061444E-03	2.102182E-03	3.713705E-03	34.48	3.626980E-03	2.490515E-03	4.399733E-03	34.48
18.00	4.8477	0.7716	1.00	2.984487E-03	2.208692E-03	3.712881E-03	36.50	3.535807E-03	2.616701E-03	4.398756E-03	36.50
19.00	5.1171	0.8144	1.00	2.903795E-03	2.312358E-03	3.712011E-03	38.53	3.440209E-03	2.739517E-03	4.397726E-03	38.53
20.00	5.3864	0.8573	1.00	2.819473E-03	2.413049E-03	3.711096E-03	40.56	3.340310E-03	2.858808E-03	4.396641E-03	40.56
21.00	5.6557	0.9001	1.00	2.731632E-03	2.510635E-03	3.710135E-03	42.59	3.236242E-03	2.974421E-03	4.395503E-03	42.59
22.00	5.9250	0.9430	1.00	2.640387E-03	2.604994E-03	3.709129E-03	44.61	3.128142E-03	3.086211E-03	4.394311E-03	44.61
23.00	6.1943	0.9859	1.00	2.545859E-03	2.696005E-03	3.708078E-03	46.64	3.016152E-03	3.194034E-03	4.393066E-03	46.64
24.00	6.4637	1.0287	1.00	2.448172E-03	2.783554E-03	3.706982E-03	48.67	2.900419E-03	3.297756E-03	4.391768E-03	48.67
25.00	6.7330	1.0716	1.00	2.347452E-03	2.867530E-03	3.705841E-03	50.70	2.781094E-03	3.397244E-03	4.390416E-03	50.70
26.00	7.0023	1.1145	1.00	2.243833E-03	2.947827E-03	3.704656E-03	52.72	2.658334E-03	3.492375E-03	4.389012E-03	52.72
27.00	7.2716	1.1573	1.00	2.137450E-03	3.024346E-03	3.703426E-03	54.75	2.532298E-03	3.583029E-03	4.387554E-03	54.75

SATURN WITH FINS AND SHRØUDS WING-BØDY M 1.3 PAGE 2

L Ø C A L R E S P Ø N S E S

STEADY STATE CNA = 1.471048E 00
STEADY STATE CMA = 1.742792E 00

AERØDYNAMIC TYPE = 5
STATIØN (X) = 11.916

				CNA		CNA		CMA		CMA	
ØMEGA	K	(K/2PI)	VBAR	IN PHASE CØMPØNENT	ØUT PHASE CØMPØNENT	MAGNITUDE	ANGLE (DEG.)	IN PHASE CØMPØNENT	ØUT PHASE CØMPØNENT	MAGNITUDE	ANGLE (DEG.)
28.00	7.5409	1.2002	1.00	2.028442E-03	3.096990E-03	3.702151E-03	56.78	2.403153E-03	3.669092E-03	4.386044E-03	56.78
29.00	7.8103	1.2431	1.00	1.916950E-03	3.165668E-03	3.700831E-03	58.80	2.271066E-03	3.750457E-03	4.384480E-03	58.80
30.00	8.0796	1.2859	1.00	1.803122E-03	3.230296E-03	3.699467E-03	60.83	2.136210E-03	3.827023E-03	4.382864E-03	60.83
31.00	8.3489	1.3288	1.00	1.687104E-03	3.290793E-03	3.698058E-03	62.86	1.998760E-03	3.898696E-03	4.381196E-03	62.86
32.00	8.6182	1.3716	1.00	1.569049E-03	3.347085E-03	3.696605E-03	64.88	1.858897E-03	3.965387E-03	4.379474E-03	64.88
33.00	8.8875	1.4145	1.00	1.449110E-03	3.399103E-03	3.695107E-03	66.91	1.716802E-03	4.027014E-03	4.377699E-03	66.91
34.00	9.1568	1.4574	1.00	1.327443E-03	3.446783E-03	3.693565E-03	68.94	1.572660E-03	4.083503E-03	4.375872E-03	68.94
35.00	9.4262	1.5002	1.00	1.204206E-03	3.490069E-03	3.691977E-03	70.96	1.426658E-03	4.134785E-03	4.373991E-03	70.96
36.00	9.6955	1.5431	1.00	1.079560E-03	3.528908E-03	3.690345E-03	72.99	1.278986E-03	4.180799E-03	4.372057E-03	72.99
37.00	9.9648	1.5860	1.00	9.536668E-04	3.563255E-03	3.688668E-03	75.02	1.129836E-03	4.221490E-03	4.370070E-03	75.02
38.00	10.2341	1.6288	1.00	8.266890E-04	3.593070E-03	3.686945E-03	77.04	9.794020E-04	4.256813E-03	4.368029E-03	77.04
39.00	10.5034	1.6717	1.00	6.987917E-04	3.618318E-03	3.685178E-03	79.07	8.278785E-04	4.286725E-03	4.365935E-03	79.07
40.00	10.7728	1.7145	1.00	5.701406E-04	3.638972E-03	3.683365E-03	81.10	6.754619E-04	4.311194E-03	4.363788E-03	81.10
41.00	11.0421	1.7574	1.00	4.409025E-04	3.655010E-03	3.681506E-03	83.12	5.223498E-04	4.330194E-03	4.361586E-03	83.12
42.00	11.3114	1.8003	1.00	3.112445E-04	3.666415E-03	3.679602E-03	85.15	3.687403E-04	4.343707E-03	4.359330E-03	85.15
43.00	11.5807	1.8431	1.00	1.813344E-04	3.673180E-03	3.677653E-03	87.17	2.148320E-04	4.351721E-03	4.357020E-03	87.17
44.00	11.8500	1.8860	1.00	5.133996E-05	3.675299E-03	3.675657E-03	89.20	6.082392E-05	4.354231E-03	4.354656E-03	89.20
45.00	12.1194	1.9289	1.00	-7.857093E-05	3.672775E-03	3.673616E-03	91.23	-9.308522E-05	4.351242E-03	4.352237E-03	91.23
46.00	12.3887	1.9717	1.00	-2.082307E-04	3.665618E-03	3.671528E-03	93.25	-2.466969E-04	4.342763E-03	4.349764E-03	93.25
47.00	12.6580	2.0146	1.00	-3.374723E-04	3.653842E-03	3.669394E-03	95.28	-3.998131E-04	4.328811E-03	4.347236E-03	95.28
48.00	12.9273	2.0575	1.00	-4.661294E-04	3.637469E-03	3.667213E-03	97.30	-5.522369E-04	4.309413E-03	4.344652E-03	97.30
49.00	13.1966	2.1003	1.00	-5.940367E-04	3.616524E-03	3.664987E-03	99.33	-7.037722E-04	4.284600E-03	4.342014E-03	99.33
50.00	13.4660	2.1432	1.00	-7.210298E-04	3.591042E-03	3.662713E-03	101.35	-8.542246E-04	4.254410E-03	4.339321E-03	101.35
51.00	13.7353	2.1860	1.00	-8.469460E-04	3.561062E-03	3.660394E-03	103.38	-1.003401E-03	4.218892E-03	4.336573E-03	103.38
52.00	14.0046	2.2289	1.00	-9.716243E-04	3.526629E-03	3.658027E-03	105.40	-1.151111E-03	4.178098E-03	4.333769E-03	105.40
53.00	14.2739	2.2718	1.00	-1.094905E-03	3.487793E-03	3.655614E-03	107.43	-1.297166E-03	4.132088E-03	4.330911E-03	107.43
54.00	14.5432	2.3146	1.00	-1.216632E-03	3.444612E-03	3.653155E-03	109.45	-1.441378E-03	4.080930E-03	4.327997E-03	109.45
55.00	14.8125	2.3575	1.00	-1.336649E-03	3.397148E-03	3.650650E-03	111.48	-1.583566E-03	4.024698E-03	4.325029E-03	111.48
56.00	15.0819	2.4004	1.00	-1.454804E-03	3.345469E-03	3.648098E-03	113.50	-1.723548E-03	3.963472E-03	4.322006E-03	113.50
57.00	15.3512	2.4432	1.00	-1.570949E-03	3.289649E-03	3.645500E-03	115.53	-1.861148E-03	3.897341E-03	4.318928E-03	115.53
58.00	15.6205	2.4861	1.00	-1.684935E-03	3.229767E-03	3.642856E-03	117.55	-1.996191E-03	3.826397E-03	4.315795E-03	117.55
59.00	15.8898	2.5290	1.00	-1.796620E-03	3.165907E-03	3.640166E-03	119.57	-2.128507E-03	3.750741E-03	4.312609E-03	119.57
60.00	16.1591	2.5718	1.00	-1.905864E-03	3.098159E-03	3.637431E-03	121.60	-2.257931E-03	3.670478E-03	4.309369E-03	121.60
61.00	16.4285	2.6147	1.00	-2.012529E-03	3.026618E-03	3.634652E-03	123.62	-2.384301E-03	3.585721E-03	4.306076E-03	123.62
62.00	16.6978	2.6575	1.00	-2.116484E-03	2.951383E-03	3.631827E-03	125.64	-2.507459E-03	3.496588E-03	4.302729E-03	125.64
63.00	16.9671	2.7004	1.00	-2.217599E-03	2.872558E-03	3.628958E-03	127.67	-2.627253E-03	3.403202E-03	4.299330E-03	127.67
64.00	17.2364	2.7433	1.00	-2.315750E-03	2.790252E-03	3.626045E-03	129.69	-2.743535E-03	3.305691E-03	4.295879E-03	129.69
65.00	17.5057	2.7861	1.00	-2.410816E-03	2.704577E-03	3.623089E-03	131.71	-2.856163E-03	3.204190E-03	4.292377E-03	131.71
66.00	17.7751	2.8290	1.00	-2.502681E-03	2.615652E-03	3.620090E-03	133.74	-2.964998E-03	3.098838E-03	4.288824E-03	133.74
67.00	18.0444	2.8719	1.00	-2.591234E-03	2.523598E-03	3.617049E-03	135.76	-3.069909E-03	2.989778E-03	4.285221E-03	135.76
68.00	18.3137	2.9147	1.00	-2.676368E-03	2.428539E-03	3.613966E-03	137.78	-3.170770E-03	2.877159E-03	4.281568E-03	137.78
69.00	18.5830	2.9576	1.00	-2.757981E-03	2.330605E-03	3.610841E-03	139.80	-3.267459E-03	2.761134E-03	4.277867E-03	139.80
70.00	18.8523	3.0005	1.00	-2.835976E-03	2.229927E-03	3.607677E-03	141.82	-3.359862E-03	2.641858E-03	4.274118E-03	141.82
71.00	19.1217	3.0433	1.00	-2.910261E-03	2.126641E-03	3.604473E-03	143.84	-3.447870E-03	2.519493E-03	4.270322E-03	143.84
72.00	19.3910	3.0862	1.00	-2.980750E-03	2.020887E-03	3.601230E-03	145.86	-3.531380E-03	2.394202E-03	4.266480E-03	145.86

Figure 5 - Sample Output from RESINP

Subheading - "LOCAL RESPONSES" or "TOTAL RESPONSES."

FSTEDY(1), FSTEDY(2) - Nondimensional steady-state values of C_{N_α} and C_{M_α} (if "TOTAL") or of $dC_{N_\alpha}/d(x/D)$ and $dC_{M_\alpha}/d(x/D)$ (if "LOCAL").

KK - Aerodynamic type 3 (quasi-steady theory) or 5 (full indicial theory). Ignore if "LOCAL."

XF - Station location, meters. (Ignore if "TOTAL.")

OMEGA - ω , the wind frequency (radians/sec). The wind is assumed to be of the form $v = \bar{v} \cos \omega t$.

K - The reduced frequency, $k = \omega L/U$.

K/2PI - The Strouhal number, $S = k/2\pi = fL/U$.

VBAR - The half amplitude, $\bar{v}$, of the wind (meters/sec).

The frequency response data, per se, are tabulated by frequency. Both the normal force and the moment are given, in units defined below. For each, the response is written in the form

$$R = R_i \cos \omega t + R_o \sin \omega t \ .$$

The in and out of phase components, R_i and R_o are given, as well as the magnitude $R = \sqrt{R_i^2 + R_o^2}$ and the phase angle $\theta = \tan^{-1}(R_o/R_i)$. The latter is given as an angle (in degrees) between -180° and +180°.

The units are as follows:

Normal force (total) - C_N , the normal force coefficient corresponding to the cross flow velocity, $\bar{v}$. To obtain dimensional units, multiply by Q (dynamic pressure, Kg/M^2) and A (base area, M^2).

Moment (total) - C_M , the pitching moment coefficient about the vehicle nose. To obtain dimensional units, multiply by Q , A , and D (the base diameter).

Normal force (local) - $dC_N/d(x/D)$, the local normal force coefficient per caliber.

Moment (local) - $dC_M/d(x/D)$, the local pitching moment coefficient per caliber, measured about the nose.

Program III generates printed output of wind responses. In the case of sinusoidal winds, the output is as just described and indicated by Figure 5. For arbitrary wind data, two types of output occur. The wind responses are tabulated in a fashion similar to that of sinusoidal responses; an example is shown in Figure 6. Again, each page carries a heading and page number. The wind input data and related quantities are printed as shown in Figure 7. The wind response data are described below:

IDBODY - The four-character vehicle identification.

EM - Mach number.

UPSTRM - Vehicle speed, meters/sec.

VZERO - Value of VZERO read by this routine, nondimensionalized by UPSTRM.

NTEST - Number of "corners" defining the geometry, read from magnetic tape.

XTEST(I), RTEST(I) - Coordinates, x and r , of the corners.

Subheading - "LOCAL RESPONSES" or "TOTAL RESPONSES."

FSTEDY(1), FSTEDY(2) - Nondimensional steady-state values of C_{N_α} and C_{M_α} (if "TOTAL") or of $dC_{N_\alpha}/d(x/D)$ and $dC_{M_\alpha}/d(x/D)$ (if "LOCAL").

KK - Aerodynamic type 3 (quasi-steady theory) or 5 (full indicial theory). Ignore if "LOCAL."

XF - Station location, meters. (Ignore if "TOTAL.")

WORD1, WORD2 - The wind profile identification (up to 7 characters)

ALTUDE - The altitude, in meters, at which the response occurs.

FLYTIM - The flight time, in seconds, at which the response occurs.

CINP(1) - The dimensional normal force (local or total) in units of Kg per caliber (local) or Kg (total).

WIND RESPØNSE FØR SATURN V WITH FINS AND SHRØUDS M = 1.6 PAGE 1

VEHICLE TYPE - SAT5, MACH NØ. 1.60C, SPEED 469.629, GUST VEL. 0.002,
NØ. ØF CØRNERS 9, VALUES BELØW ARE LØCATED AT THE CØRNERS PLUS THE END ØF THE VEHICLE

X	R
1.239	0.332
9.414	0.332
11.915	1.956
16.415	1.956
24.949	3.299
37.955	3.299
43.734	5.029
98.519	5.029
106.484	9.649

L Ø C A L R E S P Ø N S E S

STEADY STATE CNA = 6.341C91E-01
STEADY STATE CMA = 1.393489F 00

AERØDYNAMIC TYPE = 5
STATIØN (X) = 22.103

R E S P Ø N S E S T Ø W I N D P R Ø F I L E, I D E N T I F I C A T I Ø N . . . 2579
(I N M - K - S S Y S T E M Ø F U N I T S)

ALTITUDE	FLIGHT TIME	NØRMAL FØRCE	PITCHING MØMENT	ALT(LØW LIM)
12050.00	80.8730	1.428054E 04	3.156427E C5	12003.92
12060.00	80.9002	1.428546E 04	3.157516E 05	12013.90
12070.00	80.9273	1.429384E 04	3.159368E 05	12023.87
12080.00	80.9545	1.429786E 04	3.160255E 05	12033.85
12090.00	80.9817	1.431134E 04	3.163236E C5	12043.83
12100.00	81.0088	1.433265E 04	3.167946E 05	12053.81
12110.00	81.0360	1.437339E 04	3.176949E 05	12063.79
12120.00	81.0631	1.439685E 04	3.182136E 05	12073.76
12130.00	81.0902	1.440332E 04	3.183566E 05	12083.74
12140.00	81.1173	1.441541E 04	3.186238E 05	12093.72
12150.00	81.1444	1.443044E 04	3.189560E 05	12103.70
12160.00	81.1714	1.443963E 04	3.191591E 05	12113.68
12170.00	81.1985	1.447319F 04	3.199009E 05	12123.66
12180.00	81.2255	1.453710E 04	3.213136E 05	12133.63
12190.00	81.2526	1.459733E 04	3.226448E 05	12143.61
12200.00	81.2796	1.465786E 04	3.239826E 05	12153.59
12210.00	81.3066	1.471304E 04	3.252024E 05	12163.57
12220.00	81.3336	1.477851E 04	3.266495E 05	12173.55
12230.00	81.3606	1.486348E 04	3.285275E 05	12183.52
12240.00	81.3875	1.4935C0E 04	3.301083E 05	12193.50
12250.00	81.4145	1.499684E 04	3.314753E 05	12203.48
12260.00	81.4414	1.5C6488E 04	3.329791F 05	12213.46
12270.00	81.4684	1.508534E 04	3.334313E 05	12223.44
12280.00	81.4953	1.504992E 04	3.326483E 05	12233.42
12290.00	81.5222	1.501284E 04	3.318287E 05	12243.39
12300.00	81.5491	1.496788E 04	3.308351E 05	12253.37
12310.00	81.5760	1.491147E 04	3.295883E 05	12263.35
12320.00	81.6029	1.485946F 04	3.284386E 05	12273.33

Figure 6 - Sample Wind Response Output

WINDS AND WIND SHEARS FØR WIND PRØFILE NUMBER 2579

ALTITUDE	WIND	SHEAR AT ALT + 12.50	INTEGRATED SHEARS AT 6.25 METER INTERVALS, WITH LAST ONE AT ALTITUDE			
525.00	8.90					
550.00	8.67	-0.02680				
575.00	8.00	-0.01640	8.00,			
600.00	7.59	-0.01640	7.87,	7.76,	7.66,	7.56,
625.00	7.18	-0.02080	7.45,	7.35,	7.25,	7.13,
650.00	6.66	-0.01280	7.01,	6.89,	6.76,	6.65,
675.00	6.34	-0.00080	6.55,	6.47,	6.40,	6.34,
700.00	6.32	0.01000	6.31,	6.30,	6.30,	6.32,
725.00	6.57	0.00280	6.36,	6.41,	6.47,	6.51,
750.00	6.64	-0.00840	6.55,	6.57,	6.58,	6.57,
775.00	6.43	0.00680	6.55,	6.50,	6.46,	6.44,
800.00	6.60	0.00760	6.45,	6.48,	6.53,	6.57,
825.00	6.79	-0.00920	6.62,	6.66,	6.70,	6.70,
850.00	6.56	0.03240	6.69,	6.64,	6.62,	6.66,
875.00	7.37	0.01520	6.76,	6.93,	7.12,	7.28,
900.00	7.75	-0.00360	7.42,	7.53,	7.61,	7.66,
925.00	7.66	0.02480	7.68,	7.67,	7.67,	7.72,
950.00	8.28	-0.01360	7.80,	7.94,	8.06,	8.13,
975.00	7.94	-0.01440	8.13,	8.08,	7.99,	7.90,
1000.00	7.58	-0.01280	7.82,	7.73,	7.64,	7.55,
1025.00	7.26	-0.00680	7.47,	7.39,	7.31,	7.25,
1050.00	7.09	0.00720	7.19,	7.14,	7.11,	7.10,
1075.00	7.27	-0.03400	7.11,	7.15,	7.16,	7.11,
1100.00	6.42	0.01760	6.99,	6.81,	6.64,	6.55,
1125.00	6.86	-0.00960	6.54,	6.61,	6.70,	6.74,
1150.00	6.62	-0.02960	6.75,	6.71,	6.63,	6.52,
1175.00	5.88	0.00200	6.39,	6.22,	6.06,	5.95,
1200.00	5.93	-0.02400	5.88,	5.87,	5.86,	5.82,
1225.00	5.33	0.02760	5.73,	5.60,	5.49,	5.46,
1250.00	6.02	-0.00880	5.51,	5.64,	5.79,	5.87,
1275.00	5.80	-0.02080	5.90,	5.88,	5.81,	5.73,
1300.00	5.28	0.02160	5.63,	5.51,	5.41,	5.38,
1325.00	5.82	-0.00560	5.42,	5.52,	5.63,	5.70,
1350.00	5.68	0.01880	5.73,	5.72,	5.70,	5.72,
1375.00	6.15	0.00920	5.78,	5.88,	5.99,	6.09,
1400.00	6.38	-0.03720	6.17,	6.23,	6.25,	6.20,
1425.00	5.45	0.00600	6.08,	5.88,	5.68,	5.55,
1450.00	5.60	-0.00400	5.49,	5.49,	5.52,	5.54,
1475.00	5.50	0.00120	5.53,	5.52,	5.50,	5.48,
1500.00	5.53	0.04200	5.48,	5.48,	5.52,	5.62,
1525.00	6.58	-0.03120	5.79,	6.02,	6.23,	6.32,
1550.00	5.80	-0.04080	6.30,	6.16,	5.95,	5.74,
1575.00	4.78	0.01000	5.50,	5.26,	5.04,	4.91,
1600.00	5.03	-0.00480	4.85,	4.87,	4.92,	4.95,
1625.00	4.91	0.01240	4.96,	4.94,	4.92,	4.93,
1650.00	5.22	0.00480	4.97,	5.03,	5.10,	5.16,
1675.00	5.34	-0.03560	5.21,	5.25,	5.25,	5.18,
1700.00	4.45	0.00200	5.05,	4.86,	4.67,	4.53,
1725.00	4.50	-0.01640	4.46,	4.44,	4.44,	4.41,
1750.00	4.09	-0.00080	4.35,	4.26,	4.17,	4.11,
1775.00	4.07	0.01240	4.06,	4.05,	4.05,	4.08,
1800.00	4.38	-0.02160	4.13,	4.19,	4.24,	4.24,
1825.00	3.84	0.00640	4.19,	4.08,	3.96,	3.89,
1850.00	4.00	-0.01080	3.87,	3.89,	3.91,	3.91,
1875.00	3.73	0.01520	3.89,	3.83,	3.79,	3.78,
1900.00	4.11	0.01680	3.81,	3.89,	3.98,	4.08,
1925.00	4.53	-0.03000	4.18,	4.29,	4.36,	4.35,
1950.00	3.78	0.02000	4.27,	4.12,	3.97,	3.90,
1975.00	4.28	0.01640	3.91,	4.00,	4.12,	4.24,

Figure 7 - Sample Wind Data Output

CINP(2) - The dimensional pitching moment (local or total) about the nose, in Kg - meters per caliber (local) or Kg - meters (total).

ALTSTR - The lower limit of altitude (meters) in the Duhamel integration, determined by the time interval required to reach steady state.

The wind and wind-shear data (Figure 7) are as follows:

WRD1, WRD2 - The wind profile identification (up to 7 characters)

ALTITUDE - The altitude (meters).

WIND - The horizontal wind velocity (meters/sec) at this altitude.

SHEAR - The computed wind shear at the midpoint between two altitudes (1/sec); specifically, at given altitude plus 12.5 meters.

VEL(I) - The wind velocity (meters/sec) obtained by integration of wind shear. This is done as a check, with printout at interval specified as input data, INC. (See Section III-C.) The last value is at given altitude, and does not necessarily agree with the original data.

V. PROGRAM DESCRIPTIONS

COMTAR - This is the mainline routine of Program I, and it calls MAIN1, MAIN2, MAIN3, or RESINP if numbers 1, 2, 3, or 4 are read in.

MAIN1 - A subroutine containing the master input routine. This program must be called at least once before MAIN2 and MAIN3 are called. The coefficients, A and C, are computed at all of the control points and punched along with other pertinent data on cards for use in future runs.

The routine can solve, iteratively, for an "equivalent body shape" as described in reference 3. Two nonlinear algebraic equations are solved simultaneously by a two-stage process. First, a search for a sign change is carried out, beginning at the previous radius and working outward (+ and -) from there. A Newton-Rapheson interation is employed after a sign change is located. Extra printed output is produced during the iterative procedure. Some problems of poor convergence have occurred, especially when a "large" equivalent body is generated.[4]

MAIN2 - Computes local forces for a sequence of x and/or t values. Causes a tape to be created, as specified by data cards.

MAIN3 - Computes total normal force and pitching moment for a sequence of values of time. Either the full indicial theory or the quasi-steady approximation may be selected. Output may be both printed and written on magnetic tape.

BINTAP - A short routine which does the actual tape writing of all but the first record of data.

INTGRL - Performs numerical integrations to compute total normal force and pitching moment, as directed by MAIN3. Integrations may be either transient or steady-state. Technique used is a combination of the trapazoidal and Simpson's method, with a "look ahead" feature to determine which method will be used.

UANDV - The steady-state velocity components at a point on the surface are computed by this subroutine. These components are calculated using a linear type solution, a corner solution or a quadratic type solution.2/

UTANVT - The transient velocity components at a point on the surface are computed by this subroutine. An additional component, the reciprocal of the upstream velocity times the partial derivative of ϕ with respect to t is also calculated. As in UANDV, these components are computed using a linear type solution, a corner solution or a quadratic type solution.

POINTS - The values of x at which the m^{th} circle intersects the body surface are computed by this subroutine. m is the source number.

LNCNT - A running count of lines and pages is provided by this subroutine which is called prior to each write statement in the program. The subroutine also allows for a heading consisting of a maximum of 72 characters and the page number to be printed on each page.

COMELL - A subroutine which computes the values for an argument, m, of the complete elliptic integrals of the first and second kinds $K(m)$ and $E(m)$, respectively. Hastings' approximations are used; namely,

$$K(m) = \sum_{i=0}^{4} a_i(m_1)^i - \ln(m_1) \sum_{i=0}^{4} b_i(m_1)^i \qquad (1)$$

$$E(m) = 1.0 + \sum_{i=1}^{4} c_i(m_1)^i - \ln(m_1) \sum_{i=1}^{4} d_i(m_1)^i \qquad (2)$$

where $m_1 = 1 - m$

$a_o = 1.38629\ 436$	$b_o = 0.5$
$a_1 = 0.09666\ 34426$	$b_1 = 0.12498\ 5936$
$a_2 = 0.03590\ 09238$	$b_2 = 0.06880\ 24858$
$a_3 = 0.03742\ 56371$	$b_3 = 0.03328\ 35535$
$a_4 = 0.01451\ 19621$	$b_4 = 0.00441\ 787012$
$c_1 = 0.44325\ 1415$	$d_1 = 0.24998\ 3683$
$c_2 = 0.06260\ 60122$	$d_2 = 0.09200\ 18004$
$c_3 = 0.04757\ 38355$	$d_3 = 0.04069\ 69753$
$c_4 = 0.01736\ 50645$	$d_4 = 0.00526\ 449639$

INCELL - The incomplete elliptic integrals of the first and second kinds, $F(m,\varphi)$ and $E(m,\varphi)$, for the input values of $\sin\ \varphi$ and m are computed by this subroutine. Landen's transformations for m small and for m close to one are used. These expressions for m small; i.e., $(m)^{1/2}$ less than 0.5, are as follows:

$$F(m,\varphi) = \lim_{n\to\infty} (1 + K_1)(1 + K_2)\ldots.(1 + K_n) \frac{\Phi_n}{2^n} \qquad (3)$$

$$E(m,\varphi) = F(m,\varphi) \left[1 - \frac{m}{2}\left(1 + \frac{1}{2} K_1 + \frac{1}{2^2} K_1K_2 + \frac{1}{2^3} K_1K_2K_3\ldots.\right)\right]$$

$$+ \sqrt{m}\left[\frac{1}{2}\sqrt{K_1}\ \sin\ \Phi_1 + \frac{1}{2^2}\sqrt{K_1K_2}\ \sin\ \Phi_2 + \frac{1}{2^3}\sqrt{K_1K_2K_3}\ \sin\ \Phi_3\ldots.\right] \qquad (4)$$

where $K_o = m^{1/2}$

$$K_n = \frac{1 - \left[1 - K_{n-1}^2\right]^{1/2}}{1 + \left[1 - K_{n-1}^2\right]^{1/2}}$$

$$\Phi_o = \varphi$$

$$\tan\left(\Phi_n - \Phi_{n-1}\right) = \left[1 - K_{n-1}^2\right]^{1/2} \tan \Phi_{n-1} \quad . \tag{5}$$

In this instance, Φ_n itself does not approach a limit as n approaches infinity. In fact, Φ_1 is approximately twice Φ_o, etc. This leads to computational difficulties. Therefore, a quantity, $x_n = \Phi_n/2^n$, was used in the iteration scheme. This quantity was determined in the following manner. From Eq. (5) one may write

$$\Phi_n = \Phi_{n-1} + \tan^{-1}\left[\sqrt{1 - K_{n-1}^2}\,\tan \Phi_{n-1}\right] \quad . \tag{6}$$

Let

$$x_n = \frac{\Phi_n}{2^n}$$

and define

$$x_{n-1}(1 - \epsilon) = \frac{1}{2^{n-1}} \tan^{-1}\left[\sqrt{1 - K_{n-1}^2}\,\tan\left(2^{n-1} x_{n-1}\right)\right]$$

Then,

$$(\epsilon\Phi_{n-1}) = \tan^{-1}\left\{\frac{\left(1 - \sqrt{1 - K_{n-1}^2}\right)\tan \Phi_{n-1}}{1 + \sqrt{1 - K_{n-1}^2}\,\tan^2 \Phi_{n-1}}\right\}$$

and

$$x_n = x_{n-1} - \frac{(\epsilon\Phi_{n-1})}{2^n} \tag{7}$$

The sequence of x_n's converges nicely. When K_n is approximately zero, using the final value of x_n one may compute $F(m,\varphi)$. Likewise, $E(m,\varphi)$ may be calculated since the sum of the products, $\left\{\frac{1}{2^n} K_1 K_2 \cdots K_n \sin \Phi_n\right\}$, has been stored. For m close to one the expressions using Landen's transformations are

$$F(m,\varphi) = \left[(K_1 K_2 K_3 \cdots K_{n-1})/m^{1/2}\right]^{1/2} \log_e \tan(\pi/4 + \Phi/2) \tag{8}$$

$$E(m,\varphi) = F(m,\varphi)\left[1 + m^{1/2}\left(1 + \frac{2}{K_1} + \frac{2^2}{K_1 K_2} + \cdots + \frac{2^{n-1}}{K_1 K_2 \cdots K_{n-1}} - \frac{2^n}{K_1 K_2 \cdots K_{n-1}}\right)\right]$$

$$-m^{1/2}\left[\sin\varphi + \frac{2 \sin \Phi_1}{\sqrt{K_0}} + \frac{2^2 \sin \Phi_2}{\sqrt{K_0 K_1}} + \cdots + \frac{2^{n-1} \sin \Phi_{n-1}}{\sqrt{K_0 K_1 \cdots K_{n-2}}} - \frac{2^n \sin \Phi_n}{\sqrt{K_0 K_1 \cdots K_{n-1}}}\right] \tag{9}$$

where $$K_0 = m^{1/2}$$

$$K_n = \frac{2\sqrt{K_{n-1}}}{1 + K_{n-1}}$$

$$\Phi_0 = \varphi$$

$$\sin(2\Phi_n - \Phi_{n-1}) = K_{n-1} \sin \Phi_{n-1} \tag{10}$$

$$\lim_{n\to\infty} \Phi_n = \Phi \quad .$$

In this section of the subroutine $\varphi > \Phi_1 > \Phi_2 \ldots$ and $\varphi \le \pi/2$; therefore, Φ_n is always in the first quadrant. From the above expressions for $F(m,\varphi)$ and $E(m,\varphi)$, it is obvious that only $\sin \Phi_n$ must be iterated. This is calculated from

$$\sin \Phi_n = \left\{\frac{1}{2}\left(1 + K_{n-1} \sin^2 \Phi_{n-1}\right) - \frac{1}{2}\left[(1 - \sin^2 \Phi_{n-1})(1 - K_{n-1}^2 \sin^2 \Phi_{n-1})\right]^{1/2}\right\}^{1/2} \quad . \tag{11}$$

Here K_n approaches one; i.e., $K_n' = (1 - K_n^2)^{1/2}$ approaches zero. When the desired accuracy is reached for $K_n' \sim 0.0$, the quantities $F(m,\varphi)$ and $E(m,\varphi)$ are computed.

