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A STRUCTURAL WEIGHT ESTIMATION PROGRAM (SWEEP) FOR AIRCRAFT. VOLUME V - AIR INDUCTION SYSTEM AND LANDING GEAR MODULES. PART 2: LANDING GEAR MODULE

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Rockwell International Corporation

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Three computer programs were written with the objective of predicting the structural weight of aircraft through analytical methods. The first program, the structural weight estimation program (SWEEP), is a completely integrated program including routines for airloads, loads spectra, skin tem- peratures, material properties, flutter stiffness requirements, fatigue life, structural sizing, and for weight estimation of each of the major aircraft structural components. The program produces first-order weight estimates		

and indicates trends when parameters are varied. Fighters, bombers, and cargo aircraft can be analyzed by the program. The program operates within 100,000 octal units on the Control Data Corporation 6600 computer. Two stand-alone programs operating within 100,000 octal units were also developed to provide optional data sources for SWEEP. These include (1) the flexible airloads program to assess the effects of flexibility on lifting surface airloads, and (2) the flutter optimization program to optimize the stiffness distribution required for lifting surface flutter prevention.

The final report is composed of 11 volumes. This volume (volume V) contains the methodology program description, and user's information for the air induction system and landing gear modules of SWEEP.

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JAMES H. HALL, Colonel, USAF
Deputy for Development Planning

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PART 2
LANDING GEAR MODULE

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Section I

INTRODUCTION AND SUMMARY

MODULE STRUCTURE

The landing gear module is written in FORTRAN IV extended for the CDC 16600 computer. It is contained in overlay (6,0), which is considerably smaller than the 50,000-octal core limit of SWEEP.

The landing gear module consists of a main program, LANDGR, and five subroutines - LGEAR, LGWT, LOADS, LG3P, and BMOR:

- LANDGR - Reads input data
- LGEAR - Determines drag, side, and vertical loads on wheels
- LOADS - Determines axial and normal loads on strut
- LGWT - Computes weight of landing gear
- BMOR - Determines bending modulus of rupture and torsion modulus of rupture
- LG3P - Three-point interpolation routine

DESIGN PARAMETERS

The design parameters which are included in the landing gear analysis are:

- Takeoff and landing weights of aircraft
- Wing area
- Center of gravity of aircraft at takeoff and landing weights
- Distance from center of gravity to ground
- Landing speed at takeoff and landing weights
- Sink speed at takeoff and landing weights

- Load factor at takeoff and landing weights
- Coefficient of lift at takeoff and landing weights
- Material properties (density, modulus of elasticity, ultimate tensile strength, yield compression strength, Poisson's ratio)
- Fuselage station of main and nose gears
- Distance between main gear struts
- Length of main and nose gear struts
- Stroke of main and nose gears
- Piston diameter of main and nose gears
- Eccentricity of main and nose gear wheels
- Number of wheels per strut for main and nose gears
- Strut angles (fore-aft and lateral) of main gear
- Strut angle (fore-aft) of nose gear
- Dimensions of main and nose gear tires

LANDING GEAR LOADS

The landing gear loads analysis in subroutine LGEAR follows the procedure outlined in MIL-A-008862A (USAF).⁽¹⁾

The axial and normal loads on the strut are determined for eight load conditions. These eight conditions are shown in Figure 36.

The loads for the two-point landing, spin-up, spring-back, and unsymmetrical braking load conditions are determined at both the takeoff and landing weights for both the main and nose gears.

The loads for the braked roll and drift landing conditions are determined at both the takeoff and landing weights for the main gear only.

1. Military Specification MIL-A-008862A (USAF), "Airplane Strength and Rigidity, Landing and Ground Loads," 31 March 1971.

	Main Gear		Nose Gear	
	T.O. wt	Ldg wt	T.O. wt	Ldg wt
Two-point landing	X	X	X	X
Spinup	X	X	X	X
Springback	X	X	X	X
Braked roll	X	X		
Drift Landing	X	X		
Unsymmetrical Braking	X	X	X	X
Towing	X		X	
Turning	X		X	

Figure 36. Load conditions analyzed in subroutine LGEAR.

The loads for the towing and turning conditions are determined at the takeoff weight only for both the main and nose gears.

The program user may bypass the loads analysis and specify the design loads in the variable input data.

LANDING GEAR WEIGHTS

The weight of the landing gear is determined by analytical methods for as much of the gear as is practicable. A statistical method is then used to compute the "miscellaneous weight" which will produce a total weight consistent with the known weights of many past landing gears.

The parts of the landing gear which are treated analytically are listed in the following paragraphs, along with a brief summary of the method used.

OUTER CYLINDER

The geometry of the outer cylinder is shown in Figure 37. The weight is determined by calculating the areas at sections 1, 2, and 3, which are at the top, midpoint, and bottom of the outer cylinder. The area at each section is calculated by searching for the value of the ratio of outside diameter to wall thickness for which the geometric area equals the area required for strength.

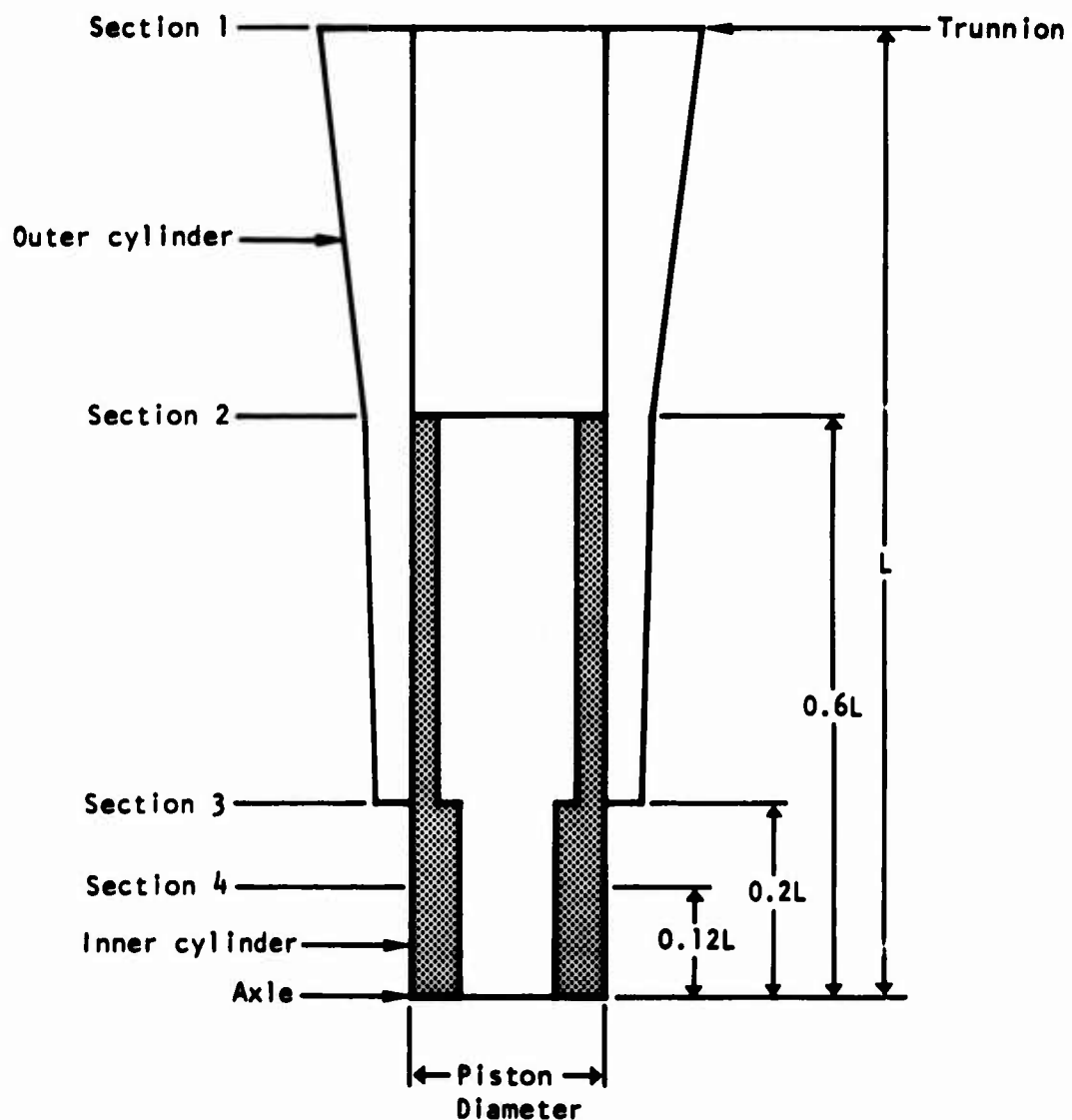


Figure 37. Inner cylinder and outer cylinder geometry.

INNER CYLINDER (PISTON)

The geometry of the inner cylinder is also shown in Figure 37. The inner cylinder has a constant outside diameter, the piston diameter, which is either given in the input data or calculated as a function of the static load. The inner cylinder extends from the axle to section 2, the midpoint of the outer cylinder. The area of the inner cylinder at section 4 is calculated in the same manner as the areas of the outer cylinder. The weight of the inner cylinder is then calculated by using the area at section 4 as the constant area from the axle to section 3, and using an area based on an assumed diameter to wall thickness ratio as the area between sections 3 and 2.

AXLE

The geometry of the axle is shown in Figure 38. The length of the axle is the width of the tire plus one-half the inner cylinder (piston) diameter.

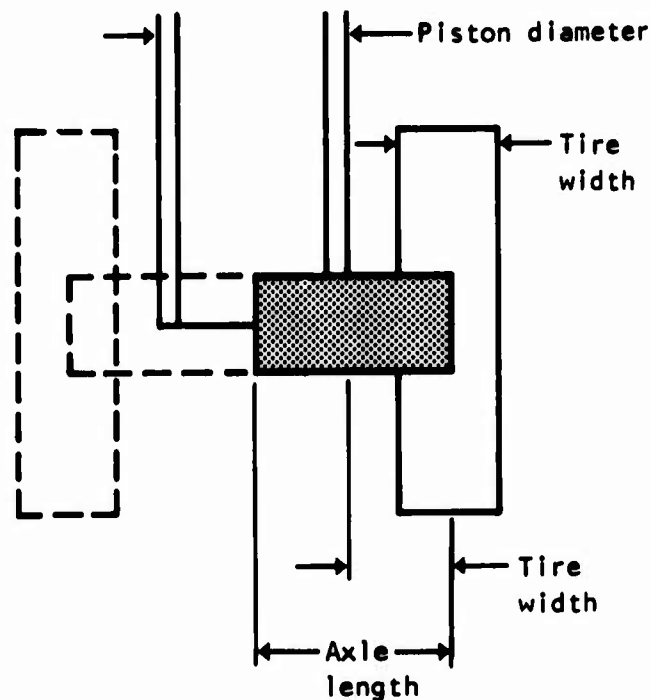


Figure 38. Axle geometry.

The bending and torsion moments on the axle are determined by assuming that the gross weight of the aircraft is divided evenly among the total number of main gear wheels, or that the static load on the nose gear is divided evenly among the nose gear wheels, but that one tire is flat when there are two wheels on a strut, and that two tires on one strut are flat when there are four wheels on a strut.

The diameter of the axle at the side of the piston is determined, and the weight is calculated by using this area as the constant diameter of the axle.

The axle is a solid cylinder, but the bending modulus of rupture and the torsion modulus of rupture used in the calculation of the diameter are based on a diameter-to-wall-thickness ratio equal to 10.

BOGIE

The geometry of the bogie is shown in Figure 39. The length of the bogie is equal to the piston diameter plus 1.1 times the outside diameter of the tires.

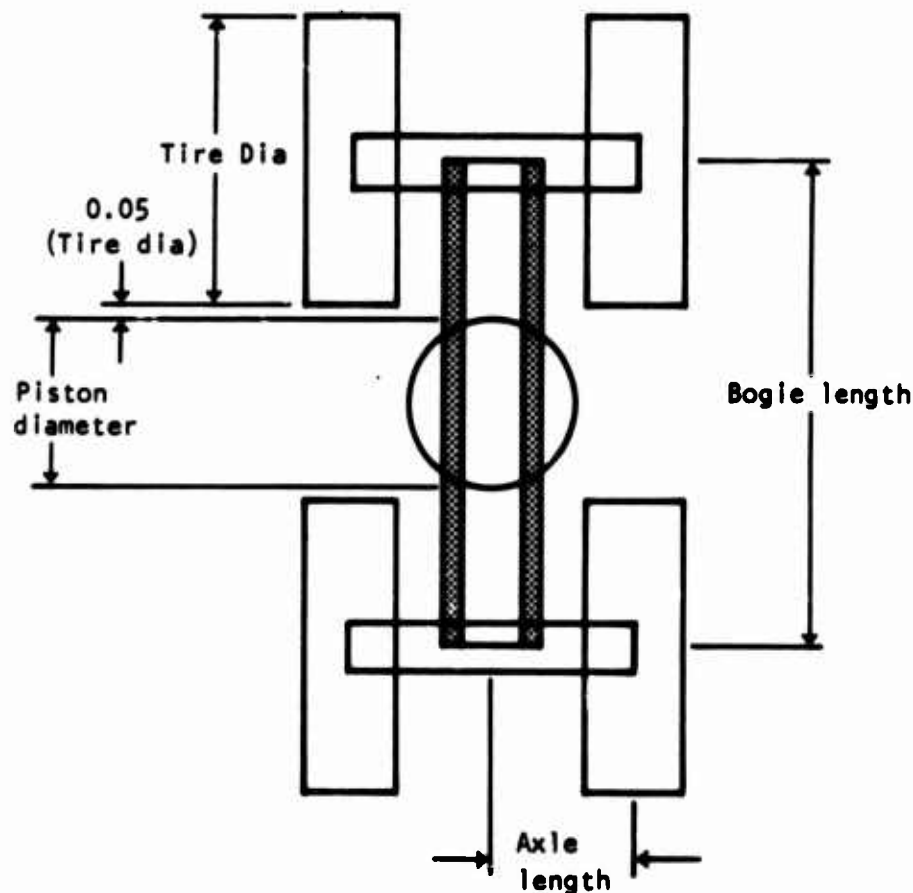


Figure 39. Bogie geometry.

The weight of the bogie is calculated only when there are four tires per strut on the main gear. The bending and torsion moments on the bogie are determined by assuming that both tires on one axle are flat. The area at the midpoint of the bogie length is calculated from the moments and an assumed value of the ratio of outside diameter to cylinder wall thickness. The weight of the bogie is calculated by using the area at the midpoint as the constant area of the bogie.

DRAG AND SIDE STRUTS

The geometry of the drag strut or the side strut is shown in Figure 40. The drag and side struts are assumed to be solid; therefore, the area is the load divided by the compression yield strength.

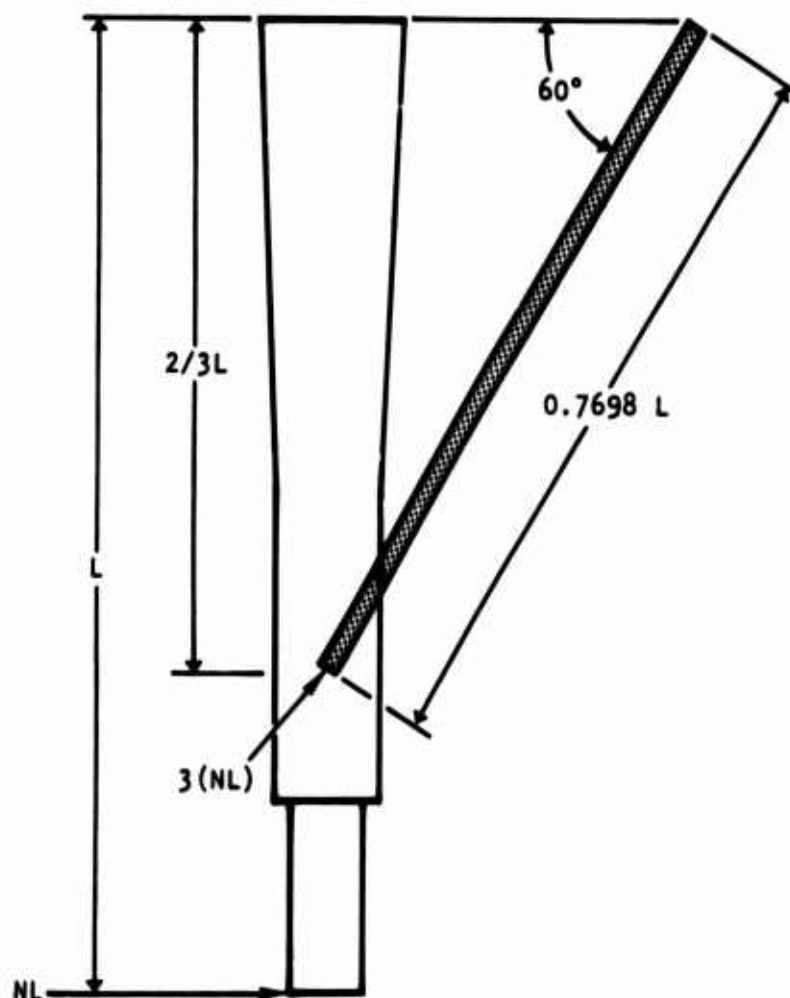


Figure 40. Drag strut or side strut geometry.

The normal load, NL, which determines the weight of the side strut is the larger of the normal loads from the drift landing and turning conditions. The normal load which determines the weight of the drag strut is the largest load from the six load conditions which act in the fore-aft direction - two-point landing, spinup, springback, braked roll, unsymmetrical braking, and towing.

OIL

The weight of the oil is a function of the stroke, the piston diameter, and an assumed oil density.

TIRES, TUBES, AND WHEELS

The weight of the tires, tubes and wheels is calculated from the diameter and width of the tires.

BRAKES

The weight of the brakes is a function of the weight of the aircraft, the landing speed, and an assumed ratio of pounds of brakes to foot-pounds of kinetic energy.

WEIGHT COEFFICIENTS

Coefficients may be applied to the calculated weights of the inner cylinder, outer cylinder, bogie drag strut, and side strut. Coefficients may also be applied to the total weight, including the calculated miscellaneous weight, of either the main gear or nose gear.

These coefficients can be used to account for configurations which are not similar to the simplified landing gear design assumed in this program.

A fixed weight may also be input to account for any weight item not included in this program.

MODULE OPERATION

MASS STORAGE

The input data to the landing gear module are contained in one data array with 116 locations. This array is stored in mass storage file record 25.

Mass storage file record 25 is read in LANDGR. No mass storage file records are written in the landing gear program.

PERMANENT DATA

The first 45 locations in the input data array are permanent data, and are read from the permanent data file, TAPE7, in the first case of each job. Table 31 lists the variables in these permanent data and the values which are stored in the permanent data file.

These permanent data values may be changed by reading new data into these locations when the variable input data for each case are read. The new value will remain in the input data for each following case in the job, but does not change the value stored in the permanent data file.

Some of the permanent data values which the program user may want to change, in order to better approximate a specific landing gear design, are as follows (refer to Table 31 for a complete list of permanent data:

1. The ultimate-to-limit-load-factor ratio (1.5 now assumed in the permanent data file)
2. The number of main gear struts (two now assumed)
3. The fraction of energy absorbed by the strut (0.1 now assumed)
4. The pounds of brake weight per foot-pound of kinetic energy (0.408×10^{-5} lb/ft-lb now assumed)
5. The density of oil (0.03 lb/in.^3 now assumed)
6. The values of diameter to cylinder wall thickness for the axle, bogie, and upper portion of the inner cylinder (10, 20, and 50, respectively, now assumed)
7. The ratio of the nose gear piston diameter to the main gear piston diameter, used, when the nose gear piston diameter is not given in the input data (0.6 now assumed).
8. The stroke coefficients, used to determine the "effective stroke" of the main and nose gears at takeoff and landing weights (1.0 now assumed)

9. The fraction of the strut length from the axle to each of the four sections at which the area is calculated (1.0, 0.6, 0.2, and 0.12 now assumed)
10. The miscellaneous weight factors for the main and nose gears

VARIABLE INPUT DATA

The variable input data are contained in locations 46 through 116 of the landing gear input data. These variable input data are described in Table 32. The variable input data in locations 46 through 116, along with the changes, if any, to the permanent data in locations 1 through 45, are placed in the SWEEP input data deck behind an identification card containing "LG" in columns 1 and 2.

The landing gear module, overlay (6,0), may be run as a stand-alone program. In this case, only the data read module the landing gear module, and, if wanted, the final output module will be called.

All of the data required for the landing gear module must be included in the landing gear data deck when the module is run in a stand-alone mode. However, when the data management module is also executed (or has been executed in a previous case in this job), the data in 17 locations of the landing gear variable data may be omitted. These locations are listed in Table 29.

The data in the 17 locations listed in Table 29 are also included in the general input data, which must be input before the data management module can be executed. Location 46, which contains the takeoff weight, is used to indicate that these data values are to be transferred to the landing gear data. The value in location 46 is stored in location 24 of array XMISC, which is in labeled common block/MISC/. When this value is 0, subroutine DLNDGR in the data management module will read mass storage record 25. The data listed in Table 29 will be placed in the landing gear data array, and the revised record 25 will be written in the mass storage file.

Note that values will be placed in all of the 17 locations listed in Table 29 when the value in location 46 is 0, so that any value input in one of the other 16 locations in the landing gear input data would be replaced.

TABLE 29. LANDING GEAR DESIGN DATA FROM DATA MANAGEMENT MODULE

Loc	Description
46	Takeoff weight, lb
47	Landing weight, lb
48	Aborted takeoff Δ weight, lb
49	Fuselage station of CG of aircraft at takeoff, in.
50	Fuselage station of CG of aircraft at landing, in.
51	Distance from aircraft CG to ground, in.
52	Fuselage station of main gear, in.
53	Fuselage station of nose gear (or tail wheel), in.
54	Distance between main gear struts, in.
72	Axle to trunnion length of main gear strut with piston extended, in.
73	Stroke of main gear, in.
81	Axle to trunnion length of nose gear with piston extended, in.
82	Stroke of nose gear, in.
89	Sink speed at takeoff weight, ft/sec
90	Sink speed at landing weight, ft/sec
91	Landing speed at takeoff weight, ft/sec
92	Landing speed at landing weight, ft/sec

Variable Input Data Options

The program user has several options when filling out the landing gear variable data. These options are summarized here, and are described in greater detail in Section II and in the notes following Table 32.

