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USER'S GUIDE FOR A REVISED COMPUTER PROGRAM TO ANALYZE THE LRC 16' TRANSONIC DYNAMICS TUNNEL ACTIVE CABLE MOUNT SYSTEM

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FOREWORD

This report is submitted to the NASA Langley Research Center in partial fulfillment of Master Agreement Contract Number NAS 1-10635-22. Part of this contract involves the revision of an existing digital program to analyze the stability of models mounted on a two-cable mount system used in the LRC 16' transonic dynamics tunnel. The program revisions, discussed in this report, will allow for analysis of an active feedback control system to be used for controlling the free-flying models. This report is considered a supplement to CR-132313 and not a replacement for it.

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LIST OF SYMBOLS

E_m = Command voltage from feedback loop ~ volts

E_{mo} = Externally applied input voltage ~ volts

$E_{m_{tot}}$ = Total voltage to torque motor ~ volts

G = Friction in active cable system ~ in. lbs/rps

I_a = Amper‹s in motor ~ amps

J_m = Inertia of active cable system ~ inches^4

K_T = Motor torque constant ~ in. lbs/amp

K_v = Motor velocity constant ~ volts/rps

K_q = Model pitch rate feedback gain ~ volts/rps

$K_{\dot{\theta}_m}$ = Pitch motor rate (tachometer) feedback gain ~ volts/rps

K_{θ_m} = Motor position feedback gain ~ volts/rad

K_r = Model yaw rate feedback gain ~ volts/rps

$K_{\dot{\psi}_m}$ = Yaw motor rate feedback gain ~ volts/rps

K_{ψ_m} = Motor position feedback gain ~ volts/rad

L_a = Motor armature inductance ~ henry

$\mathcal{L}$ = Rolling moment ~ ft. lb.

M = Pitching moment ~ ft. lb.

N = Yawing moment ~ ft. lb.

Q_o = Output torque from motor ~ in. lb.

Q_L = Load torque on motor ~ in. lb.

R_G = Motor armature resistance ~ ohms

R_d = Torque motor pulley radius ~ in.

s = Laplace operator

ΔT = Cable tension change ~ lbs.

ΔT_c = One half the total cable tension change due to active cable system $(\Delta T_i - \Delta T_{fb})$ ~ lbs.

ΔT_F = Front cable tension change due to fixed length contraint ~ lbs.

ΔT_{fb} = one half the cable tension change due to feedback = δT ~ lbs.

ΔT_i = Externally applied tension change ~ lbs.

δT = Tension change on one side of torque motor ~ lbs.

X = Axial force exerted on model ~ lbs.

Y = Side force exerted on model ~ lbs.

Z = Vertical force exerted on model ~ lbs.

(x, y, z) = Model translational displacement ~ ft.

(θ, ψ, ϕ) = Model angular displacement in pitch, yaw, and roll resp. ~ rad.

B_g = Laterial wind gust ~ rad.

α_g = Vertical wind gust ~ rad.

δ_a = Aileron deflection ~ rad.

δ_e = Elevator deflection ~ rad.

δ_r = Rudder deflection ~ rad.

θ_m = Vertical plane torque motor pulley angular displacement ~ rad.

ψ_m = Lateral plane torque motor pulley angular displacement ~ rad.

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I. INTRODUCTION

In accordance with the requirements set forth under NASA Master Agreement NAS 1-10635, Development and Implementation of Space Shuttle Structural Dynamics Modeling Technology - Task Order Number 22, the following report is submitted.

Contained in this report is a discussion of the updates to the digital computer program originally written under Task Order Number 9 and described in NASA-CR-132313. The original program modeled the dynamic characteristics of aeroelastically-scaled models "flown" on the two-cable mount system in the Langley Research Center 16' Transonic Dynamics Tunnel. The updated digital program contains the original equations plus the necessary additional equations to model an active feedback system presently being developed. The capability of analyzing a proposed new snubber system is also included. Program options and output have been expanded to include complete transfer function characteristics (numerator and denominator), frequency response data, wind-off and free airframe (w/o cable effects) characteristics.

The discussions in this report will cover only the changes made to the original program. It is assumed that CR-132313 will be used in conjunction with this report to obtain full understanding of the program.

2.0 ACTIVE FEEDBACK CONTROL SYSTEM LOGIC

The purpose of the active feedback control system is to artifically augment the stability of the cable mounted model by modulating the cable tension. There are two cables used to suspend the model in the tunnel. The tensions of these cables are controlled independently by two torque motors. Generally one cable lies in the vertical plane and the other in the horizontal plane. The vertically mounted cable is used to control the longitudinal dynamics of the system. The horizontally mounted cable is used to control the lateral-directional dynamics.

The cables are assumed to be attached to hard points on the model rather than to the tunnel wall as it was in the original program. This is necessary to effectively transform the tension change in the cable imparted by the torque motor to stabilizing forces and moments on the model. The differences between this system and the original inactive cable system and the ability of the present program to analyze both setups are discussed in detail in Appendix A.

Figure 1 presents the sign convention used in the derivation of the active cable feedback logic. This figure is generalized to account for both vertical front and rear cables as well as horizontal front and rear cables.

θ_m and Ψ_m are torque motor pulley angular displacements in the vertical and horizontal planes respectively. Note that the sense of rotation is unaltered whether the cable is located in the front or rear. Positive motor rotation corresponds to an increase in cable tension on the sides noted in the figure by "+ [illegible]". Positive ΔT is an increase in cable tension and negative ΔT is a decrease in cable tension. Positive pulley displacements results in a positive rotational moment imparted by the cable onto the model. The letters "M" and "N" show the direction of the moments induced by the positive motor rotation.

Figures 2 and 3 show block diagrams of the cable mount system with feedback loops for the longitudinal and the lateral-directional modes respectively. These two figures are similar and the discussion of figure 2 applies equally to figure 3.

In figure 2, the block in the forward loop represents the basic inactive cable mount system discussed in reference 1. A change in cable tension, ΔT_c, will result in a model motion defined by variables x, z, and θ.

The multi-feedback loops shown represent the active feedback logic, motor dynamics and system friction. The feedback loop containing the gains K_q, $K_{\dot{\theta}_m}$, and K_{θ_m} are the active elements controlling the torque motor. They are respectively, the model pitch rate gyro gain, the motor rate or tachometer gain, and the motor pulley position gain. The signals emanating from these elements are summed to give a voltage E_m. This voltage is combined with any externally applied test voltage, E_{mo}, to give a total voltage used to drive the torque motor.

The block containing the notation, "$\theta_m = f\ (x, z, \theta)$", represents the geometric relation between the model motion and the pulley motion. This is derived by determining the movement of the cable, Δl, as a function of the model motion. The "Δl" is the length of cable passing over the pulley. This value is divided by the pulley radius to determine the angular displacement of the pulley, θ_m.

The term, "$\frac{K_T}{R_a + sL_a}$", contained in various blocks represents the torque motor characteristics. K_T is the motor torque constant, R_a and L_a are the motor resistance and inductance respectively, and s is the Laplace operator. A detailed derivation of the motor dynamics is presented in Appendix B.

The output torque from the motor is reduced by the back EMF of the motor as well as by the motor inertia and system friction. This is reflected in the remaining two feedback loops. The K_v term represents the back EMF. The J_M and G terms are the system inertia and friction.

The friction gain, G, is proportional to the pulley rotational rate. Reference 2 shows that for perturbation analysis, the coulomb friction can be replaced by a term proportional to the rotational rate.

The net output torque is divided by the pulley radius, r_d, to determine the total tension change in the cable. If the cable mass is assumed negligible, the total tension can be replaced by a ΔT. The magnitude of ΔT is half the total cable tension. The ΔT is a positive tension on one side of the pulley and a negative tension on the other side. This accounts for the factor of two in the block containing $2r_d$. A derivation of this concept is shown in Appendix B.

The block diagram is written in the conventional manner in which the cable tension feedback, ΔT_{fb}, is subtracted from the input ΔT_i. The signs are accordingly adjusted. The loop, however, remains consistent with the sign convention of figure 1.

In figure 3, the block diagram differs only in the equations which the block in the forward loop represents. Here, the block represents the lateral-directional perturbation equations of motion. Y, Ψ, ϕ are the perturbation variables. The feedback gains K_r, $K_{\dot{\Psi}_m}$ and K_{Ψ_m} are the model yaw rate gyro gain, the horizontal cable torque motor tachometer gain, and the corresponding pulley displacement gain respectively.

The logic in the two block diagrams are modelled in the program using an expanded polynomial matrix representation. These matrices are shown in figure 4 and 5. They correspond to expanded versions of the basic matrices shown in figures 6.3 and 7.2 of reference 1. The following discussion of figure 4 applies equally to figure 5.

In the longitudinal mode, the basic cable mount system without feedback is represented by the 4 x 4 matrix in the upper left-hand corner of figure 4. The additional cable tension modulation due to the active feedback logic, including motor and pulley dynamics, is represented by the added ΔT_c terms in equations 1 through 3. The coefficients of ΔT_c are derived from equations 5.4-3.3 and 5.4-8 of reference 1.

The motor dynamics are defined by equation 5. Equation 6 defines the geometric relation between pulley displacement and model motion. Equation 7 defines the control law. Equations 9 and 10 represent the summation junctures in the block diagram and equation 8 is an auxiliary equation relating pulley rate to its displacement.

In figure 5, the basic system is represented by the 3 x 3 matrix in the upper left-hand corner. The extension of this basic model to include active feedback is via the ΔT_c terms in equations 1 through 3. The remaining equations are similar to those of figure 4. The only difference being that these equations represent the lateral-directional mode..

The equations of figures 4 and 5 are implemented in subroutines LONG and LAT respectively. Figures 6 and 7 show the flow charts for these subroutines.

The expanded matrices are activated in the program by KODE (13). When this code is greater than zero, the program will read in additional data to define the active feedback parameters. These parameters are tabulated in Section 5.0.

Open and closed loop characteristic roots as well as numerator roots can be derived from these matrices. The procedure for obtaining this informat'or from the program is discussed in Section 4.0.

3.0 FLYING CABLE SNUBBER SYSTEM

The snubber system used the basic flying cables with a large increase in rear cable tension providing the "snubbing" action. When the snubber system is activated the following sequence of events occurs:

1) the rear cable tension is increased to some predetermined level.
2) Next, disc brakes are applied directly to each of the f ur flying cables

Following the snubbing sequence the model responds essentially to four pre-stressed dead-ended cables. Consequently the math model for the snubbed dynamics consists of the conventional aerodynamic effects plus cable influence coefficients derived by assuming each cable to be a pre-stressed spring. The direction cosines, cable lengths, and cable tie-down geometry used for the conventional stability analysis are appropriate for the snubbed analysis, since the same cables are being used for snubbing. A schematic of the sn model is shown in Figure 8. The effects of the snubbed flying cables on both longitudinal and lateral/directional stability are modeled similar to the rear flying cables in the conventional analysis (see Sections 5.0 and 6.0 in reference 1). The force and moment contributions for each cable are calcul separately, summed and placed in the characteristic polynomial matrix. These calculations are made within subroutines LONG and LAT.

3.1 LONGITUDINAL AXIS

The general derivation for the longitudinal cable influence coefficients is presented in reference 1 and will not be repeated here. A 7 x 7 matrix with the form shown in Figure 8A is used to model each cable.

The matrix is reduced to a 3 x 3 in x, z, θ and put in the FXS array. The longitudinal stability is a 3 x 3 matrix in x, z, and θ. The matrix no longer contains ΔT_F as an independent variable because the front cable constraint equation (no change in total front cable length) is not required in the snubbed condition. Each cable acts as an independent spring restraint.

3.2 LATERAL-DIRECTIONAL AXIS

The general derivation for the lateral-directional cable influence coefficients is also presented in reference 1. The equations describing each cable are set in a 8 x 8 matrix with the form shown in Figure 8B.

The matrix is reduced to a 3 x 3 matrix in Y, ψ, and ϕ, and stored in the FXS array.

The lateral-directional stability matrix is a 3 x 3 matrix, structured exactly the same as the conventional stability matrix.

4.0 ADDITIONAL PROGRAM OPTIONS

Four additional options have been added to the Cable Mount Analysis Program. These are options to compute the numerators and denominators of the transfer function, the determination of the frequency response of any transfer function, the computation of wind-off characteristics and the computation of the wind tunnel model without cable effects (cableless model). The procedure for executing these options are discussed in this section.

4.1 TRANSFER FUNCTION OPTIONS

This option allows the computation of numerators and denominators. A detailed discussion of the procedure is presented in Section 4.1.1 and 4.1.2 for the longitudinal and lateral directional modes respectively.

4.1.1 LONGITUDINAL AXIS

The matrix shown in figure 4 is the complete longitudinal matrix. The size of the matrix to be evaluated determines the system that is being evaluated. KODE (8) is the parameter which sets the size of the matrix from which the roots are to be extracted. KODE (8) is set to either 4, 9, or 10. When KODE (8) is equal to 4, the system being evaluated is the basic inactive cable mount system as defined in reference 1. When KODE (8) is equal to 9, the open-loop roots of the active feedback system are extracted; and when KODE (8) is equal to 10, the closed-loop roots for the active feedback system are extracted.

KODE (14) and KODE (15) are the parameters which indicate to the program whether numerator or denominator roots are to be extracted. If KODE (14) is zero, the characteristic or denominator roots are extracted. If KODE (14) is non-zero, the program assumes that numerator roots are to be extracted. The program will then replace the column defined by KODE (15) by the column defined by KODE (14) in the matrix.

The basic no feedback system transfer function can be evaluated by setting KODE (8) to 4 and KODE (14) to 10. Setting KODE (15) from 1 to 4 will determine the numerator roots of the $z/\Delta T_c$, $\theta/\Delta T_c$, $\Delta T_F/\Delta T_c$ and $x/\Delta T_c$ transfer functions. Setting KODE (14) to zero will determine the denominator roots of these transfer functions. Thus the complete transfer function can be determined. Transfer function response to either elevator or gust input is possible by setting KODE (14) to 15 or 16 respectively.

The open loop zeros can be determined by setting KODE (8) to 9 and KODE (14) to 10. The variation of KODE (15) from 1 through 9 will determine the zeros for various output parameters. The open loop poles are determined by setting KODE (14) to 0.

In the closed loop numerator computation the forcing function can be either a test voltage input, E_{mo}, an externally applied tension, ΔT_i, a model elevator input, δ_e, or a vertical gust input, α_g. These inputs correspond to a KODE (14) of 11, 12, 15 or 16.

For example, if the closed loop numerator roots of the transfer function, θ/E_{mo}, are desired, KODE (14) is set to 11 and KODE (15) is set to 2. After the substitution of columns, the roots are extracted from the matrix whose size is set to 10 by KODE (8). By varying KODE (15) from 1 to 10, numerator roots of various output parameters can be obtained.

Since the model pitch rate, $\dot{\theta}$, is an important parameter and this does not appear explicitly in the matrix, the program is set up to artificially generate the frequency response for this mode. This option is activated by setting KODE (15) to 13.

The transfer function of the cableless model, defined in Section 4.3, can also be determined. The numerators $z/_{\delta e}$, $\theta/_{\delta e}$ and $x/_{\delta e}$, are determined by setting KODE (8) = 3, KODE (14) = 14, and KODE (15) from 1 through 3. The denominator roots are determined by setting KODE (14) to zero.

4.1.2 Lateral Directional Axis

KODE (9) is the parameter used in the lateral directional mode to set the size of the matrix and define the system being evaluated. KODE (9) set to 3 defines the basic cable system without feedback. KODE (9) set to 9 defines the open loop roots of the active feedback system and KODE (9) set to 10 defines the closed loop roots of the active feedback system.

The numerator option is determined by KODE (16). KODE (16) set equal to zero results in the extraction of characteristic roots. KODE (16) non-zero results in the replacement of the column defined by KODE (17) with the column defined by KODE (16) in the matrix of figure 5.

Specifically, the numerator characteristics of the basic cable system without feedback are obtained by setting KODE (9) to 3 and KODE (16) to either 10, 14, 15, or 16 depending on the type of forcing function that is desires. These are respectively a cable tension change, ΔT_c, a rudder input, δ_r, an aileron input, δ_a, or a side gust, B_g. The dependent variable is determined by KODE (17) which may vary from 1 through 3. The denominator roots are obtained by setting KODE (16) to zero.

The open loop zeros of the block diagram shown in figure 5 is determined by setting KODE (9) to 9, KODE (16) to 10 and KODE (17) from 1 through 9. The denominator or open loop poles are determined by etting KODE (16) to zero.

The closed loop numerator for the active cable system is determined by setting KODE (9) to 10. The forcing function is defined by KODE (16). This code can be 11, 12, 14, 15, or 16. They correspond to a test voltage, E_{mo}, test tension, ΔT_i, rudder input, δ_r, aileron input, δ_a, or a side wind gust, βg.

4.2 Frequency Response Option

The frequency response option will compute the complete transfer function according to Section 4.1; and then evaluates for the computed transfer function over a range of frequencies, the amplitude ratio in actual value, db's, and the phase angle. The option will compute up to 60 points over a 3 decade bandwidth with a maximum of 20 points per decade.

This option will also compute the steady state value of the transfer function to a step input of the forcing function if this value exists.

The frequency response option is activated by setting KODE (3) to +2. Since a complete transfer function must be generated prior to developing the frequency response data, KODE (14) and KODE (15) or KODE (16) and KODE (17) must be set to non zero values to define the desired transfer function. Two additional parameters, KODE (18) and KODE (19), must be set to define the frequency range and number of points to be computed. KODE (18) sets the order of the lowest frequency to be computed, e.g., KODE (18) set to -1 corresponds to .1 rps and a "+1" corresponds to 10 rps. KODE (19) set to 60 means sixty points are computed for the three decade bandwidth of the frequency response.

The frequency response option is initiated in subroutines LONG and LAT for the longitudinal and lateral directional modes respectively. The program, on sensing KODE (3) equal to 2, will effectively cycle through subroutines LONG or LAT twice, first to compute the numerator and then again to compute the denominator roots.

The information is then passed to subroutine FREQ where the frequency response data is generated with the aid of subroutine ANP.

4.3 Wind-Off Characteristics

This option is used to compute the system response without the aerodynamic effects. The dynamic characteristics reflect the system feedback, and equivalent spring and damping effects.

In this option, the normal trim operation technique is circumvented. Instead, the vehicle attitude is set to zero and the forward cable tension is defined to balance out the rear cable tension.

The program will execute this option if the velocity (AERO (49)) and the MACH number (AERO (48)) are set to zero.

4.4 Cableless Model Characteristics

This option allows the computation of the airframe characteristic roots without the cable effects. The program initially trims the vehicle assuming the cables are attached to the vehicle. After defining the trim attitude, the cable influence coefficients are set to zero.

This option defines the characteristics of a model in the wind tunnel. The equations are different from the conventional airframe analysis equations. The differences are in the relation of angle of attack to model pitch attitude (see equation 5.3-2 of ref 1) and the missing thrust terms.

Prior to extracting roots from the matrix in the longitudinal mode, the X column is shifted to the left one column eliminating the ΔT_F column in figure 4. Thus the cableless model option requires a KODE (8) of 3 reflecting a 3 x 3 matrix size.

The lateral directional mode does not require this extra step of column manipulation and KODE (9) should be set to 3.

The program will execute this option only if KODE (13) is set to -1.

5.0 INPUT DATA

The input format and the description of the elements in the input arrays will be described in this section. This discussion is meant to supersede the description contained in Section 11.0 of Reference 1.

The format for the input data is most easily explained by reproducing the "READ" statements as they appear in the program.

```
READ (IR, 150) (TITLE (I), I = 1, 20)                    (1)
150 FORMAT (20A4)
READ (IR, 200)(KODE (I), I = 1, 24)                      (2)
200 FORMAT (24I3)
```

Then either 3a or 3b: the value of KODE (7) will determine which "READ" statement will be used.

```
READ (IR,100) (AERO (I), I = 1,36)                       (3a)
100 FORMAT (6E12.5)
CALL TABIN1 (1, 36) (See Appendix A, Ref. 1)             (3b)
```

Following either (3a) or (3b) the sequence of "READ" statements continues:

```
READ (IR, 100) (AERO (I), I = 44,59)                     (4)
READ (IR, 100) (AERO (I), I = 66, 130)                   (5)
```

Now if KODE (13) is greater than zero the following "READ" statement is encountered. If KODE (13) is less than or equal to zero this "READ" statement is skipped.

```
READ (IR, 100)(AERO (I), I = 131, 160)                   (6)
```

Now if KODE (12) equals one, the following table read statement is encountered. If KODE (12) equals zero this statement is skipped.

```
CALL TABIN (1, 2) (See Appendix A, Ref 1)                (7)
```

This completes the initial sequence of input data. After completion of the first run the following statements initialize another run.

READ (IR, 150) (TITLE (I), I = 1, 20) (8)

READ (IR, 200) (KODE (I), I = 1, 24) (9)

READ (IR, 350) K,. VALUE (10)

K = element in "AERO" array to be changed

VALUE = new value of the element

If I = 1 this "READ" statement is repeated

If I = 0 the program begins computation

All succeeding cases follow the same input format starting with statement (8).

A general description of the input arrays follows:

ARRAY	DESCRIPTION
TITLE	Alpha-numeric array containing title for each run.
KODE	Array specifying program options to be exercised.
AERO	Array containing all the input data pertaining to the model, the mount system, tunnel conditions. etc.

A description of each element in the "KODE" and "AERO" arrays follows.

NAME	VALUE	DESCRIPTION
KODE (1)	-	Run number.
KODE (2)	-1	Calculate longitudinal stability.
	0	Calculate lateral/directional stability.
	+1	Calculate both longitudinal and lateral/directional stability.
KODE (3)	0	No root locus or frequency response.
	+1	Do root locus.
	+2	Do frequency response.
KODE (4)		Element in "AERO" array to be varied for root locus.
KODE (5)	0	Basic printout.
	+1	Basic printout plus various test parameters.
KODE (6)	+1	Front cable vertical-rear cable horizontal.
	+2	Front cable horizontal-rear cable vertical.
	+3	Front and rear cable vertical.
	+4	Front and rear cable horizontal
KODE (7)	0	Aero data to be input at specific mach number.
	+1	Aero data to be input in the form of tables.

NAME	VALUE	DESCRIPTION
KODE (8)	+3	Longitudinal matrix - Cableless Model (see Section 4.3)
	+4	Longitudinal matrix - no stability augmentation.
	+5	Longitudinal matrix - internal stability augmentation (see Section 9.0, Reference 1.)
	+9	Longitudinal matrix - Open loop response of Active Cable Mount System (see Section 2.0 , 4.1.1)
	+10	Longit. iinal matrix - Close loop response of Active Cable Mount System (see Section 2.0, 4.1.1)
KODE (9)	+3	Lateral/directional matrix - no stability augmentation or cableless model.
	+4	Lateral/directional matrix - internal yaw stability augmentation, (see Section 9.0, Reference 1.)
	+5	Lateral/directional matrix - internal roll and yaw stability augmentation, (see Section 9.0, Reference 1.
	+9	Lateral/directional matrix - open loop response of Active Cable Mount System (see Section 2C , 4.1.2)
	+10	Lateral/directional matrix - Close loop response of Active Cable Mount System (See Section 2.0 4.1.2)

NAME	VALUE	DESCRIPTION
KODE (10)	0	No snubbers.
	+1	Analyze conventional snubbers in unsnubbed condition - see Section 8.1, Reference 1.
	+2	Analyze conventional snubbers in snubbed condition - See Section 8.2, Reference 1.
	+3	Analyze flying cable snubber system.
KODE (11)	0	No anti-lift cable.
	+1	Anti-lift cable in.
KODE (12)	0	No unsnubbed snubber data input.
	+1	Unsnubbed snubber data will be read in.
KODE (13)	-1	Cableless Airframe Characteristics. (See Section 4.3)
	0	No active cable stability augmentation.
	+1	Active cable stability augmentation in. (See Section 2.0)
KODE (14)	0	Longitudinal system - compute denominator characteristics only.
	+10	Longitudinal system - numerator and/or frequency characteristics of inactive cable mount system for cable tension input, ΔTc. (See Section 4.1.1)
	+10	Longitudinal System - numerator and/or frequency characteristics of active cable mount system open loop for cable tension input, ΔTc. (See Section 4.1.1)

NAME	VALUE	DESCRIPTION
	+11	Longitudinal System - numerator and/or frequency characteristics of active cable mount system close loop response for test voltage input E_{mo}. (See Section 4.1.1)
	+12	Longitudinal System - numerator and/or frequency characteristics of active cable mount system close loop response for externally applied tension, ΔT_1. (See Section 4.1.1)
	+15	Longitudinal system - numerator and/or frequency characteristics for pitch control response (δe)
	+16	Longitudinal system - numerator and/or frequency characteristics for gust response (α_G).
KODE (15)		Longitudinal system - column number of output variable for which numerator and/or frequency data is desired. KODE (15) is set equal to 13 for model pitch rate response. This value must be equal or less than KODE (8). (See Section 4.1.1)
KODE (16)	0	Lateral/directional system - compute denominator characteristics only

NAME	VALUE	DESCRIPTION
	+10	Lateral/directional system - numerator and/or frequency characteristics of inactive cable mount system for tension input ΔTc. (See Section 4.1.2).
	+10	Lateral/directional system - numerator and/or frequency characteristics of active cable mount system open loop for tension input, ΔTc. (See Section 4.1.2)
	+11	Lateral/directional system - numerator and/or frequency characteristics of active cable mount system close loop for test voltage input E_{mo}. (See Section 4.1.2)
	+12	Lateral/directional system - numerator and/or frequency characteristics of active cable mount system close loop response for externally applied tension,(ΔT)/ (See Section 4.1.2)
	+14	Lateral/directional system - numerator and/or frequency characteristics for yaw control response (δr).
	+15	Lateral/directional system - numerator and or frequency characteristics for roll control response (δa).

NAME	VALUE	DESCRIPTION
	+16	Lateral/directional system - numerator and/or frequency characteristics for gust response (θ_G).
KODE (17)		Lateral/directional system - column number of independent variable for which numerator and/or frequency data is desired.
KODE (18)		Order of lowest frequency (RPS) for frequency response data.
KODE (19)		Number of data points in frequency response (Max of 60.)

NAME	UNITS	LABEL	DESCRIPTION	
AERO (1)	N.D.	CDU	$\partial C_D/\partial(u/V_o)$	$[C_{D_u}]$
AERO (2)	N.D.	CLU	$\partial C_L/\partial(u/V_o)$	$[C_{L_u}]$
AERO (3)	N.D.	CMU	$\partial C_m/\partial(u/V_o)$	$[C_{m_u}]$
AERO (4)	1/rad	CDA	$\partial C_D/\partial(\alpha)$	$[C_{D_\alpha}]$
AERO (5)	1/rad	CLA	$\partial C_L/\partial(\alpha)$	$[C_{L_\alpha}]$
AERO (6)	1/rad	CMA	$\partial C_m/\partial(\alpha)$	$[C_{m_\alpha}]$
AERO (7)	N.D.	CDQ	$\partial C_D/\partial(q\bar{c}/2V_o)$	$[C_{D_q}]$
AERO (8)	N.D.	CLQ	$\partial C_L/\partial(q\bar{c}/2V_o)$	$[C_{L_q}]$
AERO (9)	N.D.	CMQ	$\partial C_m/\partial(q\bar{c}/2V_o)$	$[C_{m_q}]$
AERO (10)	N.D.	CDO	Drag coefficient at $\alpha = 0$	$[C_{D_o}]$
AERO (11)	N.D.	CLO	Lift coefficient at $\alpha = 0$	$[C_{L_o}]$
AERO (12)	N.D.	CMO	Pitching moment at $\alpha = 0$	$[C_{m_o}]$
AERO (13)	1/rad	CDDE	$\partial C_D/\partial(\delta_e)$	$[C_{D_{\delta_e}}]$
AERO (14)	1/rad	CLDE	$\partial C_L/\partial(\delta_e)$	$[C_{D_{\delta_e}}]$
AERO (15)	1/rad	CMDE	$\partial C_m/\partial(\delta_e)$	$[C_{m_{\delta_e}}]$
AERO (16)	N.D.	CDAD	$\partial C_D/\partial(\dot{\alpha}\bar{c}/2V_o)$	$[C_{D_{\dot{\alpha}}}]$
AERO (17)	N.D.	CLAD	$\partial C_L/\partial(\dot{\alpha}\bar{c}/2V_o)$	$[C_{L_{\dot{\alpha}}}]$
AERO (18)	N.D.	CMAD	$\partial C_m/\partial(\dot{\alpha}\bar{c}/2V_o)$	$[C_{m_{\dot{\alpha}}}]$
AERO (19)	1/rad	CYB	$\partial C_y/\partial(\beta)$	$[C_{y_\beta}]$
AERO (20)	1/rad	CLB	$\partial C_\ell/\partial(\beta)$	$[C_{\ell_\beta}]$
AERO (21)	1/rad	CNB	$\partial C_n/\partial(\beta)$	$[C_{n_\beta}]$
AERO (22)	N.D.	CYP	$\partial C_y/\partial(pb/2V_o)$	$[C_{y_p}]$
AERO (23)	N.D.	CLP	$\partial C_\ell/\partial(pb/2V_o)$	$[C_{\ell_p}]$
AERO (24)	N.D.	CNP	$\partial C_n/\partial(pb/2V_o)$	$[C_{n_p}]$
AERO (25)	N.D.	CYR	$\partial C_y/\partial(rb/2V_o)$	$[C_{y_n}]$
AERO (26)	N.D.	CLR	$\partial C_\ell/\partial(rb/2V_o)$	$[C_{\ell_r}]$

NAME	UNITS	LABEL	DESCRIPTION	
AERO (27)	N.D.	CNR	$\partial C_n/\partial(rb/2V_o)$	$[C_{n_r}]$
AERO (28)	1/rad	CYDR	$\partial C_y/\partial(\delta_r)$	$[C_{y_{\delta_r}}]$
AERO (29)	1/rad	CLDR	$\partial C_\ell/\partial(\delta_r)$	$[C_{\ell_{\delta_r}}]$
AERO (30)	1/rad	CNDR	$\partial C_n/\partial(\delta_r)$	$[C_{n_{\delta_r}}]$
AERO (31)	1/rad	CYDA	$\partial C_y/\partial(\delta_a)$	$[C_{y_{\delta_a}}]$
AERO (32)	1/rad	CLDA	$\partial C_\ell/\partial(\delta_a)$	$[C_{\ell_{\delta_a}}]$
AERO (33)	1/rad	CNDA	$\partial C_n/\partial(\delta_a)$	$[C_{n_{\delta_a}}]$
AERO (34)	1/rad	CYDS	$\partial C_y/\partial(\delta_s)$	$[C_{y_{\delta_s}}]$
AERO (35)	1/rad	CLDS	$\partial C_\ell/\partial(\delta_s)$	$[C_{\ell_{\delta_s}}]$
AERO (36)	1/rad	CNDS	$\partial C_n/\partial(\delta_s)$	$[C_{n_{\delta_s}}]$
AERO (44)	in	XREF*	Distance from aerodynamic ref. center to the equation ref. center along the X body axis	
AERO (45)	in	ZREF	Distance from aerodynamic ref. center to the equation ref. center along the Z body axis	
AERO (46)	in	XCG	Distance from model mass & inertia ref. center to the equation ref. center along the X body axis	
AERO (47)	in	ZCG	Distance from model mass & inertia ref. center to the equation ref. center along the Z body axis	
AERO (48)		AMACH	Tunnel mach number	
AERO (49)	ft/sec	VO	Tunnel velocity	
AERO (50)	slugs	AM	Model mass	
AERO (51)	slug/ft^3	RHO	Tunnel density	

NAME	UNITS	LABEL	DESCRIPTION
AERO (52)	lbs	WT	Model weight
AERO (53)	ft	B	Model reference span
AERO (54)	ft	CBAR	Model reference chord
AERO (55)	ft^2	SW	Model reference wing area
AERO (56)	slug-ft^2	XIXZ	Model cross product of inertia (I_{XZ})
AERO (57)	slug-ft^2	XIXX	Model roll inertia (I_{xx}), body axis at C.G.
AERO (58)	slug-ft^2	YIYY	Model pitch inertia (I_{yy}), body axis at C.G.
AERO (59)	slug-ft^2	ZIZZ	Model yaw inertia (I_{zz}), body axis at C.G.
AERO (66)	in	WLUF	Water line-upper front cable tie-down point (fr. vert.)
AERO (67)	in	WLLF	Water line-lower front cable tie-down point (fr. vert.)
AERO (68)	in	WLUR	Water line-upper rear cable tie-down point (rr. vert.)
AERO (69)	in	WLLR	Water line-lower rear cable tie-down point (rr. vert.)
AERO (70)	in	WLHF	Water line-horizontal front cable tie-down point (fr. hor.)
AERO (71)	in	WLHR	Water line-horizontal rear cable tie-down point (rr. hor.)
AERO (72)	in	STAF	Station-front cable tie-down point (fr. vert. or hor.)
AERO (73)	in	STAR	Station-rear cable tie-down point (rr. vert. or hor.)
AERO (74)	in	BLHF	Butt line-horizontal front cable tie-down point (fr. hor.)

NAME	UNITS	LABEL	DESCRIPTION
AERO (75)	in	BLHR	Butt line-horizontal rear cable tie-down point (rr. hor.)
AERO (76)	in	WLCR	Water line-equation reference point
AERO (77)	in	STACR	Station - equation reference point
AERO (78)	in	BLCR	Butt line-equation reference point
AERO (79)	in	EF**	Distance along X body axis from ref. center to vertical front pulley
AERO (80)	in	ER	Distance along X body axis from ref. center to vertical rear pulley
AERO (81)	in	AF	Distance along X body axis from ref. center to horizontal front pulley
AERO (82)	in	AR	Distance along X body axis from ref. center to horizontal rear pulley
AERO (83)	in	HUCF	Distance along Z body axis from ref. center to upper front pulley
AERO (84)	in	HLCF	Distance along Z body axis from ref. center to lower front pulley
AERO (85)	in	HUCR	Distance along Z body axis from ref. center to upper rear pulley
AERO (86)	in	HLCR	Distance along Z body axis from ref. center to lower rear pulley
AERO (87)	in	DCF	Distance along Y body axis from ref. center to horizontal front pulley
AERO (88)	in	DCR	Distance along Y body axis from ref. center to horizontal rear pulley

NAME	UNITS	LABEL	DESCRIPTION
AERO (89)		blank	
AERO (90)	in	RVF	Radius of vertical front pulley
AERO (91)	in	RHF	Radius of horizontal front pulley
AERO (92)	in	RVR	Radius of vertical rear pulley
AERO (93)	in	RHR	Radius of horizontal rear pulley
AERO (94)	lbs	TRO	Rear cable tension
AERO (95)	lbs/in	AKR	Rear cable spring constant
AERO (96)	ft lbs/rad	COU	Pulley Coulomb friction (a_c)
AERO (97)	in	STLTT	Station - lift cable tie-down point
AERO (98)	in	WLLTT	Water line - lift cable tie-down point
AERO (99)	lbs	TLFTO	Lift cable tension
AERO (100)	lbs/in	AKLFT	Lift cable spring constant
AERO (101)		blank	
AERO (102)	in	ALTX*	Distance along X body axis from lift cable attachment point to the equation reference center
AERO (103)	in	ALTZ	Distance along Z body axis from lift cable attachment point to the equation reference center
(1) AERO (104)	ft lbs/rad/sec	CMP	Pulley rolling friction coefficient
AERO (105)	in	SNUX***	Distance along X body axis from model upper attachment point to the equation reference center
AERO (106)	in	SNUY	Distance along Y body axis from model upper snubber attachment point to the equation reference center
AERO (107)	in	SNUZ	Distance along Z body axis from model upper snubber attachment point to the equation reference center

(1) AERO (104) through AERO (122) refer to conventional snubbers except where noted.

NAME	UNITS	LABEL	DESCRIPTION
AERO (108)	in	SNLX	Distance along X body axis from model lower snubber attachment point to the equation reference center
AERO (109)	in	SNLY	Distance along Y body axis from model lower snubber attachment point to the equation reference center
AERO (110)	in	SNLZ	Distance along Z body axis from model lower snubber attachment point to the equation reference center
AERO (111)	in	SNUST	Station - upper snubber tie-down point
AERO (112)	in	SNUWL	Water line - upper snubber tie-down point
AERO (113)	in	SNUBL	Butt line - upper snubber tie-down point
AERO (114)	in	SNLST	Station - lower snubber tie-down point
AERO (115)	in	SNLWL	Water line - lower snubber tie-down point
AERO (116)	in	SNLBL	Butt line - lower snubber tie-down point
AERO (117)	lbs	TUSNO	Upper snubber, snubbed tension or flying cable snubber rear cable tension.
AERO (118)	lbs	TLSNO	Lower snubber, snubber tension
AERO (119)	lbs/in	AKSNU	Upper snubber, snubbed spring constant
AERO (120)	lbs/in	AKSNL	Lower snubber, snubbed spring constant flying cable snubber rear cable spring constant.
AERO (121)	lbs/in/sec	ADSNU	Upper snubber, snubbed damping constant or flying cable snubber front cable spring constant.