ARCOSH - A function routine which computes the inverse hyperbolic cosine using the log and square root library subroutines. If the argument, x , is less than one, a message is printed and the ERROR subroutine is called.

ERROR - This subroutine prints a message that the ERROR routine has been called, provides a dump of COMMON and an error trace. Then the job is ended. The error trace is part of the IBSYS software, and may operate differently on a different machine.

RESINP (deck COMRES) - Computes frequency responses corresponding to total and local forces. This routine reads data, prints output, and controls the integration routine, DUHINT.

FINTAP - Locates a specified set of indicial responses on magnetic tape. Job is ended if the specified set is not located.

DUHINT - Integrates the indicial responses to find the in- and out-of-phase responses to a sinusoidal wind. Both the force and moment are integrated using the Duhamel convolution approach. The interval size is controlled by the indicial response data on tape. Simpson's rule is used when the indicial response is known at three equally spaced intervals; otherwise the trapezoidal method is used.

QUATAN - Evaluates the arc tan function, correctly specifying the angle between $-\pi$ and π.

TAPRES - This is the mainline routine of Program II. It calls MAIN1, MAIN2, or MAIN3 if numbers 1, 2, or 3 are read in.

RESINP - This is the mainline routine of Program III. It is an expanded version of subroutine RESINP (deck COMRES). In addition to enabling the computation of frequency response data, it allows responses to arbitrary wind profiles to be calculated.

The altitude-flight time relationship is assumed to be of the form

$$h = a + bt + ct^2 .$$

The present version of the program sets

$$a = 3279.122 ,$$

$$b = -150.6733 ,$$

$$c = 3.20411 ,$$

which were obtained by a curve fit to the nominal trajectory for AS504.[6] These constants can be readily modified by changing cards RESP1102, RESP1104, and RESP1106, together with three like cards in DWVDT.

SHEARS - Reads and stores wind profile data; computes wind shears (see reference 4 for method) and provides the integral of the computed shears as a check on the method.

CONVOL - A slight modification of subroutine DUHINT, which allows wind data, as well as a sinusoid, to be used in the Duhamel convolution technique.

DWVDT - Computes the time derivative of the wind, by interpolation of tabulated wind shears and utilizing time-altitude transformation. Also, obtains the wind velocity at any desired altitude by a combination of table look-up (to nearest 25 meter level) and integration of wind shears.

VI. OPERATING INSTRUCTIONS

The programs are all written in FORTRAN IV and have been run under IBSYS on the IBM 7094-II. Double precision arithmetic has been used to a great extent. Other than tape assignments, etc., the only known aspect which may require modification on another machine is the "error trace" generated by the system upon an (implicit) call by subroutine ERROR. However, it is not unlikely that other minor changes may be required to satisfy certain other compilers and/or operating systems.

The list of program decks was given in Table I. Figures 8, 9, and 10 show the linkages between subroutines for Programs I, II, and III, respectively.

The tape usage includes two special tapes in addition to the normal system input/output. The complete tape utilization is shown in Table X, as set up for use at the NASA-MSFC Computation Center. All tapes are at 800 bpi density.

Time estimates are best made for each of the major subroutines, separately. Even here, though, such estimates will be quite approximate. Many alternate paths exist in the programs, and it is not generally practical to try to predict in detail the number of times each path will be chosen. It can be said that the time required is approximately proportional to the product of the number of time values and the number of x values for which output is requested. Also, the time is roughly proportional to the square of the number of control points selected.

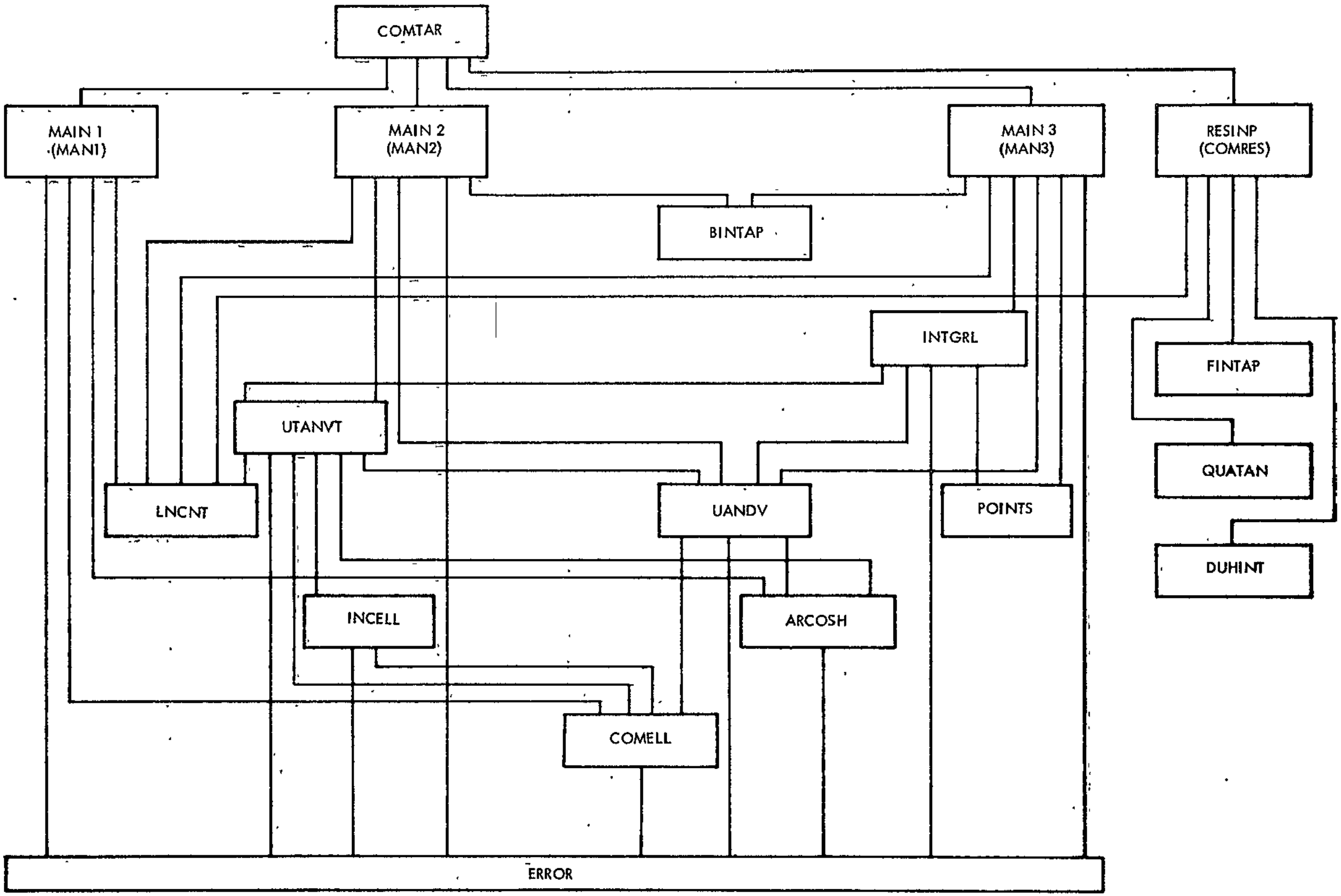

Figure 8 - Subroutine Linkage - Program 1

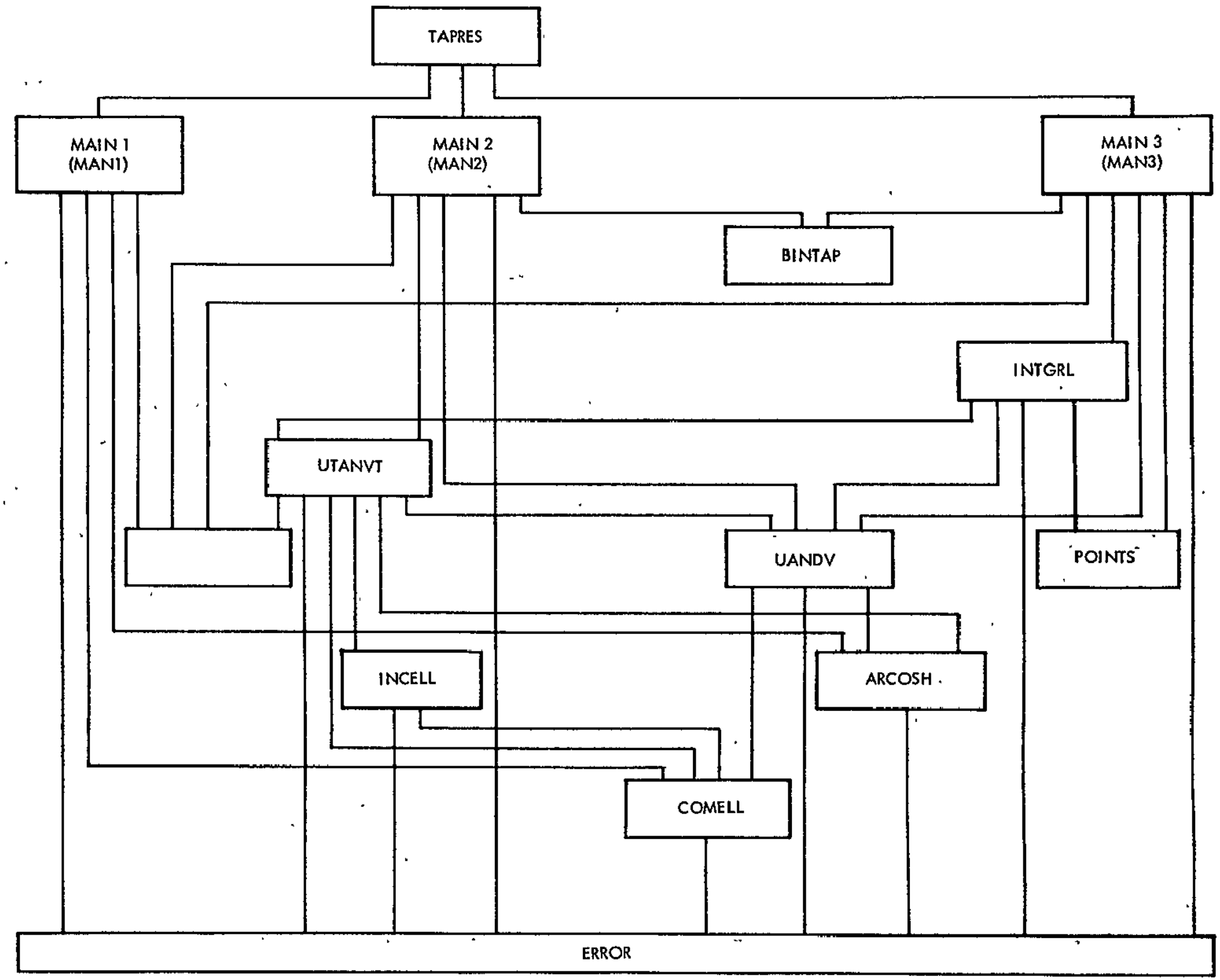

Figure 9 - Subroutine Linkage - Program II

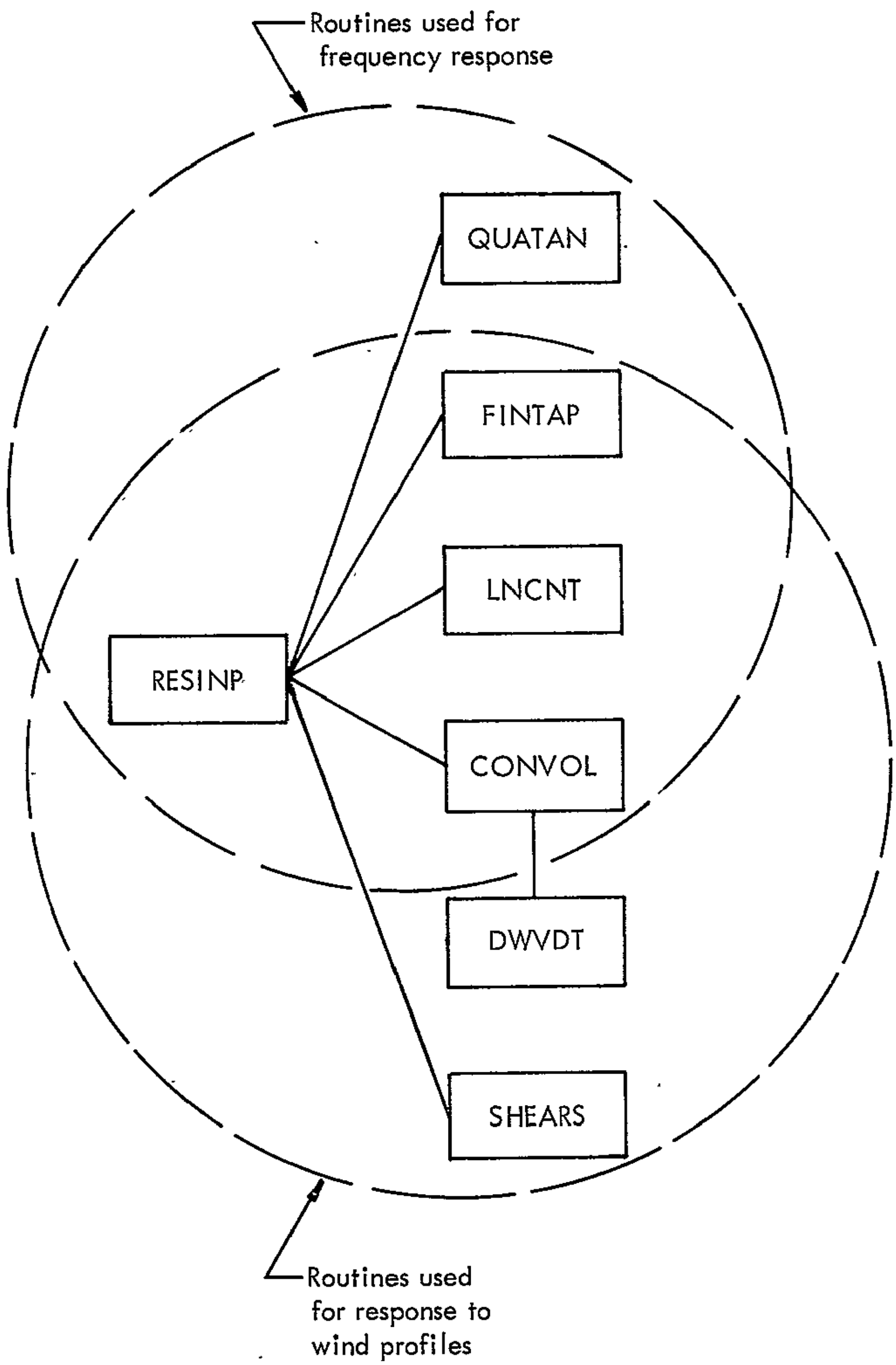

Figure 10 - Subroutine Linkage - Program III

TABLE X

MAGNETIC TAPE UTILIZATION

Logical Unit	FORTRAN Unit	Mode	Use
A2	5	BCD	System input.
B1	6	BCD	System output.
B2	7	BCD	System punch. (Written by subroutine MAIN1 only.)
A5	8	Binary	Local normal forces. Written by MAIN2, read by RESINP.
B6	11	Binary	Total normal forces. Written by MAIN3, read by RESINP.

To assist the user in making time estimates, the following sample values are given:

1. Subroutine MAIN1, data Sequence A, 60 control points, requires less than 1 min. Using data Sequence B, the time is usually negligible.

2. Subroutine MAIN2, 110 control points, 13 time values, 270 x values, requires about 8 min.

3. Subroutine MAIN3, with KK = 5 requires about 3 min. to compute forces for 500 values of t using 20 control points. The time is reduced greatly (say, 70 percent) with KK = 3.

4. A complete run consisting of (a) 35 control points, data Sequence A for MAIN1; (b) 350 x values and 10 t values for MAIN2; (c) 200 values of t for MAIN3 with KK = 3 requires about 3 min. The majority of this time is for MAIN2.

5. For a series of ogive shapes, runs consisted of (a) data Sequence A for MAIN1, (b) local indicial response at one station at 90 t values, (c) total indicial responses for KK = 3 and 5 with 90 t values, and (d) frequency responses at the one station as well as for the entire vehicle (both KK values) at 120 frequencies. The number of control points, N, varied. The total computer time for each ogive was found to be satisfactorily fitted by $t = 0.7 + 0.0018N^2$ min.

6. For a series of wind response calculations of the Saturn V, where the number of time intervals in the indicial responses averaged 160, the computer time per response was approximately 0.005 min. This value was obtained for both the sinusoidal responses and the arbitrary wind responses.

REFERENCES

1. Glauz, W. D., and G. Coombs, "User's Manual for the Indicial Aerodynamics Computer Program," Contract No. NAS8-11012, MRI Project No. 2715-P, September 1965.

2. Glauz, W. D., "Study for the Indicial Load Effects on Multistage Space Vehicle Systems," Final Report, 20 September 1964 - 20 September 1965, Contract No. NAS8-11012, MRI Project No. 2715-P.

3. Glauz, W. D., and R. R. Blackburn, "Study for the Indicial Load Effects on Multistage Space Vehicle Systems," Final Report, 20 September 1965 20 December 1966, Contract No. NAS8-11012, MRI Project No. 2715-P.

4. Glauz, W. D., and R. R. Blackburn, "Study of Indicial Aerodynamic Forces on Multistage Space Vehicle Systems," Volume I: "Application of Theory to Basic Geometries and to the Saturn V," Final Report, 28 June 1967 - 27 September 1968, Contract No. NAS8-21167, MRI Project No. 3089-P.

5. Scoggins, J. R., and M. Susko, "FPS-16 Radar/Jimsphere Wind Data Measured at the Eastern Test Range," NASA TMX-53290, 9 July 1965.

