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LOADS - A COMPUTER PROGRAM FOR DETERMINING THE SHEAR, BENDING MOMENT AND AXIAL LOADS FOR FUSELAGE TYPE STRUCTURES.

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PREFACE

The Engineering Design Integration (EDIN) System consists of a series of computer programs used in the preliminary design of aerospace vehicles. This system is operational on the Univac 1110 at NASA, Johnson Space Center. The programs in the EDIN System are used to determine aerodynamics, propulsion, mass properties, trajectory analysis, stability and control, and cost. Due to the need for a structures program, APAS (Automated Predesign of Aircraft Structures) has been acquired and adapted to the Univac Exec 8 System. APAS, however, requires shear and bending moment diagrams and axial loads for the vehicle being designed.

This requirement has resulted in two programs - LOADS and LDSTRS. The former does the actual calculations of shear, moment and axial load while the latter is used as a translator program, i.e., it takes data output by the other EDIN programs such as weights and c.g. programs and converts it to the proper format for input into the LOADS Program. The following report gives a brief description of the LOADS Program.

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LOADS - A COMPUTER PROGRAM FOR DETERMINING THE SHEAR, BENDING MOMENT AND AXIAL LOADS FOR FUSELAGE TYPE STRUCTURES.

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SUMMARY AND INTRODUCTION

LOADS Program

LOADS determines rigid body vehicle shears, bending moment and axial loads on a space vehicle due to aerodynamic loads and structure and propellant inertial loads. The program was written from an algorithm presented by E. F. Bruhn in part E1.7 of Analysis and Design of Missile Structures. An example hand calculation is also presented in Bruhn's book and was used to check LOADS. A brief description of the program and the equations used will be presented here, however, the reader should consult Bruhn's book for a more detailed discussion of the algorithm.

LOADS will be used in the EDIN System to provide inputs to a structural synthesis program, APAS, which requires vehicle shears, bending moments and axial loads. APAS will then be used to size structural elements and calculate the total weight of the basic body structure.

LOADS is operational on the Univac 1110, occupies 10505 core and typically takes less than one (1) second of CAU time to execute. All of the elements (symbolic, relocatable and absolute) of LOADS are on file ODIN-DBINIT2. All three of these elements are called LOADS while the map element is called LOADSMAP. The data for the sample case presented in Bruhn's book is in element LDS INP. The output generated from this data by LOADS varied from Bruhn's output by less than one per cent. It should be noted at this point that Bruhn used a desk calculator which can not match the accuracy of a digital computer. Further verification of the accuracy of the program can be made by noting load values at the final station where it is known that shear, moment and axial load should be zero. LOADS printed out values of 0.05, 117.1, -0.25 for these three forces respectively. Bruhn's calculations, however, produced values of -50., 103000., 1000. respectively. From these comparisons it is concluded that the LOADS program is working properly and performing the necessary calculations. The final value for the moment, 117.1 in-lbs, may be considered approximately zero when compared to a maximum bending moment of 133.1×10^6 in-lbs.

The appendix contains a brief description and list of inputs for the translator program LDSTRS.

SHEAR FORCE

The shear force at a station j is equal to the aerodynamic loads up to that station minus the lateral inertial loads due to the structure and propellant weights up to that station.

$$S_j = \sum_{i=1}^{j} (ql_i + qf_i) - \sum_{i=1}^{j} (w_i + v_i + w_{cant_i}) n_i$$

where,

ql_i is the normal aerodynamic force at station i

qf_i is the engine side force at station i

w_i is the structural weight at station i

v_i is the propellant weight at station i

w_{cant_i} is the weight of cantilevered items at station i

n_i is the lateral acceleration at station i

The weight of cantilevered items is added in at the reaction station of that item. The lateral acceleration at any station i is given by

$$n_i = \ddot{y} + \frac{\bar{x} - x_i}{12_g} \ddot{\Theta}$$

x_i is the station location

$\bar{x}$ is the vehicle c.g. location

g is the force of gravity

$\ddot{y}$ is the lateral acceleration of the vehicle c.g. or the sum of all normal forces $(ql + qf)$ divided by the total weight (W) of the vehicle.