NAME	UNITS	LABEL	DESCRIPTION
AERO (122)	lbs/in/sec	ADSNL	Lower snubber, snubbed damping constant.
AERO (123)	rad/rad/sec	AKSY	Feedback gain- yaw rate to rudder
AERO (124)	rad/rad/sec	AKPHI	Feedback gain - roll rate to aileron.
AERO (125)	rad/rad/sec	AKTHE	Feedback gain - pitch rate to elevator.
AERO (126)	blank		
AERO (127)	sec	T1SY	Time constant for lag on yaw rate feedback.
AERO (128)	sec	T2PHI	Time constant for lag on roll rate feedback.
AERO (129)	sec	T3THE	Time constant for lag on pitch rate feedback.
AERO (130)	blank		
AERO (131)	in-lbs/amp	AKSBT****	Motor torque constant (K_t)
AERO (132)	volts/rad/sec	AKSBV	Motor velocity constant (K_v)
AERO (133)	in-lbs-sec^2	AJASM	Motor inertia (J_M)
AERO (134)	ohms	RSBA	Motor armature resistance (R_a)
AERO (135)	henry	ELSBA	Motor armature inductance (L_a)
AERO (136)	in	RSBD	Radius of motor pulley (r_d)
AERO (137)	volts/rad/sec	AKTHD	Pulley rotation rate feedback ($K_{\dot{\theta}_m}$)
AERO (138)	volts/rad	AKTH	Pulley rotation displacement feedback (K_{θ_m})
AERO (139)	in-lbs/rad/sec	GDMP	Pulley friction (G)
AERO (140)	volts/rad/sec	AKQ	Model pitch rate feedback (K_q)

NAME	UNITS	LABEL	DESCRIPTION
AERO (142)	volts/rad/sec	AKPSD	Model yaw rate feedback (K_r)
AERO (143)	volts/rad	AKY	Pulley rotation displacement feedback (K_{Ψ_m})
AERO (144)	volts/rad/sec	AKYD	Pulley rotation rate feedback ($K_{\dot{\Psi}_m}$)

AERO (145) to AERO (160) blank

*See Figure 9 for pictorial representation of various reference center.

**See Figure 10 for pictorial representation of pulley geometry.

***See Figure 11 for pictorial representation of conventional snubber cable geometry.

****See Figures 2 and 3 for block diagram representations of the active cable control logic. (See appendix B for derivation)

If the aerodynamic data and/or snubber data are to be read in table format, the following discussion applies.

The first 36 tables contain the aerodynamic derivatives in stability axis versus mach number. The order is the same as AERO (1) through AERO (36). The table input format is shown in Appendix A of Reference 1. This data is read in under TABIN1.

The unsnubbed snubber data consists of two tables of input. The first table contains cable tension (lbs) versus dynamic pressure (psf) and linear distance (in) between model tie-down point and tunnel side wall. The second table contains cable angle (rad) versus dynamic pressure (psf) and linear distance (in) between model tie-down point and the tunnel side wall. The tensions and angles mentioned here are described in detail in Section 8.0 of Reference 1.

Reference

1. Barbero, P. and Chin, J.: User's Guide for a Computer Program to Analyze the LRC 16' Transonic Dynamics Tunnel Cable Mount System. NASA CR 132313, NASA Langley, Hampton, Va., Oct. 1973

2. Mc Ruer, D.T. and Bates, C.L.: Methods of Analysis and Synthesis of Piloted Aircraft Flight Control System. Bu Aer Rept AE-61-41, Bureau of Aeronautics, Navy Dept., Washington, D.C. March 1952

Appendix A

A Discussion of the Differences in Cable Attachment Points Between the Inactive and Active Cable Mount System

There exists a basic difference in the cable mount system analyzed in the original program and the present active cable system. In the original system, the front cable is attached to hard points on the tunnel wall. The cable wraps around pulleys which are fixed to the model. This cable is assumed to be fixed in length. The rear cable is similarly wrapped around pulleys fixed to the model. There is a spring which is connected in series with the rear cable which allows for play in the system. This system is pictorially represented in figure A-1.

In the present "active cable system," the front cable is attached to hard point on the model. The cable wraps around pulleys fixed to the tunnel. One of the pulleys is connected to a torque motor. The rear cable is similarly routed around pulleys fixed to the tunnel and tied to hard points on the model. The spring on the rear cable is still assumed. This system is pictorially represented in fig. A2.

The present program is capable of handling both cases. The radius of the pulleys fixed to the model must be made very small to reflect the hard attachment point in the new system, i.e. Aero (90) thru (93) inclusively must be set to .01. The pulley radius mounted to the torque motor is important in the new system and is defined by Aero (136). When the program reverts back to the original system, Aero (90) and Aero (93) is significant, and Aero (136) is ignored.

The program is capable of this dual application because of the method utilized in the analysis of the cable forces. The front and rear cables, which are respectively continuous cables, are analyzed as four individual branches. Each branch represents the cable between the model and the tunnel. These branches are numbered in both figures A1 and A2. The force components on the model contributed by each branch of cable is a function of three factors, the tension in that branch of cable, the orientation of the cable and the exact point of application of the force on the model. The impact of having pulleys fixed to the model is simply to alter the point of application. By reducing the pulley radius, the point of application is analogous to a fixed point on the model.

The other consideration is friction effects of pulleys. There are two different friction definitions, Aero (96) and Aero (104) define the friction in pulleys for the inactive cable system, whereas Aero (139) represents friction effects of the Active Cable System.

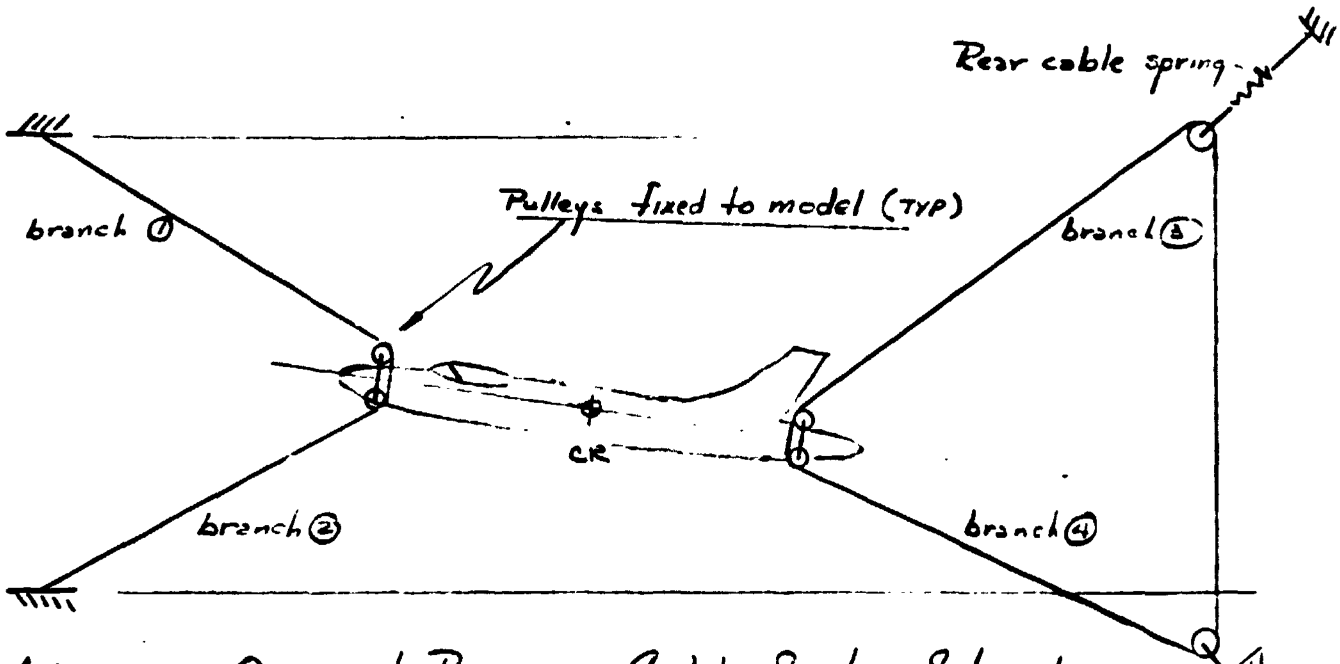

fig A·1 Original Passive Cable System Schematic

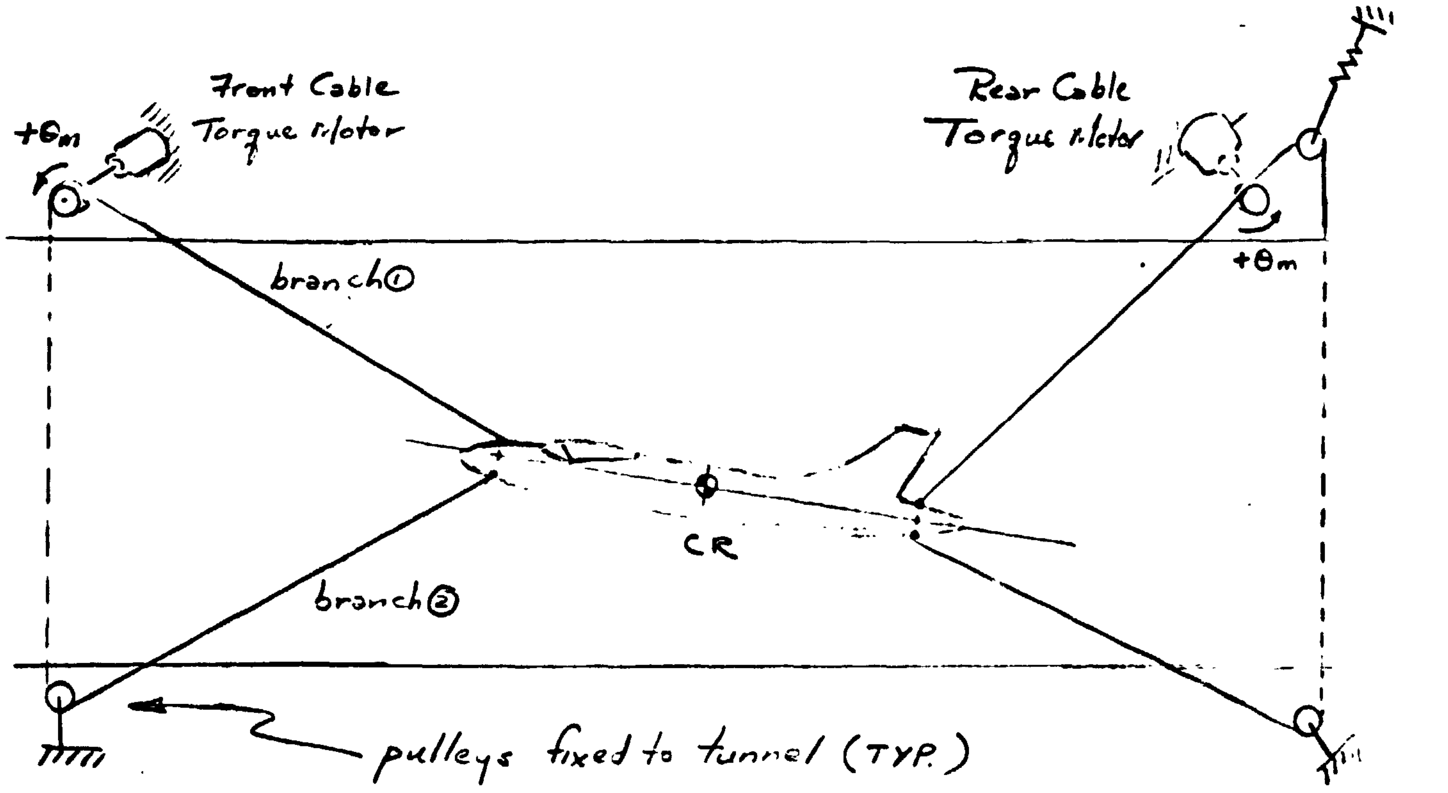

fig A·2 Active 2-Cable Mount System Schematic

APPENDIX B

Derivation of Motor Equations and Cable Tension

The net output torque from the motor is proportional to the current to the motor. The current is related to the voltage and back EMF as shown by equation 1. A list of symbol definition is given on page iii.

$$Q_o = K_T I_a = K_T \left[\frac{E_{m_{TOT}} - K_V s\, \theta_m}{R_a + sL_a} \right] . \qquad (1)$$

For two motors in parallel, the output torque is doubled:

$$Q_o' = 2Q_o$$

The load torque on the motor is due to the total change in cable tension, ΔT_{tot}, and the friction in the system. The couloumb and viscous friction can be written as proportional to the pulley rate. (See ref 2.)

$$Q_L = \Delta T_{TOT}\, r_d + Gs\theta_m \qquad (2)$$

The net torque, output minus load, will cause the motor to rotate.

$$Q_o' - Q_L = J_M \ddot{\theta}_m = J_M s^2 \theta_m \qquad (3)$$

Substituting equations (1) and (2) into equation (3) for Q_o' and Q_L respectively, the total change in cable tension, ΔT_{tot}, can be determined.

$$\Delta T_{tot} = \frac{1}{r_d} \left\{ \left[J_M s^2 + Gs + \frac{2K_T K_V' s}{R_a + sL_a} \right] \theta_m - \frac{2K_T E_{m_{TOT}}}{R_a + sL_a} \right\} \qquad (4)$$

ΔT tot is positive when the cable is in tension.

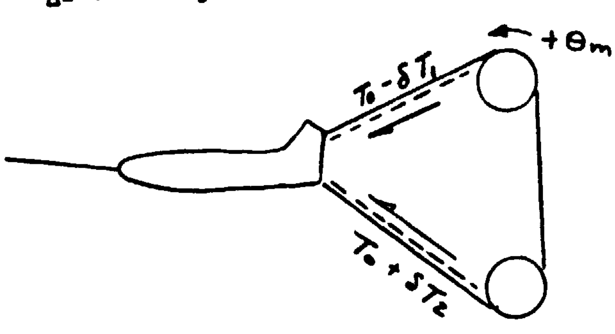

fig B-1

Looking at the larger picture shown in figure B-1, the total change in cable tension ca.. be split into two increments δT_1 and δT_2. Writing the equation of motion of the cable

$$T_0 - \delta T_1 - (T_0 + \delta T_2) = m\dot{a} \qquad (5)$$

For $m\ddot{a} \doteq 0$

$$-\delta T_1 - \delta T_2 = 0 \qquad (6)$$

and
$$\delta T_2 = -\delta T_1 \qquad (7)$$

This states that if the mass times acceleration of the cable is small and can be neglected, the increase in cable tension on one side of the torque motor is just equal to the decrease cable tension on the other side of the torque motor. This result is ideally suited for the perturbation analysis since the program actually considers the continuous cable in figure B-1 as two separate elements as indicated by the dashed lines. With the change in cable tension having equal magnitude along each element, the mechanization is simplified.

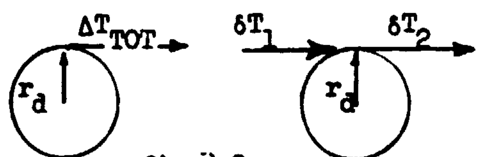

fig B-2

Figure B-2 shows the relation of the change in cable tension on one side of the torque motor, δT, to the total change in cable tension ΔT_{TOT}. Thus

$$\delta T_2 - \delta T_1 = \Delta T_{TOT} \qquad (8)$$

Substituting results from equation 7 into equation 8

$$\delta T_2 = \frac{\Delta T_{TOT}}{2} \qquad (9)$$

Replacing ΔT_{TOT} in equation (4) with equation (9), δT_2 is determined. The δT_2 corresponds to ΔT_{fb} in figures 4 and 5

$$\delta T_2 = \frac{1}{2r_d}\left\{\left[J_M s^2 + Gs + \frac{2K_T K_v s}{R_a + sL_a}\right]\theta_m - \frac{2K_T E_{mTOT}}{R_a + sL_a}\right\} \qquad (10)$$