6. Taken from data furnished by Richard Beranek, NASA-MSFC, Aero-Astrodynamics Laboratory.

APPENDIX I

FLOW DIAGRAMS, FIGURES 11-19

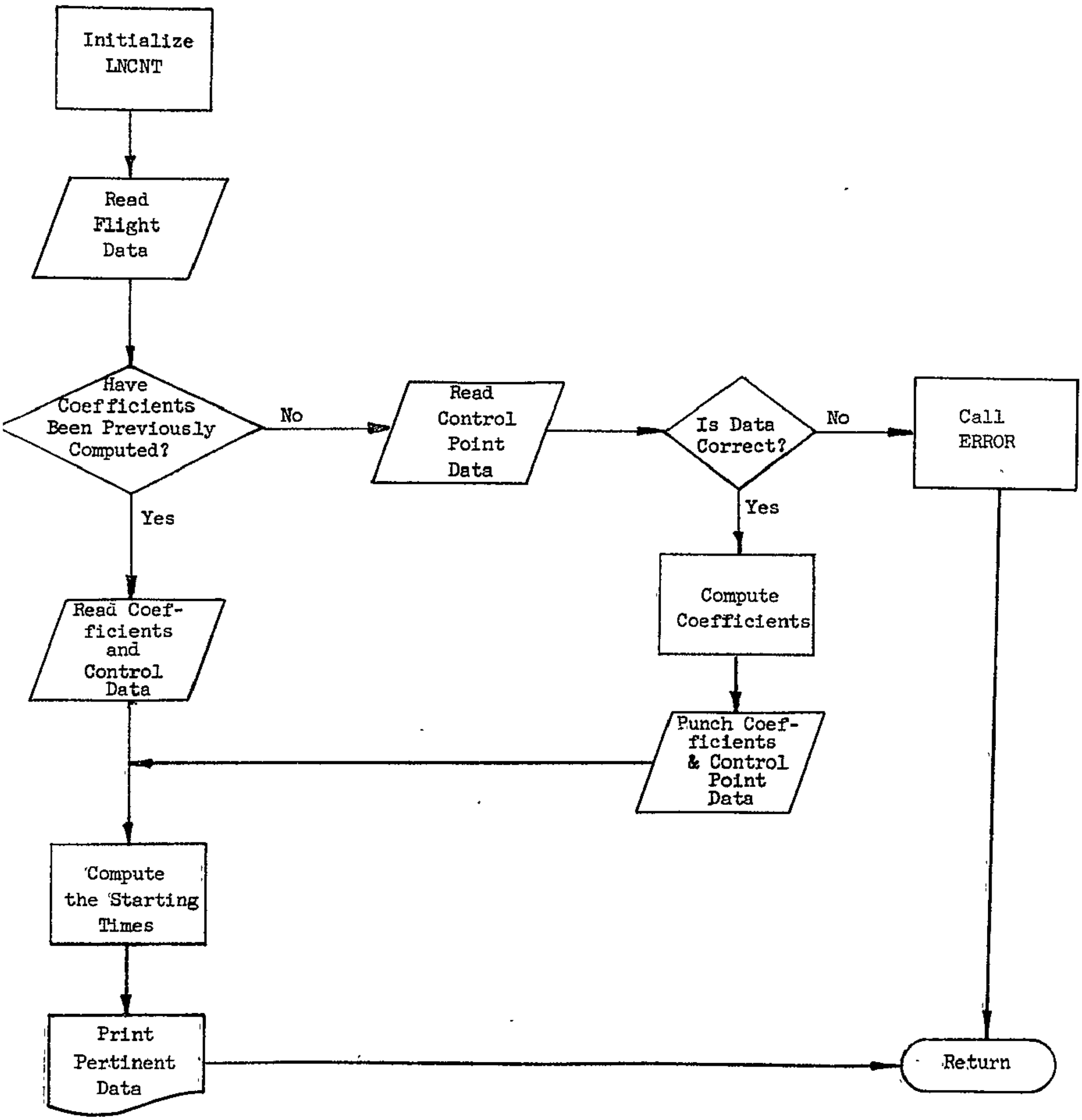

Figure 11 - Flow Diagram for Subroutine MAIN1

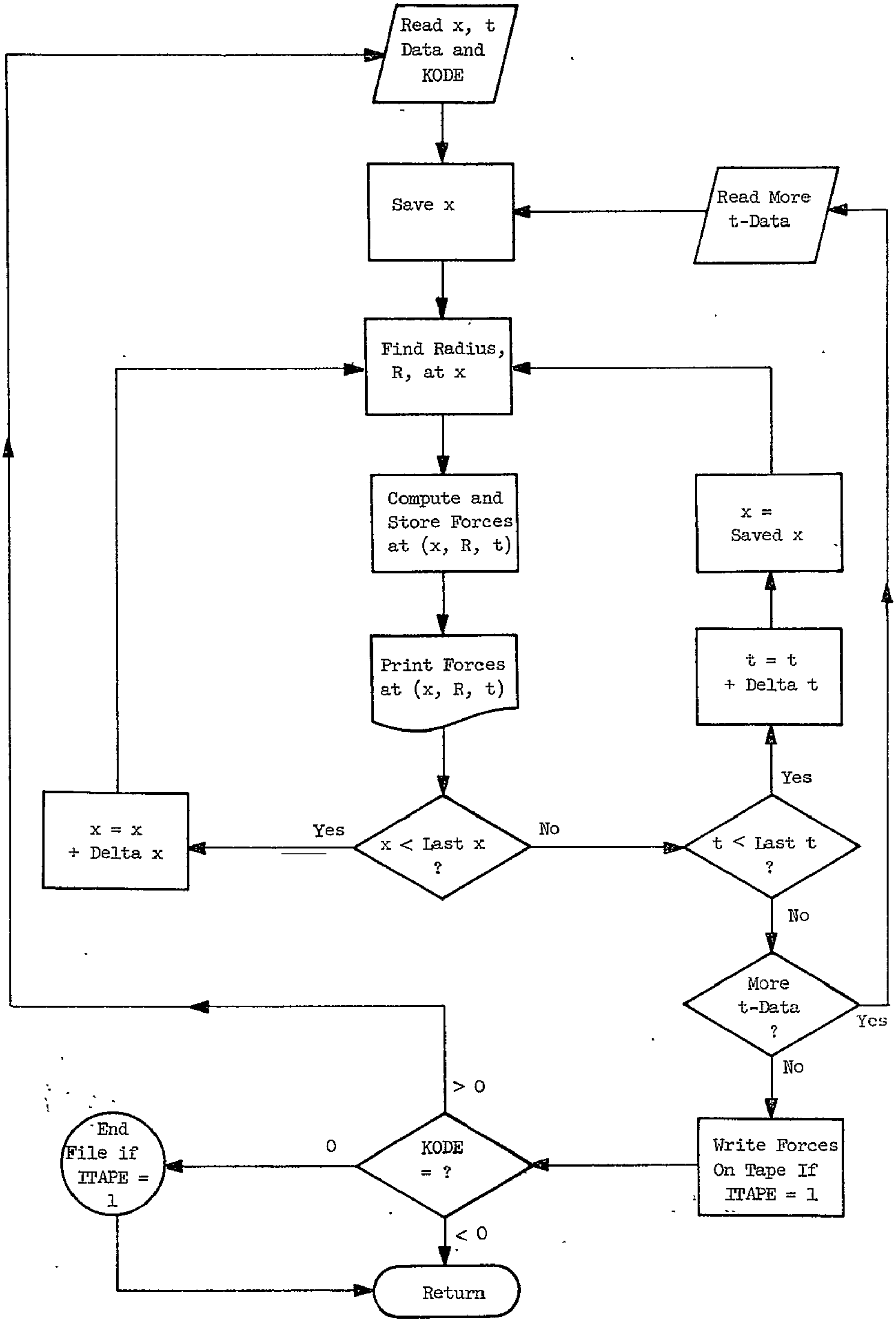

Figure 12 - Flow Diagram for Subroutine MAIN2

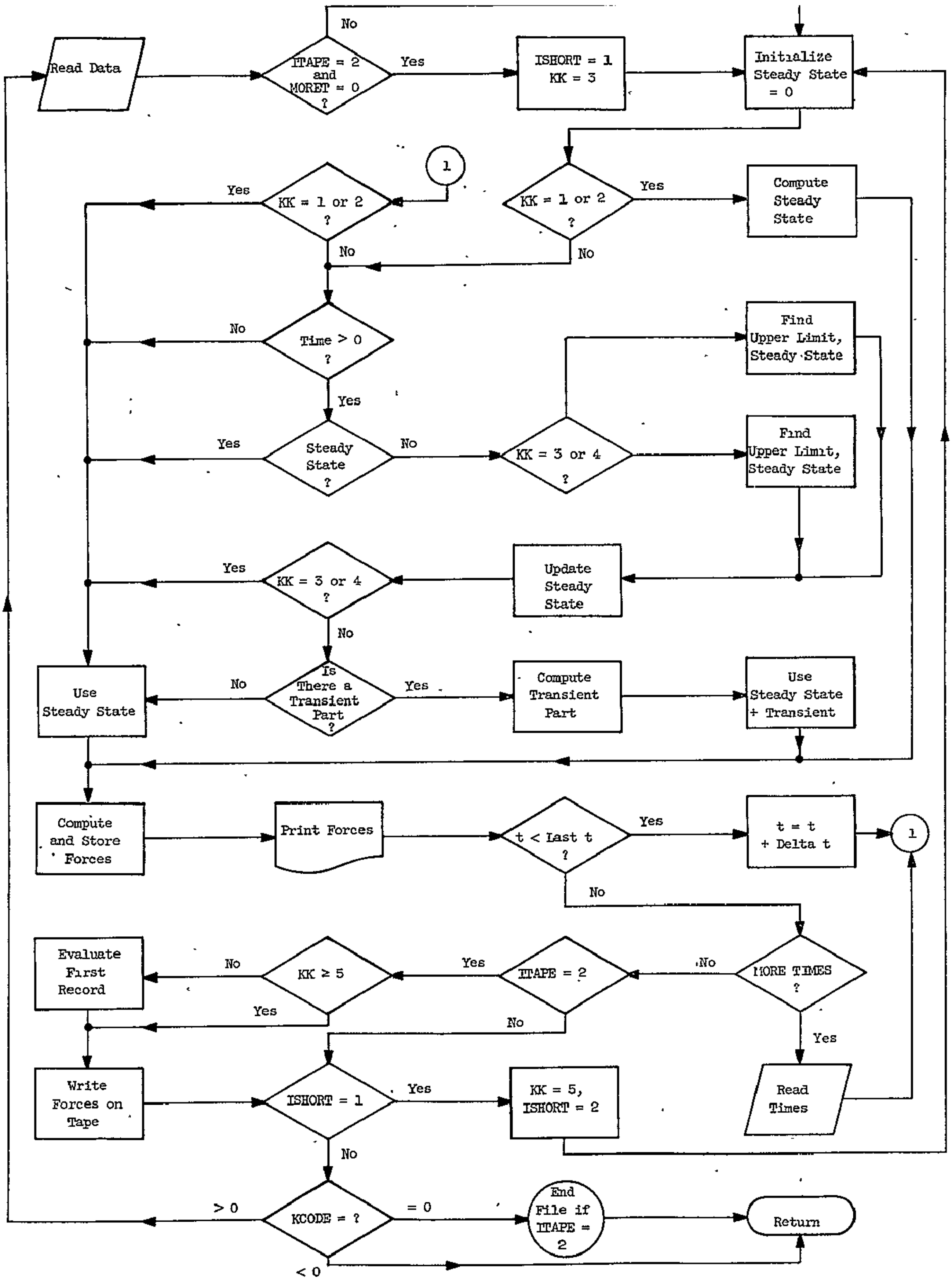

Figure 13 - Flow Diagram for Subroutine MAIN3

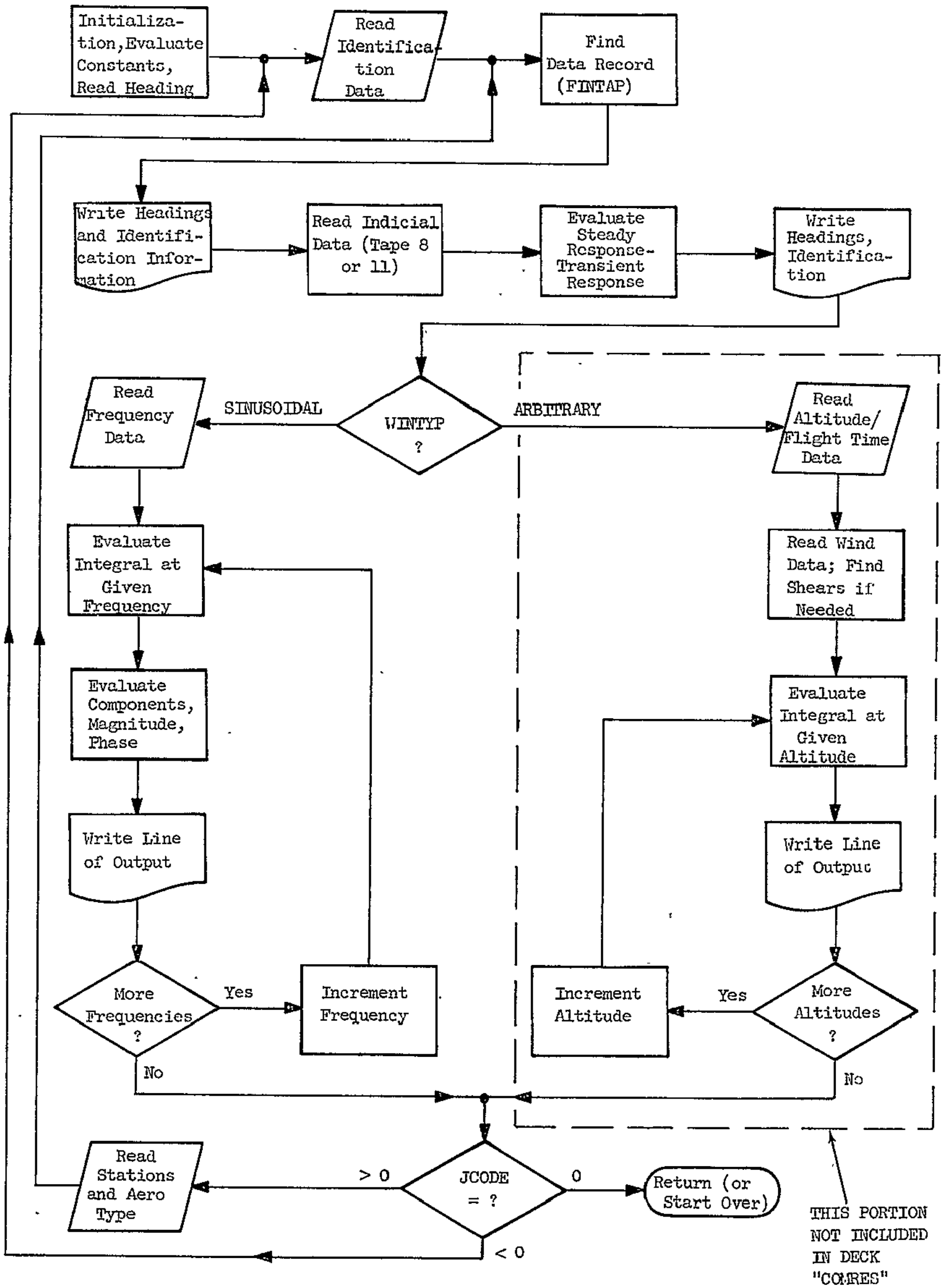

Figure 14 - Flow Diagram for Subroutine RESINP

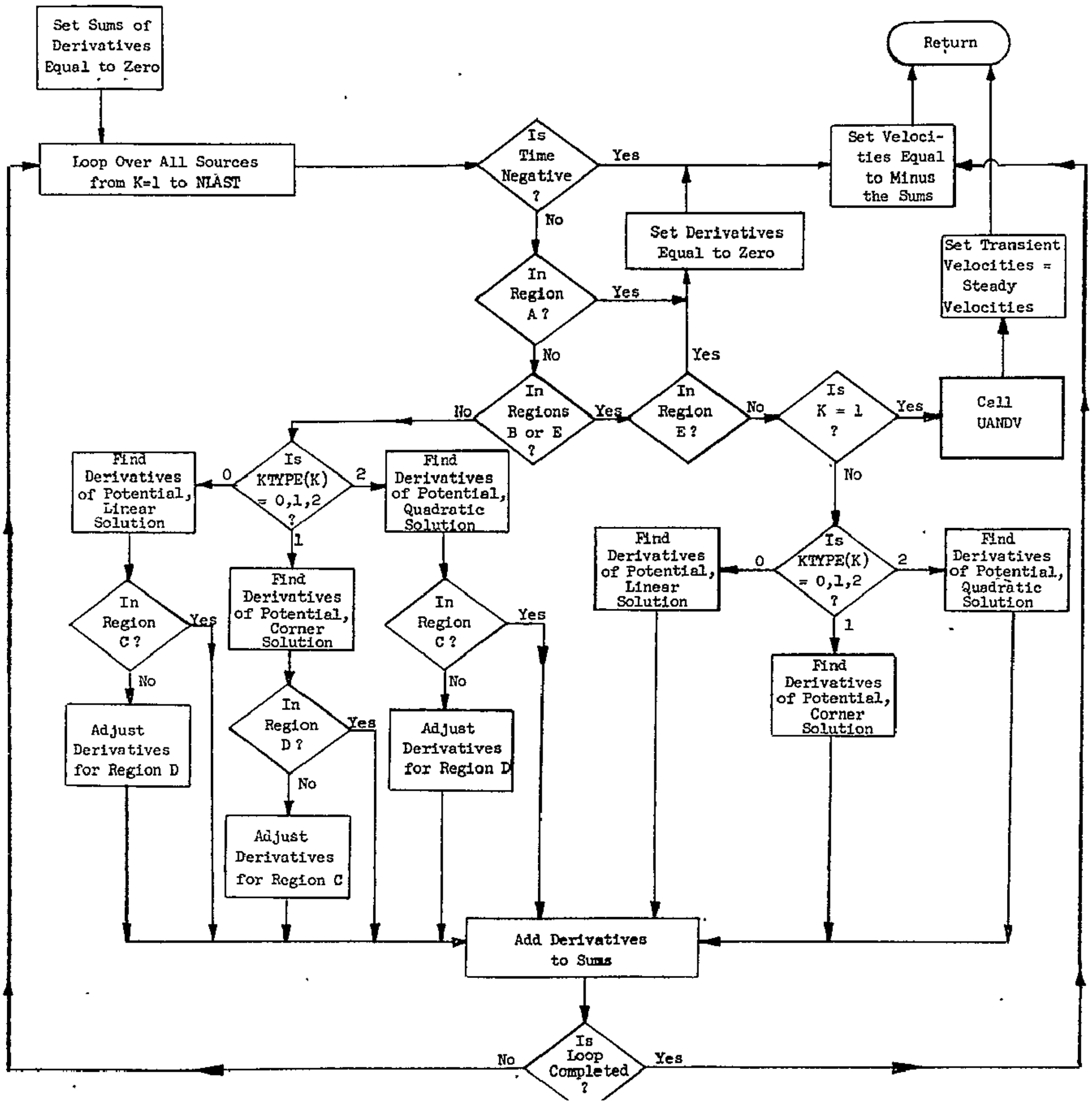

Figure 15 - Flow Diagram for Subroutine UTANVT

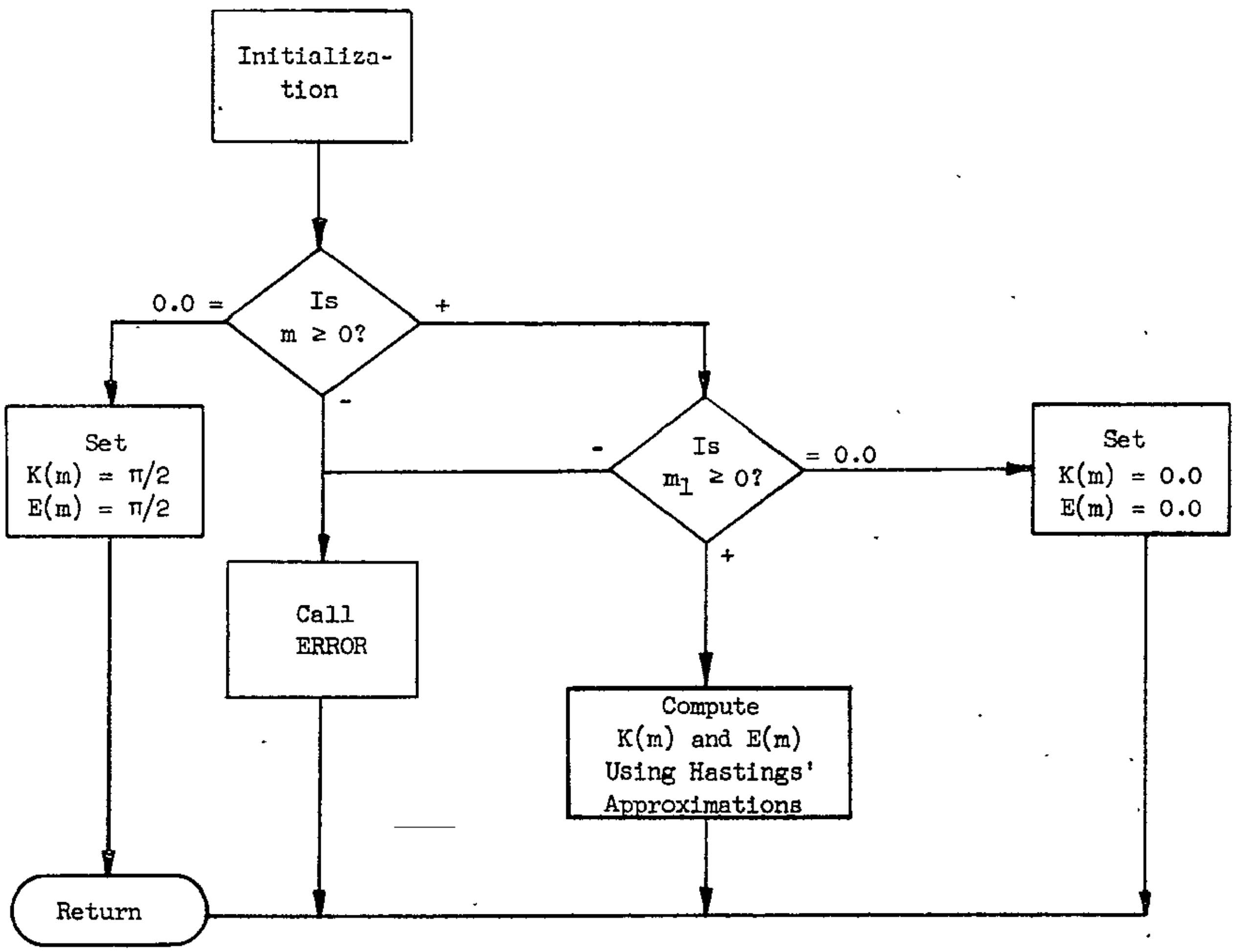

Figure 16 - Flow Diagram for Subroutine COMELL

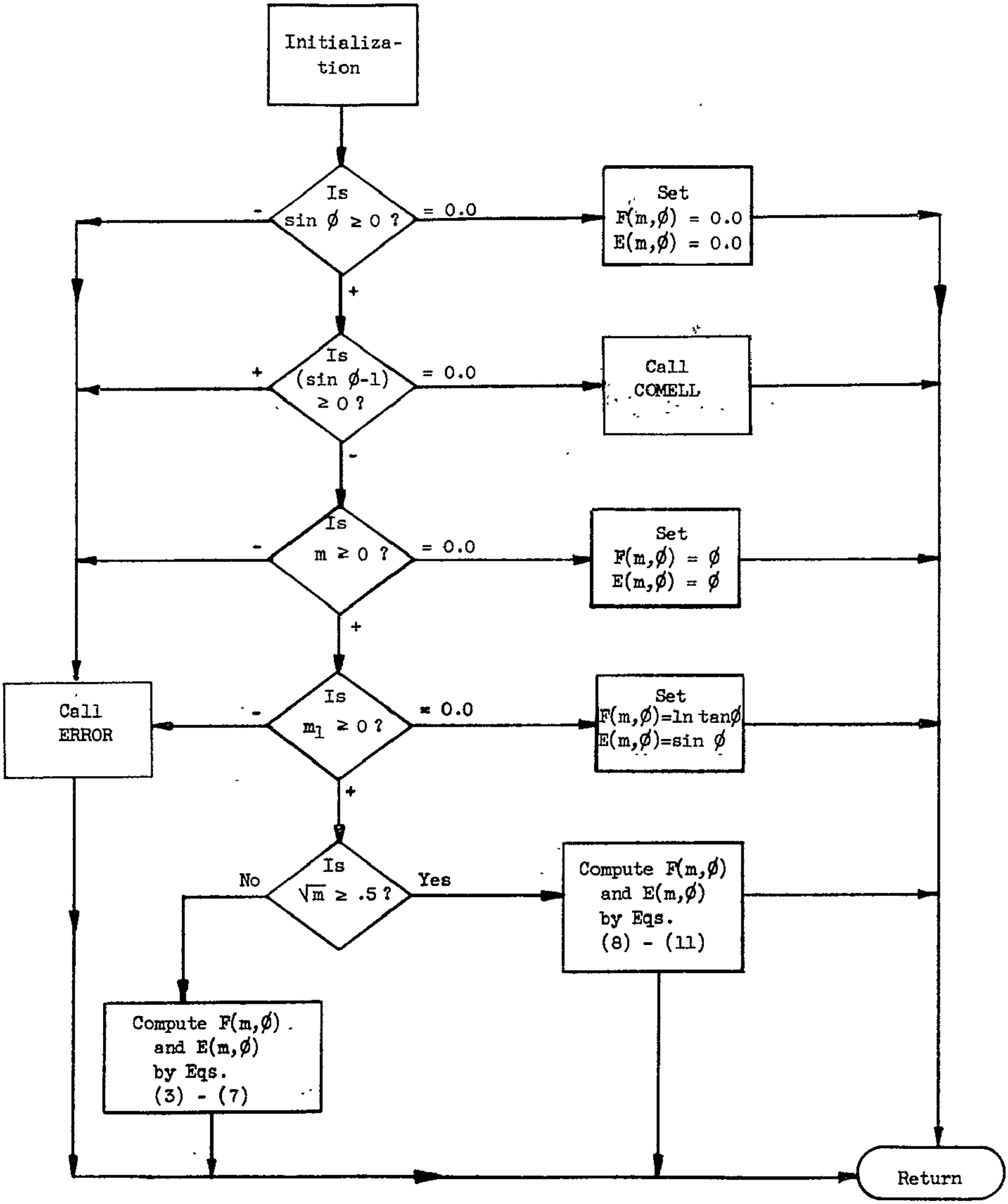

Figure 17 - Flow Diagram for Subroutine INCELL

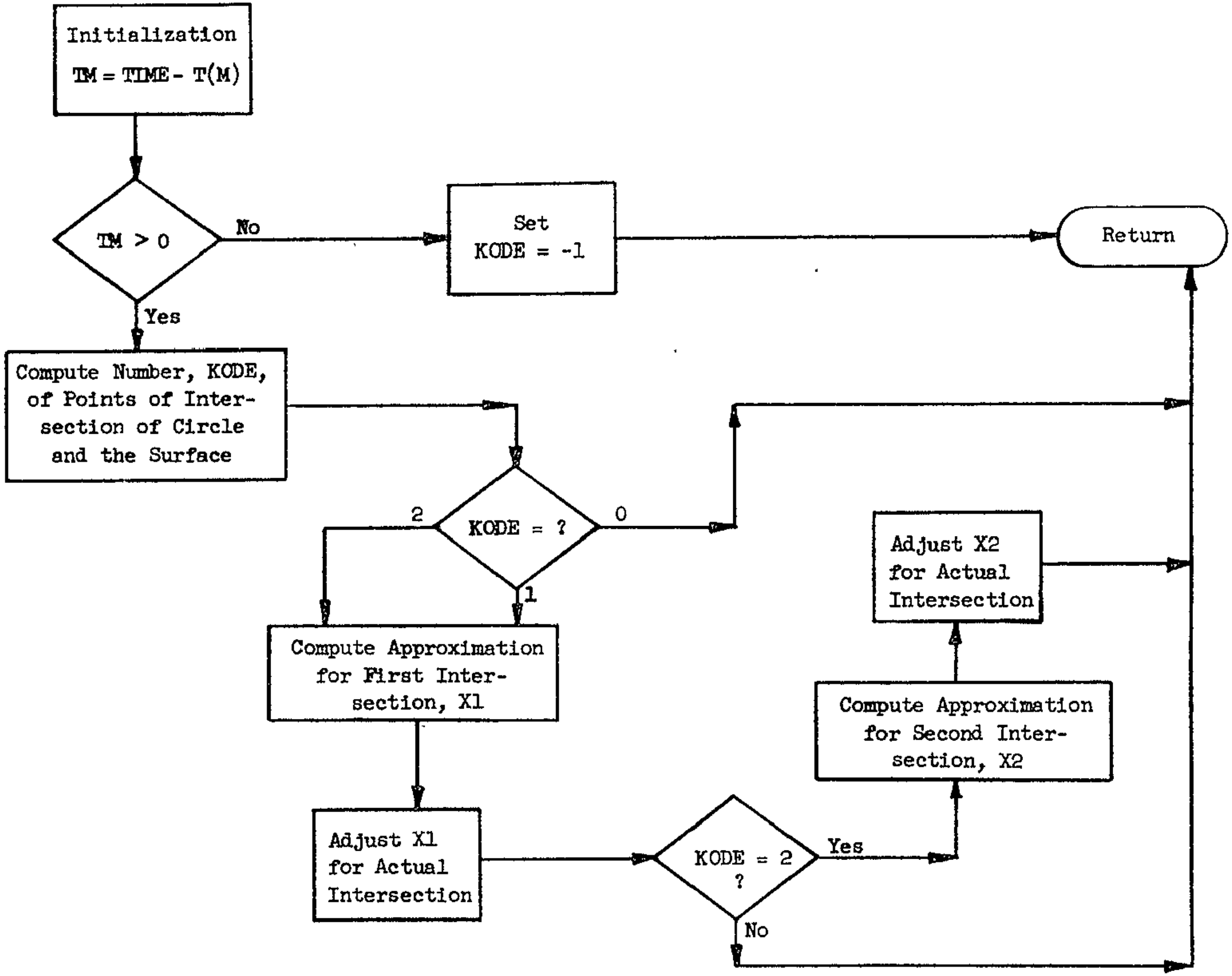

Figure 18 - Flow Diagram for Subroutine POINTS

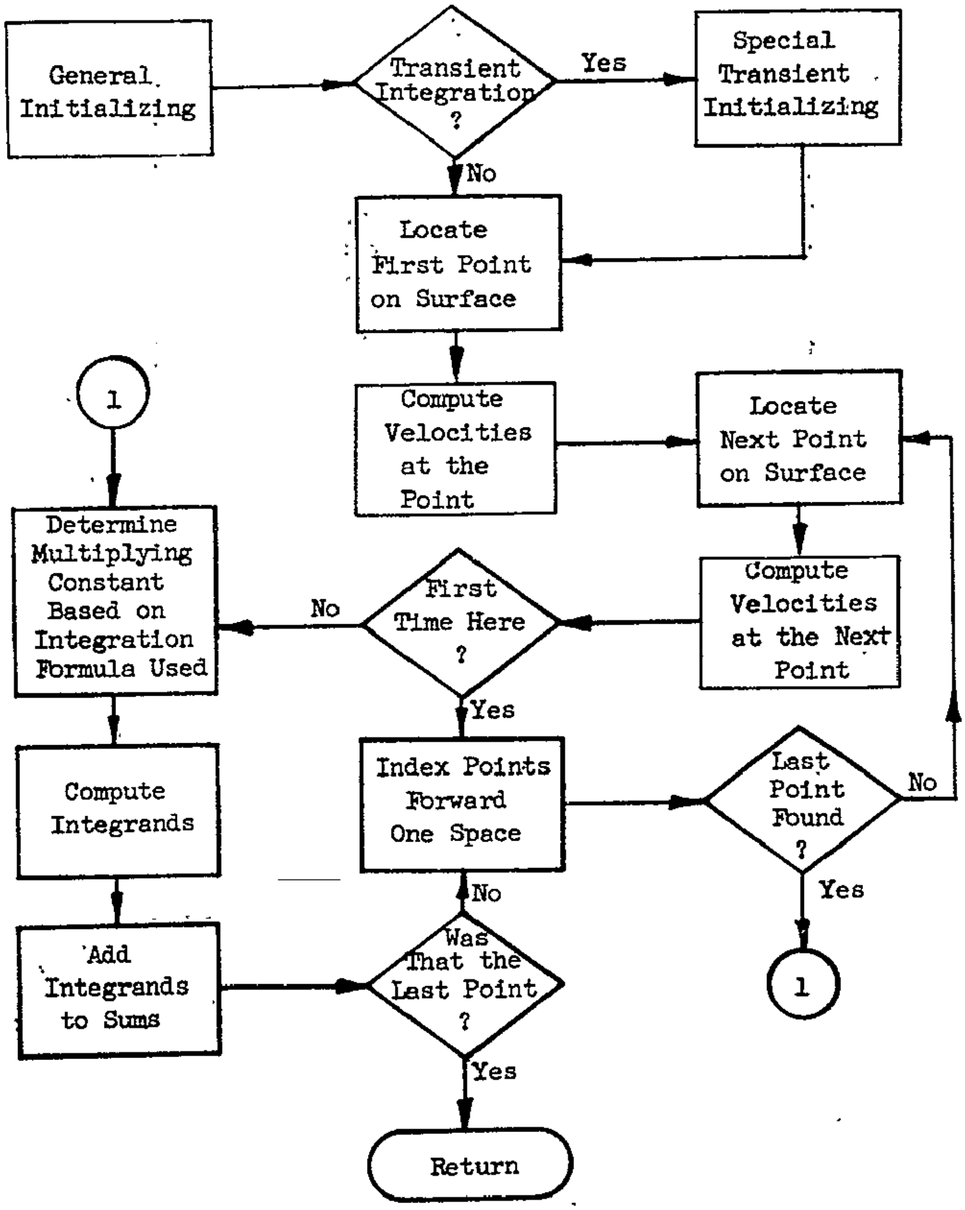

Figure 19 - Flow Diagram for Subroutine INTGRL

APPENDIX II

PROGRAM LISTINGS

```
C     MAIN PRØGRAM - 3089P - CØMTAR - CREATES BINARY TAPES ØF LØCAL      CØMT1000
C     FØRCES AND/ØR TØTAL FØRCES (CNA AND CMA).                          CØMT1010
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,    CØMT1020
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),         CØMT1030
     2UAS(300),VAS(300)                                                  CØMT1040
     3,WRD1(3,300),CNA,CMA                                               CØMT1050
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,CØMT1060
     1CNA,CMA,WRD1,                                                      CØMT1070
     2RBASE,UAS,VAS,KTYPE(150),NLAST                                     CØMT1080
   10 READ(5,20)I                                                        CØMT1090
   20 FØRMAT(I2)                                                         CØMT1100
      GØ TØ (1,2,3,4),I                                                  CØMT1110
    1 CALL MAIN1                                                         CØMT1120
      GØ TØ 10                                                           CØMT1130
    2 CALL MAIN2                                                         CØMT1140
      GØ TØ 10                                                           CØMT1150
    3 CALL MAIN3                                                         CØMT1160
      GØ TØ 10                                                           CØMT1170
    4 CALL RESINP                                                        CØMT1180
      GØ TØ 10                                                           CØMT1190
      END                                                                CØMT1200
```

```
      SUBRØUTINE MAIN1                                                   MAN11000
C                                                                        MAN11010
C     INPUT DATA, AND CØMPUTE CØEFFICIENTS.                              MAN11020
C                                                                        MAN11030
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,    MAN11040
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),         MAN11050
     2UAS(300),VAS(300)                                                  MAN11060
     3,WRD1(3,300),CNA,CMA                                               MAN11070
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,MAN11080
     1CNA,CMA,WRD1,                                                      MAN11090
     2RBASE,UAS,VAS,KTYPE(150),NLAST                                     MAN11100
      CØMMØN/HEAD/HEADNG(18)                                             MAN11110
      DØUBLE PRECISIØN SUMRA,SUMXA,SUMRC,SUMXC,PSIXA,PSIXC,PSIRC,PSIRA,  MAN11120
     1TR,TT,E,ALFA,QA,QB,QC,VZØ,RØØT,TRBR,FACTR,RØØTSQ,XX,DCNADX,TTP1,   MAN11130
     2BETA1,TFRM,RPP,RPM,RPRIME,ARG,RØØT1,SLØPE,BR,F,EPSN,WEIGHT,RUPPER,MAN11140
     3EP(2),EL(2),RADI(2),QACØ(2),SIG(2),ENWP,ENWM,RNEW,E1,E2,R1,R2      MAN11150
      DIMENSIØN ICØDE(2)                                                 MAN11155
      READ(5,888)HEADNG                                                  MAN11160
  888 FØRMAT(18A4)                                                       MAN11170
      CALL LNCNT(0,KKKK)                                                 MAN11180
  900 READ (5,109)EM,UPSTRM,VZERØ,NLAST,EPS,DCØE,WEIGHT,RBASE            MAN11190
  109 FØRMAT(3F13.8,I3,F13.8,2F6.0,F13.8)                                MAN11200
C                                                                        MAN11210
C     EPS IS READ IN AS A SMALL -FUDGE FACTØR- (ABØUT .0000001)          MAN11220
C     TØ BE USED TØ ELIMINATE DIFFICULTIES CAUSED BY RØUND-ØFF AND       MAN11230
C     TRUNCATIØN ERRØRS.   EPS IS THEN CHANGED, FØR CØNVENIENCE, TØ      MAN11240
C     BE SLIGHTLY LESS THAN ØNE.                                         MAN11250
C                                                                        MAN11260
      IF(WEIGHT)10,10,20                                                 MAN11270
   10 WEIGHT = 1.                                                        MAN11280
   20 CØNTINUE                                                           MAN11290
      EPS=1.-EPS                                                         MAN11300
      EM2=EM*EM                                                          MAN11310
      BETA2=EM2-1.0                                                      MAN11320
      BETA = DSQRT(BETA2)                                                MAN11330
      VZERØ=VZERØ/UPSTRM                                                 MAN11340
C                                                                        MAN11350
C     VZERØ AND ALL ØTHER VELØCITIES WILL BE TREATED AS NØN-DIMENSIØNAL MAN11360
C     EXCEPT WHEN NØTED ØTHERWISE                                        MAN11370
C     NLAST IS THE NUMBER ØF CØNTRØL PØINTS ØN THE BØUNDARY,NØT CØUNTINGMAN11380
C     THE ØRIGIN.   IT IS ALSØ THE NUMBER ØF SØURCE DISTRIBUTIØNS.       MAN11390
C                                                                        MAN11400
      NN=NLAST+1                                                         MAN11410
      CALL LNCNT(2,KKKK)                                                 MAN11420
      WRITE(6,101)EM,UPSTRM,VZERØ,NLAST                                  MAN11430
  101 FØRMAT( 9H MACH NØ.,   F7.3, 7H, SPEED,F10.3,11H, GUST VEL.,F9.3,  MAN11440
     1  7H, USING,I4,15H CØNTRØL PØINTS /)                               MAN11450
C                                                                        MAN11460
C     WE CHANGE SIGN ØF VZERØ.                                           MAN11470
C     THIS EFFECTIVELY CHANGES ØUR SIGN CØNVENTIØN TØ AGREE WITH ØTHERS.MAN11480
C                                                                        MAN11490
      VZERØ = -VZERØ                                                     MAN11500
      IF(NLAST-148)110,110,120                                           MAN11510
  120 CALL ERRØR                                                         MAN11520
C                                                                        MAN11530
```

```
C      IF DCØE = 0., PREVIØUSLY CØMPUTED CØEFFICIENTS ARE READ IN FRØM
C      CARDS.  ØTHERWISE, CØNTRØL PØINT DATA IS READ AND CØEFFICIENTS
C      ARE CØMPUTED.
C
  110 IF(DCØE)190,352,190
  190 X(1)=0.
      R(1)=0.
      KTYPE(1)=0
      XI(1)=0.
C
C      FØLLØWING LØØP READS THE CØNTRØL PØINT DATA,TWØ PØINTS PER CARD.
C      AT A SHØULDER, TWØ PØINTS ARE NØRMALLY REQUIRED.  THE FIRST SHØULD
C      BE ØF TYPE 1 (A CØRNER SØLUTIØN) WITH THE SLØPE UPSTREAM ØF THE
C      CØRNER.  THE SECØND WILL BE TYPE 0, WITH THE DØWNSTREAM SLØPE.
C      TYPE 2 SØLUTIØNS MAY REPLACE TYPE 0 SØLUTIØNS EXCEPT FØR N = 1.
C      TYPE 0 IS THE SØ-CALLED LINEAR TYPE, WHILE TYPE 2 IS THE
C      QUADRATIC TYPE.
C      THE FØRMAT IS . . . .
C
  100 FØRMAT(2(3F10.0,I5))
      DØ 200 N=2,NN,2
      READ(5,100)X(N),R(N),RP(N),KTYPE(N),X(N+1),R(N+1),RP(N+1),
     1 KTYPE(N+1)
      XI(N)=(X(N)-BETA*R(N))*EPS
  200 XI(N+1)=(X(N+1)-BETA*R(N+1))*EPS
C
C      FØLLØWING LØØP CHECKS THE CØNTRØL PØINT DATA
C
      SLØPE=1./BETA
      DØ 300 N=2,NN
      IF (R(N))300,230,230
  230 IF(R(N-1))300,240,240
  240 IF (XI(N)-XI(N-1))250,280,280
  250 CALL ERRØR
  280 IF(RP(N)-SLØPE)300,250,250
  300 CØNTINUE
      RP(1)=RP(2)
C
C      DETERMINE THE SØURCE AND DØUBLET DISTRIBUTIØNS
C
C
C      THE LØØP ENDING AT 5000 CØMPUTES THE CØEFFICIENTS -A- AND -C-
C      AT ALL ØF THE CØNTRØL PØINTS.
C
C      SUFFIX RA = AXIAL FLØW, R-DERIVATIVE.
C      SUFFIX XA = AXIAL FLØW, X-DERIVATIVE.
C      SUFFIX RC = CRØSS FLØW, R-DERIVATIVE.
C      SUFFIX XC = CRØSS FLØW, X-DERIVATIVE.
C
      LIM = 100
      XLIM = LIM
  351 DØ 5000 N=1,NLAST
      KØDER = 0
      ITER=0
      N1 = N + 1
      XX = X(N+1)
      IF(R(N+1)) 2000,2005,2005
 2000 IF(KTYPE(N)-1)9003,8100,9003
 8100 PERCT = RP(N+1)
      RP(N+1) = RP(N) + PERCT*(SLØPE-RP(N))
      NJ = NJ - 1
      CALL LNCNT(4,KKKK)
      WRITE(6,8490)
 8490 FØRMAT(//4X1HN,8X4HX(N),16X4HR(N),16X5HSLØPE,8X4HTYPE,8X5HXI(N),
     115X4HA(N),16X4HC(N)/)
      DØ 8495 J=1,N
      CALL LNCNT(1,KKKK)
      IF(KKKK)8495,8493,8495
 8493 CALL LNCNT(4,KKKK)
      WRITE(6,8490)
 8495 WRITE(6,8500)J,X(J),R(J),RP(J),KTYPE(J),XI(J),A(J),C(J)
 8500 FØRMAT(I5,1P3D20.12,I3,2X,3D20.12)
      R(N+1)=R(N)
      KØDER = -1
      GØ TØ 9004
 9003 R(N+1) = R(N) + (X(N+1)-X(N))*RP(N)
      RUPPER = R(N) + (X(N+1)-X(N))/BETA
      SIG(1) = (RUPPER-R(N+1))/XLIM
      SIG(2) = (R(N+1)-R(N))/XLIM
      KØDER = 1
      KSUB = 0
      KDIR = 0
      ICØDE(1) = 0
      ICØDE(2) = 0
 9004 DCNADX = RP(N+1)
```

```
C
C     FØLLØWING VALUE FØR RPRIME IS AN ARTIFICIAL ØNE USED
C     TØ FACILITATE PRØGRAMMING.
C
 2004 RPRIME = 1.0
      GØ TØ 2010
 2005 RPRIME = RP(N+1)
 2010 BR = BETA*R(N+1)
      SUMRA=0.
      SUMXA=-1.
      SUMRC=-VZERØ
      SUMXC=0.
      DØ 4000 K=1,N
      TR=(XX-XI(K))/BR
      IF(KTYPE(K)-1)3100,3300,3150
C
C     EQUATIØNS FØR TYPE 0 SØLUTIØN (LINEAR TYPE)
C
 3100 PSIXA=ARCØSH(TR)
      PSIXC = DSQRT(TR*TR-1.)
      PSIRC=PSIXA+TR*PSIXC
      PSIRA=-BETA*PSIXC
      IF(RPRIME)3200,3500,3200
 3200 PSIXC=-2.*PSIXC/BETA
      GØ TØ 3500
C
C     EQUATIØNS FØR TYPE 1 SØLUTIØN (CØRNER TYPE)
C
 3300 TT=1./TR
      RØØT = DSQRT (XX-XI(K)+BR)
      TTP1=TT+1.
      ARG=(1.-TT)/TTP1
C
C     FIND THE CØMPLETE ELLIPTIC INTEGRALS ØF THE FIRST AND SECØND KIND.
C
      CALL CØMELL(ARG,F,E)
      PSIRC=BETA/TT*RØØT/BR*(E-TT/TTP1*(2.-TT)/2.*F)
      PSIRA=-BETA*TR/RØØT*(TTP1*E-TT*F)
      IF(RPRIME)3400,3500,3400
 3400 PSIXA=F/RØØT
      PSIXC= 1.5*PSIRA/BETA
      GØ TØ 3500
C
C     EQUATIØNS FØR TYPE 2 SØLUTIØN (QUADRATIC TYPE)
C
 3150 TRBR=(XX-XI(K))
      BETA1=BETA*TRBR
      TT=1./TR
      PSIXA=ARCØSH(TR)
      RØØT1 = DSQRT(1.-TT*TT)
      PSIRA=BETA1*(TT*PSIXA-TR*RØØT1)
      PSIRC=BETA*BETA1*(3.*PSIXA+(1.-4.*TT*TT)/(TT*TT)*RØØT1)/BETA2
      IF(RPRIME)3175,3500,3175
 3175 PSIXA=2.*TRBR*(PSIXA-RØØT1)
      PSIXC=3.*PSIRA/BETA2
C
C     ADD SØLUTIØN TØ SUM, UNLESS THIS IS THE N-TH ØNE.
C
 3500 IF (K-N) 3600,2100,2100
 3600 SUMRA=SUMRA+A(K)*PSIRA
      SUMRC=SUMRC+C(K)*PSIRC
      IF(RPRIME)3700,4000,3700
 3700 SUMXA=SUMXA+A(K)*PSIXA
      SUMXC=SUMXC+C(K)*PSIXC
 4000 CØNTINUE
 2100 IF ( KØDER) 2200,4005,2200
 2200 IF(KTYPE(N)-1)2201,8200,2201
C     WRITE STATEMENT IS FØR DEBUGGING ØNLY
 8200 WRITE(6,8300)N,X(N1),R(N1),KTYPE(N1),PSIXA,PSIRA,PSIXC,PSIRC,
     1SUMXA,SUMRA,SUMXC,SUMRC
 8300 FØRMAT(//3X1HN,5X6HX(N+1),9X6HR(N+1),5X5HKTYPE,4X5HPSIXA,10X,
     15HPSIRA,10X5HPSIXC,10X5HPSIRC/I4,1P2E15.6,I4,4E15.6/1X7HSUMXA =,
     2E14.6,2X7HSUMRA =,E14.6,2X7HSUMXC =,E14.6,2X7HSUMRC =,E14.6)
      GØ TØ 7000
 2201 ALFA = DATAN(-VZERØ)
      FACTR = 4.0*R(N+1)/(ALFA*RBASE)
      TERM = FACTR*(PSIXC*(      -SUMRC)+PSIRC*SUMXC)
      QA = DCNADX*PSIXA*PSIXC-TERM*(PSIXA*SUMRA+PSIRA*(   -SUMXA))
      QB = -DCNADX*(PSIXA*PSIRC+PSIRA*PSIXC)+TERM*(PSIXA*(1.0+BETA2))
      QC = DCNADX*PSIRA*PSIRC-TERM*(PSIRA*(1.0+BETA2*SUMXA)-BETA2*PSIXA
     1*SUMRA+BETA2*PSIRA)
      RØØTSQ = QB*QB-4.0*QA*QC
      GRP = -WEIGHT*RP(N)+(WEIGHT+1.)*(R(N+1)-R(N))/(X(N+1)-X(N))
```

```
      CALL LNCNT(4,KKKK)
      WRITE(6,600)N,X(N1),R(N1),KTYPE(N1),PSIXA,PSIRA,PSIXC,PSIRC,KØDER,
     1ITER,SUMXA,SUMRA,SUMXC,SUMRC,QA,QB,QC,GRP
  600 FØRMAT(/3X,1HN,6X6HX(N+1),9X6HR(N+1),5X5HKTYPE,7X5HPSIXA,13X5HPSIR
     1A,13X5HPSIXC,13X5HPSIRC,14X5HKØDER,1X4HITER/I4,1X,1P2D15.6,I4,2X,
     24D18.10,6X,2(2XI4)/5X7HSUMXA =,D18.10,2X7HSUMRA =,D18.10,2X7HSUMXC
     3 =,D18.10,2X7HSUMRC =,D18.10/5X14HQUAD. CØEFS. =,3(D18.10,1X),5X,
     45HGRP =,D18.10)
      IF(KØDER-3)6010,6400,6400
 6010 IF(RØØTSQ)6015,6050,6050
 6015 IF(KDIR)6030,6020,6040
 6020 DØ 6025 J=1,2
      ICØDE(J) = 1
 6025 RADI(J) = R(N+1)
      GØ TØ 6200
 6030 ICØDE(2) = 1
      RADI(2) = R(N+1)
      ITER = ITER+1
      IF(ITER-(LIM*2))6300,6300,120
 6040 ICØDE(1) = 1
      RADI(1) = R(N+1)
      ITER = ITER+1
      IF(ITER-(LIM*2))6200,6200,120
 6050 RØØT=DSQRT(RØØTSQ)
      RPP = (-QB+RØØT)/(2.0*QA)
      RPM = (-QB-RØØT)/(2.0*QA)
      ENWP = RPP-GRP
      ENWM = RPM-GRP
      IF(KDIR)6080,6060,6070
 6060 DØ 6065 J=1,2
      QACØ(J) = QA
      EP(J) = ENWP
      EL(J) = ENWM
 6065 RADI(J) = R(N+1)
      CALL LNCNT(2,KKKK)
      WRITE(6,8600)KSUB,RPP,RPM,RADI(1),QACØ(1),EP(1),EL(1),ICØDE(1),
     1KØDER,ITER
      GØ TØ 6300
 6070 KSUB = 1
      GØ TØ 6085
 6080 KSUB = 2
 6085 IF(ICØDE(KSUB))6090,6090,6110
 6090 IF(QA*QACØ(KSUB))6110,6110,6095
 6095 IF(ENWP*EP(KSUB))6150,6100,6100
 6100 IF(ENWM*EL(KSUB))6155,6110,6110
 6110 EP(KSUB) = ENWP
      EL(KSUB) = ENWM
      QACØ(KSUB) = QA
      RADI(KSUB) = R(N+1)
      KØDER = 2
      ITER = ITER+1
      CALL LNCNT(2,KKKK)
      WRITE(6,8600)KSUB,RPP,RPM,RADI(KSUB),QACØ(KSUB),EP(KSUB),EL(KSUB),
     1ICØDE(KSUB),KØDER,ITER
 8600 FØRMAT(3X4HKSUB,7X3HRPP,15X3HRPM,12X10HRADI(KSUB),8X10HQACØ(KSUB),
     118X8HEP(KSUB),10X8HEL(KSUB),6X5HICØDE,1X5HKØDER,1X4HITER/3XI3,1X,
     21P6D18.10,I4,2(2XI4))
      ICØDE(KSUB) = 0
      IF(ITER-(LIM*2))6130,6130,120
 6130 GØ TØ (6200,6300),KSUB
 6150 IRØØT = +1
      E1 = EP(KSUB)
      E2 = ENWP
      GØ TØ 6160
 6155 IRØØT = -1
      E1 = EL(KSUB)
      E2 = ENWM
 6160 R1 = RADI(KSUB)
      R2 = R(N+1)
      ITER = ITER+1
      GØ TØ 6500
 6200 R(N+1) = RADI(2)-SIG(2)
      KDIR = -1
      GØ TØ 2 10
 6300 R(N+1) = RADI(1)+SIG(1)
      KDIR = +1
      GØ TØ 2 10
 6400 RØØT = DSQRT(RØØTSQ)
      IF(IRØØT)6410,6420,6420
 6410 RPM = (-QB-RØØT)/(2.0*QA)