$$\ddot{y} = \frac{1}{W}\sum_{i=1}^{n} (ql_i + qf_i)$$

$\ddot{\Theta}$ is the pitching acceleration in radius/second^2

$$\ddot{\Theta} = \frac{1}{12I}\sum_{i=1}^{n} (ql_i + qf_i)(\bar{x} - x_i)$$

where I is the vehicle moment of inertia in slug-feet^2:

$$I = \frac{1}{144g}\sum_{i=1}^{n} w_i r_i^2 + v_i \rho_i^2 + (w_i + w_{cant_i} + v_i)(x_i - \bar{x})^2$$

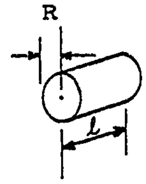
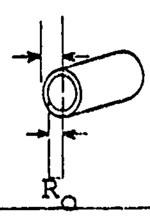
r_i is the vehicle radius of gyration

ρ_i is the propellant radius of gyration

It should be noted that there is no radius of gyration term for cantilevered items. It is assumed that this term will be small compared to the other terms. The radius of gyration can be determined from the following figure:

TABLE E1.7.11

RADIUS OF GYRATION - FORMULAS

TYPE	SHAPE	DIAGRAM	RADIUS OF GYRATION FORMULA
1	Solid Tube		$r = \left[\frac{3R^2 + \ell^2}{12}\right]^{1/2}$
2	Hollow Tube	As 1	$r = \left[\frac{6R^2 + \ell^2}{12}\right]^{1/2}$
3	Liquid Propellant	As 1	$\rho = \left[\frac{\ell^2}{12}\right]^{1/2}$
4	Cylinder		$r = \left[\frac{3(R^2 + R_o^2) + \ell^2}{12}\right]^{1/2}$

BENDING MOMENT

The moment at a station j is given by:

$$M_j = \sum_{i=1}^{j} S_{i-1}(X_i - X_{i-1}) - \frac{1}{12g} \sum_{i=1}^{j} (w_i r_i^2 + v_i \rho_i^2)\ddot{\Theta}$$

$$+ \sum_{i=1}^{j} (q l_i)\Delta X_i - \sum_{i=1}^{j} W_{cant_i} n_i \Delta X_i$$

The first term accounts the area under the shear diagram assuming point load applications. The second term involving the pitching acceleration, accounts for a distributed non-uniform load. The third term adds the moment due to the aerodynamic forces on externally cantilevered items. The fourth term introduces a correction moment for internally cantilevered items. ΔX is the distance from the point where cantilevered item is attached to the tank wall to the C.G. location of that item. It should be noted that the second term neglects the contribution of cantilevered items. Once again, it has been assumed that the radius of gyration of cantilevered items will be small in comparison to the vehicle radii of gyration.

AXIAL LOAD

The axial load at a station j is the sum of the drag, thrust and inertial loads up to that station. Two formulas are used to determine axial load depending on whether or not the station passes through a solid propellant tank or a liquid propellant tank. This is due to the fact that solid propellant is attached to the tank walls and creates an incremental load while liquid propellant loads only the tank bottom. Thus, if the station j passes through a solid propellant tank, the axial load is given by:

$$P_i = \sum_{i=1}^{j} f_i + n_a \sum_{i=1}^{j} (w_i + w_{cant_i} + v_i)$$

n_a is the axial acceleration

$$n_a = \sum_{i=1}^{n} f_i \Big/ \sum_{i=1}^{n} (w_i + w_{cant_i} + v_i)$$

f_i are the tangential forces where f_n = - THRUST

It should be noted that the weight of the cantilevered items is added in at the reaction station.

If the station j passes through a liquid fuel tank or no fuel tank at all, the axial load is given by:

$$P_i = \sum_{i=1}^{j} f_i + n_a \sum_{i=1}^{j} w_i + w_{cant_i})$$

and if the station j is at the bottom of a liquid propellant tank, the axial load becomes:

$$P_i = \sum_{i=1}^{j} f_i + n_a \sum_{i=1}^{j} (w_i + w_{cant_i}) + n_a \sum_{i=1}^{k} v_i$$

k_i is the station at the bottom of the liquid propellant tank.