1. The calculation of the landing gear loads may be bypassed. In this case, the program user must specify the design loads in the input data.
2. The auxiliary gear may be a tail wheel instead of a nose gear. The tail wheel weight is determined by a single statistical equation.
3. The piston diameter may be input, or the program may compute the piston diameter from the static load on the strut.
4. The landing speeds may be input, or the program may compute the landing speeds from the coefficients of lift, the wing area, and the takeoff and landing weights.
5. The load factors may be input, or the program may compute the load factors from the strokes, the sink speeds, the wing lift coefficient, and the tire diameter.
6. The wheel, tire, and tube weights may be input, or they may be computed by the program from the tire dimensions.
7. The brake weight may be input, or the program may compute the brake weight from the takeoff weight and the landing speed.
8. The inertia of the main gear wheels, tires, tubes, and brakes may be input, or it may be computed by the program from the wheel, tire, tube, and brake weights and the tire dimensions.
9. The effect of the deflections (fore-aft, lateral, and angular) of the strut may be included or may be omitted in the calculations of the weight of the inner and outer cylinders. If there are no deflections (and the eccentricity of the wheels is 0), the axial load on the strut has no moment arm, and all the bending moment on the strut comes from the normal load.

The program first computes the weight of the inner and outer cylinders with no deflections on the strut. If the deflections are not to be included, this completes the analysis. If the effect of the deflection is to be included, the deflections are determined and

the weights are recalculated with the increased moment resulting from the deflection. This loop continues for a maximum of six passes, or until the difference between the areas calculated at section 2, Figure 37, for two successive passes is less than a given tolerance.

OUTPUT

Program LANDGR and subroutine LGEAR will produce printed output if the appropriate print indicator is turned on. Program LANDGR will print (on one page) the variable input data in locations 46 through 116. Subroutine LGEAR will print (on one page) the landing gear loads.

The weight summary, design data, deflections, and CG data for the main gear (one page) and the nose gear (one page) are always printed in subroutine LGWT.

Comments, Warning Messages, and Error Messages

There are no warning messages or error messages printed in the landing gear program.

The only comment printed is a reminder to the program user that if the design load conditions indicators are all 0, this means that the loads were not computed but were supplied by the user in the input data.

Section II

METHODS AND FORMULATIONS

GENERAL DISCUSSION

An analytical approach to strut weight estimation which is applicable to both main and nose gears is used. This approach idealizes the strut as a cantilevered member designed to the spectrum of ground loads. Wheels, brakes, tires, and tube weights are either user input or calculated by the program. Statistical equations are used to calculate these components.

Specific design data development and weight calculation functions are divided into separate routines which are called by the landing gear weight estimation module control program LANDGR. Methods employed are described herein in the order that they are used in the program. Table 30 is a list of symbols that are used in the formulations that follow. Subscript I in this table is used to represent the four strut sections, Figure 37.

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS

Symbol	Description	Units
AA	Scratch variable	
A	Distance from CG to main gear, either A_{TO} or A_L	in.
ACM	Scratch variable	
A_L	Distance from CG at landing to main gear	in.
A_{TO}	Distance from CG at takeoff to main gear	in.
AG	Geometric area for assumed value of DOT	in. ²
AL	Axial load on strut at this load condition	lb
ALOAD	Axial load on strut	lb
AL _{SB}	Axial load on either main or nose gear strut at either takeoff or landing weight for spring-back condition	lb
ANG	Angle between resultant load and strut	radians
AREA _I	Maximum of areas computed at section I for each load condition	in. ²
AREAC	Final area of cylinder section for load condition	in. ²
AS	Area required for strength for assumed value of DOT	in. ²
AXLGTH	Length of axle	in.

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS (CONT)

Symbol	Description	Units
AXLOAD	Total load on axles for either main or nose gear	lb
A1	Fore-aft angle of strut	radians
A2	Lateral angle of strut	radians
BB	Scratch variable	
B	Distance from CG to nose gear, either B_{T0} or B_L	in.
B_L	Distance from CG at landing to nose gear	in.
B_{T0}	Distance from CG at takeoff to nose gear	in.
BCM	Scratch variable	
BD	Diameter of bogie	in.
BMAX	Bending moment on each axle	in.-lb
BMB	Bending moment at midpoint of bogie	in.-lb
BMR_I	Resultant of fore-aft and lateral bending moments at section I	in.-lb
BMRU	Bending modules of rupture	lb/in. ²
BMY_I	Fore-aft bending moment at section I	in.-lb
BMYDZ	Fore-aft bending moment from condition which produced max area at section 2	in.-lb
BMZ_I	Lateral bending moment at section I	in.-lb
BMZDZ	Lateral bending moment from condition which produced max area at section 2	in.-lb
BOGL	Length of bogie	in.
BRAKES	Weight of brakes per aircraft	lb
BRC	Braked roll constant	
BWT	Weight of bogie	lb
CG_{T0}	CG of aircraft at takeoff	in.
CGG	Distance from CG to ground	in.
CL_L	Coefficient of lift at landing weight	
CL_{T0}	Coefficient of lift at takeoff weight	
CL_W	Wing lift coefficient	
CRFA	Cosine of angle between resultant load and fore-aft direction	
CRL	Cosine of angle between resultant load and lateral direction	
CRV	Cosine of angle between resultant load and vertical	
CSFA	Cosine of angle between strut and fore-aft direction	
CSL	Cosine of angle between strut and lateral direction	
CSV	Cosine of angle between strut and vertical	

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS (CONT)

Symbol	Description	Units
DF	Drag (fore-aft) load on wheels	lb
DIA _I	Outside diameter of cylinder at section I for assumed value of DOT	in.
DIAAX	Diameter of axle at side of piston	in.
DIADZ	Diameter of outer cylinder at section 2	in.
DIAM	Final outside diameter of cylinder for this load condition	in.
DIST	Distance from main gear to nose gear	in.
DLLNG _I	Length from ground to section I	in.
DMGS	Distance between main gear struts	in.
DOIL	Density of oil	lb/in. ³
DOT	Diameter to wall thickness ratio	
DOTB	Assumed value of DOT for bogie	
DOT32	Assumed value of DOT of inner cylinder between sections 2 and 3	
DOVRT2	Diameter to wall thickness ratio at section 2	
DOVT	Final interpolated value of DOT for which R = 1	
DP	Piston diameter, either DP _M or DP _N	in.
DP _M	Diameter of main gear piston	in.
DP _N	Diameter of nose gear piston	in.
DSWT	Weight of main or nose gear side strut	lb.
DWT	Aborted takeoff delta weight	lb.
E	Modulus of elasticity	lb/in. ²
ECC	Eccentricity of wheels	in.
FCY	Compression yield stress	lb/in. ²
FEA	Fraction of energy absorbed by strut	
FS _M	Fuselage station of main gear	in.
FS _N	Fuselage station of nose gear	in.
FTOW	Tow load	lb
FVSU	Vertical spinup load at time TSU on either main or nose gear at either takeoff or landing weight	lb
g	Gravitational constant	ft/sec ²
G	Modulus of rigidity	lb/in. ²
GRWT	Gross weight, either GRWT _{T0} or GRWT _L	lb
GRWT _L	Landing gross weight	lb
GRWT _{T0}	Takeoff gross weight	lb

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS (CONT)

Symbol	Description	Units
I	Section index	
I2	Moment of inertia at section 2	in. ⁴
IW	Inertia of wheels, tires, tubes, and brakes, either IW_M or IW_N	slug-ft ²
IW_M	Inertia, per strut, of main gear wheels, tires, tubes, and brakes	slug-ft ²
IW_N	Inertia of nose gear wheels, tires, and tubes	slug-ft ²
$LNGTM_I$	Length from axle to section I	in.
NG	Load factor, either NG_L or NG_{T0}	
NG_L	Load factor at landing weight	
NG_{T0}	Load factor at takeoff weight	
NL	Normal load on the strut at this load condition	lb
NLSB	Normal load on either main or nose gear strut at either takeoff or landing weight for springback condition	lb
NLSU	Normal load on either main or nose gear strut at either takeoff or landing weight for spinup condition	lb
OD	Outside diameter of tires, either OD_M or OD_N	in.
OD_M	Outside diameter of main gear tires	in.
OD_N	Outside diameter of nose gear tires	in.
Φ_{IAX}	Angular deflection at bottom of strut	radians
Φ_I	Angular deflection at section I	radians
PI	Ratio of circumference of circle to diameter of circle	
PLOAD	Normal load on strut	lb
R	Ratio of area required for strength to geo- metric area	
RADPD	Scratch variable	
RB2	Ratio of deflections at bottom of strut to deflections at section 2	
RHO	Density of material	lb/in. ³
RI2	Ratio of deflection at section I to deflection at section 2	
RLOAD	Resultant load of drag, side, and vertical loads on wheels	lb

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS (CONT)

Symbol	Description	Units
S_W	Wing area	ft ²
SF	Side (lateral) load on wheels	lb
SS	Sink speed	ft/sec
SS_L	Sink speed at landing weight	ft/sec
SS_{TO}	Sink speed at takeoff weight	ft/sec
SSWT	Weight of main or nose gear side strut	lb
STREFF	Effective stroke of main or nose gear at takeoff or landing weight	ft
STROKE	Stroke of either main or nose gear	in.
$STROKE_L$	Effective stroke of main gear at landing weight	ft
$STROKE_{TO}$	Effective stroke of main gear at takeoff weight	ft
$STRUT_M$	Number of main gear struts	
STRUTS	Number of struts, main, or nose gear (always 1 for nose gear)	
SW	Static load on each main gear strut	lb
T	Ultimate tensile strength divided by 1,000	lb/in. ² $\times 10^{-3}$
TAILWT	Weight of tail wheel	lb
TMAX	Torsion moment on each axle	in.-lb
TMB	Torsion moment at midpoint of bogie	in.-lb
TMOR	Torsion modulus of rupture	lb/in. ²
TOTAL	Total weight of either main or nose gear	lb
TOTCAL	Total calculated structure weight of either main or nose gear	lb
TOTLNG	Length of strut, axle to trunion	in.
TOTSTW	Total calculated weight of either main or nose gear	lb
TPM_I	Torsional bending moment at section I	in.-lb
TPHIDZ	Torsion moment from condition which produced max area at section 2	in.-lb
TSU	Time for wheel circumferential velocity to reach ground velocity	sec
TT_M	Weight per aircraft of main gear tubes and tires	lb
TT_N	Weight per aircraft of nose gear tubes and tires	lb
TV	Time to develop vertical reaction	sec

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS (CONT)

Symbol	Description	Units
VF	Vertical load on wheels	lb
VL	Landing speed, either VL_{T0} or VL_L	ft/sec
VL_L	Landing speed at landing weight	ft/sec
VL_{T0}	Landing speed at takeoff weight	ft/sec
VMX	Maximum vertical load, either $VMXMG_{T0}$, $VMXMG_L$, $VMXNG_{T0}$, or $VMXNG_L$	lb
$VMXMG_L$	Maximum vertical load on main gear at landing weight	lb
$VMXMG_{T0}$	Maximum vertical load on main gear at takeoff weight	lb
$VMXNG_L$	Maximum vertical load on nose gear at landing weight	lb
$VMXNG_{T0}$	Maximum vertical load on nose gear at takeoff weight	lb
W	Width of tires, either W_M or W_N	in.
W_M	Width of main gear tires	in.
W_N	Width of nose gear tires	in.
WCB	Weight coefficient for bogie	
WCDS	Weight coefficient for drag strut	
WCIC	Weight coefficient for inner cylinder	
WCMG	Weight coefficient for main gear	
WCNG	Weight coefficient for nose gear	
WCOC	Weight coefficient for outer cylinder	
WCSS	Weight coefficient for side strut	
$WHEEL_M$	Weight per aircraft of main gear wheels	lb
$WHEEL_N$	Weight per aircraft of nose gear wheels	lb
WMI	Input miscellaneous weight	lb
WS	Number of wheels per strut, either WS_M or WS_N	
WS_M	Wheels per strut on main gear	
WS_N	Wheels per strut on nose gear	
WTAXL	Total weight of axles for either main or nose gear	lb
WTMISC	Miscellaneous weight of either main or nose gear	lb
WTIC	Weight of inner cylinder	lb
WTOC	Weight of outer cylinder	lb
WTOIL	Weight of oil for either main or nose gear	lb
WTT_M	Weight per wheel of main gear wheel, tire, and tube	lb

TABLE 30. LIST OF SYMBOLS IN METHODS AND FORMULATIONS (CONCL)

Symbol	Description	Units
WTT _N	Weight per wheel of nose gear wheel, tire, and tube	lb
WTT _B	Weight wheels, tires, tubes, and brake for either main or nose gear	lb
Y _{AX}	Fore-aft deflection at bottom of strut	in.
Y _I	Fore-aft deflection at section I	in.
Z _{AX}	Lateral deflection at bottom of strut	in.
Z _I	Lateral deflection at section I	in.

OPTIONAL INPUT VARIABLES

The landing speeds; the load factor; the piston diameters; the wheel, tire, and tube weights; the brake weight; and the inertia of the main gear wheels, tires, tubes, and brakes must be determined if these variables were not given in the input data.

LANDING SPEED

The landing speeds are calculated from the aircraft weights, the wing area, and the coefficients of lift.

$$V_{L_{T0}} = 34.7776 \left(\frac{GRWT_{T0} - DWT}{S_W CL_{T0}} \right)^{0.5} \quad (1)$$

$$V_{L_L} = 34.7776 \left(\frac{GRWT_L}{S_W CL_L} \right)^{0.5} \quad (2)$$

VL_{T0} = landing speed at takeoff weight, ft/sec
 VL_L = landing speed at landing weight, ft/sec
 $GRWT_{T0}$ = takeoff gross weight, lb
 $GRWT_L$ = landing gross weight, lb
 S_W = wing area, ft²
 CL_{T0} = coefficient of lift at takeoff weight
 CL_L = coefficient of lift at landing weight
 DWT = aborted takeoff delta weight, lb

LOAD FACTORS

The load factors are calculated from the strokes, the sink speeds, the wing lift coefficient, and the tire diameter.

$$NG_{T0} = \frac{(1-FEA) \left(\frac{SS_{T0}^2}{2g} + (1-CL_W) \left(0.98 \text{ STROKE}_{T0} + 0.08 \frac{OD_M}{12} \right) \right)}{0.8 \text{ STROKE}_{T0}} + CL_W \quad (3)$$

$$NG_L = \frac{(1-FEA) \left(\frac{SS_L^2}{2g} + (1-CL_W) \left(0.98 \text{ STROKE}_L + 0.08 \frac{OD_M}{12} \right) \right)}{0.8 \text{ STROKE}_L} + CL_W \quad (4)$$

NG_{T0} = load factor at takeoff weight
 NG_L = load factor at landing weight
 FEA = fraction of energy absorbed by strut
 SS_{T0} = sink speed at takeoff weight, ft/sec
 SS_L = sink speed at landing weight, ft/sec

- CL_W = wing lift coefficient
 $STROKE_{TO}$ = effective stroke of main gear at takeoff weight, ft
 $STROKE_L$ = effective stroke of main gear at landing weight, ft
 OD_M = outside diameter of main gear tires, in.
 g = gravitational constant (32.172), ft/sec²

PISTON DIAMETERS

The main gear piston diameter is a function of the static load.

$$SW = \frac{GRWT_{TO} \left| \frac{CG_{TO} - FS_N}{FS_M - FS_N} \right|}{STRUT_M} \quad (5)$$

- SW = static load on each main gear strut, lb
 CG_{TO} = CG of aircraft at take-off, in.
 FS_N = fuselage station of nose gear, in.
 FS_M = fuselage station of main gear, in.
 $STRUT_M$ = number of main gear struts

If SW is greater than 77,295, the piston diameter is calculated by equation 6.

$$DP_M = \left(\frac{4}{15,000 \text{ PI}} SW \right)^{0.5} \quad (6)$$

- DP_M = diameter of main gear piston, in.
 PI = ratio of circumference of circle to diameter of circle (3.1416)

If SW is less than 77,295, the scratch variables ACM, BCM, AA, BB, and RADPD are determined, and the piston diameter is then calculated by equation 7.

$$\left. \begin{array}{l} \text{ACM} = 187.5 \\ \text{BCM} = 380.0 \end{array} \right\} \text{SW} < 5,542$$

$$\left. \begin{array}{l} \text{ACM} = 126.7 \\ \text{BCM} = 545.0 \end{array} \right\} 5,542 < \text{SW} < 33,819$$

$$\left. \begin{array}{l} \text{ACM} = 95.6 \\ \text{BCM} = 720.0 \end{array} \right\} 33,819 < \text{SW} < 77,295$$

$$\text{AA} = -0.333 \left(\frac{\text{BCM}}{\text{ACM}} \right)^2$$

$$\text{BB} = \frac{2}{27} \left(\frac{\text{BCM}}{\text{ACM}} \right)^3 - \frac{4}{\text{PI}} \frac{\text{SW}}{\text{ACM}}$$

$$\text{RADPD} = \left(\frac{\text{BB}^2}{4} + \frac{\text{AA}^3}{27} \right)^{0.5}$$

$$\text{DP}_M = \left(\frac{-\text{BB}}{2} + \text{RADPD} \right)^{0.333} + \left(\frac{-\text{BB}}{2} - \text{RADPD} \right)^{0.333} - \frac{\text{BCM}}{3 \text{ ACM}} \quad (7)$$

The nose gear piston diameter is a function of the main gear piston diameter.

$$\text{DP}_N = 0.6 \text{ DP}_M \quad (8)$$

DP_N = diameter of nose gear piston, in.

WHEEL, TIRE, AND TUBE WEIGHTS

The wheel, tire, and tube weights are calculated from the width and diameter of the wheels.

$$WTT_M = 0.425 OD_M W_M + 0.00023 \left(\frac{OD_M W_M}{100} \right)^7 \quad (9)$$

$$WTT_N = 0.4 OD_N W_N + 0.0000024 \left(\frac{OD_N W_N}{100} \right)^8 \quad (10)$$

WTT_M = weight per wheel of main gear wheel, tire, and tube, lb

WTT_N = weight per wheel of nose gear wheel, tire, and tube, lb

OD_N = outside diameter of nose gear tires, in.

W_M = width of main gear tires, in.

W_N = width of nose gear tires, in.

45 percent of the wheel, tire, and tube weight is in the wheels; therefore, the total wheel, tire, and tube weights can be computed by equations 11 through 14.

$$WHEEL_M = 0.45 WS_M WTT_M \quad (11)$$

$$TT_M = 1.222 WHEEL_M \quad (12)$$

$$WHEEL_N = 0.45 WS_N WTT_N \quad (13)$$

$$TT_N = 1.222 WHEEL_N \quad (14)$$

$WHEEL_M$ = weight per aircraft of main gear wheels, lb

$WHEEL_N$ = weight per aircraft of nose gear wheels, lb

TT_M = weight per aircraft of main gear tubes and tire, lb

TT_N = weight per aircraft of nose gear tubes and tires, lb

WS_M = wheels per strut on main gear

WS_N = wheels per strut on nose gear

BRAKE WEIGHT

The brake weight is calculated from the takeoff weight and the landing speed. All the brake weight is in the main landing gear.

$$BRAKES = 0.010783 GRWT_{TO} VL_{TO}^2 0.00000408 \quad (15)$$

$BRAKES$ = weight of brakes per aircraft, lb

ROTATING INERTIA OF WHEEL ASSEMBLY

Polar moment of inertia for main gear wheels, tires, tubes, and brakes is calculated from the wheel, tire, tube, and brake weights and the tire dimensions.

$$IW_M = \frac{\left(\frac{OD_M}{12(2.52)}\right)^2 TT_M + \left(\frac{OD_M - 1.818 W_M}{12(2.5)}\right)^2 (0.65 BRAKES + WHEEL_M)}{STRUT_M g} \quad (16)$$

IW_M = inertia, per strut, of main gear wheels, tires, tubes, and brakes, slug-ft²

AXIAL AND NORMAL STRUT LOADS

The axial and normal loads on the strut at each load condition are determined by first finding the ground reactions on the wheels. The resultant of these loads is then computed by equation 17.

$$RLOAD = (VF^2 + DF^2 + SF^2)^{0.5} \quad (17)$$

RLOAD = resultant load of the drag, side, and vertical loads on the wheels, lb

VF = vertical load on the wheels, lb

DF = drag (fore-aft) load on the wheels, lb

SF = side (lateral) load on the wheels, lb

The direction cosines of the resultant load are then computed.

$$CRV = \frac{VF}{RLOAD} \quad (18)$$

$$CRFA = \frac{DF}{RLOAD} \quad (19)$$

$$CRL = \frac{SF}{RLOAD} \quad (20)$$

CRV = cosine of the angle between the resultant load and the vertical

CRFA = cosine of the angle between the resultant load and the fore-aft direction

CRL = cosine of the angle between the resultant load and the lateral direction

The direction cosines of the main gear strut are functions of the fore-aft and lateral angles in the input data.

$$CSV = \cos \left[\tan^{-1} \left[\frac{1}{(\cos [A1])^2} + \frac{1}{(\cos [A2])^2} - 2 \right]^{0.5} \right] \quad (21)$$

$$CSFA = \cos \left[\tan^{-1} \left[\frac{1}{(\sin [A1])^2} + \frac{1}{(\cos [A2])^2} - 2 \right]^{0.5} \right] \quad (22)$$

$$CSL = \cos \left[\tan^{-1} \left[\frac{1}{(\cos [A1])^2} + \frac{1}{(\cos [A2])^2} - 2 \right]^{0.5} \right] \quad (23)$$

CSV = cosine of the angle between the strut and the vertical

CSFA = cosine of the angle between the strut and the fore-aft direction

CSL = cosine of the angle between the strut and the lateral direction

A1 = fore-aft angle of strut, radians

A2 = lateral angle of strut, radians

The lateral angle (A2) of the nose gear strut is always 0; therefore, equations 21 through 23 reduce to 24 through 26 for the nose gear.

$$CSV = \cos [A1] \quad (24)$$

$$CSFA = \sin [A1] \quad (25)$$

$$CSL = 0 \quad (26)$$

The direction cosines of the resultant force and the direction cosines of the strut can then be combined to compute the angle between the resultant load and the strut.

$$ANG = \cos^{-1} [CSV CRV + CSFA CRFA + CSL CRL] \quad (27)$$

ANG = angle between the resultant load and the strut, radians

The axial and normal loads on the strut are then computed.

$$ALOAD = RLOAD \cos [ANG] \quad (28)$$

$$PLOAD = RLOAD \sin [ANG] \quad (29)$$

ALOAD = axial load on the strut, lb

PLOAD = normal load on the strut, lb

LANDING AND GROUND LOADS

The ground reactions on the wheels (VF, DF, and SF) for each load condition are determined in accordance with the procedure outline in MIL-A-008862A.⁽¹⁾ After the loads have been determined, the program then, except for the spring-back condition, uses the method described in equations 17 through 29 to find the axial and normal loads on the strut.

TWO-POINT LANDING

The vertical load on the wheels at the two-point landing condition is the maximum vertical load.