APPENDIX C

PROGRAM LISTINGS

```
C  THIS IS THE ACTIVE TWO CABLE MOUNT SYSTEM ANALYSES PROGRAM
C  DEVELOPED JULY,74 TO MAY,75
C
      COMMON/INPUT/IW,IR
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON ZZZ(200)
      COMMON/TAB1/ZZ(300)
      COMMON/DU/DUM(10,10)
      COMMON/ANAME/NAME(16),NAME1(16)
      DIMENSION TITLE(20),SAVE(50),SAVE1(150),IKH(160)
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1            (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2            (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3            (AERO(10),  CDO),(AERO(11),  CLO),(AERO(12),  CMO),
     4            (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5            (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6            (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7            (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8            (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9            (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A            (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B            (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS),
     C            (AERO(44), XREF),(AERO(45), ZREF),(AERO(46),  XCG),
     D            (AERO(47),  ZCG)
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VO   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  ),
     1            (AERO (63),THETA)
      EQUIVALENCE(AERO (66), WLUF),(AERO(67), WLLF),(AERO(68), WLUR),
     1            (AERO (69), WLLR),(AERO(70), WLHF),(AERO(71), WLHR),
     2            (AERO (72), STAF),(AERO(73), STAR),(AERO(74), BLHF),
     3            (AERO (75), BLHR),(AERO(76), WLCR),(AERO(77),STACR),
     4            (AERO (78), BLCR),(AERO(79),   EF),(AERO(80),   ER),
     5            (AERO (81),   AF),(AERO(82),   AR),(AERO(83), HUCF),
     6            (AERO (84), HLCF),(AERO(85), HUCR),(AERO(86), HLCR),
     7            (AERO (87),  DCF),(AERO(88),  DCR),
     8            (AERO (90),  RVF),(AERO(91),  RHF),(AERO(92),  RVR),
     9            (AERO(93),   RHR),(AERO(94),  TRC),(AERO(95),  AKR),
     A            (AERO(96),   COU),(AERO(97),STLTT),(AERO(98),WLLTT),
     B            (AERO(99),TLETC),(AERO(100),AKLET),
     C            (AERO(102),ALTX),(AERO(103), ALTZ),(AERO(104),  CMP)
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4            (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5            (AERO(120),AKSNL),(AERO(121),ADSNU),(AERO(122),ADSNL),
     6            (AERO(123), AKSY),(AERO(124),AKPHI),(AERO(125),AKTHE),
     7            (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128),T2PHI),
     8            (AERO(129),T3THE),(AERO(130), T4AZ)
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1            (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
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     2              (AERODP( 7), CXQP),(AERODP( 8), CZQP),(AERODP( 9), CMQP),
     3              (AERODP(10), CXQP),(AERODP(11), CZQP),(AERODP(12), CMQP),
     4              (AERODP(13),CXDEP),(AERODP(14),CZDEP),(AERODP(15),CMDEP),
     5              (AERODP(16),CXADP),(AERODP(17),CZADP),(AERODP(18),CMADP),
     6              (AERODP(19), CYBP),(AERODP(20), CLBP),(AERODP(21), CNBP),
     7              (AERODP(22), CYPP),(AERODP(23), CLPP),(AERODP(24), CNPP),
     8              (AERODP(25), CYRP),(AERODP(26), CLRP),(AERODP(27), CNRP),
     9              (AERODP(28),CYDRP),(AERODP(29),CLDRP),(AERODP(30),CNDRP),
     A              (AERODP(31),CYDAP),(AERODP(32),CLDAP),(AERODP(33),CNDAP),
     B              (AERODP(34),CYDSP),(AERODP(35),CLDSP),(AERODP(36),CNDSP)
      EQUIVALENCE (SN( 1),   GX1),(SN( 2),   GY1),(SN( 3),   GZ1),
     1               (SN( 4),   GX2),(SN( 5),   GY2),(SN( 6),   GZ2),
     2               (SN( 7),   GX3),(SN( 8),   GY3),(SN( 9),   GZ3),
     3               (SN(10),   GX4),(SN(11),   GY4),(SN(12),   GZ4),
     4               (SN(13),   THU),(SN(14),   THL),(SN(15),   ALU),
     5               (SN(16),   ALL),
     6               (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7               (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8               (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9               (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
      KASE=0
      IR=5
      IW=6
      LLL=0
      DO 11 J=1,50
   11 SAVE(J)=9999.
      DO 12 I=1,150
   12 AERO(I)=0.
      LL=0
      READ(IR,150)(TITLE(I),I=1,20)
      READ(IR,200)(KODE(I),I=1,24)
  200 FORMAT(26I3)
      WRITE(IW,170) KODE(1),(TITLE(I),I=1,20)
  170 FORMAT(1H1,3X,'CASE NO=',I3,4X,20A4)
      CALL RITE
      WRITE(IW,171)(I,I=1,24),(KODE(I),I=1,24)
      IF(KODE(7).EQ.1) GO TO 10
      READ(IR,100)(AERO(I),I=1,36)
      GO TO 20
   10 CALL TABIN1(1,36,NG)
      IF(NG.EQ.0) GO TO 20
      WRITE(IW,300) NG
  300 FORMAT(//,' ERROR IN READING TABLES 1-36,NG=',I2)
      GO TO 500
   20 READ(IR,100)(AERO(I),I=44,59)
      READ(IR,100)(AERO(I),I=66,130)
      IF(KODE(13).GT.0.)READ(IR,100)(AERO(I),I=131,160)
  100 FORMAT(6E12.5)
      IF(AERO(48).EQ.0..AND.AERO(49).EQ.0.)WRITE(IW,1003)
 1003 FORMAT(25X,'WIND OFF CHARACTERISTICS')
      IF(KODE(12).NE.1) GO TO 32
      CALL TABIN(1,2,NG)
      IF(NG.EQ.0) GO TO 32
      WRITE(IW,420) NG
  420 FORMAT(' ERROR IN READING SNUBBER DATA TABLE,NG=',I3)
```

```
      GO TO 500
 1000 DO 28 I=1,150
   28 AERO(I)=SAVE1(I)
      READ(IR,150,END=500)(TITLE(I),I=1,20)
  150 FORMAT(20A4)
      KASE=1
      DO 34 J=1,50
   34 SAVE(J)=9999.
      READ(IR,200)(KODE(I),I=1,24)
      WRITE(IW,170) KODE(1),(TITLE(I),I=1,20)
      CALL RITE
      IKM=0
      DO 26 I=1,160
      READ(IR,350)K,VALUE
      IKH(I)=K
      IF(K.LT.1)GO TO 22
      IKM=IKM+1
      AERO(K)=VALUE
   26 IF(K.LT.37)SAVE(K)=AERO(K)
   22 IF(AERO(48).EQ.0..AND.AERO(49).EQ.0.)WRITE(IW,1003)
      WRITE(IW,171)(I,I=1,24),(KODE(I),I=1,24)
  171 FORMAT(//' CODE NOS. FOR THIS CASE.',/,24I5,/,24I5)
      WRITE(IW,352)
  352 FORMAT(3X,'DATA CHANGE')
  350 FORMAT(I3,E12.5)
      IF(IKM.LE.0)GO TO 24
      DO 24 I=1,IKM
      K=IKH(I)
      VALUE=AERO(K)
   24 WRITE(IW,351)K,VALUE
  351 FORMAT(3X,I3,3X,E12.5)
      LL=0
   32 IF(KODE(7).EQ.0) GO TO 31
      DO 30 I=1,36
      CALL STINT1(AMACH,0.0,I,I,AERO(I),NG)
      IF(NG.NE.0) GO TO 40
   30 CONTINUE
      DO 36 J=1,36
   36 IF(SAVE(J).NE.9999.) AERO(J)=SAVE(J)
      GO TO 31
   40 WRITE(IW,400) I,NG
  400 FORMAT(//,' ERROR IN TABLE NO',I4,'NG=',I3)
      GO TO 500
  360 FORMAT(6E10.3)
   31 IF(KASE.EQ.1) GO TO 9
      WRITE(IW,801)
  801 FORMAT(5X,'INPUT DATA AS SPECIFIED IN AERO ARRAY')
      WRITE(IW,800)(I,AERO(I),I=1,150)
  800 FORMAT(5(2X,'AERO(',I3,')=',G10.3))
    9 DO 25 I=1,150
   25 SAVE1(I)=AERO(I)
      IF(KODE(3).EQ.0) GO TO 48
      IF(KODE(3).EQ.2)WRITE(IW,43)
   43 FORMAT('     FREQUENCY RESPONSE  COMPUTATION')
      IF(KODE(3).EQ.2)GO TO 48
```

```
   42 DO 27 I=1,150
   27 AERO(I)=SAVE1(I)
      CALL OUTLDC
      IF(LL.EQ.0) GO TO 1000
   48 CALL TRAN1
      IF(KODE(5).EQ.0) GO TO 49
      WRITE(IW,802)
  802 FORMAT(4X,'AERO DATA IN STAB. AXIS AT EQUAT. REF. CENTER')
      WRITE(IW,800)(I,AERO(I),I=1,36)
   49 CALL TRIM
      CALL TRANS
      IF(KODE(5).EQ.0) GO TO 50
      WRITE(IW,803)
  803 FORMAT(4X,'AERO DATA IN BODY AXIS AT EQUAT. REF. CENTER')
      WRITE(IW,804)(I,AEROP(I),I=1,36)
  804 FORMAT(5(2X,'AEROP(',I3,')=',G10.3))
   50 IF(KODE(2)) 70,80,90
   70 WRITE(IW,700)
  700 FORMAT('  **** LONGITUDINAL STABILITY ****')
      IF(KODE(14).EQ.0)GO TO 702
      IDX=KODE(14)
      IDN=KODE(15)
      IF(KODE(13).NE.-1.)GO TO 706
      IF(KODE(15).EQ.3.)IDN=4
      IF(KODE(15).LE.3.)GO TO 706
      KODE(15)=3.
      WRITE(IW,707)
  707 FORMAT(3X,'KODE(15) IS INCORRECT FOR CABLELESS MODEL OPTION,KODE(1
     1 5) IS SET TO 3.')
  706 WRITE(IW,701)NAME(IDN),NAME(IDX)
  701 FORMAT('  COMPUTATION OF ',A4,'/',A4,' NUMERATOR ROOTS')
  702 CALL LONG
      IF(KODE(3).EQ.1) GO TO 42
      GO TO 1000
   80 WRITE(IW,750)
  750 FORMAT('  **** LATERAL/DIRECTIONAL STABILITY ****')
      IF(KODE(16).EQ.0)GO TO 703
      IDX=KODE(16)
      IDN=KODE(17)
      WRITE(IW,701)NAME1(IDN),NAME1(IDX)
  703 CALL LAT
      IF(KODE(3).EQ.1) GO TO 42
      GO TO 1000
   90 WRITE(IW,700)
      IF(KODE(14).EQ.0) GO TO 704
      IDX=KODE(14)
      IDN=KODE(15)
      IF(KODE(13).NE.-1.)GO TO 708
      IF(KODE(15).EQ.3.)IDN=4
      IF(KODE(15).LE.3.)GO TO 708
      KODE(15)=3.
      WRITE(IW,707)
  708 WRITE(IW,701)NAME(IDN),NAME(IDX)
  704 CALL LONG
      WRITE(IW,750)
```

```
      IF(KODE(16).EQ.0) GO TO 705
      IDX=KODE(16)
      IDN=KODE(17)
      WRITE(IW,701)NAME1(IDN),NAME1(IDX)
  705 CALL LAT
      IF(KODE(3).EQ.1) GO TO 42
      GO TO 1000
  500 STOP
      END
      SUBROUTINE PUTLOC
      COMMON/INPUT/IW,IR
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
      IF(LL.GT.0) GO TO 42
      II=KODE(4)
      VARY= ABS(AERO(II)*.1)
      ANOM= AERO(II)
      L=0
      LL=1
      WRITE(IW ,600) II
  600 FORMAT(      1H1,3X,'  ROOT LOCUS VARYING AERO(',I3,')')
   42 L=L+1
      II=KODE(4)
      AERO(II)=ANOM-5.*VARY+L*VARY
      IF(L.GT.9) GO TO 44
      WRITE(IW,180) KODE(4),AERO(II)
  180 FORMAT(/2X,5HAERO(,I3,2H)=,G12.5)
      RETURN
   44 AERO(II)=ANOM
      LL=0
      RETURN
      END
      BLOCK DATA
      COMMON/ANAME/NAME(16),NAME1(16)
      DATA NAME/'  Z ','THET',' DTF',' X ','DTFB','THTM',' EMT',
     1'THMD',' EM ',' DTC',' EMD',' DT ','THTD','    ',
     2'DELE','ALFG'/,NAME1/'  Y ',' PSI',' PHI','DTFB','PSIM',
     2' EMT','PSMD','PSID',' EM ',' DTC',' EMD',' DT ','    ',
     3'DELR','DELA','BETG'/
      END
      SUBROUTINE FREQ (ROOTS,K4A,TFG)
      COMMON/INPUT/IW,IR
      COMMON /DAT/AERO(175),AEROP(50),KODE(26),LL
      COMMON/PLOT/OM(61),AMP(61),ANGLE(61),XMP(61),KV
      COMMON/ANAME/NAME(16),NAME1(16)
      COMPLEX ROOTS(1)
      COMPLEX CNU(29)
      DIMENSION DOM(21)
      DATA DOM/1.,1.2,1.5,1.7,2.0,2.5,3.0,3.5,4.0,4.5,5.0,5.5,
     16.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
      IL=0
      IN1=KODE(14)
      IN2=KODE(15)
      IF(KODE(13).NE.-1.)GO TO 32
      IF(KODE(15).EQ.3.)IN2=4
      IF(KODE(15).LE.3.)GO TO 32
```

```
      KODE(15)=3.
      WRITE(IW,707)
  707 FORMAT(3X,'KODE(15) IS INCORRECT FOR CABLELESS MODEL OPTION,KODE(1
     1 5) IS SET TO 3.')
   32 GO TO 31
      ENTRY FREQ2(ROOTS,K4A,TFG)
      IL=1
      IN1=KODE(16)
      IN2=KODE(17)
   31 CALL ANP(CNU,0.,KN,AMPNO,PHSNO,ITYPN)
      CALL ANP(ROOTS,0.,K4A,AMPDO,PHSDO,ITYPD)
      TGAIN=TGN/TFG
      SGN=ABS(TGAIN)/TGAIN
      IF(AMPDO.NE.0.)SSGN=TGAIN*AMPNO/AMPDO
      ITYPE=ITYPD-ITYPN
      IF(KODE(19).LE.10)GO TO 3
      IN=20
      IK=1
      GO TO 4
    3 IF(KODE(19).LE.5)GO TO 5
      IN=10
      IK=2
      GO TO 4
    5 IN=5
      IK=4
    4 INIT=KODE(18)
      K=IN*3+1
      KV=K
      IDX=0
      DO 1 I=1,K
      IDX=IDX+1
      IF(IDX.LE.IN)GO TO 2
      INIT=INIT+1
      IDX=1
    2 OM(I)=DOM((IDX-1)*IK+1)*(10.)**INIT
      CALL ANP(CNU,OM(I),KN,AMPN,PHSN,IDUM)
      CALL ANP(ROOTS,OM(I),K4A,AMPD,PHSD,IDUM)
      AMP(I)=20.*(ALOG10(AMPN/AMPD)+ALOG10(ABS(TGAIN)))
      XMP(I)=TGAIN*AMPN/AMPD
      ANGLE(I)=(PHSN-PHSD)*57.29578
      IF(SGN.LT.0.)ANGLE(I)=ANGLE(I)+180.
    1 CONTINUE
      IF(IL.EQ.0)WRITE(IW,10)NAME(IN2),NAME(IN1)
      IF(IL.NE.0)WRITE(IW,10)NAME1(IN2),NAME1(IN1)
   10 FORMAT(1H1,' FREQUENCY RESPONSE OF THE ',2X,1A4,'/',1A4,2X,
     1'TRANSFER FUNCTION')
      IF(AMPDO.NE.0.)WRITE(IW,17)SSGN
      IF(AMPDO.EQ.0.)WRITE(IW,18)ITYPE
   17 FORMAT('  STEADY STATE GAIN =',2X,E11.4,//)
   18 FORMAT('  SYSTEM TYPE =',2X,I4)
      IF(IN.GE.20)GO TO 6
      WRITE(IW,11)
   11 FORMAT(//,2X,' FREQ(RPS) ',2X,'AMP RAT(DB)',2X,' PHASE(DEG) '
     1,2X,'AMP. VALUE ')
      DO 7 I=1,K
```

```
    7 WRITE(IW,12)OM(I),AMP(I),ANGLE(I),XMP(I)
   12 FORMAT(4(2X,E11.4),5X,4(2X,E11.4))
      GO TO 8
    6 WRITE(IW,13)
   13 FORMAT(//,2X,' FREQ(RPS) ',2X,'AMP RAT(DB)',2X,' PHASE(DEG) ',2X
     1,'AMP. VALUE ',7X,
     2' FREQ(RPS) ',2X,'AMP RT(DB)',2X,' PHASE(DEG) ',2X,'AMP. VALUE ')
      K=K/2+1
      DO 9 I=1,K
      IF(I.NE.K)GO TO 9
      WRITE(IW,15)OM(I+30),AMP(I+30),ANGLE(I+30),XMP(I+30)
   15 FORMAT(57X,4(2X,E11.4))
      GO TO 8
    9 WRITE(IW,12)OM(I),AMP(I),ANGLE(I),XMP(I),OM(30+I),AMP(30+I),
     1ANGLE(30+I),XMP(30+I)
    8 WRITE(IW,14)
   14 FORMAT(1H1)
      RETURN
      ENTRY FREQ1(ROOTS,K4A,TFG)
      KN=K4A
      TGN=TFG
      IF(KN.EQ.0)RETURN
      DO 20 I=1,K4A
      CNU(I)=ROOTS(I)
   20 CONTINUE
      RETURN
C     DEBUG UNIT(3), INIT
      END
      SUBROUTINE ANP(CXU,OM,KX,AMP,ANG,ITYPE)
      DIMENSION CXU(2,1)
      ITYPE=0
      ANG=0.
      AMP=1.0
      IF(KX.EQ.0)RETURN
      DO 1 I=1,KX
      XRL=-CXU(1,I)
      YIM=OM-CXU(2,I)
      AMP=SQRT(XRL*XRL+YIM*YIM)*AMP
      IF(XRL.EQ.0..AND.YIM.EQ.0.)GO TO 2
      ANG=ATAN2(YIM,XRL)+ANG
      GO TO 1
    2 ANG=ANG
      ITYPE=ITYPE+1
    1 CONTINUE
      RETURN
C     DEBUG UNIT(3), INIT(ANG,XRL,YIM)
      END
      SUBROUTINE TRANS
C THIS ROUTINE CALCULATES BODY AXIS AERO DATA AT CR FROM STAR.
C AXIS AERO DATA AT CR
      COMMON /DAT/ AERO(175),AEROP(50),KODE(26),LL
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1           (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2           (AERO( 7),  CDO),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3           (AERO(10),  CDD),(AERO(11),  CLD),(AERO(12),  CMD),
```

```
     4            (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5            (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6            (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7            (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8            (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9            (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A            (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B            (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS),
     C            (AERO(44), XREF),(AERO(45), ZREF),(AERO(46),  XCG),
     D            (AERO(47),  ZCG),(AERO(63),THETA)
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1            (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
     2            (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP),
     3            (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP),
     4            (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP),
     5            (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP),
     6            (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP),
     7            (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP),
     8            (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP),
     9            (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP),
     A            (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP),
     B            (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)
      ALPHA=THETA
      SNALF= SIN(ALPHA)
      COALF= COS(ALPHA)
      SNSQ = SNALF**2
      COSQ = COALF**2
      SNCO = SNALF*COALF
      CDU=CDU+2.*(CDO+CDA*THETA)
      CLU=CLU+2.*(CLO+CLA*THETA)
      CDA=CDA-(CLO+CLA*THETA)
      CLA=CLA+CDO+CDA*THETA
      CXUP=-CLA*SNSQ-CDU*COSQ+(CDA+CLU)*SNCO
      CZUP= CDA*SNSQ-CLU*COSQ+(CLA-CDU)*SNCO
      CMUP= -CMA *SNALF+ CMU *COALF
      CXAP= CLU*SNSQ-CDA*COSQ+(CLA-CDU)*SNCO
      CZAP=-CDU*SNSQ-CLA*COSQ-(CDA+CLU)*SNCO
      CMAP=  CMU *SNALF+ CMA *COALF
      CXQP= CLQ*SNALF-CDQ*COALF
      CZQP=-(CDQ*SNALF+CLQ*COALF)
      CMQP= CMQ
      CZADP=-CLAD*COALF+CDAD*SNALF
      CXADP=-CDAD*COALF-CLAD*SNALF
      CMADP= CMAD
      CXDEP= CLDE*SNALF-CDDE*COALF
      CZDEP=-CDDE*SNALF-CLDE*COALF
      CMDEP= CMDE
      CXOP=-CDO*COALF-CLO*SNALF
      CZOP=-CLO*COALF+CDO*SNALF
      CMOP=CMO
      CYBP= CYB
      CNBP=  CLB *SNALF+ CNB *COALF
      CLBP= -CNB *SNALF+ CLB *COALF
      CYPP= (-CYR*SNALF+ CYP*COALF)
      CNPP=(-CLR*SNSQ+ CNP*COSQ+ (CLP- CNR)*SNCO)
```

```
      CLPP=( CNR*SNSQ+ CLP*COSQ+ (CLR+ CNP)*SNCO)
      CYRP= ( CYP*SNALF+ CYR*COALF)
      CNRP=( CLP*SNSQ+ CNR*COSQ+ (CLR+ CNP)*SNCO)
      CLRP=(-CNP*SNSQ+ CLR*COSQ+ (CLP- CNR)*SNCO)
      CYDAP= CYDA
      CNDAP= CLDA*SNALF+ CNDA*COALF
      CLDAP= -CNDA*SNALF+ CLDA*COALF
      CYDRP= CYDR
      CNDRP= CLDR*SNALF+ CNDR*COALF
      CLDRP=-CNDR*SNALF+ CLDR*COALF
      CYDSP= CYDS
      CLDSP=-CNDS*SNALF+ CLDS*COALF
      CNDSP= CLDS*SNALF+ CNDS*COALF
      RETURN
      END
      SUBROUTINE TRAN1
C  THIS ROUTINE TRANSFORMS INERTIA DATA & STABILITY AXIS AERO DATA
C  TO THE EQUATION REFERENCE CENTER
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
      EQUIVALENCE(AERO( 1),  CDU) (AERO( 2),  CLU),(AERO( 3),  CMU),
     1           (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2           (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3           (AERO(10),  CDD),(AERO(11),  CLD),(AERO(12),  CMD),
     4           (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5           (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6           (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7           (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8           (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9           (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A           (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B           (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS),
     C           (AERO(44), XREF),(AERO(45), ZREF),(AERO(46),  XCG),
     D           (AERO(47),  ZCG),(AERO(63),THETA)
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VO   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  )
C  INERTIA TRANSFORMATIONS
      X=XCG/12.
      Z=ZCG/12.
      XIXX=XIXX+AM*(Z**2)
      YIYY=YIYY+AM*(X**2)+AM*(Z**2)
      ZIZZ=ZIZZ+AM*(X**2)
      XIXZ=XIXZ-AM*X*Z
C  AERO DATA TRANSFORMATIONS
      X=XREF/(12.*CBAR)
      Z=ZREF/(12.*CBAR)
      CMD=CMD-Z*CDD+X*CLD
      CMQ=CMQ-X*(-CLQ+2.*CMA)-2.*X*X*CLA-Z*CDQ+2.*X*Z*CDA
      CLQ=CLQ-2.*X*CLA+4.*Z*CLD
      CDQ=CDQ-2.*X*CDA+4.*Z*CDD
      CMA=CMA-Z*CDA+X*CLA
      CMDE=CMDE-Z*CDDE+X*CLDE
      X=XREF/(12.*B)
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      Z=ZREF/(12.*8)                                                    CAB01190
      CNR=CNR+X*(2.*CNB+CYR+2.*X*CYB)                                   CAB01200
      CLR=CLR+X*(CLB-Z*CYB)-Z*CYR                                       CAB01210
      CNP=CNP-2.*Z*(CNB+X*CYB)+X*CYP                                    CAB01220
      CLP=CLP-Z*(CYP-2.*Z*CYB)-2.*Z*CLB                                 CAB01230
      CYR=CYR+2.*X*CYB                                                  CAB01240
      CYP=CYP-2.*Z*CYB                                                  CAB01250
      CNB=CNB+X*CYB                                                     CAB01260
      CNDR=CNDR+X*CYDR                                                  CAB01270
      CNDA=CNDA+X*CYDA                                                  CAB01280
      CNDS=CNDS+X*CYDS                                                  CAB01290
      CLB=CLB-Z*CYB                                                     CAB01300
      CLDR=CLDR-Z*CYDR                                                  CAB01310
      CLDA=CLDA-Z*CYDA                                                  CAB01320
      CLDS=CLDS-Z*CYDS                                                  CAB01330
      RETURN                                                            CAB01340
      END                                                               CAB01350
      SUBROUTINE LATSN                                                  CAB00010
      COMMON/INOUT/IW,IR                                                CAB00020
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL                        CAB00030
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)                CAB00040
      COMMON ZZZ(200)                                                   CAB00050
      COMMON/DU/DUM(10,10)                                              CAB00060
      COMMON/TAB1/ZZ(800)                                               CAB00070
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ), CAB00080
     1(AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),            CAB00090
     2(AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),            CAB00100
     3(AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),            CAB00110
     4(AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),            CAB00120
     5(AERO(120),AKSNL),(AERO(49),   VO),(AERO(51),   RHO),             CAB00130
     6(AERO(63),THETA),(AERO(121),ADSNU),(AERO(122),ADSNL)              CAB00140
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),         CAB00150
     1(SN( 4),   GX2),(SN( 5),   GY2),(SN( 6),   GZ2),                  CAB00160
     2(SN( 7),   GX3),(SN( 8),   GY3),(SN( 9),   GZ3),                  CAB00170
     3(SN(10),   GX4),(SN(11),   GY4),(SN(12),   GZ4),                  CAB00180
     4(SN(13),   THU),(SN(14),   THL),(SN(15),   ALU),                  CAB00190
     5(SN(16),   ALL),                                                  CAB00200
     6(SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),                     CAB00210
     7(SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),                     CAB00220
     8(SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),                     CAB00230
     9(SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)                      CAB00240
      DIMENSION TOPR(3,3),TOPL(3,3),BOTR(3,3),BOTL(3,3)                 CAB00250
      COT(BBB)=1./TAN(BBB)                                              CAB00260
      GXY(A,AA,C)             = (-A*COT(AA)/C)*12.                      CAB00270
      GXSY(A,AA,C,D,E,F)      = -(A*SIN(AA)+C*D*COT(E))/F               CAB00280
      GXPHI(A,AA,C,D,E,F,G)   = (A*AA*COT(C)-D*E*COT(F))/G              CAB00290
      GYY(A,AA)               = (SIN(A)/AA)*12.                         CAB00300
      GYSY(A,AA,C,D,E,F)      = (A*AA*COT(C)+D*SIN(E))/F                CAB00310
      GYPHI(A,AA,C,D,E,F)     = -(A*SIN(AA)+C*D*COT(E))/F               CAB00320
      GZY(A,AA,C)             = (-A*COT(AA)/C)*12.                      CAB00330
      GZSY(A,AA,C,D,E,F,G)    = (A*AA*COT(C)-D*E*COT(F))/G              CAB00340
      GZPHI(A,AA,C,D,E,F)     = (A*AA*COT(C)+D*SIN(E))/F                CAB00350
      ALY(A)                 = -A                                       CAB00360
      ALSY(A,AA,C,D)         =  (A*AA-C*D)/12.                          CAB00370
      ALPHI(A,AA,C,D)        =  (A*AA-C*D)/12.                          CAB00380
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```
      DO 1005 I=1,3
      DO 1005 J=1,3
      SNU(I,J)=0
 1005 SNUD(I,J)=0
      DO 1006 I=1,10
      DO 1006 J=1,10
 1006 DUM(I,J)=0
      IF(KODE(10).EQ.0) GO TO 1002
C  TERMS FOR SNUBBER EFFECTS (LAT)
      CALL DRCSN(THETA)
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
      DUM(1,2) = -TUSNO*GX1
      DUM(1,3) =  TUSNO*GZ1
      DUM(1,5) =  -TUSNO*SIN(THGY1)
      DUM(1,7) =  GY1
      DUM(2,2) =  SNUX*TUSNO*GX1/12.+SNUY*TUSNO*GY1/12.
      DUM(2,3) =  -SNUX*TUSNO*GZ1/12.
      DUM(2,4) =  -SNUY*TUSNO*SIN(THGX1)/12.
      DUM(2,5) =  SNUX*TUSNO*SIN(THGY1)/12.
      DUM(2,7) =  (-SNUX*GY1+SNUY*GX1)/12.
      DUM(3,2) =  -SNUZ*TUSNO*GX1/12.
      DUM(3,3) =   SNUZ*TUSNO*GZ1/12.+SNUY*TUSNO*GY1/12.
      DUM(3,5) =  -SNUZ*TUSNO*SIN(THGY1)/12.
      DUM(3,6) =   SNUY*TUSNO*SIN(THGZ1)/12.
      DUM(3,7) =  (-SNUY*GZ1+SNUZ*GY1)/12.
      DUM(4,1) =   GXY(GY1,THGX1,ALU)
      DUM(4,2) =   GXSY(-SNUY,THGX1,-SNUX,GY1,THGX1,ALU)
      DUM(4,3) =   GXPHI(-SNUZ,GY1,THGX1,-SNUY,GZ1,THGX1,ALU)
      DUM(4,4) =  -1.
      DUM(5,1) =   GYY(THGY1,ALU)
      DUM(5,2) =   GYSY(-SNUY,GX1,THGY1,-SNUX,THGY1,ALU)
      DUM(5,3) =   GYPHI(-SNUZ,THGY1,-SNUY,GZ1,THGY1,ALU)
      DUM(5,5) =  -1.
      DUM(6,1) =   GZY(GY1,THGZ1,ALU)
      DUM(6,2) =   GZSY(-SNUY,GX1,THGZ1,-SNUX,GY1,THGZ1,ALU)
      DUM(6,3) =   GZPHI(-SNUZ,GY1,THGZ1,-SNUY,THGZ1,ALU)
      DUM(6,6) =  -1.
      IF(KODE(10).EQ.2) GO TO 1010
      CALL DRCSN(THETA)
      Q=.5*RHO*VO*VO
      ALU1=ALU+1.
       CALL STINT(Q,ALU1,0,1,1,TUSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALU2=ALU-1.
      CALL STINT(Q,ALU2,0,1,1,TUSN2,NG)
      IF(NG.NE.0) GO TO 5000
      GO TO 5001
 5000 WRITE(IW,5002) NG,ALL,ALU,G
 5002 FORMAT('ERROR IN SNUBBER TABLE 1,NG=',I2,3XF10.3)
      RETURN
 5001 CONTINUE
      AKTU=(TUSN1-TUSN2)/2.
      AKSNU=AKTU
 1010 CONTINUE
      DUM(7,7) =  -1.
```

```
      DUM(7,8) =   AKSNU*12.
      DUM(8,1) =   ALY(GY1)
      DUM(8,2) =   ALSY(-SNUY,GX1,-SNUX,GY1)
      DUM(8,3) =   ALPHI(-SNUZ,GY1,-SNUY,GZ1)
      DUM(8,8) =  -1.
      IF(KODE(10).EQ.1) GO TO 1015
      DO 1016 I=1,3
      DO 1016 J=1,3
 1016 SNUD(I,J)=DUM(I,7)*ADSNU*DUM(8,J)*12.
 1015 CALL MASH(3,8)
      DO 1050 I=1,3
      DO 1050 J=1,3
 1050 TOPR(I,J)= DUM(I,J)
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
      DUM(1,2) =  -TUSNO*GX2
      DUM(1,3) =   TUSNO*GZ1
      DUM(1,5) =  -TUSNO*SIN(THGY2)
      DUM(1,7) =  GY2
      DUM(2,2) =   SNUX*TUSNO*GX2/12.-SNUY*TUSNO*GY2/12.
      DUM(2,3) =  -SNUX*TUSNO*GZ2/12.
      DUM(2,4) =   SNUY*TUSNO*SIN(THGX2)/12.
      DUM(2,5) =   SNUX*TUSNO*SIN(THGY2)/12.
      DUM(2,7) =  (-SNUX*GY2-SNUY*GX2)/12.
      DUM(3,2) =  -SNUZ*TUSNO*GX2/12.
      DUM(3,3) =   SNUZ*TUSNO*GZ2/12.-SNUY*TUSNO*GY2/12.
      DUM(3,5) =  -SNUZ*TUSNO*SIN(THGY2)/12.
      DUM(3,6) =  -SNUY*TUSNO*SIN(THGZ2)/12.
      DUM(3,7) =   (SNUY*GZ2+SNUZ*GY2)/12.
      DUM(4,1) =   GXY(GY2,THGX2,ALU)
      DUM(4,2) =   GXSY(SNUY,THGX2,-SNUX,GY2,THGX2,ALU)
      DUM(4,3) =   GXPHI(-SNUZ,GY2,THGX2,SNUY,GZ2,THGX2,ALU)
      DUM(4,4) =  -1.
      DUM(5,1) =   GYY(THGY2,ALU)
      DUM(5,2) =   GYSY(SNUY,GX2,THGY2,-SNUX,THGY2,ALU)
      DUM(5,3) =   GYPHI(-SNUZ,THGY2,SNUY,GZ2,THGY2,ALU)
      DUM(5,5) =  -1.
      DUM(6,1) =   GZY(GY2,THGZ2,ALU)
      DUM(6,2) =   GZSY(SNUY,GX2,THGZ2,-SNUX,GY2,THGZ2,ALU)
      DUM(6,3) =   GZPHI(-SNUZ,GY2,THGZ2,SNUY,THGZ2,ALU)
      DUM(6,6) =  -1.
      IF(KODE(10).EQ.2) GO TO 1020
      CALL DRCSN(THETA)
      ALU1=ALU+1.
       CALL STINT(0,ALU1,0,1,1,TUSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALU2=ALU-1.
      CALL STINT(0,ALU2,0,1,1,TUSN2,NG)
      IF(NG.NE.0) GO TO 5000
      AKTU=(TUSN1-TUSN2)/2.
      AKSNU=AKTU
 1020 CONTINUE
      DUM(7,7) =  -1.
      DUM(7,8) =   AKSNU*12.
      DUM(8,1) =   ALY(GY2)
      DUM(8,2) =   ALSY(SNUY,GX2,-SNUX,GY2)
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```
      DUM(8,3) =   ALPHI(-SNUZ,GY2,SNUY,GZ2)
      DUM(8,8) =  -1.
      IF(KODE(10).EQ.1) GO TO 1025
      DO 1026 I=1,3
      DO 1026 J=1,3
 1026 SNUD(I,J) =SNUD(I,J)+DUM(I,7)*AKSNU*DUM(8,J)*12.
 1025 CALL MASH(3,8)
      DO 1060 I=1,3
      DO 1060 J=1,3
 1060 TOPL(I,J)= DUM(I,J)
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
      DUM(1,2) =  -TLSNO*GX3
      DUM(1,3) =   TLSNO*GZ3
      DUM(1,5) =  -TLSNO*SIN(THGY3)
      DUM(1,7) =  GY3
      DUM(2,2) =   SNLX*TLSNO*GX3/12.-SNLY*TLSNO*GY3/12.
      DUM(2,3) =  -SNLX*TLSNO*GZ3/12.
      DUM(2,4) =   SNLY*TLSNO*SIN(THGX3)/12.
      DUM(2,5) =   SNLX*TLSNO*SIN(THGY3)/12.
      DUM(2,7) =  (-SNLX*GY3-SNLY*GX3)/12.
      DUM(3,2) =   SNLZ*TLSNO*GX3/12.
      DUM(3,3) =  -SNLZ*TLSNO*GZ3/12.-SNLY*TLSNO*GY3/12.
      DUM(3,5) =   SNLZ*TLSNO*SIN(THGY3)/12.
      DUM(3,6) =  -SNLY*TLSNO*SIN(THGZ3)/12.
      DUM(3,7) =   (SNLY*GZ3-SNLZ*GY3)/12.
      DUM(4,1) =   GXY(GY3,THGX3,ALL)
      DUM(4,2) =   GXSY(SNLY,THGX3,-SNLX,GY3,THGX3,ALL)
      DUM(4,3) =   GXPHI(SNLZ,GY3,THGX3,SNLY,GZ3,THGX3,ALL)
      DUM(4,4) =  -1.
      DUM(5,1) =   GYY(THGY3,ALL)
      DUM(5,2) =   GYSY(SNLY,GX3,THGY3,-SNLX,THGY3,ALL)
      DUM(5,3) =   GYPHI(SNLZ,THGY3,SNLY,GZ3,THGY3,ALL)
      DUM(5,5) =  -1.
      DUM(6,1) =   GZY(GY3,THGZ3,ALL)
      DUM(6,2) =   GZSY(SNLY,GX3,THGZ3,-SNLX,GY3,THGZ3,ALL)
      DUM(6,3) =   GZPHI(SNLZ,GY3,THGZ3,SNLY,THGZ3,ALL)
      DUM(6,6) =  -1.
      IF(KODE(10).EQ.2) GO TO 1030
      CALL DRCSN(THETA)
      ALL1=ALL+1.
      CALL STINT(0,ALL1,C,1,1,TLSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALL2=ALL-1.
      CALL STINT(0,ALL2,C,1,1,TLSN2,NG)
      IF(NG.NE.0) GO TO 5000
       AKTL=(TLSN1-TLSN2)/2.
      AKSNL=AKTL
 1030 CONTINUE
      DUM(7,7) =  -1.
      DUM(7,8) =   AKSNL*12.
      DUM(8,1) =   ALY(GY3)
      DUM(8,2) =   ALSY(SNLY,GX3,-SNLX,GY3)
      DUM(8,3) =   ALPHI(SNLZ,GY3,SNLY,GZ3)
      DUM(8,8) =  -1.
      IF(KODE(10).EQ.1) GO TO 1035
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      DO 1036 I=1,3
      DO 1036 J=1,3
 1036 SNUD(I,J)=SNUD(I,J)+DUM(I,7)*ADSNL*DUM(8,J)*12.
 1035 CALL MASH(3,8)
      DO 1070 I=1,3
      DO 1070 J=1,3
 1070 ROTL(I,J)= DUM(I,J)
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
      DUM(1,2) =  -TLSNO*GX4
      DUM(1,3) =  TLSNO*GZ4
      DUM(1,5) =  -TLSNO*SIN(THGY4)
      DUM(1,7) =  GY4
      DUM(2,2) =   SNLX*TLSNO*GX4/12.+SNLY*TLSNO*GY4/12.
      DUM(2,3) =  -SNLX*TLSNO*GZ4/12.
      DUM(2,4) =  -SNLY*TLSNO*SIN(THGX4)/12.
      DUM(2,5) =   SNLX*TLSNO*SIN(THGY4)/12.
      DUM(2,7) =  (-SNLX*GY3+SNLY*GX4)/12.
      DUM(3,2) =   SNLZ*TLSNO*GX4/12.
      DUM(3,3) =  -SNLZ*TLSNO*GZ4/12.+SNLY*TLSNO*GY4/12.
      DUM(3,5) =   SNLZ*TLSNO*SIN(THGY4)/12.
      DUM(3,6) =   SNLY*TLSNO*SIN(THGZ4)/12.
      DUM(3,7) =  (-SNLY*GZ4-SNLZ*GY4)/12.
      DUM(4,1) =   GXY(GY4,THGX4,ALL)
      DUM(4,2) =   GXSY(-SNLY,THGX4,-SNLX,GY4,THGX4,ALL)
      DUM(4,3) =   GXPHI(SNLZ,GY4,THGX4,-SNLY,GZ4,THGX4,ALL)
      DUM(4,4) =  -1.
      DUM(5,1) =   GYY(THGY4,ALL)
      DUM(5,2) =   GYSY(-SNLY,GX4,THGY4,-SNLX,THGY4,ALL)
      DUM(5,3) =   GYPHI(SNLZ,THGY4,-SNLY,GZ4,THGY4,ALL)
      DUM(5,5) =  -1.
      DUM(6,1) =   GZY(GY4,THGZ4,ALL)
      DUM(6,2) =   GZSY(-SNLY,GX4,THGZ4,-SNLX,GY4,THGZ4,ALL)
      DUM(6,3) =   GZPHI(SNLZ,GY4,THGZ4,-SNLY,THGZ4,ALL)
      DUM(6,6) =  -1.
      IF(KODE(10).EQ.2) GO TO 1040
      CALL DRCSN(THETA)
      ALL1=ALL+1.
      CALL STINT(Q,ALL1,C,1,1,TLSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALL2=ALL-1.
      CALL STINT(Q,ALL2,C,1,1,TLSN2,NG)
      IF(NG.NE.0) GO TO 5000
       AKTL=(TLSN1-TLSN2)/2.
      AKSNL=AKTL
 1040 CONTINUE
      DUM(7,7) =  -1.
      DUM(7,8) =   AKSNL*12.
      DUM(8,1) =   ALY(GY4)
      DUM(8,2) =   ALSY(-SNLY,GX4,-SNLX,GY4)
      DUM(8,3) =   ALPHI(SNLZ,GY4,-SNLY,GZ4)
      DUM(8,8) =  -1.
      IF(KODE(10).EQ.1) GO TO 1045
      DO 1046 I=1,3
      DO 1046 J=1,3
 1046  SNUD(I,J)=SNUD(I,J)+DUM(I,7)*ADSNL*DUM(8,J)*12.
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 1045 CALL MASH(3,8)                                                   CAB02590
      DO 1080 I=1,3                                                    CAB02600
      DO 1080 J=1,3                                                    CAB02610
 1080 BOTR(I,J)= DUM(I,J)                                              CAB02620
      DO 1090 I=1,3                                                    CAB02630
      DO 1090 J=1,3                                                    CAB02640
 1090 SNU (I,J)= TOPR(I,J)+TOPL(I,J)+BOTL(I,J)+BOTR(I,J)               CAB02650
      IF(KODE(10).EQ.2) RETURN                                         CAB02660
      DO 1095 I=1,3                                                    CAB02670
      DO 1095 J=1,3                                                    CAB02680
 1095 SNUD(I,J)=0                                                      CAB02690
      RETURN                                                           CAB02700
 1002 DO 1004 I=1,3                                                    CAB02710
      DO 1004 J=1,3                                                    CAB02720
      SNUD(I,J)=0                                                      CAB02730
 1004 SNU(I,J)=0                                                       CAB02740
      RETURN                                                           CAB02750
      END                                                              CAB02760
      SUBROUTINE TRIM                                                  CAB00010
C       CABLE  SUSPENSION  SYSTEM  TRIM  ROUTINE                       CAB00020
      COMMON/INPUT/IW,IR                                               CAB00030
      COMMON /DAT/ AERO(175),AEROP(50),KODE(26),LL                     CAB00040
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF        CAB00050
      DIMENSION ANG(5,3)                                               CAB00060
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),   CAB00070
     1           (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),   CAB00080
     2           (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),   CAB00090
     3           (AERO(10),  CDD),(AERO(11),  CLD),(AERO(12),  CMD),   CAB00100
     4           (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),   CAB00110
     5           (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),     CAB00120
     6           (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),   CAB00130
     7           (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),   CAB00140
     8           (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),   CAB00150
     9           (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),   CAB00160
     A           (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),   CAB00170
     B           (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS)    CAB00180
      EQUIVALENCE(AERO(46),XCG),(AERO(47),ZCG)                         CAB00190
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VO   ),(AERO (50),   AM) CAB00200
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),    WT),(AERO (53),B   ) CAB00210
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ) CAB00220
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ ) CAB00230
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  ),CAB00240
     1(AERO(63),THETA)                                                 CAB00250
      EQUIVALENCE(AERO (66), WLUF),(AERO(67), WLLF),(AERO(68), WLUR),  CAB00260
     1           (AERO (69), WLLR),(AERO(70), WLHF),(AERO(71), WLHR),  CAB00270
     2           (AERO (72), STAF),(AERO(73), STAR),(AERO(74), BLHF),  CAB00280
     3           (AERO (75), BLHR),(AERO(76), WLCR),(AERO(77),STACR),  CAB00290
     4           (AERO (78), BLCR),(AERO(79),   EF),(AERO(80),   ER),  CAB00300
     5           (AERO (81),   AF),(AERO(82),   AR),(AERO(83), HUCF),  CAB00310
     6           (AERO (84), HLCF),(AERO(85), HUCR),(AERO(86), HLCR),  CAB00320
     7           (AERO (87),  DCF),(AERO(88),  DCR),(AERO(89),  ALF),  CAB00330
     8           (AERO (90),  RVF),(AERO(91),  RHF),(AERO(92),  RVR),  CAB00340
     9           (AERO(93),  RHR),(AERO(94),  TRO),(AERO(95),  AKR),   CAB00350
     A           (AERO(96), ALFO),(AERO(97),STLTT),(AERO(98),WLLTT),   CAB00360
     B           (AERO(99),TLFTO),(AERO(100),AKLFT),(AERO(101),ALLTO), CAB00370
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C             (AERO(102),ALTX),(AERO(103),ALTZ)
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1            (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
     2            (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP),
     3            (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP),
     4            (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP),
     5            (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP),
     6            (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP),
     7            (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP),
     8            (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP),
     9            (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP),
     A            (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP),
     B            (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)
      RTD=57.2958
      THETA=0.
      DELALF=.001
      DTF=.1
      DALFAW=0.0
      DDELTE=0.0
      DTHRST=0.0
      ICNTR=0
      FIRST=0.
      THINT=0.
      ALFINT=THETA
      DELINT=0.
      THRSTO=THINT
    1 IF(VO.EQ.0.)THRSTO=-TR*(COS(ADC(3,1))+COS(ADC(4,1)))/(COS(ADC(1,1
     1)+COS(ADC(2,1)))
      VAL5=COS(ADC(3,1))
      VAL6=COS(ADC(4,1))
      VAL7=COS(ADC(1,1))
      VAL8=COS(ADC(2,1))
      ALFAWO=ALFINT
      DELTEO=DELINT
      QS=RHO*VO*VO*.5*SW
  209 THRSTI=THRSTO+DTHRST
      ALFAWI=ALFAWO+DALFAW
      DELTEI=DELTEO+DDELTE
      ICNTR=ICNTR+1
      IF(ICNTR.GT.100)GO TO 520
      VAL1=ALFAWI*RTD
      VAL2=DELTEI*RTD
      VAL3=THRSTI
      CALL EQU(ALFAWI,DELTEI,THRSTI,F0,G0,H0,FIRST)
      IF (VO.NE.0..OR.FIRST.NE.0.) GO TO 2
      FIRST=1.
      GO TO 1
    2 IF(FIRST.NE.1.)FIRST=1.
C  COMPUTES PARTIALS
      ALFAWI=ALFAWI+DELALF*0.5
      CALL EQU(ALFAWI,DELTEI,THRSTI,F1,G1,H1,1.)
      ALFAWI=ALFAWI-DELALF
      CALL EQU(ALFAWI,DELTEI,THRSTI,F2,G2,H2,1.)
      ALFAWI=ALFAWI+DELALF*0.5
      FALFWO=(F1-F2)/DELALF
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      GALFWO=(G1-G2)/DELALF
      HALFWO=(H1-H2)/DELALF
      FDELEO=-QS*(CLDE*COS(ALFAWI)+CDDE*SIN(ALFAWI))
      GDELEO=QS*(CLDE*SIN(ALFAWI)-CDDE*COS(ALFAWI))
      HDELEO=QS*CBAR*CMDE
      THRSTI=THRSTI+DTF
      CALL EQU(ALFAWI,DELTEI,THRSTI,F1,G1,H1,1.)
      THRSTI=THRSTI-2.*DTF
      CALL EQU(ALFAWI,DELTEI,THRSTI,F2,G2,H2,1.)
      THRSTI=THRSTI+DTF
      FTHSTO=(F1-F2)/(DTF*2.)
      GTHSTO=(G1-G2)/(DTF*2.)
      HTHSTO=(H1-H2)/(DTF*2.)
C     SET UP ITERATION EQUATIONS
      FI=FO+FALFWO*DALFAW+FDELEO*DDELTE+FTHSTO*DTHRST
      GI=GO+GALFWO*DALFAW+GDELEO*DDELTE+GTHSTO*DTHRST
      HI=HO+HALFWO*DALFAW+HDELEO*DDELTE+HTHSTO*DTHRST
      ACCZ=FI/AM
      ACCX=GI/AM
      THEDOT=HI/YIYY
      IF(VO.EQ.0.)GO TO 42
      IF(ABS(ACCZ).LT..01)GO TO 1005
      GO TO 1100
 1005 IF(ABS(ACCX).LT..01)GO TO 1007
      GO TO 1100
 1007 IF(ABS(THEDOT).LE.0.001)GO TO 42
C     NOW COMPUTE PARAMETER INCREMENTS FROM MATRIX EQUATIONS
 1100 DETRM=FALFWO*GDELEO*HTHSTO+FDELEO*GTHSTO*HALFWO+FTHSTO*GALFWO*
     1HDELEO-FTHSTO*GDELEO*HALFWO-FALFWO*GTHSTO*HDELEO-FDELEO*GALFWO*
     2HTHSTO
      DALFAW=(-(GDELEO*HTHSTO-GTHSTO*HDELEO)*FO+(FDELEO*HTHSTO-FTHSTO
     1*HDELEO)*GO-(FDELEO*GTHSTO-FTHSTO*GDELEO)*HO)/DETRM
      DDELTE=(+(GALFWO*HTHSTO-GTHSTO*HALFWO)*FO-(FALFWO*HTHSTO-HALFWO
     1*FTHSTO)*GO+(FALFWO*GTHSTO-FTHSTO*GALFWO)*HO)/DETRM
      DTHRST=(-(GALFWO*HDELEO-GDELEO*HALFWO)*FO+(FALFWO*HDELEO-FDELEO
     1*HALFWO)*GO-(FALFWO*GDELEO-FDELEO*GALFWO)*HO)/DETRM
      THRSTO=THRSTI
      ALFAWO=ALFAWI
      DELTEO=DELTEI
      GO TO 200
  520 WRITE(IW,521)
  521 FORMAT('  TRIM ITERATION EXCEEDS LIMITS')
      GO TO 522
   42 CALL EQU(ALFAWI,DELTEI,THRSTI,FO,GO,HO,1.)
  522 DO 523 IZZ=1,4
      DO 523 IZK=1,3
      ANG(IZZ,IZK)=ADC(IZZ,IZK)*RTD
  523 CONTINUE
      THETA=ALFAWI
      DE=DELTEI
      TF=THRSTI
      THETD=THETA*RTD
      DED=DE*RTD
      DO 524 IZZ=1,4
      IF(KODE(5).EQ.0) GO TO 528
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      WRITE(IW,525)IZZ,XLGTH(IZZ),(ANG(IZZ,IZK),ARM(IZZ,IZK),IZK=1,3)
  525 FORMAT(' CABLE GEOMETRY-CABLE NO.',I2,5X,'CABLE LENGTH=',E15.6,
     1' IN',/,3X,'  DIR. COS.=DEG   ARM-IN',/,(3(3X,2E15.6,/)),//)
  524 CONTINUE
      IF(VO.EQ.0.)WRITE(IW,529)
  529 FORMAT(' COMPUTATION OF WIND OFF CONDITION,TRIM ROUTINE NOT USED')
      WRITE(IW,526)ICNTR,ACCZ,ACCX,THEDOT
  526 FORMAT(' ITERATION PARAMETER =',I5,/,2X,'ACCZ  =',E15.8,
     1/,2X,'ACCX =',E15.8,/,2X,'THEDOT=',E15.8,' RAD/SEC')
  528 WRITE(IW,527)THETD,DED,TF,TR
  527 FORMAT(//,'VEH. ATT.,DEFLTN,& CABLE TENSION',/,
     12X,'THETA =',F6.2,' DEG',/,2X,'DELTA =',F6.2,' DEG',/,2X
     2,'FRT CAB. TENSION=',E15.6,' LBS',/,
     32X,'RR CAB. TENSION =',E15.6,' LBS')
      RETURN
C     DEBUG UNIT(3),INIT(VAL1,VAL2,VAL3,FI,GI,HI,
C    1FALFWD,GALFWD,HALFWD,FDELFD,GDELFD,HDELFD,
C    2FTHSTD,GTHSTD,HTHSTD,DALFAW,DDELTE,DTHRST,
C    3ACCZ,ACCX,THEDOT,TF,VAL5,VAL6,VAL7,VAL8)
      END
      SUBROUTINE EQU(THETA,DE,TF,FF,GG,HH,FIRST)
C        CABLE  SUSPENSION  SYSTEM  TRIM  EQUATIONS
      COMMON/INPUT/IW,IR
      COMMON /DAT/ AERO(175),AEROP(50),KODE(26),LL
      COMMON / FLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,DUMMY
      REAL*8 XNM1,XNM2,YNM1,YNM2
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1           (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2           (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3           (AERO(10),  CDO),(AERO(11),  CLO),(AERO(12),  CMO),
     4           (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5           (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6           (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7           (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8           (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9           (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A           (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B           (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS)
      EQUIVALENCE(AERO(46),XCG),(AERO(47),ZCG)
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VO   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  )
      EQUIVALENCE(AERO (66), WLUF),(AERO(67), WLLF),(AERO(68), WLUR),
     1           (AERO (69), WLLR),(AERO(70), WLHF),(AERO(71), WLHR),
     2           (AERO (72), STAF),(AERO(73), STAR),(AERO(74), BLHF),
     3           (AERO (75), BLHR),(AERO(76), WLCR),(AERO(77),STACR),
     4           (AERO (78), BLCR),(AERO(79),   EF),(AERO(80),   ER),
     5           (AERO (81),   AF),(AERO(82),   AR),(AERO(83), HUCF),
     6           (AERO (84), HLCF),(AERO(85), HUCR),(AERO(86), HLCR),
     7           (AERO (87),  DCF),(AERO(88),  DCR),(AERO(89),  ALF),
     8           (AERO (90),  RVF),(AERO(91),  RHF),(AERO(92),  RVR),
     9           (AERO(93),   RHR),(AERO(94),  TRO),(AERO(95),  AKR),
     A           (AERO(96), ALRC),(AERO(97),STLTT),(AERO(98),WLLTT),
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     B              (AERO(99),TLFTO),(AERO(100),AKLFT),(AERO(101),ALLTO),
     C              (AERO(102),ALTX),(AERO(103),ALTZ)
      DATA XNM1,XNM2 /'VERTICAL','HORIZNTL'/
      RTD=57.2958
      VAL1=THETA
      Q = RHO*VO*VO/2.0
   64 IND=KODE(6)
      GO TO (501,502,503,504),IND
  501 YNM1=XNM1
      YNM2=XNM2
      CALL FPLYV(STAF,WLUF,WLLF,HUCF,HLCF,EF,RVF,THETA,1)
      CALL RPLYH(STAR,BLHR,WLHR,-AR,DCR,C.,RHR,THETA,3)
      GO TO 505
  502 YNM1=XNM2
      YNM2=XNM1
      CALL FPLYH(STAF,BLHF,WLHF,AF,DCF,C.,RHF,THETA,1)
      CALL FPLYV(STAR,WLUR,WLLR,HUCR,HLCR,ER,RVR,THETA,3)
      GO TO 505
  503 YNM1=XNM1
      YNM2=XNM1
      CALL FPLYV(STAF,WLUF,WLLF,HUCF,HLCF,EF,RVF,THETA,1)
      CALL FPLYV(STAR,WLUR,WLLR,HUCR,HLCR,ER,RVR,THETA,3)
      GO TO 505
  504 YNM1=XNM2
      YNM2=XNM2
      CALL RPLYH(STAF,BLHF,WLHF,AF,DCF,C.,RHF,THETA,1)
      CALL RPLYH(STAR,BLHR,WLHR,-AR,DCR,C.,RHR,THETA,3)
  505 IF(KODE(11))506,507,506
  506 WLLT = WLCR + ALTX*SIN(THETA) - ALTZ*COS(THETA)
      STALT = STACR - ALTX*COS(THETA) - ALTZ*SIN(THETA)
      XLGTH(5) = SQRT((WLLTT - WLLT)**2 + (STLTT - STALT)**2)
      IF(FIRST.NE.0.)GO TO 12
      ELLO=XLGTH(5)
   12 ELL=XLGTH(5)
      TLFT = TLFTO+AKLFT*(ELL-ELLO)
      ARM(5,1)=ALTX
      ARM(5,2)=0
      ARM(5,3)=ALTZ
      FXLTT = (TLFT*(STALT - STLTT))/XLGTH(5)
      FZLTT = (TLFT*(WLLT - WLLTT))/XLGTH(5)
      FXLTB = FXLTT*COS(THETA) - FZLTT*SIN(THETA)
      FZLTB = FZLTT*COS(THETA) + FXLTT*SIN(THETA)
      YMLFT =( FXLTB*ALTZ - FZLTB*ALTX)/12.
      ADC(5,1)=ARCOS(FXLTB/TLFT)
      ADC(5,2)=3.14159/2.
      ADC(5,3)=ARCOS(FZLTB/TLFT)
      GO TO 508
  507 FXLTB=0.
      FZLTB=0.
      YMLFT=0.
      XLGTH(5)=0.
      TLFT=0.
      DO 13 IA=1,3
      ARM(5,IA)=0.
      ADC(5,IA)=0.
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   13 CONTINUE
  508 CALL SNTRM(FXSN,FZSN,EMSN,THETA)
      IF (FIRST.NE.0.)GO TO 510
      IF(KODE(5).EQ.0) GO TO 512
      WRITE(IW,509)YNM1,YNM2
  509 FORMAT(' CABLE CONFIGURATION ON MODEL',/,
     1' FRONT CABLE IS ',A8,' AND REAR CABLE IS ',A8)
  512 ELO=XLGTH(3)+XLGTH(4)
  510 EL=XLGTH(3)+XLGTH(4)
      TR=TRO+AKR*(EL-ELO)
      ELIFT=Q*SW*(CLO+CLA*THETA+CLDE*DE)
      ADRAG=Q*SW*(CDO+CDA*THETA+CDDE*DE)
      FXAIR=-ADRAG*COS(THETA)+ELIFT*SIN(THETA)
      FZAIR=-ADRAG*SIN(THETA)-ELIFT*COS(THETA)
      WGTX=-32.2*AM*SIN(THETA)
      WGTZ=32.2*AM*COS(THETA)
      EMWGT=(ZCG*WGTX-XCG*WGTZ)/12.
      FXCR=TR*(COS(ADC(3,1))+COS(ADC(4,1)))
      FZCR=TR*(COS(ADC(3,3))+COS(ADC(4,3)))
      FXCFH=TF*(COS(ADC(1,1))+COS(ADC(2,1)))
      FZCFH=TF*(COS(ADC(1,3))+COS(ADC(2,3)))
      EMOC=0.
      DO 511 I=1,4
      TENS=TF
      IF(I.GT.2)TENS=TR
      EMOC=EMOC+TENS*(COS(ADC(I,1))*ARM(I,3)-COS(ADC(I,3))*ARM(I,1))
  511 CONTINUE
      EMOC=EMOC/12.
      AEROM=Q*SW*CBAR*(CMO+CMA*THETA+CMDE*DE)
      FF=FZCFH+FZCR+FZLTR+FZSN+WGTZ+FZAIR
      GG=FXCFH+FXCR+FXLTR+FXSN+WGTX+FXAIR
      HH=EMOC+YMLFT+EMSN+EMWGT+AEROM
      RETURN
      END
      SUBROUTINE FPLYV(STAV,WLU,WLL,HHU,HHL,EP,RAD,THETA,IF)
      COMMON /DAT/AERO(175),AEROP(50),KODE(26),LL
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      EQUIVALENCE (AERO(76),WLCR),(AERO(77),STACR),(AERO(78),BLCR)
      PI=3.14159
   33 GAMU= ATAN(HHU/EP)
      T1= EP*EP +HHU*HHU
      T2= THETA +GAMU
      IF(IF.EQ.3) T2=GAMU-THETA
      WLUC= WLCR +SQRT(T1)*SIN(T2)
      T3= WLU -WLUC
      T4= ABS(STACR -STAV) -SQRT(T1)*COS(T2)
      XLUP= SQRT(T3*T3+T4*T4)
      XLU= SQRT(XLUP*XLUP -RAD*RAD)
      BUP= ATAN(T3/T4)
      DBU= ATAN(RAD/XLU)
      BETAU=(BUP -DBU)*RTD
      GAML= ATAN(HHL/EP)
      T5= EP*EP +HHL*HHL
      T6= THETA -GAML
      IF(IF.EQ.3) T6=-(THETA+GAML)
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      WLLC= WLCR +SQRT(T5)*SIN(T6)
      T7= WLLC -WLL
      T8= ABS(STACR -STAV) -SQRT(T5)*COS(T6)
      XLLP= SQRT(T7*T7 +T8*T8)
      XLL= SQRT(XLLP*XLLP -RAD*RAD)
      BLP= ATAN(T7/T8)
      DBL= ATAN(RAD/XLL)
      BETAL= (BLP -DBL)*RTD
      IF(IF.EQ.1)GO TO 1
      XLGTH(3)=XLU
      XLGTH(4)=XLL
      ADC(3,1)=BETAU/RTD-THETA+PI
      ADC(3,2)=-PI/2.
      ADC(3,3)=PI/2.-ADC(3,1)
      ADC(4,1)=PI-(BETAL/RTD-THETA)
      ADC(4,2)=-PI/2
      ADC(4,3)=PI/2-ADC(4,1)
      ARM(3,1)=-EP+RAD*SIN(ADC(3,1))
      ARM(3,2)=0.
      ARM(3,3)=-HHU+RAD*COS(ADC(3,1))
      ARM(4,1)=-EP-RAD*SIN(ADC(4,1))
      ARM(4,2)=0.
      ARM(4,3)=HHL-RAD*COS(ADC(4,1))
      RETURN
    1 XLGTH(1)=XLU
      XLGTH(2)=XLL
      ADC(1,1)=-BETAU/RTD+THETA
      ADC(1,2)=PI/2.
      ADC(1,3)=PI/2.-ADC(1,1)
      ADC(2,1)=BETAL/RTD+THETA
      ADC(2,2)=PI/2.
      ADC(2,3)=PI/2.-ADC(2,1)
      ARM(1,1)=EP+RAD*SIN(ADC(1,1))
      ARM(1,2)=0.
      ARM(1,3)=-HHU-RAD*COS(ADC(1,1))
      ARM(2,1)=EP-RAD*SIN(ADC(2,1))
      ARM(2,2)=0.
      ARM(2,3)=HHL+RAD*COS(ADC(2,1))
      RETURN
      END
      SUBROUTINE RPLYH(STAD,BLD,WLD,XP,YP,ZP,RAD,THETA,IF)
      COMMON /DAT/AERO(175),AEROP(50),KODE(26),LL
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      EQUIVALENCE(AERO(76),WLCR),(AERO(77),STACR),(AERO(78),BLCR)
      PI=3.14159
      XWT=STACR-STAD
      ZWT=WLCR-WLD
      XB=XWT*COS(THETA)-ZWT*SIN(THETA)
      ZB=XWT*SIN(THETA)+ZWT*COS(THETA)
      T9= BLD -YP
      T10=XB-XP
      XLHIP= SQRT(T9*T9 +T10*T10)
      BHIP= ATAN2(T9,T10)
      XLHI= SQRT(XLHIP*XLHIP -RAD*RAD)
      DBHI= ATAN(RAD/XLHI)
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      BHI= BHIP -DBHI
      T11=ZB-ZP
      XL=SQRT(XLHI*XLHI+T11*T11)
      TH10=T10-RAD*COS(BHI)
      TH9=T9-RAD*SIN(BHI)
      IF(IF.EQ.3)GO TO 3
      XLGTH(1)=XL
      XLGTH(2)=XL
      ADC(1,1)=ARCOS(TH10/XL)
      ADC(1,2)=ARCOS(TH9/XL)
      ADC(1,3)=ARCOS(T11/XL)
      ADC(2,1)=-ADC(1,1)
      ADC(2,2)=PI-ADC(1,2)
      ADC(2,3)=ADC(1,3)
      ARM(1,1)=XP-RAD*SIN(BHI)
      ARM(1,2)=YP+RAD*COS(BHI)
      ARM(1,3)=0.
      ARM(2,1)=ARM(1,1)
      ARM(2,2)=-ARM(1,2)
      ARM(2,3)=0.
      RETURN
    3 XLGTH(3)=XL
      XLGTH(4)=XL
      ADC(3,1)=ARCOS(TH10/XL)
      ADC(3,2)=ARCOS(TH9/XL)
      ADC(3,3)=ARCOS(T11/XL)
      ADC(4,1)=-ADC(3,1)
      ADC(4,2)=PI-ADC(3,2)
      ADC(4,3)=ADC(3,3)
      ARM(3,1)=XP+RAD*SIN(BHI)
      ARM(3,2)=YP-RAD*COS(BHI)
      ARM(3,3)=0.
      ARM(4,1)=ARM(3,1)
      ARM(4,2)=-ARM(3,2)
      ARM(4,3)=0.
      RETURN
      END
      SUBROUTINE DLGTH(C1,C2,C3,IC,IDX)
C  COMPUTES D/L-LGTH EQ FOR X-Z-THETA OR Y-PSI-PHI COEFF
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      IF(IDX.NE.0)GO TO 1
      C1=-COS(ADC(IC,1))
      C2=-COS(ADC(IC,3))
      C3=(ARM(IC,1)*COS(ADC(IC,3))-ARM(IC,3)*COS(ADC(IC,1)))/12.
      RETURN
    1 C1=-COS(ADC(IC,2))
      C2=(ARM(IC,2)*COS(ADC(IC,1))-ARM(IC,1)*COS(ADC(IC,2)))/12.
      C3=(ARM(IC,3)*COS(ADC(IC,2))-ARM(IC,2)*COS(ADC(IC,3)))/12.
      RETURN
      END
      SUBROUTINE DCOSLG(IC,CX1,CZ1,CT1,CX3,CZ3,CT3)
C  COMPUTES D-DIR COS EQS FOR X-Z-THETA COEFF.
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      CX1=SIN(ADC(IC,1))/XLGTH(IC)*12.
      IF(ABS(ADC(IC,3)-3.14159).GT..00001) GO TO 2
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      XVAL=1000.
      GO TO 1
    2 XVAL=COTAN(ADC(IC,3))
    1 CZ1=-COS(ADC(IC,3))*COTAN(ADC(IC,1))/XLGTH(IC)*12.
      XWT=ARM(IC,1)
      ZWT=ARM(IC,3)
      CT1=(ZWT*SIN(ADC(IC,1))+XWT*COS(ADC(IC,3))*COTAN(ADC(IC,1)))/
     1XLGTH(IC)
      CX3=-COS(ADC(IC,1))*XVAL/XLGTH(IC)*12.
      CZ3=SIN(ADC(IC,3))/XLGTH(IC)*12.
      CT3=-(ZWT*COS(ADC(IC,1))*XVAL+XWT*SIN(ADC(IC,3)))
     1/XLGTH(IC)
      RETURN
      END
C  THIS IS A DOUBLE PRECISION VERSION OF CABLE4 TO BE USED
C  WITH THE LRC MATRIX REDUCTION AND IBM ROOT
C  FINDING ROUTINE
      SUBROUTINE LONG
      COMMON/INPUT/IW,IR
      COMMON /DAT/ AERO(175),AEROP(50),KODE(26),LL
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      COMMON /DUM/DUM(10,10)
      COMMON/ERO/C4(30)
      EQUIVALENCE(AERO(46),XCG),(AERO(47),ZCG)
      EQUIVALENCE(AERO (63),THETA),(AERO (49),VO   ),(AERO (50),    AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),    WT),(AERO (53),B     )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (56),ZIZZ ),
     1           (AERO(95),AKR),(AERO(100),AKLFT)
      EQUIVALENCE(AERO(117),TUSNO),(AERO(119),AKSNU),(AERO(120),AKSNL)
      EQUIVALENCE(AERO(123), AKSY),(AERO(124),AKPHI),(AERO(125),AKTHE),
     1           (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128),T2PHI),
     2           (AERO(129),T3THE),(AERO(130), T4AZ)
      EQUIVALENCE(AERO(131),AKSBT),(AERO(132),AKSBV),(AERO(133),AJASM),
     1           (AERO(134),RSBA) ,(AERO(135),ELSBA),(AERO(136), RSBD),
     2           (AERO(137),AKTHD),(AERO(138), AKTH),(AERO(139), GDMP),
     3           (AERO(140), AKO )
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1           (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
     2           (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP),
     3           (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP),
     4           (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP),
     5           (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP),
     6           (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP),
     7           (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP),
     8           (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP),
     9           (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP),
     A           (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP),
     B           (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)
      DIMENSION CMAT(14,14,3),RMAT(14,3)
      COMPLEX ROOTS(44)
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON /ROUGH/FRIC(3,6)
      DIMENSION FXS(3,4)
      DO 10 J=1,3
```

```
      DO 10 K=1,4                                                       CAB00420
   10 FXS(J,K)=0.                                                       CAB00430
      DO 1 IC=1,5                                                       CAB00440
      DO 3 J=1,10                                                       CAB00450
      DO 3 K=1,10                                                       CAB00460
    3 DUM(J,K)=0.                                                       CAB00470
      IF(KODE(10).EQ.3)GO TO 649                                        CAB00480
      TENS=TF                                                           CAB00490
      IF(IC.GT.2) TENS=TR                                               CAB00500
      IF(IC.GT.4) TENS=TLFT                                             CAB00510
      DUM(1,2)= - TENS * COS(ADC(IC,3))                                 CAB00520
      DUM(1,5)= - TENS * SIN (ADC(IC,1))                                CAB00530
      DUM(2,2)= TENS * COS(ADC(IC,1))                                   CAB00540
      DUM(2,6)= - TENS * SIN(ADC(IC,3))                                 CAB00550
      DUM(3,2)=( ARM(IC,3)*DUM(1,2)-ARM(IC,1)*DUM(2,2))/12.             CAB00560
      DUM(3,5)= ARM(IC,3)*DUM(1,5)/12.                                  CAB00570
      DUM(3,6)=-ARM(IC,1)*DUM(2,6)/12.                                  CAB00580
      IF(IC.GT.2) GO TO 2                                               CAB00590
      DUM(1,3)=COS(ADC(IC,1))                                           CAB00600
      DUM(2,3)=COS(ADC(IC,3))                                           CAB00610
      DUM(3,3)=(ARM(IC,3)*DUM(1,3)-ARM(IC,1)*DUM(2,3))/12.              CAB00620
      CALL DLGTH (CX,CZ,CT,1,0)                                         CAB00630
      CALL DLGTH (CXP,CZP,CTP,2,0)                                      CAB00640
      CX= CX + CXP                                                      CAB00650
      XPZ =-(CZ+CZP)/CX                                                 CAB00660
      DUM(4,1) =XPZ                                                     CAB00670
      XPT =-(CT+CTP)/CX                                                 CAB00680
      DUM(4,2)=XPT                                                      CAB00690
      DUM(4,4)= -1                                                      CAB00700
      CALL DCOS_G ( IC,DUM(5,4),DUM(5,1),DUM(5,2),DUM(6,4),             CAB00710
     1DUM(6,1),DUM(6,2))                                                CAB00720
      DUM(5,5)=-1                                                       CAB00730
      DUM(6,6)=-1                                                       CAB00740
      CALL MASH(3,6)                                                    CAB00750
      DO 4 J=1,3                                                        CAB00760
      DO 4 K=1,3                                                        CAB00770
    4 FXS(J,K)=FXS(J,K)+DUM(J,K)                                        CAB00780
      GO TO 1                                                           CAB00790
    2 IF(IC.GT.4)GO TO 5                                                CAB00800
      CALL DLGTH(CX,CZ,CT,3,0)                                          CAB00810
      CALL DLGTH(CXP,CZP,CTP,4,0)                                       CAB00820
      DUM(7,1)=CZ+CZP                                                   CAB00830
      DUM(7,2)=CT+CTP                                                   CAB00840
      DUM(7,3)=CX+CXP                                                   CAB00850
      DUM(4,7)=AKP*12.                                                  CAB00860
    8 DUM(1,4)=COS(ADC(IC,1))                                           CAB00870
      DUM(2,4)=COS(ADC(IC,3))                                           CAB00880
      DUM(3,4)=(ARM(IC,3)*DUM(1,4)-ARM(IC,1)*DUM(2,4))/12.              CAB00890
      CALL DCOS_G(IC,DUM(5,3),DUM(5,1),DUM(5,2),DUM(6,3),DUM(6,1),DUM   CAB00900
     1(6,2))                                                            CAB00910
      DUM(4,4)=-1                                                       CAB00920
      DUM(5,5)=-1                                                       CAB00930
      DUM(6,6)=-1                                                       CAB00940
      DUM(7,7)=-1                                                       CAB00950
      CALL MASH(3,7)                                                    CAB00960
```

```
      DO 6 J=1,3
      DO 6 K=1,3
      IF(K.NE.3)FXS(J,K)=FXS(J,K)+DUM(J,K)
    6 IF(K.EQ.3)FXS(J,4)=FXS(J,4)+DUM(J,K)
      GO TO 1
    5 IF(KODE(11).EQ.0)GO TO 1
      CALL DLGTH(DUM(7,3),DUM(7,1),DUM(7,2),5,0)
      DUM(4,7)=AKLFT*12.
      GO TO 8
    1 CONTINUE
C  ADD SNUBBER INCREMENTS
      CALL LONGSN
      DO 7 J=1,3
      FXS(J,1)=FXS(J,1)+SNU(J,2)
      FXS(J,2)=FXS(J,2)+SNU(J,3)
    7 FXS(J,4)=FXS(J,4)+SNU(J,1)
      CALL FRICT(0)
C  ZERO  CABLE EFFECTS FOR CABLELESS MODEL CHAR.
      IF(KODE(13).NE.-1.)GO TO 649
      DO 84 J=1,3
      DO 84 K=1,4
   84 FXS(J,K)=0.
      DO 85 J=1,3
      DO 85 K=1,6
   85 FRIC(J,K)=0.
      DO 86 J=1,3
      DO 86 K=1,3
   86 SNUD(J,K)=0.
C  THE CABLE FORCES/MOMENTS PARTIALS ARE COMPLETED
C  AERO. DATA IS NOW COMPUTED
  649 Q=RHO*VO*VO/2.
      QS=Q*SW
      IF(VO.NE.0.)QSV=QS/VO
      IF(VO.EQ.0.)QSV=0.
      XU=CXUP*QSV
      ZU=CZUP*QSV
      EMU=CMUP*QSV*CBAR
      XA=CXAP*QSV
      ZA=CZAP*QSV
      EMA=CMAP*QSV*CBAR
      IF(VO.NE.0.)XQ=CXQP*QSV*CBAR/(VO*2.)
      IF(VO.EQ.0.)XQ=0.
      IF(VO.NE.0.)ZQ=CZQP*QSV*CBAR/(VO*2.)
      IF(VO.EQ.0.)ZQ=0.
      EMQ=CMQP*QSV*CBAR/2.
      XDE=CXDEP*QS
      ZDE=CZDEP*QS
      EMDE=CMDEP*QS*CBAR
      IF(VO.NE.0.)XAD=CXADP*QSV*CBAR/(VO*2.)
      IF(VO.EQ.0.)XAD=0.
      IF(VO.NE.0.)ZAD=CZADP*QSV*CBAR/(VO*2.)
      IF(VO.EQ.0.)ZAD=0.
      IF(VO.NE.0.)EMAD=CMADP*QSV*CBAR/(2.*VO)
      IF(VO.EQ.0.)EMAD=0.
      IROW=14
```

```
      ICOL=14
      IORDER=3
   42 DO 20 I=1,IROW
      DO 20 J=1,ICOL
      DO 20 K=1,IORDER
   20 CMAT(I,J,K)=0.0
      IF(KODE(10).EQ.3)GO TO 650
C   FX EQUATION
      CMAT(1,1,1)=-FXS(1,1)
      CMAT(1,1,2)=-XA-SNUD(1,2)-FRIC(1,5)-FRIC(1,2)
      CMAT(1,1,3)=-XAD
      CMAT(1,2,1)=-FXS(1,2)+WT*COS(THETA)-XA*VO
      CMAT(1,2,2)=-XO-XAD*VO-SNUD(1,3)-FRIC(1,6)-FRIC(1,3)
      CMAT(1,2,3)=ZCG*AM/12.
      CMAT(1,3,1)=-FXS(1,3)
      CMAT(1,4,1)=-FXS(1,4)
      CMAT(1,4,2)=-XU-SNUD(1,1)-FRIC(1,4)-FRIC(1,1)
      CMAT(1,4,3)=AM
      CMAT(1,5,1)=-XDE
C   FZ EQUATION
      CMAT(2,1,1)=-FXS(2,1)
      CMAT(2,1,2)=-ZA-SNUD(2,2)-FRIC(2,5)-FRIC(2,2)
      CMAT(2,1,3)=AM-ZAD
      CMAT(2,2,1)=-FXS(2,2)+WT*SIN(THETA)-ZA*VO
      CMAT(2,2,2)=-ZO-ZAD*VO-SNUD(2,3)-FRIC(2,6)-FRIC(2,3)
      CMAT(2,2,3)=-XCG*AM/12.
      CMAT(2,3,1)=-FXS(2,3)
      CMAT(2,4,1)=-FXS(2,4)
      CMAT(2,4,2)=-ZU-SNUD(2,1)-FRIC(2,4)-FRIC(2,1)
      CMAT(2,5,1)=-ZDE
C   MOMENT EQUATION
      CMAT(3,1,1)=-FXS(3,1)
      CMAT(3,1,2)=-EMA-SNUD(3,2)-FRIC(3,5)-FRIC(3,2)
      CMAT(3,1,3)=-EMAD*CBAR-XCG*AM/12.
      CMAT(3,2,1)=-FXS(3,2)-EMA*VO+ZCG*WT*COS(THETA)/12.
     1-XCG*WT*SIN(THETA)/12.
      CMAT(3,2,2)=(-EMO-EMAD*VO)*CBAR-SNUD(3,3)-FRIC(3,6)-FRIC(3,3)
      CMAT(3,2,3)=YIYY
      CMAT(3,3,1)=-FXS(3,3)
      CMAT(3,4,1)=-FXS(3,4)
      CMAT(3,4,2)=-EMU-SNUD(3,1)-FRIC(3,4)-FRIC(3,1)
      CMAT(3,4,3)=ZCG*AM/12.
      CMAT(3,5,1)=-EMDE
C   ELIMINATION OF DTF COL FOR CABLELESS MODEL CHAR.
      IF(KODE(13).NE.-1.)GO TO 81
      IF(KODE(8).NE.3.)WRITE(IW,82)
   82 FORMAT( 5X,'KODE(8).HAS BEEN SET BY PROG. TO 3. FOR CABLELESS MODE
     1L CHARACTERISTICS')
      KODE(8)=3.
      DO 83 I=1,3
      DO 83 J=1,3
   83 CMAT(I,3,K)=CMAT(I,4,K)
      GO TO 31
C   CONSTRAINT EQUATION
   81 CMAT(4,1,1)=-XPZ
```

```
      CMAT(4,2,1)=-XPT
      CMAT(4,4,1)=1
C  ACTIVE CABLE CONTROL EQS.

      IF (KODE(13).LE.0)GO TO 30
      CMAT(1,5,1)=0.0
      CMAT(2,5,1)=0.0
      CMAT(3,5,1)=0.0
      IF(KODE(6).EQ.1.OR.KODE(6).EQ.3)GO TO 46
      IC2=4
      IC1=3
      GO TO 47
   46 IC2=1
      IC1=2
   47 CMAT(1,10,1)=-(COS(ADC(IC2,1))-COS(ADC(IC1,1)))
      CMAT(2,10,1)=-(COS(ADC(IC2,3))-COS(ADC(IC1,3)))
      CMAT(3,10,1)=-(ARM(IC2,3)*COS(ADC(IC2,1))-ARM(IC2,1)*COS(ADC(IC2,3
     1)))/12.+(ARM(IC1,3)*COS(ADC(IC1,1))-ARM(IC1,1)*COS(ADC(IC1,3)))/12
     2.
C  EQ OF MOTOR DYN.
      CMAT(5,5,1)=+2.*F S BD*FSBA
      CMAT(5,5,2)=+2.*FSBD*FLSBA
      CMAT(5,7,1)=+AKSBT*2.
      CMAT(5,6,2)=-AKSBT*2.*AKSBV-GDMP*FSBA
      CMAT(5,6,3)=-AJASM*FSBA-GDM *FLSBA
      CMAT(5,8,3)=-AJASM*ELSBA
C  EQ RELATING PULLEY ROTATION TO SYS. GEOM.,MOTOR ON TOP
      CALL DLGTH(CMAT(6,4,1),CMAT(6,1,1),CMAT(6,2,1),IC1,0)
      CMAT(6,6,1)=-FSBD/12.
C  ACTIVE CABLE FEEDBACK EQ.
      CMAT(7,2,2)=AKO
      CMAT(7,6,1)=AKTH
      CMAT(7,6,2)=AKTHD
      CMAT(7,9,1)=-1.
C  TOTAL VOLTAGE EQ EM + EMC
      CMAT(9,7,1)=-1.
      CMAT(9,9,1)=1.
      CMAT(9,11,1)=1.
C  RELATION OF THM TO THMD
      CMAT(8,8,1)=-1.
      CMAT(8,6,2)=1.
C  RELATION OF TFDBK TO DTC AND INPUT DT
      CMAT(10,5,1)=1.
      CMAT(10,10,1)=1.
      CMAT(10,12,1)=-1.
      GO TO 31
C  FEEDBACK LOOP EQUATION
   30 CMAT(5,2,2)=AKTHE
      CMAT(5,5,2)=-TATHE
      CMAT(5,5,1)=-1.
   31 ITHD=0
      IF(KODE(14).EQ.0)GO TO 32
C  SUBST. COL IDX INTO COL IDN TO GET NUMERATOR ROOTS
      IDX=KODE(14)
      IDN=KODE(15)
```

```
      IF(IDN.NE.13)GO TO 52
      IDN=2
      ITHD=13
   52 IF(IDX.GT.14)GO TO 38
      DO 34 I=1,14
      DO 34 K=1,3
      BMAT(I,K)=CMAT(I,IDN,K)
   34 CMAT(I,IDN,K)=-CMAT(I,IDX,K)
      GO TO 32
   38 DO 37 I=1,14
      DO 37 K=1,3
      BMAT(I,K)=CMAT(I,IDN,K)
   37 CMAT(I,IDN,K)=0.0
      IF(IDX.EQ.16)GO TO 39
      CMAT(1,IDN,1)=XDE
      CMAT(2,IDN,1)=ZDE
      CMAT(3,IDN,1)=EMDE
      GO TO 32
   39 CMAT(1,IDN,1)=XA
      CMAT(2,IDN,1)=ZA
      CMAT(3,IDN,1)=EMA
   32 N=KODE(8)
  655 CALL MATRIX(CMAT,N,ROOTS,K4A,IER)
      IF(KODE(14).EQ.0)GO TO 35
      DO 36 I=1,14
      DO 36 K=1,3
   36 CMAT(I,IDN,K)=BMAT(I,K)
C  35 IF(KODE(5).NE.0) WRITE(IW,100) IER
C 100 FORMAT(2X,'IER=',I3,3X,'SEE SUBR  ROEB AND PERM FOR ERROR CODE')
C  THE ROOTS OF THE CHARAC. EQUAT. ARE IN THE COMPLEX ARRAY 'ROOTS'
C  AND THE NUMBER OF ROOTS IS 'K4A'
   35 K4A=K4A-1
      IF(ITHD.NE.13)GO TO 70
      K4A=K4A+1
      ROOTS(K4A)=(0.0,0.0)
      DO 71 I=1,K4A
      C4(K4A+2-I)=C4(K4A+1-I)
   71 CONTINUE
      C4(1)=0.
   70 CALL PRINTR(IW,ROOTS,K4A)
      GO TO 651
  650 CONTINUE
C     NEW SNUBBER EFFECTS
      KODE(14)=0
      DO 600 IC=1,4
      DO 201 I=1,10
      DO 201 J=1,10
  201 DUM(I,J)=0.
      TC=TF-TR+TUSNO
      IF(IC.GT.2) TC=TUSNO
      DUM(1,3)=-TC*COS(ADC(IC,3))
      DUM(1,4)=-TC*SIN(ADC(IC,1))
      DUM(1,6)=COS(ADC(IC,1))
      DUM(2,3)=TC*COS(ADC(IC,1))
      DUM(2,5)=-TC*SIN(ADC(IC,3))
```

```
      DUM(2,6)=COS(ADC(IC,3))                                           CABC3170
      DUM(3,3)=(ARM(IC,3)*DUM(1,3)-ARM(IC,1)*DUM(2,3))/12.              CABC3180
      DUM(3,4)=ARM(IC,3)*DUM(1,4)/12.                                   CABC3190
      DUM(3,5)=-ARM(IC,1)*DUM(2,5)/12.                                  CABC3200
      DUM(3,6)=(ARM(IC,3)*DUM(1,6)-ARM(IC,1)*DUM(2,6))/12.              CABC3210
      CALL DCOSLG(IC,DUM(4,1),DUM(4,2),DUM(4,3),DUM(5,1),DUM(5,2),      CABC3220
     1 DUM(5,3))                                                        CABC3230
      DUM(4,4)=-1.                                                      CABC3240
      DUM(5,5)=-1.                                                      CABC3250
      DUM(6,6)=-1.                                                      CABC3260
      DUM(6,7)=AKSNU*12.                                                CABC3270
      IF(IC.GT.2) DUM(6,7)=AKSNL*12.                                    CABC3280
      CALL DLGTH(DUM(7,1),DUM(7,2),DUM(7,3),IC,0)                       CABC3290
      DUM(7,7)=-1.                                                      CABC3300
      CALL MASH(3,7)                                                    CABC3310
      DO 200 J=1,3                                                      CABC3320
      DO 200 K=1,3                                                      CABC3330
  200 FXS(J,K)=FXS(J,K)+DUM(J,K)                                        CABC3340
  600 CONTINUE                                                          CABC3350
      CMAT(1,2,2)=-XA                                                   CABC3360
      CMAT(1,2,3)=-XAD                                                  CABC3370
      CMAT(1,3,1)=WT*COS(THETA)-XA*VO                                   CABC3380
      CMAT(1,3,2)=-XQ-XAD*VO                                            CABC3390
      CMAT(1,3,3)=ZCG*AM/12.                                            CABC3400
      CMAT(1,1,2)=-XU                                                   CABC3410
      CMAT(1,1,3)=AM                                                    CABC3420
      CMAT(2,2,2)=-ZA                                                   CABC3430
      CMAT(2,2,3)=AM-ZAD                                                CABC3440
      CMAT(2,3,1)=WT*SIN(THETA)-ZA*VO                                   CABC3450
      CMAT(2,3,2)=-ZQ-ZAD*VO                                            CABC3460
      CMAT(2,3,3)=-XCG*AM/12.                                           CABC3470
      CMAT(2,1,2)=-ZU                                                   CABC3480
      CMAT(3,2,2)=-EMA                                                  CABC3490
      CMAT(3,2,3)=-EMAD*CBAR-XCG*AM/12.                                 CABC3500
      CMAT(3,3,1)=-EMA*VO+ZCG*WT*COS(THETA)/12.-XCG*WT*SIN(THETA)/12.   CABC3510
      CMAT(3,3,2)=(-EMQ-EMAD*VO)*CBAR                                   CABC3520
      CMAT(3,3,3)=YIYY                                                  CABC3530
      CMAT(3,1,2)=-EMU                                                  CABC3540
      CMAT(3,1,3)=ZCG*AM/12.                                            CABC3550
      DO 700 I=1,3                                                      CABC3560
      DO 700 J=1,3                                                      CABC3570
  700 CMAT(I,J,1)=CMAT(I,J,1)-FXS(I,J)                                  CABC3580
      IW=6                                                              CABC3590
      N=3                                                               CABC3600
      GO TO 655                                                         CABC3610
  651 CONTINUE                                                          CABC3620
      IF(KODE(3).NE.2)RETURN                                            CABC3630
      IF(KODE(14).EQ.0)GO TO 41                                         CABC3640
      WRITE(IW,43)                                                      CABC3650
   43 FORMAT(//'  COMPUTATION OF THE DENOMINATOR ROOTS'//)              CABC3660
      LKODE=KODE(14)                                                    CABC3670
      KODE(14)=0                                                        CABC3680
      CALL FREQ1(ROOTS,K4A,C4(K4A+1))                                   CABC3690
      GO TO 42                                                          CABC3700
   41 KODE(14)=LKODE                                                    CABC3710
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      CALL FREQ(ROOTS,K4A,C4(K4A+1))                                    CABC3720
      RETURN                                                            CABC3730
      END                                                               CABC3740
      SUBROUTINE PRINTR (LOUT,RT,NROOT)                                 CABC0010
      COMMON/FRQ/C4(30)                                                 CABC0020
      DIMENSION RT(2,1)                                                 CABC0030
      K4=NROOT+1                                                        CABC0040
      WRITE(LOUT,1)(C4(I),I=1,K4)                                       CABC0050
    1 FORMAT('  POLYNOMIAL W CONST TERM FIRST',/,(E27.6,4E16.6))        CABC0060
COMMENT   PRINTS PERTINENT INFORMATION ABOUT CHARACTERISTIC ROOTS       CABC0070
      WRITE(LOUT,507)                                                   CABC0080
  507 FORMAT(       '    REAL         IMAGINARY      T H/D-SEC     1/T H/',CABC0090
     1              'D      PERIOD-SEC     DNATF-CPS   UNDNAT-CPS   DAMP ',CABC0100
     2              'RATIO     DECAY RATIO '                             )CABC0110
      NEXT=1                                                            CABC0120
      IF( NROOT.GT.0 ) GO TO 5                                          CABC0130
      WRITE(LOUT,2)                                                     CABC0140
    2 FORMAT(5X,'NO ROOTS')                                             CABC0150
      RETURN                                                            CABC0160
    5 DO 530 I=1,NROOT                                                  CABC0170
      IF(NEXT.EQ.2) GO TO 777                                           CABC0180
      SIG=RT(1,I)                                                       CABC0190
      ASIG=ABS(SIG)                                                     CABC0200
      AWD=ABS(RT(2,I))                                                  CABC0210
      THDI= ASIG*1.442695                                               CABC0220
      THD= 99999.                                                       CABC0230
      IF(THDI.GT.1.E-5) THD= 1./THDI                                    CABC0240
      IF(AWD.EQ.0.) GO TO 531                                           CABC0250
      NEXT=2                                                            CABC0260
      WD=-AWD                                                           CABC0270
      DNAT= AWD * .159155                                               CABC0280
      PER= 99999.                                                       CABC0290
      IF(DNAT.GT.1.E-5) PER= 1./DNAT                                    CABC0300
      UNDNAT= SQRT(ASIG**2+AWD**2) *.1591550                            CABC0310
      DAMPR= 0.                                                         CABC0320
      IF( AWD - 1.E15 * ASIG ) 503,504,504                              CABC0330
  503 DAMPR= SIGN ( COS( ATAN ( AWD/ASIG ) ), -SIG )                    CABC0340
  504 CHDI= THDI*PER                                                    CABC0350
      DECR= 99999.                                                      CABC0360
      ARG= SIG * PER                                                    CABC0370
      IF(ARG.LT.174.6) DECR= EXP (ARG)                                  CABC0380
      WRITE(LOUT,529) SIG,WD,THD,THDI,PER,DNAT,UNDNAT,DAMPR,DECR         CABC0390
  529 FORMAT(E12.4,2X,1H+,E11.4,8E13.4)                                 CABC0400
      GO TO 530                                                         CABC0410
  531 WRITE(LOUT,532) SIG,THD,THDI                                      CABC0420
  532 FORMAT(E12.4,14X,2E13.4)                                          CABC0430
      GO TO 530                                                         CABC0440
  777 NEXT=1                                                            CABC0450
  530 CONTINUE                                                          CABC0460
      RETURN                                                            CABC0470
      END                                                               CABC0480
      SUBROUTINE MASH (NN,N)                                            CABC0490
      COMMON /DU/DUM(10,10)                                             CABC0500
C   NN = FINAL MATRIX SIZE                                              CABC0510
C   N =  ORIGINAL MATRIX SIZE                                           CABC0520
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```
      INN=N-NN
      DO 1001 LL=1,INN
      L=N+1-LL
      II=L-1
      JJ=L-1
      DO 1001 I=1,II
      DO 1001 J=1,JJ
 1001 DUM(I,J)= DUM(I,J)+DUM(L,J)*DUM(I,L)/(-DUM(L,L))
      RETURN
      END
      SUBROUTINE LAT
      COMMON/INPUT/IW,IR
      COMMON /DAT/ AERO(175),AEROP(50),KODE(26),LL
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      COMMON /DU/DUM(10,10)
      COMMON/FRO/C4(30)
      EQUIVALENCE(AERO(46),XCG),(AERO(47),ZCG)
      EQUIVALENCE(AERO (63),THETA),(AERO (49),VO   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),    WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ ),
     1           (AERO(95),AKR),(AERO(100),AKLFT)
      EQUIVALENCE(AERO(117),THUSNO),(AERO(119),AKSNU),(AERO(120),AKSNL)
      EQUIVALENCE(AERO(123), AKSY),(AERO(124),AKPHI),(AERO(125),AKTHE),
     1           (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128),T2PHI),
     2           (AERO(129),T3THE),(AERO(130), T4AZ)
      EQUIVALENCE(AERO(131),AKSBT),(AERO(132),AKSBV),(AERO(133),AJASM),
     1           (AERO(134),RSBA) ,(AERO(135),ELSBA),(AERO(136), RSBD),
     2           (AERO(137),AKTHO),(AERO(138), AKTH),(AERO(139), DAMP),
     3           (AERO(140),   AKO),(AERO(141),   AKZ),(AERO(142),AKPSO),
     4           (AERO(143),   AKY),(AERO(144), AKYO)
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1           (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
     2           (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP),
     3           (AEROP(10), CXDP),(AEROP(11), CZDP),(AEROP(12), CMDP),
     4           (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP),
     5           (AEROP(16),CXADP),(AEROP(17),CZADP) AEROP(18),CMADP),
     6           (AEROP(19), CYBP),(AEROP(20), CLBP)  EROP(21), CNBP),
     7           (AEROP(22), CYPP),(AEROP(23), CLPP),.AEROP(24), CNPP),
     8           (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP),
     9           (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP),
     A           (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP),
     B           (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)
      DIMENSION CMAT(14,14,3),BMAT(14,3)
      COMPLEX ROOTS(44)
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON /ROUGH/FRIC(3,6)
      DIMENSION FXS(3,3)
      DO 10 J=1,3
      DO 10 K=1,3
   10 FXS(J,K)=0.
      IF(KODE(10).EQ.3)GO TO 650
      DO 111 IC=1,5
      IF(KODE(11).EQ.0.AND.IC.EQ.5)GO TO 1
      DO 3 J=1,8
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```
      DO 3 K=1,8
    3 DUM(J,K)=0.
      TENS=TF
      IF(IC.GT.2)TENS=TR
      IF(IC.GT.4)TENS=TLFT
      CA1=COS(ADC(IC,1))
      CA2=COS(ADC(IC,2))
      CA3=COS(ADC(IC,3))
      IF(ABS(CA1).LT..0001) CA1=0.
      IF(ABS(CA2).LT..0001) CA2=0.
      IF(ABS(CA3).LT..0001) CA3=0.
      DUM(1,2)=-TENS*CA1
      DUM(1,3)=TENS*CA3
      DUM(1,4)=CA2
      DUM(1,6)=-TENS*SIN(ADC(IC,2))
      DUM(2,2)=( ARM(IC,1)*DUM(1,2)-ARM(IC,2)*TENS*CA2)/12.
      DUM(2,3)= ARM(IC,1)*DUM(1,3)/12.
      DUM(2,4)=(ARM(IC,1)*CA2-ARM(IC,2)*CA1)/12.
      DUM(2,5)= ARM(IC,2)*TENS*SIN(ADC(IC,1))/12.
      DUM(2,6)= ARM(IC,1)*DUM(1,6)/12.
      DUM(4,4)=-1.
      DUM(4,8)=0.
      IF(IC.GT.2)DUM(4,8)=AKR*12.
      IF(IC.GT.4)DUM(4,8)=AKLFT*12.
      DUM(3,2)=-ARM(IC,3)*DUM(1,2)/12.
      DUM(3,3)=(-ARM(IC,3)*DUM(1,3)-ARM(IC,2)*TENS*CA2)/12.
      DUM(3,4)=(ARM(IC,2)*CA3-ARM(IC,3)*CA2)/12.
      DUM(3,7)=-ARM(IC,2)*TENS*SIN(ADC(IC,3))/12.
      DUM(3,6)=-ARM(IC,3)*DUM(1,6)/12.
      CALL DCOSD(IC,DUM(5,1),DUM(5,2),DUM(5,3),DUM(6,1),DUM(6,2),DUM(
     16,3),DUM(7,1),DUM(7,2),DUM(7,3))
      DUM(5,5)=-1.
      DUM(6,6)=-1.
      DUM(7,7)=-1.
      IF(IC.GT.2)GO TO 2
      CALL MASH(3,7)
    6 DO 4 J=1,3
      DO 4 K=1,3
    4 FXS(J,K)=FXS(J,K)+DUM(J,K)
      GO TO 1
    2 IF(IC.GT.4)GO TO 5
      CALL DLGTH(CY,CPS,CPH,3,1)
      CALL DLGTH(CYP,CPSP,CPHP,4,1)
      DUM(8,1)=CY+CYP
      DUM(8,2)=CPS+CPSP
      DUM(8,3)=CPH+CPHP
      DUM(8,8)=-1.
      CALL MASH(3,8)
      GO TO 6
    5 IF(KODE(11).EQ.0)GO TO 1
      CALL DLGTH(DUM(8,1),DUM(8,2),DUM(8,3),5,1)
      DUM(8,8)=-1.
      CALL MASH(3,8)
      GO TO 6
    1 CONTINUE
```