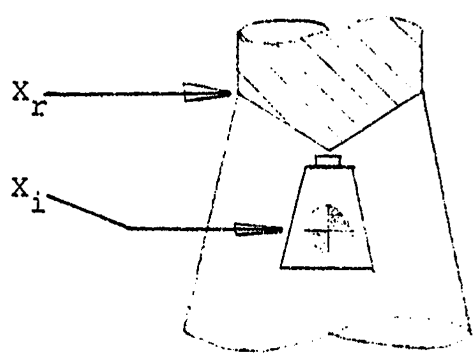
CANTILEVERED ITEMS

Cantilevered items are structures which are attached to the vehicle and will create a bending moment on the vehicle under lateral acceleration. The point at which the item is attached to the vehicle is called the reaction station and it is assumed that the moment created by the item can be introduced at this point.

Internally cantilevered items consist of engines which will introduce a correction moment at the reaction station. The moment arm, DELX, is

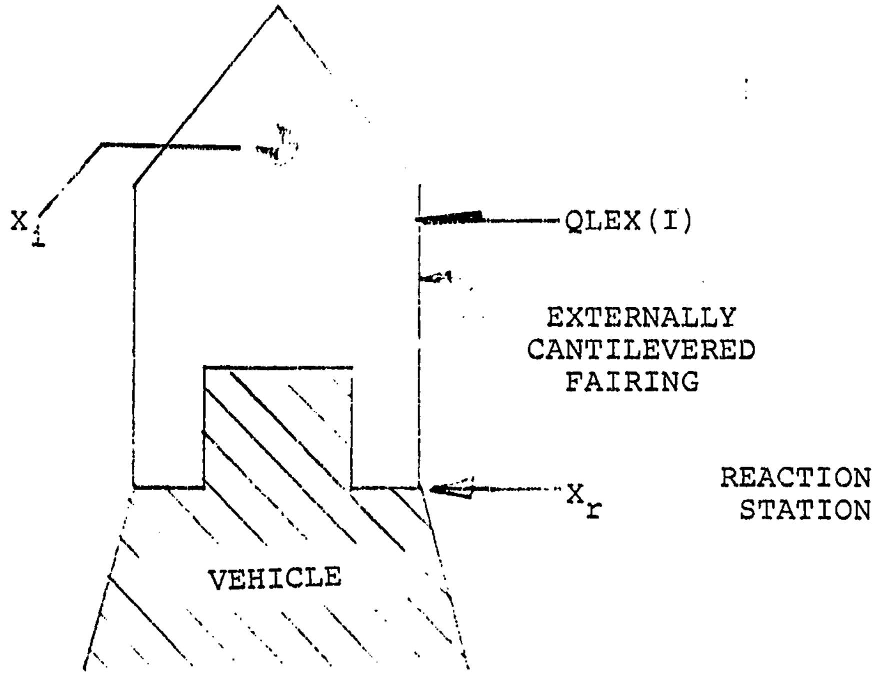
$$\Delta X = X_r - X_i$$

and should be negative. X_r is the location of the reaction station and X_i is the location of the engine c.g.

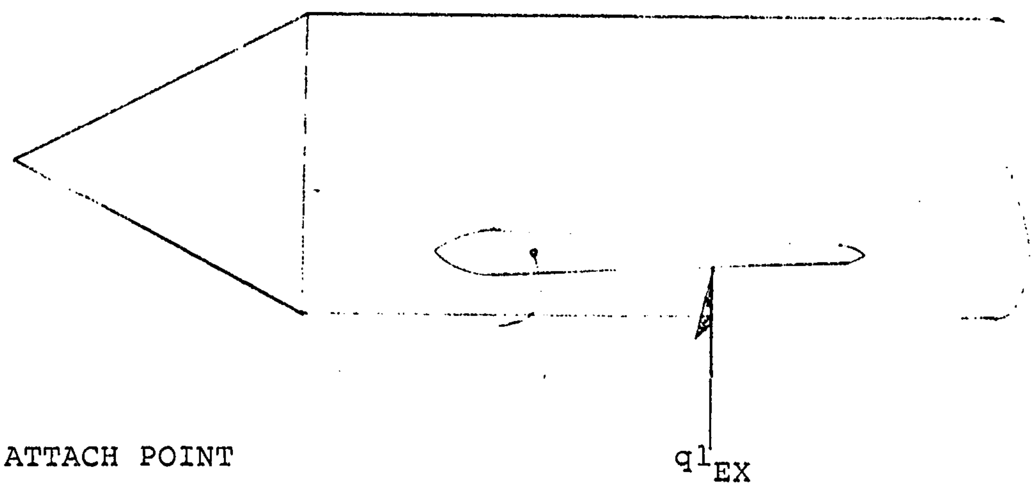


INTERNALLY CANTILEVERED ENGINE

Externally cantilevered items can be of two types - (1) fairings or (2) wing surfaces such as canards, wings, stabilizers, etc. The normal aerodynamic force acting on a fairing will create a moment which is added to the total moment at the vehicle reaction station:



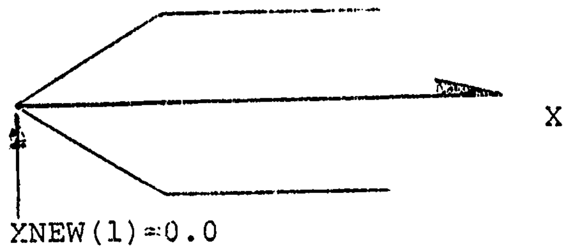
The normal aerodynamic force acting on a wing will create a moment which is differenced from the total moment at the attach point.



LOADS INPUT

The following is a list of the input variables for program LOADS. All of the variables are dimensioned by 100 except for IBOT which is dimensioned 20 and N and NLASX which are not dimensioned. All data is read in by namelist NML.

XNEW(I) - X station in inches. The first station must always equal zero - XNEW(1)=0.0. XNEW(I) is referenced from the nose of the vehicle.



W(I) - Weight of the i^{th} section in lbs. This includes everything except fuel, oxidizer and payload weight. W(1)=0.0 always.

V(I) - Weight of fuel or oxidizer in the i^{th} section in lbs. V(1)=0.0.

WCANTI(I) - Weight of internally cantilevered item in lbs. This is input at the X station which locates the c.g. of the cantilevered item. WCANTI(1)=0.0.

DELX(I) - Distance between internally cantilevered item c.g. and item attach point in inches. This is input at the X station which locates the attach point of the item and is usually negative. DELX(1)=0.0.

WCANTE(I) - Weight of externally cantilevered item in lbs. This is input at the X station which locates the c.g. of the cantilevered item. WCANTE(1)=0.0.

EXDELX(I) - Distance between externally cantilevered item c.g. and item attach point in inches. This is input at the X station which locates the attach point of the item and is usually negative. EXDELX(1)=0.0.