The maximum vertical loads on the main gear are computed by equations 30 and 31.

$$VMXMG_{T0} = \frac{1.5 (NG_{T0} - CL_W) (GRWT_{T0} - DWT)}{2} \quad (30)$$

$$V_{\text{MOMG}}_L = \frac{1.5 (N_{G_L} - C_{L_W}) \text{GRWT}_L}{2} \quad (31)$$

V_{MOMG}_{T0} = maximum vertical load on main gear at takeoff weight,
lb

V_{MOMG}_L = maximum vertical load on main gear at landing weight,
lb

The maximum vertical loads on the nose gear are determined from the maximum vertical loads on the main gear.

$$V_{\text{MONG}}_{T0} = 2 V_{\text{MOMG}}_{T0} \left(\frac{A_{T0}}{\text{DIST}} \right) \quad (32)$$

$$V_{\text{MONG}}_L = 2 V_{\text{MOMG}}_L \left(\frac{A_L}{\text{DIST}} \right) \quad (33)$$

V_{MONG}_{T0} = maximum vertical load on nose gear at takeoff weight,
lb

V_{MONG}_L = maximum vertical load on nose gear at landing weight,
lb

A_{T0} = distance from CG at takeoff to main gear, in.

A_L = distance from CG at landing to main gear, in.

DIST = distance from main gear to nose gear, in.

The two-point landing loads are determined for both the main and nose gears at both the takeoff and landing weights. Therefore, the routine in equations 17 through 29 is executed four times. In each case, the drag load is one-quarter of the vertical load and the side load is 0.

$V_F = V_{\text{MOMG}}_{T0}, V_{\text{MOMG}}_L, V_{\text{MONG}}_{T0}, \text{ and } V_{\text{MONG}}_L$

$D_F = 0.25 V_F$

$S_F = 0$

SPINUP

Before computing the spinup loads, the inertia of the nose gear wheels, tires, and tubes must be determined. (The inertia of the main gear wheels, tires, tubes, and brakes has already been determined.)

$$IW_N = \frac{\left(\frac{OD_N}{12 \cdot 2.52}\right)^2 TT_N + \left(\frac{OD_N - 1.818 W_N}{12 \cdot 2.5}\right) WHEEL_N}{g} \quad (27)$$

IW_N = inertia of nose gear wheels, tires, and tubes, slug-ft²

The spinup loads are determined for both the main and nose gears at both the takeoff and landing weights; therefore, equations 28 through 35 are executed four times, each time followed by the routine in equations 17 through 29.

TV, the time to develop the spinup vertical reaction, is computed by equation 28.

$$TV = \frac{SS - \left(SS^2 - 1.5 (NG - CL_W) 29.8 \left(\frac{STREFF}{2} + 0.08 OD \right) \right)^{0.5}}{1.5 (NG - CL_W) 14.9} \quad (28)$$

TV = time to develop the vertical reaction, sec

SS = sink speed, either SS_{T0} or SS_L , ft/sec

NG = load factor, either NG_{T0} or NG_L

STREFF = effective stroke of main or nose gear at takeoff or landing weight, ft

OD = outside diameter of tires, either OD_M or OD_N , ft

TSU, the time for the wheel circumferential velocity to reach ground velocity, is computed by equation 29.

$$TSU = \frac{VL IW}{0.55 VMX (0.432 OD)^2} + 0.363 TV \quad (29)$$

TSU = time for wheel circumferential velocity to reach ground velocity, sec

VL = landing speed, either VL_{T0} or VL_L , ft/sec

IW = inertia of the wheels, tires, tubes, and brakes, either IW_M or IW_N , slug-ft²

VMX = maximum vertical load, either VMX_{T0} , VMX_L , or VMX_{NG_L} , lb

If TSU is greater than TV, TSU is recomputed by equation 30.

$$TSU = \frac{TV}{0.5 \text{ PI}} \left(\cos^{-1} \left[1 - \frac{VL \text{ IW PI}}{1.1 (0.4320D)^2 \text{ VMX TV}} \right] \right) \quad (30)$$

FVSU, the vertical load at time TSU, is computed by either equation 31 or 32.

$$FVSU = \text{VMX} \sin \left[\frac{\text{PI}}{2} \frac{\text{TSU}}{\text{TV}} \right] \quad \text{when } TV > TSU \quad (31)$$

$$FVSU = \text{VMX} \quad \text{when } TSU > TV \quad (32)$$

FVSU = the vertical spinup load at time TSU on either the main or nose gear at either the takeoff or landing weight, lb

The vertical, drag, and side loads are then determined by equations 33 through 35.

$$VF = FVSU \quad (33)$$

$$DF = 0.55 \text{ FVSU} \quad (34)$$

$$SF = 0 \quad (35)$$

SPRINGBACK

The springback loads are determined for both the main and nose gears at both the takeoff and landing weights.

The springback loads are computed from the maximum vertical loads, the previously computed spinup loads, and the fore-aft angle of the strut, without going through the routine in equations 17 through 29.

$$AL_{SB} = VMX \text{ CSV} \quad (36)$$

$$NL_{SB} = \text{AMAX1} \left[0.893 \text{ NL}_{SU}, 0.893 \text{ NL}_{SU} + 0.9 \text{ FVSU} \sin[A1] \right] \\ + VMX \sin[A1] \quad (37)$$

AL_{SB} = axial load on either the main or nose gear strut at either the takeoff or landing weight for the springback condition, lb

NL_{SB} = normal load on either the main or nose gear strut at either the takeoff or landing weight for the springback condition, lb

NL_{SU} = normal load on either the main or nose gear strut at either the takeoff or landing weight for the spinup condition, lb

BRAKED ROLL

The braked roll loads are determined at both the takeoff and landing weights for the main gear only.

$$VF = \frac{1.5 \text{ GRWT BRC}}{2} \quad (38)$$

$$DF = 0.8 VF \quad (39)$$

$$SF = 0 \quad (40)$$

GRWT = gross weight, either $GRWT_{TO}$ or $GRWT_L$, lb

BRC = braked roll constant (1.0 at takeoff, 1.2 at landing)

DRIFT LANDING

The drift landing loads are determined at both takeoff and landing weights for the main gear only.

$$VF = 0.5 VMX \quad (41)$$

$$DF = 0 \quad (42)$$

$$SF = 0.8 VF \quad (43)$$

UNSYMMETRICAL BRAKING

The unsymmetrical braking loads are determined for both the main and nose gears at both the takeoff and landing weights.

Before computing the unsymmetrical braking loads, B_{TO} and B_L must be defined.

B_{TO} = distance from CG at takeoff to nose gear, in.

B_L = distance from CG at landing to nose gear, in.

The main gear loads at takeoff and landing are computed by equation 44 through 46.

$$VF = \frac{1.5 GRWT B}{0.4 CGG + 2 DIST} \quad (44)$$

$$DF = 0.8 VF \quad (45)$$

$$SF = 0 \quad (46)$$

B = distance from CG to nose gear, either B_{T0} or B_L , in.

CGG = distance from CG to ground, in.

The nose gear loads at takeoff and landing are computed by equations 47 through 49.

$$VF = \left(\frac{A}{DIST} + \frac{0.4 B CGG}{DIST^2} \right) 1.5 GRWT \quad (47)$$

$$DF = AMIN1 \left[0.8 VF, \frac{B DMGS 1.5 GRWT}{4 DIST^2} \right] \quad (48)$$

$$SF = 0 \quad (49)$$

A = distance from CG to main gear, either A_{T0} or A_L , in.

$DMGS$ = distance between main gear struts, in.

$AMIN1$ = absolute minimum of the two arguments

TOWING

The towing loads are determined for both the main and nose gears at the takeoff weight only.

$FTOW$, the tow load, must first be computed as a function of the takeoff weight.

$$FTOW = 0.3 GRWT_{T0} \quad (\text{when } GRWT_{T0} \leq 30,000) \quad (50)$$

$$FTOW = \frac{6 \text{ GRWT}_{T0}}{70} + 6,429 \quad (\text{when } 30,000 \leq \text{GRWT}_{T0} < 100,000) \quad (51)$$

$$FTOW = 0.15 \text{ GRWT}_{T0} \quad (\text{when } \text{GRWT}_{T0} \geq 100,000) \quad (52)$$

$$FTOW = \text{tow load, lb}$$

The main gear towing loads are then computed by equations 53 through 55.

$$VF = \frac{1.5 \text{ GRWT}_{T0} B_{T0}}{2 \text{ DIST}} \quad (53)$$

$$DF = 1.5 FTOW 0.75 \quad (54)$$

$$SF = 0 \quad (55)$$

The nose gear towing loads are computed by equation 56 through 58.

$$VF = \frac{A_{T0} 1.5 \text{ GRWT}_{T0}}{\text{DIST}} \quad (56)$$

$$DF = 1.5 FTOW \quad (57)$$

$$SF = 0 \quad (58)$$

TURNING

The turning loads are determined for both the main and nose gear at the takeoff weight only.

The main gear turning loads are computed by equations 59 through 61.

$$VF = 1.5 \text{ GRWT}_{T0} \left(\frac{0.5 B_{T0}}{\text{DIST}} + \text{AMIN1} \left[\frac{0.5 B_{T0}}{\text{DIST}}, \frac{0.5 \text{ CGG}}{\text{DMGS}} \right] \right) \quad (59)$$

$$DF = 0 \quad (60)$$

$$SF = VF \text{ AMIN1} \left[0.5, \frac{0.5 B_{T0} \text{ DMGS}}{\text{DIST CGG}} \right] \quad (61)$$

The nose gear turning loads are computed by equations 62 through 64.

$$VF = \frac{A_{T0} 1.5 \text{ GRWT}_{T0}}{\text{DIST}} \quad (62)$$

$$DF = 0 \quad (63)$$

$$SF = VF \text{ AMIN1} \left[0.5, \frac{0.5 B_{T0} \text{ DMGS}}{\text{DIST CGG}} \right] \quad (64)$$

STRUT DESIGN LOADS

The inner and outer cylinder weights are determined by computing the area at the four sections shown in Figure 37. The area at each section is computed for each load condition at which loads have been computed (or input), with the maximum area being saved for the final weight calculation.

The analysis of the inner and outer cylinders is identical for the main and nose gears (except that the drift landing condition does not apply to the nose gear); therefore, only the main gear calculations are described.

The deflections at the bottom of the strut must be determined before the moments at a section can be computed. The deflections are assumed to be proportional to the square of the distance from the trunion; therefore, if the deflections at section 2 are known, the deflections at the bottom of the strut (the axle) can be computed by equations 65 through 68.

$$RB2 = \left(\frac{TOTLNG}{TOTLNG - LENGTH_2} \right)^2 \quad (65)$$

$$Y_{AX} = Y_2 RB2 \quad (66)$$

$$Z_{AX} = Z_2 RB2 \quad (67)$$

$$PHI_{AX} = PHI_2 RB2 \quad (68)$$

RB2 = ratio of deflection at bottom of strut to deflection

Y_{AX} = fore-aft deflection at bottom of strut, in.

Z_{AX} = lateral deflection at bottom of strut, in.

PHI_{AX} = angular deflection at bottom of strut, radians

Y_2 = fore-aft deflection at section 2, in.

Z_2 = lateral deflection at section 2, in.

PHI_2 = angular deflection at section 2, radians

TOTLNG = length of strut, axle to trunion, in.

LENGTH₂ = length from axle to section 2, in.

When the deflections at the bottom of the strut are known, the fore-aft bending moment at section I (I = 1, 2, 3, or 4) can be computed by equation 69 (for each load condition except drift landing). Equation 69 is illustrated in Figure 41.

$$BM_{Y_I} = \left(Y_{AX} + \left| ECC \sin [PHI_{AX}] \right| - Y_I \right) AL + LENGTH_I NL \quad (69)$$

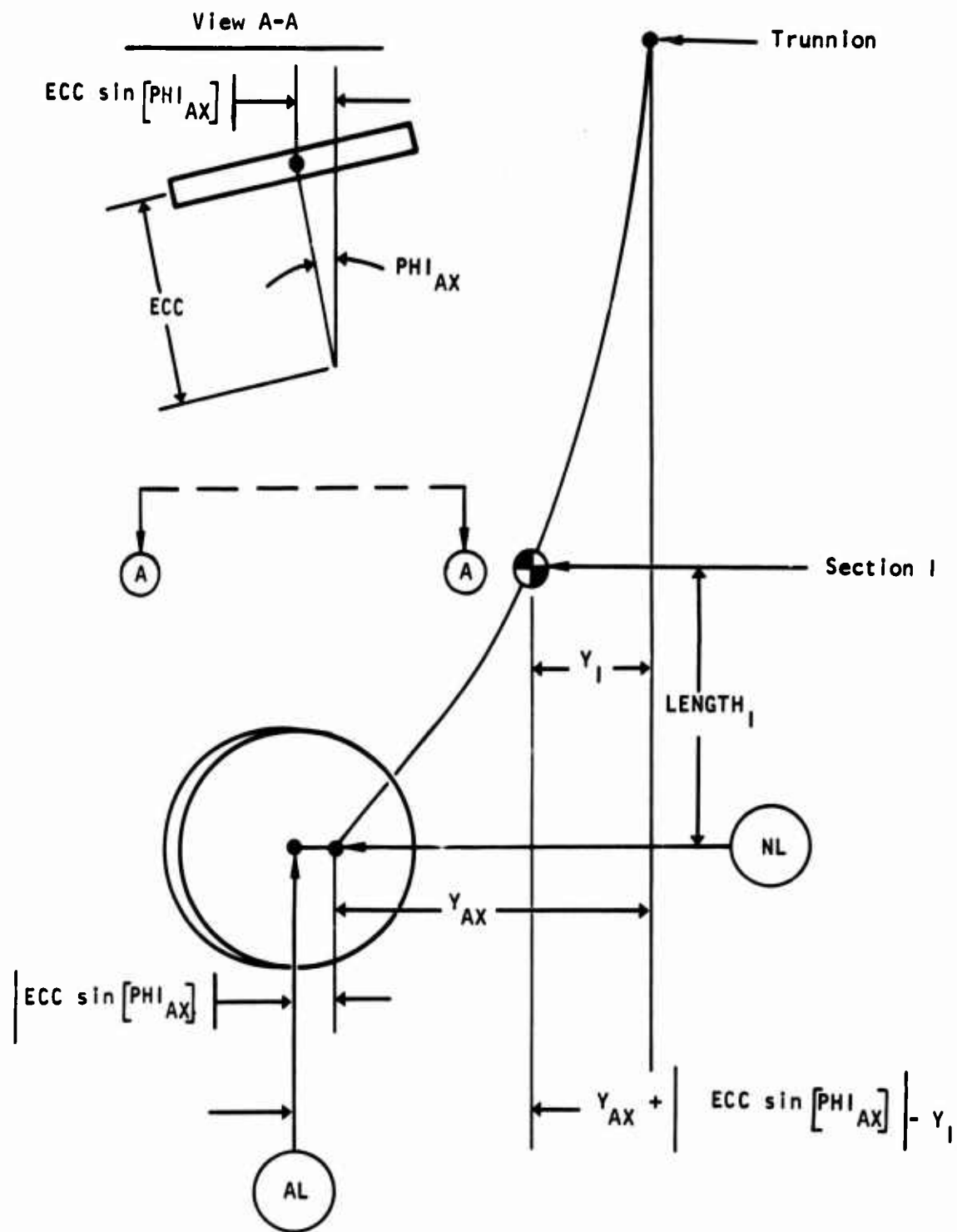


Figure 41. Geometry representation for fore-aft bending moment derivation.

BM_{Y_I} = fore-aft bending moment at section I (I = 1, 2, 3 or 4),
in.-lb

ECC = eccentricity of wheels, in.

Y_I = fore-aft deflection at section I, in.

$LNTH_I$ = length from axle to section I, in.

AL = axial load on strut at this load condition, lb

NL = normal load on strut at this load condition, lb

The deflections are initialized at 0. When the deflections are 0, equation 69 reduces to 70.

$$BM_{Y_I} = LNTH_I NL \quad (70)$$

The lateral bending moment at section I is computed by equation 71 (for each load condition except drift landing). Equation 71 is illustrated in Figure 42.

$$BM_{Z_I} = \left(Z_{AX} + \left| ECC \cos \left[PHI_{AX} \right] \right| - Z_I \right) AL \quad (71)$$

BM_{Z_I} = lateral bending moment at section I, in.-lb

Z_I = lateral deflection at section I, in.

If the deflection are all 0, equation 71 reduces to equation 72.

$$BM_{Z_I} = \left| ECC \right| AL \quad (72)$$

The torsional bending moment is determined by using the normal load in place of the axial load in equation 71; therefore, it can be computed by equation 73.

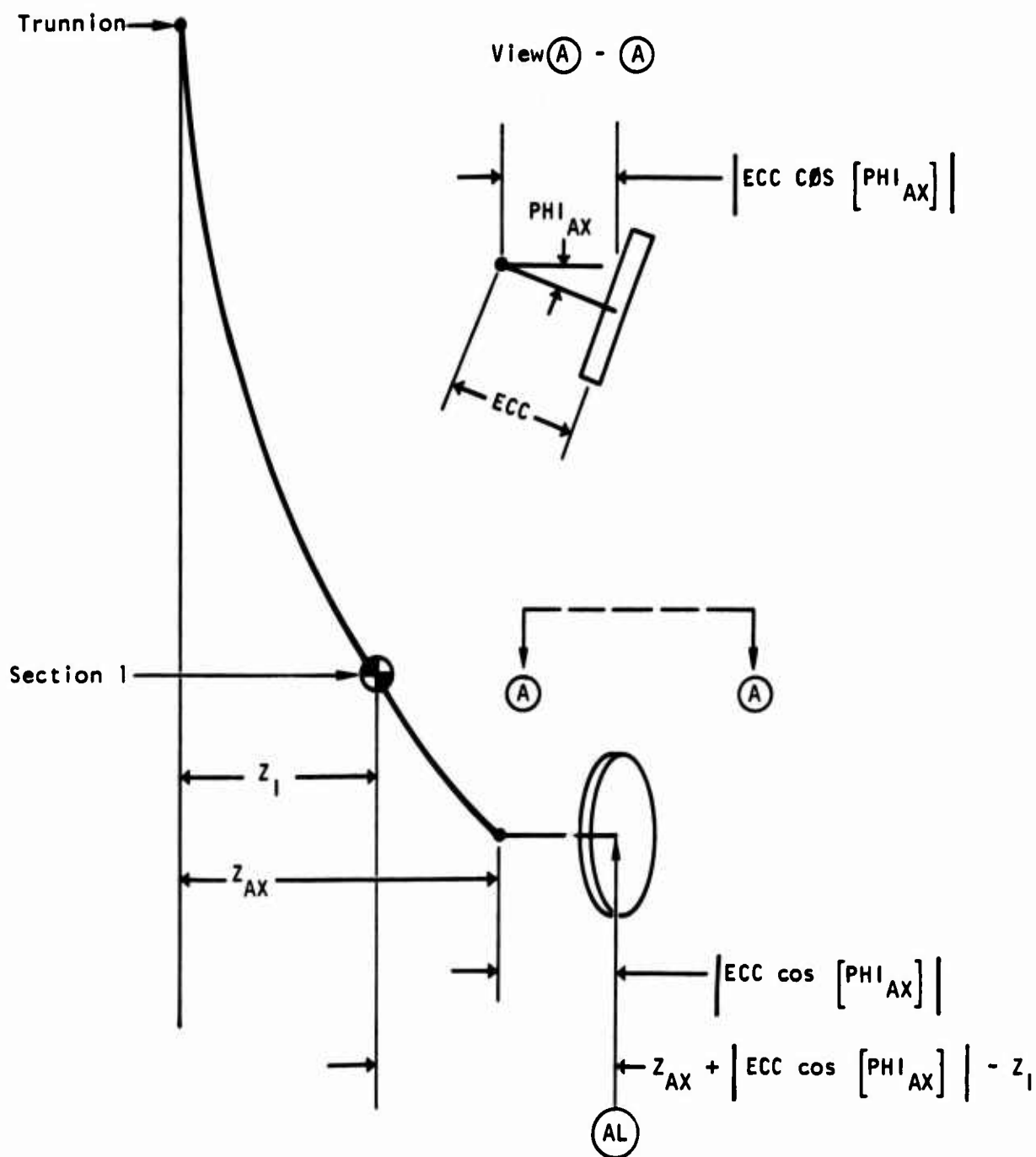


Figure 42. Geometry representation for lateral bending moment derivation.

$$TPHI_I = BMZ_I \left[\frac{NL}{AL} \right] \quad (73)$$

$TPHI_I$ = torsional bending moment at section I, in.-lb

For the drift landing condition, EMY_I and $TPHI_I$ are 0. The normal load acts at the ground instead of at the bottom of the strut; therefore, the distance from the section to the ground must first be found. The tire deflection is assumed to be 8 percent of the outside diameter. Equation 74 is used to calculate the distance.

$$DLLNG_I = LENGTH_I + \frac{OD_M}{2} - 0.08 OD_M \quad (74)$$

$DLLNG_I$ = length from ground to section I, in.

The normal load computed for the drift landing condition is 0.8 times the axial load. This normal load acts inboard, as shown in Figure 43. A normal load equal to 0.6 times the axial load (and therefore equal to 0.75 times the computed normal load) acts outboard on the opposite strut.

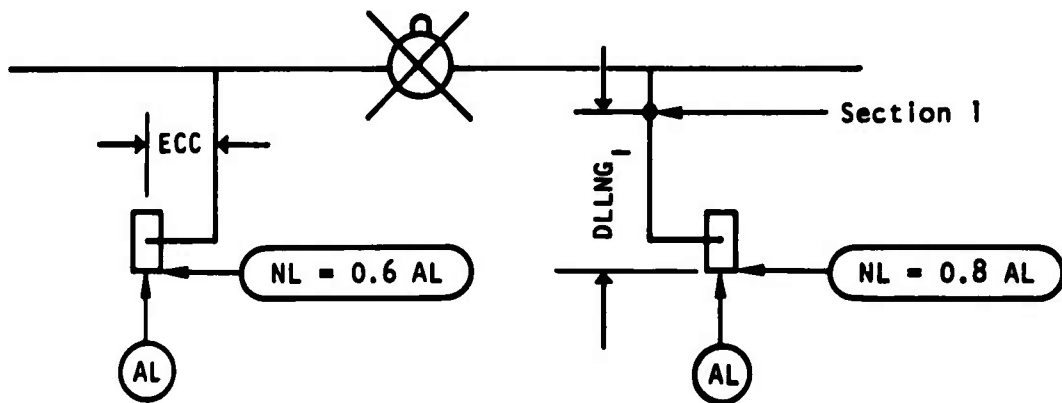


Figure 43. Drift landing normal loads.