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  111 CONTINUE
C   COMPLETE SUMMATION OF CABLE FORCES & MOMENTS
C   ADD SNUBBER INCREMENTS
  112 CALL LATSN
      DO 8 J=1,3
      DO 8 K=1,3
    8 FXS(J,K)=FXS(J,K)+SNU(J,K)
      CALL FRICT(1)
C   ZERO CABLE EFFECTS FOR CABLELESS MODEL OPTION
      IF(KODE(13).NE.-1)GO TO 620
      IF(KODE(9).NE.3)WRITE(IW,22)
   22 FORMAT(5X,'KODE(9) HAS BEEN SET BY PROG TO 3 FOR CABLELESS MODEL C
     1HARACTERISTICS')
      KODE(9)=3
      DO 20 J=1,3
      DO 20 K=1,3
      SNUD(J,K)=0.
   20 FXS(J,K)=0.
      DO 21 J=1,3
      DO 21 K=1,6
   21 FRIC(J,K)=0.
      GO TO 620
  650 CONTINUE
      KODE(16)=0
      DO 610 I=1,3
      DO 610 J=1,6
  610 FRIC(I,J)=0.
      DO 611 I=1,3
      DO 611 J=1,3
      SNU(I,J)=0.
  611 SNUD(I,J)=0.
      DO 600 IC=1,4
      DO 605 I=1,10
      DO 605 J=1,10
  605 DUM(I,J)=0.
      TC=TF-TR+TUSNO
      IF(IC.GT.2) TC=TUSNO
      CA1=COS(ADC(IC,1))
      CA2=COS(ADC(IC,2))
      CA3=COS(ADC(IC,3))
      IF(ABS(CA1).LT..0001) CA1=0.
      IF(ABS(CA2).LT..0001) CA2=0.
      IF(ABS(CA3).LT..0001) CA3=0.
      DUM(1,2)=-TC*CA1
      DUM(1,3)=TC*CA3
      DUM(1,4)=CA2
      DUM(1,6)=-TC*SIN(ADC(IC,2))
      DUM(2,2)=(ARM(IC,1)*DUM(1,2)-ARM(IC,2)*TC*CA2)/12.
      DUM(2,3)=ARM(IC,1)*DUM(1,3)/12.
      DUM(2,4)=(ARM(IC,1)*CA2-ARM(IC,2)*CA1)/12.
      DUM(2,5)=ARM(IC,2)*TC*SIN(ADC(IC,1))/12.
      DUM(2,6)=ARM(IC,1)*DUM(1,6)/12.
      DUM(3,2)=-ARM(IC,3)*DUM(1,2)/12.
      DUM(3,3)=(-ARM(IC,3)*DUM(1,3)-ARM(IC,2)*TC*CA2)/12.
      DUM(3,4)=(ARM(IC,2)*CA3-ARM(IC,3)*CA2)/12.
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```
      DUM(3,7)=-ARM(IC,2)*TC*SIN(ADC(IC,3))/12.
      DUM(3,6)=-ARM(IC,3)*DUM(1,6)/12.
      DUM(4,4)=-1.
      DUM(4,8)=AKSNU*12.
      IF(IC.GT.2) DUM(4,8)=AKSNL*12.
      CALL DCOSD(IC,DUM(5,1),DUM(5,2),DUM(5,3),DUM(6,1),DUM(6,2),
     1 DUM(6,3),DUM(7,1),DUM(7,2),DUM(7,3))
      DUM(5,5)=-1.
      DUM(6,6)=-1.
      DUM(7,7)=-1.
      DUM(8,8)=-1.
      CALL DLGTH(DUM(8,1),DUM(8,2),DUM(8,3),IC,1)
      CALL MASH(3,8)
      DO 649 J=1,3
      DO 649 K=1,3
  649 FXS(J,K)=FXS(J,K)+DUM(J,K)
  600 CONTINUE
C  ADD AERO INCREMENTS
  620 Q=.5*RHO*VO*VO
      QS=Q*SW
      IF(VO.NE.0.)QSV=QS/VO
      IF(VO.EQ.0.)QSV=0.
      IF(VO.NE.0.)BOV=B/(2.*VO)
      IF(VO.EQ.0.)BOV=0.
      YV=CYBP*QSV
      ELV=CLBP*QSV*B
      ENV=CNBP*QSV*B
      YP=CYPP*QS*BOV
      ELP=CLPP*BOV*QS*B
      ENP=CNPP*BOV*QS*B
      YR=CYRP*QS*BOV
      ELR=CLRP*BOV*QS*B
      ENR=CNRP*BOV*QS*B
      YDR=CYDRP*QS
      ENDR=CNDRP*QS*B
      ELDR=CLDRP*QS*B
      YDA=CYDAP*QS
      ENDA=CNDAP*QS*B
      ELDA=CLDAP*QS*B
      YDS=CYDSP*QS
      ENDS=CNDSP*QS*B
      ELDS=CLDSP*QS*B
   42 DO 113 I=1,14
      DO 113 J=1,14
      DO 113 K=1,3
  113 CMAT(I,J,K)=0.0
C  Y FORCE EQUATION
      CMAT(1,1,1)=-FXS(1,1)
      CMAT(1,1,2)=-YV-SNUD(1,1)-FRIC(1,4)-FRIC(1,1)
      CMAT(1,1,3)=AM
      CMAT(1,2,1)=-FXS(1,2)+YV*VO-WT*SIN(THETA)
      CMAT(1,2,2)=-YP-SNUD(1,2)-FRIC(1,5)-FRIC(1,2)
      CMAT(1,2,3)=AM*XCG/12.
      CMAT(1,3,1)=-FXS(1,3)-WT*COS(THETA)
      CMAT(1,3,2)=-YR-SNUD(1,3)-FRIC(1,6)-FRIC(1,3)
```