N	-	Number of stations to end of fuselage-type structure.
ISV(I)	-	Propellant radius of gyration indicator. ISV(I)=0 - No propellant. ISV(I)=3 - Liquid Propellant. ISV(I)=4 - Solid Propellant.
ISW(I)	-	Structure radius of gyration indicator. ISW(I)=1 - Solid tube. ISW(I)=2 - Hollow tube. ISW(I)=4 - Cylinder.
IBOT(I)	-	Station number representing bottom of liquid fuel or oxidizer tank.
QL(I)	-	Normal aerodynamic force on vehicle in lbs. QL(1)=0.0.
QLEX(I)	-	Normal aerodynamic force on externally cantilevered item in lbs. QLEX(1)=0.0.
DELQL(I)	-	Distance between normal force on externally cantilevered item and attach point of cantilevered item. This is input at the X station which locates the attach point of the cantilevered item. DELQL(1)=0.0.
F(I)	-	Tangential aerodynamic force. F(1)=0.0.
R(I)	-	Radius in inches. R(1)=0.0.
RO(I)	-	Internal radius for ISV(I)=3 in inches. RO(1)=0.0.
NLASX	-	Total number of stations.

```
C          ***LOADS PROGRAM***
C          REFERENCE 'ANALYSIS AND DESIGN OF MISSLE STRUCTURES'
C          BY E.F. BRUHN, PART E1.7.
      DIMENSION    X(100),     F(100),     V(100),      W(100),
     *             QL(100), WCANTE(100), WCANTI(100), ISW(100),
     *             ISV(100),  DELX(100), EXDELX(100),     L(100),
     *             RGSQ(100),     R(100), RHOSQ(100),  R0(100),
     *             ACCLAT(100), SHEAR(100), MOMENT(100), P(100),
     *             IBOT(20), SAVEM(100), QLEX(100), DELQL(100),
     *             XNEW(100), SAVEME(100), TITLE(5)
      REAL MOMENT, IMNT, L
      NAMELIST/NML/    XNEW,     W,     V, WCANTI, DELX, EXDELX,     N,
     *                 ISV,  ISW, IBOT, DELQL,  QLEX,     QL,     F,
     *                  R,   R0, WCANTE, NLASX, TITLE
C
C          PROGRAM LOADS DETERMINES SHEAR, BENDING MOMENT, AND
C          AXIAL LOAD ON A ROCKET DUE TO AERODYNAMIC LOADS AND
C          STRUCTURE AND PROPELLANT INERTIAL LOADS.  DATA IS
C          READ FROM NAMELIST NML WHICH WAS WRITTEN ON FILE 8
C          BY THE TRANSLATOR PROGRAM, LDSTRS.  OUTPUT IS WRITTEN
C          ON FILE 14 FOR USE BY THE STRUCTURAL SYNTHESIS PRO-
C          GRAM, APAS
C
      DATA G/32.2/
      DATA L/100*0./
      DATA SAVEM/100*0./
      DATA SAVEME/100*0./
      DATA WVSUM,SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,SUM7/8*0./
      DATA FC,JPI,JPE,JSI,JSE,JSE2,JSEL/7*0./
      DATA TERM1,TERM2,TERM3,TERM4,FSUM/5*0./
      DATA TP1,TP2,TP3,VSUM/4*0./
      REWIND 11
      REWIND 8
      READ(8,NML)
      PRINT 1,TITLE
    1 FORMAT(////,30X,'***LOADS PROGRAM***',/,25X,5A6,//)
      DO 9 I=1,100
      X(I)=XNEW(I)
    9 CONTINUE
C          DETERMINE C.G. LOCATION OF VEHICLE
      DO 10 I=1,NLASX
      SUM1 = W(I) + WCANTE(I) + WCANTI(I) + V(I)
      WVSUM = SUM1 + WVSUM
      SUM2 = SUM1*X(I) + SUM2
   10 CONTINUE
      XBAR = SUM2/WVSUM
C
C          DETERMINE RADIUS OF GYRATION (SQUARED)
C          ISW-ISV = 1 ^ SOLID TUBE
C                    2 ^ HOLLOW TUBE
C                    3 ^ LIQUID PROPELLANT
C                    4 ^ CYLINDER (SOLID PROPELLANT)
C
      DO 20 I=2,N
      L(I) = X(I)-X(I-1)
      IF(ISW(I) .EQ. 1) RGSQ(I) = (3.*R(I)**2 + L(I)**2)/12.
      IF(ISW(I) .EQ. 2) RGSQ(I) = (6.*R(I)**2 + L(I)**2)/12.
      IF(ISW(I) .EQ. 4) RGSQ(I) = (3.*(R(I)**2 + R0(I)**2) + L(I)**2)