If the eccentricity is negative (outboard), as shown in Figure 43. The moment at a section will be greater from the smaller normal load acting outboard than from the larger normal load acting inboard if the eccentricity is greater than 10 percent of the length from the ground to the section.

$$(0.6 \text{ AL}) (\text{DLLNG}_I) + (\text{AL}) (\text{ECC}) > (0.8 \text{ AL}) (\text{DLLNG}_I) - (\text{ECC}) (\text{AL}) \quad (75)$$

$$\text{if } |\text{ECC}| > \frac{\text{DLLNG}_I}{10}$$

In this case, equation 75 is used to compute the lateral bending moment, using a normal load equal to 0.75 times the computed normal load. Equation 75 is illustrated in Figure 44.

$$\text{BMZ}_I = (Z_{AX} + |\text{ECC}| - Z_I) \text{ AL} + \text{DLLNG}_I 0.75 \text{ NL} \quad (76)$$

If the deflections are all 0, equation 76 reduces to equation 77.

$$\text{BMZ}_I = |\text{ECC}| \text{ AL} + \text{DLLNG}_I 0.75 \text{ NL} \quad (77)$$

When the eccentricity is negative but less than one-tenth of the distance to the ground, the lateral bending moment for drift landing is computed by equation 78. Equation 78 is illustrated in Figure 45.

$$\text{BMZ}_I = (Z_{AX} - Z_I - |\text{ECC}|) \text{ AL} + \text{DLLNG}_I \text{ NL} \quad (78)$$

If the deflections are all 0, equation 78 reduces to equation 79.

$$\text{BMX}_I = -|\text{ECC}| \text{ AL} + \text{DLLNG}_I \text{ NL} \quad (79)$$

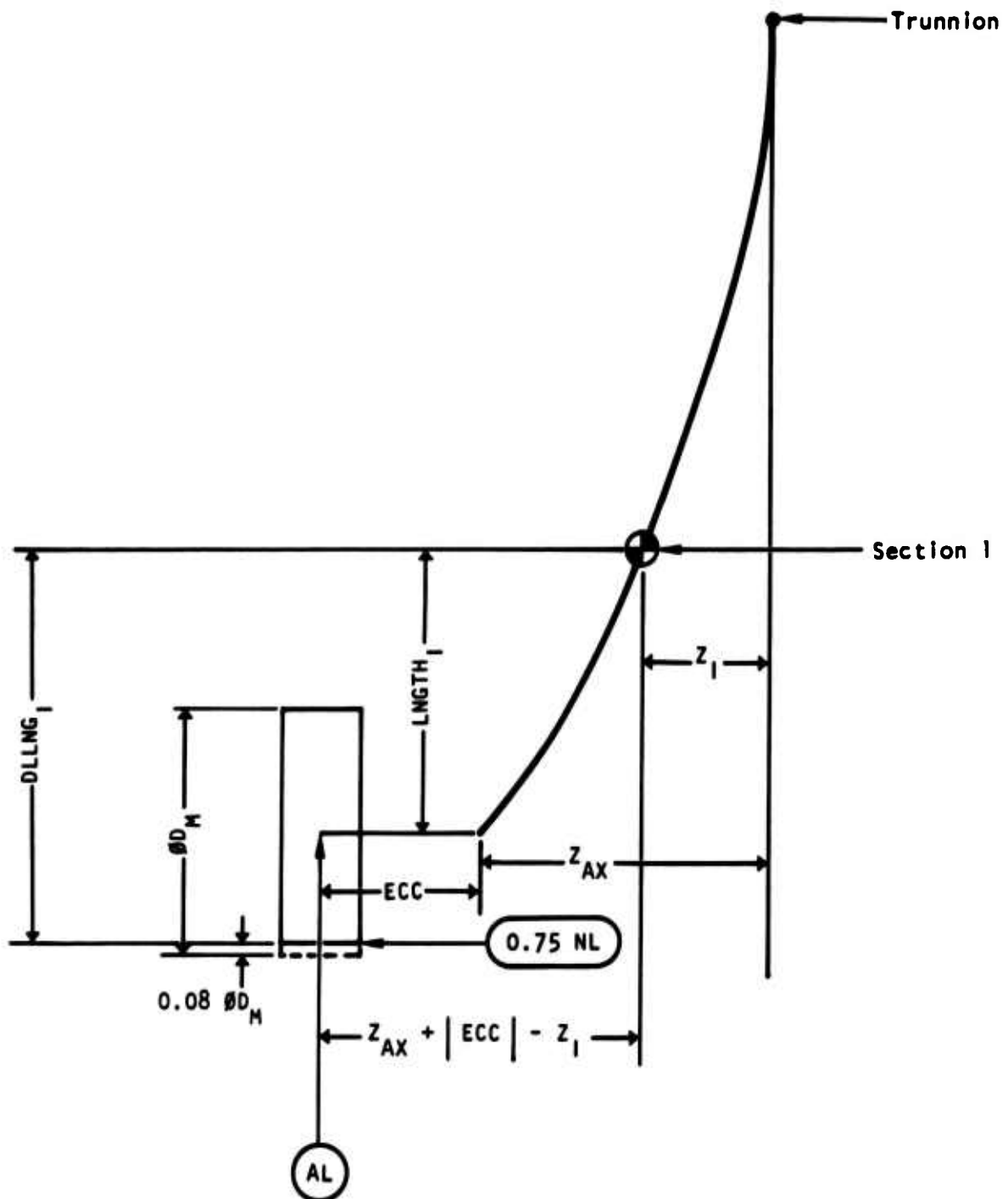
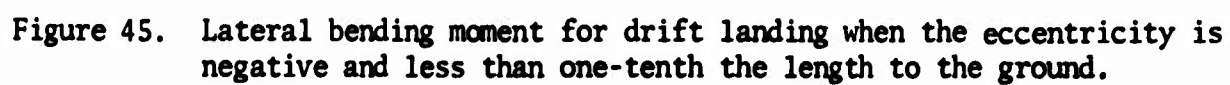


Figure 44. Lateral bending moment for drift landing when the eccentricity is negative and greater than one-tenth the length to the ground.



When the eccentricity is positive (inboard), the lateral bending moment from the computed normal load acting inboard is always the larger moment. This bending moment is computed by equation 80. Equation 80 is illustrated in Figure 46.

$$BMZ_I = (Z_{AX} + ECC - Z_I) AL + DLLNG_I NL \quad (80)$$

If the deflections are all 0, equation 80 reduces to equation 81.

$$BMZ_I = ECC AL + DLLNG_I NL \quad (81)$$

The resultant of the fore-aft and lateral bending moments is computed by equation 82.

$$BMR_I = (BMY_I^2 + BMZ_I^2)^{0.5} \quad (82)$$

BMR_I = resultant of fore-aft and lateral bending moments at section I

STRUT SYNTHESIS

The area of the cylinder at each section is determined by finding the value of the cylinder diameter to wall thickness ratio for which the area required for strength is equal to the geometric area.

The search starts by assuming three values of diameter-to-wall-thickness ratio, and then computing the outside diameter of the cylinder for each of the assumed ratios. The outside diameter of the inner cylinder at section 4 is the piston diameter, DP_M . The outside diameter of the outer cylinder at sections 1, 2, and 3 is computed by equation 83. The 0.625 added to the piston diameter is the assumed average packing ring dimension.

$$DIA_I = \frac{DOT (DP_M + 0.625)}{DOT - 2} \quad (83)$$

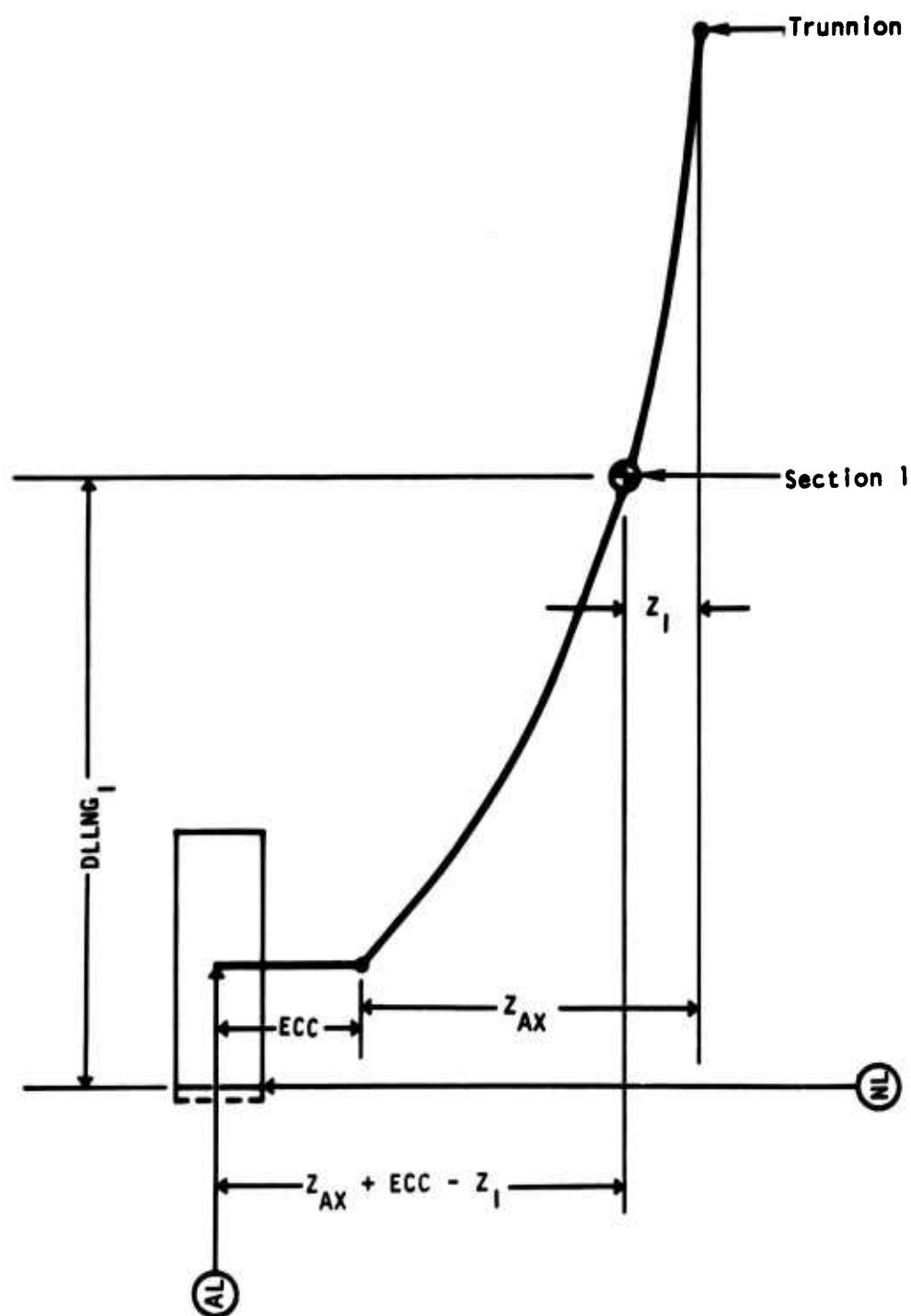


Figure 46. Lateral bending moment for drift landing when the eccentricity is positive.

DIA_I = outside diameter of cylinder at section I for assumed value of diameter to wall thickness ratio, in.

DOT = diameter to wall thickness ratio

Before the area can be computed, the bending modulus of rupture and the torsion modulus of rupture must be determined as functions of the diameter-to-wall-thickness ratio and the ultimate tensile strength of the material.

$$\begin{aligned} BMRU = & \left((0.000390625 T - 0.3125) T + 14.21875 \right) DOT - \\ & - 0.0546875 T^2 - 903.125 \left(DOT - (3.2421875 T - 2903.125) T \right. \\ & \left. - 142890.625 \right) \end{aligned} \quad (84)$$

$$\begin{aligned} TMOR = & \left((0.00109375 T - 0.396875) T + 47.5 \right) DOT + (0.05 T - 27.25) T \\ & + 1725.0 \left(DOT + 143.4875 T + 38702.5 \right) \end{aligned} \quad (85)$$

$BMRU$ = bending modulus of rupture, lb/in.²

$TMOR$ = torsion modulus of rupture, lb/in.²

T = ultimate tensile strength divided by 1,000, lb/in.² $\times 10^{-3}$

Figures 47 and 48 show the results of equation 84 and 85 for values of ultimate tensile strength from 180 to 260K, and for values of diameter-to-wall-thickness ratio from 10.0 to 50.0.

The area required for strength can then be computed by equation 86.

$$AS = \frac{8}{DIA_I \left(1 + \left(1 - \frac{2}{DOT} \right)^2 \right)} \left(\left(\frac{BMR_I}{BMRU} \right)^2 + \left(\frac{TPHI_I}{TMOR} \right)^2 \right)^{0.5} + \frac{AL}{FCY} \quad (86)$$

BENDING MODULUS OF RUPTURE VS DIAMETER/THICKNESS RATIO
FOR VALUES OF ULTIMATE TENSILE STRENGTH FROM 180K TO 260K

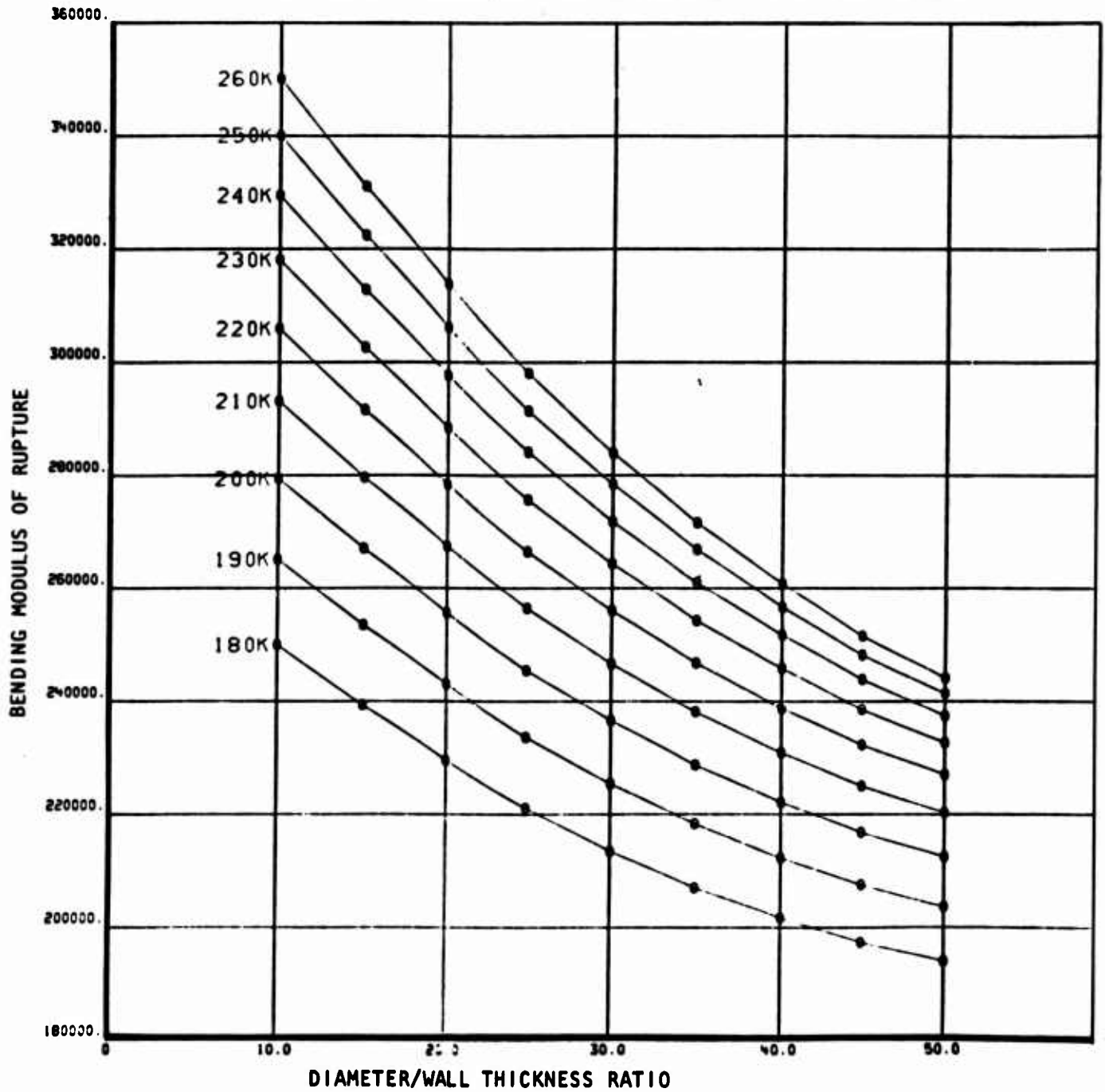


Figure 47. Bending modulus of rupture.

BENDING MODULUS OF RUPTURE VS DIAMETER/THICKNESS RATIO
FOR VALUES OF ULTIMATE TENSILE STRENGTH FROM 180K TO 260K

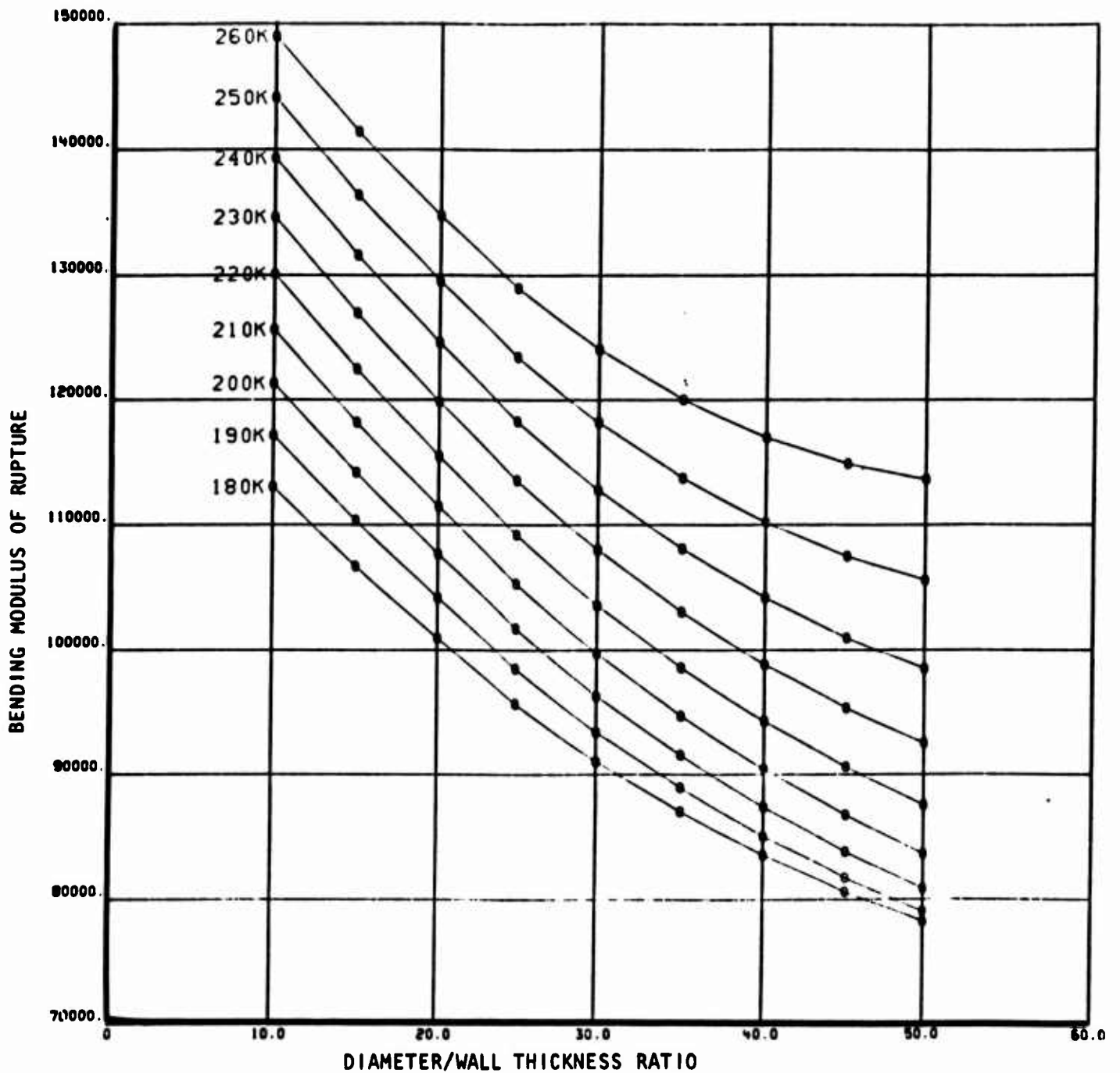


Figure 48. Torsion modulus of rupture.

AS = area required for strength for assumed value of DOT, in.²

FCY = compression yield stress, lb/in.²

The geometric area for the assumed value of diameter to wall thickness is computed by equation 87.

$$AG = \pi \text{ DIA}_I^2 \left(\frac{\text{DOT}-1}{\text{DOT}^2} \right) \quad (87)$$

AG = geometric area for assumed value of DOT, in.²

The ratio of the area required for strength to the geometric area is then determined for each of the three assumed values of diameter-to-wall-thickness ratio.

$$R = \frac{AS}{AG} \quad (88)$$

R = ratio of area required for strength to geometric area

The program interpolates in the three assumed values of DOT to find the value for which R = 1. Three new values of DOT are then assumed (the interpolated value, and one on either side), and a second pass is made through equations 83 to 88. The program interpolates for the final value of the diameter-to-wall-thickness ratio, and then calculates the final diameter and area.

$$\text{DIAM} = \frac{\text{DOVT} (\text{DP}_M + 0.625)}{\text{DOVT}-2} \quad (89)$$

$$\text{AREAC} = \pi \text{ DIAM}^2 \left(\frac{\text{DOVT}-1}{\text{DOVT}^2} \right) \quad (90)$$

DIAM = final outside diameter of cylinder for this load condition, in.

AREAC = final area of cylinder section for this load condition, in.²

DOVT = final interpolated value of DOT for which R = 1

AREAC is saved if it is greater than any area previously computed at that section for another load condition.

At section 2, the diameter, DIAM, and the three moments are also saved, for use in the deflection analysis.

DEFLECTION ANALYSIS

As noted earlier, the deflections are initialized at 0. The first pass through the calculations of the area of the four cylinder sections (equations 65 through 90) is made with deflections equal to 0; therefore, equations 69, 71, 76, 78, and 80 reduce to equations 70, 72, 77, 79, and 81.

If the input data indicate that the deflection analysis is to be omitted, the program goes on to compute the inner and outer cylinder weights after the first pass through the area calculations.

If the deflections are to be included, the deflections at section 2 are computed, and the deflections at the other sections are then determined by assuming that the deflections are proportional to the square of the distance from the trunnion.

The moment of inertia at section 2 must be determined before the deflections can be calculated.

$$I_2 = \frac{\text{PI DIADZ}^4 \left(1 - \frac{1}{\text{DOVRT2}}\right) \left(1 - \left(\frac{2}{\text{DOVRT2}}\right) \left(1 - \frac{1}{\text{DOVRT2}}\right)\right)}{8 \text{DOVRT2}} \quad (91)$$

I_2 = moment of inertia at section 2, in.⁴

DIADZ = diameter of outer cylinder at section 2, in.