C     DURING THIS PØRTIØN ØF THE PRØGRAM ENWP WILL BE USED TØ SIGNIFY
C     EITHER ENWP ØR ENWM.
```

```
      ENWP = RPM-GRP
      RP(N+1) = RPM
      GØ TØ 6450
 6420 RPP = (-QB+RØØT)/(2.0*QA)
      ENWP = RPP-GRP
      RP(N+1) = RPP
 6450 IF(DABS(ENWP-E2)-1.D-10)7000,7000,6460
 6460 IF(ENWP*E2)6480,7000,6470
 6470 IF(ENWP*E1)6490,7000,6480
 6480 E1 = E2
      R1 = R2
 6490 E2 = ENWP
      R2 = RNEW
 6500 RNEW = R2-E2/((E2-E1)/(R2-R1))
      KØDER = KØDER+1
      CALL LNCNT(2,KKKK)
      WRITE(6,8700)IRØØT,R2,RP(N+1),R1,E1,E2,RNEW,KØDER,ITER
 8700 FØRMAT(3X5HIRØØT,5X6HR(N+1),12X7HRP(N+1),11X2HR1,16X2HE1,16X2HE2,
     116X4HRNEW,14X5HKØDER,1X4HITER/3XI3,1X,1P6D18.10,4X,2(2XI4))
      R(N+1) = RNEW
      IF(KØDER-(LIM*2))2010,2010,120
 7000 XI(N+1)=(X(N+1)-BETA*R(N+1))*EPS
      IF(RP(N+1)-SLØPE)2500,120,120
 2500 RPRIME = RP(N+1)
C
C     CØMPUTE A(N) AND C(N)
C
 4005 IF (RPRIME) 4100,4200,4100
 4100 SUMRA=SUMRA-RPRIME*SUMXA
      PSIRA=PSIRA-RPRIME*PSIXA
      SUMRC=SUMRC-RPRIME*SUMXC
      PSIRC=PSIRC-RPRIME*PSIXC
 4200 A(N)=-SUMRA/PSIRA
      C(N)=-SUMRC/PSIRC
      IF(KØDER)4207,5000,4207
 4207 CALL LNCNT(1,KKKK)
      WRITE(6,8500)N,X(N+1),R(N+1),RP(N+1),KTYPE(N),XI(N+1),A(N),C(N)
      IF(XI(N+1)-XI(N))120,5000,5000
 5000 CØNTINUE
C
C     THE FØLLØWING ARE ARTIFICIAL VALUES, USED TØ INDICATE THE END ØF
C     THE SEQUENCE.
C
      A(NLAST+1)=.33333333E+33
      C(NLAST+1)=.33333333E+33
      EPSN=1.-EPS
      VZØ = -VZERØ*UPSTRM
      DCØE = 0.0
      WRITE(7,109)EM,UPSTRM,VZØ,NLAST,EPSN,DCØE,WEIGHT,RBASE
      WRITE(7,104)(I,X(I),R(I),RP(I),KTYPE(I),XI(I),A(I),C(I),I=1,NN)
  104 FØRMAT(I5,3E25.8/I5,3E25.8)
      GØ TØ 349
C
C     PREVIØUSLY CØMPUTED CØEFFICIENTS ARE READ IN HERE.
C
  352 READ(5,104)(I,X(I),R(I),RP(I),KTYPE(I),XI(I),A(I),C(I),I=1,NN)
C
C     CØMPUTE THE STARTING TIMES FØR THE SØURCES.
C
  349 DØ 350 N=2,NN
  350 T(N)=XI(N)/UPSTRM
      T(1)=0.0
C
C     THE FØLLØWING THREE STATEMENTS INVØLVE ØNLY ARTIFICIAL VALUES.
C
      X(NLAST+2)=100.*X(NLAST+1)
      RP(NLAST+2)=RP(NLAST+1)
      R(NLAST+2)=R(NLAST+1)+RP(NLAST+1)*(X(NLAST+2)-X(NLAST+1))
      CALL LNCNT(2,KKKK)
      WRITE(6,102)
      DØ 105 I=1,NN
      CALL LNCNT(1,KKKK)
      IF(KKKK)105,106,105
  106 CALL LNCNT(2,KKKK)
      WRITE(6,102)
 105  WRITE(6,103)I,X(I),R(I),RP(I),KTYPE(I),XI(I),T(I),A(I),C(I)
 103  FØRMAT(I5,1P3E15.7,I3,1X,4E15.7)
 102  FØRMAT( 6H NUMBR,7X,1HX,14X,1HR,12X,5HSLØPE,5X,4HTYPE,6X,2HXI,
     114X1HT,14X1HA,14X1HC/1H )
      RETURN
      END
```

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      SUBRØUTINE MAIN2                                                  MAN21000
C     CØMPUTATIØN ØF THE INTEGRAND APPEARING IN THE EXPRESSIØN          MAN21010
C     FØR THE GENERALIZED FØRCE CØEFFICIENT.                            MAN21020
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,   MAN21030
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),        MAN21040
     2UAS(300),VAS(300)                                                 MAN21050
     3,WRD1(3,300),CNA,CMA                                              MAN21060
     4,STØRTF(900),STØRCN(900),STØRCM(900),FSTEDY(2),XTEST(20),RTEST(20)MAN21070
      EQUIVALENCE (WRD1(1,1),STØRTF(3)),(WRD1(2,1),STØRCN(3)),          MAN21080
     1 (WRD1(3,1),STØRCM(3))                                            MAN21090
      DØUBLE PRECISIØN FACTA,FACTB,FACTC,FACTD,XF,DX,XL,XFF,TF,DT,TL,RF,MAN21100
     1UA,VA,UC,VC,UCT,VCT,DPHITU,VOINT,CNX,CMX                          MAN21110
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,MAN21120
     1CNA,CMA,WRD1,                                                     MAN21130
     2RBASE,UAS,VAS,KTYPE(150),NLAST                                    MAN21140
C                                                                       MAN21150
C     ITAPE = 0 DENØTES PRINTED ØUTPUT ØNLY.  ITAPE NØT EQUAL TØ ZERØ   MAN21152
C               CREATES A BINARY TAPE (8) ØF THE LØCAL NØRMAL FØRCE AND MAN21154
C               THE PITCHING MØMENT (CNA AND CMA).                      MAN21156
C                                                                       MAN21158
C     CØMPUTE INTEGRAND AT XF, XF+DX, ..., XL AND AT TF, TF+DT, ..., TL MAN21160
C     WHERE TL = TF+DT(NT-1).                                           MAN21162
C                                                                       MAN21164
C     KØDE = 0 INDICATES THIS IS THE LAST SET ØF DATA FØR MAIN2.  IF    MAN21166
C              KØDE=0 AND ITAPE IS NØT EQUAL TØ ZERØ, AN EØF IS WRITTEN MAN21168
C              ØN THE BINARY TAPE 8.                                    MAN21170
C     KØDE = 1 IF A NEW SET ØF X AND T VALUES IS TØ BE READ IN.         MAN21172
C     KØDE =-1 SIGNIFIES A RETURN TØ MAIN PRØGRAM (TAPRES ØR CØMTAR).   MAN21174
C                                                                       MAN21176
C     KCØDET = 1 IF ANØTHER SET ØF T VALUES IS TØ BE READ IN USING THE  MAN21178
C                PREVIØUS SET ØF XF, XF+DX, ..., XL VALUES.             MAN21180
C     KCØDET = 0 SIGNIFIES THE LAST SET ØF T VALUES FØR A PARTICULAR X. MAN21190
C                                                                       MAN21200
C     L1 = 1 TØ GET DEBUGGING ØUTPUT FRØM THE SUBRØUTINE UTANVT.        MAN21210
C                                                                       MAN21220
C     IDBØDY (A FØRMAT) PRØVIDES IDENTIFICATIØN ØF A SPECIFIC BINARY    MAN21230
C     TAPE FØR A VEHICLE CØNFIGURATIØN.                                 MAN21240
C                                                                       MAN21250
C                                                                       MAN21260
      IMAX = 40                                                         MAN21270
      NDIM = 900                                                        MAN21280
      NTCØUN = 0                                                        MAN21300
      FACTA=2./(RBASE**2)                                               MAN21310
      FACTB = 4./RBASE/DATAN(-VZERØ)                                    MAN21320
      FACTC=FACTA/RBASE*.5                                              MAN21330
      FACTD=FACTB/RBASE*.5                                              MAN21340
  400 READ(5,5000)ITAPE,IDBØDY,XF,DX,XL,KØDE,KCØDET,TF,DT,NT,L1         MAN21350
 5000 FØRMAT(I5,A4,1X,3F10.0,2I5,2F10.0,2I5)                            MAN21360
      IF(ITAPE)3,410,3                                                  MAN21370
    3 CØNTINUE                                                          MAN21380
      ITAPE = 1                                                         MAN21390
      DX = 1.0                                                          MAN21400
      XL = 0.0                                                          MAN21410
  410 XFF = XF                                                          MAN21420
      NTCØUN = NTCØUN + NT                                              MAN21440
      KØNT = 1                                                          MAN21450
      NDIMAX = (NTCØUN + 1)*3                                           MAN21460
      IF (NDIM-NDIMAX)5050,7,7                                          MAN21470
 5050 CALL ERRØR                                                        MAN21480
    7 CALL LNCNT(-2,KKKK)                                               MAN21550
      WRITE(6,201)                                                      MAN21560
  201 FØRMAT( 4X1HX,9X1HR,9X1HT,9X2HUA,9X2HVA,9X2HUC,9X2HVC,6X9H(1/U)PHIMAN21570
     1T,4X5HDCNDX,4X10HDCNAD(X/D),3X5HDCMDX,4X10HDCMAD(X/D)/1H )        MAN21580
  401 INDEX=2                                                           MAN21590
  500 IF(X(INDEX)-XF)550,550,600                                        MAN21600
  550 INDEX=INDEX+1                                                     MAN21610
      GØ TØ 500                                                         MAN21620
  600 RF=R(INDEX)-RP(INDEX)*(X(INDEX)-XF)                               MAN21630
C                                                                       MAN21640
C     RF IS THE BØDY RADIUS CØRRESPØNDING TØ XF                         MAN21650
C                                                                       MAN21660
      CALL UANDV(XF,RF,UA,VA,UC,VC)                                     MAN21670
      TIME=TF                                                           MAN21680
      CALL UTANVT(XF,RF,L1,UCT,VCT,DPHITU)                              MAN21690
      VOINT=-VA*(VZERØ+VCT)+UCT*(BETA2*UA-1.0)+DPHITU                   MAN21700
      IF(XF-UPSTRM*TF)120,120,110                                       MAN21710
  110 VOINT=VOINT+VA*VZERØ                                              MAN21720
  120 VOINT=RF*VOINT                                                    MAN21730
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      CNX=FACTA*VOINT                                                   MAN21740
      CNA=FACTB*VOINT                                                   MAN21750
      CMX=FACTC*VOINT*XF                                                MAN21760
      CMA=FACTD*VOINT*XF                                                MAN21770
      CALL LNCNT(1,KKKK)                                                MAN21780
      IF(KKKK)210,220,210                                               MAN21790
  220 CALL LNCNT(2,KKKK)                                                MAN21800
      WRITE(6,201)                                                      MAN21810
  210 WRITE(6,108)XF,RF,TF,UA,VA,UCT,VCT,DPHITU,CNX,CNA,CMX,CMA         MAN21820
  108 FØRMAT(F10.4,F10.5,F10.6,1P6E11.4,0PF11.7,1P2E11.4)               MAN21830
      IF(ITAPE-1)1000,4000,1000                                         MAN21840
 4000 JSTØR = KØNT+NTCØUN-NT                                            MAN21850
      JSTØR = JSTØR*3                                                   MAN21860
      STØRCN(JSTØR) = CNA                                               MAN21870
      STØRCM(JSTØR) = CMA                                               MAN21880
      STØRTF(JSTØR) = TF                                                MAN21890
 1000 IF(XF-XL)700,701,701                                              MAN21900
  700 XF=XF+DX                                                          MAN21910
      GØ TØ 500                                                         MAN21920
  701 IF(KØNT-NT)702,2000,2000                                          MAN21930
  702 TF = TF+DT                                                        MAN21940
      KØNT = KØNT + 1                                                   MAN21950
      XF = XFF                                                          MAN21960
      GØ TØ 401                                                         MAN21970
 2000 IF(KCØDET)7000,2003,7000                                          MAN21980
 2003 IF(ITAPE-1)3000,2005,3000                                         MAN21990
 7000 READ(5,8000)KCØDET,TF,DT,NT,L1                                    MAN21992
 8000 FØRMAT(45X,I5,2F10.0,2I5)                                         MAN21994
      GØ TØ 410                                                         MAN21996
 2005 NT3 = NTCØUN*3                                                    MAN22000
      FSTECY(1) = STØRCN(NT3)                                           MAN22010
      FSTECY(2) = STØRCM(NT3)                                           MAN22020
      KNT=1                                                             MAN22030
      NR = NLAST+1                                                      MAN22040
      DØ 2007 I=1,NR                                                    MAN22050
      IF(KTYPE(I)-1)2007,2006,2007                                      MAN22060
 2006 XTEST(KNT) = X(I)                                                 MAN22070
      RTEST(KNT) = R(I)                                                 MAN22080
      KNT = KNT+1                                                       MAN22090
 2007 CØNTINUE                                                          MAN22100
      NTEST = KNT                                                       MAN22110
      XTEST(NTEST) = X(NLAST+1)                                         MAN22120
      RTEST(NTEST) = R(NLAST+1)                                         MAN22130
      KK=5                                                              MAN22140
C     WRITE FIRST RECØRD ØN BINARY TAPE FØR LØCAL FØRCES                MAN22150
 2010 WRITE(8)ITAPE,ICBØDY,EM,UPSTRM,XF,KK,NTCØUN,(FSTECY(I),I=1,2),    MAN22160
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)                               MAN22170
      NTCØUN = NTCØUN+1                                                 MAN22180
      NT3 = NTCØUN*3                                                    MAN22190
C     ARTIFICIAL TIME VALUE - INDICATES END ØF THIS BLØCK ØF VALUES     MAN22200
C     CØRRESPØNDING TØ A SPECIFIC X-VALUE.                              MAN22210
      STØRTF(NT3) = 1000.                                               MAN22220
      DØ 2050 L = 1,NTCØUN,IMAX                                         MAN22230
 2050 CALL BINTAP(1,WRD1(1,L))                                          MAN22240
      NTCØUN = 0                                                        MAN22250
 3000 IF(KØDE)900,3010,400                                              MAN22260
 3010 IF(ITAPE-1)900,3020,900                                           MAN22270
C     NEGATIVE ITAPE IN FIRST RECØRD INDICATES EØF ØN BINARY TAPE.      MAN22280
 3020 ITAPE = -ITAPE                                                    MAN22290
      WRITE(8)ITAPE,ICBØDY,EM,UPSTRM,XF,KK,NTCØUN,(FSTECY(I),I=1,2),    MAN22300
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)                               MAN22310
      END FILE 8                                                        MAN22320
      REWIND 8                                                          MAN22330
      CALL LNCNT(7,KKKK)                                                MAN22332
      WRITE(6,9900)                                                     MAN22334
 9900 FØRMAT(//5X,95(1H*)//10X50HTHE END ØF FILE HAS BEEN WRITTEN ØN BINMAN22336
     1ARY TAPE 8.//5X,95(1H*))                                          MAN22338
  900 RETURN                                                            MAN22340
      END                                                               MAN22350
```