```fortran
      CMAT(1,3,3)=-AM*ZCG/12.
C  YAW EQUATION
      CMAT(2,1,1)=-FXS(2,1)
      CMAT(2,1,2)=-ENV-SNUD(2,1)-FRIC(2,4)-FRIC(2,1)
      CMAT(2,1,3)=AM*XCG/12.
      CMAT(2,2,1)=-FXS(2,2)+ENV*VO-XCG*WT*SIN(THETA)/12.
      CMAT(2,2,2)=-ENP-SNUD(2,2)-FRIC(2,5)-FRIC(2,2)
      CMAT(2,2,3)=ZIZZ
      CMAT(2,3,1)=-FXS(2,3)-XCG*WT*COS(THETA)/12.
      CMAT(2,3,2)=-ENP-SNUD(2,3)-FRIC(2,6)-FRIC(2,3)
      CMAT(2,3,3)=-XIXZ
C  ROLL EQUATION
      CMAT(3,1,1)=-FXS(3,1)
      CMAT(3,1,2)=-ELV-SNUD(3,1)-FRIC(3,4)-FRIC(3,1)
      CMAT(3,1,3)=-AM*ZCG/12.
      CMAT(3,2,1)=-FXS(3,2)+ELV*VO+ZCG*WT*SIN(THETA)/12.
      CMAT(3,2,2)=-ELP-SNUD(3,2)-FRIC(3,5)-FRIC(3,2)
      CMAT(3,2,3)=-XIXZ
      CMAT(3,3,1)=-FXS(3,3)+ZCG*WT*COS(THETA)/12.
      CMAT(3,3,2)=-ELP-SNUD(3,3)-FRIC(3,6)-FRIC(3,3)
      CMAT(3,3,3)=XIXX
C  ACTIVE CABLE CONTROL EQUATIONS
      IF(KODE(13).NE.1)GO TO 30
      IF(KODE(6).EQ.1.OR.KODE(6).EQ.4)GO TO 46
      IC2=2
      IC1=1
      GO TO 47
   46 IC2=4
      IC1=3
   47 CMAT(1,10,1)=+(COS(ADC(IC2,2))-COS(ADC(IC1,2)))
      CMAT(3,10,1)=+(ARM(IC2,2)*COS(ADC(IC2,3))-ARM(IC2,3)*COS(ADC(IC2,2
     1)))/12.-(ARM(IC1,2)*COS(ADC(IC1,3))-ARM(IC1,3)*COS(ADC(IC1,2)))/12
     2.
      CMAT(2,10,1)=+(ARM(IC2,1)*COS(ADC(IC2,2))-AR   .2,2)*COS(ADC(IC2,
     11)))/12.-(ARM(IC1,1)*COS(ADC(IC1,2))-ARM(IC1,2)*COS(ADC(IC1,1)
     2))/12.
C EQ. OF MOTOR DYN.
      CMAT(4,4,1)=+2.*RSBD*RSBA
      CMAT(4,4,2)=+2.*RSBD*ELSBA
      CMAT(4,6,1)=+AKSBT*2.
      CMAT(4,5,2)=-AKSBT*2.*AKSBV-GDMP*RSBA
      CMAT(4,5,3)=-AJASM*RSBA-GDMP*ELSBA
      CMAT(4,7,3)=-AJASM*ELSBA
      CALL DLGTH(CMAT(5,1,1),CMAT(5,2,1),CMAT(5,3,1),IC1,1)
      CMAT(5,5,1)=+RSBD/12.
C  EQ FOR TOTAL VOLTAGE=ACTIVE SYSTEM+INPUT VOLTAGE,EMO
      CMAT(9,6,1)=-1.
      CMAT(9,9,1)=1.
      CMAT(9,11,1)=1.
C  FEEDBACK CONTROL EQ.
      CMAT(6,2,2)=AKPSD
      CMAT(6,5,1)=AKY
      CMAT(6,7,1)=AKYD
      CMAT(6,9,1)=-1.
C  RELATE ANGULAR RATES TO ANGULAR DISPLACEMENTS
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```
      CMAT(8,2,2)=1.
      CMAT(8,8,1)=-1.
      CMAT(7,5,2)=1.
      CMAT(7,7,1)=-1.
C  RELATION OF DTC TO DT AND DTFB
      CMAT(10,4,1)=1.
      CMAT(10,10,1)=1.
      CMAT(10,12,1)=-1.
      GO TO 31
C  RUDDER FEEDBACK LOOP
   30 CMAT(4,2,2)=AKSY
      CMAT(4,4,2)=-T3SY
      CMAT(4,4,1)=-1.
C  AILERON FEEDBACK LOOP
      CMAT(5,3,2)=AKPHI
      CMAT(5,5,2)=-T2PHI
      CMAT(5,5,1)=-1.
      CMAT(1,4,1)=-QS*CYDRP
      CMAT(1,5,1)=-QS*CYDAP
      CMAT(2,4,1)=-QS*B*CNDRP
      CMAT(2,5,1)=-QS*B*CNDAP
      CMAT(3,4,1)=-QS*B*CLDRP
      CMAT(3,5,1)=-QS*B*CLDAP
   31 IF(KODE(16).EQ.0)GO TO 32
C  SUBST. COL IDX INTO COL IDN TO GET NUMERATOR ROOTS
      IDX=KODE(16)
      IDN=KODE(17)
      IF(IDX.GT.13)GO TO 38
      DO 34 I=1,14
      DO 34 K=1,3
      BMAT(I,K)=CMAT(I,IDN,K)
   34 CMAT(I,IDN,K)=-CMAT(I,IDX,K)
      GO TO 32
   38 DO 37 I=1,14
      DO 37 K=1,3
      BMAT(I,K)=CMAT(I,IDN,K)
   37 CMAT(I,IDN,K)=0.0
      IF(IDX.EQ.15)GO TO 39
      IF(IDX.EQ.16)GO TO 41
      CMAT(1,IDN,1)=YDR
      CMAT(2,IDN,1)=ENDR
      CMAT(3,IDN,1)=ELDR
      GO TO 32
   39 CMAT(1,IDN,1)=YDA
      CMAT(2,IDN,1)=ENDA
      CMAT(3,IDN,1)=ELDA
      GO TO 32
   41 CMAT(1,IND,1)=YV
      CMAT(2,IDN,2)=ENV
      CMAT(3,IDN,3)=ELV
   32 N=KODE(9)
      CALL MATRIX(CMAT,N,ROOTS,K4A,IER)
      IF(KODE(16).EQ.0)GO TO 35
      DO 36 I=1,14
      DO 36 K=1,3
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   36 CMAT(I,IDN,K)=RMAT(I,K)                                                 CAB03830
C  35 IF(KODE(5).NE.0) WRITE(IW,100) IER                                      CAB03840
C 100 FORMAT(2X,'IER=',I3,3X,'SEE SUBR. POFR AND PRBM FOR ERROR CODE')        CAB03850
C  THE ROOTS OF THE CHARACTERISTIC EQUAT. ARE IN THE COMPLEX ARRAY            CAB03860
C  'ROOTS' AND THE NUMBER OF ROOTS IS 'K4A'                                   CAB03870
   35 K4A=K4A-1                                                               CAB03880
      CALL PRINTR(IW,ROOTS,K4A)                                               CAB03890
      IF(KODE(3).NE.2)RETURN                                                  CAB03900
      IF(KODE(16).EQ.0)GO TO 44                                               CAB03910
      WRITE(IW,43)                                                            CAB03920
   43 FORMAT(//'  COMPUTATION OF THE DENOMINATOR ROOTS'//)                    CAB03930
      LKODE=KODE(16)                                                          CAB03940
      KODE(16)=0                                                              CAB03950
      CALL FREQ1(ROOTS,K4A,C4(K4A+1))                                         CAB03960
      GO TO 42                                                                CAB03970
   44 KODE(16)=LKODE                                                          CAB03980
      CALL FREQ2(ROOTS,K4A,C4(K4A+1))                                         CAB03990
      RETURN                                                                  CAB04000
      END                                                                     CAB04010
      SUBROUTINE DCOSD(IC,CY1,CPSI1,CPHI1,CY2,CPSI2,CPHI2,CY3,CPSI3,          CAB04020
     1CPHI3)                                                                  CAB04030
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF                CAB04040
      IF(ABS(ADC(IC,3)-3.14159).GT..00001)GO TO 2                             CAB04050
      XVAL=1000.                                                              CAB04060
      GO TO 1                                                                 CAB04070
    2 XVAL=COTAN(ADC(IC,3))                                                   CAB04080
    1 XWT=ARM(IC,1)                                                           CAB04090
      YWT=ARM(IC,2)                                                           CAB04100
      ZWT=ARM(IC,3)                                                           CAB04110
      CY1=-COS(ADC(IC,2))*COTAN(ADC(IC,1))/XLGTH(IC)*12.                      CAB04120
      CPSI1=-(YWT*SIN(ADC(IC,1))+XWT*COS(ADC(IC,2))*COTAN(ADC(IC,1)))         CAB04130
     1/XLGTH(IC)                                                              CAB04140
      CPHI1=(ZWT*COS(ADC(IC,2))*COTAN(ADC(IC,1))-YWT*COS(ADC(IC,3))*          CAB04150
     1COTAN(ADC(IC,1)))/XLGTH(IC)                                             CAB04160
      CY2=SIN(ADC(IC,2))/XLGTH(IC)*12.                                        CAB04170
      CPSI2=(YWT*COS(ADC(IC,1))*COTAN(ADC(IC,2))+XWT*SIN(ADC(IC,2)))/         CAB04180
     1XLGTH(IC)                                                               CAB04190
      CPHI2=-(ZWT*SIN(ADC(IC,2))+YWT*COS(ADC(IC,3))*COTAN(ADC(IC,2)))         CAB04200
     1/XLGTH(IC)                                                              CAB04210
      CY3=-COS(ADC(IC,2))*XVAL/XLGTH(IC)*12.                                  CAB04220
      CPSI3=(YWT*COS(ADC(IC,1))*XVAL-XWT*COS(ADC(IC,2))*                      CAB04230
     1XVAL)/XLGTH(IC)                                                         CAB04240
      CPHI3=(ZWT*COS(ADC(IC,2))*XVAL+YWT*SIN(ADC(IC,3)))                      CAB04250
     1/XLGTH(IC)                                                              CAB04260
      RETURN                                                                  CAB04270
      END                                                                     CAB04280
      SUBROUTINE SNTRM (FXSN,FZSN,AMSN,THETA)                                 CAB00010
      COMMON/INPUT/IW,IR                                                      CAB00020
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL                              CAB00030
      COMMON ZZZ(200)                                                         CAB00040
      COMMON/TAB1/ZZ(300)                                                     CAB00050
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)                      CAB00060
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),       CAB00070
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),      CAB00080
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),      CAB00090
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     3          (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4          (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5          (AERO(120),AKSNL),(AERO(49),    VO),(AERO(51),   RHO),
     6          (AERO(76),WLCR),(AERO(77),STACR),
     7          (AERO(78),BLCR)
      EQUIVALENCE (SN( 1),   GX1),(SN( 2),   GY1),(SN( 3),   GZ1),
     1          (SN( 4),   GX2),(SN( 5),   GY2),(SN( 6),   GZ2),
     2          (SN( 7),   GX3),(SN( 8),   GY3),(SN( 9),   GZ3),
     3          (SN(10),   GX4),(SN(11),   GY4),(SN(12),   GZ4),
     4          (SN(13),   THU),(SN(14),   THL),(SN(15),   ALU),
     5          (SN(16),   ALL),
     6          (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7          (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8          (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9          (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
      IF(KODE(10).EQ.0) GO TO 5005
      IF(KODE(10).EQ.3) GO TO 5005
      CALL DRCSN(THETA)
      IF(KODE(10).NE.1) GO TO 5003
C TERMS TO MODEL SNUBBER EFFECTS (MODEL UNSNUBBED)
      Q=.5*RHO*VO*VO
      CALL STINT(Q,ALU,0,1,1,TUSN,NG)
      IF(NG.NE.0) GO TO 5000
      CALL STINT(Q,ALL,0,1,1,TLSN,NG)
      IF(NG.NE.0) GO TO 5000
      CALL STINT(Q,ALU,0,2,2,THUSN,NG)
      IF(NG.NE.0) GO TO 5000
      CALL STINT(Q,ALL,0,2,2,THLSN,NG)
      IF(NG.EQ.0) GO TO 5001
 5000 WRITE(IW,5002) NG,ALL,ALU,Q
 5002 FORMAT(2X,'ERROR IN SNUBBER TABLE 1-2  , NG=',I3,3E10.3)
      RETURN
 5001 CONTINUE
C      CALCULATING FORCE AND MOMENT EFFECTS
      CALL DRCUSN(THETA)
      FXUSN= 2.*TUSN*GX1
      FZUSN= 2.*TUSN*GZ1
      AMUSN= -FXUSN*SNUZ+SNUX*FZUSN
      FXLSN= 2.*TLSN*GX3
      FZLSN= 2.*TLSN*GZ3
      AMLSN= FXLSN*SNLZ+FZLSN*SNLX
      FXSN = FXUSN+FXLSN
      FZSN = FZUSN+FZLSN
      AMSN =(AMUSN+AMLSN)/12.
      RETURN
 5003 CONTINUE
C  TERMS TO MODEL SNUBBER EFFECTS (MODEL SNUBBED)
      FXUSN= 2.*TUSNO*GX1
      FZUSN= 2.*TUSNO*GZ1
      AMUSN =-FXUSN*SNUZ+FZUSN*SNUX
      FXLSN= 2.*TLSNO*GX3
      FZLSN= 2.*TLSNO*GZ3
      AMLSN = FXLSN*SNLZ+FZLSN*SNLX
      FXSN = FXUSN+FXLSN
      FZSN = FZUSN+FZLSN
```

```
      AMSN =(AMUSN+AMLSN)/12.
      RETURN
 5005 FXSN=0
      FZSN=0
      AMSN=0
      RETURN
      END
      SUBROUTINE LONGSN
      COMMON/INPUT/IW,IP
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON ZZZ(200)
      COMMON/TAB1/ZZ(800)
      COMMON/DU/DUM(10,10)
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1           (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2           (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3           (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4           (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5           (AERO(120),AKSNL),(AERO(49),    VO),(AERO(51),   RHO),
     6           (AERO(63),THETA),(AERO(121),ADSNU),(AERO(122),ADSNL)
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),
     1           (SN( 4),  GX2),(SN( 5),  GY2),(SN( 6),  GZ2),
     2           (SN( 7),  GX3),(SN( 8),  GY3),(SN( 9),  GZ3),
     3           (SN(10),  GX4),(SN(11),  GY4),(SN(12),  GZ4),
     4           (SN(13),  THU),(SN(14),  THL),(SN(15),  ALU),
     5           (SN(16),  ALL),
     6           (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7           (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8           (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9           (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
      DIMENSION FTOP(3,3),FBOT(3,3)
      COT(A)=1./TAN(A)
      DO 1001 I=1,3
      DO 1001 J=1,3
      SNU(I,J)=0
 1001 SNUD(I,J)=0
      DO 5102 I=1,10
      DO 5102 J=1,10
 5102 DUM(I,J)=0
      IF(KODE(10).NE.1) GO TO 1000
C  TERMS FOR UNSNUBBED SNUBBER EFFECTS (LONG)
      DO 1004 I=1,7
      DO 1004 J=1,7
 1004 DUM(I,J)=0
      CALL DRCUSN(THETA)
      DUM(1,3)= -2.*TUSNO*GZ1
      DUM(1,4)= -2.*TUSNO*SIN(THGX1)
      DUM(1,6)=  2.*GX1
      DUM(2,3)=  2.*TUSNO*GX1
      DUM(2,5)= -2.*TUSNO*SIN(THGZ1)
      DUM(2,6)=  2.*GZ1
      DUM(3,3)= (-SNUZ*DUM(1,3)+SNUX*DUM(2,3))/12.
      DUM(3,4)= -SNUZ*DUM(1,4)/12.
      DUM(3,5)=  SNUX*DUM(2,5)/12.
```

```
      DUM(3,6)= (-SNUZ*DUM(1,6)+SNUX*DUM(2,6))/12.
      DUM(4,1)=(SIN(THGX1)/ALU)*12.
      DUM(4,2)= (-GZ1*COT(THGX1)/ALU)*12.
      DUM(4,3)= -SNUZ*SIN(THGX1)/ALU-SNUX*GZ1*COT(THGX1)/ALU
      DUM(4,4)=  -1.
      DUM(5,1)= (-GX1*COT(THGZ1)/ALU)*12.
      DUM(5,2)=  (SIN(THGZ1)/ALU)*12.
      DUM(5,3)=  SNUZ*GX1*COT(THGZ1)/ALU + SNUX*SIN(THGZ1)/ALU
      DUM(5,5)= -1.
      CALL DFCSN(THETA)
      Q=.5*RHO*V0*V0
      ALU1=ALU+1.
      CALL STINT(Q,ALU1,C,1,1,TUSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALU2=ALU-1.
      CALL STINT(Q,ALU2,C,1,1,TUSN2,NG)
      IF(NG.EQ.0) GO TO 5001
 5000 WRITE(IW,5002) NG,ALL,ALU,Q
 5002 FORMAT('ERROR IN TABLE 1-2,NG=',I2,3XE10.3)
      RETURN
 5001 CONTINUE
      AKTU=(TUSN1-TUSN2)/2.
      DUM(6,6)= -1.
      DUM(6,7)= AKTU*12.
      DUM(7,1)= -GX1
      DUM(7,2)= -GZ1
      DUM(7,3)=((-SNUX+ALU*GX1)*GZ1-(-SNUZ+ALU*GZ1)*GX1)/12.
      DUM(7,7)= -1.
      CALL MASH(3,7)
      DO 1005 I=1,3
      DO 1005 J=1,3
 1005 FTOP(I,J)=DUM(I,J)
      CALL DFCUSN(THETA)
      DUM(1,3)= -2.*TLSNO*GZ3
      DUM(1,4)= -2.*TLSNO*SIN(THGX3)
      DUM(1,6)=  2.*GX3
      DUM(2,3)=  2.*TLSNO*GX3
      DUM(2,5)= -2.*TLSNO*SIN(THGZ3)
      DUM(2,6)=  2.*GZ3
      DUM(3,3)=  (SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.
      DUM(3,4)=  SNLZ*DUM(1,4)/12.
      DUM(3,5)=  SNLX*DUM(2,5)/12.
      DUM(3,6)=  (SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.
      DUM(4,1)=  (SIN(THGX3)/ALL)*12.
      DUM(4,2)= (-GZ3*COT(THGX3)/ALL)*12.
      DUM(4,3)=  SNLZ*SIN(THGX3)/ALL - SNLX*GZ3*COT(THGX3)/ALL
      DUM(4,4)=  -1.
      DUM(5,1)=  (-GX3*COT(THGZ3)/ALL)*12.
      DUM(5,2)=  (SIN(THGZ3)/ALL)*12.
      DUM(5,3)=  -SNLZ*GX3*COT(THGZ3)/ALL + SNLX*SIN(THGZ3)/ALL
      DUM(5,5)=  -1.
      CALL DFCSN(THETA)
      ALL1=ALL+1.
      CALL STINT(Q,ALL1,C,1,1,TLSN1,NG)
      IF(NG.NE.0) GO TO 5003
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      ALL2=ALL-1.
      CALL STINT(Q,ALL2,0,1,1,TLSN2,NG)
      IF(NG.EQ.0) GO TO 5004
 5003 WRITE(IW,5002) NG,ALL,ALU,Q
      RETURN
 5004 CONTINUE
      AKTL=(TLSN1-TLSN2)/2.
      DUM(6,6)=  -1.
      DUM(6,7)=  AKTL*12.
      DUM(7,1)=  -GX3
      DUM(7,2)=  -GZ3
      DUM(7,3)=((-SNLX+ALL*GX3)*GZ3-(SNLZ+ALL*GZ3)*GX3)/12.
      DUM(7,7)=  -1.
      CALL MASH(3,7)
      DO 1008 I=1,3
      DO 1008 J=1,3
 1008 FBOT(I,J)=DUM(I,J)
      DO 1009 I=1,3
      DO 1009 J=1,3
      SNUD(I,J)=0
 1009 SNU(I,J)= FTOP(I,J)+FBOT(I,J)
      RETURN
 1000 IF(KODE(10).EQ.0) GO TO 1002
C   TERMS FOR SNUBBED SNUBBER EFFECTS(LONG)
      CALL DRCSN(THETA)
      DO 1006 I=1,7
      DO 1006 J=1,7
 1006 DUM(I,J)=0
      DUM(1,3)= -2.*TUSNO*GZ1
      DUM(1,4)= -2.*TUSNO*SIN(THGX1)
      DUM(1,6)=  2.*GX1
      DUM(2,3)=  2.*TUSNO*GX1
      DUM(2,5)= -2.*TUSNO*SIN(THGZ1)
      DUM(2,6)=  2.*GZ1
      DUM(3,3)= (-SNUZ*DUM(1,3)+SNUX*DUM(2,3))/12.
      DUM(3,4)= -SNUZ*DUM(1,4)/12.
      DUM(3,5)=  SNUX*DUM(2,5)/12.
      DUM(3,6)= (-SNUZ*DUM(1,6)+SNUX*DUM(2,6))/12.
      DUM(4,1)=  (SIN(THGX1)/ALU)*12.
      DUM(4,2)= (-GZ1*COT(THGX1)/ALU)*12.
      DUM(4,3)= -SNUZ*SIN(THGX1)/ALU-SNUX*GZ1*COT(THGX1)/ALU
      DUM(4,4)=  -1.
      DUM(5,1)= (-GX1*COT(THGZ1)/ALU)*12.
      DUM(5,2)=  (SIN(THGZ1)/ALU)*12.
      DUM(5,3)=  SNUZ*GX1*COT(THGZ1)/ALU + SNUX*SIN(THGZ1)/ALU
      DUM(5,5)= -1.
      DUM(6,6)= -1.
      DUM(6,7)= AKSNU*12.
      DUM(7,1)= -GX1
      DUM(7,2)= -GZ1
      DUM(7,3)= ((-SNUX+ALU*GX1)*GZ1-(-SNUZ+ALU*GZ1)*GX1)/12.
      DUM(7,7)= -1.
      DO 10 I=1,3
      DO 10 J=1,3
   10 SNUD(I,J)=DUM(I,6)*ADSNU*DUM(7,J)*12.
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```
      CALL MASH(3,7)                                                    CAB02300
      DO 1007 I=1,3                                                     CAB02310
      DO 1007 J=1,3                                                     CAB02320
 1007 FTOP(I,J)=DUM(I,J)                                                CAB02330
      DUM(1,3)= -2.*TLSNO*GZ3                                           CAB02340
      DUM(1,4)= -2.*TLSNO*SIN(THGX3)                                    CAB02350
      DUM(1,6)=  2.*GX3                                                 CAB02360
      DUM(2,3)=  2.*TLSNO*GX3                                           CAB02370
      DUM(2,5)= -2.*TLSNO*SIN(THGZ3)                                    CAB02380
      DUM(2,6)=  2.*GZ3                                                 CAB02390
      DUM(3,3)=  (SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.                      CAB02400
      DUM(3,4)=  SNLZ*DUM(1,4)/12.                                      CAB02410
      DUM(3,5)=  SNLX*DUM(2,5)/12.                                      CAB02420
      DUM(3,6)=  (SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.                      CAB02430
      DUM(4,1)=  (SIN(THGX3)/ALL)*12.                                   CAB02440
      DUM(4,2) = (-GZ3*COT(THGX3)/ALL)*12.                              CAB02450
      DUM(4,3)=  SNLZ*SIN(THGX3)/ALL - SNLX*GZ3*COT(THGX3)/ALL          CAB02460
      DUM(4,4)=  -1.                                                    CAB02470
      DUM(5,1)=  (-GX3*COT(THGZ3)/ALL)*12.                              CAB02480
      DUM(5,2)=  (SIN(THGZ3)/ALL)*12.                                   CAB02490
      DUM(5,3)=  -SNLZ*GX3*COT(THGZ3)/ALL + SNLX*SIN(THGZ3)/ALL         CAB02500
      DUM(5,5)=  -1.                                                    CAB02510
      DUM(6,6)=  -1.                                                    CAB02520
      DUM(6,7)=  AKSN *12.                                              CAB02530
      DUM(7,1)=  -GX                                                    CAB02540
      DUM(7,2)=  -GZ                                                    CAB02550
      DUM(7,3)= ((-SNLX+ALL*GX3)*GZ3 -(SNLZ+ALL*GZ3)*GX3)/12.           CAB02560
      DUM(7,7)=  -1.                                                    CAB02570
      DO 20 I=1,3                                                       CAB02580
      DO 20 J=1,3                                                       CAB02590
   20 SNUD(I,J)=SNUD(I,J)+DUM(I,6)*AUSNL*DUM(7,J)*12.                   CAB02600
      CALL MASH(3,7)                                                    CAB02610
      DO 1010 I=1,3                                                     CAB02620
      DO 1010 J=1,3                                                     CAB02630
 1010 FBOT(I,J)=DUM(I,J)                                                CAB02640
      DO 1011 I=1,3                                                     CAB02650
      DO 1011 J=1,3                                                     CAB02660
 1011 SNU(I,J)= FTOP(I,J)+FBOT(I,J)                                     CAB02670
      RETURN                                                            CAB02680
 1002 DO 1003 I=1,3                                                     CAB02690
      DO 1003 J=1,3                                                     CAB02700
      SNUD(I,J)=0                                                       CAB02710
 1003 SNU(I,J)=0                                                        CAB02720
      RETURN                                                            CAB02730
      END                                                               CAB02740
      SUBROUTINE DECSN(THETA)                                           CAB00010
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL                        CAB00020
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)                CAB00030
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ), CAB00040
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),CAB00050
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),CAB00060
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),CAB00070
     4            (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),CAB00080
     5            (AERO(120),AKSNL),                                    CAB00090
     6            (AERO(76),WLCF),(AERO(77),STACF),(AERO(78),BLCF)      CAB00100
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      EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1),
     1            (SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2),
     2            (SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3),
     3            (SN(10), GX4),(SN(11), GY4),(SN(12), GZ4),
     4            (SN(13), THU),(SN(14), THL),(SN(15), ALU),
     5            (SN(16), ALL),
     6            (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7            (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8            (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9            (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
C  CALCULATION OF SNUBBER CABLE DIRECTION COSINES
      XB1= (STACR-SNUST)*COS(THETA)-(WLCR-SNUWL)*SIN(THETA)
      ZB1= (WLCR-SNUWL)*COS(THETA)+(STACR-SNUST)*SIN(THETA)
      XB2= XB1
      ZB2= ZB1
      XB3= (STACR-SNLST)*COS(THETA)-(WLCR-SNLWL)*SIN(THETA)
      ZB3= (WLCR-SNLWL)*COS(THETA)+(STACR-SNLST)*SIN(THETA)
      XB4= XB3
      ZB4=ZB3
      DX1= XB1+SNUX
      DY1= -SNUBL+SNUY
      DZ1= ZB1+SNUZ
      DX2= DX1
      DY2= SNUBL-SNUY
      DZ2= DZ1
      DX3= XB3+SNLX
      DY3= SNLBL-SNLY
      DZ3= ZB3-SNLZ
      DX4= DX3
      DY4= -SNLBL+SNLY
      DZ4= DZ3
      ALUSQ=  DX1**2 + DY1**2 + DZ1**2
      ALU = SQRT(ALUSQ)
      ALLSQ = DX3**2 + DY3**2 + DZ3**2
      ALL = SQRT(ALLSQ)
      GX1 = DX1/ALU
      GY1 = DY1/ALU
      GZ1 = DZ1/ALU
      GX2 = DX2/ALU
      GY2 = DY2/ALU
      GZ2 = DZ2/ALU
      GX3 = DX3/ALL
      GY3 = DY3/ALL
      GZ3 = DZ3/ALL
      GX4 = DX4/ALL
      GY4 = DY4/ALL
      GZ4 = DZ4/ALL
      DO 1 I=19,30
      J=I-18
    1 SN(I)=ARCOS(SN(J))
      RETURN
      END
      SUBROUTINE DECUSN(THETA)
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
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      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4            (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5            (AERO(120),AKSNL),
     6            (AERO(76),WLCP),(AERO(77),STACP),(AERO(78),BLCP)
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),
     1            (SN( 4),  GX2),(SN( 5),  GY2),(SN( 6),  GZ2),
     *            (SN( 7),  GX3),(SN( 8),  GY3),(SN( 9),  GZ3),
     3            (SN(10),  GX4),(SN(11),  GY4),(SN(12),  GZ4),
     4            (SN(13),  THU),(SN(14),  THL),(SN(15),  ALU),
     5            (SN(16),  ALL),
     6            (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7            (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8            (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9            (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
C    CALCULATION FOR EFFECTIVE DIRECTION COSINES FOR UNSNUBBED CASE
      AYL = SNLBL-(BLCP+SNLY)
      AZL =-SNLWL-(WLCP+SNLZ+SNLX*SIN(THETA))
      AYU = SNUBL-(BLCP+SNUY)
      AZU = SNUWL-(WLCP+SNUZ-SNUX*SIN(THETA))
      THU= ATAN(AZU/AYU)
      THL= ATAN(AZL/AYL)
      ALU=AYU/(SIN(THUSN)*COS(THU))
      GX1S= -COS(THUSN)
      GY1S= -AYU/ALU
      GZ1S= -AZU/ALU
      GX1 = GX1S*COS(THETA)-GZ1S*SIN(THETA)
      GY1 = GY1S
      GZ1 = GZ1S*COS(THETA)+GX1S*SIN(THETA)
      GX2 = GX1
      GY2 =-GY1
      GZ2 = GZ1
      ALL=AYL/(SIN(THLSN)*COS(THL))
      GX3S= -COS(THLSN)
      GY3S= AYL/ALL
      GZ3S= AZL/ALL
      GX3 = GX3S*COS(THETA)-GZ3S*SIN(THETA)
      GY3 = GY3S
      GZ3 = GZ3S*COS(THETA)+GX3S*SIN(THETA)
      GX4 = GX3
      GY4 =-GY3
      GZ4 = GZ3
      DO 1 I=19,30
      J=I-18
    1 SN(I)=ARCOS(SN(J))
      RETURN
      END
      SUBROUTINE RITE
      COMMON/INOU/ IW,IR
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
      IF(KODE(6).GT.1) GO TO 1
      WRITE(IW,100)
  100 FORMAT(25X,*FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL*)
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```
      GO TO 4
    1 IF(KODE(6).GT.2) GO TO 2
      WRITE(IW,200)
  200 FORMAT(25X,'FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL')
      GO TO 4
    2 IF(KODE(6).GT.3) GO TO 3
      WRITE(IW,300)
  300 FORMAT(25X,'BOTH CABLES VERTICAL')
      GO TO 4
    3 WRITE(IW,400)
  400 FORMAT(25X,'BOTH CABLES HORIZONTAL')
    4 CONTINUE
      IF(KODE(10).EQ.0) GO TO 5
      IF(KODE(10).EQ.1) GO TO 6
      WRITE(IW,500)
  500 FORMAT(25X,'SNUBBERS SNUBBED')
      GO TO 7
    5 WRITE(IW,600)
  600 FORMAT(25X,'NO SNUBBERS')
      GO TO 7
    6 WRITE(IW,700)
  700 FORMAT(25X,'SNUBBERS UNSNUBBED')
    7 CONTINUE
      IF(KODE(11).EQ.0) GO TO 8
      WRITE(IW,800)
  800 FORMAT(25X,'LIFT/ANTI-LIFT CABLE IN')
      GO TO 9
    8 WRITE(IW,900)
  900 FORMAT(25X,'NO LIFT/ANTI-LIFT CABLE')
    9 CONTINUE
      IF(KODE(13).LE.0.)WRITE(IW,1000)
      IF(KODE(13).GT.0.)WRITE(IW,1001)
      IF(KODE(13).EQ.-1.)WRITE(IW,1002)
 1000 FORMAT(25X,'FEEDBACK LOGIC NOT IN')
 1001 FORMAT(25X,'FEEDBACK LOGIC IN')
 1002 FORMAT(25X,'CABLELESS MODEL CHARACTERISTICS')
      RETURN
      END
      SUBROUTINE STINT(A1,A2,A3,MINTBL,MAXTBL,FCT,NG)
      EQUIVALENCE (X(1),NUMPTS(1))
      COMMON NUMPTS(1)
      DIMENSION X(1)
      I7=NUMPTS(1)/3
70    IF(MINTBL-MAXTBL)71,71,110
   71 DO 73 II=MINTBL,MAXTBL
      NJ=NUMPTS(II)+1
      IF(A3-X(NJ))72,74,73
   72 IF(II-MINTBL) 110,112,75
   73 CONTINUE
      GO TO 112
   75 IK = 1
      IL =2
      NM=NJ
  101 DO 97 II=IK,IL
      NJ =NUMPTS(II)+1
```