DOVRT2 = diameter-to-wall-thickness ratio at section 2

The deflections at section 2 can now be calculated by equations 92 through 94.

$$Y_2 = \frac{BMYDZ (TOTLNG - LENGTH_2)^2}{2 E I_2} \quad (92)$$

$$Z_2 = \frac{BMZDZ (TOTLNG - LENGTH_2)^2}{2 E I_2} \quad (93)$$

$$PHI_2 = \frac{TPHIDZ (TOTLNG - LENGTH_2)}{2 G I_2} \quad (94)$$

BMYDZ = fore-aft bending moment from load condition which produced maximum area at section 2, in.-lb

BMZDZ = lateral bending moment from load condition which produced maximum area at section 2, in.-lb

TPHIDZ = torsion moment from load condition which produced the maximum area at section 2, in.-lb

E = modulus of elasticity, lb/in.²

G = modulus of rigidity, lb/in.²

The deflections at sections 3 and 4 are then calculated by equations 95 through 98.

$$RI_2 = \left(\frac{TOTLNG - LENGTH_1}{TOTLNG - LENGTH_2} \right)^2 \quad (95)$$

$$Y_I = Y_2 RI_2 \quad (96)$$

$$Z_I = Z_2 RI_2 \quad (97)$$

$$PHI_I = PHI_2 RI_2 \quad (98)$$

RI_2 = ratio of deflection at section 2

PHI_I = angular deflection at section I, radians

The program then returns to recalculate the areas at the four sections, starting with equation 65. This loop continues for six passes, or until the area at section 2 is closer to the area from the previous pass than a given tolerance.

INNER AND OUTER CYLINDER WEIGHT

The weight of the outer cylinder is determined from the areas of sections 1, 2, and 3.

$$WTOC = \left(\frac{AREA_1 + 2 AREA_2 + AREA_3}{4} \right) (LNGTH_1 - LNGTH_3)$$

$$STRUTS RHO WCOC \quad (99)$$

$WTOC$ = weight of outer cylinder, lb

$AREA_I$ = maximum of areas computed at section I for each load condition, in.²

$STRUTS$ = number of struts, main or nose gear (always for nose gear)

RHO = density of material, lb/in.³

$WCOC$ = weight coefficient for outer cylinder

The inner cylinder extends from the axle to section 2, the midpoint of the outer cylinder, as shown in Figure 37. The diameter of the inner cylinder is DP_M , the piston diameter. The part of the inner cylinder from the axle to section 3 has the area computed at section 4, and the part from section 3 to section 2 has an area based on an assumed diameter-to-wall-thickness ratio.

$$WTIC = \left(\frac{PI DP_M^2 (DOT32-1) (LNGTH_2 - LNGTH_3)}{DOT32^2} + AREA_4 LNGTH_3 \right) \quad (100)$$

STRUTS RHO WCIC

WTIC = weight of inner cylinder, lb

DOT32 = assumed diameter-to-thickness ratio of inner cylinder
between sections 2 and 3

WCIC = weight coefficient for inner cylinder

AXLE WEIGHT

There is one axle for each wheel on both the main gear and nose gear. The length of the axle is computed by equation 101. (See Figure 38.)

$$AXLGTH = W + \frac{DP}{2} \quad (101)$$

AXLGTH = length of axle, in.

W = width of tires, either W_M or W_N , in.

DP = piston diameter, either DP_M or DP_N , in.

The total load on the axles is computed by equation 102 for the main gear, and 103 for the nose gear.

$$AXLOAD = GRWT_{10} \quad (102)$$

$$AXLOAD = GRWT_{T0} - SW STRUT_M \quad (103)$$

AXLOAD = total load on axles for either main or nose gear, lb

The bending moment at the side of the piston and the torsion moment are computed by equations 104 and 105. These equations assume that one tire is flat when there are two wheels on a main or nose gear strut, and that two tires on a strut are flat when there are four wheels on the main gear struts.

$$BMAX = 1.5 \left(\frac{AXLOAD}{AMAX1 [2, WS]} \right) W \left(\frac{2}{STRUTS} \right) \quad (104)$$

$$TMAX = 1.5 \left(\frac{0.8 AXLOAD}{AMAX1 [2, WS]} \right) \left(\frac{OD}{2} \right) \left(\frac{2}{STRUTS} \right) \quad (105)$$

BMAX = bending moment on each axle, in.-lb

TMAX = torsion moment on each axle, in.-lb

WS = number of wheels per strut, either WS_M or WS_N

AMAX1 = absolute maximum of the two arguments

Although the axle is a solid cylinder, the bending modulus of rupture and torsion modulus of rupture are computed by equations 84 and 85, using a value of diameter-to-wall-thickness ratio equal to 10. The diameter of the axle at the side of the piston can now be computed.

$$DIAAX = \left(\frac{32}{PI} \left(\left(\frac{BMAX}{BMRU} \right)^2 + \left(\frac{TMAX}{2 TMOR} \right)^2 \right)^{0.5} \right)^{0.333} \quad (106)$$

DIAAX = diameter of axle at side of piston, in.

The total weight of all the axles on either the main or nose gear can then be computed by equation 107.

$$WTAXL = \pi \left(\frac{DIAAX}{2} \right)^2 AXLGTH \text{ WS STRUTS } RHO \quad (107)$$

WTAXL = total weight of axles for either main or nose gear

BOGIE WEIGHT

The weight of the bogie is calculated only when there are four wheels per strut on the main gear. The length of the bogie is computed by equation 108. (See Figure 39.)

$$BOGL = 1.1 OD_M + DP_M \quad (108)$$

BOGL - length of bogie, in.

Each half of the bogie is a separate structural element, supporting the loads on two axles. Each tire will normally carry one-eighth of the total aircraft weight, but when both tires on one axle are flat, the two remaining tires on that strut will each carry one-fourth of the total weight. Assuming a side load of 0.8 times the vertical load, equations 109 and 110 will compute the bending moment and torsion moment at the midpoint of the bogie.

$$BMB = \left(\left(1.5(2) \left(\frac{GRWT_{T0}}{4} \right) \left(\frac{2}{STRUT_M} \right) \right)^2 + \left(1.5(2) \left(\frac{0.8 GRWT_{T0}}{4} \right) \left(\frac{2}{STRUT_M} \right) \right)^2 \right)^{0.5} \frac{BOGL}{2} \quad (109)$$

$$TMB = 1.5(2) \left(\frac{0.8 GRWT_{T0}}{4} \right) \left(\frac{2}{STRUT_M} \right) \left(\frac{OD_M}{2} \right) \quad (110)$$

BMB = bending moment at midpoint of bogie, in.-lb

TMB = torsion moment at midpoint of bogie, in.-lb

The bending modulus of rupture and the torsion modulus of rupture are computed by equations 84 and 85, using an assumed value of diameter-to-wall-thickness ratio. The diameter of the bogie can then be calculated by equation 111.

$$BD = \left(\frac{\frac{32}{\pi} \left(\frac{BMB}{BMRU} \right)^2 + \left(\frac{TMB}{TMOR} \right)^2}{1 + \left(\frac{DOTB-2}{DOTB} \right)^2} \right)^{0.333} \quad (111)$$

BD = diameter of bogie, in.

DOTB = assumed value of diameter-to-wall-thickness ratio for bogie

The weight of the bogie can then be computed by equation 112.

$$BWT = \pi BD^2 \left(\frac{DOTB-1}{DOTB} \right) BOGL \text{ STRUT}_M \text{ RHO WCB} \quad (112)$$

BWT = weight of bogie, lb

WCB = weight coefficient for bogie

SIDE STRUT AND DRAG STRUT WEIGHT

The weight of the main gear side strut is computed for the drift landing and turning conditions. The maximum weight is saved. The nose gear side strut is computed for the turning condition. (See Figure 40.)

$$SSWT = 0.7698 \text{ TOTLNG} \left(\frac{3 \text{ NL}}{\text{FCY}} \right) \text{ RHO STRUTS WCSS} \quad (113)$$

SSWT = weight of main or nose gear side strut, lb

WCSS = side strut weight coefficient

The weight of the drag strut is computed for all conditions except drift landing and turning. The maximum weight is saved.

$$DSWT = 0.7698 \text{ TOTLNG} \left(\frac{3 \text{ NL}}{\text{FCY}} \right) \text{ RHO STRUTS WCDS} \quad (114)$$

DSWT = weight of main or nose gear side strut, lb

WCDS = drag strut weight coefficient

OIL WEIGHT

The weight of the oil is calculated by equation 115.

$$\text{WTOIL} = \text{PI} \left(\frac{\text{DP}}{2} \right)^2 1.5 \text{ STROKE STRUTS DOIL} \quad (115)$$

WTOIL = weight of oil for either main or nose gear, lb

STROKE = stroke of either main or nose gear, in.

DOIL = density of oil, lb/in.³

MISCELLANEOUS WEIGHT

The miscellaneous weight is a function of TOTCAL, the total calculated structure weight, and TOTSTW, the total calculated weight.

$$\text{TOTCAL} = \text{WTOC} + \text{WTIC} + \text{WTAXL} + \text{WTOIL} + \text{SSWT} + \text{DSWT} + \text{BWT} \quad (116)$$

$$\text{TOTSTW} = \text{TOTCAL} + \text{WTTB} \quad (117)$$

TOTCAL = total calculated structure weight of either main or nose gear, lb

TOTSTW = total calculated weight of either main or nose gear, lb

WTTB = weight of wheels, tires, tubes, and brakes for either main or nose gear, lb

The miscellaneous weight is calculated by equation 118 for the main gear, and equation 119 for the nose gear.

$$\begin{aligned} \text{WTMISC} = & (\text{WCMG}-1) \text{TOTCAL} + \text{WCMG} (0.25 \text{TOTSTW} + 0.50 \text{TOTCAL} \\ & + 0.001 \text{GRWT}_{\text{T0}}) \end{aligned} \quad (118)$$

$$\text{WTMISC} = (\text{WCNG}-1) \text{TOTCAL} + \text{WCNG} (0.25 \text{TOTSTW} + 0.50 \text{TOTCAL} + 15) \quad (119)$$

WTMISC = miscellaneous weight of either main or nose gear, lb

WCMG = main gear weight coefficient

WCNG = nose gear weight coefficient

TOTAL WEIGHT

The total weight of the main gear is calculated by equation 120, and the total weight of the nose gear by equation 121.

$$\text{TOTAL} = \text{TOTSTW} + \text{WTMISC} + \text{WMI} \quad (120)$$

$$\text{TOTAL} = \text{TOTSTW} + \text{WTMISC} \quad (121)$$

TOTAL = total weight of either main or nose gear, lb

WMI = input miscellaneous weight, lb

TAIL WHEEL WEIGHT

If the auxiliary gear is a tail wheel instead of a nose gear, equation 122 is used, where TOTSTW is the total calculated weight of the main gear.

$$\text{TAILWT} = \frac{\text{TOTSTW}^{0.2963} (\text{GRWT}_{\text{TO}} - \text{SW STRUT}_{\text{M}})^{0.6238}}{e^{2.024}} \quad (122)$$

TAILWT = weight of tail wheel, lb

CENTER OF GRAVITY

The centers of gravity of the main gear and the nose gear are determined by calculating the center of gravity of the total of the calculated components (inner cylinder, outer cylinder, axle, brakes, tires, etc.). This assumes that the miscellaneous weight has the same CG as the calculated components.

Section III

PROGRAM DESCRIPTION

GENERAL DISCUSSION

The methods, equations, and logic discussed in section II have been programmed in FORTRAN for the CDC 6600 computer. The landing gear program is in overlay (6, 0) of SWEEP. This overlay contains the main program (LANDGR) and five subroutines. The program subroutine flow diagram is shown in Figure 49. The functional flow diagram is shown in Figure 50.

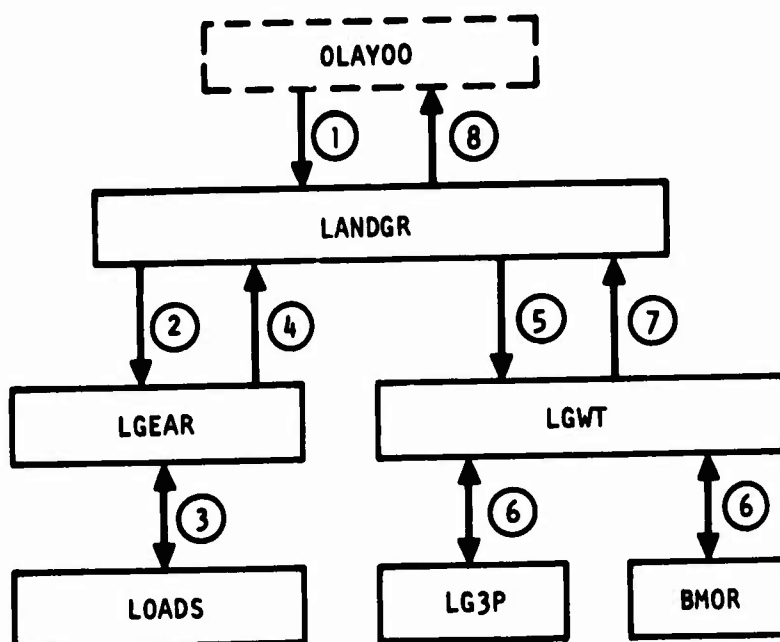


Figure 49. Subroutine flow diagram.

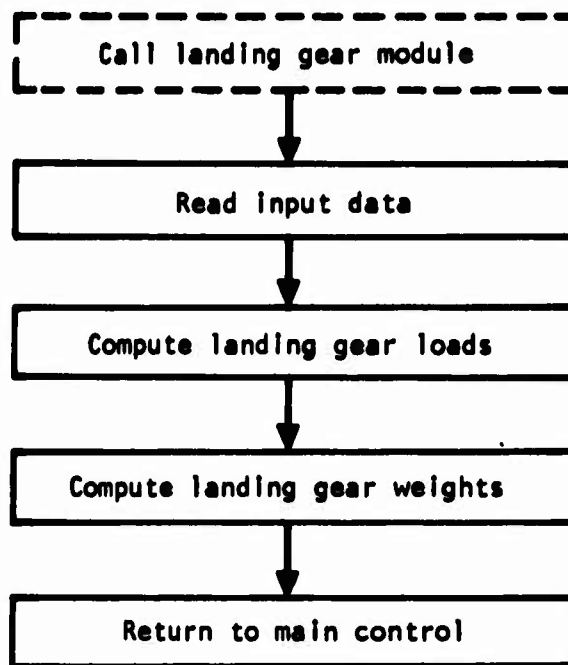


Figure 50. Functional flow diagram.

MASS STORAGE FILES

Mass storage file record 25 is the only record read in the landing gear program. Record 25 is read in program LANDGR. No mass storage file records are written in the landing gear program.

Record 25 contains the landing gear input data array D. Array D is placed in labeled common block/LGDATA/ so that the input data may be transferred to subroutines LGEAR and LGWT.

INPUT DATA

The input to the landing gear program is contained in Array D, which has 116 locations.

The first 45 locations contain permanent data which are read from the permanent data file, TAPE 7. Table 31 contains a description of the permanent data and lists the values which are stored in the permanent data file. These stored values may be changed when the variable input data for the landing gear are read.

Locations 46 through 116 in Array D contain the variable input data. The variable input data are described in Table 32.

TABLE 31. INPUT ARRAY D -- PERMANENT DATA

Loc	Description	Value	Subroutine Reference
1	Fraction of energy absorbed by strut	0.1	LGEAR
2	Ratio of nose gear piston diameter to main gear piston diameter	.6	LGWT
3	Spinup coefficient	1.4	LGEAR
4	Springback coefficient	.893	LGEAR
5	Main gear miscellaneous weight factor	.25	LGWT
6	Main gear miscellaneous weight factor	.50	LGWT
7	Main gear miscellaneous weight factor	.001	LGWT
8	Nose gear miscellaneous weight factor	.25	LGWT
9	Nose gear miscellaneous weight factor	.50	LGWT

TABLE 31. INPUT ARRAY D -- PERMANENT DATA (CONT)

Loc	Description	Value	Subroutine Reference
10	Two-point coefficient	.25	LGEAR
11	Drift landing coefficient	.8	LGEAR
12	Area tolerance (square inches)	.1	LGWT
13	Landing speed constant	34.7776	LGEAR
14	Load factor constant	.98	LGEAR
15	Load factor constant	.08	LGEAR
16	Load factor constant	.8	LGEAR
17	Tail wheel weight equation constant	2.024	LGWT
18	Tail wheel weight equation constant	.2963	LGWT
19	Tail wheel weight equation constant	.6238	LGWT
20	Diameter-to-thickness ratio factor	.8	LGWT
21	Diameter-to-thickness ratio factor	1.0	LGWT
22	Diameter-to-thickness ratio factor	1.2	LGWT
23	Main gear stroke coefficient at takeoff	1.0	LGEAR
24	Main gear stroke coefficient at landing	1.0	LGEAR
25	Pounds of brake per foot-pound of kinetic energy	$.408 \times 10^{-5}$	LGEAR
26	Diameter-to-thickness ratio of inner cylinder above section 2	50.0	LGWT
27	Negligible load check (pounds)	100.0	LGWT
28	Diameter-to-thickness ratio of bogie	20.0	LGWT
29	Assumed diameter-to-thickness ratio	10.0	LGWT
30	Assumed diameter-to-thickness ratio	30.0	LGWT
31	Assumed diameter-to-thickness ratio	50.0	LGWT
32	Diameter-to-thickness ratio of axle	10.0	LGWT
33	Nose gear stroke coefficient at takeoff	1.0	LGEAR
34	Nose gear stroke coefficient at landing	1.0	LGEAR
35	Number of main gear struts	2.0	LGEAR, LGWT
36	Density of oil (pounds/cubic inch)	.03	LGWT
37	Braked roll constant	1.0	LGEAR
38	Braked roll constant	1.2	LGEAR
39	Fraction of strut length to section 1	1.00	LGWT

TABLE 31. INPUT ARRAY D - PERMANENT DATA (CONCL)

Loc	Description	Value	Subroutine Reference
40	Fraction of strut length to section 2	.60	LGWT
41	Fraction of strut length to section 3	.20	LGWT
42	Fraction of strut length to section 4	.12	LGWT
43	Ultimate-to-limit ratio	1.5	LGEAR, LGWT
44	Not used		
45	Not used		

TABLE 32. INPUT ARRAY D - VARIABLE DATA

Loc	Description	Units	Note(s)	Subroutine Reference
46	Takeoff weight	lb	1	LGEAR, LGWT
47	Landing weight	lb	1	LGEAR, LGWT
48	Aborted takeoff Δ weight	lb	1	LGEAR
49	Fuselage station of CG of aircraft at takeoff	in.	1	LGEAR, LGWT
50	Fuselage station of CG of aircraft at landing	in.	1	LGEAR
51	Distance from aircraft CG to ground	in.	1	LGEAR
52	Fuselage station of main gear	in.	1	LGEAR, LGWT
53	Fuselage station of nose gear (or tail wheel)	in.	1	LGEAR, LGWT
54	Distance between main gear struts	in.	1	LGEAR
55	Ultimate tensile strength of material	lb/in. ²		LGWT
56	Poisson's ration of material			LGWT
57	Compression yield stress of material	lb/in. ²		LGWT
58	Modulus of elasticity of material	lb/in. ²		LGWT
59	Density of material	lb/in. ³		LGWT
60	Main gear deflection indicator		2	LGWT
61	Nose gear deflection indicator		2,3	LGWT
62	Auxiliary gear indicator		3	LGEAR, LGWT
63	Weight coefficient for main gear			LGWT
64	Weight coefficient for nose gear		3	LGWT

TABLE 32. INPUT ARRAY D - VARIABLE DATA (CONT)

Loc	Description	Units	Note(s)	Subroutine Reference
65	Weight coefficient for outer cylinder of main and nose gear			LGWT
66	Weight coefficient for inner cylinder of main and nose gear			LGWT
67	Weight coefficient for bogie			LGWT
68	Weight coefficient for main gear drag strut		2	LGWT
69	Weight coefficient for main gear side strut		2	LGWT
70	Weight coefficient for nose gear drag strut		2,3	LGWT
71	Weight coefficient for nose gear side strut		2,3	LGWT
72	Axle to trunnion length of main gear with piston extended	in.	1	LGWT
73	Stroke of main gear	in.	1,4	LGEAR, LGWT
74	Piston diameter of main gear	in.	5	LGWT
75	Eccentricity of main gear wheels	in.	6	LGWT
76	Wheels per strut on main gear		7	LGEAR, LGWT
77	Fore-aft angle of main gear strut	deg	8	LGEAR, LGWT
78	Lateral angle of main gear strut	deg	8	LGEAR, LGWT
79	Outside diameter of main gear tires	in.		LGEAR, LGWT
80	Width of main gear tires	in.		LGEAR, LGWT
81	Axle to trunnion length of nose gear with piston extended	in.	1,3	LGWT
82	Stroke of nose gear	in.	1,3,4	LGEAR, LGWT
83	Piston diameter of nose gear	in.	3,5	LGWT
84	Eccentricity of nose gear wheels	in.	3,6	LGWT
85	Wheels per strut on nose gear		3,7	LGEAR, LGWT
86	Fore-aft angle of nose gear strut	deg	3,8	LGEAR, LGWT
87	Outside diameter of nose gear tires	in.	3	LGEAR, LGWT
88	Width of nose gear tires	in.	3	LGEAR, LGWT
89	Sink speed at takeoff weight	ft/sec	1,9	LGEAR, LGWT
90	Sink speed at landing weight	ft/sec	1	LGEAR
91	Landing speed at takeoff weight	ft/sec	1,10	LGEAR
92	Landing speed at landing weight	ft/sec	1,10	LGEAR
93	Limit load factor at takeoff weight		11	LGEAR
94	Limit load factor at landing weight		11	LGEAR
95	Coefficient of lift at takeoff weight		10	LGEAR
96	Coefficient of lift at landing weight		10	LGEAR

TABLE 32. INPUT ARRAY D - VARIABLE DATA (CONT)

Loc	Description	Units	Note(s)	Subroutine Reference
97	Area of wing	ft ²	10	LGEAR
98	Wing lift coefficient			LGEAR
99	Not used			LGEAR
100	Main gear wheel weight per aircraft	lb	12	LGEAR
101	Inertia of main gear wheels, tires, tubes, and brakes	slug ft ²	13	LGEAR
102	Main gear tire weight per aircraft	lb	12	LGEAR
103	Brake weight per aircraft	lb	12	LGEAR
104	Main gear miscellaneous weight per aircraft	lb	14	LGWT
105	Nose gear wheel weight per aircraft	lb	3,12	LGEAR
106	Nose gear tire weight per aircraft	lb	3,12	LGEAR
107	Main gear axial load } any conditions	lb	9	LGEAR
108	Main gear normal load } except turning or drift landing	lb	9	LGEAR
109	Main gear axial load } Drift landing	lb	9	LGEAR
110	Main gear normal load }			
111	Main gear axial load } Turning	lb	9	LGEAR
112	Main gear normal load }	lb	9	LGEAR
113	Nose gear axial load } Any conditions	lb	3,9	LGEAR
114	Nose gear normal load } except turning	lb	3,9	LGEAR
115	Nose gear axial load } Turning	lb	3,9	LGEAR
116	Nose gear normal load }	lb	3,9	LGEAR

1. If the takeoff weight is not input in location 46 of the landing gear data, the data in locations 47-54, 72, 73, 81, 82 and 89-92 should also be omitted. The data in these locations will be transferred from the general input data to the landing gear input data in subroutine DLNDGR in the data management module.