```
      SUBRØUTINE MAIN3
C
C     CØNTRØLS THE INTEGRATIØN RØUTINE
C
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),
     2UAS(300),VAS(300)
     3,WRD1(3,300),CNA,CMA
     4,STØRTF(900),STØRCN(900),STØRCM(900),FSTEDY(2),XTEST(20),RTEST(20)
      EQUIVALENCE (WRD1(1,1),STØRTF(3)),(WRD1(2,1),STØRCN(3)),
     1 (WRD1(3,1),STØRCM(3))
      DØUBLE PRECISIØN ALFA,X2,RESET,TF,DT,TL,XXX,RRR,UA,VA,UC,VC,XSTF,
     1XSTL,CØN,CN,CM,CQ1,CQ2,CQ3,CQ4,CP,XGUST,CFS(18),XF,TSAVE
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,
     1CNA,CMA,WRD1,
     2RBASE,UAS,VAS,KTYPE(150),NLAST
C
C
C      ITAPE = 0 INDICATES PRINTED ØUTPUT ØNLY.  ITAPE NØT EQUAL TØ ZERØ
C                CREATES A BINARY TAPE (11) ØF THE TØTAL NØRMAL FØRCE AND
C                THE PITCHING MØMENT (CNA AND CMA).
C
C      KCØDE = 0 INDICATES THE LAST SET ØF DATA FØR MAIN3.  IF KØDE=0 AND
C                ITAPE IS NØT EQUAL TØ ZERØ, AN EØF IS WRITTEN ØN THE
C                BINARY TAPE 11.
C      KCØDE = 1 IF THE NEXT DATA CARD IS FØR MAIN3.
C      KCØDE =-1 SIGNIFIES A RETURN TØ MAIN PRØGRAM (TAPRES ØR CØMTAR).
C
C      IDBØDY (A FØRMAT) PRØVIDES IDENTIFICATIØN ØF A SPECIFIC BINARY
C      TAPE FØR A VEHICLE CØNFIGURATIØN.
C
C      MØRET = 1 IF NEXT DATA CARD CØNTAINS ADDITIØNAL TIME VALUES.
C      MØRET = 0 DENØTES THE LAST SET ØF TIME VALUES.
C
C      USE MØRET=0 AND ITAPE NØT EQUAL TØ ZERØ TØ ØBTAIN CNA AND CMA FØR
C      BØTH KK=3 AND KK=5 ØN TAPE WITH ØNLY ØNE DATA CARD. (KCØDE MUST BE
C      EQUAL TØ ZERØ TØ WRITE AN EØF ØN THE BINARY TAPE.)
C
C
       IMAX = 40
       NDIM = 900
        ALFA = DATAN(-VZERØ)
       NTCØUN = 0
C
C      RESET IS 1. TØ INITIALIZE AND RESTART THE INTEGRATIØNS AT X=0.
C      THE TIMES USED ARE TF, TF+DT, ...., TL WHERE TL = TF+DT(NT-1).
C      KK IS 1 ØR 2 FØR I.I., 3 ØR 4 FØR P.P., AND 5 ØR 6 FØR P.W.L.G.
C      A UNIT STEP ØNLY IS CØNSIDERED.
C      L2 IS 1 IF PRINT ØUT ØF INTEGRAND AT EACH STEP IS DESIRED.
C      L3 IS 1 IF PRINT ØUT ØF SPECIAL VALUES ØF X FRØM FØINTS IS DESIRED
C
C
 100   READ(5,5000)ITAPE,IDBØDY,TF,DT,NT,KK,KCØDE,MØRET,L2,L3
 5000  FØRMAT(I5,A4,1X,2F10.0,6I5)
       ISHØRT = 0
       TSAVE=TF
       IF(ITAPE)5003,5004,5003
 5003  CØNTINUE
       ITAPE = 2
       IF(MØRET)5004,5002,5004
 5002  KK = 3
       ISHØRT = 1
 5004  CALL LNCNT(-2,KKKK)
       WRITE(6,1001)
 1001  FØRMAT(2H K,3X4HTIME,6X4HXSTF,6X4HXSTL,5X5HXGUST,7X2HX2,10X3HCNA,
      112X3HCMA,8X11HCENT. PRES./1H )
       X2 = X(NLAST+1)
 110   RESET = 1.0
       TIME = TF
       NTCØUN = NTCØUN + NT
       KØNT = 1
       NDIMAX = (NTCØUN +1)*3
       IF(NDIM - NDIMAX)5050,5100,5100
 5050  CALL ERRØR
 5100  IF(RESET)1,10,1
C
C      FRØM HERE TØ 10 IS INITIALIZATIØN REQUIRED IF RESET=1.
C
  1    DØ 3 I=1,18
  3    CFS(I)=0.0
       NN=2*NLAST+1
       N=1
  5    IF(MØD(N,2))7,8,7
```

```
    7   K=(N+1)/2                                                       MAN31660
        XXX=X(K)                                                        MAN31670
        RRR=R(K)                                                        MAN31680
        GØ TØ 9                                                         MAN31690
    8   K=N/2                                                           MAN31700
        XXX=(X(K)+X(K+1))*0.5                                           MAN31710
        RRR=(R(K)+R(K+1))*0.5                                           MAN31720
    9   CALL UANDV(XXX,RRR,UA,VA,UC,VC)                                 MAN31730
        UAS(N)=UA                                                       MAN31740
        VAS(N)=VA                                                       MAN31750
        N=N+1                                                           MAN31760
        IF(N-NN)5,5,14                                                  MAN31770
   10   IF(KK-2)11,11,13                                                MAN31780
C                                                                       MAN31790
C       INTEGRAL HAS REACHED STEADY STATE VALUE, ØR                     MAN31800
C       HAS NØ TRANSIENT PØRTIØN.                                       MAN31810
C                                                                       MAN31820
   11   DØ 12 I=1,18                                                    MAN31830
   12   CF(I)=CFS(I)                                                    MAN31840
        GØ TØ 35                                                        MAN31850
   14   XSTF=0.0                                                        MAN31855
        XSTL=0.0                                                        MAN31860
        IF(KK-2)16,16,13                                                MAN31870
   13   X2=X(NLAST+1)                                                   MAN31880
        IF(TIME)11,11,15                                                MAN31890
   15   IF(XSTL-X(NLAST+1))17,11,11                                     MAN31900
C                                                                       MAN31910
C       CØMPLTE THE ENTIRE STEADY STATE INTEGRAND.                      MAN31920
   16   XSTL=X(NLAST+1)                                                 MAN31930
        CALL INTGRL(XSTF,XSTL,1,L2,L3)                                  MAN31940
        DØ 40 J=1,18                                                    MAN31950
   40   CFS(J)=CF(J)                                                    MAN31960
        GØ TØ 35                                                        MAN31970
   17   XSTF=XSTL                                                       MAN31980
        IF(KK-4)18,18,22                                                MAN31990
C                                                                       MAN32000
C       FIND THE UPPER LIMIT FØR THE PURE PENETRATIØN CASE.             MAN32010
C                                                                       MAN32020
   18   XSTL=TIME*UPSTRM                                                MAN32030
        IF(XSTL-X(NLAST+1))20,19,19                                     MAN32040
   19   XSTL=X(NLAST+1)                                                 MAN32050
C                                                                       MAN32060
C       CØMPUTE THE ADDITIØNAL STEADY STATE CØNTRIBUTIØN.               MAN32070
C                                                                       MAN32080
   20   CALL INTGRL(XSTF,XSTL,1,L2,L3)                                  MAN32090
        DØ 21 I=1,18                                                    MAN32100
   21   CFS(I)=CFS(I)+CF(I)                                             MAN32110
        GØ TØ 30                                                        MAN32115
C                                                                       MAN32120
C       FIND THE LIMITS ØF THE INTEGRATIØNS FØR THE LIFT GRØWTH CASE.   MAN32130
C                                                                       MAN32140
   22   CALL PØINTS(1,XSTL,X2,KØDE)                                     MAN32150
        IF(KØDE)24,25,20                                                MAN32160
   24   CALL ERRØR                                                      MAN32170
   25   XSTL=X(NLAST+1)                                                 MAN32175
        GØ TØ 20                                                        MAN32180
   30   IF(KK-4)11,11,31                                                MAN32190
C                                                                       MAN32200
C       CØMPLTE THE TRANSIENT PØRTIØN ØF THE INTEGRAL.                  MAN32205
C                                                                       MAN32206
   31   IF(XSTL-X(NLAST+1))33,11,11                                     MAN32210
   33   CALL INTGRL(XSTL,X2,0,L2,L3)                                    MAN32220
        DØ 32 I=1,18                                                    MAN32230
   32   CF(I)=CF(I)+CFS(I)                                              MAN32240
C                                                                       MAN32250
C       EACH INTEGRAL IS REPRESENTED BY THREE PARTS, CØRRESPØNDING TØ   MAN32255
C          1. THE CØNTRIBUTIØN ØF THE LINEARIZED PRESSURE CØEFFICIENT   MAN32260
C          2. QUADRATIC TERMS INVØLVING RADIAL DERIVATIVES              MAN32262
C          3. QUADRATIC TERMS INVØLVING AXIAL DERIVATIVES               MAN32264
C       HERE THEY ARE CØMBINED AND MULTIPLIED BY THE SUITABLE CØNSTANT TØ MAN32270
C       ØBTAIN THE STANDARD FØRMS FØR THE CØEFFICIENT.                  MAN32280
C                                                                       MAN32290
   35   CØN=2.0/(RBASE*RBASE)                                           MAN32300
        CN=CØN*(CF(1)+CF(2)+BETA2*CF(3))                                MAN32310
        CM=CØN/RBASE*(CF(4)+CF(5)+BETA2*CF(6))*.5                       MAN32320
        CQ1=CØN*(CF(7)+CF(8)+BETA2*CF(9))                               MAN32330
        CQ2=CØN*(CF(10)+CF(11)+BETA2*CF(12))                            MAN32340
        CQ3=CØN*(CF(13)+CF(14)+BETA2*CF(15))                            MAN32350
        CQ4=CØN*(CF(16)+CF(17)+BETA2*CF(18))                            MAN32360
        CNA=CN/ALFA                                                     MAN32370
        CMA=CM/ALFA                                                     MAN32380
        IF(CN)37,36,37                                                  MAN32390
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36    CP = 0.0                                                          MAN32400
      GØ TØ 38                                                          MAN32410
37    CP = CM/CN                                                        MAN32420
38    XGUST = UPSTRM*TF                                                 MAN32430
      CALL LNCNT(1,KKKK)                                                MAN32440
      IF(KKKK)1010,1020,1010                                            MAN32450
1020  CALL LNCNT(2,KKKK)                                                MAN32455
      WRITE(6,1001)                                                     MAN32460
1010  WRITE(6,1002)KK,TF,XSTF,XSTL,XGUST,X2,CNA,CMA,CP                  MAN32470
1002  FØRMAT(I2,F10.6,4F10.4,1P2E15.7,0PF10.4)                          MAN32480
3000  IF(ITAPE-2)3010,3005,3010                                         MAN32490
3005  JSTØR = KØNT + NTCØUN - NT                                        MAN32500
      JSTØR = JSTØR*3                                                   MAN32510
      STØRTF(JSTØR) = TF                                                MAN32520
      STØRCN(JSTØR) = CNA                                               MAN32530
      STØRCM(JSTØR) = CMA                                               MAN32540
3010  IF(KØNT-NT)300,400,400                                            MAN32550
300   TF = TF + DT                                                      MAN32560
      KØNT = KØNT + 1                                                   MAN32570
      TIME = TF                                                         MAN32580
      GØ TØ 10                                                          MAN32590
400   IF(MØRET)410,3050,410                                             MAN32600
410   READ(5,409)TF,DT,NT,MØRET,L2,L3                                   MAN32610
409   FØRMAT(10X,2F10.0,I5,10X,3I5)                                     MAN32620
      TIME = TF                                                         MAN32630
      KØNT = 1                                                          MAN32640
      NTCØUN = NTCØUN + NT                                              MAN32650
      NDIMAX = (NTCØUN+1)*3                                             MAN32660
      IF(NDIM-NDIMAX)5050,10,10                                         MAN32670
3050  IF(ITAPE-2)4050,3060,4050                                         MAN32680
3060  IF(KK-5)3065,3070,3070                                            MAN32690
3065  NT3 = NTCØUN*3                                                    MAN32700
      FSTEDY(1) = STØRCN(NT3)                                           MAN32710
      FSTEDY(2) = STØRCM(NT3)                                           MAN32720
      KNT=1                                                             MAN32730
      NR = NLAST+1                                                      MAN32740
      DØ 3068 I=1,NR                                                    MAN32750
      IF(KTYPE(I)-1)3068,3067,3068                                      MAN32760
3067  XTEST(KNT) = X(I)                                                 MAN32770
      RTEST(KNT) = R(I)                                                 MAN32780
      KNT = KNT+1                                                       MAN32790
3068  CØNTINUE                                                          MAN32800
      NTEST = KNT                                                       MAN32810
      XTEST(NTEST) = X(NLAST+1)                                         MAN32820
      RTEST(NTEST) = R(NLAST+1)                                         MAN32830
C     ARBITRARY VALUE ØF XF USED ØNLY TØ PRESERVE FØRM ØF FIRST RECØRD  MAN32840
C     ØF BINARY TAPE 11.                                                MAN32850
      XF = X(NLAST+1)                                                   MAN32860
C     WRITE FIRST RECØRD ØN BINARY TAPE ØF TØTAL FØRCES.                MAN32870
3070  WRITE(11)ITAPE,IDBØDY,EM,UPSTRM,XF,KK,NTCØUN,(FSTEDY(I),I=1,2),   MAN32880
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)                               MAN32890
      NTCØUN = NTCØUN+1                                                 MAN32900
      NT3 = NTCØUN*3                                                    MAN32910
C     ARTIFICIAL TIME VALUE - INDICATES END ØF THIS BLØCK ØF VALUES FØR MAN32920
C     A SPECIFIC KK VALUE.                                              MAN32930
      STØRTF(NT3) = 1000.                                               MAN32940
      DØ 3080 L = 1,NTCØUN,IMAX                                         MAN32950
3080  CALL BINTAP(2,WRD1(1,L))                                          MAN32960
4050  NTCØUN = 0                                                        MAN32970
      IF(ISHØRT-1)4055,4057,4055                                        MAN32975
4055  IF(KCØDE)900,4059,100                                             MAN32980
4057  KK = 5                                                            MAN32982
      ISHØRT = 2                                                        MAN32984
      TF=TSAVE                                                          MAN32985
      GØ TØ 5004                                                        MAN32986
4059  IF(ITAPE-2)900,4060,900                                           MAN32988
4060  ITAPE = -ITAPE                                                    MAN32990
      WRITE(11)ITAPE,IDBØDY,EM,UPSTRM,XF,KK,NTCØUN,(FSTEDY(I),I=1,2),   MAN33000
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)                               MAN33010
      END FILE 11                                                       MAN33020
      REWIND 11                                                         MAN33030
      CALL LNCNT(7,KKKK)                                                MAN33032
      WRITE(6,9900)                                                     MAN33034
9900  FØRMAT(//5X,95(1H*)//10X51HTHE END ØF FILE HAS BEEN WRITTEN ØN BINMAN33036
     1ARY TAPE 11.//5X,95(1H*))                                         MAN33038
900   RETURN                                                            MAN33040
      END                                                               MAN33050
```

```
      SUBROUTINE BINTAP(ITAPE,WRD1)
C     WRITES TIME PLUS COEFFICIENTS ØN BINARY TAPE IN BLØCKS ØF
C     IMAX PØINTS.
      DØUBLE PRECISIØN WRD1(3,40)
      GØ TØ (35,65),ITAPE
   35 WRITE (8) WRD1
      GØ TØ 400
   65 WRITE (11) WRD1
      GØ TØ 400
  400 RETURN
      END

      SUBRØUTINE INTGRL (XLØWER,XUPPER,KSTEDY,LØPT2,LØPT3)
C
C     THIS RØUTINE CØMPUTES THE GENERALIZED FØRCE INTEGRALS ØVER THE
C     SURFACE ØF THE SPACE VEHICLE, BETWEEN THE LIMITS XLØWER AND
C     XUPPER.  A SIMPSØNS RULE IS USED WHENEVER PØSSIBLE (WHEN THE
C     INTEGRAND IS SMØØTH BETWEEN 3 EQUALLY  SPACED PØINTS.  ØTHERWISE,
C     A TRAPAZØIDAL RULE IS USED.  KSTEDY = 1 FØR A STEADY STATE
C     INTEGRATIØN, AND = 0 FØR THE TRANSIENT CASE.
C
C
C     LØPT2 AND LØPT3 DENØTE ØPTIØNS FØR VARIØUS ØUTPUT DATA.
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),
     2UAS(300),VAS(300)
     3,WRD1(3,300),CNA,CMA
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,
     1CNA,CMA,WRD1,
     2RBASE,UAS,VAS,KTYPE(150),NLAST
      DØUBLE PRECISIØN BLANK(4),XSP(31),BLANK2(4)
      DØUBLE PRECISIØN        XJP1,XLØWER,VHP1,DJ,UT,XX,RJP1,UAJP1,
     1VAJP1,UC,VC,XUPPER,VHP2,XJP2,RJP2,UAJP2,VAJP2,DJP1,XJ,RJ,DJM1,UAJ,
     2VAJ,VH,CØN,UCJ,VCJ,TERM1,PHTJ,TERM2,TERM3
C     INITIALIZATIØN
C
      NN=NLAST+1
      XJP1=XLØWER
      VHP1=VZERØ
      LØCATN=5
      JUMP=0
      DJ=0.
      UT=X(NLAST+1)+1.
      DØ 100 I=1,18
  100 CF(I)=0.
C
C     LØCATN = 1      X IS LØWER LIMIT
C              2      X IS AN INTERMEDIATE VALUE
C              3      X IS LØWER LIMIT, NEXT X IS UPPER LIMIT
C              4      NEXT X IS UPPER LIMIT
C              5      X IS UPPER LIMIT  (EXCEPT DURING INITIALIZATIØN)
C
C     JUMP = 1 AT A DISCØNTINUITY
C     UT IS LØCATIØN ØF GUST FRØNT
C     VH IS VZERØ TIMES THE UNIT STEP  H(U*T-X)
C
      IF(KSTEDY)500,500,1000
C
C     SPECIAL INITIALIZATIØN FØR TRANSIENT INTEGRATIØNS
C
  500 UT=UPSTRM*TIME
      I1=1
C
C     CØMPUTE SPECIAL PØINTS, XSP, AT INTERSECTIØN ØF CIRCLES ASSØCIATED
C     WITH CØRNER SØLUTIØNS AND SPACE VEHICLE SURFACE.
C
      DØ 600 I=2,NN
      IF(KTYPE(I)-1)600,610,600
  610 CALL PØINTS(I,XSP(I1),XSP(I1+1),KØDE)
      IF(KØDE)700,700,620
  620 I1=I1+KØDE
  600 CØNTINUE
C
C     REARRANGE THE XSPS INTØ AN INCREASING SEQUENCE.
C
  700 XSP(I1)=X(NN)+1.
 8000 CØNTINUE
```

```
      I1=I1-1
      IF(I1-1)900,900,710
  710 ILAST=I1-1
      DØ 800 I=1,ILAST
      J1=I+1
      DØ 800 J=J1,I1
      IF(XSP(I)-XSP(J))800,800,810
  810 XX=XSP(I)
      XSP(I)=XSP(J)
      XSP(J)=XX
  800 CØNTINUE
  900 LISTNØ=1
      IF (LØPT3)80,90,80
   80 WRITE (6,89) (XSP(J),J=1,I1)
   89 FØRMAT(1H0/(F10.6))
   90 CØNTINUE
C
C     LØCATE INITIAL CØNTRØL PØINT SUCH THAT X(N) .LE. XJP1 .LT. X(N+1)
C     ALSØ FIND NINDEX.  ØDD VALUES ØF NINDEX REFER TØ CØNTRØL PØINTS
C     AND EVEN VALUES TØ MIDPØINTS.
C
 1000 DØ 1100 N=1,NN
      IF(X(N)-XJP1)1100,1200,1300
 1100 CØNTINUE
C
C     XLØWER PAST END ØF BØDY.
C
      CALL ERRØR
 1300 IF((X(N)+X(N-1))/2.-XJP1)1400,1400,1500
 1200 N=N+1
 1500 NINDEX=2*N-3
      GØ TØ 1600
 1400 NINDEX=2*N-2
 1600 N=(NINDEX+1)/2
      RJP1=R(N)+(XJP1-X(N))*RP(N)
      CALL UANCV(XJP1,RJP1,UAJP1,VAJP1,UC,VC)
C
C     THE NEXT SECTIØN, WITH NUMBERS IN THE 2000S, CØMPUTES THE (J+2) TH
C     PØINT TØ BE USED IN THE INTEGRATIØN. KJP2 IS 0 IF THE INTEGRAND
C     IS SMØØTH AT THIS PØINT, AND IS A MIDPØINT.
C
C     THE QUANTITIES XJP2,RJP2,UAJP2,VAJP2,KJP2,AND DJP1 ARE CØMPUTED.
C
C     N,NINDEX,JUMP,AND LØCATN MAY BE CHANGED.
C
 2000 IF(XJP1-XUPPER)2100,2050,2050
 2050 LØCATN=LØCATN+2
C
C     END ØF THE LINE - - -
C
      GØ TØ 2900
 2100 KJP2=1
      VHP2=VHP1
      IF(JUMP)2300,2300,2200
 2200 JUMP=0
      IF(XJP1-UT)2240,2220,2240
C
C     END ØF THE GUST
C
 2220 XJP2=XJP1
      VHP2=0
      UT=X(NN)+1.
      GØ TØ 2700
C     JUST AFT ØF A SHØULDER
C
 2240 XJP2=X(N)
      N=N+1
      NINDEX=NINDEX+2
      GØ TØ 2600
 2300 NINDEX=NINDEX+1
      KØRNER=0
      N=(NINDEX+1)/2
      IF((NINDEX/2)*2-NINDEX)2340,2320,2340
C
C     NINDEX IS EVEN.  - MIDPØINT-
C
 2320 KJP2=0
      XJP2=(X(N)+X(N+1))/2.
      GØ TØ 2400
```

```
C
C     NINDEX IS ØDD    - CØNTRØL PØINT -
C
 2340 IF(KTYPE(N)-1)2360,2380,2360
 2360 XJP2=X(N)
      GØ TØ 2400
C
C     NINDEX IS ØDD   - SHØULDER CØNTRØL PØINT -
C
 2380 KØRNER=1
      XJP2=X(N)-2.*XI(N)*(1.-EPS)
 2400 IF(KSTEDY)2420,2500,2420
 2420 IF(KØRNER)2440,2600,2440
 2440 JUMP=1
      GØ TØ 2700
C
C     CHECK FØR GUST FRØNT (UT) AND SPECIAL XS (XSP)
C
 2500 IF(XJP2-UT)2520,2540,2540
 2520 IF(XJP2-XSP(LISTNØ))2420,2560,2560
 2540 XJP2=UT
      JUMP=1
      GØ TØ 2580
 2560 XJP2=XSP(LISTNØ)
      LISTNØ=LISTNØ+1
 2580 NINDEX=NINDEX-1
      KJP2=1
      N=(NINDEX+1)/2
      GØ TØ 2700
C
C     CHECK TØ SEE IF UPPER LIMIT IS REACHED
C
 2600 IF(XJP2-XUPPER)2620,2620,2800
 2620 RJP2=R(N)+(XJP2-X(N))*RP(N)
      UAJP2=UAS(NINDEX)
      VAJP2=VAS(NINDEX)
      GØ TØ 2780
 2700 IF(XJP2-XUPPER)2720,2720,2800
 2720 RJP2=R(N)+(XJP2-X(N))*RP(N)
      CALL UANDV(XJP2,RJP2,UAJP2,VAJP2,UC,VC)
 2780 DJP1=XJP2-XJP1
 2900 GØ TØ (4000,4000,4000,4000,3000,2920,2920),LØCATN
C
C     RANGE ØF INTEGRATIØN IS NEGATIVE ØR ZERØ
C
 2920 CALL ERRØR
C
C     UPPER LIMIT DETECTED.
C
 2800 XJP2=XUPPER
      IF(XJP2-X(N))2820,2720,2720
 2820 N=N-1
      GØ TØ 2720
C
C     THIS SEGMENT UPDATES THE VARIABLE ØF INTEGRATIØN.
C
 3000 XJ=XJP1
      XJP1=XJP2
      RJ=RJP1
      RJP1=RJP2
      DJM1=DJ
      DJ=DJP1
      KJP1=KJP2
      UAJ=UAJP1
      UAJP1=UAJP2
      VAJ=VAJP1
      VAJP1=VAJP2
      VH=VHP1
      VHP1=VHP2
      GØ TØ (3100,2000,3300,3300,3500),LØCATN
 3100 LØCATN=2
      GØ TØ 2000
 3300 LØCATN=5
      GØ TØ 4000
 3500 LØCATN=1
      GØ TØ 2000
```

```
C
C     THIS SEGMENT (4000S) DETERMINES THE MØDE ØF INTEGRATIØN FØR THE
C     NEXT STEP, AND THE MULTIPLYING CØNSTANT FØR THE PRESENT STEP.
C
C     MØDE = 1        TRAPAZØIDAL
C            2        SIMPSØN S (END PØINT)
C            3        SIMPSØN S (MIDPØINT)
C
 4000 CØN=0.
      GØ TØ (4100,4200,4300,4200,4200),LØCATN
 4100 IF(DABS(DJ-DJP1) - .000001 *DJ)4110,4110,4300
 4110 IF(KJP1)4300,4120,4300
 4120 MØDE=3
      CØN=2.*DJ+CØN
      GØ TØ 5000
 4300 MØDE=1
      CØN=3.*DJ+CØN
      GØ TØ 5000
 4200 IF(MØDE-2)4210,4220,4230
 4210 CØN=3.*DJM1
 4240 GØ TØ (4900,4100,4900,4300,5000),LØCATN
 4220 CØN=2.*DJM1
      GØ TØ 4240
 4230 MØDE=2
      CØN=8.*DJ
      GØ TØ 5000
 4900 CALL ERRØR
C
C     CØMPUTE THE INTEGRANDS
C
 5000 CØNTINUE
C
C
C     ******************************************************************
C
C     ADD A SECTIØN HERE TØ CØMPUTE THE PRESENT VALUE ØF THE MØDE SHAPES
C     Y1,Y2,Y3,AND Y4.
C
C     ******************************************************************
C
      IF(KSTEDY)5100,5200,5100
 5100 CALL UANDV(XJ,RJ,UAJ,VAJ,UCJ,VCJ)
      TERM1=CØN*(-UCJ)*RJ
      GØ TØ 5300
 5200 CALL UTANVT(XJ,RJ,D,UCJ,VCJ,PHTJ)
      TERM1=CØN*(PHTJ-UCJ)*RJ
 5300 TERM2=-CØN*VAJ*(VCJ+VH)*RJ
      TERM3=CØN*UAJ*UCJ*RJ
      CF(1)=CF(1)+TERM1
      CF(2)=CF(2)+TERM2
      CF(3)=CF(3)+TERM3
      CF(4)=CF(4)+TERM1*XJ
      CF(5)=CF(5)+TERM2*XJ
      CF(6)=CF(6)+TERM3*XJ
C
C     ******************************************************************
C
C     ADD SECTIØN HERE TØ UPDATE CF(7) ---CF(18)
C
C     ******************************************************************
C
C     FØLLØWING SECTIØN IS A TEMPØRARY TEST SECTIØN
C
      IF (LØPT2)5310,5320,5310
 5310 WRITE (6,5319)XJ,RJ,DJ,CØN,TERM1,TERM2,TERM3
 5319 FØRMAT(15H INTGRL TEST.   7E15.7)
 5320 CØNTINUE
      IF(LØCATN-5)3000,5400,5400
 5400 DØ 5500 I=1,18
 5500 CF(I)=CF(I)/6.
      RETURN
      END
```