```
      NI = IZ+II
      IO =NUMPTS(NI)
      IP =IO+NJ
      DO 77 IQ=1,IO
      NN= NJ+IQ
      IF (A1-X(NN))76,78,77
   76 IF(IQ-1) 110,112,79
   77 CONTINUE
      GO TO 112
   78 IG =-1
      GO TO 80
   79 IG =+1
   80 NI=NI+IZ
      IB = NUMPTS(NI)
      DO 82 IA=1,IB
      NS=IP+IA
      IF (A2-X(NS))81,83,82
   81 IF(IA-1) 110,112,84
   82 CONTINUE
      GO TO 112
   83 IH =-1
      GO TO 85
   84 IH =+1
   85 NE=IP+IB+IQ+IO*IA-IO
      NR=NE-IO
      IF(IG+IH) 86,88,91
   86 IF (X(NE)-99998.5E9)87,113,113
   87 FCT = X(NE)
      GO TO 95
   88 IF(IG) 89,110,93
   89 IF(AMAX1(X(NE),X(NR))-99998.5E9)90,113,113
   90 FCT =X(NE)-(X(NS)-A2)*(X(NE)-X(NR))/(X(NS)-X(NS-1))
      GO TO 95
   91 IF(AMAX1(X(NE),X(NR),X(NE-1),X(NR-1))-99998.5E9)92,113,113
   92 FCT = ((X(NS)-A2)*((X(NN)-A1)*X(NR-1)-(X(NN-1)-A1)*X(NR)
     1)-(X(NS-1)-A2)*((X(NN)-A1)*X(NE-1)-(X(NN-1)-A1)*X(NE)))
     2/((X(NS)-X(NS-1))*(X(NN)-X(NN-1)))
      GO TO 95
   93 IF(AMAX1(  X(NE),  X(NE-1))-99998.5E9) 94,113,113
   94 FCT =   X(NE)-(  X(NN)-A1)*(  X(NE)-  X(NE-1))/(  X(NN)-  X(NN-1))
   95 GO TO (96,98,99),IF
   96 DUMSTG =FCT
   97 II =II-1
   98 FCT =DUMSTG-(  X(NM)-A3)*(DUMSTG-FCT)/(  X(NM)-  X(NJ))
   99 RETURN
   74 IK =3
      IL =3
      GO TO 101
  110 NG =2
      GO TO 99
  112 NG =3
      GO TO 99
  113 NG =4
      GO TO 99
      END
```

```
      SUBROUTINE TABIN(NUMTBL,NZ,NG)
      COMMON NUMPTS(1)
      COMMON/INOUT/IW,IR
      COMMON /TABOUT/ NIMTBL,ISEQ
      DIMENSION XUMPTS(1)
      INTEGER*2 LABEL(27)
      EQUIVALENCE (XUMPTS(1),NUMPTS(1)),(DUMMY(1),MUMMY)
      DIMENSION DUMMY(10)
      MCR=0
   10 IZ=IABS(NZ)
      NUNIT=5
      IF(NZ.LT.0) NUNIT=8
      NIMTBL = NUMTBL
      NG=0
      NUMPTS(1)=IZ+IZ+IZ
  102 READ(NUNIT,57) K, L1N, L2N, LABEL, ISEQ
      IF(MCR.EQ.0) GO TO 3
    4 WRITE(IW,1) K,L1N,L2N,LABEL,ISEQ
    1 FORMAT(3I5, 10X,27A2,I46)
   57 FORMAT(8XI4,2I2,27A2,I2)
    3 IF(ISEQ) 69,58,69
   58 IF(K) 99, 99, 59
   59 M = IZ + NIMTBL
      NUMPTS(M) = L1N
      M = M + IZ
      NUMPTS(M) = L2N
      IF(NUMTBL-NIMTBL)17,70,17
   17 NUMPTS(NIMTBL) = MUMMY
   70 N1 = (L1N-1) / 9 + 1
      DO 68 IS = 1,N1
      L3 = (IS-1) * 9 + 1
      IF (IS-N1) 60, 61, 60
   60 L4 = L3 + 8
      GO TO 62
   61 L4 = L1N
   62 L5 = NUMPTS(NIMTBL) + 1
      L6 = L5 + L3
      L7 = L5 + L4
      JJ = 0
      LM = L5 + L1N
      LN = LM + L2N
   63 READ(NUNIT,64) (DUMMY(K),K=1,10), ISEQ
   64 FORMAT (10E7.0,I2)
      IF(MCR.EQ.0) GO TO 5
    6 WRITE( IW,2)DUMMY,ISEQ
    2 FORMAT(10E12.4,I5)
    5 XUMPTS(L5)= DUMMY(1)
      K = 2
      DO 65 J = L6,L7
      XUMPTS(J) = DUMMY(K)
   65 K = K+1
      ISQQ=(IS-1)*(L2N+1)+JJ+1
      IF(ISEQ-ISQQ) 69,66,69
   66 L6 = LN + L3
      L7 = LN + L4
```

```
      LS = LM + 1 + JJ
      IF (JJ-L2N) 67, 68, 69
  67  JJ = JJ + 1
      LN = LN + L1N
      GO TO 63
  68  CONTINUE
 109  MUMMY = NUMPTS(NIMTBL) + (L1N+1) * (L2N+1)
 108  NIMTBL = NIMTBL + 1
      GO TO 102
  69  NG = 1
  99  RETURN
      END
      SUBROUTINE STINT1(A1,A2,A3,MINTBL,MAXTBL,FCT,NG)
      EQUIVALENCE (X(1),NUMPTS(1))
      COMMON/TAB1/NUMPTS(1)
      DIMENSION X(1)
      IZ=NUMPTS(1)/3
 70   IF(MINTBL-MAXTBL)71,71,110
   71 DO 73 II=MINTBL,MAXTBL
      NJ=NUMPTS(II)+1
      IF(A3-X(NJ))72,74,73
   72 IF(II-MINTBL) 110,112,75
   73 CONTINUE
      GO TO 112
   75 IK = 1
      IL =2
      NM=NJ
  101 DO 97 II=IK,IL
      NJ =NUMPTS(II)+1
      NI = IZ+II
      IO =NUMPTS(NI)
      IP =IO+NJ
      DO 77 IQ=1,IO
      NN= NJ+IQ
      IF (A1-X(NN))76,78,77
   76 IF(IQ-1) 110,112,79
   77 CONTINUE
      GO TO 112
   78 IG =-1
      GO TO 80
   79 IG =+1
   80 NI=NI+IZ
      IB = NUMPTS(NI)
      DO 82 IA=1,IB
      NS=IP+IA
      IF (A2-X(NS))81,83,82
   81 IF(IA-1) 110,112,84
   82 CONTINUE
      GO TO 112
   83 IH =-1
      GO TO 85
    4 IH =+1
      ... +IB+IQ+IO*IA-IO
         -IO
           IH) 86,88,91
```

```
   86 IF (X(NF)-99998.5E9)87,113,113
   87 FCT = X(NE)
      GO TO 95
   88 IF(IG) 89,110,93
   89 IF(AMAX1(X(NE),X(NR))-99998.5E9)90,113,113
   90 FCT =X(NE)-(X(NS)-A2)*(X(NE)-X(NF))/(X(NS)-X(NS-1))
      GO TO 95
   91 IF(AMAX1(X(NE),X(NF),X(NE-1),X(NR-1))-99998.5E9)92,113,113
   92 FCT = ((X(NS)-A2)*((X(NN)-A1)*X(NF-1)-(X(NN-1)-A1)*X(NF)
     1)-(X(NS-1)-A2)*((X(NN)-A1)*X(NE-1)-(X(NN-1)-A1)*X(NE)))
     2/((X(NS)-X(NS-1))*(X(NN)-X(NN-1)))
      GO TO 95
   93 IF(AMAX1(  X(NE),  X(NE-1))-99998.5E9) 94,113,113
   94 FCT =   X(NE)-(   X(NN)-A1)*(   X(NE)-   X(NE-1))/(   X(NN)-   X(NN-1))
   95 GO TO (96,98,99),IF
   96 DUMSTG =FCT
   97 II =II-1
   98 FCT =DUMSTG-(   X(NM)-A3)*(DUMSTG-FCT)/(   X(NM)-   X(NJ))
   99 RETURN
   74 IK =3
      IL =3
      GO TO 101
  110 NG =2
      GO TO 99
  112 NG =3
      GO TO 99
  113 NG =4
      GO TO 99
      END
      SUBROUTINE TABIN1(NUMTBL,NZ,NG)
      COMMON/INPUT/IW,IF
      COMMON/TAB1/NUMPTS(1)
      COMMON /TABOU1/ NIMTBL,ISOO
      DIMENSION XUMPTS(1)
      INTEGER*2 LABEL(27)
      EQUIVALENCE (XUMPTS(1),NUMPTS(1)),(DUMMY(1),MUMMY)
      DIMENSION DUMMY(10)
      MCR=0
   10 IZ=IABS(NZ)
      NUNIT=5
      IF(NZ.LT.0) NUNIT=8
      NIMTBL = NUMTBL
      NG=0
      NUMPTS(1)=IZ+IZ+IZ
  102 READ(NUNIT,57) K,   N, L2N, LABEL, ISEQ
      IF(MCR.EQ.0) GO TO 3
    4 WRITE(IW,1) K,LIN,L2N,LABEL,ISEQ
    1 FORMAT(3I5, 10X,27A2,I46)
   57 FORMAT(8XI4,2I2,27A2,I2)
    3 IF(ISEQ) 69,58,69
   58 IF(K) 99, 99, 59
   59 M = IZ + NIMTBL
      NUMPTS(M) = LIN
      M = M + IZ
      NUMPTS(M) = L2N
```

```
      IF(NUMTBL-NIMTBL)17,70,17
   17 NUMPTS(NIMTBL) = MUMMY
   70 N1 = (LIN-1) / 9 + 1
      DO 68 IS = 1,N1
      L3 = (IS-1) * 9 + 1
      IF (IS-N1) 60, 61, 60
   60 L4 = L3 + 8
      GO TO 62
   61 L4 = LIN
   62 L5 = NUMPTS(NIMTBL) + 1
      L6 = L5 + L3
      L7 = L5 + L4
      JJ = 0
      LM = L5 + LIN
      LN = LM + L2N
   63 READ(NUNIT,64) (DUMMY(K),K=1,10), ISEQ
   64 FORMAT (10E7.0,I2)
      IF(MCR.EQ.0) GO TO 5
    6 WRITE(IW,2)DUMMY,ISEQ
    2 FORMAT(10E12.4,I5)
    5 XUMPTS(L5)= DUMMY(1)
      K = 2
      DO 65 J = L6,L7
      XUMPTS(J) = DUMMY(K)
   65 K = K+1
      ISQQ=(IS-1)*(L2N+1)+JJ+1
      IF(ISEQ-ISQQ) 69,66,69
   66 L6 = LN + L3
      L7 = LN + L4
      L5 = LM + 1 + JJ
      IF (JJ-L2N) 67, 68, 69
   67 JJ = JJ + 1
      LN = LN + LIN
      GO TO 63
   68 CONTINUE
  109 MUMMY = NUMPTS(NIMTBL) + (LIN+1) * (L2N+1)
  108 NIMTBL = NIMTBL + 1
      GO TO 102
   69 NG = 1
   99 RETURN
      END
      SUBROUTINE FRICT(IDX)
      COMMON/LAT/AERO(175),AERDP(50),KODE(26)
      COMMON/ROUGH/FRIC(3,6)
      EQUIVALENCE (AERO(96),COU),(AERO(104),CMP)
      DO 1 I=1,3
      DO 1 J=1,6
    1 FRIC(I,J)=0.
      IF(CMP.EQ.0..AND.COU.EQ.0.)RETURN
      IND=KODE(6)
      IF(IDX.NE.0)GO TO 2
C  LONGITUDINAL PULLEY FRICTION COMPUTATION
      GO TO(10,11,12,13),IND
   10 CALL FRVT(1)
      RETURN
```

```
   11 CALL FRVT(3)
      RETURN
   12 CALL FRVT(1)
      CALL FRVT(3)
   13 RETURN
C  LATERAL DIRECTIONAL FRICTION COMPUTATION
    2 GO TO(20,21,22,23),IND
   20 CALL FRHZ(3)
      RETURN
   21 CALL FRHZ(1)
   22 RETURN
   23 CALL FRHZ(1)
      CALL FRHZ(3)
      RETURN
      END
      SUBROUTINE FRVT(IC)
C  COMPUTES THE FRICT. EFFECT OF THE VERT PULLEYS ON THE LONG. DYN.
      COMMON/DAT/AERO(175),AEROP(50),KODE(26)
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      COMMON/ROUGH/FRIC(3,6)
      EQUIVALENCE (AERO(90),RVF),(AERO(92),RVR),(AERO(96),COU),
     1(AERO(104),CMP)
      DIMENSION DT1(3),DT2(3)
      IF(IC.EQ.3)GO TO 1
      TENS=TF
      RAD=RVF/12.
      AVX=(ADC(2,1)-ADC(1,1))/2.
      CAX=COS(AVX)
      CAZ=SIN(AVX)
      GO TO 2
    1 TENS=TR
      RAD=RVR/12.
      AVX=3.14159+(ADC(4,1)-ADC(3,1))/2.
      CAX=COS(AVX)
      CAZ=SIN(AVX)
    2 ARMX=(ARM(IC,1)+ARM(IC+1,1))/24.
      ARMZ=(ARM(IC+1,3)-ARM(IC,3))/24.
      ENORX=TENS*COS(ADC(IC,1))
      ENORZ=TENS*(1.+COS(ADC(IC,3)))
      ENORM=SQRT(ENORX**2+ENORZ**2)
      CMPP=CMP/ENORM
      FACU=CMPP*ENORM/RAD**2
      ENORX=TENS*COS(ADC(IC+1,1))
      ENORZ=TENS*(1.+COS(ADC(IC+1,3)))
      ENORM=SQRT(ENORX**2+ENORZ**2)
      CMPP=CMP/ENORM
      FACL=CMPP*ENORM/RAD**2
      FACT=4.*COU/(3.14159*RAD**2)
      CALL DLGTH(CX,CZ,CT,IC,0)
      CALL DLGTH(CXP,CZP,CTP,IC+1,0)
      DT1(1)=FACT *(CXP-CX)
      DT1(2)=FACT *(CZP-CZ)
      DT1(3)=FACT *(CTP-CT)
      DT2(1)=FACL*CXP-FACU*CX
      DT2(2)=FACL*CZP-FACU*CZ
```

```
      DT2(3)=FACL*CTP-FACU*CT
      DO 3 I=1,3
      FRIC(1,I)=FRIC(1,I)+DT1(I)*CAX
      FRIC(1,I+3)=FRIC(1,I+3)+DT2(I)*CAX
      FRIC(2,I)=FRIC(2,I)+DT1(I)*CAZ
      FRIC(2,I+3)=FRIC(2,I+3)+DT2(I)*CAZ
      FRIC(3,I)=FRIC(3,I)+DT1(I)*RAD+DT1(I)*CAX*ARMZ-DT1(I)*CAZ*ARMX
      FRIC(3,I+3)=FRIC(3,I+3)+DT2(I)*RAD+DT2(I)*CAX*ARMZ-DT2(I)*CAZ*ARMX
    3 CONTINUE
      RETURN
      END
      SUBROUTINE FRHZ(IC)
C  COMPUTES THE FRICT. EFFECT OF THE HORZ PULLEYS ON THE LAT. DIR. DYN.
      COMMON/DAT/AERO(175),AEROP(50),KODE(26)
      COMMON/PLYCHA/STD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      COMMON/ROUGH/FRIC(3,6)
      EQUIVALENCE (AERO(91),RHF),(AERO(93),RHP),(AERO(96),COU),
     1(AERO(104),CMP)
      DIMENSION DT1(3),DT2(3)
      IF(IC.EQ.3)GO TO 1
      TENS=TF
      RAD=RHF/12.
      GO TO 2
    1 TENS=TF
      RAD=RHF/12.
    2 ENORX=TENS*COS(ADC(IC,1))
      ENORY=TENS*(1.+COS(ADC(IC,2)))
      ENORM=SQRT(ENORY*ENORY+ENORX*ENORX)
      CMPP=CMP/ENORM
      FACL=CMPP*ENORM/RAD**2
      FACT=4.*COU/(3.14159*RAD**2)
      CALL DLGTH(CY,CPSI,CPHI,IC,1)
      CALL DLGTH(CYP,CPSIP,CPHIP,IC+1,1)
      DT1(1)=FACT*(CY-CYP)
      DT1(2)=FACT*(CPSI-CPSIP)
      DT1(3)=FACT*(CPHI-CPHIP)
      DT2(1)=FACL*(CY-CYP)
      DT2(2)=FACL*(CPSI-CPSIP)
      DT2(3)=FACL*(CPHI-CPHIP)
      DO 3 I=1,3
      FRIC(1,I)=FRIC(1,I)+DT1(I)*COS(ADC(IC,2))
      FRIC(1,I+3)=FRIC(1,I+3)+DT2(I)*COS(ADC(IC,2))
      FRIC(2,I)=FRIC(2,I)+DT1(I)*RAD-DT1(I)*COS(ADC(IC,1))*ARM(IC,2)
     1/12.+DT1(I)*COS(ADC(IC,2))*ARM(IC,1)/12.
      FRIC(2,I+3)=FRIC(2,I+3)+DT2(I)*RAD-DT2(I)*COS(ADC(IC,1))*ARM(IC,2)
     1/12.+DT2(I)*COS(ADC(IC,2))*ARM(IC,1)/12.
      FRIC(3,I)=FRIC(3,I)+DT1(I)*RAD+DT1(I)*COS(ADC(IC,3))*ARM(IC,2)
     1/12.-ARM(IC,3)/12.*DT1(I)*COS(ADC(IC,2))
      FRIC(3,I+3)=FRIC(3,I+3)+DT2(I)*RAD+DT2(I)*COS(ADC(IC,3))*ARM(IC,2)
     1/12.-ARM(IC,3)/12.*DT2(I)*COS(ADC(IC,2))
    3 CONTINUE
      RETURN
      END
      SUBROUTINE MATRIX(CMAT,N,ROOTS,KAA,IER)
      COMMON/DAT/AERO(175),AEROP(50),KODE(26),LL
```

```
      COMMON/ERO/C4(30)
      DIMENSION CMAT(14,14,3),MAT(14,14),KOUNT(30),C5(30)
      COMPLEX AMAT(14,14),ROOTS(29)
      DOUBLE PRECISION BMAT(14,14,30),D(30,4)
      NP=-2
      IF(KODE(5).EQ.1) NP=1
      CALL MAPOL(CMAT,C4,ROOTS,K4A,14,NP,3,30,KOUNT,
     1 AMAT,BMAT,MAT,C5,D,N)
      RETURN
      END
      SUBROUTINE MAPOL(CMAT,C4,ROOTS,K4A,MCOL,NP,
     1    IN,  N,  KOUNT,  AMAT,  BMAT,  MAT,  C5,  D)
      COMMON/INOUT/IW,IR
      DIMENSION AMAT(MCOL,1), MAT(MCOL,1), BMAT(MCOL,MCOL,1)
     1          ,C4(1), ROOTS(1), KOUNT(1),CMAT(MCOL,MCOL,1)
     2          ,C5(1)
      DOUBLE PRECISION  BMAT, SA, F, D(N,1),DR
     *  ,  FBMAT
      COMPLEX  DET,FCMPLX, AMAT,   G,   YA1,   YA,   SCMPLX
      COMPLEX  G3, ROOTS,CR
   12  FORMAT (   2I3, 1P5D16.6/(D22.6,4D16.6))
   14 FORMAT(1H0,2(1PE24.6,E16.6))
   15 FORMAT(1H-,14X,4HREAL,11X,9HIMAGINARY,19X,5HERROR)
   22  FORMAT (   3I3, 1P5E16.6/(E25.6,4E16.6))
 2614  FORMAT (/1PE24.6,E16.6,E30.6)
      DATA CR/Z7FFFFFFFFFFFFFFF/
      NCOL=MCOL
   10 NROW=NCOL
      ENP=10.**NP
      INN=IN+1
       DO 107 I=1,NROW
       DO 107 J=1,NCOL
       MAT(I,J) = 0
      DO 112 K=INN,N
  112 BMAT(I,J,K)=0.D0
       DO 107  K=1,IN
      BMAT(I,J,K)=CMAT(I,J,K)
      IF(CMAT(I,J,K))108,107,108
  108   MAT(I,J) = K
C     THE NUMBER IN MAT IS ONE GREATER THAN THE DEGREE OF THE POLYNOMIAL
  107 CONTINUE
       JS= 1
      IF(NP.LT.0)GO TO 128
         ASSIGN 128 TO MZ
        GO TO 920
   99  ASSIGN 257 TO MZ
  920  WRITE(IW,23)
   23 FORMAT(55H0POSITION AND COEFFICIENTS OF EACH POLYNOMIAL OF MATRIX)
        DO 951 J9= 1,NCOL
        DO 951 I9= 1,NCOL
        K1 = MAT(I9,J9)
       IF(K1) 951,951,952
  952   WRITE(IW,12)I9,J9, (BMAT(I9,J9,K), K=1,K1)
  951   CONTINUE
      GO TO MZ, (139,257,128,1105)
```

```
C DET CONTAINS VALUE OF DETERMINANT OF BMAT WITH G=1
 1281   WRITE(IW,1282)DET
 1282   FORMAT ( 12H DETERMINANT1P2E16.7)
  128 NC = 0
C  COUNT NUMBER OF NON-ZERO ELEMENTS BELOW THE DIAGONAL IN COLUMN JS
      DO 120 I=JS,NROW
      IF (MAT(I,JS))99,120,121
  121 NC = NC +1
      IS = I
  120 CONTINUE
     IF(NC-1) 17,125,130
   17 WRITE(IW,16)
   16 FORMAT(' MATRIX IS SINGULAR')
     GO TO 257
  125 IF(IS-JS)99,1401,123
C     ONE INTER CHANGE TRIANGULARIZES THE COLUMN. .
  123 DO 126 J=JS,NCOL
      KI = MAX0(MAT(IS,J), MAT(JS,J))
      MA = MAT(IS,J)
      MAT(IS,J) = MAT(JS,J)
      MAT(JS,J) = MA
      DO 126 K= 1,KI
         SA  = BMAT(IS,J,K)
      BMAT(IS,J,K) = BMAT(JS,J,K)
  126 BMAT(JS,J,K) =-SA
      GO TO 1401
  130 IS = JS+1
C LOOP 137 REDUCES ALL ELEMENTS BELOW DIAGONAL IN COLUMN JS BY
C AT LEAST ONE DEGREE
     I=IS
  139 IF(MAT(I,JS))99,137,129
  129 IF (MAT(JS,JS)) 99,133,132
  132 IF (MAT(I,JS) - MAT(JS,JS)) 133,134,134
  133 DO 131 J= JS,NCOL
      KI= MAX0(MAT(JS,J), MAT(I,J))
      MA = MAT(JS,J)
      MAT(JS,J) = MAT(I,J)
      MAT(I,J) =  MA
      DO 131 K= 1,KI
      SA = BMAT(I,J,K)
      BMAT(I,J,K) = BMAT(JS,J,K)
  131 BMAT(JS,J,K) =-SA
      GO TO 139
  134 KI = MAT(I,JS)
      KJS = MAT(JS,JS)
      KD  = KI - KJS
      F = BMAT(I,JS,KI)/ BMAT(JS,JS,KJS)
      IF(DABS(F)- 4.0) 1052,1051,1051
 1051 IF(KD) 99,133,1052
 1052 DO 235 J=JS,NCOL
      KJS = MAT(JS,J)
     IF(KJS.EQ.0) GO TO 235
      DO 135 K=  1 ,KJS
      KI = K + KD
     FBMAT=F*BMAT(JS,J,K)
```

```
      IF(KI-N) 141,141,2
    2 WRITE(IW,3)
    3 FORMAT(79H0DEGREE OF POLYNOMIAL FORMED WHILE TRIANGULARIZING ORIGI
     1NAL MATRIX IS TOO HIGH   )
      GO TO 257
  141 IF ( DABS ( FBMAT - BMAT(I,J,KI) ) .LE. 2.D-6 * DABS ( FBMAT ) )
     1    GO TO 136
      BMAT(I,J,KI)= BMAT(I,J,KI)- FBMAT
      GO TO 135
  136  BMAT(I,J,KI) = 0.D0
  135  CONTINUE
  235 CONTINUE
C                                                               DRONTS LL
      J=JS
  142 CONTINUE
      KI=MAT(JS,J)+KD
      KJ=MAT(I,J)
      IF(KI.LT.KJ) KI=KJ
       MAT(I,J) = 0
       DO 140 K=1,KI
      IF(BMAT(I,J,K))138,140,138
  138  MAT(I,J) = K
  140  CONTINUE
      J=J+1
      IF (J.LE.NCOL) GO TO 142
  137 I=I+1
      IF(I.LE.NROW) GO TO 139
      IF(NP) 128,128,1105
 1401  JS = JS +1
       IF( JS-NCOL)128,150,150
  150 IF(NP.LT.0)GO TO 153
      WRITE(IW,13)
   13  FORMAT ( 1H ,20(1H ),13H FINAL MATRIX)
       DO 151 J=1,NCOL
       DO 151 I=1,NROW
       K1 = MAT(I,J)
       IF(K1) 99,151,152
  152  WRITE(IW,12)I, J, (BMAT(I,J,K), K=1,K1)
  151  CONTINUE
  153 LK=1
C LOOP 160-ROOTS OF POLYNOMIALS ON DIAGONAL OF TRIANGULARIZED MATRIX ARE
C          FOUND AND STORED IN ARRAY ROOTS.
C          COEFFICIENTS OF THE POLYNOMIAL EQUIVALENT OF THE DETERMINANT
C          OF THE MATRIX ARE COMPUTED AND STORED IN ARRAY C4 WITH
C          C4(1) THE CONSTANT TERM.
       DO 160 J=1,NCOL
       K1 = MAT(J,J)
      MMM=K1+1
      K2=K1-1
        DO 163 K=1,K1
      MM=MMM-K
  163 D(MM,4)= BMAT(J,J,K)
      IF(K1.EQ.1) GO TO 1020
  161 CALL POLYRT(D(1,4),ROOTS(2*LK-1),KOUNT(LK),K2,D(1,1),D(1,2),D(1,3)
     1)
```

```
      KM1=K1/2
      LK=LK+KM1
      IF(MOD(K1,2).NE.0)GO TO 1020
C DUMMY ELEMENT STORED IN ARRAY ROOTS IF POLYNOMIAL IS OF ODD DEGREE
   54 ROOTS(2*LK-2)=0.
 1020 IF(J.EQ.1)GO TO 1004
 1001    DO 1002 K= 1,K4A
 1002    C5(K) = C4(K)
         DO 1006 K= 1,N
 1006      C4(K) = 0.0
           IF(K1) 99,160,1000
 1000      DO 1003  K=1,K1
      MM=MM+1
           DO 1003  K3=1,K4A
        K4 = K+K3-1
 1003 C4(K4) = C4(K4) + D(MM,4)*C5(K3)
         K4A = K4
        GO TO 160
 1004    DO 1005  K= 1,K1
      MM=MMM-K
 1005 C4(K) = D(MM,4)
        K4A = K1
  160   CONTINUE
      CALL JUGGLE(ROOTS,ROOTS,KOUNT,K4A)
        DO 306 I=1,NROW
        DO 306 J=1,NCOL
      MAT(I,J)=IN
      DO 306 K=1,IN
  306 BMAT(I,J,K)=CMAT(I,J,K)
      IF(NP.LT.-1)GO TO 202
  201  WRITE(IW,15)
  202 IF(LK.EQ.1) GO TO 1110
 1111 L=1
   62 G=ROOTS(L)
   64  ASSIGN 244 TO MDT
         GO TO 2511
  244 G1=ABS(C4(1))
C LOOP 2610 - PLACE LARGEST PRODUCT,C4(I)*G**(I-1), IN G1
C G3= ERROR ESTIMATE      G=ROOT
        DO 2610 L9=2,K4A
      G2=CABS(G)
        G2=ABS(C4(L9)*G2**(L9-1))
      IF(G1-G2)2611,2610,2610
 2611 G1=G2
 2610  CONTINUE
C DET CONTAINS VALUE OF POLYNOMIAL EQUIVALENT OF DETERMINANT OF
C MATRIX AT ROOT
      IF(G1.EQ.0.)GO TO 25
      G3=DET/G1
      GO TO 26
   25 G3=(0.,0.)
   26 IF(CABS(G3).LE.END.AND.NP.LT.-1) GO TO 255
      WRITE(IW,27)
   27 FORMAT(5X,'THE FOLLOWING EXTRACTED ROOT HAVE POOR ACCURACY')
      WRITE(IW,15)
```

C-2

```
      WRITE(IW,14) G,G3
  256 L=L+1
      IF(K4A-1.GE.L)GO TO 62
      IF(NP.LT.-1) GO TO 257
 1110 WRITE(IW,1010)(C4(K),K=1,K4A)
 1010     FORMAT (11HOPOLYNOMIAL1P5E16.6/(E27.6,4E16.6))
  257 RETURN
 1105 ASSIGN 1281 TO MDT
      G=(1.,0.)
C     LOOP 210
C EVALUATE EACH POLYNOMIAL OF THE ORIGINAL MATRIX FOR ROOT G
C AND STORE IN AMAT ARRAY
 2511 DO 210 I = 1,NROW
       DO 210 J=1,NCOL
       K = MAT(I,J)
      YA=(0.,0.)
        IF(K-1)  210,205,227
  227 YA=CMPLX(SNGL(BMAT(I,J,K)),0.)
          K = K-1
  205 YA1=CMPLX(SNGL(BMAT(I,J,K)),0.)
      YA=YA1+YA*G
       K = K-1
       IF(K) 99,210,205
  210 AMAT(I,J)=YA
      JJ=1
  225  DO 213J=JJ,NCOL
      IF(CABS(AMAT(JJ,J))) 220,213,220
  213  CONTINUE
      DET = (0.,0.)
      GO TO 229
  220  IF(J-JJ)99,230,221
  221  DO 222 I= 1,NROW
      SCMPLX = AMAT(I,J)
      AMAT(I,J)=AMAT(I,JJ)
  222 AMAT(I,JJ)=-SCMPLX
  230  JS1 = JJ + 1
       DO 224 I=JS1,NROW
      FCMPLX=AMAT(I,JJ)/AMAT(JJ,JJ)
      IF(CABS(FCMPLX)) 226,224,226
  226  DO 223 J=JJ,NCOL
  223 AMAT(I,J)=AMAT(I,J)-AMAT(JJ,J)*FCMPLX
  224      CONTINUE
      JJ=JJ+1
      IF(JJ.LT.NCOL) GO TO 225
      DET=(1.,0.)
       DO 242 J=1,NCOL
  242 DET=DET*AMAT(J,J)
  229 GO TO MDT, (1281,244,256)
      ENTRY  MAPDY    (CMAT  ,C4     ,ROOTS ,K4A    ,MCOL  ,NP,
     1,  IN,  N,  KOUNT,  AMAT,  BMAT,  MAT,  C5,  D ,MCO)
      NCOL=MCO
      GO TO 10
      END
      SUBROUTINE JUGGLE(ROOTS,RT,KOUNT,K4A)
      DOUBLE PRECISION ROOTS(1)
```

```
      COMPLEX RT(1)
      REAL*8 CR
      DATA CR/Z7FFFFFFFFFFFFFFF/
      DIMENSION KOUNT(1)
      K=1
      I=1
    1 IF(KOUNT(I).GE.0)GO TO 3
      RT(K) = CMPLX(SNGL(ROOTS(2*I-1)),SNGL(ROOTS(2*I)))
      RT(K+1)=CONJG(RT(K))
      K=K+2
      GO TO 5
    3 RT(K)=CMPLX(SNGL(ROOTS(2*I-1)),0.)
      K=K+1
      IF(ROOTS(2*I).EQ.CR )GO TO 5
      RT(K)=CMPLX(SNGL(ROOTS(2*I)),0.)
      K=K+1
    5 I=I+1
      IF(K.GE.K4A )RETURN
      GO TO 1
      END
      SUBROUTINE POLYRT(AO,ROOT,KOUNT,MM,Q,A,T)
      DIMENSION KOUNT( 3)
      DOUBLE PRECISION AO(5),ROOT(5),Q(5),T(3),A(5)
      DOUBLE PRECISION B1(1),B2(1),X,Y,D1
      DOUBLE PRECISION  D2      , DABS    , TOL     , S1      , S2
      COMMON /BARK/ D1,D2,X,NIX
      M = MM
   90 IF (AO(M+1)) 100,95,100
   95 ROOT(M) = 0.D0
      KOUNT((M+1)/2) = 0
      M = M - 1
      GO TO 90
  100 TOL = 1.D5
      IF (M - 1) 460,103,106
  103 ROOT(1) = -AO(2) /AO(1)
      KOUNT(1) = 0
      GO TO 460
  106 KODE = -1
      N = M
      N1 = N + 1
      K = 0
      DO 110  I = 1,N1
  110 A(I) = AO(I)
      IF(A(N-1))115,112,115
  112 B1(1)= 1.D-5
      B2(1)= 1.D-8
      GO TO 120
  115 B2(1)=-A(N+1)/A(N-1)
      B1(1)= -B2(1)* (A(N-2)/A(N-1))  -  A(N)/A(N-1)
  120 IF (N - 2) 121,122,130
  121 KOUNT(K+1) = 0
      A(2) =-A(2) / A(1)
      GO TO 310
  122 KOUNT(K+1) = 0
      A(2) =-A(2) / A(1)
```

```
      A(3) =-A(3) / A(1)
      GO TO 310
  130 CALL GROWL(T(N-2),Q(N  ))
      ITER8 = 0
      KEY = 30
      INK = 15
      MURDER=20
      LOVE = 4
  220 ITER8 = ITER8 + 1
  230 Q(1) = A(1)
      Q(2) = A(2)  +  B1(1)* Q(1)
      DO 240  J = 3,N1
  240 Q(J) = A(J)  +  B1(1)* Q(J-1)  +  B2(1)* Q(J-2)
      T(1) = Q(1)
      T(2) = Q(2)  +  B1(1)* T(1)
      DO 250  J = 5,N1
  250 T(J-2) = Q(J-2)  +  B1(1)* T(J-3)  +  B2(1)* T(J-4)
      X= B1(1)* T(N-1)  +  B2(1)* T(N-2)
      CALL RUFF (T,Q)
      B1(1)= B1(1)+ D1
      B2(1)= B2(1)+ D2
      IF (KODE) 260,260,280
  260 IF (TOL* DABS(D1)  -  DABS(B1(1))) 261,261,270
  261 IF (TOL* DABS(D2)  -  DABS(B2(1))) 262,262,270
  262 IF (KODE) 265,263,460
  263 KODE = 1
  264 S1 = DABS(D1)
      S2 = DABS(D2)
      GO TO 220
  265 LOVE = LOVE - 1
      IF (LOVE) 220,290,220
  270 IF (ITER8 - KEY) 220,271,271
  271 MURDER = MURDER - 1
      IF (MURDER) 409,285,272
  272 KEY = KEY + INK
      B2(1)=-B2(1)-.5D0*(B1(1)**2)
      GO TO 220
  280 IF (4.D0* DABS(D1)  -  S1) 281,410,410
  281 IF (4.D0* DABS(D2)  -  S2) 264,410,410
  285 ITER8 = 999
  290 K = K + 1
      KOUNT(K) = ITER8  +  10
      A(N) = B1(1)
      A(N1) = B2(1)
      N = N - 2
      N1 = N1 - 2
      DO 300  I = 1,N1
  300 A(I) = Q(I)
      IF(DABS(B1(1)).LT..1D0*DSQRT(DABS(B2(1))))
     1B1(1)=.1D0*DSQRT(DABS(B2(1)))
      GO TO 120
  310 DO 320  I = 1,M
      X = A0(I+1)
      A0(I+1) = A(I+1)
  320 A(I+1) = X
```