2. If the main gear deflection indicator in location 60, or the nose gear deflection indicator in location 61, is 0, the deflections of the strut will be determined. If the deflection indicator is 1, the deflection analysis will be bypassed in subroutine LGWT.

In theory, the deflections would be determined when there are no drag and side struts supporting the main strut, and bypassed when there are supporting struts. However, there is no restriction in the program, and the user may have both deflections and supporting struts, or neither.

TABLE 32. INPUT ARRAY D - VARIABLE DATA (CONT)

The drag and side strut weights are always computed in subroutine LGWT, but may be deleted by setting the corresponding weight coefficient to 0. The weight coefficients are in locations 68 through 71.

3. If the auxiliary gear indicator in location 62 is 1, the auxiliary gear is a nose gear. The weight of the nose gear is determined in the same manner as the main gear. If location 62 is 0, the auxiliary gear is a tail wheel. The weight of a tail wheel is calculated from a single statistical equation; therefore, the nose gear data in locations 61, 62, 64, 81-88, 105, 106, and 113-116 may be omitted.
4. The main gear stroke in location 73 and the nose gear stroke in location 82 are in the vertical direction, not parallel to the strut (unless the strut is perpendicular).
5. If the piston diameter of the main gear is not input in location 74, it will be computed in subroutine LGWT as a function of the static load.

If the piston diameter of the nose gear is not input in location 83, it will be computed in LGWT as a function of the main gear piston diameter.

6. The eccentricity is measured as shown in Figure 51. The eccentricity is positive in the inboard direction, negative in the outboard direction.

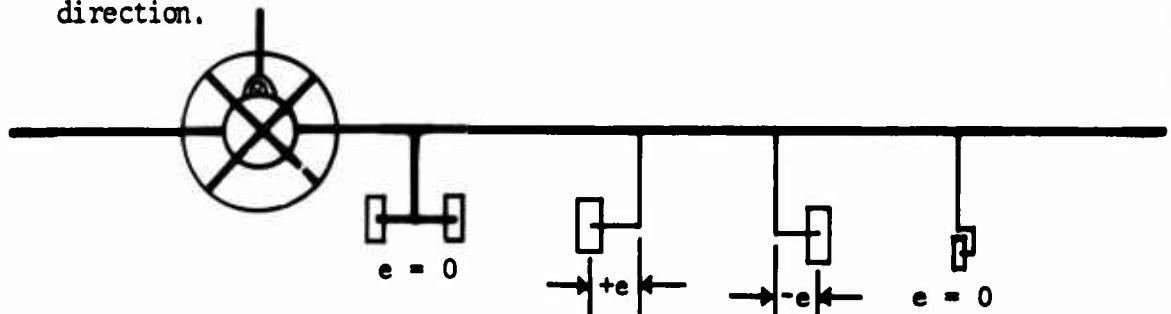


Figure 51. Sign convention for main gear eccentricity.

7. The main gear must have 1, 2, or 4 wheels per strut. If there are 4 wheels per strut, the weight of the bogie will be determined in subroutine LGWT.

The nose gear must have 1 or 2 wheels per strut.

TABLE 32. INPUT ARRAY D - VARIABLE DATA (CONT)

8. The fore-aft and lateral angles of the main gear strut are measured as shown in Figure 52. The fore-aft angle is positive in the forward direction; the lateral angle is positive in the outboard direction. The nose gear has only a fore-aft angle, as shown in Figure 53.

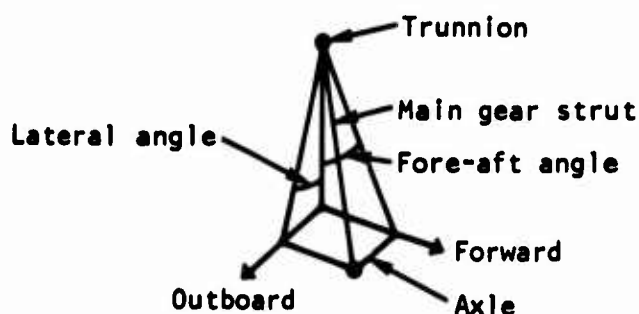


Figure 52. Main gear strut angles.

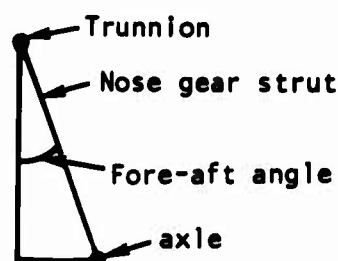


Figure 53. Nose gear strut angles.

9. If the sink speed is input in location 89 in the landing gear data, the loads will be computed in subroutine LGEAR, and the input loads in locations 107 through 116 may be omitted.

If the sink speed is not input, the loads cannot be computed; one or more sets of loads must be input for both the main gear and the nose gear. If more than one set of loads is input, the program will determine the critical loads, just as when all the loads are computed.

If the main gear input loads are from either the two-point landing, spinup, springback, braked roll, unsymmetrical braking, or towing conditions, they are input in locations 107 and 108. The loads are in the fore-aft direction, and must be input if the weight of the main gear drag strut is to be computed.

If the main gear input loads are from the drift landing condition, they are input in locations 109 and 110; if from turning, they are input in locations 111 and 112. Either the turning or drift landing loads must be input if the weight of the main gear side strut is to be computed.

TABLE 32. INPUT ARRAY D - VARIABLE DATA (CONCL)

If the nose gear input loads are from any condition except turning, they are input in location 113 and 114. These loads are in the fore-aft direction, and must be input if the weight of the nose gear drag strut is to be computed.

If the nose gear input loads are from the turning condition, they are input in locations 115 and 116. The turning loads must be input if the weight of the side strut is to be computed.

10. If the landing speed at takeoff weight is input in location 91, the landing speed at landing weight must also be input in location 92, and the wing area in location 97 and the lift coefficients in locations 95 and 96 may be omitted. If location 91 is 0, both landing speeds will be computed from the input data in locations 95, 96, and 97.
11. If the load factor at takeoff weight is input in location 93, the load factor at landing weight must also be input in location 94. If location 93 is 0, both load factors will be computed.
12. If the main gear wheel weight is input in location 100, the main gear tire and brake weights in locations 102 and 103 and the nose gear wheel and tire weights in locations 105 and 106 must also be input. If location 100 is 0, the wheel, tire, and brake weights for both the main and nose gears will be computed in subroutine LGEAR.
13. If the inertia of the main gear wheels, tires, and brakes is not input in location 101, it will be computed.
14. The miscellaneous weight input in location 104 is in addition to the miscellaneous weight computed by statistical methods in subroutine LGWT.

LABELED COMMON BLOCKS

The common block labeled/IPRINT/contains array IP (80). Each location in array IP is a print indicator. A "0" indicates print, or "1" indicates do not print.

Location 59 in array IP is used in program LANDGR to determine whether the input data will be printed.

Location 60 in array IP is used in subroutine LGEAR to indicate whether the landing gear loads will be printed.

The common block labeled/FDATT/contains array FDAT (60). The weight summary data from each component of the aircraft are stored in array FDAT. Locations 41 through 50 in array FDAT are used to store the weights and fuselage stations of the main gear and either the nose gear or tail wheel. These variables are described in Table 33.

TABLE 33. FDAT ARRAY VARIABLES

LOC	Description	Subroutine Reference
41	Total main gear weight, lb	LGWT
42	Main gear wheel, tube, tire, and brake weight, lb	LGWT
43	Main gear strut weight, lb	LGWT
44	Main gear miscellaneous weight, lb	LGWT
45	Fuselage station of main gear, in.	LGWT
46	Total weight of nose gear or tail wheel, lb	LGWT
47	Nose gear wheel, tube, and tire weight, lb	LGWT
48	Nose gear strut weight, lb	LGWT
49	Nose gear miscellaneous weight, lb	LGWT
50	Fuselage station of nose gear or tail wheel, in.	LGWT

The common block labeled/LGDATA/appears in the landing gear program only. This common block contains the input data array D; the landing gear loads array FLOAD; and the wheel, tire, tube, and brake weights.

The input array D is described in Tables 31 and 32.

The landing gear loads are computed in subroutine LGEAR and stored in array FLOADS. This array is described in Table 34.

The wheel, tire, tube, and brake weights are also computed in subroutine LGEAR. These variables are described in Table 35.

SUBROUTINE DESCRIPTIONS

PROGRAM LANDGR

General Description

Deck name:	LANDGR
Entry name:	OVERLAY (5HALPHA, 6,0)
Called by:	OLAYOO
Subroutines called:	LGEAR, LGWT

Program LANDGR is the main program of the landing gear module. It reads the input data from mass storage file record 25, and prints the variable input data if the print indicator is on. It then calls subroutine LGEAR to compute the landing gear loads, and subroutine LGWT to compute the landing gear weights.

Variables Calculated

Variable	Description
N	General index

Labeled Common Blocks

IP (59), which is taken from common block/IPRINT/, indicates whether the variable input data in locations 46 to 116 of the input data array will be printed (Figure 54).

TABLE 34. ARRAY LOADS IN LGDATA BLOCK

LOC	Description	Units	Subroutine Reference
1	Axial load - two-point landing	lb	LGEAR,LGWT
2	Normal load - two-point landing		
3	Axial load - spinup		
4	Normal load - spinup		
5	Axial load - springback		
6	Normal load -springback		
7	Axial load - braked roll		
8	Normal load - braked roll		
9	Axial load - drift landing		
10	Normal load - drift landing		
11	Axial load - unsymmetrical braking		
12	Normal load - unsymmetrical braking		
13	Axial load - towing		
14	Normal load - towing		
15	Axial load - turning		
16	Normal load - turning	lb	LGEAR,LGWT

Main gear at
takeoff
weight

TABLE 34. ARRAY FLOADS IN LGDATA BLOCK (CONT)

LOC	Description	Units	Subroutine Reference
17	Axial load - two-point landing	1b	LGEAR,LGWT
18	Normal load - two-point landing		
19	Axial load - spinup		
20	Normal load - spinup		
21	Axial load - springback		
22	Normal load - springback		
23	Axial load - braked roll		
24	Normal load - braked roll		
25	Axial load - drift landing		
26	Normal load - drift landing		
27	Axial load - unsymmetrical braking		
28	Normal load - unsymmetrical braking		
29			
30			
31			
32		1b	LGEAR,LGWT

Main gear at
takeoff
weight

TABLE 34. ARRAY FLOODS IN LGDATA BLOCK (CONT)

LOC	Description	Units	Subroutine Reference
33	Axial load - two-point landing	lb	LGEAR, LGWT
34	Normal load - two-point landing		
35	Axial load - spinup		
36	Normal load - spinup		
37	Axial load - springback		
38	Normal load - springback		
39			
40			
41	Nose gear at takeoff weight		
42			
43			
43	Axial load - unsymmetrical braking		
44	Normal load - unsymmetrical braking		
45	Axial load - towing		
46	Normal load - towing		
47	Axial load - turning		
48	Normal load - turning	lb	LGEAR, LGWT

TABLE 34. ARRAY FLOODS IN LGDATA BLOCK (CONCL)

LOC	Description	Units	Subroutine Reference
49	Axial load - two-point landing	lb.	LGEAR, LGWT
50	Normal load - two-point landing		
41	Axial load - spinup		
52	Normal load - spinup		
53	Axial load - springback		
54	Normal load - springback		
55			
56			
57			
58			
59	Axial load - unsymmetrical braking		
60	Normal load - unsymmetrical braking	lb	LGEAR, LGWT

TABLE 35. WHEEL, TIRE, TUBE, AND BRAKE WEIGHTS
IN LGDATA BLOCK

Variable	Description	Units	Subroutine Reference
TTAUX	Weight per aircraft of nose gear tubes and tires	lb	LGEAR, LGWT
TTMAIN	Weight per aircraft of main gear tubes and tires		
WHEELA	Weight per aircraft of nose gear wheels		
WHEELM	Weight per aircraft of main gear wheels		
BRAKES	Weight of brakes	lb	LGEAR, LGWT

*** LANDING GEAR DATA ***

46 TAKE-OFF WEIGHT	317998.94	81 NOSE GEAR LENGTH	41.50
47 LANDING WEIGHT	257499.06	82 NOSE GEAR STROKE	12.00
48 ABORTED TAKE-OFF DELTA WT	0.0	83 NOSE GEAR PISTON DIAMETER	0.0
49 AIRCRAFT CG AT TAKE-OFF	931.54	84 NOSE GEAR ECCENTRICITY	0.0
50 AIRCRAFT CG AT LANDING	925.17	85 NOSE GEAR WHEELS/STRUT	2.00
51 AIRCRAFT CG TO GROUND	153.58	86 STRUT ANGLE (FORE-AFT)	0.0
52 MAIN GEAR FUSELAGE STATION	991.77	87 NOSE GEAR TIRE OD	36.00
53 NOSE GEAR FUSELAGE STATION	354.75	88 NOSE GEAR TIRE WIDTH	11.00
54 DIST BETWEEN STRUTS	210.00	89 TAKE-OFF WEIGHT SINK SPEED	6.00
55 HEAT TREATMENT OF MATERIAL	240000.00	90 LANDING WEIGHT SINK SPEED	10.00
56 POISSONS RATIO	0.33	91 TAKE-OFF WT LANDING SPEED	231.83
57 FCY	165000.00	92 LANDING WT LANDING SPEED	208.61
58 MODULUS OF ELASTICITY	30000000.00	93 TAKE-OFF WT LOAD FACTOR	0.0
59 DENSITY OF MATERIAL	0.28	94 LANDING WEIGHT LOAD FACTOR	0.0
60 MAIN DEFLECTION INDICATOR	0.0	95 CL AT TAKE-OFF WEIGHT	0.0
61 NOSE DEFLECTION INDICATOR	0.0	96 CL AT LANDING WEIGHT	0.0
62 AUXILIARY GEAR INDICATOR	1.00	97 WING AREA	0.0
63 MAIN GEAR WEIGHT COEFF	1.00	98 WING LIFT COEFFICIENT	1.00
64 NOSE GEAR WEIGHT COEFF	1.00	99 TOTAL LANDING GEAR WEIGHT	0.0
65 OUTER CYL WEIGHT COEFF	1.00	100 MAIN GEAR WHEEL WEIGHT	0.0
66 INNER CYL WEIGHT COEFF	1.00	101 MAIN GEAR INERTIA	0.0
67 BOGIE WEIGHT COEFF	1.00	102 MAIN GEAR TIRE WEIGHT	0.0
68 MAIN DRAG STRUT WT COEFF	4.00	103 BRAKE WEIGHT	0.0
69 MAIN SIDE STRUT WT COEFF	0.0	104 MISCELLANEOUS WEIGHT	0.0
70 NOSE DRAG STRUT WT COEFF	4.00	105 NOSE GEAR WHEEL WEIGHT	0.0
71 NOSE SIDE STRUT WT COEFF	0.0	106 NOSE GEAR TIRE WEIGHT	0.0
72 MAIN GEAR LENGTH	61.70	107 MAIN GEAR AL (FORE-AFT)	0.0
73 MAIN GEAR STROKE	28.00	108 MAIN GEAR NL (FORE-AFT)	0.0
74 MAIN GEAR PISTON DIAMETER	0.0	109 MAIN GEAR AL (DRIFT LAND)	0.0
75 MAIN GEAR ECCENTRICITY	0.0	110 MAIN GEAR NL (DRIFT LAND)	0.0
76 MAIN GEAR WHEELS/STRUT	4.00	111 MAIN GEAR AL (TURNING)	0.0
77 STRUT ANGLE (FORE-AFT)	0.0	112 MAIN GEAR NL (TURNING)	0.0
78 STRUT ANGLE (LATERAL)	0.0	113 NOSE GEAR AL (FORE-AFT)	0.0
79 MAIN GEAR TIRES OD	44.00	114 NOSE GEAR NL (FORE-AFT)	0.0
80 MAIN GEAR TIRE WIDTH	16.00	115 NOSE GEAR AL (TURNING)	0.0
		116 NOSE GEAR NL (TURNING)	0.0

Figure 54. Sample output from LANDGR of variable landing gear data.

The input data array D (Tables 31 and 32) is placed in common block/LGDATA/ so that the input data may be transferred to subroutines LGEAR and LGWT.

Mass Storage File Records

Mass storage file record 25, which contains landing gear data array D, is read. No mass storage file records are written.

SUBROUTINE LOADS

General Description

Deck name: LOADS
 Entry name: LOADS
 Called by: LGEAR
 Subroutines called: None

Subroutine LOADS computes the axial and normal loads on the strut from the drag, side, and vertical loads on the wheels.

Variables Input

Variable	Description	Units
CSFA	Cosine of the angle between strut and fore-aft direction	
CSL	Cosine of angle between strut and lateral direction	
CSV	Cosine of angle between strut and vertical	
DF	Drag (fore-aft) load on wheels	lb
SF	Side (lateral) load on wheels	lb
VF	Vertical load on wheels	lb

Variables Calculated

Variable	Description	Units
ANG	Angle between strut and resultant load	radians
AXLOAD	Axial load on strut	lb
CRFA	Cosine of angle between resultant load and fore-aft direction	
CRL	Cosine of angle between resultant load and lateral direction	
CRV	Cosine of angle between resultant load and vertical	
PLOAD	Normal load on strut	lb
RLOAD	Resultant load of drag, side, and vertical loads on wheels	lb

SUBROUTINE LG3P

General Description

Deck name: LG3P
Entry name: LG3P
Called by: LGWT
Subroutines called: None

Subroutine LG3P is a three-point interpolation routine. A second degree curve, of the form shown in equation 123, is passed through three points in order to determine the value of Y for a given value of X.

$$Y_P = \frac{(X_P - X_1)(X_P - X_2)Y_3}{(X_1 - X_3)(X_2 - X_3)} + \frac{(X_P - X_2)(X_P - X_3)Y_1}{(X_1 - X_2)(X_1 - X_3)} + \frac{(X_P - X_1)(X_P - X_3)Y_2}{(X_1 - X_2)(X_2 - X_3)} \quad (123)$$

Arrays Input

Array (Dimension)	Description
X(3)	Three values of X
Y(3)	Three values of Y corresponding to X(3)

Variables Input

Variable	Description
XP	Value of X for which a value of Y will be determined

Arrays Calculated

Array (Dimension)	Description
V(9)	Used for temporary storage of elements in equation 1

Variables Calculated

Variable	Description
YP	Value of Y corresponding to XP

SUBROUTINE BMOR

General Description

Deck name: BMOR
Entry name: BMOR
Called by: LGWT
Subroutines called: None

Subroutine BMOR computes the bending modulus of rupture and the torsion modulus of rupture as functions of the ultimate tensile strength of the material and the ratio of the diameter of the cylinder to the wall thickness.

Variables Input

Variable	Description	Units
DT	Ratio of diameter of cylinder to cylinder wall thickness	
HT	Ultimate tensile strength of material	lb/in. ²

Variables Calculated

Variable	Description	Units
AFB	Scratch variable	
AST	Scratch variable	
BFB	Scratch variable	
BMRU	Bending modulus of rupture	lb/in. ²
BST	Scratch variable	
CFB	Scratch variable	
CST	Scratch variable	
TMOR	Tension modulus of rupture	lb/in. ²
X	Diameter-to-thickness ratio	
Z	Ultimate tensile strength divided by 1,000	lb/in. ² X 10 ⁻³

SUBROUTINE LGEAR

General Description

Deck name:	LGEAR
Entry name:	LGEAR
Called by:	LANDGR
Subroutines called:	LOADS

Subroutine LGEAR computes the landing gear loads. The axial and normal loads on the strut are determined for eight load conditions.

The loads for the two-point landing, spinup, springback, and unsymmetrical, braking load conditions are determined at both the takeoff and landing weights for both the main and nose gears.

The loads for the braked roll and drift landing conditions are determined at both takeoff and landing weights for the main gear only.

The loads for the towing and turning conditions are determined at the takeoff weight only for both the main and nose gears.

Labeled Common Blocks

IP (60), which is taken from common block/IPRINT/, indicates whether the landing gear loads will be printed in subroutine LGEAR (Figure 55).

Input data array D is transferred from program LANDGR to subroutine LGEAR in common block/LGDATA/. Array D is described in Tables 31 and 32.

The landing gear loads computed in subroutine LGEAR are stored in array FLOADS, which is placed in common block/LGDATA/. Array LFOADS is described in Table 34.

The wheel, tire, tube, and brake weights computed in subroutine LGEAR are placed in common block/LGDATA/. These variables are described in Table 35.

		WEIGHT	LOAD FACTOR	LANDING SPEED (FT/SEC)	SINKING SPEED (FT/SEC)
TAKE-OFF LANDING	317998.9	1.270	231.8	6.00	
	257499.1	1.749	206.6	10.00	

LANDING GEAR LOADS					
MAIN LANDING GEAR			NOSE LANDING GEAR		
		TAKE-OFF	LANDING	TAKE-OFF	LANDING
TWO POINT	AXIAL	64336.	144712.	12166.	30261.
	NORMAL	16084.	36178.	3042.	7565.
SPIN UP	AXIAL	62425.	125775.	12166.	28642.
	NORMAL	48667.	96847.	9368.	22054.
SPRING BACK	AXIAL	64336.	144712.	12166.	30261.
	NORMAL	42917.	86470.	8364.	19691.
BRAKED ROLL	AXIAL	238499.	231749.		
	NORMAL	190799.	185399.		
DRIFT LANDING	AXIAL	32168.	72356.		
	NORMAL	25735.	57885.		
UNSYS. BRAKING	AXIAL	196955.	157722.	86751.	73738.
	NORMAL	157564.	126178.	35595.	28504.
TOWING	AXIAL	215949.		45101.	
	NORMAL	53662.		71550.	
TURNING	AXIAL	390368.		45101.	
	NORMAL	195184.		22550.	

Figure 55. Sample output from LGear of landing gear loads.