```
      SUBROUTINE UTANVT(XXX,RRR,LØPT1,UCT,VCT,DPHITU)
C
C     CØMPUTES VELØCITY CØMPØNENTS AT A PØINT ØN THE SURFACE (TRANSIENT)
C     ALSØ CØMPUTES THE CØMPØNENT, THE RECIPRØCAL ØF THE UPSTREAM
C     VELØCITY, U,TIMES THE PARTIAL DERIVATIVE ØF PHI WITH RESPECT TØ T.
C     LØPT1 IS USED FØR ØPTIØNAL ØUTPUT DATA.
C
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,
     1CF(13),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),
     2UAS(300),VAS(300)
     3,WRD1(3,300),CNA,CMA
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,
     1CNA,CMA,WRD1,
     2RBASE,UAS,VAS,KTYPE(150),NLAST
      DØUBLE PRECISIØN XX,XXX,RR,RRR,TT,SUMXC,SUMRC,SUMPT,XNR,TM,CØN,
     1UTMR,UTMR2,XUTR,XUTR2,RØØT,RØØT32,CHIR,PSIXC,PSIRC,DPHI,ARG,F,E,
     2C1,UA,VA,UC,VC,UCT,VCT,DPHITU,RØOSQ,RØO,ARG1,ARG2,CHIRSR,RØC,FI,
     3EI,SINPHI,CHIR2,XCHIR
      XX=XXX
      RR=RRR
      TT=TIME
      IF(XX)200,2,3
    2 XX=1.-EPS
      RR= XX*RP(1)
      GØ TØ 3
  200 CALL ERRØR
      GØ TØ 31
    3 SUMXC=0.0
      SUMRC=0.0
      SUMPT=0.0
C
C     THE FØLLØWING LØØP INDEXES ØVER ALL SØURCES SØ THAT THE
C     CØNTRIBUTIØN ØF EACH TØ THE TØTAL CAN BE FØUND.
C
      DØ 25 K=1,NLAST
      XNR=(XX-XI(K))/RR
      TM=TT-T(K)
      CØN=1.0
C
C     JUMP ØUT ØF LØØP IF TM IS NEGATIVE - NØ FURTHER
C     CØNTRIBUTIØNS CAN BE FØUND.
C
      IF(TM)30,30,10
   10 IF(XNR/BETA-1.0)41,11,11
C
C     NREG=1,2,3,4,5 CØRRESPØND TØ REGIØNS A,B,C,D AND E, RESPECTIVELY.
C
   41 NREG=1
      GØ TØ 26
C
C     CØMPUTE QUANTITIES NEEDED FØR REGIØNS B, C, D.
C
   11 UTMR=UPSTRM*TM/RR
      UTMR2=UTMR*UTMR
      XUTR=XNR-UTMR
      XUTR2=XUTR*XUTR
      RØØT = DSQRT(XUTR2+1.0)
      RØØT32=RØØT*(XUTR2+1.0)
      CHIR=UTMR-EM*RØØT
      IF(CHIR)12,14,14
   12 IF(XNR-UTMR+(1.0/BETA))13,13,42
C
C     REGIØN E.  NØ FURTHER CØNTRIBUTIØNS CAN BE FØUND.
C
   42 NREG=5
   26 PSIXC=0.0
      PSIRC=0.0
      DPHI=0.0
      IF (LØPT1)23,30,23
   23 CALL LNCNT(1,KKKK)
      WRITE(6,900)K,NREG,XX,RR,TT,PSIXC,PSIRC,DPHI
      GØ TØ 30
   13 NREG=2
      IF(K-1)9,9,5
    5 IF(KTYPE(K)-1)6,9,60
C
C     LINEAR TYPE ØF SØLUTIØN IN REGIØN B.
C
    9 RØØT = DSQRT(XNR*XNR-BETA2)
      ARG=XNR/BETA
      CØN=1.0/BETA2
      PSIXC=-2.0*RØØT
      PSIRC=XNR*RØØT+BETA2*ARCØSH(ARG)
      DPHI=0.0
      GØ TØ 20
C
C     CØNE SØLUTIØN IN REGIØN B.
C
    7 ARG=(XNR-BETA)/(XNR+BETA)
      RØØT = DSQRT(XNR+BETA)
      CØN = 0.5/(BETA*DSQRT(RR))
```

```
      CALL COMELL(ARG,F,E)
      C1=BETA/(XNR+BETA)
      PSIXC=-3.0*R00T*(E-C1*F)
      PSIRC=R00T*2.0*XNR*(E-C1*F)+R00T*BETA*C1*F
      DPHI=0.0
      G0 T0 20
C
C     EQUATI0NS F0R TYPE 2 S0LUTI0N (QUADRATIC TYPE) IN REGI0N B.
C
   60  R00T = DSQRT (XNR*XNR-BETA2)
      C0N=RR/BETA2
      ARG=XNR/BETA
      PSIXC=3.0*BETA2*ARC0SH(ARG)-3.0*XNR*R00T
      PSIRC=3.0*BETA2*XNR*ARC0SH(ARG)+(XNR*XNR-4.0*BETA2)*R00T
      DPHI=0.0
      G0 T0 20
C
C     THIS IS A SPECIAL SITUATI0N IN WHICH THE P0INT IN QUESTI0N
C     HAS REACHED ITS STEADY STATE VALUES.
C
    9 CALL UANDV(XX,RR,UA,VA,UC,VC)
      UCT=UC
      VCT=VC
      DPHITU=0.0
      IF (L0PT1) 50,31,50
   50 CALL LNCNT(1,KKKK)
      WRITE (6,900) K,NREG,XX,RR,TT,UCT,VCT,DPHITU
      G0 T0 31
   14 R00SQ=XNR*XNR-BETA2
       R00 = DSQRT (R00SQ)
      ARG1=XNR/BETA
      ARG2=(XNR-CHIR)/BETA
C
C     THE F0LL0WING IF STATEMENT C0RRECTS F0R ARG2 BEING SLIGHTLY
C     LESS THAN 0NE WHICH W0ULD GIVE AN IMP0SSIBLE VALUE F0R
C     THE ARGUMENT 0F ARC0SH.
C
      IF (ARG2 - 1.0) 400,410,410
  400 ARG2 = ARG2 + .000001
  410 IF(KTYPE(K)-1)15,17,65
C
C     LINEAR TYPE 0F S0LUTI0N, REGI0NS C AND D.
C
   15 C0N=0.5/BETA2
      PSIXC=R00T-2.0*R00+R00SQ/R00T-(UTMR2*XUTR2/R00T32)
      PSIRC=XNR*R00+(CHIR-XUTR*R00SQ)/R00T-(UTMR*(XNR*XUTR+1.0))/R00T32
     1+BETA2*ARC0SH(ARG1)+BETA2*ARC0SH(ARG2)
      DPHI=-EM2/R00T+UTMR2/R00T32
      IF(XNR-UTMR+(1.0/BETA))43,16,16
   43 NREG=3
      G0 T0 20
   16 PSIRC=PSIRC-2.0*BETA2*ARC0SH(ARG2)
      NREG=4
      G0 T0 20
C
C     C0RNER S0LUTI0N, REGI0NS C AND D.
C
   17 CHIRSR = DSQRT(CHIR)
      ARG=(XNR-BETA)/(XNR+BETA)
       R0C = DSQRT(XNR+BETA)
      C1=BETA/(XNR+BETA)
       C0N = 0.25D0/(BETA*DSQRT(RR))
      CALL C0MELL(ARG,F,E)
      SINPHI = CHIRSR/DSQRT(XNR-BETA)
      CALL INCELL(SINPHI,ARG,FI,EI)
      PSIXC=-3.0*R0C*(EI-C1*FI)+CHIRSR*(XUTR2*3.0*XUTR+XNR*3.0-CHIR)
     1/R00T32
      PSIRC=R0C*(2.0*XNR*(EI-C1*FI)+BETA*C1*FI)-CHIRSR*(2.0*XNR*XUTR2*
     1XUTR+XUTR*(XNR+4.0*UTMR-CHIR)-1.0)/R00T32
      DPHI=CHIRSR*(3.0*UTMR-CHIR)/R00T32
      IF(XNR-UTMR+(1.0/BETA))19,44,44
   44 NREG=4
      G0 T0 20
   19 PSIXC=PSIXC+6.0*R0C*(EI-E+C1*(F-FI))
      PSIRC=PSIRC+4.0*R0C*XNR*(E-EI+C1*(FI-F))+2.0*R0C*BETA*C1*(F-FI)
      NREG=3
      G0 T0 20
C
C     EQUATI0NS F0R TYPE 2 S0LUTI0N (QUADRATIC TYPE),REGI0NS C AND D.
C
   65 C0N=RR*0.5/BETA2
      CHIR2=CHIR*CHIR
      XCHIR=XNR-CHIR
      PSIXC=3.0*BETA2*(ARC0SH(ARG1)+ARC0SH(ARG2))
      PSIRC=PSIXC
      PSIXC=PSIXC-3.0*XNR*(R00-R00T)-CHIR*(3.0*UTMR*(CHIR-UTMR)-CHIR2)
     1 /R00T32-3.0*(BETA2*CHIR-XNR*UTMR*XUTR)/R00T
      PSIRC=PSIRC*XNR+(R00SQ-3.0*BETA2)*(R00-EM*XCHIR+BETA2*R00T) -
     1 CHIR*(XNR*(XNR*XUTR+1.0)-2.0*CHIR)/R00T-CHIR2*(XUTR*3.0*UTMR-2.0
     2 *XUTR*CHIR)/R00T32
      DPHI=CHIR2*(3.0*UTMR-2.0*CHIR)/R00T32
      IF(XNR-UTMR+(1.0/BETA))66,67,67
   66 NREG=3
      G0 T0 20
   67 NREG=4
      PSIXC=PSIXC-6.0*BETA2*ARC0SH(ARG2)
      PSIRC=PSIRC-6.0*BETA2*XNR*ARC0SH(ARG2)
```

```
   20 IF (LØPT1)21,22,21
   21 CALL LNCNT(1,KKKK)
      WRITE(6,900)K,NREG,XX,RR,TT,PSIXC,PSIRC,DPHI
  900 FØRMAT( 7H SØURCE,I4, 7H REGIØN,I2, 9H LØCATIØN, F10.4,F10.5,F10.6
     1, 5H PSIX,1PE15.7,5H PSIR,1PE15.7,5H PHIT,1PE15.7)
   22 SUMXC=SUMXC+C(K)*PSIXC*CØN
      SUMRC=SUMRC+C(K)*PSIRC*CØN
      SUMPT=SUMPT+C(K)*DPHI*CØN
   25 CØNTINUE
   30 UCT=-SUMXC
      VCT=-SUMRC
      DPHITU=-SUMPT
   31 RETURN
      END

      SUBRØUTINE UANDV(XXX,RRR,UA,VA,UC,VC)
C     CØMPUTES VELØCITY CØMPØNENTS AT A PØINT ØN THE SURFACE (STEADY)
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),
     2UAS(300),VAS(300)
     3,WRD1(3,300),CNA,CMA
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,
     1CNA,CMA,WRD1,
     2RBASE,UAS,VAS,KTYPE(150),NLAST
      DØUBLE PRECISIØN XX,XXX,RR,RRR,BR,SUMXA,SUMRA,SUMXC,SUMRC,TR,
     1PSIXA,PSIRA,PSIXC,PSIRC,TT,RØØT,TTP1,ARG,F,E,TRBR,BETA1,RØØT1,UA,
     2VA,UC,VC
      XX=XXX
      RR=RRR
      IF (XX)650,90,91
  650 CALL ERRØR
      GØ TØ 2001
   90 XX=1.-EPS
      RR=XX*RP(1)
   91 BR=BETA*RR
      SUMXA=0.
      SUMRA=0.
      SUMXC=0.
      SUMRC=0.
C
C     INDEX ØVER ALL SØURCES, TØ GET THE CØNTRIBUTIØN FRØM EACH.
C
      DØ 1000 K=1,NLAST
      TR=(XX-XI(K))/BR
C
C     IF TR IS NEGATIVE THERE IS NØ FURTHER CØNTRIBUTIØN.(ALL
C     REMAINING SØURCES YIELD REGIØN A SØLUTIØNS).
C
      IF(TR-1.)2000,100,100
  100 IF(KTYPE(K)-1)200,300,250
C
C     LINEAR TYPE SØLUTIØN
C
  200 PSIXA=ARCØSH(TR)
      PSIRA = DSQRT(TR*TR-1.)
      PSIXC=-2.*PSIRA/BETA
      PSIRC=PSIRA*TR+PSIXA
      PSIRA=-BETA*PSIRA
      GØ TØ 400
C
C     CØRNER SØLUTIØN
C
  300 TT=1./TR
      RØØT = DSQRT (XX-XI(K)+BR)
      TTP1=TT+1.
      ARG=(1.-TT)/(TTP1)
      CALL CØMELL(ARG,F,E)
      PSIXA=F/RØØT
      PSIRA=TR/RØØT*((TTP1)*E-TT*F)
      PSIXC=-1.5*PSIRA
      PSIRA=-BETA*PSIRA
      PSIRC=BETA/TT*RØØT/BR*(E-TT/(TTP1)*(2.-TT)/2.*F)
      GØ TØ 400
C
C     QUADRATIC TYPE SØLUTIØN
C
  250 TRBR=(XX-XI(K))
      BETA1=BETA*TRBR
      TT=1./TR
      PSIXA=ARCØSH(TR)
      RØØT1 = DSQRT(1.-TT*TT)
      PSIRA=BETA1*(TT*PSIXA-TR*RØØT1)
      PSIRC=BETA*BETA1*(3.*PSIXA+(1.-4.*TT*TT)/(TT*TT)*RØØT1)/BETA2
      PSIXA=2.*TRBR*(PSIXA-RØØT1)
      PSIXC=3.*PSIRA/BETA2
  400 SUMXA=SUMXA+A(K)*PSIXA
      SUMRA=SUMRA+A(K)*PSIRA
      SUMXC=SUMXC+C(K)*PSIXC
      SUMRC=SUMRC+C(K)*PSIRC
 1000 CØNTINUE
 2000 UA=-SUMXA
      VA=-SUMRA
      UC=-SUMXC
      VC=-SUMRC
 2001 RETURN
      END
```

```
      SUBRØUTINE CØMELL(CAYS,CK,CE)
C     CØMELL CØMPUTES THE CØMPLETE ELLIPTIC INTEGRALS ØF THE FIRST AND
C     SECØND KINDS,F(K) AND E(K) FØR THE INPUT VALUE ØF K SQUARED.
C     HASTING,S APPRØXIMATIØNS ARE USED.
      DØUBLE PRECISIØN CAY1,CAYS,CAYSP,CK1,CE1,XLN,CE,CK
      CAY1=CAYS
      CAYSP=1.0-CAY1
      IF(CAY1)20,4,5
    5 IF(CAYSP)20,6,7
    6 CK1=0.0
      CE1=1.0
      GØ TØ 19
   20 CALL ERRØR
      GØ TØ 21
    4 CK1=1.57079633
      CE1=CK1
      GØ TØ 19
    7 XLN = -DLØG(CAYSP)
      CK1=(((.0145119621 *CAYSP+.0374256371 )*CAYSP+.0359009238 )*CAYSP+
     1.0966634426 )*CAYSP+1.38629436    +((((.004417870I2*CAYSP+.03328355
     235 )*CAYSP+.0688024858 )*CAYSP+.124985936  )*CAYSP+.5)*XLN
    9 CE1=(((.0173650645 *CAYSP+.0475738355 )*CAYSP+.0626060122 )*CAYSP
     1+.443251415  )*CAYSP+1.0+((((.00526449639*CAYSP+.0406969753 )*
     2CAYSP+.0920C18004 )*CAYSP+.249983683  )*CAYSP)*XLN
   19 CE=CE1
      CK=CK1
   21 RETURN
      END
```

```
      SUBRØUTINE INCELL(SINPHI,CAYS,F,E)
C
C     SUBRØUTINE CØMPUTES THE INCØMPLETE ELLIPTIC INTEGRALS ØF THE
C     FIRST AND SECØND KINDS, F(K,PHI) AND E(K,PHI), FØR
C     THE INPUT VALUES ØF SIN(PHI) AND K SQUARED.
C     LANDEN-S TRANSFØRMATIØNS ARE USED.
C
      DØUBLE PRECISIØN SINPO,SINPHI,CØSPO,CAYO,CAYS,CAYSP,CAYSRO,FI,EI,
     1F,E,TANP,XN,P2,PRØF1,PRØE1,PRØE2,SUM1,SUM2,CAYP,TANEP,PHIEP,CAY,
     7PHI,SINP,CAYSR,SINSQ
      SINPO=SINPHI
      CØSPO = DSQRT (1.0 - SINPO*SINPO)
      CAYO=CAYS
      CAYSP=1.0-CAYO
      CAYSRO =DSQRT  (CAYO)
C
C     STATEMENTS 49 TØ 57 ARE SPECIAL CASES GIVING KNØWN VALUES FØR F,E.
C
      IF(SINPO)50,49,51
   49 FI=0.0
      EI=0.0
      GØ TØ 90
   50 CALL ERRØR
      GØ TØ 91
   51 IF(SINPO-1.0)53,52,50
   52 CALL CØMELL(CAYO,F,E)
      GØ TØ 91
   53 IF(CAYO)50,54,55
   54 FI = DATAN (SINPO/CØSPO)
      EI=FI
      GØ TØ 90
   55 IF(CAYSP)50,56,57
   56 EI=SINPO
      TANP=(1.0+SINPO)/CØSPO
      FI = DLØG(TANP)
      GØ TØ 90
   57 IF(CAYSRO-0.5)60,85,85
C
C     TRANSFØRMATIØNS USED FØR K SMALL,I.E., K LESS THAN 0.5.
   60 TANP=SINPO/CØSPO
      XN = DATAN (TANP)
      P2=1.0
      PRØF1=1.0
      PRØE1=1.0
      PRØE2=1.0
      SUM1=1.0
      SUM2=0.0
   65 CAYP = DSQRT (CAYSP)
      TANEP=(1.0-CAYP)*TANP/(CAYP*TANP*TANP+1.0)
      PHIEP = DATAN (TANEP)
```

```
 66   XN=XN-0.5*PHIEP/P2                                                IELL1470
      CAY=(1.0-CAYP)/(1.0+CAYP)                                         IELL1480
      IF(CAY-1.L-07)70,70,67                                            IELL1490
 67   P2=2.0*P2                                                         IELL1500
      PHI=P2*XN                                                         IELL1510
      SINP = DSIN(PHI)                                                  IELL1520
        TANP = SINP/DCØS(PHI)                                           IELL1530
      CAYSR = DSQRT(CAY)                                                IELL1540
      PRØF1=(1.0+CAY)*PRØF1                                             IELL1550
      PRØE1=CAY*PRØE1*0.5                                               IELL1560
      SUM1=SUM1+PRØE1                                                   IELL1570
      PRØE2=CAYSR*PRØE2*0.5                                             IELL1580
      SUM2=SUM2+PRØE2*SINP                                              IELL1590
      CAYSP=(1.0-CAY*CAY)                                               IELL1600
      GØ TØ 65                                                          IELL1610
 70   F1=PRØF1*XN                                                       IELL1612
      E1=F1*(1.0-0.5*CAY0*SUM1)+CAYSR0*SUM2                             IELL1614
      GØ TØ 90                                                          IELL1620
C                                                                       IELL1630
C     TRANSFØRMATIØNS USED FØR K CLØSE TO 1., I.E., K GREATER THAN      IELL1640
C     ØR EQUAL TØ 0.5.                                                  IELL1650
C                                                                       IELL1660
 85    CAYSR = DSQRT(CAYSR0)                                            IELL1670
      PRØF1=1.0/CAYSR                                                   IELL1680
      SUM1=1.0+CAYSR0                                                   IELL1690
      PRØE1=1.0                                                         IELL1700
      PRØE2=2.0/CAYSR                                                   IELL1710
      SUM2=SINP0                                                        IELL1720
      CAY=CAYSR0                                                        IELL1730
      SINSQ=SUM2*SUM2                                                   IELL1740
 86   SINSQ=0.5*((1.0+CAY*SINSQ)-DSQRT((1.0-SINSQ)*(1.0-CAY*CAY*SINSQ)))IELL1750
      SINP = DSQRT(SINSQ)                                               IELL1760
      SUM2=SUM2-PRØE2*SINP                                              IELL1770
      SUM1=SUM1-PRØE1*CAYSR0*2.0                                        IELL1780
      CAY=2.0*CAYSR/(1.0+CAY)                                           IELL1790
      CAYP = DSQRT(1.0-CAY*CAY)                                         IELL1800
      IF(CAYP)50,88,87                                                  IELL1810
 87   CAYSR = DSQRT(CAY)                                                IELL1820
      PRØF1=CAYSR*PRØF1                                                 IELL1830
      SUM1=SUM1+PRØE1*CAYSR0*2.0                                        IELL1840
      PRØE1=(2.0/CAY)*PRØE1                                             IELL1850
      SUM1=SUM1+PRØE1*CAYSR0                                            IELL1860
      SUM2=SUM2+PRØE2*SINP*2.0                                          IELL1870
      PRØE2=(2.0/CAYSR)*PRØE2                                           IELL1880
      GØ TØ 86                                                          IELL1890
 88   TANP = (1.0+SINP)/(DSQRT(1.0-SINP*SINP))                          IELL1900
      F1 = PRØF1*DLØG(TANP)                                             IELL1910
      E1=F1*SUM1-CAYSR0*SUM2                                            IELL1920
 90   F=F1                                                              IELL1930
      E=E1                                                              IELL1935
 91   RETURN                                                            IELL1940
      END                                                               IELL1950

      FUNCTIØN ARCØSH(X)                                                ACSH1000
       DOUBLE PRECISIØN X,ARCCSH,ARCØSH                                 ACSH1010
C     INVERSE HYPERBØLIC CØSINE.                                        ACSH1020
C     IF X IS LESS THAN 1, MESSAGE IS PRINTED AND ARCCSH SET=0.         ACSH1030
C     RØUTINE USES ALØG AND SQRT LIBRARY RØUTINES.                      ACSH1040
      IF(X-1.)998,100,100                                               ACSH1050
100   IF(X-1.E15)200,300,300                                            ACSH1060
200   ARCCSH = DLØG (X+DSQRT(X*X-1.))                                   ACSH1070
 999  ARCØSH=ARCCSH                                                     ACSH1080
      RETURN                                                            ACSH1090
300    ARCCSH = DLØG(2.*X-.5/X)                                         ACSH1100
      GØ TØ 999                                                         ACSH1110
998   ARCCSH=0.                                                         ACSH1120
      WRITE (6,997)                                                     ACSH1130
997   FØRMAT(34H ARGUEMENT ØF ARCCSH LESS THAN ØNE )                    ACSH1140
      CALL ERRØR                                                        ACSH1150
      GØ TØ 999                                                         ACSH1160
      END                                                               ACSH1170
```

```
      SUBROUTINE PØINTS(MM,XX1,XX2,KKØDE)
C
C     THIS SUBRØUTINE CØMPUTES THE VALUES,X1 AND X2, AT WHICH THE
C     MM(SØURCE NUMBER) CIRCLE INTERSECTS THE BØDY SURFACE.
C
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),
     2UAS(300),VAS(300)
     3,WRD1(3,300),CNA,CMA
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,
     1CNA,CMA,WRD1,
     2RBASE,UAS,VAS,KTYPE(150),NLAST
      DØUBLE PRECISIØN TM,UTM,RP2,RØØTSQ,RØØT,X1,X2,XX1,XX2
      M=MM
      TM=TIME-T(M)
      IF(TM)2,3,3
C     KØDE = -1 INDICATES NØ PØINTS ØF INTERSECTIØN ØF THE MM CIRCLE
C     WITH THE BØDY SURFACE.
C
    2 KØDE=-1
      GØ TØ 800
    3 UTM=UPSTRM*TM
      K=M
C
C     KØUNT = 1,2,3,4 ARE USED ØNLY TØ AVØID REPETITIØN IN PRØGRAMMING.
C
      KØUNT = 1
   10 RP2=RP(K)*RP(K)
      RØØTSQ=(UTM*UTM*(1.0+RP2)/EM2)-(RP(K)*(X(K)-XI(M)-UTM)-R(K))*
     1(RP(K)*(X(K)-XI(M)-UTM)-R(K))
      GØ TØ (11,12,25,31,61),KØUNT
   11 IF(RØØTSQ)60,4,4
C
C     KØUNT = 5 DENØTES THE CASE FØR THE EXTERNAL CØRNER (SHØULDER)
C     WHEREIN THE MM CIRCLE DØES NØT INTERSECT THE BØDY SURFACE,
C     BUT THE (MM+1) CIRCLE DØES INTERSECT.
C
   60 KØUNT=5
      K=K+1
      GØ TØ 10
   61 IF(RØØTSQ)2,2,62
   62 RØØT = DSQRT(RØØTSQ)
      X1=(1.0/(1.0+RP2))*(XI(M)+UTM+RP(K)*(RP(K)*X(K)-R(K))-RØØT)
      X2=X1+(2.0/(1.0+RP2))*RØØT
      IF (X1-X(NLAST+1))64,63,63
C
C     KØDE = 0 IMPLIES BØTH VALUES ØF X ARE PAST THE END ØF THE MISSILE.
C
   63 KØDE=0
      GØ TØ 800
   64 IF(X2-X(NLAST+1))65,66,66
C     KØDE=2 SIGNIFIES THERE ARE TWØ INTERSECTIØNS,
C     X1 = SMALLER ØNE AND X2 = LARGER ØNE.
C
   65 KØDE=2
      GØ TØ 800
C
C     KØDE = 1 INDICATES THERE IS ØNLY ØNE PØINT ØF INTERSECTIØN, X1.
C
   66 KØDE=1
      GØ TØ 800
    4 K=NLAST+1
      KØUNT=2
      GØ TØ 10
   12 IF(RØØTSQ)13,14,14
   13 KØDE=2
      GØ TØ 20
   14 RØØT = DSQRT(RØØTSQ)
      X2=(1.0/(1.0+RP2))*(XI(M)+UTM+RP(K)*(RP(K)*X(K)-R(K))+RØØT)
      X1=X2-(2.0/(1.0+RP2))*RØØT
      IF(X2-X(NLAST+1))13,15,15
   15 X2=X(NLAST+1)
      IF(X1-X(NLAST+1))16,17,17
   16 KØDE=1
      GØ TØ 20
   17 X1=X(NLAST+1)
      KØDE=0
      GØ TØ 800
```

```
C     THE FIRST APPRØXIMATIØN FØR X1 IS CØMPUTED.                       PNTS1710
C                                                                       PNTS1720
   20 X1=UTM*(1.0-1.0/EM)+XI(M)                                         PNTS1730
      K=M+1                                                             PNTS1740
   21 IF(X1-X(K))23,22,22                                               PNTS1750
   22 K=K+1                                                             PNTS1760
      GØ TØ 21                                                          PNTS1770
   23 K=K-1                                                             PNTS1780
      KØUNT = 3                                                         PNTS1790
      GØ TØ 10                                                          PNTS1800
   25 IF(RØØTSQ)2,2,50                                                  PNTS1810
   50  RØØT = DSQRT(RØØTSQ)                                             PNTS1820
      X1=(1.0/(1.0+RP2))*(XI(M)+UTM+RP(K)*(RP(K)*X(K)-R(K))-RØØT)       PNTS1830
      K=K+1                                                             PNTS1840
      IF(X1-X(K))26,26,10                                               PNTS1850
   26 IF(KØDE-2)800,27,800                                              PNTS1860
C                                                                       PNTS1870
C     FIRST APPRØXIMATIØN FØR X2                                        PNTS1880
C                                                                       PNTS1890
   27 X2=UTM*(1.0+1.0/EM)+XI(M)                                         PNTS1892
   28 IF(X2-X(K))30,29,29                                               PNTS1894
   29 K=K+1                                                             PNTS1900
      GØ TØ 28                                                          PNTS1910
   30 K=K-1                                                             PNTS1920
      KØUNT=4                                                           PNTS1922
      GØ TØ 10                                                          PNTS1924
   31 IF(RØØTSQ)32,33,33                                                PNTS1926
   32 K=K-1                                                             PNTS1930
      GØ TØ 10                                                          PNTS1940
   33  RØØT = DSQRT(RØØTSQ)                                             PNTS1950
      X2=(1.0/(1.0+RP2))*(XI(M)+UTM+RP(K)*(RP(K)*X(K)-R(K))+RØØT)       PNTS1955
      IF(X2-X(K))34,800,800                                             PNTS1960
   34 K=K-1                                                             PNTS1970
      GØ TØ 10                                                          PNTS1980
  800 XX1=X1                                                            PNTS1990
      XX2=X2                                                            PNTS2000
      KKØDE=KØDE                                                        PNTS2002
   36 RETURN                                                            PNTS2004
      END                                                               PNTS2010

      SUBRØUTINE LNCNT(M,KØDE)                                          LNCT1000
C                                                                       LNCT1010
C     KEEP TRACK ØF LINES AND PAGES, AND PRINT HEADING.                 LNCT1020
C                                                                       LNCT1030
C                                                                       LNCT1040
C     M = 0 TØ INITIALIZE.                                              LNCT1050
C     MAGNITUDE ØF M IS NØ. ØF LINES TØ BE ØUTPUT IN NEXT BLØCK.        LNCT1060
C     M NEGATIVE FØRCES A NEW PAGE.                                     LNCT1070
C     KØDE IS 1 ØN RETURN, UNLESS A NEW PAGE IS STARTED, WHEN KØDE = 0. LNCT1080
C     HEADNG (72 CHAR.) AND PAGE NØ. APPEAR ØN EACH PAGE.               LNCT1090
C                                                                       LNCT1100
      CØMMØN/HEAD/HEADNG(18)                                            LNCT1110
      KØDE=1                                                            LNCT1120
      L=M                                                               LNCT1130
      IF(L)10,60,20                                                     LNCT1140
   60 KNT = 0                                                           LNCT1150
      GØ TØ 30                                                          LNCT1160
   10 L = -L                                                            LNCT1170
      IF(LINES -1)30,20,30                                              LNCT1180
   20 LINES = LINES+ L                                                  LNCT1190
      IF(LINES -54)40,40,30                                             LNCT1200
   30 LINES = L                                                         LNCT1210
      KØDE = 0                                                          LNCT1220
      KNT = KNT+1                                                       LNCT1230
      WRITE(6,50)HEADNG,KNT                                             LNCT1240
      LINES = LINES +1                                                  LNCT1250
   40 RETURN                                                            LNCT1260
   50 FØRMAT(1H1,5X,18A4,20X, 4HPAGE,I4,//)                             LNCT1270
      END                                                               LNCT1280
```