     *                             /12.
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```
      IF(ISV(I) .EQ. 3) RHOSQ(I) = L(I)**2/12.
      IF(ISV(I) .EQ. 4) RHOSQ(I) = (3.*(R(I)**2 + RO(I)**2) + L(I)**2)
     *                           /12.
   20 CONTINUE
C
C          CALCULATE TOTAL MOMENT OF INERTIA IN SLUG FEET**2
C
      DO 30 I=1,NLASX
      SUM3 = W(I)*RGSQ(I) + V(I)*RHOSQ(I)
     *     + (W(I) + WCANTE(I) + WCANTI(I) + V(I))*(X(I)-XBAR)**2
     *     + SUM3
   30 CONTINUE
      IMNT = 1./(144.*G)*SUM3
C
C          CALCULATE PITCHING ACCELERATION IN RADIANS/SEC**2
C
      DO 40 I=1,NLASX
      SUM4 = (QL(I)+QLEX(I))*(XBAR-X(I)) + SUM4
   40 CONTINUE
      THETAD = 1./(12.*IMNT)*SUM4
C
C          LATERAL ACCELERATION AT C.G. AND AT ANY STATION
C
      DO 50 I=1,NLASX
      SUM5 = QL(I) + QLEX(I) + SUM5
   50 CONTINUE
      YDD = (1./WVSUM)*SUM5
      DO 60 I=1,NLASX
      ACCLAT(I) = YDD + (XBAR-X(I))*THETAD/(12.*G)
   60 CONTINUE
C
C          ***********CALCULATE VEHICLE SHEAR***********
C          CANTILEVERED ITEMS ARE ACCOUNTED FOR AT THEIR REACTION
C          STATIONS.  DELX AND EXDELX ARE GIVEN VALUES AT THE ATTACH
C          POINTS.  WCANTI AND WCANTE ARE GIVEN VALUES AT THE C.G.
C          OF THE CANTILEVERED ITEM.
C
      DO 70 I=1,N
      SUM6 = QL(I) + SUM6
      IF(DELX(I) .NE. 0.) GO TO 72
      IF(EXDELX(I) .NE. 0.) GO TO 74
      SUM7 = (W(I) + V(I))*ACCLAT(I) + SUM7
      GO TO 76
   72 CONTINUE
      JSI = JSI + 1
      IF(JSI .GT. NLASX) GO TO 80
      IF(WCANTI(JSI) .EQ. 0.) GO TO 72
      SAVEM(I) = WCANTI(JSI)*ACCLAT(JSI)
      IF(EXDELX(I) .NE. 0.) GO TO 74
      SUM7 = (W(I) + V(I))*ACCLAT(I) + SAVEM(I) + SUM7
      GO TO 76
   74 CONTINUE
      JSE = JSE + 1
      IF(JSE .GT. NLASX) GO TO 80
      IF(WCANTE(JSE) .EQ. 0.) GO TO 74
      SAVEME(I)=WCANTE(JSE)*ACCLAT(JSE)
      SUM7 = SAVEME(I) + (W(I) + V(I))*ACCLAT(I) +
     *       SAVEM(I) + SUM7
   75 CONTINUE
```

```
      JSEL=JSEL+1
      IF(JSEL .GT. NLASX) GO TO 80
      IF(QLEX(JSEL) .EQ. 0.) GO TO 75
      SUM7 = SUM7 - QLEX(JSEL)
   76 SHEAR(I) = SUM6 - SUM7
   70 CONTINUE
      GO TO 85
   80 CONTINUE
      PRINT 82, N, N, N, JSI, JSE, JSEL
   82 FORMAT(/////,5X,'NUMBER OF CANTILEVERED WEIGHTS INPUT',
     *       /5X,'DOES NOT MATCH NUMBER OF MOMENT ARMS INPUT',
     *       /5X,'IF JSI EXCEEDS ',I3,', CHECK INPUT FOR INTERNALLY',
     *       ' CANTILEVERED ITEMS',/5X,'IF JSE EXCEEDS ',I3,', CHECK',
     *       ' EXTERNALLY CANTILEVERED ITEMS',/5X,'IF JSEL EXCEEDS ',
     *       I3,', CHECK LIFT FORCES (QLEX) ON EXTERNALLY ',/5X,
     *       ' CANTILEVERED ITEMS',/5X,'JSI=',I4,5X,'JSE=',I4,5X,'JSEL='
     *       ,I4)
      STOP
   85 CONTINUE
C
C          ***********CALCULATE VEHICLE BENDING MOMENT***********
C
      DO 90 I=2,N
C          THE FIRST MOMENT TERM, TERM1, ACCOUNTS FOR THE AREA
C          UNDER THE SHEAR DIAGRAM.
      TERM1 = SHEAR(I-1)*(X(I)-X(I-1)) + TERM1
C
C          THE SECOND MOMENT TERM, TERM2, ACCOUNTS FOR PITCHING ACCELERA-
C          TION. NOTE THAT THE CANTILEVERED ITEMS HAVE BEEN NEGLECTED.
C          IT IS ASSUMED THAT THE RADIUS OF GYRATION OF THESE ITEMS WILL
C          BE SMALL IN RELATION TO THE REST OF THE VEHICLE.
C