```
      NORDER = -1                                             CBL03880
      N = M                                                   CBL03890
      N1 = N + 1                                              CBL03900
      L = N                                                   CBL03910
      K = 0                                                   CBL03920
      CALL GROWL(T(N-2),Q(N))                                 CBL03930
  330 IF (L - 1) 440,340,400                                  CBL03940
  340 ITER8 = 0                                               CBL03950
      Q(1) = A(1)                                             CBL03960
      B1(1)= A0(2)                                            CBL03970
  350 ITER8 = ITER8 + 1                                       CBL03980
      DO 360  J = 2,N1                                        CBL03990
  360 Q(J) = A(J)   +  B1(1)* Q(J-1)                          CBL04000
      T(1) = Q(1)                                             CBL04010
      DO 370  J = 3,N1                                        CBL04020
  370 T(J-1) = Q(J-1)   +  B1(1)* T(J-2)                      CBL04030
      D1 = Q(N1) / T(N)                                       CBL04040
      B1(1)= B1(1)+ D1                                        CBL04050
      IF (DABS(B1(1))  -  TOL* DABS(D1)) 380,390,390          CBL04060
  380 IF (ITER8 - 8) 350,385,350                              CBL04070
  385 ITER8 = 9                                               CBL04080
  390 KOUNT(K+1) = ITER8                                      CBL04090
      A0(2) = B1(1)                                           CBL04100
      GO TO 440                                               CBL04110
  400 K = K + 1                                               CBL04120
      KODE = 0                                                CBL04130
      B1(1)= A0(L)                                            CBL04140
      B2(1)= A0(L+1)                                          CBL04150
      ITER8 = KOUNT(K)                                        CBL04160
      KEY = ITER8 + 8                                         CBL04170
      IF (M - 2) 220,409,220                                  CBL04180
  409 ITER8 = ITER8 + 1                                       CBL04190
  410 X= B1(1)**2  +  4.D0* B2(1)                             CBL04200
      IF (X) 420,430,430                                      CBL04210
  420 A0(L) = .5D0* DSQRT(-X)                                 CBL04220
      A0(L+1) = .5D0* B1(1)                                   CBL04230
      KOUNT(K) = -ITER8                                       CBL04240
      L = L - 2                                               CBL04250
      GO TO 330                                               CBL04260
  430 X = DSQRT(X)                                            CBL04270
      IF (B1(1)) 432,431,431                                  CBL04280
  432 X = -X                                                  CBL04290
  431 A0(L) = .5D0* (B1(1)+ X)                                CBL04300
      A0(L+1) = -B2(1)/ A0(L)                                 CBL04310
  433 KOUNT(K) = ITER8                                        CBL04320
      L = L - 2                                               CBL04330
      GO TO 330                                               CBL04340
  440 J = N1                                                  CBL04350
      DO 450  I = 1,N                                         CBL04360
      ROOT(I) = A0(J)                                         CBL04370
      A0(J) = A(J)                                            CBL04380
  450 J = J - 1                                               CBL04390
  460 RETURN                                                  CBL04400
       END                                                    CBL04410
      SUBROUTINE GROWL(A,Y)                                   CBL04420
```

```
      DOUBLE PRECISION A(2),B,X(2),Y(2),T                               CBL04430
      COMMON /BARK/ X,B,NIX                                             CBL04440
      RETURN                                                            CBL04450
      ENTRY RUFF                                                        CBL04460
      NIX = 0                                                           CBL04470
      IF (ABS(SNGL(B)) - ABS(SNGL(A(2)))) 100,120,110                   CBL04480
  100 T = B / A(2)                                                      CBL04490
      X(2) = (T*Y(1) - Y(2)) / (A(2) - T*A(1))                          CBL04500
      X(1) =-(A(1)*X(2) + Y(1)) / A(2)                                  CBL04510
      RETURN                                                            CBL04520
  110 T = A(2) / B                                                      CBL04530
      X(2) = (T*Y(2) - Y(1)) / (A(1) - T*A(2))                          CBL04540
      X(1) = -(A(2)*X(2) + Y(2)) / B                                    CBL04550
      RETURN                                                            CBL04560
  120 IF (SNGL(B)) 110,130,110                                          CBL04570
  130 NIX = 1                                                           CBL04580
      RETURN                                                            CBL04590
      END                                                               CBL04600
                                                                        CBL04610
                                                                        CBL04620
```

Appendix D

Sample Input

```
  SAMPLE INPUT FOR ACTIVE CABLE PROG-BASIC LONG CHAR. W COMP PRT OUT
  1 -1  0  0  1  2  0  4  3  0  0  0  1
0.          0.          0.          0.          5.80        -1.86
0.          10.95       -14.68      .0500       .0824       .033
0.          .935        -1.630      0.          0.          -7.77
-1.062      -.1109      .1227       -.0341      -.1863      .0231
.3780       .0824       -.1132      .1923       .0091       -.0681
.2380       -.1162      -.0714      .0005       -.0005      -.0001
1.1         0.          4.          0.          .865        446.
4.72        .000805     152.0       9.16        1.4         11.5
-.8         3.60        21.4        22.95
0.          0.          96.         -96.        -5.         -5.
75.0        263.        96.         0.          -5.         185.
0.          0.          6.          27.8        0.          0.
0.          .9          .9          4.0         0.
.01         .00         .01         .00         100.0       40.
0.          181.        96.         152.        6.667
4.          -5.8        0.          2.          3.          2.
2.          3.          2.          180.        96.         72.
180.        -96.        72.         80.         80.         50.
50.         5.          50.         0.          0.          0.
0.          0.          0.          0.
13.8        1.53        .2374       7.0         .022        3.0
.00         00.         3.          0.00        0.          0.
0.          0.          .0          0.0         0.000       0.
0.          0.          0.          0.          0.          0.
0.          0.          0.          0.          0.          0.
  SAMPLE DATA-LONG CHAR OF THETA/EMO TRANS FUNC W FEEDBACK & FREQ RESP.
  1 -1  2  0  0  2  0 10  3  0  0  0  1 11  2  0  0 -1 60
137 7.5
138 -100.
140 -100.

  SAMPLE INPUT OF VEL=0. W LIFT CABLE -CHAR. ROOTS OPTION
  1 -1  0  0  0  2  0  9  3  0  1  0  1  0  8  0  0
  48 0.
  49 0.

  SAMPLE INPUT FOR CABLELESS MODEL W TRANSFER FUNCTION OPTION
  1  1  0  0  0  2  0  3 10  0  0  0 -1 15  3
  48 .865
  49 446.

  SAMPLE OF ACTIVE CABLE SYSTEM-LAT DIR MODE W TRANS. FUNC. OP.
  1  0  0  0  0  2  0 10 10  0  0  0  1       11  2
```

Appendix E

Sample Output

```
CASE NO= 1          SAMPLE INPUT FOR ACTIVE CABLE PROG-BASIC LONG CHAR. W COMP PRT OUT
                      FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL
                      NO SNUBBERS
                      NO LIFT/ANTI-LIFT CABLE
                      FEEDBACK LOGIC IN

CODE NOS. FOR THIS CASE.
  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24
  1  -1   0   0   1   2   0   4   3   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0
   INPUT DATA AS SPECIFIED IN AERO ARRAY
 AERO(  1)= 0.0          AERO(  2)= 0.0          AERO(  3)= 0.0          AERO(  4)= 0.0          AERO(  5)=  5.80
 AERO(  6)= -1.86        AERO(  7)= 0.0          AERO(  8)=  10.9        AERO(  9)= -14.7        AERO( 10)= 0.500E-01
 AERO( 11)= 0.924E-01    AERO( 12)= 0.330E-01    AERO( 13)= 0.0          AERO( 14)= 0.935        AERO( 15)= -1.63
 AERO( 16)= 0.0          AERO( 17)= 0.0          AERO( 18)= -7.77        AERO( 19)= -1.06        AERO( 20)=-0.111
 AERO( 21)= 0.123        AERO( 22)=-0.341E-01    AERO( 23)=-0.186        AERO( 24)= 0.231E-01    AERO( 25)= 0.378
 AERO( 26)= 0.924E-01    AERO( 27)=-0.113        AERO( 28)= 0.192        AERO( 29)= 0.910E-02    AERO( 30)=-0.681E-01
 AERO( 31)= 0.238        AERO( 32)=-0.116        AERO( 33)=-0.714E-01    AERO( 34)= 0.500E-03    AERO( 35)=-0.500E-03
 AERO( 36)=-0.100E-03    AERO( 37)= 0.0          AERO( 38)= 0.0          AERO( 39)= 0.0          AERO( 40)= 0.0
 AERO( 41)= 0.0          AERO( 42)= 0.0          AERO( 43)= 0.0          AERO( 44)=  1.10        AERO( 45)= 0.0
 AERO( 46)=  4.00        AERO( 47)= 0.0          AERO( 48)= 0.865        AERO( 49)=  446.        AERO( 50)=  4.72
 AERO( 51)= 0.905E-03    AERO( 52)=  152.        AERO( 53)=  9.16        AERO( 54)=  1.40        AERO( 55)=  11.5
 AERO( 56)=-0.900        AERO( 57)=  3.60        AERO( 58)=  21.4        AERO( 59)=  22.9        AERO( 60)= 0.0
 AERO( 61)= 0.0          AERO( 62)= 0.0          AERO( 63)= 0.0          AERO( 64)= 0.0          AERO( 65)= 0.0
 AERO( 66)= 0.0          AERO( 67)= 0.0          AERO( 68)=  96.0        AERO( 69)= -96.0        AERO( 70)= -5.00
 AERO( 71)= -5.00        AERO( 72)=  75.0        AERO( 73)=  263.        AERO( 74)=  96.0        AERO( 75)= 0.0
 AERO( 76)= -5.00        AERO( 77)=  185.        AERO( 78)= 0.0          AERO( 79)= 0.0          AERO( 80)=  6.00
 AERO( 81)=  27.8        AERO( 82)= 0.0          AERO( 83)= 0.0          AERO( 84)= 0.0          AERO( 85)= 0.900
 AERO( 86)= 0.900        AERO( 87)=  4.00        AERO( 88)= 0.0          AERO( 89)= 0.0          AERO( 90)= 0.100E-01
 AERO( 91)= 0.0          AERO( 92)= 0.100E-01    AERO( 93)= 0.0          AERO( 94)=  100.        AERO( 95)=  40.0
 AERO( 96)= 0.0          AERO( 97)=  181.        AERO( 98)=  96.0        AERO( 99)=  152.        AERO(100)=  6.67
 AERO(101)= 0.0          AERO(102)=  4.00        AERO(103)= -5.80        AERO(104)= 0.0          AERO(105)=  2.00
 AERO(106)=  3.00        AERO(107)=  2.00        AERO(108)=  2.00        AERO(109)=  3.00        AERO(110)=  2.00
 AERO(111)=  180.        AERO(112)=  96.0        AERO(113)=  72.0        AERO(114)=  180.        AERO(115)= -96.0
 AERO(116)=  72.0        AERO(117)=  80.0        AERO(118)=  80.0        AERO(119)=  50.0        AERO(120)=  50.0
 AERO(121)=  5.00        AERO(122)=  50.0        AERO(123)= 0.0          AERO(124)= 0.0          AERO(125)= 0.0
 AERO(126)= 0.0          AERO(127)= 0.0          AERO(128)= 0.0          AERO(129)= 0.0          AERO(130)= 0.0
 AERO(131)=  13.8        AERO(132)=  1.53        AERO(133)= 0.237        AERO(134)=  7.00        AERO(135)= 0.220E-01
 AERO(136)=  3.00        AERO(137)= 0.0          AERO(138)= 0.0          AERO(139)=  3.00        AERO(140)= 0.0
 AERO(141)= 0.0          AERO(142)= 0.0          AERO(143)= 0.0          AERO(144)= 0.0          AERO(145)= 0.0
 AERO(146)= 0.0          AERO(147)= 0.0          AERO(148)= 0.0          AERO(149)= 0.0          AERO(150)= 0.0
 AERO(151)= 0.0          AERO(152)= 0.0          AERO(153)= 0.0          AERO(154)= 0.0          AERO(155)= 0.0
 AERO(156)= 0.0          AERO(157)= 0.0          AERO(158)= 0.0          AERO(159)= 0.0          AERO(160)= 0.0
   AERO DATA IN STAB. AXIS AT EQUAT. REF. CENTER
 AERO(  1)= 0.0          AERO(  2)= 0.0          AERO(  3)= 0.0          AERO(  4)= 0.0          AERO(  5)=  5.80
 AERO(  6)= -1.48        AERO(  7)= 0.0          AERO(  8)=  10.2        AERO(  9)= -13.8        AERO( 10)= 0.500E-01
 AERO( 11)= 0.924E-01    AERO( 12)= 0.394E-01    AERO( 13)= 0.0          AERO( 14)= 0.935        AERO( 15)= -1.57
 AERO( 16)= 0.0          AERO( 17)= 0.0          AERO( 18)= -7.77        AERO( 19)= -1.06        AERO( 20)=-0.111
 AERO( 21)= 0.112        AERO( 22)=-0.341E-01    AERO( 23)=-0.186        AERO( 24)= 0.228E-01    AERO( 25)= 0.357
 AERO( 26)= 0.813E-01    AERO( 27)=-0.107        AERO( 28)= 0.192        AERO( 29)= 0.910E-02    AERO( 30)=-0.682E-01
 AERO( 31)= 0.239        AERO( 32)=-0.116        AERO( 33)=-0.690E-01    AERO( 34)= 0.500E-03    AERO( 35)=-0.500E-03
 AERO( 36)=-0.950E-04    AERO(
CABLE CONFIGURATION ON MODEL
FRONT CABLE IS HORIZNTL AND REAR CABLE IS VERTICAL
CABLE GEOMETRY-CABLE NO. 1      CABLE LENGTH=   0.123377E 03 IN
    DIR. COS.=DEG    ARM-IN
     0.492327E 02    0.278000E 02
     0.417822E 02    0.400000E 01
     0.890904E 02    0.0

CABLE GEOMETRY-CABLE NO. 2      CABLE LENGTH=   0.123377E 03 IN
    DIR. COS.=DEG    ARM-IN
```

```
   -0.482327E 02   0.278000E 02
    0.139218E 03  -0.400000E 01
    0.893804E 02   0.0

CABLE GEOMETRY-CABLE NO. 3      CABLE LENGTH=   0.123383E 03 IN
    DIR. COS.=DEG    ARM-IN
     0.233272E 03  -0.600801E 01
    -0.899999E 02   0.0
    -0.143272E 03  -0.905980E 00

CABLE GEOMETRY-CABLE NO. 4      CABLE LENGTH=   0.115261E 03 IN
    DIR. COS.=DEG    ARM-IN
     0.129705E 03  -0.600769E 01
    -0.899999E 02   0.0
    -0.397053E 02   0.906388E 00

ITERATION PARAMETER =     4
 ACCZ  -  .-3954200E-03
 ACCX  - .97968825E-03
 THEDOT=-0.24915906E-03 RAD/SEC

EH. ATT..DEFLTN.& CABLE TENSION
 THETA =  1.03 DEG
 DELTA = -1.37 DEG
 FRT CAB. TENSION=    0.127591E 03 LBS
 RR CAB. TENSION =    0.100214E 03 LBS
   AERO DATA IN BODY AXIS AT EQUAT. REF. CENTER
 AEROP(  1)=-0.985E-01  AEROP(  2)=-0.270       AEROP(  3)= 0.266E-01  AEROP(  4)= 0.290       AEROP(  5)= -5.85
 AEROP(  6)= -1.48      AEROP(  7)= 0.183       AEROP(  8)= -10.2      AEROP(  9)= -13.8       AEROP( 10)=-0.515E-01
 AEROP( 11)=-0.815E-01  AEROP( 12)= 0.384E-01   AEROP( 13)= 0.168E-01  AEROP( 14)=-0.935       AEROP( 15)= -1.57
 AEROP( 16)= 0.0        AEROP( 17)= 0.0         AEROP( 18)= -7.77      AEROP( 19)= -1.06       AEROP( 20)=-0.113
 AEROP( 21)= 0.110      AEROP( 22)=-0.405E-01   AEROP( 23)=-0.188      AEROP( 24)= 0.213E-01   AEROP( 25)= 0.356
 AEROP( 26)= 0.778E-01  AEROP( 27)=-0.105       AEROP( 28)= 0.192      AEROP( 29)= 0.103E-01   AEROP( 30)=-0.660E-01
 AEROP( 31)= 0.238      AEROP( 32)=-0.115       AEROP( 33)=-0.711E-01  AEROP( 34)= 0.500E-03   AEROP( 35)=-0.498E-03
 AEROP( 36)=-0.104E-03  AEROP(
 **** LONGITUDINAL STABILITY ****

POSITION AND COEFFICIENTS OF EACH POLYNOMIAL OF MATRIX
 1  1     1.8941760 01    -5.9931590-01
 2  1     3.3059370 01     1.2073010 01    4.7199990 00
 3  1    -5.2585630 01     4.2774080 00   -1.5380850 00
 4  1     2.4095160-02
 1  2    -1.0142810 02    -5.9438310-04
 2  2     5.2885830 03     3.3013000-02   -1.5733320 00
 3  2     2.5107020 03     4.3576570 01    2.1924420 01
 4  2    -5.5822390-02
 1  3    -1.3322140 00
 2  3    -3.2099920-02
 3  3     7.4264720-02
 1  4     7.4674460 02     2.0334480-01    4.7199990 00
 2  4     1.9539790 01     5.5767700-01
 3  4     1.1631300 01    -7.7013730-02
 4  4     1.0000000 00
DETERMINANT  -5.2237613E 05   0.0
DETERMINANT  -5.2237513E 05   0.0
DETERMINANT  -5.2237606E 05   0.0
DETERMINANT  -5.2237594E 05   0.0
DETERMINANT  -5.2237591E 05   0.0
DETERMINANT  -5.2237600E 05   0.0
```

DETERMINANT	-5.2237631E 05	0.0
DETERMINANT	-5.2237656E 05	0.0
DETERMINANT	-5.2237656E 05	0.0
DETERMINANT	-5.2237673E 05	0.0
DETERMINANT	-5.2237638E 05	0.0

FINAL MATRIX

1	1	-1.8941760 01				
1	2	1.0142810 02	1.3890080 00			
2	2	-7.5621330 03				
1	3	1.3322140 00				
2	3	-7.1607840 00	2.2080230-01			
3	3	3.2953250 00				
1	4	-7.4874460 02	-2.5076220 01	-4.7199990 00		
2	4	4.0577710 03	8.5925760 02	4.1839170 02	-7.8229660-01	
3	4	-1.8852030 03	-9.8791580 01	-1.2470600 02	-2.5457170 00	-5.7921880-01
4	4	-1.0192070 00	-2.6078880-02	-5.9759080-02	-1.3476300-03	-2.8554620-04

REAL	IMAGINARY	ERROR	
-8.398477E-03	4.329021E 00	-2.922648E-07	-2.386554E-07
-8.398477E-03	-4.329021E 00	-2.922648E-07	2.386554E-07
-2.351342E 00	1.359896E 01	-9.908530E-08	4.166396E-07
-2.351342E 00	-1.359896E 01	-9.908530E-08	-4.166396E-07

POLYNOMIAL -4.810885E 05 -1.230982E 04 -2.820763E 04 -6.361116E 02 -1.347842E 02

POLYNOMIAL W CONST TERM FIRST
-0.481088E 06 -0.123098E 05 -0.282076E 05 -0.636112E 03 -0.134784E 03

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
-0.8398E-02	+-0.4329E 01	0.8253E 02	0.1212E-01	0.1451E 01	0.6890E 00	0.6890E 00	0.1941E-02	0.9879E 00
-0.2351E 01	+-0.1360E 02	0.2948E 00	0.3392E 01	0.4620E 00	0.2164E 01	0.2196E 01	0.1704E 00	0.3374E 00

CASE NO= 2 SAMPLE DATA-LONG CHAR OF THETA/EMO TRANS FUNC W FEEDBACK & FREQ RESP.
FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE
FEEDBACK LOGIC IN

CODE NOS. FOR THIS CASE.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	-1	2	0	0	2	0	10	3	0	0	0	1	11	2	0	0	-1	60	0	0	0	0	0

DATA CHANGE
137 7.5000
138 [illegible]00.00
140 [illegible].00
FREQUENCY RESPONSE COMPUTATION

EM. ATT.,DEFLTN.& CABLE TENSION
THETA = 1.03 DEG
DELTA = -1.33 DEG
FRT CAB. TENSION= 0.127591E 03 LBS
RR CAB. TENSION = 0.100214E 03 LBS
++++ LONGITUDINAL STABILITY ++++
COMPUTATION OF THETA/ EMO NUMERATOR ROOTS
POLYNOMIAL W CONST TERM FIRST
0.969847E 03 0.153241E 02 0.523025E 02

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
-0.1465E 00	+-0.4304E 01	0.4732E 01	0.2113E 00	0.1460E 01	0.6850E 00	0.6853E 00	0.3402E-01	0.8074E 00

COMPUTATION OF THE DENOMINATOR ROOTS

POLYNOMIAL W CONST TERM FIRST
0.603359E 07 0.391416E 06 0.399395E 06 0.718007E 04 0.150616E 04
0.465812E 01

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
-0.3986E 00	+-0.4017E 01	0.1739E 01	0.5751E 00	0.1564E 01	0.6394E 00	0.6425E 00	0.9875E-01	0.5361E 00
-0.1596E 01	+-0.1569E 02	0.4344E 00	0.2302E 01	0.4003E 00	0.2498E 01	0.2511E 01	0.1011E 00	0.5279E 00
-0.3194E 03		0.2170E-02	0.4607E 03					

FREQUENCY RESPONSE OF THE THET/ EMD TRANSFER FUNCTION
STEADY STATE GAIN = 0.1607E-03

FREQ(RPS)	AMP RAT(DB)	PHASE(DEG)	AMP. VALUE	FREQ(RPS)	AMP RT(DB)	PHASE(DEG)	AMP. VALUE
0.1000E 00	-0.7588E 02	-0.2813E 00	0.1608E-03	0.5000E 01	-0.7930E 02	0.6857E 01	0.1084E-03
0.1200E 00	-0.7588E 02	-0.3376E 00	0.1608E-03	0.5500E 01	-0.7775E 02	0.4034E 01	0.1295E-03
0.1500E 00	-0.7588E 02	-0.4222E 00	0.1608E-03	0.6000E 01	-0.7693E 02	0.1681E 01	0.1423E-03
0.1700E 00	-0.7587E 02	-0.4786E 00	0.1608E-03	0.6500E 01	-0.7636E 02	-0.1988E 00	0.1521E-03
0.2000E 00	-0.7587E 02	-0.5633E 00	0.1608E-03	0.7000E 01	-0.7587E 02	-0.1800E 01	0.1608E-03
0.2500E 00	-0.7587E 02	-0.7049E 00	0.1608E-03	0.7500E 01	-0.7543E 02	-0.3251E 01	0.1693E-03
0.3000E 00	-0.7587E 02	-0.8468E 00	0.1609E-03	0.8000E 01	-0.7498E 02	-0.4634E 01	0.1781E-03
0.3500E 00	-0.7587E 02	-0.9895E 00	0.1609E-03	0.8500E 01	-0.7453E 02	-0.6005E 01	0.1876E-03
0.4000E 00	-0.7586E 02	-0.1133E 01	0.1610E-03	0.9000E 01	-0.7406E 02	-0.7413E 01	0.1982E-03
0.4500E 00	-0.7586E 02	-0.1277E 01	0.1611E-03	0.9500E 01	-0.7355E 02	-0.8900E 01	0.2101E-03
0.5000E 00	-0.7585E 02	-0.1421E 01	0.1612E-03	0.1000E 02	-0.7300E 02	-0.1051E 02	0.2238E-03
0.5500E 00	-0.7585E 02	-0.1567E 01	0.1612E-03	0.1200E 02	-0.7022E 02	-0.1953E 02	0.3085E-03.
0.6000E 00	-0.7584E 02	-0.1714E 01	0.1613E-03	0.1500E 02	-0.6376E 02	-0.6413E 02	0.6487E-03
0.6500E 00	-0.7584E 02	-0.1862E 01	0.1615E-03	0.1700E 02	-0.6576E 02	-0.1278E 03	0.5154E-03
0.7000E 00	-0.7583E 02	-0.2012E 01	0.1616E-03	0.2000E 02	-0.7345E 02	-0.1592E 03	0.2125E-03
0.7500E 00	-0.7583E 02	-0.2163E 01	0.1617E-03	0.2500E 02	-0.8084E 02	-0.1713E 03	0.9078E-04
0.8000E 00	-0.7582E 02	-0.2315E 01	0.1618E-03	0.3000E 02	-0.8551E 02	-0.1760E 03	0.5304E-04
0.8500E 00	-0.7581E 02	-0.2470E 01	0.1620E-03	0.3500E 02	-0.8900E 02	-0.1789E 03	0.3550E-04
0.9000E 00	-0.7580E 02	-0.2625E 01	0.1621E-03	0.4000E 02	-0.9181E 02	-0.1810E 03	0.2566E-04
0.9500E 00	-0.7579E 02	-0.2783E 01	0.1623E-03	0.4500E 02	-0.9419E 02	-0.1828E 03	0.1951E-04
0.1000E 01	-0.7579E 02	-0.2944E 01	0.1625E-03	0.5000E 02	-0.9626E 02	-0.1843E 03	0.1538E-04
0.1200E 01	-0.7574E 02	-0.3609E 01	0.1632E-03	0.5500E 02	-0.9810E 02	-0.1856E 03	0.1245E-04
0.1500E 01	-0.7566E 02	-0.4702E 01	0.1648E-03	0.6000E 02	-0.9975E 02	-0.1869E 03	0.1029E-04
0.1700E 01	-0.7559E 02	-0.5518E 01	0.1661E-03	0.6500E 02	-0.1013E 03	-0.1881E 03	0.8648E-05
0.2000E 01	-0.7547E 02	-0.6932E 01	0.1685E-03	0.7000E 02	-0.1026E 03	-0.1892E 03	0.7372E-05
0.2500E 01	-0.7518E 02	-0.1014E 02	0.1741E-03	0.7500E 02	-0.1039E 03	-0.1903E 03	0.6358E-05
0.3000E 01	-0.7476E 02	-0.1571E 02	0.1828E-03	0.8000E 02	-0.1051E 03	-0.1913E 03	0.5538E-05
0.3500E 01	-0.7431E 02	-0.2865E 02	0.1925E-03	0.8500E 02	-0.1063E 03	-0.1923E 03	0.4865E-05
0.4000E 01	-0.7760E 02	-0.6377E 02	0.1318E-03	0.9000E 02	-0.1073E 03	-0.1933E 03	0.4306E-05
0.4500E 01	-0.8415E 02	0.1521E 00	0.6202E-04	0.9500E 02	-0.1083E 03	-0.1943E 03	0.3837E-05
				0.1000E 03	-0.1093E 03	-0.1952E 03	0.3438E-05

CASE NO= 3 SAMPLE INPUT OF VEL=0. W LIFT CABLE -CHAR. ROOTS OPTION
FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL
NO SNUBBERS
LIFT/ANTI-LIFT CABLE IN
FEEDBACK LOGIC IN
WIND OFF CHARACTERISTICS

CODE NOS. FOR THIS CASE.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	-1	0	0	0	2	0	9	3	0	1	0	1	0	8	0	0	0	0	0	0	0	0	0

DATA CHANGE
48 0.0
49 0.0

EH. ATT..DEFLTN.& CABLE TENSION
THETA = -0.00 DEG
DELTA = 0.0 DEG
FRT CAB. TENSION= 0.906780E 02 LBS
RR CAB. TENSION = 0.100000E 03 LBS
++++ LONGITUDINAL STABILITY ++++
POLYNOMIAL W CONST TERM FIRST
0.736854E 06 0.231583E 04 0.650357E 05 0.204398E 03 0.141327E 04
0.444172E 01

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
-0.3182E 03		0.2178E-02	0.4590E 03					
0.0	+-0.4492E 01	0.1000E 06	0.0	0.1399E 01	0.7149E 00	0.7149E 00	0.0	0.1000E 01
0.0	+-0.5084E 01	0.1000E 06	0.0	0.1236E 01	0.8091E 00	0.8091E 00	0.0	0.1000E 01

```
CASE NO= 4      SAMPLE INPUT FOR CABLELESS MODEL W TRANSFER FUNCTION OPTION
                FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL
                NO SNUBBERS
                NO LIFT/ANTI-LIFT CABLE
                FEEDBACK LOGIC NOT IN
                CABLELESS MODEL CHARACTERISTICS

CODE NOS. FOR THIS CASE.
  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24
  1   1   0   0   0   2   0   3  10   0   0   0  -1  15   3   0   0   0   0   0   0   0   0   0
 DATA CHANGE
  44    0.86500
       446.00

EH. ATT..DEFLTN.& CABLE TENSION
 THETA =  1.03 DEG
 DELTA = -1.33 DEG
FRT CAB. TENSION=   0.127591E 03 LBS
RR CAB. TENSION =   0.100214E 03 LBS
**** LONGITUDINAL STABILITY ****
COMPUTATION OF   X /DELE NUMERATOR ROOTS
POLYNOMIAL W CONST TERM FIRST
          0.0               0.315421E 07  -0.999774E 06  -0.582850E 04   0.156621E 04
   REAL        IMAGINARY    T H/D-SEC     1/T H/D     PERIOD-SEC   DNATF-CPS   UNDNAT-CPS   DAMP RATIO    DECAY RATIO
 0.0                        0.1000E 06   0.0
 0.3146E 01                 0.2203E 00   0.4539E 01
-0.2502E 02                 0.2771E-01   0.3609E 02
 0.2559E 02                 0.2709E-01   0.3692E 02
**** LATERAL/DIRECTIONAL STABILITY ****
   KODE(3) HAS BEEN SET BY PROG TO 3 FOR CABLELESS MODEL CHARACTERISTICS
   THE FOLLOWING EXTRACTED ROOT HAVE POOR ACCURACY