Variables Calculated

Variable	Description	Units
A1	Fore-aft angle of strut	radians
A2	Lateral angle of strut	radians
CSFA	Cosine of angle between strut and fore-aft direction	
CSL	Cosine of angle between strut and lateral direction	
CSV	Cosine of angle between strut and vertical	
DF	Drag (fore-aft) load on wheels	lb
DIST	Distance from main gear to nose gear (fuselage stations)	in.
FDSU	Maximum spinup drag load	lb
FNGML	Element in equation for TVFACT	
FNS	Element in turning load equation	
FTOW	Tow load	lb
FVSU	Vertical load at time TSU	lb
I	Loads index: I = 1 - Main gear at takeoff weight I = 17 - Main gear at landing weight I = 33 - Nose gear at takeoff weight I = 49 - Nose gear at landing weight	
K	Weight index: K = 1 - Takeoff weight K = 2 - Landing weight	

Variable	Description	Units
L	Component index: L = 1 - Main gear L = 2 - Nose gear	
N	General index	
N02	General index	
SF	Side (lateral) load on wheels	lb
TSU	Time required for wheel circumferential velocity to reach ground velocity	sec
TSUFAC	Element in equation for TSU	
TV	Time required to develop vertical reaction	sec
TVFACT	Element in equation for TV	
VF	Vertical load on wheels	lb
WTTAUX	Weight per wheel of nose gear wheel, tube, and tire	lb
WTTMAI	Weight per wheel of main gear wheel, tube, and tire	lb

Arrays Calculated

Array (location)	Description	Units
A(1)	Distance from CG at takeoff to main gear (fuselage stations)	in.
A(2)	Distance from CG at landing to main gear (fuselage stations)	in.
B(1)	Distance from CG at takeoff to nose gear (fuselage stations)	in.

Array (location)	Description	Units
B(2)	Distance from CG at landing to nose gear (fuselage stations)	in.
DELTIR(1)	Deflection of main gear tires	ft
DELTIR(2)	Deflection of nose gear tires	ft
FIW(1)	Inertia of main gear wheels, tires, tubes, and brakes	slug-ft ²
FIW(2)	Inertia of nose gear wheels, tires, and tubes	slug-ft ²
FNG(1)	Load factor at takeoff weight	
FNG(2)	Load factor at landing weight	
FVMAX(1)	Maximum vertical load at takeoff weight	lb
FVMAX(2)	Maximum vertical load at landing weight	lb
GRWT(1)	Takeoff gross weight	lb
GRWT(2)	Landing gross weight	lb
OD(1)	Outside diameter of main gear tires	ft
OD(2)	Outside diameter of nose gear tires	ft
PRAD(1)	Rolling radius of main gear tires	ft
PRAD(2)	Rolling radius of nose gear tires	ft
STROKE(1)	Effective stroke at takeoff weight	ft
STROKE(2)	Effective stroke at landing weight	ft
VL(1)	Landing speed at takeoff weight	ft/sec
VL(2)	Landing speed at landing weight	ft/sec

SUBROUTINE LGWT

General Description

Deck name:	LGWT
Entry name:	LGWT
Called by:	LANDGR
Subroutines called:	BMOR, LG3P

Subroutine LGWT computes the weight of the main landing gear and the weight of either the nose gear or the tail wheel.

The total landing gear weight is the sum of the weights of the inner cylinder, outer cylinder, axle, bogie, drag strut, side strut, oil, wheels, tires, tubes, brakes, and miscellaneous components. Weight summary results are printed by this routine (Figures 56 and 57).

Labeled Common Blocks

Input array D is transferred from program LANDGR to subroutine LGWT in common block/LGDATA/. Array D is described in Tables 31 and 32.

The landing gear loads which were stored in array FLOADS in subroutine LGEAR are transferred to subroutine LGWT in common block/LGDATA/. Array FLOADS is described in Table 34.

The wheel, tire, tube, and brake weights are transferred from subroutine LGEAR to subroutine LGWT in common block/LGDATA/. These variables are described in Table 35.

The weights and fuselage stations of the main gear and either the nose gear or tail wheel are stored in array FDAT in labeled common block/FDATT/. These variables are described in Table 33.

MAIN LANDING GEAR WEIGHTS (POUNDS)

OUTER CYLINDER	365.8
PISTON	156.0
AXLE	501.6
OIL	241.9
DRAG STRUT	369.1
SIDE STRUT	0.0
WHEELS	1148.1
TIRES	1403.2
MISC (CALC.)	2823.5
BRAKES	751.9
BOGIE	605.3
MISC (INPUT)	0.0

TOTAL	8366.3
-------	--------

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MAIN LANDING GEAR DESIGN DATA

	DESIGN LOAD CONDITION **	AREA (SQ IN)	DIAMETER TO THICKNESS RATIO	BENDING MODULUS OF RUPTURE	TORSIONAL MODULUS OF RUPTURE
OUTER CYLINDER	16	18.09	26.65	279844.	116402.
	16	12.86	36.29	258504.	107003.
	2	9.11	50.00	237500.	98514.
PISTON (20 PCT OF LENGTH FROM AXLE)	2	7.52	50.00	237500.	98514.

PISTON DIAMETER (INCHES)	11.05
AFT DEFLECTION (INCHES)	2.16
SIDE DEFLECTION (INCHES)	0.0
ANGLE OF TWIST (RADIAN)	0.0

CG - BELOW TRUNION POINT	54.3
CG - OUTBOARD (INBOARD) FROM TRUNION POINT	0.0
CG - AFT (FORWARD) FROM TRUNION POINT	0.9

Figure 56. Sample output from LGWT of nose gear weight summary.

NOSE LANDING GEAR WEIGHTS (POUNDS)

OUTER CYLINDER	43.2	SIDE STRUT	0.0
PISTON	18.9	WHEELS	142.7
AXLE	23.2	TIRES	174.4
OIL	18.7	MISC (CALC.)	207.1
DRAG STRUT	46.5		
		TOTAL	674.6

NOSE LANDING GEAR DESIGN DATA

	DESIGN LOAD CONDITION **	AREA (SQ IN)	DIAMETER TO THICKNESS RATIO	BENDING MODULUS OF RUPTURE	TORSIONAL MODULUS OF RUPTURE
OUTER CYLINDER	14	6.38	28.90	274388.	113959.
TOP	14	4.34	41.07	249940.	103395.
MIDDLE	2	3.52	50.00	237500.	98514.
PISTON (20 PCT OF LENGTH FROM AXLE)	2	2.71	50.00	237500.	98514.
PISTON DIAMETER (INCHES)					34.9
AFT DEFLECTION (INCHES)					0.0
SIDE DEFLECTION (INCHES)					0.9
ANGLE OF TWIST (RADIANS)					

** DESIGN LOAD CONDITION INDICATORS

	TAKE-OFF WEIGHT	LANDING WEIGHT
TWC POINT	2	18
SPIN UP	4	20
SPRING BACK	6	22
BRAKED ROLL	8	24
DRIFT LANDING	10	26
UNSYMMETRICAL BRAKING	12	28
TCWING	14	
TURNING	16	

(IF THE DESIGN LOAD CONDITION INDICATORS ARE ALL 0, THE DESIGN LOADS WERE GIVEN IN THE INPUT DATA)

Figure 57. Sample output from LGWT of main gear weight summary.

Variables Calculated

Variable	Description	Units
AQM	Constant in piston diameter equation	
AREAC	Area of cylinder section	in. ²
AREA2S	Area of section 2 from previous pass in deflection loop	in. ²
AXLGTH	Length of axle	lb
AXLOAD	Total load on axles	lb
BQM	Constant in piston diameter equation	
BD	Diameter of bogie	in.
BMAX	Bending moment on axle	in.-lb.
BMB	Bending moment on bogie	in.-lb.
BMFACT	Ratio of deflection at bottom of strut to deflection at section 2	
BMOD	Bending modulus of rupture for axle	lb/in. ²
BMOFR	Bending modulus of rupture at cylinder section	lb/in. ²
BMR	Resultant bending moment	in.-lb.
BMY	Fore-aft bending moment	in.-lb.
BMYDZ	Design fore-aft bending moment at section 2	in.-lb.
BMZ	Lateral bending moment	in.-lb.
BMZDZ	Design lateral bending moment at section 2	in.-lb.
BOGL	Length of bogie	in.
BOGWT	Weight of bogie	lb.

Variable	Description	Units
COSTHE	Cosine of angle between strut and vertical	
DEFLI	Deflection indicator	
DEFLP	Angular deflection at bottom of strut	radians
DEFLY	Fore-aft deflection at bottom of strut	in.
DEFLZ	Lateral deflection at bottom of strut	in.
DELTA	Weight coefficient	
DELYR	Deflection of tires	in.
DIAAX	Diameter of axle	in.
DIADZ	Diameter of cylinder at section 2	in.
DIAM	Diameter of cylinder	in.
DLFLNG	Length from section to ground for drift landing condition	in.
DOTINT	Interpolated value of diameter-to-thickness ratio	
DOVT	Final value of diameter-to-thickness ratio	
DP	Diameter of piston	in.
DSF	Weight coefficient for drag strut	
DSTRWT	Weight of drag strut	lb
ECCET	Eccentricity	in.
FIG	Moment of inertia at section 2	in. ⁴
GMOD	Modulus of rigidity	lb/in. ²
HT	Ultimate tensile strength	lb/in. ²

Variable	Description	Units
I	Section subscript	
J	Loads subscript	
L	Loads index	
LOOP	Deflection loop counter	
M	General index	
N	Index in diameter-to-thickness ratio search	
NTRIP	Component indicator (1 = main gear, 2 = nose gear)	
ODTYR	Outside diameter of tires	in.
PASS	Ratio check counter	
PI	Ratio of circumference of circle to diameter	
RADPD	Element in piston diameter equation	
SMALA	Element in piston diameter equation	
SMALB	Element in piston diameter equation	
SSF	Weight coefficient for side strut	
SSTRWT	Weight of side strut	lb
STROKE	Stroke of piston	in.
STRUTS	Number of struts	
SW	Static load on each strut	lb
TAILWT	Weight of tail wheel	lb

Variable	Description	Units
TMAX	Torsion moment on axle	in.-lb.
TMB	Torsion moment on bogie	in.-lb
TMOD	Torsion modulus of rupture for axle	lb/in. ²
TMOFR	Torsion modulus of rupture at cylinder section	lb/in. ²
TOTAL	Total weight of main or nose gear	lb
TOTCAL	Total calculated weight of landing gear structure	lb
TOTLNG	Axle to trunnion length of gear with piston extended	in.
TOTSTW	Total calculated weight	lb.
TPHI	Torsion bending moment	in.-lb
TPHIDZ	Design torsion bending moment at section 2	in.-lb
VOLAX	Volume of axle	in. ³
VOLOIL	Volume of oil	in. ³
WBT	Weight of brakes, wheels, tires, and tubes	lb
WHEELS	Number of wheels per strut	
WIDTH	Width of tires	in.
WTAXL	Weight of axle	lb
WTBRK	Weight of brakes	lb
WTIC	Weight of inner cylinder	lb

Variable	Description	Units
WTMISC	Calculated miscellaneous weight	lb
WTOC	Weight of outer cylinder	lb
WTOIL	Weight of oil	lb
WTTT	Weight of tubes and tires	lb
WTWHL	Weight of wheels	lb
XAWTBB	Fore-aft distance from trunnion to CG of wheels, tires, tubes, and brakes	in.
XCG	Fore-aft distance from trunnion to CG of main or nose gear	in.
XCGDS	Fore-aft distance from trunnion to CG of drag strut	in.
XCGIC	Fore-aft distance from trunnion to CG of inner cylinder	in.
XCGOC	Fore-aft distance from trunnion to CG of outer cylinder	in.
XCGOIL	Fore-aft distance from trunnion to CG of oil	in.
XCGSS	Fore-aft distance from trunnion to CG of side strut	in.
XFB	Bending modulus of rupture for bogie	lb/in. ²
XFT	Torsion modulus of rupture for bogie	lb/in. ²
YAWTBB	Lateral distance from trunnion to CG of wheels, tires, tubes, and brakes	in.
YCG	Lateral distance from trunnion to CG of main nose gear	in.
YCGDS	Lateral distance from trunnion to CG of drag strut	in.

Variable	Description	Units
YCGIC	Lateral distance from trunnion to CG of inner cylinder	in.
YCGOC	Lateral distance from trunnion to CG of outer cylinder	in.
YCGOIL	Lateral distance from trunnion to CG of oil	in.
YCGSS	Lateral distance from trunnion to CG of side strut	in.
ZAWTBB	Vertical distance from trunnion to CG of wheels, tires, tubes, and brakes	in.
ZCG	Vertical distance from trunnion to CG of main or nose gear	in.
ZCGDS	Vertical distance from trunnion to CG of drag strut	in.
ZCGIC	Vertical distance from trunnion to CG of inner cylinder	in.
ZCGOC	Vertical distance from trunnion to CG of outer cylinder	in.
ZCGOIL	Vertical distance from trunnion to CG of oil	in.
ZCGSS	Vertical distance from trunnion to CG of side strut	in.

Arrays Calculated

Array (location)	Description	Units
ANGLE(1)	Fore-aft angle of strut	radians
ANGLE(2)	Lateral angle of strut	radians
AREAN(1)	Final area of section 1	in. ²
AREAN(2)	Final area of section 2	in. ²
AREAN(3)	Final area of section 3	in. ²
AREAN(4)	Final area of section 4	in. ²
AS(1)	Cylinder area required for strength for DOT(1)	in. ²
AS(2)	Cylinder area required for strength for DOT(2)	in. ²
AS(3)	Cylinder area required for strength for DOT(3)	in. ²
DIA(1)	Outside diameter of strut for DOT(1)	in.
DIA(2)	Outside diameter of strut for DOT(2)	in.
DIA(3)	Outside diameter of strut for DOT(3)	in.
DOT(1)	First assumed value of diameter-to- thickness ratio	
DOT(2)	Second assumed value of diameter-to- thickness ratio	
DOT(3)	Third assumed value of diameter-to- thickness ratio	
DOVRTN(1)	Final diameter-to-thickness ratio of section 1	
DOVRTN(2)	Final diameter-to-thickness ratio of section 2	

Array (location)	Description	Units
DOVRTN(3)	Final diameter-to-thickness ratio of section 3	
DOVRTN(4)	Final diameter-to-thickness ratio of section 4	
FLNGTH(1)	Length from axle to section 1	in.
FLNGTH(2)	Length from axle to section 2	in.
FLNGTH(3)	Length from axle to section 3	in.
FLNGTH(4)	Length from axle to section 4	in.
GRWT(1)	Takeoff gross weight	lb.
GRWT(2)	Landing gross weight	lb.
LODIDN(1)	Design condition identification for section 1	
LODIDN(2)	Design condition identification for section 2	
LODIDN(3)	Design condition identification for section 3	
LODIDN(4)	Design condition identification for section 4	
PFB(1)	Bending modulus of rupture at section 1	lb/in. ²
PFB(2)	Bending modulus of rupture at section 2	lb/in. ²
PFB(3)	Bending modulus of rupture at section 3	lb/in. ²
PFB(4)	Bending modulus of rupture at section 4	lb/in. ²

Array (location)	Description	Units
PFST(1)	Torsion modulus of rupture at section 1	lb/in. ²
PFST(2)	Torsion modulus of rupture at section 2	lb/in. ²
PFST(3)	Torsion modulus of rupture at section 3	lb/in. ²
PFST(4)	Torsion modulus of rupture at section 4	lb/in. ²
PHI(1)	Angular deflection at section 1	radians
PHI(2)	Angular deflection at section 2	radians
PHI(3)	Angular deflection at section 3	radians
PHI(4)	Angular deflection at section 4	radians
RAT(1)	Ratio of strength area to geometric area for DOT(1)	
RAT(2)	Ratio of strength area to geometric area for DOT(2)	
RAT(3)	Ratio of strength area to geometric area for DOT(3)	
Y(1)	Fore-aft deflection at section 1	in.
Y(2)	Fore-aft deflection at section 2	in.
Y(3)	Fore-aft deflection at section 3	in.
Y(4)	Fore-aft deflection at section 4	in.
Z(1)	Lateral deflection at section 1	in.
Z(2)	Lateral deflection at section 2	in.
Z(3)	Lateral deflection at section 3	in.
Z(4)	Lateral deflection at section 4	in.

APPENDIX B
LANDING GEAR MODULE
FLOW CHARTS AND FORTRAN LISTS

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FOR
AUTOFLOW CHART SET

FERTMAN MOBILE LANDING GEAR MOBILE

CHART TITLE - INTRODUCTORY COMMENTS

CHART TITLE - PROCEDURES

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 (000013) 2.02 (000013) 2.03
 (000010) 2.00 5001
 (000107) 2.17 50.2 (000017) 2.05
 (000113) 2.20 5

CHART TITLE - NON-PROCEDURAL STATEMENTS

CHART TITLE - INTRODUCTORY COMMENTS

CHART TITLE - SUBROUTINE OVERIGHT,MT,DOWN,UPPER

(000120) 0.01 OVER (000710) 25.00-X (000011) 25.04-X (000004) 25.00-X (000010) 20.03-X

CHART TITLE - INTRODUCTORY COMMENTS

CHART TITLE - SUBROUTINE LGEAR

(000140) 0.01 LGEAR (000100) 2.10-X
 (000157) 0.01 00 (000104) 0.03
 (000170) 0.04 300 (000104) 0.03
 (000100) 0.05 310
 (000105) 0.05 320 (000170) 0.04
 (000100) 0.07 300 (000102) 0.05
 (000105) 0.08 330 (000100) 0.07
 (000107) 0.10 010
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 (000014) 10.05 050 (000000) 0.10 (000007) 10.01
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 (000010) 10.00 337
 (000000) 10.10 330
 (000000) 10.10 (000000) 10.11
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 (000005) 11.02 340
 (000005) 11.02 (000005) 11.03
 (000020) 11.04 340 (0000021) 10.11
 (000020) 11.07 (000027) 11.00
 (000027) 11.00 352
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 (000000) 13.18 432
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(000304)	14.01	000	(000345)	13.05	
(000305)	14.04	000			
(000306)	14.05	000	(000308)	14.04	
(000307)	15.01	430	(000346)	13.05	
(000308)	15.02	445	(000309)	15.07	
(000309)	15.03	445			
(000310)	15.10	440			
(000311)	15.11	450	(000310)	15.09	
(000312)	15.12	450	(000310)	15.10	
(000401)	16.01	404	(000310)	15.10	
(000402)	16.02	400	(000310)	15.11	(000400) 15.12
(000413)	16.07	400	(000310)	14.04	(000310) 15.07
(000410)	16.08	400	(000410)	16.08	
(000422)	16.10	000	(000410)	16.08	
(000423)	16.11	002			
(000423)	16.11		(000423)	16.12	
(000443)	16.17	534	(000410)	16.08	(000410) 16.08
(000444)	16.18	000			
(000455)	16.22		(000455)	17.25	
(000457)	16.24	711	(000455)	16.23	
(000458)	16.25	712	(000455)	16.23	
(000453)	17.01	713	(000455)	16.23	
(000455)	17.02	714	(000455)	16.23	
(000455)	17.03	715	(000455)	16.23	
(000472)	17.04	716	(000455)	16.23	
(000475)	17.05	717	(000455)	16.23	
(000476)	17.05	718	(000455)	16.23	
(000481)	17.07	731	(000455)	16.24	(000452) 16.25 (000455) 17.01 (000474) 17.04
(000480)	17.13	735	(000455)	17.02	(000471) 17.03
(000494)	17.19	739	(000477)	17.05	(000455) 17.05
(000490)	17.25	710	(000455)	17.12	(000453) 17.10
(000501)	17.26	1000	(000504)	11.14	(000443) 16.17

CHART TITLE - NON-PROCEDURAL STATEMENTS

CHART TITLE - INTRODUCTORY COMMENTS

CHART TITLE - SUBROUTINE LOG

(000510)	20.01	LOG	(000111)	2.10-E	
(000545)	20.05	1000			
(000571)	21.01	2001	(000504)	20.00	
(000580)	21.02	2002			
(000581)	21.03	2003	(000571)	21.01	
(000582)	21.04	2004			
(000585)	21.05	2005	(000581)	21.03	
(000586)	21.05	2006			
(000588)	21.07	2005	(000585)	21.05	
(000570)	21.08	2007	(000588)	21.02	(000584) 21.04
(000577)	22.01	1000	(000584)	20.00	
(000580)	22.02	2000	(000571)	21.05	(000570) 21.10
(000581)	22.03	1070			
(000581)	22.03		(000581)	22.04	
(000512)	22.12	1074	(001127)	24.12	
(000516)	22.14		(000510)	22.10	
(000510)	22.15	1071			
(000523)	22.17	1070	(000702)	20.00	
(000525)	22.18		(000773)	20.14	
(000543)	23.01	1000	(000541)	22.20	
(000545)	23.02		(000771)	20.13	
(000571)	23.03	2010			
(000582)	23.04	2015	(000545)	23.02	(000571) 23.03
(000584)	23.05	2016			
(000588)	23.07	1001	(000571)	23.03	
(000589)	23.08	1002			
(000589)	23.10	2000	(000583)	23.05	
(000570)	23.11	2002	(000571)	23.05	
(000570)	23.12	2000	(000589)	23.05	
(000581)	23.14	2001			
(000582)	23.15	2002			
(000589)	23.16	2007	(000589)	23.13	(000581) 23.14 (000582) 23.15

REFERENCE: (SOURCE, SEQUENCE NO. AND PAGE/ROW)

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(000003)	23.18	2000		
(000003)	23.18		(000000)	23.18
(000000)	23.21	2000	(000700)	25.10
(000700)	23.22	2070	(000775)	25.23
(000701)	23.23	2070		
(000701)	23.23		(000701)	23.24
(000704)	24.01	2004	(000002)	23.15
(000704)	25.01	2000	(000000)	23.21
(000705)	25.02	2001		
(000705)	25.02		(000705)	25.03
(000708)	25.05	2000	(000702)	23.24
(000710)	25.06		(000717)	25.09
(000717)	25.08	2000		
(000740)	25.11	2000	(000700)	25.10
(000721)	25.12	2030		
(000702)	25.13	2031		
(000723)	25.14	2032	(000721)	25.12
(000725)	25.15	2040	(000702)	25.13
(000705)	25.16	2041		
(000705)	25.16		(000705)	25.17
(000720)	25.19	2000	(000723)	25.14
(000733)	25.21	2001		
(000733)	25.21		(000733)	25.22
(000737)	25.01	2000	(000702)	25.13
(000745)	25.03	2000	(000723)	25.14
(000745)	25.04	2005	(000720)	25.02
(000747)	25.05	2030	(000741)	25.11
(000700)	25.06	2030		
(000705)	25.08	2010	(000745)	25.04
(000702)	25.10	2000	(000703)	25.07
(000700)	25.12	2000		
(000771)	25.13	2000	(000703)	25.07
(000773)	25.14	2000	(000701)	25.08
(000770)	27.01	4000	(000700)	25.11
(000011)	27.02	5000	(000770)	27.01
(000014)	27.03	5010	(000001)	27.02
(000010)	27.05	5020	(000007)	25.11
(000024)	27.07	5040	(000770)	25.10
(000702)	28.01	4030	(000002)	27.05
(000701)	28.04	4037	(000770)	27.01
(000702)	28.05		(000012)	28.14
(000704)	28.06	4000		
(000004)	28.08	5010	(000704)	28.07
(000010)	28.12	5012	(000011)	27.02
(000011)	28.13	5013	(000007)	25.11
(000011)	28.13		(000011)	28.14
(000000)	28.15	5030	(000002)	27.05
(000004)	28.01	5031	(000030)	28.15
(000007)	28.05	5030		
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(000003)	28.12	5000	(000030)	28.16
(000000)	28.14	5000		
(000004)	28.15	5002		
(000000)	28.18	5110	(000000)	28.10
(000005)	28.20	5120	(000000)	28.22
(000000)	28.22	5100	(000000)	28.10
(000002)	28.23	5121	(000000)	28.21
(000000)	28.24	5130	(000000)	28.21
(000000)	28.25	5130		
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(000015)	28.02	5023	(000000)	28.25
(000010)	28.03	5000		
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(000004)	28.07	740	(000002)	28.25
(000000)	28.01	740	(000000)	28.25
(000070)	28.14	5140	(000007)	28.27
(000077)	28.15	5141		
(000070)	28.16	5024	(000077)	28.15
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(000000)	31.10	0002	(000077) 31.10
(000000)	31.10	0003	(000000) 31.10
(001001)	31.01	010	(000000) 31.10
(001000)	32.04	010	(000000) 31.04
(0010.1)	32.07	010	(001011) 32.00
(001017)	32.00	010	(001011) 32.00
(001000)	32.00	000	(001010) 32.07
(001040)	32.12	0703	(001000) 32.11
(001000)	32.13	0704	(001000) 32.11
(001000)	32.14	10	(001000) 32.13
(001001)	33.01	00	(001000) 32.13
(001000)	33.03	30	(001000) 32.10
(001070)	33.04	0000	(001000) 33.03 (001004) 33.11
(001070)	33.00	0200	(001000) 33.03
(001070)	33.00	1.74	(001070) 33.00
(001070)	33.07	047	
(001007)	34.01	044	(001070) 33.00
(001000)	34.00	0100	
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(001111)	34.00	0103	(001007) 34.00
(001114)	34.10	0100	(001100) 34.13
(001100)	34.13	0100	(001107) 34.00