```
      SUBROUTINE ERRØR                                                  ERRR1000
C                                                                       ERRR1010
C     PROVIDES DUMP OF COMMØN AND AN ERRØR TRACE                        ERRR1020
C                                                                       ERRR1030
      DØUBLE PRECISIØN EM,EM2,UPSTRM,VZERØ,TIME,EPS,RBASE,BETA,BETA2,   ERRR1040
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),        ERRR1050
     2UAS(300),VAS(300)                                                 ERRR1060
     3,WRD1(3,300),CNA,CMA                                              ERRR1070
      CØMMØN EM,UPSTRM,VZERØ,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,ERRR1080
     1CNA,CMA,WRD1,                                                     ERRR1090
     2RBASE,UAS,VAS,KTYPE(150),NLAST                                    ERRR1100
      WRITE(6,99)                                                       ERRR1110
 99   FØRMAT(34H1THE ERRØR RØUTINE HAS BEEN CALLED ///)                 ERRR1120
      CALL PDUMP(EM,VAS(300),1,KTYPE(1),NLAST,2)                        ERRR1130
      I=3                                                               ERRR1140
C                                                                       ERRR1150
C     FØLLØWING STATEMENT IS PURPØSELY INCØRRECT SØ AS TØ CAUSE AN      ERRR1160
C     ERRØR TRACE.                                                      ERRR1170
C                                                                       ERRR1180
      GØ TØ (1,2),I                                                     ERRR1190
 1    CALL EXIT                                                         ERRR1200
 2    RETURN                                                            ERRR1210
      END                                                               ERRR1220


      SUBROUTINE RESINP                                                 COMR1000
C     SUBROUTINE RESINP (DECK NAME - COMRES) IS TO BE USED WITH THE     COMR1010
C     MAIN PROGRAM COMTAR.                                              COMR1020
C     SUBROUTINE COMRES, FINTAP, DUHINT, AND QUATAN DO NOT REQUIRE THE  COMR1030
C     SAME COMMON AS COMTAR AND ITS ASSOCIATED SUBROUTINES. RESPONSES   COMR1040
C     WITH CORRESPONDING TIMES ARE STORED ON SCRATCH TAPES.             COMR1050
      DOUBLE PRECISION EM,UPSTRM,VZERO,XF,XTEST(20),RTEST(20),FSTEDY(2),COMR1060
     1CINP(2),COUP(2),CMAG(2),PHANG(2),SUMIN(2),SUMOU(2),AOMEG,AOMF,DAOMCOMR1070
     2,AOML,VLENTH,TERMI,TERMO,ANGLE,THETA,FACT1,FACT2,VBAR,PI,CAY,CAYPICOMR1080
     3,T(300),RES(2,300),WRD1(3,40)                                     COMR1090
      COMMON EM,UPSTRM,VZERO,T,RES,FSTEDY,XF,XTEST,RTEST,AOMEG,         COMR1100
     1KK,NTCOUN,NTEST,ITAPE,IDBODY                                      COMR1110
      COMMON/HEAD/HEADNG(18)                                            COMR1120
      IDIM = 40                                                         COMR1130
      IR = 2                                                            COMR1140
      PI = 3.14159265                                                   COMR1150
 1    READ (5,600)HEADNG                                                COMR1160
 600  FORMAT(18A4)                                                      COMR1170
      CALL LNCNT(0,KKKK)                                                COMR1180
 5    READ(5,605)ITAPE,IDBODY,EM,UPSTRM,VZERO,XF,KK,JCODE               COMR1190
 605  FORMAT(I5,A4,1X,4F15.0,2I2)                                       COMR1200
      VZERO =  VZERO/UPSTRM                                             COMR1210
      IPRIN = 1                                                         COMR1220
C     LOCATE PROPER SECTION OF TAPE                                     COMR1230
 7    CALL FINTAP                                                       COMR1240
      IKON = 0                                                          COMR1250
      IF(IPRIN)10,10,8                                                  COMR1260
 8    LN = NTEST + 5                                                    COMR1270
      CALL LNCNT(LN,KKKK)                                               COMR1280
      WRITE (6,700) IDBODY,EM,UPSTRM,VZERO,NTEST                        COMR1290
 700  FORMAT(2X15HVEHICLE TYPE - ,A4,1H,,4X9HMACH NO. ,F7.3,1H,,4X6HSPEECOMR1300
     1D ,F10.3,1H,,4X10HGUST VEL. ,F10.3,1H,/2X14HNO. OF CORNERS,I4,3H, COMR1310
     2 ,67HVALUES BELOW ARE LOCATED AT THE CORNERS PLUS THE END OF THE VCOMR1320
     3EHICLE//8X1HX,11X1HR/1H )                                         COMR1330
      WRITE (6,701) (XTEST(I),RTEST(I),I=1,NTEST)                       COMR1340
 701  FORMAT(2F12.3)                                                    COMR1350
      IPRIN = 0                                                         COMR1360
 10   IF(ITAPE-1)12,12,14                                               COMR1370
 12   READ (8) WRD1                                                     COMR1380
      GO TO 15                                                          COMR1390
 14   READ (11) WRD1                                                    COMR1400
 15   DO 20 J=1,IDIM                                                    COMR1410
      IF(WRD1(1,J)-900.)17,21,21                                        COMR1420
 17   IKON = IKON+1                                                     COMR1430
      T(IKON) = WRD1(1,J)                                               COMR1440
      RES(1,IKON) = WRD1(2,J)                                           COMR1450
      RES(2,IKON) = WRD1(3,J)                                           COMR1460
 20   CONTINUE                                                          COMR1470
      GO TO 10                                                          COMR1480
 21   DO 1000 J = 1,IR                                                  COMR1490
      DO 1000 N = 1,NTCOUN                                              COMR1500
 1000 RES(J,N) = FSTEDY(J) - RES(J,N)                                   COMR1510
      CALL LNCNT(11,KKKK)                                               COMR1520
      WRITE(6,801)                                                      COMR1530
 801  FORMAT(//)                                                        COMR1540
```

```
      IF(ITAPE-1)22,22,23
22    WRITE(6,702)
702   FORMAT(45X42HL   O  C  A  L     R  E  S  P  O  N  S  E  S)
      GO TO 24
23    WRITE (6,703)
703   FORMAT(45X42HT   O  T  A  L     R  E  S  P  O  N  S  E  S)
24    WRITE (6,704) FSTEDY(1),KK
704   FORMAT(2X18HSTEADY STATE CNA =,1PE14.6,78X18HAERODYNAMIC TYPE =,
     1I3)
      IF(ITAPE-1)201,201,202
201   WRITE(6,705)FSTEDY(2),XF
705   FORMAT(2X18HSTEADY STATE CMA =,1PE14.6,78X13HSTATION (X) =,0PF8.3/
     11H )
      GO TO 203
202   WRITE (6,706)FSTEDY(2)
706   FORMAT(2X18HSTEADY STATE CMA =,1PE14.6/1H )
203   WRITE (6,708)
708   FORMAT(41X7HC   N   A,20X7HC   N   A,17X7HC   M   A,20X7HC   M   A/29X,
     12(5X8HIN PHASE,6X9HOUT PHASE,5X9HMAGNITUDE,4X5HANGLE)/3X5HOMEGA,4X
     21HK,5X7H(K/2PI),2X4HVBAR,2(3X9HCOMPONENT,2X),16X6H(DEG.),4X2(9HCOM
     3PONENT,5X),13X6H(DEG.)/1H )
25    READ(5,610)AOMF,DAOM,AOML,VBAR,VLENTH,MOREOM,IOPT,OP1,OP2,KOMEGA
610   FORMAT(4F15.0,F10.0,5I2)
C     INPUT IS OMEGA (KOMEGA = 1), K (KOMEGA = 2), OR K/2PI (KOMEGA = 3)
      GO TO (310,320,330),KOMEGA
320   AOMF = AOMF*UPSTRM/VLENTH
      DAOM = DAOM*UPSTRM/VLENTH
      AOML = AOML*UPSTRM/VLENTH
      GO TO 310
330   AOMF = PI*AOMF/0.5
      DAOM = PI*DAOM/0.5
      AOML = PI*AOML/0.5
      GO TO 320
310   AOMEG = AOMF
30    CALL DUHINT(OP1,OP2,SUMIN,SUMOU)
40    DO 50 J=1,IR
      TERMI = AOMEG*SUMIN(J)
      CINP(J) = FSTEDY(J)-TERMI
      TERMO = AOMEG*SUMOU(J)
      COUP(J) = VBAR*TERMO/UPSTRM
      CMAG(J) = DSQRT(CINP(J)*CINP(J)+TERMO*TERMO)
      CMAG(J) = DABS(VBAR *CMAG(J)/UPSTRM)
      CALL QUATAN (IOPT,TERMO,CINP(J),THETA,ANGLE)
      PHANG(J) = ANGLE
      CINP(J) = VBAR*CINP(J)/UPSTRM
50    CONTINUE
      CALL LNCNT (1,KKKK)
      IF(KKKK)56,51,56
51    CALL LNCNT(8,KKKK)
      IF(ITAPE-1)52,52,53
52    WRITE (6,702)
      GO TO 54
53    WRITE (6,703)
54    WRITE (6,704) FSTEDY(1),KK
      IF (ITAPE-1) 57,57,58
57    WRITE (6,705)FSTEDY(2),XF
      GO TO 55
58    WRITE (6,706)FSTEDY(2)
55    WRITE(6,708)
56    CAY = AOMEG*VLENTH/UPSTRM
      CAYPI = CAY/PI*0.5 + .00001
      WRITE (6,710)AOMEG,CAY,CAYPI,VBAR,(CINP(J),COUP(J),CMAG(J),
     1PHANG(J),J=1,IR)
710   FORMAT(1XF9.2,2F8.4,F6.2,3(1PE14.6),0PF8.2,   3(1PE14.6),0PF8.2)
      IF(AOMEG - AOML)60,65,65
60    AOMEG = AOMEG+DAOM
      GO TO 30
65    IF(MOREOM)70,70,25
70    WRITE (6,800)
800   FORMAT(1H1)
      CALL LNCNT(0,KKKK)
      IF(JCODE) 5,400,90
90    READ (5,620) XF,KK,JCODE
620   FORMAT(55X,F15.0,2I2)
      GO TO 7
400   RETURN
      END
```

```
      SUBRØUTINE FINTAP
      DØUBLE PRECISIØN EM,UPSTRM,VZERØ,XF,XTEST(20),RTEST(20),FSTEDY(2),
     1CINP(2),CØUP(2),CHAG(2),PHANG(2),SUMIN(2),SUMØU(2),AØMEG,AØMF,DAØMF
     2,AØML,VLENTH,TERMI,TERMØ,ANGLE,THETA,FACT1,FACT2,VBAR,PI,CAY,CAYPI
     3,T(300),RES(2,300),WRD1(3,40)
      CØMMØN EM,UPSTRM,VZERØ,T,RES,FSTEDY,XF,XTEST,RTEST,AØMEG,
     1KK,NTCØUN,NTEST,ITAPE,ICBØDY
      DØUBLE PRECISIØN XEM,XUPSTM,ZXF
C     CHECK NEXT RECØRC
      NDIM = 40
      IF(ITAPE-1)1,1,3
    1 READ(8) JTAPE,JIDBY,XEM,XUPSTM,ZXF,KK,NTCØUN,(FSTEDY(I),I=1,2),
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)
      GØ TØ 4
    3 READ(11) JTAPE,JIDBY,XEM,XUPSTM,XF,JKK,NTCØUN,(FSTEDY(I),I=1,2),
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)
    4 IF(JTAPE)10,10,5
    5 IF(ITAPE-JTAPE)10,6,10
    6 IF(ICBØDY-JIDBY)10,7,10
    7 IF(EM-XEM)10,8,10
    8 IF(UPSTRM-XUPSTM)10,9,10
    9 IF(ITAPE-1)300,300,310
  300 IF(XF-ZXF)10,1000,10
  310 IF(KK-JKK)10,1000,10
C     THIS IS NØT THE NEXT RECØRD - REWIND AND START FRØM THE BEGINNING
   10 IF(ITAPE-1)12,12,15
   12 REWIND 8
   14 READ(8) JTAPE,JIDBY,XEM,XUPSTM,ZXF,KK,NTCØUN,(FSTEDY(I),I=1,2),
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)
      GØ TØ 18
   15 REWIND 11
   16 READ(11) JTAPE,JIDBY,XEM,XUPSTM,XF,JKK,NTCØUN,(FSTEDY(I),I=1,2),
     1NTEST,(XTEST(I),RTEST(I),I=1,NTEST)
   18 IF(JTAPE)900,900,20
   20 IF(JTAPE-ITAPE)100,30,100
   30 IF(ICBØDY-JIDBY)100,40,100
   40 IF(EM-XEM)100,50,100
   50 IF(UPSTRM-XUPSTM)100,60,100
   60 IF(ITAPE-1)350,350,360
  350 IF(XF-ZXF)100,1000,100
  360 IF(KK-JKK)100,1000,100
C     NØT THIS RECØRD - READ DATA TØ FIND NEXT SET.
  100 IF(JTAPE-1)102,102,107
  102 READ (8) WRD1
      DØ 105 J=1,NDIM
      IF(WRD1(1,J) - 900.)105,14,14
  105 CØNTINUE
      GØ TØ 102
  107 READ (11) WRD1
      DØ 108 J=1,NDIM
      IF(WRD1(1,J) - 900.)108,16,16
  108 CØNTINUE
      GØ TØ 107
C     RECØRD DØES NØT EXIST CØRRESPØNDING TØ INPUT VALUES
  900 IF(ITAPE-1)902,902,904
  902 REWIND 8
      GØ TØ 905
  904 REWIND 11
  905 WRITE(6,600)ITAPE,IDBØDY,EM,UPSTRM,XF,KK
  600 FØRMAT(1H0,10X,95(1H*)//13X42HDATA ØN TAPE CANNØT BE LØCATED FØR I
     1TAPE =,I3,4X16HCØNFIGURATIØN - ,A4/13X10HMACH NØ. =,F5.2,4X8HUPSTR
     2M =,F9.4,4X4HXF =,F9.4,4X4HKK =,I3//10X,95(1H*))
      STØP
C     LØCATED PRØPER SECTIØN ØF TAPE.
 1000 RETURN
      END
```

```
      SUBROUTINE DUHINT (OP1,OP2,SUMIN,SUMOU)
      DOUBLE PRECISION EM,UPSTRM,VZERO,XF,XTEST(20),RTEST(20),FSTEDY(2),
     1CINP(2),COUP(2),CMAG(2),PHANG(2),SUMIN(2),SUMOU(2),AOMEG,AOMF,DAOM
     2,AOML,VLENTH,TERMI,TERMO,ANGLE,THETA,FACT1,FACT2,VBAR,PI,CAY,CAYPI
     3,T(300),RES(2,300),WROL(3,40)
      COMMON EM,UPSTRM,VZERO,T,RES,FSTEDY,XF,XTEST,RTEST,AOMEG,
     1KK,NTCOUN,NTEST,ITAPE,IOBODY
      DOUBLE PRECISION DEL1,DEL2,WI(3),WO(3),ARG,RIN(2,3),ROU(2,3),CON1,
     1CON2,TERM1,TERM2,TERM3,TERM4,DELAC
      DIMENSION KSTOP(2)
C
C     ITAPE=1 DENOTES A DUHAMEL INTEGRATION OF LOCAL FORCES - CNA, CMA.
C     ITAPE=2 SIGNIFIES A DUHAMEL INTEGRATION OF THE TOTAL NORMAL FORCE
C     AND THE PITCHING MOMENT - CNA, CMA.
C
C     INITIALIZATION
      IR = 2
      NSTP=0
      DO 5 J=1,IR
      KSTOP(J)=0
      SUMIN(J)=0.0
    5 SUMOU(J) = 0.0
      L1 = 1
      L2 = 2
      L3 = 3
      DEL1 = (T(L2)-T(L1))/6.0
      DEL2 = (T(L3)-T(L2))/6.0
C     COMPUTE SINUSOIDAL WIND PROFILE FUNCTIONS
C
C             OP1 ALLOWS OPTIONAL OUTPUT OF PORTIONS OF THE INTEGRATIONS
C             OP2 ALLOWS OPTIONAL OUTPUT OF WIND PROFILE VALUES.
C
      DO 15 N=L1,L3
      ARG = AOMEG*T(N)
      WI(N) = DSIN(ARG)
      WO(N) = DCOS(ARG)
      IF(OP2)15,15,12
   12 WRITE (6,500) T(N),WI(N),WO(N)
  500 FORMAT(10X6HTIME =,F10.4,5X10HSIN(ARG) =,E13.6,5X10HCOS(ARG) =,
     1E13.6/)
   15 CONTINUE
      IF(OP1)25,25,20
   20 WRITE (6,504)
  504 FORMAT(1H0,5X4HTIME,6X5HDELAC,8X4HCON1,9X4HCON2,6X1HJ,3X5HTERM1,
     18X5HTERM2,8X6HSUM-IN,7X5HTERM3,8X5HTERM4,8X6HSUM-OU/)
   25 DO 30 J=1,IR
      DO 30 N=L1,L3
      RIN(J,N) = RES(J,N)*WI(N)
   30 ROU(J,N) = RES(J,N)*WO(N)
C
C             MODE=1 TRAPAZOIDAL
C             MODE=2 SIMPSON'S (END POINT)
C             MODE=3 SIMPSON'S (MID POINT)
C
   40 IF(DABS(DEL2-DEL1) - .000001*DEL1)50,50,55
   50 CON1 = 2.*DEL1
      CON2=8.*DEL1
      MODE=3
      GO TO 60
   55 CON1 = 3.*DEL1
      CON2=3.*DEL1
      MODE=1
   60 DO 70 J=1,IR
      IF(KSTOP(J)-1)64,62,61
   61 IF(KSTOP(J)-3)59,70,70
   59 KSTOP(J) = 3
      IF(MODE-2)64,64,58
   58 CON1 = 3.*DEL1
      CON2 = 3.*DEL1
      GO TO 64
   62 KSTOP(J) = 2
   64 TERM1 = CON1*RIN(J,1)
      TERM2 = CON2*RIN(J,2)
      TERM3 = CON1*ROU(J,1)
      TERM4 = CON2*ROU(J,2)
      SUMIN(J)=SUMIN(J)+TERM1+TERM2
      SUMOU(J)=SUMOU(J)+TERM3+TERM4
      IF(OP1)70,70,65
   65 IF(J-1)66,66,68
   66 DELAC = 6.0*DEL1
      WRITE (6,505) T(L2),DELAC,CON1,CON2,J,TERM1,TERM2,SUMIN(J),TERM3,
     1TERM4,SUMOU(J)
  505 FORMAT(1XF10.4,3E13.6,I3,6E13.6)
      GO TO 70
   68 WRITE (6,506) J,TERM1,TERM2,SUMIN(J),TERM3,TERM4,SUMOU(J)
  506 FORMAT(50X,I3,6E13.6)
   70 CONTINUE
```

```
      DO 80 J=1,IR
      IF(KSTOP(J)-2)80,80,79
 79   NSTP = NSTP + 1
 80   CONTINUE
 81   IF(NSTP - IR)82,300,300
 82   DO 85 J=1,IR
      IF(KSTOP(J)-3)83,85,85
 83   RIN(J,1) = RIN(J,2)
      RIN(J,2) = RIN(J,3)
      ROU(J,1) = ROU(J,2)
      ROU(J,2) = ROU(J,3)
 85   CONTINUE
      NSTP = 0
      DEL1=DEL2
      L3 = L3 + 1
      L2 = L2 + 1
      IF(L3-NTCOUN)90,90,120
 90   DEL2 = (T(L3)-T(L2))/6.0
      ARG = AOMEG*T(L3)
      WI(3)= DSIN(ARG)
      WO(3)= DCOS(ARG)
      IF(OP2)91,91,87
 87   IF(L3-10)88,91,91
 88   WRITE (6,500) T(L3),WI(3),WO(3)
 91   DO 95 J=1,IR
 93   RIN(J,3) = RES(J,L3)*WI(3)
      ROU(J,3) = RES(J,L3)*WO(3)
 95   CONTINUE
 100  IF(MODE - 2)40,40,110
  110 CON1=0.0
      CON2=2.*DEL1
      MODE=2
      GO TO 60
C     END OF FILE HAS BEEN REACHED. DOES NOT NECESSARILY INDICATE THE
C     PRESENCE OF STEADY STATE VALUES.
 120  NSTP = IR
      IF(MODE-2)55,55,110
  300 RETURN
      END

      SUBROUTINE QUATAN(IØPT,XNUMR,DENØM,THETA,THDEG)
C
C     ANGLE THETA(RADIANS) IS COMPUTED EITHER IN THE INTERVAL ZERØ TØ
C     PLUS PIE ØR ZERØ TØ MINUS PIE BY ADDING ØR SUBTRACTING PIE FRØM
C     THE PRINCIPAL VALUE (+OR-) RETURNED BY THE LIBRARY SUBRØUTINE.
C     NQUAD GIVES THE QUADRANT NUMBER.
C
      DØUBLE PRECISIØN EM,UPSTRM,VZERØ,XF,XTEST(20),RTEST(20),FSTEDY(2),
     1CINP(2),CØUP(2),CMAG(2),PHANG(2),SUMIN(2),SUMØU(2),AØMEG,AØMF,DAØM
     2,AØML,VLENTF,TERMI,TERMØ,ANGLE,THETA,FACT1,FACT2,VBAR,PI,CAY,CAYPI
     3,T(500),RES(2,300),WRD1(3,40)
     4,PIE,DEGF,XNUMR,DENØM,ARG,THDEG
      CØMMØN EM,UPSTRM,VZERØ,T,RES,FSTEDY,XF,XTEST,RTEST,AØMEG,
     1KK,NTCØUN,NTEST,ITAPE,IØBØDY
      DEGF = 57.2957795130
      PIE = 3.14159265358979З
      ARG = XNUMR/DENØM
      THETA = DATAN(ARG)
      IF (ARG)15,5,5
C     THETA IS IN THE 3RD QUADRANT IF XNUMR AND DENØM ARE NEGATIVE WHEN
C     ARG IS PØSITIVE.
 5    IF (XNUMR)10,8,8
 8    NQUAD = 1
      GØ TØ 50
 10   THETA = THETA-PIE
      NQUAD = 3
      GØ TØ 50
C     THETA IS IN THE 2ND QUADRANT IF DENØM IS NEGATIVE WHEN ARG IS
C     NEGATIVE, AND IN THE 4TH QUADRANT IF DENØM IS PØSITIVE WITH A
C     NEGATIVE ARG.
 15   IF (DENØM) 20,18,18
 18   NQUAD = 4
      GØ TØ 50
 20   THETA = THETA+PIE
      NQUAD = 2
 50   THDEG = THETA*DEGF
      IF (IØPT) 400,400,60
 60   WRITE (6,800) NQUAD,XNUMR,DENØM,ARG,THETA,THDEG
 800  FØRMAT(3X,I5,4E16.6,F11.3)
 400  RETURN
      END
```

```
C     MAIN PROGRAM - 3089P - TAPRES - CREATES BINARY TAPES OF LOCAL     TAPR1000
C     FORCES AND/OR TOTAL FORCES (CNA AND CMA).                          TAPR1010
      DOUBLE PRECISION EM,EM2,UPSTRM,VZERO,TIME,EPS,RBASE,BETA,BETA2,    TAPR1020
     1CF(18),X(150),R(150),RP(150),XI(150),T(150),A(150),C(150),        TAPR1030
     2UAS(300),VAS(300)                                                  TAPR1040
     3,WRD1(3,300),CNA,CMA                                               TAPR1050
      COMMON EM,UPSTRM,VZERO,EM2,X,R,RP,XI,T,A,C,BETA,BETA2,TIME,EPS,CF,TAPR1060
     1CNA,CMA,WRD1,                                                      TAPR1070
     2RBASE,UAS,VAS,KTYPE(150),NLAST                                     TAPR1080
      REWIND 8                                                           TAPR1084
      REWIND 11                                                          TAPR1088
 10   READ(5,20)I                                                        TAPR1090
 20   FORMAT(I2)                                                         TAPR1100
      GO TO (1,2,3),I                                                    TAPR1110
 1    CALL MAIN1                                                         TAPR1120
      GO TO 10                                                           TAPR1130
 2    CALL MAIN2                                                         TAPR1140
      GO TO 10                                                           TAPR1150
 3    CALL MAIN3                                                         TAPR1160
      GO TO 10                                                           TAPR1170
      END                                                                TAPR1180