      TERM2 = (W(I)*RGSQ(I) + ''(I)*RHOSQ(I))*THETAD + TERM2
C
C          TERM3 ACCOUNTS FOR AERO LOADS (QL) ON EXTERNALLY
C          CANTILEVERED ITEMS ONLY.
C
      IF(DELQL(I) .EQ. 0.) GO TO 96
   92 CONTINUE
      JSE2 = JSE2 + 1
      IF(JSE2 .GT. NLASX) GO TO 98
      IF(QLEX(JSE2) .EQ. 0.) GO TO 92
      TERM3 = QLEX(JSE2)*DELQL(I) + TERM3
      GO TO 96
   98 CONTINUE
      PRINT 99, JSE2
      STOP
   99 FORMAT(/////,5X,'ERROR IN LOADS PROGRAM IN ATTEMPT TO',/5X,
     *        'CALCULATE TERM3 MOMENT CONTRIBUTION',
     *        /5X,'JSE2=',I4)
   96 CONTINUE
C          THE FOURTH MOMENT TERM, TERM4, ACCOUNTS FOR
C          CANTILEVERED ITEMS WHICH OVERHANG FROM THEIR REACTION
C          STATIONS.
      TERM4 = SAVEM(I)*DELX(I) + SAVEME(I)*EXDELX(I) + TERM4
      MOMENT(I) = TERM1 - 1./(12.*G)*TERM2 + TERM3 - TERM4
   90 CONTINUE
```

```
C
C           ***********CALCULATE AXIAL LOAD***********
C
      DO 110 I=1,N
      FSUM = F(I) + FSUM
  110 CONTINUE
      AXACCL = -FSUM/WVSUM
      TEMP = 0.
      ISTEP = 1
      DO 120 I=1,N
      TP1 = F(I) + TP1
      IF(DELX(I) .NE. 0.) GO TO 112
      IF(EXDELX(I) .NE. 0.) GO TO 114
      TP2 = W(I) + TP2
      GO TO 115
  112 CONTINUE
      JPI = JPI + 1
      IF(JPI .GT. NLASX) GO TO 130
      IF(WCANTI(JPI) .EQ. 0.) GO TO 112
      TEMP = WCANTI(JPI)
      IF(EXDELX(I) .NE. 0.) GO TO 114
      TP2 = W(I) + TEMP + TP2
      TEMP = 0.
      GO TO 115
  114 CONTINUE
      JPE = JPE + 1
      IF(JPE .GT. NLASX) GO TO 130
      IF(WCANTE(JPE) .EQ. 0.) GO TO 114
      TP2 = W(I) + WCANTE(JPE) + TEMP + TP2
      TEMP = 0.
      GO TO 115
  130 CONTINUE
      PRINT 131,JPI,JPE
  131 FORMAT(/////,5X,'ERROR IN LOADS PROGRAM WHILE CALCULATING',
     *         /5X,'AXIAL LOAD.  JPI=',I4,'  JPE=',I4)
      STOP
  115 CONTINUE
      IF(ISV(I)-3) 122,124,126
C
C           - ^ NO PROPELLANT IN THIS SECTION
C           0 ^ LIQUID PROPELLANT
C           + ^ SOLID PROPELLANT
C
  126 CONTINUE
      TP3 = V(I) + TP3
      GO TO 122
  124 CONTINUE
      IF(I .EQ. IBOT(ISTEP)) GO TO 125
      VSUM = V(I) + VSUM
      GO TO 122
  125 CONTINUE
      VSUM = V(I) + VSUM
      TP3 = VSUM + TP3
      VSUM = 0.
      ISTEP = ISTEP + 1
  122 CONTINUE
      P(I) = TP1 + AXACCL*TP2 + AXACCL*TP3
  120 CONTINUE
```

```
C
C         PRINT RESULTS
C
      PRINT 1000
 1000 FORMAT(8X,'STATION',9X,'SHEAR',6X,'MOMENT',7X,'AXIAL LOAD'/,
     *          8X,'INCHES',11X,'LBS',7X,'IN-LBS',11X,'LBS',/)
      DO 250 I=1,N
      J=I-1
      P(I)=-1.*P(I)
      WRITE(11) X(I),SHEAR(I),MOMENT(I),P(I)
      PRINT 1050,X(I), SHEAR(I), MOMENT(I), P(I), J
 1050 FORMAT(5X,G11.4,5X,G11.4,1X,G11.4,1X,G11.4,1X,G12.4,3X,I3)
  250 CONTINUE
      ENDFILE 11
      REWIND 11
      CALL ADDREL(14,1HX,100,X)
      CALL ADDREL(14,5HSHEAR,100,SHEAR)
      CALL ADDREL(14,6HMOMENT,100,MOMENT)
      CALL ADDREL(14,1HP,100,P)
      END
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APPENDIX