          REAL              IMAGINARY                           ERROR

       -2.673369E-03      0.0                            7.894731E-02    0.0
 POLYNOMIAL W CONST TERM FIRST
          0.0              0.0             0.255240E 03    0.955461E 05    0.265519E 05
          0.217112E 04     0.386945E 03
   REAL        IMAGINARY    T H/D-SEC     1/T H/D     PERIOD-SEC   DNATF-CPS   UNDNAT-CPS   DAMP RATIO    DECAY RATIO
 0.0                        0.1000E 06   0.0
-0.2673E-02                 0.2593E 03   0.3857E-02
-0.3972E 01                 0.1745E 00   0.5732E 01
-0.8177E 00   +-0.7834E 01  0.8477E 00   0.1180E 01   0.8016E 00   0.1247E 01   0.1254E 01   0.1038E 00   0.5192E 00
 0.0                        0.1000E 06   0.0
```

CASE NO= 5 SAMPLE OF ACTIVE CABLE SYSTEM-LAT DIR MODE W TRANS. FUNC. OP.
FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE
FEEDBACK LOGIC IN

CODE NOS. FOR THIS CASE.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	0	0	0	2	0	10	10	0	0	0	1	0	0	11	2	0	0	0	0	0	0	0

DATA CHANGE
C 0.0

EH. ATT..DEFLTN.& CABLE TENSION
THETA = 1.03 DEG
DELTA = -1.33 DEG
FRT CAB. TENSION= 0.127591E 03 LBS
RR CAB. TENSION = 0.100214E 03 LBS
++++ LATERAL/DIRECTIONAL STABILITY ++++
COMPUTATION OF PSI/ EMO NUMERATOR ROOTS
POLYNOMIAL W CONST TERM FIRST
-0.345004E 05 -0.179903E 05 -0.904558E 04 -0.159327E 04 -0.294450E 03

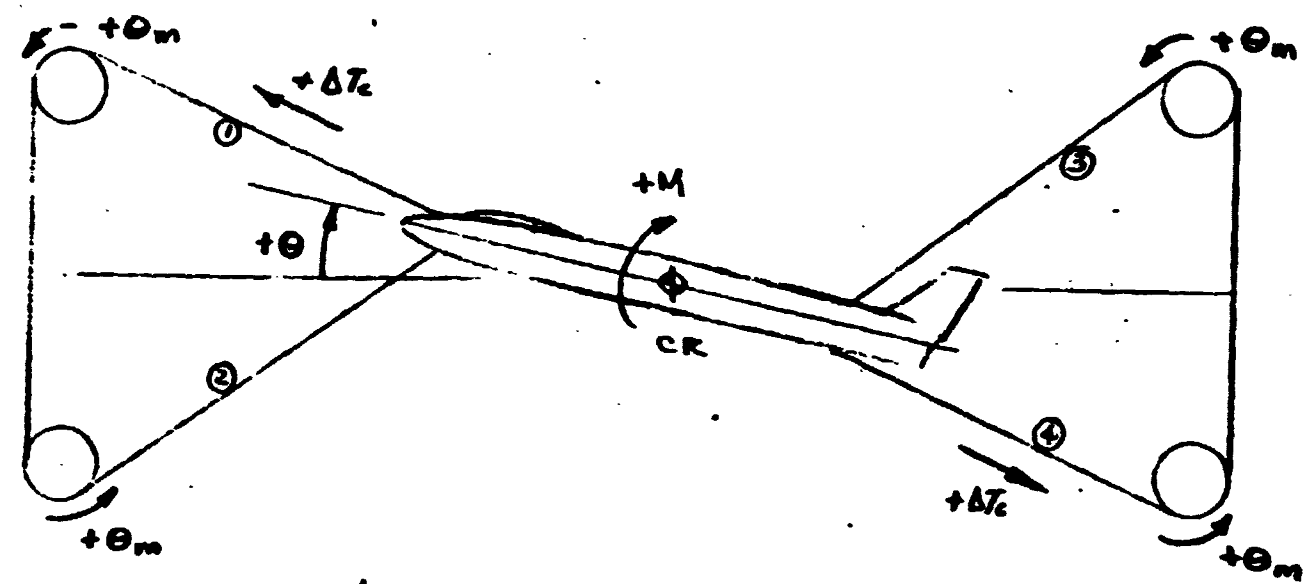
REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
-0.1220E 01	+-0.2390E 01	0.5680E 00	0.1760E 01	0.2629E 01	0.3804E 00	0.4271E 00	0.4547E 00	0.4045E-01
-0.1485E 01	+-0.3750E 01	0.4667E 00	0.2143E 01	0.1676E 01	0.5968E 00	0.6419E 00	0.3682E 00	0.8303E-01

FIGURES

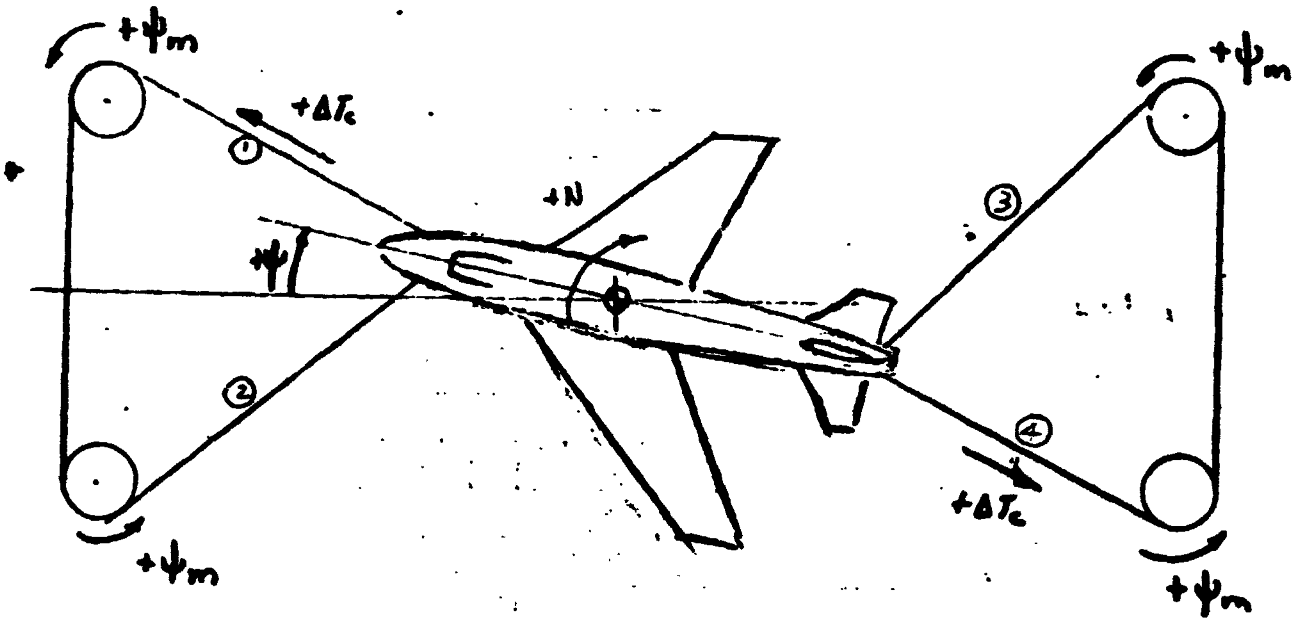
FIGURE 1

ACTIVE CABLE MOUNT SYSTEM

DEFINITION OF PULLEY MOTION, θ_m, ψ_m



a) LONGITUDINAL CABLE CONTROL



b) DIRECTIONAL CABLE CONTROL

Figure 2

ACTIVE CABLE MOUNT SYSTEM

LONGITUDINAL BLOCK DIAGRAM

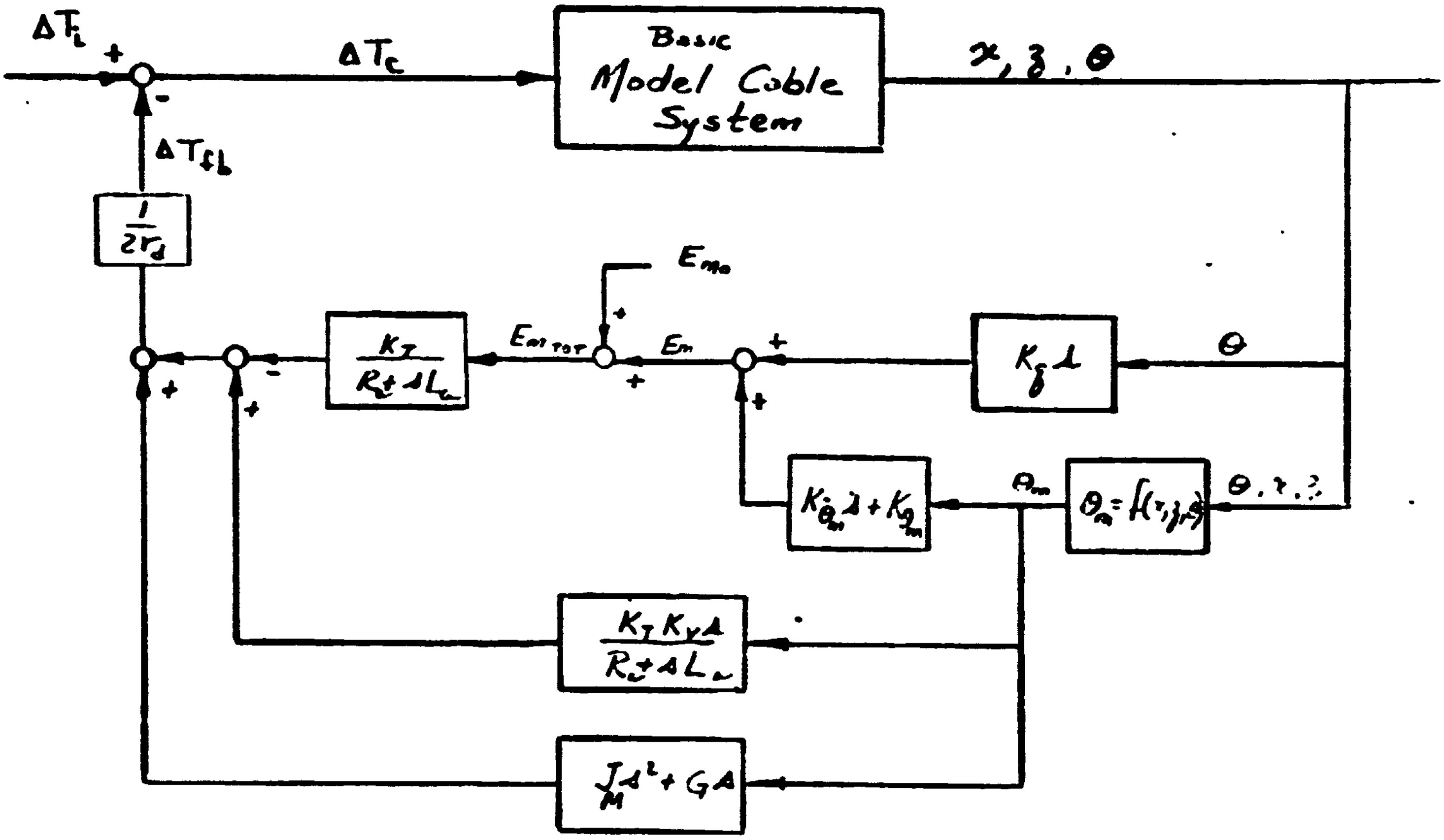
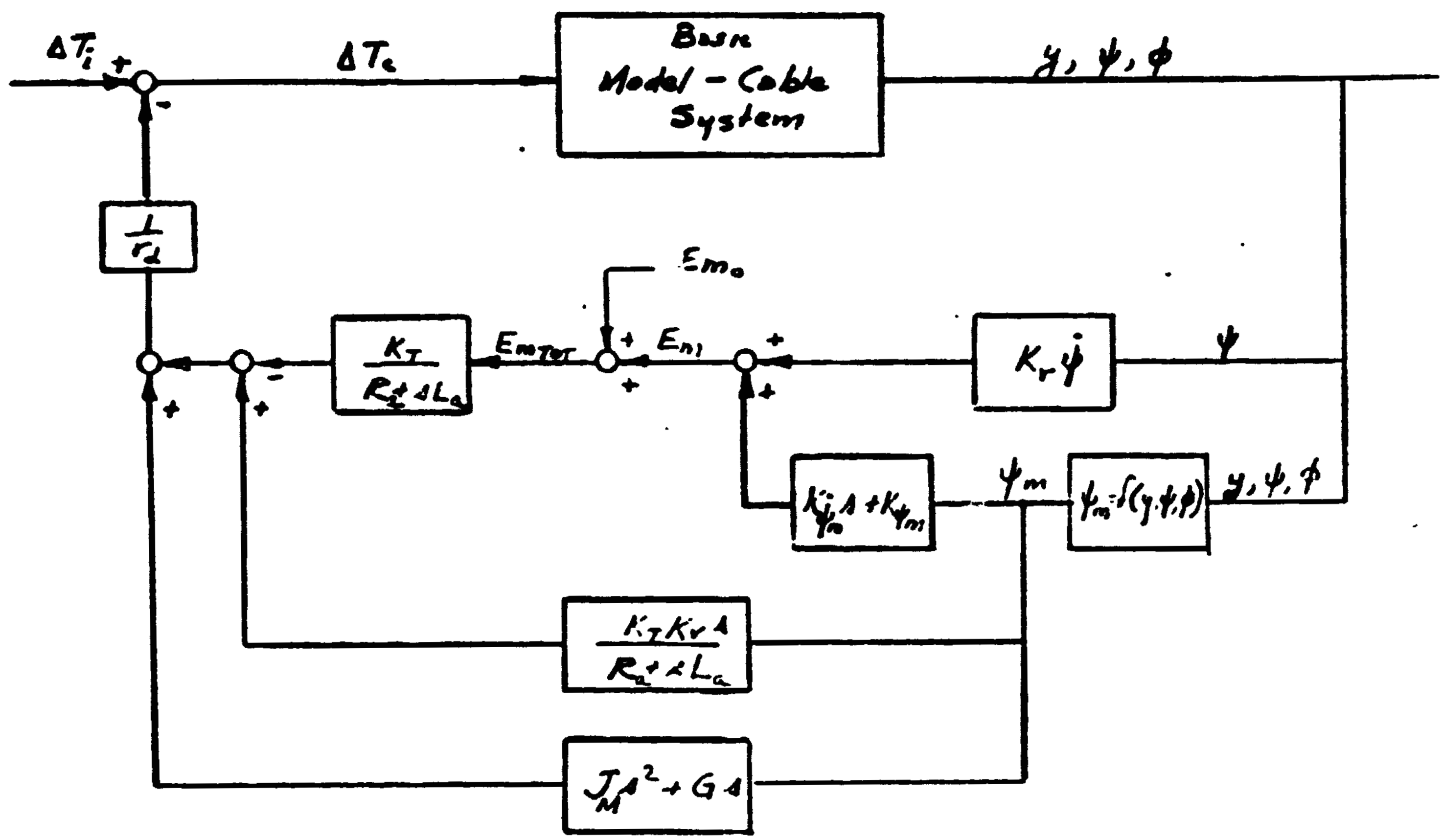


Figure 3

ACTIVE CABLE MOUNT SYSTEM

LATERAL DIRECTIONAL BLOCK DIAGRAM



ACTIVE CABLE MOUNT SYSTEM

EXTENDED LONGITUDINAL MATRIX

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫
z	θ	ΔT_i	ν	ΔT_{fb}	θ_m	$E_{m_{TOT}}$	$\dot{\theta}_m$	E_m	ΔT_c	E_{m_o}	ΔT_i
Basic Matrix of Inactive Cable-Model Sys (see ref. 1)					Eq.	①					
						②					
						③					
						④					
						⑤					
						⑥					
						⑦					
						⑧					
						⑨					
						⑩					
						⑪					
						⑫					

Eq. 1. $m\ddot{x} - \Sigma F_{x_o} - \frac{\partial F_x}{\partial \Delta T_c} \Delta T_c = 0$

Eq. 2. $m\ddot{z} - \Sigma F_{z_o} - \frac{\partial F_z}{\partial \Delta T_c} \Delta T_c = 0$

Eq. 3. $I_{yy}\ddot{\theta} - \Sigma M_y - \frac{\partial M_y}{\partial \Delta T_c} \Delta T_c = 0$

Eq. 4. $x - \frac{\partial x}{\partial z} z - \frac{\partial x}{\partial \theta} \theta = 0$

Eq. 5. $\Delta T_{fb} (2r_d) (R_a + sL_a) - (J_M s^2 + Gs) (R_a + L_a s)\theta_m + 2K_T K_v s \theta_m + 2K_T E_{m_{TOT}} = 0$

Eq. 6. $\theta_m r_d - \left[\frac{\partial \Delta \ell}{\partial_x} x + \frac{\partial \Delta \ell}{\partial z} z + \frac{\partial \Delta \ell}{\partial \theta} \theta \right] = 0$

Eq. 7. $E_m = K_{\theta_m} \theta_m + K_{\dot{\theta}_m} \dot{\theta}_m + K_q q$ where $q = \dot{\theta}$

Eq. 8. $\dot{\theta}_m = \theta_m s$

Eq. 9. $E_{m_{TOT}} = E_m + W_{m_o}$

Eq. 10. $\Delta T_c = \Delta T_i - \Delta T_{fb}$

ACTIVE CABLE MOUNT SYSTEM

EXTENDED LATERAL-DIRECTIONAL MATRIX

1	2	3	4	5	6	7	8	9	10	11	12
y	ψ	ϕ	ΔT_{fb}	ψ_m	$E_{m_{TOT}}$	$\dot{\psi}_m$	$\dot{\psi}$	E_m	ΔT_c	E_{m_o}	ΔT_i
Basic Matrix of Inactive Cable-Mod.l Sys (see ref 1.)					Eq	1					
						2					
						3					
						4					
						5					
						6					
						7					
						8					
						9					
						10					
						11					
						12					

Eq. 1. $m\ddot{y} - \Sigma Fy_o - \frac{\partial F_y}{\partial \Delta T_c}\Delta T_c = 0$

Eq. 2 $I_{zz}\Psi - I_{xz}\dot{\phi} - \Sigma N_o - \frac{\partial N}{\partial \Delta T_c}\Delta T_c = 0$

Eq. 3. $I_{xx}\dot{\phi} - I_{xz}\Psi - \Sigma \mathcal{L}_o - \frac{\partial \mathcal{L}}{\partial \Delta T_c}\Delta T_c = 0$

Eq. 4. $\Delta T_{fb}(2r_d)(R_a + sL_a) - (J_M s^2 + Gs)(R_a + sL_a)\Psi_m + 2K_T K_v s \Psi_m + 2K_T E_{m_{TOT}} = 0$

Eq. 5. $\Psi_m r_d + \left[\frac{\partial \Delta\ell}{\partial y} y + \frac{\partial \Delta\ell}{\partial \Psi}\Psi + \frac{\partial \Delta\ell}{\partial \phi}\phi\right] = 0$

Eq. 6. $E_m = K_{\Psi_m}\Psi_m + K_{\dot{\Psi}_m}\dot{\Psi}_m + K_r\dot{\Psi}$

Eq. 7. $\dot{\Psi}_m - s\Psi_m = 0$

Eq. 8. $\dot{\Psi} - s\Psi = 0$

Eq. 9. $E_{m_{TOT}} = E_m + E_{m_o}$

Eq. 10. $\Delta T_c = \Delta T_i \quad \Delta T_{fb}$

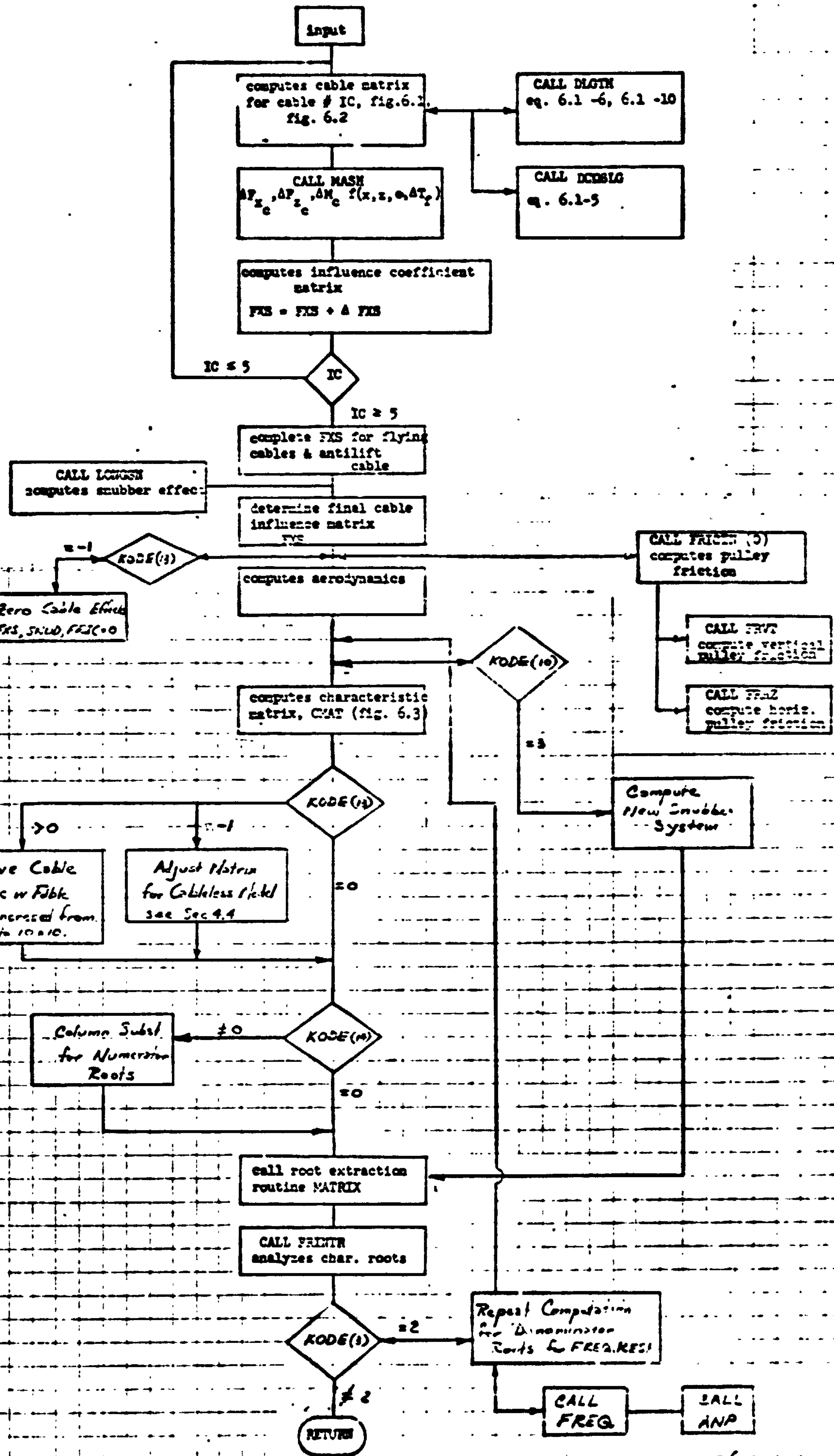


FIGURE 6 SUBROUTINE LONG FLOW CHART

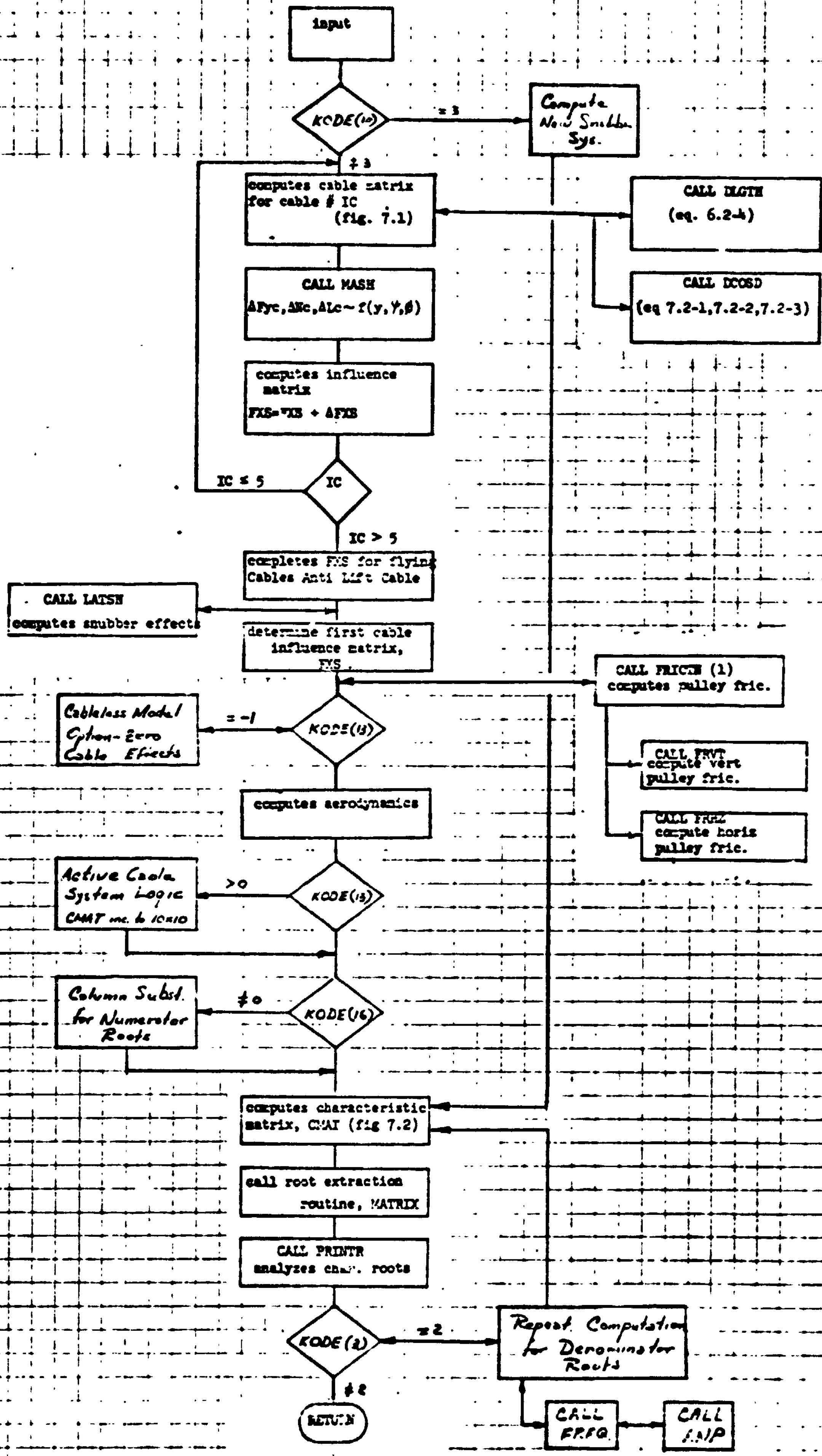


FIGURE 7 SUBROUTINE LAT FLOW CHART

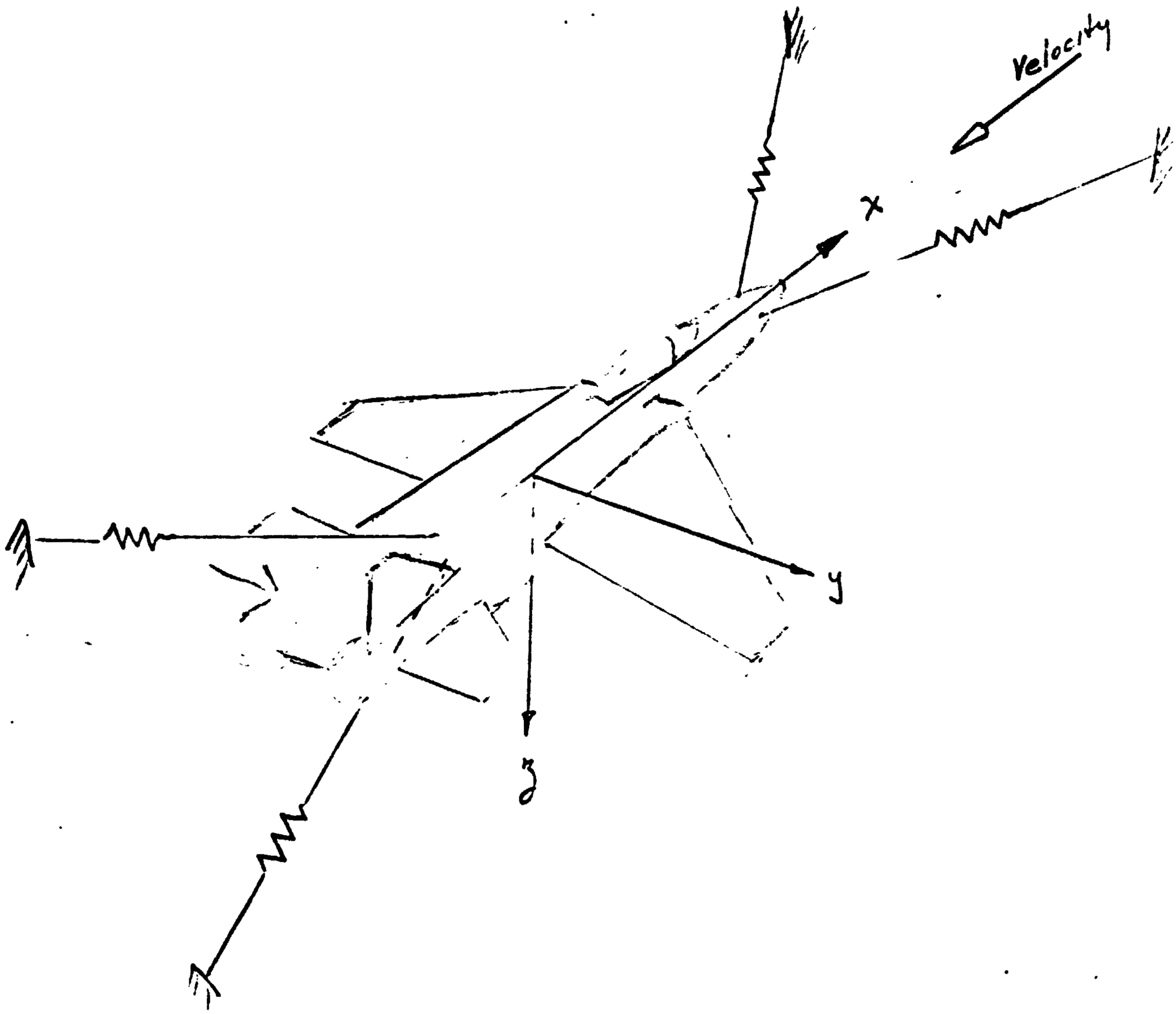


Figure 8. Schematic for Snubbed Model

X	Z	Θ	$\Delta\alpha_x$	$\Delta\alpha_z$	ΔT	Δl
		$-ZT\cos\alpha_z$	$-ZT\sin\alpha_x$		$Z\cos\alpha_x$	
		$ZT\cos\alpha_x$		$-ZT\sin\alpha_z$	$Z\cos\alpha_z$	
		$-ZT l_z\cos\alpha_z$ $-ZT l_x\cos\alpha_x$	$-ZT l_z\sin\alpha_x$	$ZT l_x\sin\alpha_z$	$Z l_z\cos\alpha_x$ $-Z l_x\cos\alpha_z$	
$1/l\sin\alpha_x$		$l_z/l\sin\alpha_x$	-1			
$1/l\sin\alpha_z$		$l_x/l\sin\alpha_z$		-1		$\cot\alpha_z/l$
					-1	K
$-\cos\alpha_x$	$-\cos\alpha_z$	$-l_z\cos\alpha_x$ $-l_y\cos\alpha_z$				-1

FIGURE 84: LONGITUDINAL CABLE INFLUENCE MATRIX

Y	ψ	ϕ	T	$\Delta\alpha_x$	$\Delta\alpha_y$	$\Delta\alpha_z$	$\Delta\ell$
	$-T\cos\alpha_x$	$T\cos\alpha_z$	$\cos\alpha_y$		$-T\sin\alpha_y$		
	$-\ell_x T\cos\alpha_x - \ell_y T\cos\alpha_y$	$\ell_x T\cos\alpha_z$	$\ell_x\cos\alpha_y - \ell_y\cos\alpha_x$	$\ell_y T\sin\alpha_x$	$-\ell_x T\sin\alpha_y$		
	$+\ell T\cos\alpha_x$	$-\ell_z T\cos\alpha_z - \ell_y T\cos\alpha_y$	$\ell_y\cos\alpha_z - \ell_z\cos\alpha_y$		$+\ell_z T\sin\alpha_y$	$-\ell_y T\sin\alpha_z$	
			-1				K
$\frac{-\cos\alpha_y\cot\alpha_y}{-\ell}$	$(\ell_y\sin\alpha_x + \ell_x\cos\alpha_y\cot\alpha_x)/\ell$	$(\ell_z\cos\alpha_y\cot\alpha_x - \ell_y\cos\alpha_y\cot\alpha_x)/\ell$		-1			
$\sin\alpha_y/\ell$	$(\ell_y\cos\alpha_x\cot\alpha_y + \ell_x\sin\alpha_y)/\ell$	$(-\ell_z\sin\alpha_y + \ell_y\cos\alpha_z\cot\alpha_y)/\ell$			-1		
$\frac{-\cos\alpha_y\cot\alpha_z}{\ell}$	$(\ell_y\cos\alpha_y\cot\alpha_z - \ell_x\cos\alpha_y\cot\alpha_z)/\ell$	$\ell_z\cos\alpha_y\cot\alpha_z + \ell_y\sin\alpha_z/\ell$				-1	

FIGURE 8B : LATERAL/DIRECTIONAL CABLE INFLUENCE MATRIX

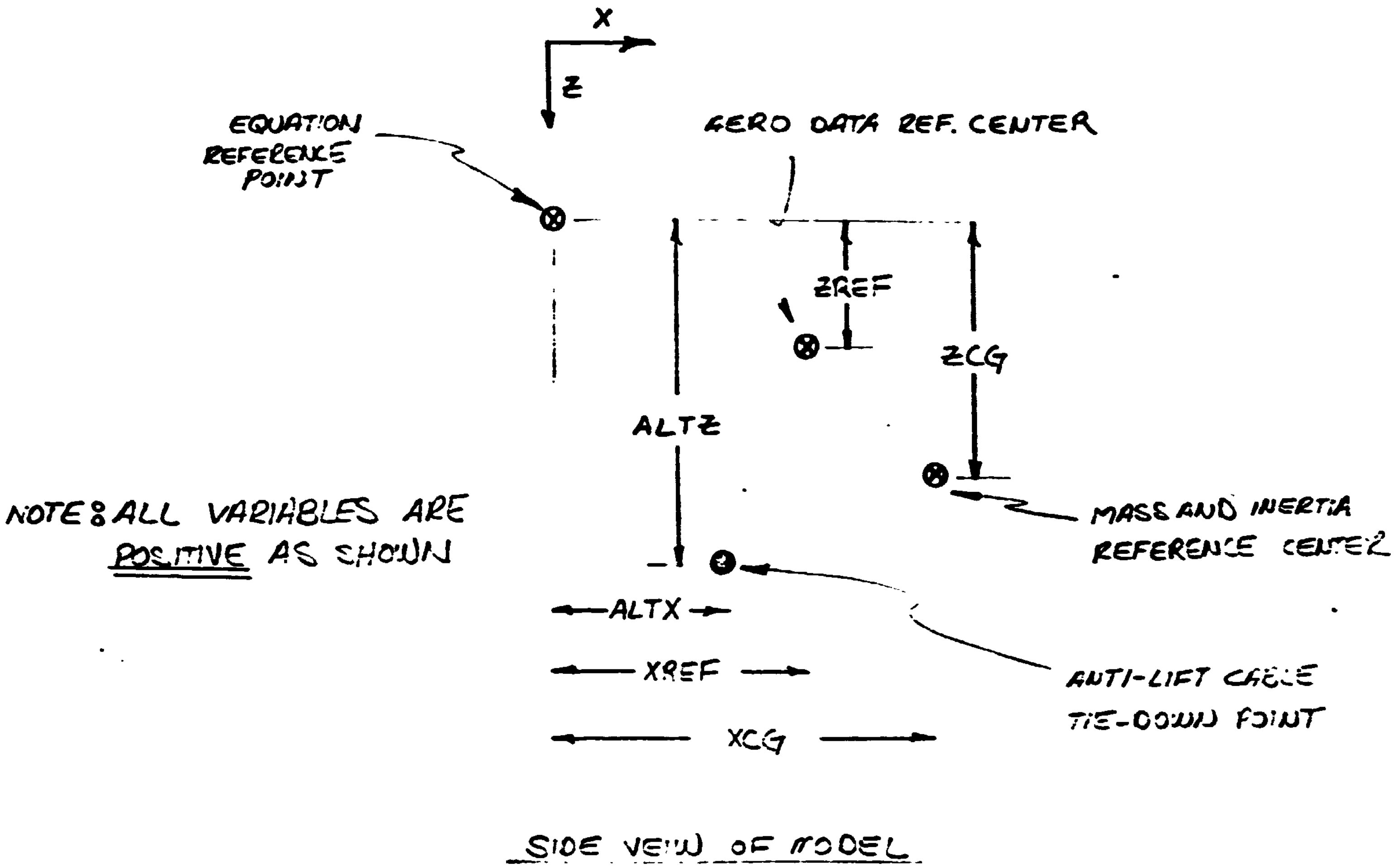


FIG. 9 - REFERENCE CENTER AND LIFT CABLE INPUT DATA

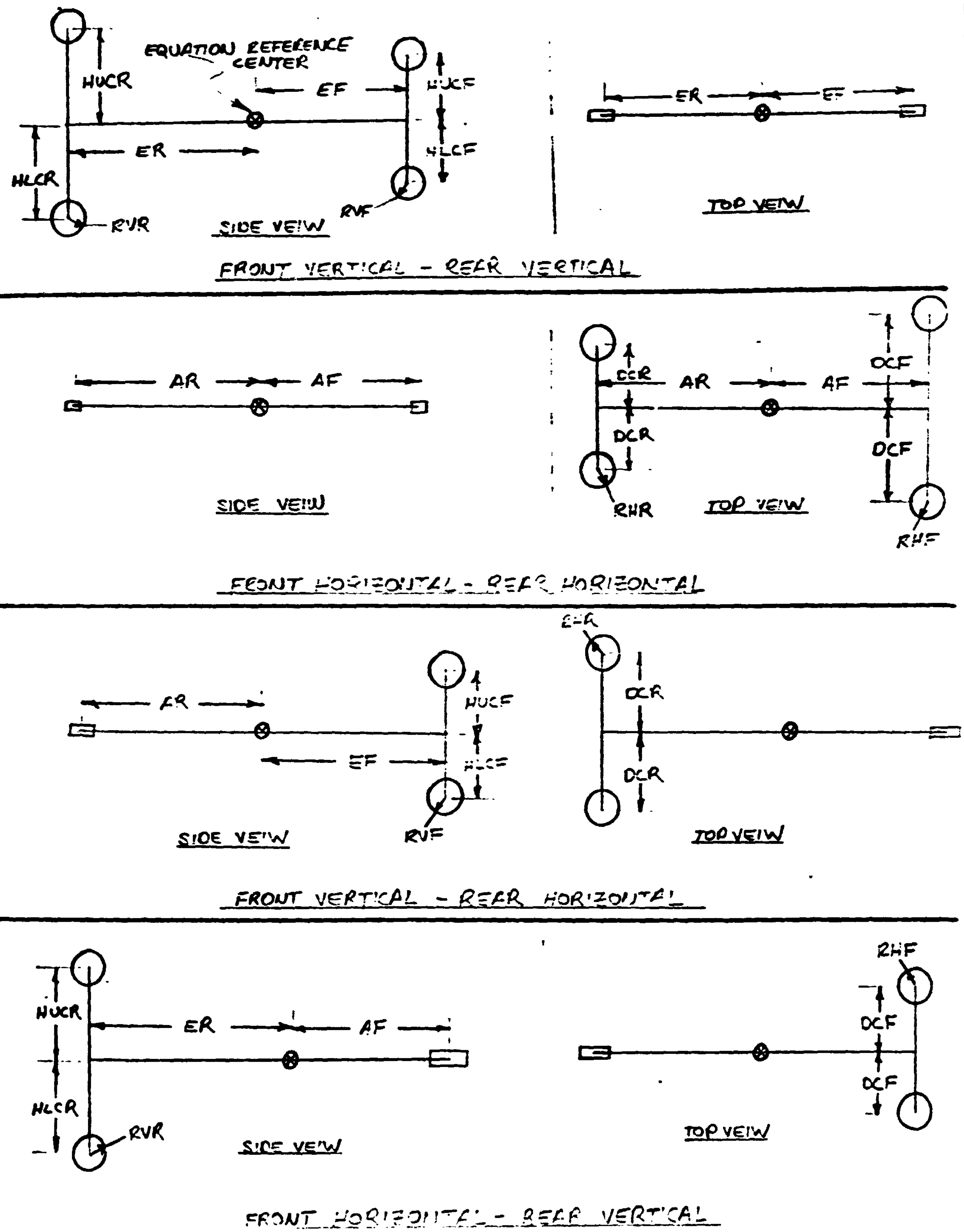


FIG. 10 - PULLEY GEOMETRY

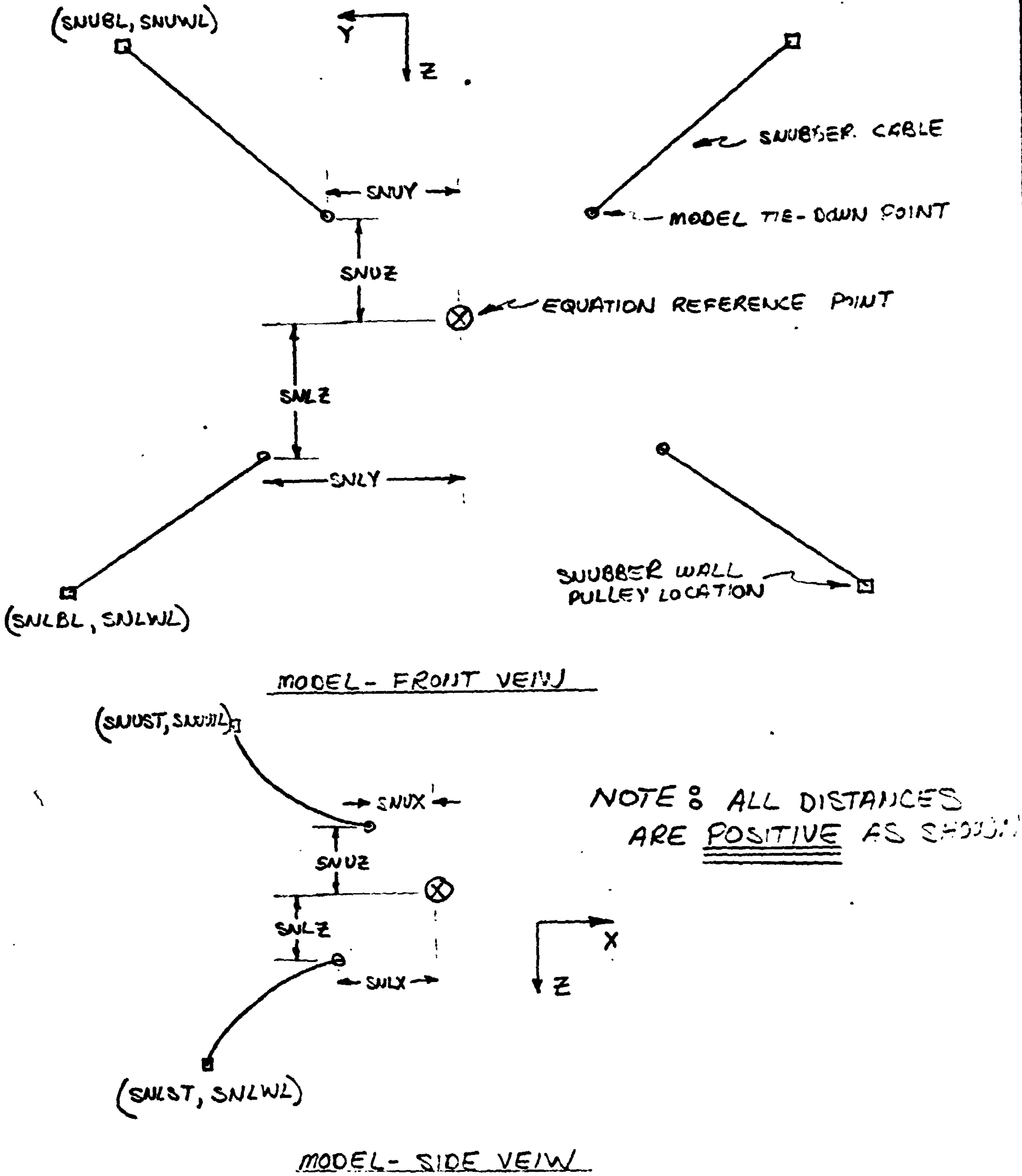


FIG. 11 - SNUBBER CABLE ARRANGEMENT