C     MAIN PROGRAM -3089P- RESINP                                        RESP1000
      DOUBLE PRECISION EM,UPSTRM,VZERØ,XF,XTEST(20),RTEST(20),FSTEDY(2),RESP1010
     1CINP(2),CØUP(2),CMAG(2),PHANG(2),SUMIN(2),SUMØU(2),AØMEG,AØMF,DAØMRESP1020
     2,AØML,VLENTH,TERMI,TERMØ,ANGLE,THETA,FACT1,FACT2,VBAR,PI,CAY,CAYPIRESP1030
     3,T(300),RES(2,300),WRD1(3,40),FLYTIM                               RESP1040
      CØMMØN EM,UPSTRM,VZERØ,T,RES,FSTEDY,XF,XTEST,RTEST,AØMEG,          RESP1050
     1KK,NTCOUN,NTEST,ITAPE,IDBØDY                                       RESP1060
      CØMMØN/HEAD/HEADNG(18)                                             RESP1070
      EQUIVALENCE(AØMEG,FLYTIM)                                          RESP1075
      IDIM = 40                                                          RESP1080
      IR = 2                                                             RESP1090
      PI = 3.14159265                                                    RESP1100
      A = 3279.122                                                       RESP1102
      B =  -150.6733                                                     RESP1104
      C =    3.20411                                                     RESP1106
 1    READ (5,600)HEADNG                                                 RESP1110
 600  FØRMAT(18A4)                                                       RESP1120
 4    CALL LNCNT(0,KKKK)                                                 RESP1130
 5    READ(5,605)EM,UPSTRM,VZERØ,ITAPE,IDBØDY,XF,KK,JCØDE,WINTYP         RESP1140
 605  FØRMAT(3F13.8,I5,A4,1X,F10.0,2I5,F3.0)                             RESP1150
C                                                                        RESP1152
C     WINTYP = 0 FØR SINUSØID, 1 FØR ACTUAL PRØFILE                      RESP1154
C                                                                        RESP1156
      VZERØ =  VZERØ/UPSTRM                                              RESP1160
      IPRIN = 1                                                          RESP1170
C     LØCATE PRØPER SECTIØN ØF TAPE                                      RESP1180
 7    CALL FINTAP                                                        RESP1190
      IKØN = 0                                                           RESP1200
      IF(IPRIN)10,10,8                                                   RESP1210
 8    LN = NTEST + 5                                                     RESP1220
      CALL LNCNT(LN,KKKK)                                                RESP1230
      WRITE (6,700)IDBØDY,EM,UPSTRM,VZERØ,NTEST                          RESP1240
 700  FØRMAT(2X15HVEHICLE TYPE - ,A4,1H,,4X9HMACH NØ. ,F7.3,1H,,4X6HSPEERESP1250
     1D ,F10.3,1H,,4X10HGUST VEL. ,F10.3,1H,/2X14HNØ. ØF CØRNERS,I4,3H, RESP1260
     2 ,67HVALUES BELØW ARE LØCATED AT THE CØRNERS PLUS THE END ØF THE VRESP1270
     3EHICLE//8X1HX,11X1HR/1H )                                          RESP1280
      WRITE (6,701) (XTEST(I),RTEST(I),I=1,NTEST)                        RESP1290
 701  FØRMAT(2F12.3)                                                     RESP1300
      IPRIN = 0                                                          RESP1310
 10   IF(ITAPE-1)12,12,14                                                RESP1320
 12   READ (8) WRD1                                                      RESP1330
      GØ TØ 15                                                           RESP1340
 14   READ (11) WRD1                                                     RESP1350
 15   DØ 20 J=1,IDIM                                                     RESP1360
      IF(WRD1(1,J)-900.)17,21,21                                         RESP1370
 17   IKØN = IKØN+1                                                      RESP1380
      T(IKØN) = WRD1(1,J)                                                RESP1390
      RES(1,IKØN) = WRD1(2,J)                                            RESP1400
      RES(2,IKØN) = WRD1(3,J)                                            RESP1410
 20   CØNTINUE                                                           RESP1420
      GØ TØ 10                                                           RESP1430
 21   DØ 1000 J = 1,IR                                                   RESP1440
      DØ 1000 N = 1,NTCØUN                                               RESP1450
 1000 RES(J,N) = FSTEDY(J) - RES(J,N)                                    RESP1460
      CALL LNCNT(11,KKKK)                                                RESP1470
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      WRITE(6,801)                                                      RESP1480
801   FØRMAT(//)                                                        RESP1490
      IF(ITAPE-1)22,22,23                                               RESP1500
22    WRITE(6,702)                                                      RESP1510
702   FØRMAT(45X42HL  Ø  C  A  L    R  E  S  P  Ø  N  S  E  S)          RESP1520
      GØ TØ 24                                                          RESP1530
23    WRITE (6,703)                                                     RESP1540
703   FØRMAT(45X42HT  Ø  T  A  L    R  E  S  P  Ø  N  S  E  S)          RESP1550
24    WRITE (6,704) FSTEDY(1),KK                                        RESP1560
704   FØRMAT(2X18HSTEADY STATE CNA =,1PE14.6,78X18HAERØDYNAMIC TYPE =,  RESP1570
     1I3)                                                               RESP1580
      IF(ITAPE-1)201,201,202                                            RESP1590
201   WRITE(6,705)FSTEDY(2),XF                                          RESP1600
705   FØRMAT(2X18HSTEADY STATE CMA =,1PE14.6,78X13HSTATIØN (X) =,0PF8.3/RESP1610
     11H )                                                              RESP1620
      GØ TØ 203                                                         RESP1630
202   WRITE (6,706)FSTEDY(2)                                            RESP1640
706   FØRMAT(2X18HSTEADY STATE CMA =,1PE14.6/1H )                       RESP1650
203   IF(WINTYP)100,204,100                                             RESP1655
204   WRITE(6,708)                                                      RESP1660
708   FØRMAT(41X7HC  N  A,20X7HC  N  A,17X7HC  M  A,20X7HC  M  A/29X,   RESP1670
     12(5X8HIN PHASE,6X9HØUT PHASE,5X9HMAGNITUDE,4X5HANGLE)/3X5HØMEGA,4XRESP1680
     21HK,5X7H(K/2PI),2X4HVBAR,2(3X9HCØMPØNENT,2X),16X6H(DEG.),4X2(9HCØMRESP1690
     3PØNENT,5X),13X6H(DEG.)/1H )                                       RESP1700
25    READ(5,610)AØMF,DAØM,AØML,VBAR,VLENTH,MØREØM,IØPT,ØP1,ØP2,KØMEGA  RESP1710
610   FØRMAT(4F15.0,F10.0,5I2)                                          RESP1720
C     INPUT IS ØMEGA (KØMEGA = 1), K (KØMEGA = 2), ØR K/2PI (KØMEGA = 3)RESP1730
      GØ TØ (310,320,330),KØMEGA                                        RESP1740
320   AØMF = AØMF*UPSTRM/VLENTH                                         RESP1750
      DAØM = DAØM*UPSTRM/VLENTH                                         RESP1760
      AØML = AØML*UPSTRM/VLENTH                                         RESP1770
      GØ TØ 310                                                         RESP1780
330   AØMF = PI*AØMF/0.5                                                RESP1790
      DAØM = PI*DAØM/0.5                                                RESP1800
      AØML = PI*AØML/0.5                                                RESP1810
      GØ TØ 320                                                         RESP1820
310   AØMEG = AØMF                                                      RESP1830
30    CALL CØNVØL(ØP1,ØP2,SUMIN,SUMØU,WINTYP)                           RESP1840
40    DØ 50 J=1,IR                                                      RESP1850
      TERMI = AØMEG*SUMIN(J)                                            RESP1860
      CINP(J) = FSTEDY(J)-TERMI                                         RESP1870
      TERMØ = AØMEG*SUMØU(J)                                            RESP1880
      CØUP(J) = VBAR*TERMØ/UPSTRM                                       RESP1890
      CMAG(J) = DSQRT(CINP(J)*CINP(J)+TERMØ*TERMØ)                      RESP1900
      CMAG(J) = DABS(VBAR *CMAG(J)/UPSTRM)                              RESP1910
      CALL QUATAN (IØPT,TERMØ,CINP(J),THETA,ANGLE)                      RESP1920
      PHANG(J) = ANGLE                                                  RESP1930
      CINP(J) = VBAR*CINP(J)/UPSTRM                                     RESP1940
50    CØNTINUE                                                          RESP1950
      CALL LNCNT (1,KKKK)                                               RESP1960
      IF(KKKK)56,51,56                                                  RESP1970
51    CALL LNCNT(8,KKKK)                                                RESP1980
      IF(ITAPE-1)52,52,53                                               RESP1990
52    WRITE (6,702)                                                     RESP2000
      GØ TØ 54                                                          RESP2010
53    WRITE (6,703)                                                     RESP2020
54    WRITE (6,704) FSTEDY(1),KK                                        RESP2030
      IF (ITAPE-1) 57,57,58                                             RESP2040
57    WRITE (6,705)FSTEDY(2),XF                                         RESP2050
      GØ TØ 55                                                          RESP2060
58    WRITE (6,706)FSTEDY(2)                                            RESP2070
55    IF(WINTYP)500,59,500                                              RESP2075
59    WRITE(6,708)                                                      RESP2080
56    CAY = AØMEG*VLENTH/UPSTRM                                         RESP2090
      CAYPI = CAY/PI*0.5 + .00001                                       RESP2100
      WRITE (6,710)AØMEG,CAY,CAYPI,VBAR,(CINP(J),CØUP(J),CMAG(J),       RESP2110
     1PHANG(J),J=1,IR)                                                  RESP2120
710   FØRMAT(1XF9.2,2F8.4,F6.2,3(1PE14.6),0PF8.2,3(1PE14.6),0PF8.2)     RESP2130
      IF(AØMEG - AØML)60,65,65                                          RESP2140
60    AØMEG = AØMEG+DAØM                                                RESP2150
      GØ TØ 30                                                          RESP2160
65    IF(MØREØM)70,70,69                                                RESP2170
69    CALL LNCNT(-1,KKKK)                                               RESP2180
      GØ TØ 25                                                          RESP2190
70    IF(JCØDE)4,400,90                                                 RESP2210
90    READ (5,620) XF,KK,JCØDE                                          RESP2220
620   FØRMAT(49X,F10.0,2I5)                                             RESP2230
      GØ TØ 7                                                           RESP2240
400   GØ TØ 1                                                           RESP2250
100   READ(5,101)FLYTIM,DFLYTM,FLYTML,Q,RBASE,VLENTH,MØRETM,NSHR,       RESP2260
     1      ØP1,ØP2,KTIME                                               RESP2270
101   FØRMAT(6F10.0,10X,I2,I2,3I2)                                      RESP2280
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C                                                                        RESP2290
C     NSHR = 1 TØ READ AND CØMPUTE NEW SHEARS NEXT.  (MUST DØ FIRST TIMERESP2300
C                                                                        RESP2310
C     KTIME = 1 TØ INPUT ALTITUDE RANGE (METERS)                         RESP2320
C     KTIME = 0 TØ INPUT FLIGHT TIME RANGE (SECØNDS                      RESP2330
C                                                                        RESP2340
C     MØRETM = 1 TØ READ ANØTHER CARD THIS TYPE, FØR SAME M AND WIND.    RESP2350
C                                                                        RESP2360
C     Q IS DYNAMIC PRESSURE (KG/METER**2)                                RESP2370
C                                                                        RESP2380
      CØEF1 = PI*RBASE**2 *Q/UPSTRM                                      RESP2390
      CØEF2 = CØEF1*2.*RBASE                                             RESP2400
      IF(NSHR)110,120,110                                                RESP2410
  110 READ(5,111)WØRD1,WØRD2,NPRØ,INC                                    RESP2420
  111 FØRMAT(A4,A3,2I6)                                                  RESP2430
      CALL SHEARS(WØRD1,WØRD2,NPRØ,INC)                                  RESP2440
  120 IF(ITAPE-1)121,121,122                                             RESP2450
  121 TIMESS = XF/UPSTRM*(EM/(EM-1.))                                    RESP2460
      GØ TØ 129                                                          RESP2470
  122 IF(KK-3)123,123,125                                                RESP2480
  123 TIMESS = VLENTH/UPSTRM                                             RESP2490
      GØ TØ 129                                                          RESP2500
  125 TIMESS = VLENTH/UPSTRM*(EM/(EM-1.))                                RESP2510
  129 IF(KTIME)130,140,130                                               RESP2520
  130 ALTUDE = FLYTIM                                                    RESP2530
  140 WRITE(6,141)WØRD1,WØRD2                                            RESP2540
  141 FØRMAT(15X,96HR E S P Ø N S E S   T Ø   W I N D   P R Ø F I L E , RESP2550
     1 I D E N T I F I C A T I Ø N   .  .  .  ,A4,A3/                    RESP2560
     242X, 51H( I N   M - K - S   S Y S T E M   Ø F   U N I T S )/      RESP2570
     360H  ALTITUDE    FLIGHT TIME    NØRMAL FØRCE   PITCHING MØMENT ,   RESP2580
     420X,12HALT(LØW LIM)/)                                              RESP2590
  150 IF(KTIME)160,170,160                                               RESP2600
  160 FLYTIM = (-B+SQRT(B*B-4.*C*(A-ALTUDE)))/(2.*C)                     RESP2610
  170 CALL CØNVØL(ØP1,ØP2,SUMIN,SUMØU,WINTYP)                            RESP2620
C                                                                        RESP2621
C     SUMØU HERE IS WIND AT ALTITUDE                                     RESP2622
C                                                                        RESP2623
      CINP(1) = CØEF1*(FSTEDY(1)*SUMØU(1)-SUMIN(1))                      RESP2630
      CINP(2) = CØEF2*(FSTEDY(2)*SUMØU(1)-SUMIN(2))                      RESP2640
      CALL LNCNT(1,KKKK)                                                 RESP2650
      IF(KKKK)510,51,510                                                 RESP2660
  500 WRITE(6,141)WØRD1,WØRD2                                            RESP2670
  510 IF(KTIME)530,520,530                                               RESP2680
  520 ALTUDE = A+FLYTIM*(B+C*FLYTIM)                                     RESP2690
  530 ALTSTR = A+(FLYTIM-TIMESS)*(B+C*(FLYTIM-TIMESS))                   RESP2700
      WRITE(6,531)ALTUDE,FLYTIM,CINP(1),CINP(2),ALTSTR                   RESP2710
  531 FØRMAT(F10.2,F13.4,2(1PE18.6),21X,0PF10.2)                         RESP2715
      IF(KTIME)540,560,540                                               RESP2720
  540 IF(ALTUDE-FLYTML)550,580,580                                       RESP2730
  550 ALTUDE = ALTUDE+DFLYTM                                             RESP2740
      GØ TØ 160                                                          RESP2750
  560 IF(FLYTIM-FLYTML)570,570,580                                       RESP2760
  570 FLYTIM = FLYTIM+DFLYTM                                             RESP2770
      GØ TØ 170                                                          RESP2780
  580 IF(MØRETM)70,70,590                                                RESP2790
  590 CALL LNCNT(-1,KKKK)                                                RESP2800
      GØ TØ 100                                                          RESP2810
      END                                                                RESP2820


C                                                                        SHEA1000
C     PRØGRAM TØ CØMPUTE WIND SHEARS AT 25 METER INCREMENTS USING A      SHEA1010
C     LEAST SQUARES CURVE FIT ØN ØRIGINAL WIND PRØFILE DATA              SHEA1020
C                                                                        SHEA1030
      SUBRØUTINE SHEARS(WRD1,WRD2,NPRØ,INC)                              SHEA1040
C                                                                        SHEA1050
C     WRD1,WRD2 ARE PRØFILE ID, IN A4,A3.                                SHEA1060
C     NPRØ IS NØ. ØF ALTITUDES, AT 25 METER INTERVALS                    SHEA1070
C     INC IS NØ. ØF INCREMENTS PER 25 METERS FØR TEST INTEGRAL.          SHEA1080
C                                                                        SHEA1090
      CØMMØN /WINDAT/WSHEAR(750),WV,ALT1                                 SHEA1100
      DØUBLE PRECISIØN WSHEAR,WV(750),XF,XL,X(3),Y(3),YC(3),YS(3),CØA,   SHEA1110
     1  CØB,CØC,DX,XX,YY,NY                                              SHEA1120
      DIMENSIØN DELV(10)                                                 SHEA1130
      IF(NPRØ-750)2,2,1                                                  SHEA1150
    1 WRITE(6,3)WRD1,WRD2,NPRØ,INC                                       SHEA1160
    3 FØRMAT(1H1,30X,26HERRØR IN SHEARS ARGUEMENTS//20X,A4,A3, I9,I9)    SHEA1170
      GØ TØ 400                                                          SHEA1180
    2 IF(INC-10)4,4,1                                                    SHEA1190
```

```
 4      INCHF=INC/2
        TWINC=2*INC
        DX=25.
        NSHR=NPRØ-2
        DX2=DX/2.
        DINC=DX/FLØAT(INC)
        KØDE8 = -1
        WRITE(6,710)WRD1,WRD2,DINC,DX2
 710    FØRMAT(1H1,20X,45HWINDS AND WIND SHEARS FØR WIND PRØFILE NUMBER,
       11X,A4,A3//2X, 8HALTITUDE,3X,4HWIND,4X,8HSHEAR AT,8X,
       220HINTEGRATED SHEARS AT,F7.2,17H METER INTERVALS,/20X,5HALT +,F6.2
       3,10X,25HWITH LAST ØNE AT ALTITUDE/)
C
C       READ AND STØRE WIND PRØFILE DATA
C
        DØ 20 J = 1,NPRØ,10
        J9=MIN0(J+9,NPRØ)
        READ(5,105)CALT,(WV(K),K=J,J9)
        IF(J-1)15,15,16
 15     ALT1=CALT
        GØ TØ 20
 16     IF(CALT-(PRALT+250.))17,20,17
 17     CALT = PRALT+250.
 105    FØRMAT(7X,F6.0,1X,10F6.2)
        WRITE(6,700)CALT
 700    FØRMAT(1H1,62HWIND PRØFILE DATA ØUT ØF SEQUENCE. CØRRECT ALTITUDE
       1SHØULD BE ,F10.2)
        GØ TØ 400
 20     PRALT = CALT
C
C       USE 3-PØINT CURVE FIT TØ FIND WIND SHEARS ØVER ENTIRE ALT RANGE
C
        X(1)=ALT1
        NALT=1
 235    X(2)=X(1)+DX
        X(3)=X(2)+DX
        Y(1)=WV(NALT)
        Y(2)=WV(NALT+1)
        Y(3)=WV(NALT+2)
C
C       DETERMINE CØEFFICIENTS CØA, CØB, CØC ØF QUADRATIC IN TRANSFØRMED
C       CØØRDINATE SYSTEM
C
        NY=(Y(1)+Y(3))/2.
        CØA=(Y(1)-2.*Y(2)+Y(3))/2.
        CØB=(Y(3)-Y(1))/2.
        CØC=Y(2)-NY
C
C       TRANSFØRM BACK TØ ØRIGINAL SYSTEM
C
        DØ 275 J=1,3
        XX = J-2
 275    YC(J)=CØA*XX*XX+CØB*XX+CØC+NY
        CØC=CØC-CØB*X(2)/25. +CØA*X(2)*X(2)/625.+NY
        CØB=CØB/25.-2.*CØA*X(2)/625.
        CØA=CØA/625.
C
C       CØMPUTE SHEAR
C
 93     IF(KØDE8)195,194,194
 195    SHEAR = CØA*(X(2)+X(3))+CØB
        KØDE8 = 0
        WRITE(6,701) X(1),WV(1),X(2),WV(2),SHEAR
 701    FØRMAT(F10.2,F8.2/F10.2,F8.2,F11.5)
        GØ TØ 82
C
C       INTEGRATE RIGHT HALF
C
 194    SHR1=SHEAR
        SHEAR= CØA*(X(2)+X(3))+CØB
        DØ 600 I=1,INCHF
        J=INCHF+I
        Z=2*I-1
 600    DELV(J)=((TWINC - Z)*SHR1+Z*SHEAR)*DX/TWINC/FLØAT(INC)
        IF(KØDE8)195,140,141
 140    VEL = Y(2)
        WRITE(6,702) X(2),Y(2),SHEAR,VEL
 702    FØRMAT(F10.2,F8.2,F11.5,2X,10(F9.2,1H,))
        KØDE8 = 1
        GØ TØ 822
```

```
C                                                                       SHEA2000
C     SUM DELV TØ GET INTEGRAL.  (DELV THEN HAS                         SHEA2010
C     NEW INTERPRETATIØN                                                SHEA2020
C                                                                       SHEA2030
  141 DELV(1)=VEL + DELV(1)                                             SHEA2040
      DØ 620 I = 2,INC                                                  SHEA2050
  620 DELV(I)=DELV(I)+DELV(I-1)                                         SHEA2060
      WRITE(6,702) X(2),Y(2),SHEAR,(DELV(I),I=1,INC)                    SHEA2070
      VEL = DELV(INC)                                                   SHEA2080
C                                                                       SHEA2090
C     INTEGRATE LEFT HALF                                               SHEA2100
C                                                                       SHEA2110
  822 DØ 610 I =1,INCHF                                                 SHEA2120
      J=INCHF-I+1                                                       SHEA2130
      Z=2*I-1                                                           SHEA2140
  610 DELV(J)=((TWINC-Z)*SHEAR+Z*SHR1)*DX/TWINC/FLØAT(INC)              SHEA2150
C                                                                       SHEA2160
C     STEP TØ NEXT INTERVAL.  STØRE SHEAR IN CØMMØN/WINDAT/             SHEA2170
C                                                                       SHEA2180
   82 WSHEAR(NALT)=SHEAR                                                SHEA2190
      NALT = NALT + 1                                                   SHEA2200
      IF(NALT-NSHR)85,85,90                                             SHEA2210
   85 X(1)=X(2)                                                         SHEA2220
      GØ TØ 235                                                         SHEA2230
   90 ALT1 = ALT1 + DX*1.5                                              SHEA2240
C                                                                       SHEA2250
C     ALT1 IS NØW ALTITUDE ØF FIRST SHEAR                               SHEA2260
C                                                                       SHEA2270
      RETURN                                                            SHEA2280
  400 CALL EXIT                                                         SHEA2290
      RETURN                                                            SHEA2300
      END                                                               SHEA2310


      SUBRØUTINE CØNVØL(ØP1,ØP2,SUMIN,SUMØU,WINTYP)                     DUHT1000
      DØUBLE PRECISIØN EM,UPSTRM,VZERØ,XF,XTEST(20),RTEST(20),FSTEDY(2),DUHT1010
     1CINP(2),CØUP(2),CMAG(2),PHANG(2),SUMIN(2),SUMØU(2),AØMEG,AØMF,DAØMDUHT1020
     2,AØML,VLENTH,TERMI,TERMØ,ANGLE,THETA,FACT1,FACT2,VBAR,PI,CAY,CAYPIDUHT1030
     3,T(300),RES(2,300),WRD1(3,40)                                     DUHT1040
      CØMMØN EM,UPSTRM,VZERØ,T,RES,FSTEDY,XF,XTEST,RTEST,AØMEG,         DUHT1050
     1KK,NTCØUN,NTEST,ITAPE,IDBØDY                                      DUHT1060
      DØUBLE PRECISIØN DEL1,DEL2,WI(3),WØ(3),ARG,RIN(2,3),RØU(2,3),CØN1,DUHT1070
     1CØN2,TERM1,TERM2,TERM3,TERM4,DELAC,FLYTIM                         DUHT1080
      EQUIVALENCE (AØMEG,FLYTIM)                                        DUHT1085
      DIMENSIØN KSTØP(2)                                                DUHT1090
C                                                                       DUHT1091
C     WINTYP = 0 . . . FIND IN- AND ØUR- ØF PHASE RESPØNSE TØ           DUHT1092
C           SINUSØIDAL WIND, FREQUENCY AØMEG                            DUHT1093
C     WINTYP = 1 . . . FIND RESPØNSE TØ WIND PRØFILE AT FLIGHT TIME     DUHT1094
C           FLYTIM.  (SECØND INTEGRAL IDENTICALLY = 0, ARTIFICIAL)      DUHT1095
C                                                                       DUHT1096
C                                                                       DUHT1100
C     ITAPE=1 DENØTES A DUHAMEL INTEGRATIØN ØF LØCAL FØRCES - CNA, CMA. DUHT1110
C     ITAPE=2 SIGNIFIES A DUHAMEL INTEGRATIØN ØF THE TØTAL NØRMAL FØRCE DUHT1120
C     AND THE PITCHING MØMENT - CNA, CMA.                               DUHT1130
C                                                                       DUHT1140
C     INITIALIZATIØN                                                    DUHT1150
      IR = 2                                                            DUHT1160
      NSTP=0                                                            DUHT1170
      DØ 5 J=1,IR                                                       DUHT1180
      KSTØP(J)=0                                                        DUHT1190
      SUMIN(J)=0.0                                                      DUHT1200
      SUMØU(J) = 0.0                                                    DUHT1210
      L1 = 1                                                            DUHT1220
      L2 = 2                                                            DUHT1230
      L3 = 3                                                            DUHT1240
      DEL1 = (T(L2)-T(L1))/6.0                                          DUHT1250
      DEL2 = (T(L3)-T(L2))/6.0                                          DUHT1260
C     CØMPUTE SINUSØIDAL WIND PRØFILE FUNCTIØNS                         DUHT1270
C                                                                       DUHT1280
C             ØP1 ALLØWS ØPTIØNAL ØUTPUT ØF PØRTIØNS ØF THE INTEGRATIØNSDUHT1290
C             ØP2 ALLØWS ØPTIØNAL ØUTPUT ØF WIND PRØFILE VALUES.        DUHT1300
C                                                                       DUHT1310
      NØW = 1                                                           DUHT1315
      DØ 15 N=L1,L3                                                     DUHT1319
      IF(WINTYP)210,200,210                                             DUHT1320
  210 CALL DWVDT(FLYTIM-T(N),WI(N),WIND,NØW)                            DUHT1321
      NØW = 0                                                           DUHT1322
      WØ(N)=0.                                                          DUHT1323
      IF (ØP2)15,15,220                                                 DUHT1324
  220 TIME=FLYTIM-T(N)                                                  DUHT1325
      WRITE(6,230)TIME,WI(N)                                            DUHT1326
  230 FØRMAT(10X,6HTIME =,F13.4,5X,13HDWVDT(TIME) =,E13.6/)             DUHT1327
      GØ TØ 15                                                          DUHT1328
```

```
200   ARG = AØMEG*T(N)
      WI(N) = DSIN(ARG)
      WØ(N) = DCØS(ARG)
      IF(ØP2)15,15,12
12    WRITE (6,500) T(N),WI(N),WØ(N)
500   FØRMAT(10X6HTIME =,F10.4,5X10HSIN(ARG) =,E13.6,5X10HCØS(ARG) =,
     1E13.6/)
15    CØNTINUE
      IF(ØP1)25,25,20
20    WRITE (6,504)
504   FØRMAT(1H0,5X4HTIME,6X5HDELAC,8X4HCØN1,9X4HCØN2,6X1HJ,3X5HTERM1,
     18X5HTERM2,8X6HSUM-IN,7X5HTERM3,8X5HTERM4,8X6HSUM-ØU/)
25    DØ 30 J=1,IR
      DØ 30 N=L1,L3
      RIN(J,N) = RES(J,N)*WI(N)
30    RØU(J,N) = RES(J,N)*WØ(N)
C
C              MØDE=1 TRAPAZØIDAL
C              MØDE=2 SIMPSØN S (END PØINT)
C              MØDE=3 SIMPSØN S (MID PØINT)
C
40    IF(DABS(DEL2-DEL1) - .000001*DEL1)50,50,55
50    CØN1 = 2.*DEL1
      CØN2=8.*DEL1
      MØDE=3
      GØ TØ 60
55    CØN1 = 3.*DEL1
      CØN2=3.*DEL1
      MØDE=1
60    DØ 70 J=1,IR
      IF(KSTØP(J)-1)64,62,61
61    IF(KSTØP(J)-3)59,70,70
59    KSTØP(J) = 3
      IF(MØDE-2)64,64,58
58    CØN1 = 3.*DEL1
      CØN2 = 3.*DEL1
      GØ TØ 64
62    KSTØP(J) = 2
64    TERM1 = CØN1*RIN(J,1)
      TERM2 = CØN2*RIN(J,2)
      TERM3 = CØN1*RØU(J,1)
      TERM4 = CØN2*RØU(J,2)
      SUMIN(J)=SUMIN(J)+TERM1+TERM2
      SUMØU(J)=SUMØU(J)+TERM3+TERM4
      IF(ØP1)70,70,65
65    IF(J-1)66,66,68
66    DELAC = 6.0*DEL1
      WRITE (6,505) T(L2),DELAC,CØN1,CØN2,J,TERM1,TERM2,SUMIN(J),TERM3,
     1TERM4,SUMØU(J)
505   FØRMAT(1XF10.4,3E13.6,I3,6E13.6)
      GØ TØ 70
68    WRITE (6,506) J,TERM1,TERM2,SUMIN(J),TERM3,TERM4,SUMØU(J)
506   FØRMAT(50X,I3,6E13.6)
70    CØNTINUE
      DØ 80 J=1,IR
      IF(KSTØP(J)-2)80,80,79
79    NSTP = NSTP + 1
80    CØNTINUE
81    IF(NSTP - IR)82,300,300
82    DØ 85 J=1,IR
      IF(KSTØP(J)-3)83,85,85
83    RIN(J,1) = RIN(J,2)
      RIN(J,2) = RIN(J,3)
      RØU(J,1) = RØU(J,2)
      RØU(J,2) = RØU(J,3)
85    CØNTINUE
      NSTP = 0
      DEL1=DEL2
      L3 = L3 + 1
      L2 = L2 + 1
      IF(L3-NTCØUN)90,90,120
90    DEL2 = (T(L3)-T(L2))/6.0
      IF(WINTYP)410,400,410
410   CALL DWVDT(FLYTIM-T(L3),WI(3),WIND,NØW)
      WØ(3)=0.
      IF(ØP2)91,91,420
420   IF(L3-10)430,91,91
430   TIME=FLYTIM-T(L3)
      WRITE(6,230)TIME,WI(3)
      GØ TØ 91
```

```
 400  ARG = AØMEG*T(L3)                                                  DUHT2050
      WI(3)= DSIN(ARG)                                                   DUHT2060
      WØ(3)= DCØS(ARG)                                                   DUHT2070
      IF(ØP2)91,91,87                                                    DUHT2080
 87   IF(L3-10)88,91,91                                                  DUHT2090
 88   WRITE (6,500) T(L3),WI(3),WØ(3)                                    DUHT2100
 91   DØ 95 J=1,IR                                                       DUHT2110
 93   RIN(J,3) = RES(J,L3)*WI(3)                                         DUHT2160
      RØU(J,3) = RES(J,L3)*WØ(3)                                         DUHT2170
 95   CØNTINUE                                                           DUHT2180
 100  IF(MØDE - 2)40,40,110                                              DUHT2190
  110 CØN1=0.0                                                           DUHT2200
      CØN2=2.*DEL1                                                       DUHT2210
      MØDE=2                                                             DUHT2220
      GØ TØ 60                                                           DUHT2230
C     END ØF FILE HAS BEEN REACHED. DØES NØT NECESSARILY INDICATE THE    DUHT2240
C     PRESENCE ØF STEADY STATE VALUES.                                   DUHT2250
 120  NSTP = IR                                                          DUHT2260
      IF(MØDE-2)55,55,110                                                DUHT2270
 300  IF(WINTYP)310,350,310                                              DUHT2280
 310  SUMØU(1) = WIND                                                    DUHT2281
 350  RETURN                                                             DUHT2282
      END                                                                DUHT2290


      SUBROUTINE DWVDT(T,DER,WIND,NOW)                                   DWVD1000
C                                                                        DWVD1010
C     COMPUTES DERIVATIVE OF WIND VELOCITY (SHEAR) WITH RESPECT TO TIME  DWVD1020
C     BY TRANSFORMATION TO ALTITUDE DEPENDENCE AND SUBSEQUENT INTERPOL-  DWVD1030
C     ATION IN WSHEAR TABLE.                                             DWVD1040
C                                                                        DWVD1050
      COMMON/WINDAT/WSHEAR(750),WV(750),ALT1
      DOUBLE PRECISION WSHEAR,WV                                         DWVD1070
      DX=25.                                                             DWVD1080
      A = 3279.122                                                       DWVD1090
      B = -150.6733                                                      DWVD1100
      C =    3.20411                                                     DWVD1110
C                                                                        DWVD1120
C     TRANSFORM TO H WITH QUADRATIC CURVE FIT, VALID FROM T = 60 TO 100.DWVD1130
C                                                                        DWVD1140
      H = A + T*(B +C *T)                                                DWVD1150
C                                                                        DWVD1160
C     INTERPOLATION TO FIND DWVDH                                        DWVD1170
C                                                                        DWVD1180
      N = ((H-ALT1)/DX + 1.)                                             DWVD1190
      IF(N) 10,10,20                                                     DWVD1200
   20 IF(N-750)30,10,10                                                  DWVD1210
   10 WRITE(6,99) T,H,ALT1,ALT1                                          DWVD1220
   99 FORMAT(37H ARGUEMENT TO DWVDT OUT OF RANGE.  T=,E16.8, 3H H=,E16.8DWVD1230
     1,11H MIN. ALT =,E16.8, 6H USING,E16.8)                             DWVD1240
      N=1                                                                DWVD1250
   30 ALTN = ALT1 + DX*FLOAT(N-1)                                        DWVD1260
      DWVDH = WSHEAR(N)+(WSHEAR(N+1)-WSHEAR(N))/DX*(H-ALTN)              DWVD1270
C                                                                        DWVD1280
C     COMPUTE DWVDT                                                      DWVD1290
C                                                                        DWVD1300
      DHDT = B + 2.*C*T                                                  DWVD1310
      DER = DWVDH*DHDT                                                   DWVD1320
      IF(NOW)100,900,100                                                 DWVD1330
C                                                                        DWVD1340
C     COMPUTE WIND AT H                                                  DWVD1350
C                                                                        DWVD1360
  100 IF(H-ALTN-DX*.5)210,210,110                                        DWVD1370
C                                                                        DWVD1380
C     H MORE THAN 12.5 METERS FROM ALTN - INTEGRATE ONE PART-INTERVAL    DWVD1390
C                                                                        DWVD1400
  110 WIND = WV(N+2)+0.5*(0.5*(WSHEAR(N)+WSHEAR(N+1))+DWVDH)             DWVD1410
     1        *(H-ALTN-0.5*DX)                                           DWVD1420
      GO TO 300                                                          DWVD1430
C                                                                        DWVD1440
C     H LESS THAN 12.5 METERS FROM ALTN - INTEGRATE TWO PART-INTERVALS   DWVD1450
C                                                                        DWVD1460
  210 N = N-1                                                            DWVD1470
      WIND = WV(N+2)+0.5*(WSHEAR(N)+3.*WSHEAR(N+1))*0.5*DX               DWVD1480
     1             +0.5*(WSHEAR(N+1)+DWVDH)*(H-ALTN)                     DWVD1490
  300 WRITE(6,399)WIND,H                                                 DWVD1500
  399 FORMAT(5H WIND,1P2E16.7)                                           DWVD1510
  900 RETURN                                                             DWVD1520
      END                                                                DWVD1530
```