Program LDSTRS is a translator program which takes data from other EDIN programs and arranges it in proper form to be input into the LOADS Program. Stations are synthesized according to the maximum allowable distance between any two adjacent stations which is an input. The nose of the vehicle is assumed to be an ellipse with structural (and propellant) weight distributed according to the integral of the ellipse. For the rest of the vehicle, structural and propellant weights are distributed according to section length and radius. Moment arms are calculated for cantilevered items and are output at the station which represents the attach point for the item.

LDSTRS INPUT

LDSTRS is a program which takes data from the data base and arranges in the proper form to be input into the LOADS program. LDSTRS also synthesizes stations so that a smoother loads analysis will be produced. Data is read into program LDSTRS by namelist $IN. All stations are referenced from the nose of the vehicle.

ENDPY	- Station at end of payload bay in inches.
WPYLD	- Weight of payload in pounds.
BGNPY	- Station at beginning of payload bay in inches.
EXCTCG(I)	- C.G. location of externally cantilevered item. Up to 10 externally cantilevered items may be input.
EXCTWT(I)	- Weight of externally cantilevered item. Dimensioned by 10, the weight of i^{th} item must correspond to EXCTCG(I).
INCTCG(I)	- C.G. location of internally cantilevered item. Up to 10 items may be input.
INCTWT(I)	- Weight of the i^{th} internally cantilevered item.
EXCTAT(I)	- Location of attach point of externally cantilevered item.
INCTAT(I)	- Location of attach point of internally cantilevered item.
WTOT(I)	- Total structural weight of the i^{th} stage less the weight of cantilevered items. Up to 4 stages may be input with WTOT(1) = weight of last stage, WTOT(2)= weight of next to last stage, etc.
ENDSTG(I)	- Station at end of stage. ENDSTG(1)=0.0, ENDSTG(2)= end of final stage, etc.
VLOX(I)	- Weight of LOX in i^{th} tank. Up to 10 tanks may be input.
VRP(I)	- Weight of liquid propellant in i^{th} tank. Up to 10 tanks may be input.

WLXST(I) - Weight of i^{th} LOX tank structure.

WRPST(I) - Weight of i^{th} liquid propellant tank structure.

BGNLX(I) - Station which denotes beginning of i^{th} LOX tank.

ENDLX(I) - Station which denotes end of i^{th} LOX tank.

BGNRP(I) - Station which denotes beginning of i^{th} liquid propellant tank.

ENDRP(I) - Station which denotes end of i^{th} liquid propellant tank.

VSLD(I) - Weight of solid propellant in i^{th} tank. Up to 10 tanks may be input.

WVSST(I) - Weight of i^{th} solid propellant tank structure.

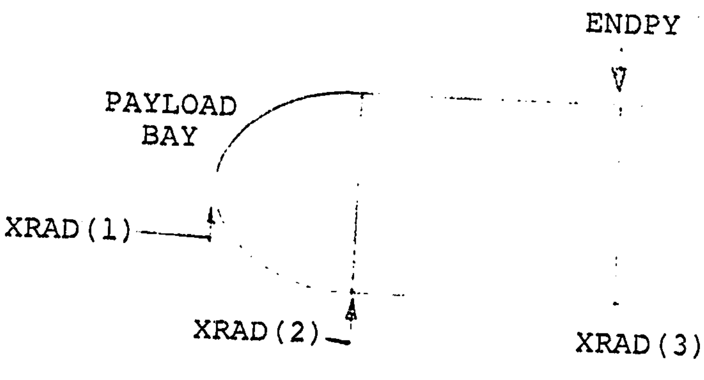
VSRADI(I) - Internally radius of i^{th} solid propellant tank.

BGNVS(I) - Station which denotes beginning of i^{th} solid propellant tank.

ENDVS(I) - Station which denotes end of i^{th} solid propellant tank.

RADGYR(I) - Radius of gyration indicator. Up to 10 may be input with each RADGYR(I) corresponding to XRAD(I).

XRAD(I) - Station at which radius and radius of gyration have been input. XRAD(1)=0.0 XRAD(2)= point at which slope of ellipse becomes zero, XRAD(3) = ENDPY.



RAD(I)	- Radius at i^{th} station. RAD(1)=0.0, RAD(I)=XPAD(I).
QLEXF(I)	- Normal aerodynamic force on externally cantilevered item.
XQLEXF(I)	- Location of QLEXF(I).
QLF(I)	- Normal aerodynamic force on vehicle. Up to 20 may be input.
XQL(I)	- Location of QL(I).
FF(I)	- Tangential aerodynamic force. Up to 10 may be input.
XF(I)	- Location of FF(I).
XMAX	- Maximum allowable distance between any two adjacent stations.