CHART TITLE - NON-PROCEDURAL STATEMENTS

CHART TITLE - INTRODUCTORY COMMENTS

CHART TITLE - SUBROUTINE L03P(X,Y,WP,VP)

(001140)	37.01	L03P	(000730) 35.10-X	(001137) 35.01-X
(001103)	37.00	00		

CHART TITLE - NON-PROCEDURAL STATEMENTS

CHART TITLE - INTRODUCTORY COMMENTS

CHART TITLE - SUBROUTINE L040(COV,CFA,CFL,V,W,W,AILO,C,PL040)

(001102)	40.01	L040	(000304) 13.07-X	(000337) 13.02-X	(000304) 14.03-X	(000302) 15.00-X	(000300) 15.00-X
			(000370) 15.02-X	(000301) 15.04-X	(000307) 15.00-X	(000404) 16.03-X	(000411) 16.00-X

03/07/76

TABLE OF DIAGNOSTICS

AUTOFLOW CHART SET - SHEEP

PAGE 1

LOCATION

DIAGNOSTIC

CARD ID PAGE/BOX

10000191

2.04

UNDEFINED - 'READING' EXTERNAL REFERENCE

PROGRAM FLOW CHARTS
OF
LANDING GEAR MODULE

CHART TITLE - INTRODUCTORY COMMENTS

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#####
PROGRAM LAGER
#####

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CHART TITLE - PROCEDURES

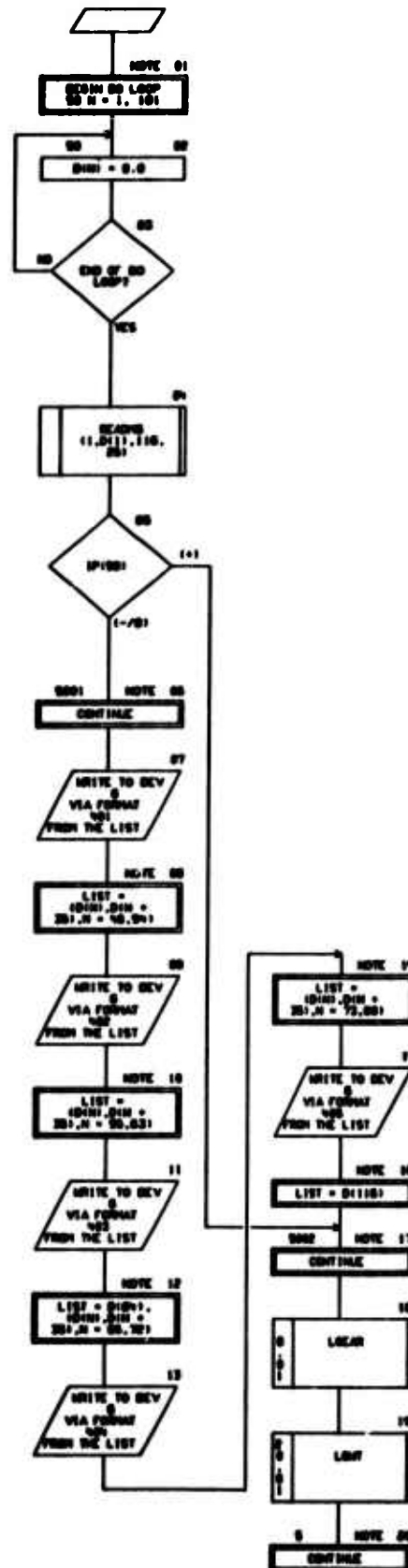


CHART TITLE - NON-PROCEDURAL STATEMENTS

```

PROGRAM LAMGR
COMMON /LSDATA/IN(100),FLD(100),TTRN,TTHIN,WHEELA,WTCOL,BRAKES
COMMON /IPRINT/IP(100)
401 FORMAT(1H,2H,3H*** VARIABLE LANDING GEAR DATA ***,1H,
      2H** LAMGR - (P100) ***
      10H,20H 45 TAKE-OFF HEIGHT .F12.2,
      10H,20H 51 NOSE GEAR LENGTH .F12.2/
      10H,20H 47 LANDING HEIGHT .F12.2,
      10H,20H 52 NOSE GEAR STROKE .F12.2/
      10H,20H 49 ABSORBED TAKE-OFF DELTA MT .F12.2,
      10H,20H 53 NOSE GEAR PISTON DIAMETER .F12.2/
      10H,20H 46 AIRCRAFT CG AT TAKE-OFF .F12.2,
      10H,20H 54 NOSE GEAR ECCENTRICITY .F12.2/
      10H,20H 50 AIRCRAFT CG AT LANDING .F12.2,
      10H,20H 55 NOSE GEAR WHEELS/STRT .F12.2/
      10H,20H 51 AIRCRAFT CG TO GROUND .F12.2,
      10H,20H 56 STRUT ANGLE (FORE-AFT) .F12.2/
      10H,20H 52 MAIN GEAR FUELAGE STATION.F12.2,
      10H,20H 57 NOSE GEAR TIRE CD .F12.2/
      10H,20H 53 NOSE GEAR FUELAGE STATION.F12.2,
      10H,20H 58 NOSE GEAR TIRE WIDTH .F12.2/
      10H,20H 54 DIST BETWEEN STRUTS .F12.2,
      10H,20H 55 TAKE-OFF HEIGHT SINK SPEED.F12.2)
402 FORMAT(
      10H,20H 55 HEAT TREATMENT OF MATERIAL .F12.2,
      10H,20H 56 LANDING HEIGHT SINK SPEED .F12.2/
      10H,20H 56 POISSONS RATIO .F12.2,
      10H,20H 51 TAKE-OFF MT LANDING SPEED .F12.2/
      10H,20H 57 FCY .F12.2,
      10H,20H 52 LANDING MT LANDING SPEED .F12.2/
      10H,20H 58 MODULUS OF ELASTICITY .F12.2,
      10H,20H 53 TAKE-OFF MT LOAD FACTOR .F12.2/
      10H,20H 58 DENSITY OF MATERIAL .F12.2,
      10H,20H 54 LANDING HEIGHT LOAD FACTOR.F12.2/
      10H,20H 59 MAIN DEFLECTION INDICATOR .F12.2,
      10H,20H 55 CL AT TAKE-OFF HEIGHT .F12.2/
      10H,20H 51 NOSE DEFLECTION INDICATOR .F12.2,
      10H,20H 55 CL AT LANDING HEIGHT .F12.2/
      10H,20H 52 AUXILIARY GEAR INDICATOR .F12.2,
      10H,20H 57 WING AREA .F12.2/
      10H,20H 53 MAIN GEAR HEIGHT COEFF .F12.2,
      10H,20H 58 WING LIFT COEFFICIENT .F12.2)
403 FORMAT(
      10H,20H 54 NOSE GEAR HEIGHT COEFF .F12.2,
      /
      10H,20H 55 UPPER CYL HEIGHT COEFF .F12.2,
      10H,20H 56 MAIN GEAR WHEEL HEIGHT .F12.2/
      10H,20H 55 LOWER CYL HEIGHT COEFF .F12.2,
      10H,20H 51 MAIN GEAR INERTIA .F12.2/
      10H,20H 57 BULK HEIGHT COEFF .F12.2,
      10H,20H 52 MAIN GEAR TIRE HEIGHT .F12.2/
      10H,20H 53 MAIN BRAG STRUT MT COEFF .F12.2,
      10H,20H 53 BRAG HEIGHT .F12.2/
      10H,20H 55 MAIN SIDE STRUT MT COEFF .F12.2,
      10H,20H 54 MISCELLANEOUS HEIGHT .F12.2/
      10H,20H 56 BRAG STRUT MT COEFF .F12.2,
      10H,20H 56 NOSE GEAR WHEEL HEIGHT .F12.2/
      10H,20H 51 NOSE SIDE STRUT MT COEFF .F12.2,
      10H,20H 55 NOSE GEAR TIRE HEIGHT .F12.2/
      10H,20H 56 MAIN GEAR LENGTH .F12.2,
      10H,20H 57 MAIN GEAR AL (FORE-AFT) .F12.2)
404 FORMAT(
      10H,20H 53 MAIN GEAR STROKE .F12.2,

```

CHART TITLE - NON-PROCEDURAL STATEMENTS

10N,30H05 MAIN GEAR NL (FORE-AFT)	,F12.2/
10N,30H 74 MAIN GEAR PISTON DIAMETER	,F12.2.
10N,30H05 MAIN GEAR AL (DRIFT LOAD)	,F12.2/
10N,30H 75 MAIN GEAR ECCENTRICITY	,F12.2.
10N,30H15 MAIN GEAR NL (DRIFT LOAD)	,F12.2/
10N,30H 75 MAIN GEAR WHEELS/STRUT	,F12.2.
10N,30H11 MAIN GEAR AL (TURNING)	,F12.2/
10N,30H 77 STRUT ANGLE (FORE-AFT)	,F12.2.
10N,30H12 MAIN GEAR NL (TURNING)	,F12.2/
10N,30H 78 STRUT ANGLE (LATERAL)	,F12.2.
10N,30H13 NOSE GEAR AL (FORE-AFT)	,F12.2/
10N,30H 79 MAIN GEAR TIRES OD	,F12.2.
10N,30H14 NOSE GEAR NL (FORE-AFT)	,F12.2/
10N,30H 80 MAIN GEAR TIRE WIDTH	,F12.2.
10N,30H15 NOSE GEAR AL (TURNING)	,F12.2/
405 FWD/1/1	
00N,30H16 NOSE GEAR NL (TURNING)	,F12.2/

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AUTOFLOW CHART SET - SHEEP LANDING BEAR NEEDLE

PAGE 00

CHART TITLE - INTRODUCTORY COMMENTS

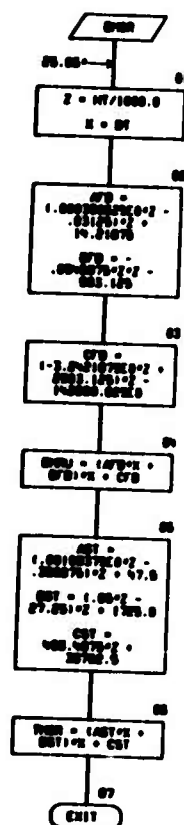
.....
SUBROUTINE OVER
.....

03/27/74

SUBJ: TITLE - SLEIGHT OF HAND; OVER: 01.07.0000, 0001, 0002, 0003, 0004, 0005, 0006, 0007, 0008, 0009, 0010, 0011, 0012, 0013, 0014, 0015, 0016, 0017, 0018, 0019, 0020, 0021, 0022, 0023, 0024, 0025, 0026, 0027, 0028, 0029, 0030, 0031, 0032, 0033, 0034, 0035, 0036, 0037, 0038, 0039, 0040, 0041, 0042, 0043, 0044, 0045, 0046, 0047, 0048, 0049, 0050, 0051, 0052, 0053, 0054, 0055, 0056, 0057, 0058, 0059, 0060, 0061, 0062, 0063, 0064, 0065, 0066, 0067, 0068, 0069, 0070, 0071, 0072, 0073, 0074, 0075, 0076, 0077, 0078, 0079, 0080, 0081, 0082, 0083, 0084, 0085, 0086, 0087, 0088, 0089, 0090, 0091, 0092, 0093, 0094, 0095, 0096, 0097, 0098, 0099, 0100, 0101, 0102, 0103, 0104, 0105, 0106, 0107, 0108, 0109, 0110, 0111, 0112, 0113, 0114, 0115, 0116, 0117, 0118, 0119, 0120, 0121, 0122, 0123, 0124, 0125, 0126, 0127, 0128, 0129, 0130, 0131, 0132, 0133, 0134, 0135, 0136, 0137, 0138, 0139, 0140, 0141, 0142, 0143, 0144, 0145, 0146, 0147, 0148, 0149, 0150, 0151, 0152, 0153, 0154, 0155, 0156, 0157, 0158, 0159, 0160, 0161, 0162, 0163, 0164, 0165, 0166, 0167, 0168, 0169, 0170, 0171, 0172, 0173, 0174, 0175, 0176, 0177, 0178, 0179, 0180, 0181, 0182, 0183, 0184, 0185, 0186, 0187, 0188, 0189, 0190, 0191, 0192, 0193, 0194, 0195, 0196, 0197, 0198, 0199, 0200, 0201, 0202, 0203, 0204, 0205, 0206, 0207, 0208, 0209, 0210, 0211, 0212, 0213, 0214, 0215, 0216, 0217, 0218, 0219, 0220, 0221, 0222, 0223, 0224, 0225, 0226, 0227, 0228, 0229, 0230, 0231, 0232, 0233, 0234, 0235, 0236, 0237, 0238, 0239, 0240, 0241, 0242, 0243, 0244, 0245, 0246, 0247, 0248, 0249, 0250, 0251, 0252, 0253, 0254, 0255, 0256, 0257, 0258, 0259, 0260, 0261, 0262, 0263, 0264, 0265, 0266, 0267, 0268, 0269, 0270, 0271, 0272, 0273, 0274, 0275, 0276, 0277, 0278, 0279, 0280, 0281, 0282, 0283, 0284, 0285, 0286, 0287, 0288, 0289, 0290, 0291, 0292, 0293, 0294, 0295, 0296, 0297, 0298, 0299, 0300, 0301, 0302, 0303, 0304, 0305, 0306, 0307, 0308, 0309, 0310, 0311, 0312, 0313, 0314, 0315, 0316, 0317, 0318, 0319, 0320, 0321, 0322, 0323, 0324, 0325, 0326, 0327, 0328, 0329, 0330, 0331, 0332, 0333, 0334, 0335, 0336, 0337, 0338, 0339, 0340, 0341, 0342, 0343, 0344, 0345, 0346, 0347, 0348, 0349, 0350, 0351, 0352, 0353, 0354, 0355, 0356, 0357, 0358, 0359, 0360, 0361, 0362, 0363, 0364, 0365, 0366, 0367, 0368, 0369, 0370, 0371, 0372, 0373, 0374, 0375, 0376, 0377, 0378, 0379, 0380, 0381, 0382, 0383, 0384, 0385, 0386, 0387, 0388, 0389, 0390, 0391, 0392, 0393, 0394, 0395, 0396, 0397, 0398, 0399, 0400, 0401, 0402, 0403, 0404, 0405, 0406, 0407, 0408, 0409, 0410, 0411, 0412, 0413, 0414, 0415, 0416, 0417, 0418, 0419, 0420, 0421, 0422, 0423, 0424, 0425, 0426, 0427, 0428, 0429, 0430, 0431, 0432, 0433, 0434, 0435, 0436, 0437, 0438, 0439, 0440, 0441, 0442, 0443, 0444, 0445, 0446, 0447, 0448, 0449, 0450, 0451, 0452, 0453, 0454, 0455, 0456, 0457, 0458, 0459, 0460, 0461, 0462, 0463, 0464, 0465, 0466, 0467, 0468, 0469, 0470, 0471, 0472, 0473, 0474, 0475, 0476, 0477, 0478, 0479, 0480, 0481, 0482, 0483, 0484, 0485, 0486, 0487, 0488, 0489, 0490, 0491, 0492, 0493, 0494, 0495, 0496, 0497, 0498, 0499, 0500, 0501, 0502, 0503, 0504, 0505, 0506, 0507, 0508, 0509, 0510, 0511, 0512, 0513, 0514, 0515, 0516, 0517, 0518, 0519, 0520, 0521, 0522, 0523, 0524, 0525, 0526, 0527, 0528, 0529, 0530, 0531, 0532, 0533, 0534, 0535, 0536, 0537, 0538, 0539, 0540, 0541, 0542, 0543, 0544, 0545, 0546, 0547, 0548, 0549, 0550, 0551, 0552, 0553, 0554, 0555, 0556, 0557, 0558, 0559, 0560, 0561, 0562, 0563, 0564, 0565, 0566, 0567, 0568, 0569, 0570, 0571, 0572, 0573, 0574, 0575, 0576, 0577, 0578, 0579, 0580, 0581, 0582, 0583, 0584, 0585, 0586, 0587, 0588, 0589, 0590, 0591, 0592, 0593, 0594, 0595, 0596, 0597, 0598, 0599, 0600, 0601, 0602, 0603, 0604, 0605, 0606, 0607, 0608, 0609, 0610, 0611, 0612, 0613, 0614, 0615, 0616, 0617, 0618, 0619, 0620, 0621, 0622, 0623, 0624, 0625, 0626, 0627, 0628, 0629, 0630, 0631, 0632, 0633, 0634, 0635, 0636, 0637, 0638, 0639, 0640, 0641, 0642, 0643, 0644, 0645, 0646, 0647, 0648, 0649, 0650, 0651, 0652, 0653, 0654, 0655, 0656, 0657, 0658, 0659, 0660, 0661, 0662, 0663, 0664, 0665, 0666, 0667, 0668, 0669, 0670, 0671, 0672, 0673, 0674, 0675, 0676,

ALTOFLAM CHARTER 1 - SHEEP LANDING BEAR HIDE

PAGE 04



05/07/74

AUTOFLEX CHART SET - SHEEP LANDING BEAR HIDE

PAGE 07

CHART TITLE - INTRODUCTORY COMMENTS

.....
SUBROUTINE LGRN
.....

CHART TITLE - SUBROUTINE LGEAR

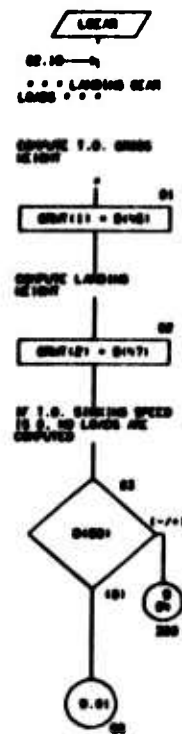


CHART TITLE - SUBROUTINE LEGAL

MOVE GIVEN LOADS TO
FLIGHT ARRAY

00.00 → 01

```

FLIGHTS(1) = 01001
FLIGHTS(2) = 011001
FLIGHTS(3) = 011001
FLIGHTS(4) = 011001
  
```

02

```

FLIGHTS(15) = 01111
FLIGHTS(16) = 011101
FLIGHTS(17) = 011101
FLIGHTS(18) = 011101
  
```

03

```

FLIGHTS(19) = 011101
FLIGHTS(20) = 011101
  
```

COMPUTE LANDING
SPEEDS IF NOT GIVEN

00.00 → 04

```

04001
  
```

05

```

V(1) = 01101
*SQRT((00011) -
  01001) / 01001
V(2) = 01101
*SQRT((00012) -
  01001) / 01001
  
```

MOVE GIVEN LANDING
SPEEDS TO TEMP

06

```

V(11) = 01001
V(12) = 01001
  
```

IF T.O. SINK SPEED IS
0, SET V(11) AND GO TO
07

07

```

07001
  
```

COMPUTE ANGLE
FUNCTIONS

08

```

A1 = 0177/07.0007
A2 = 0170/07.0007
  
```

09

```

A0
  
```

10

```

COSV = COS(A0)
COSFA = 0.0
COSL = COS(A0)
  
```

10.00

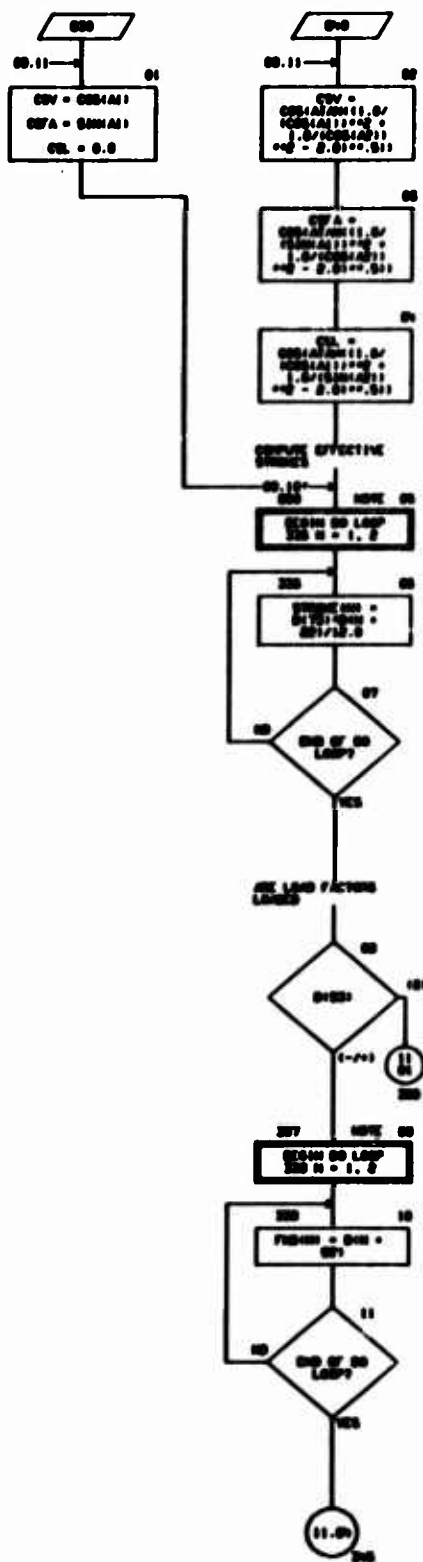
11

```

A0
  
```

10.00

CHART TITLE - SUBROUTINE LOAD



598

CHART TITLE - SUBROUTINE LGEAR

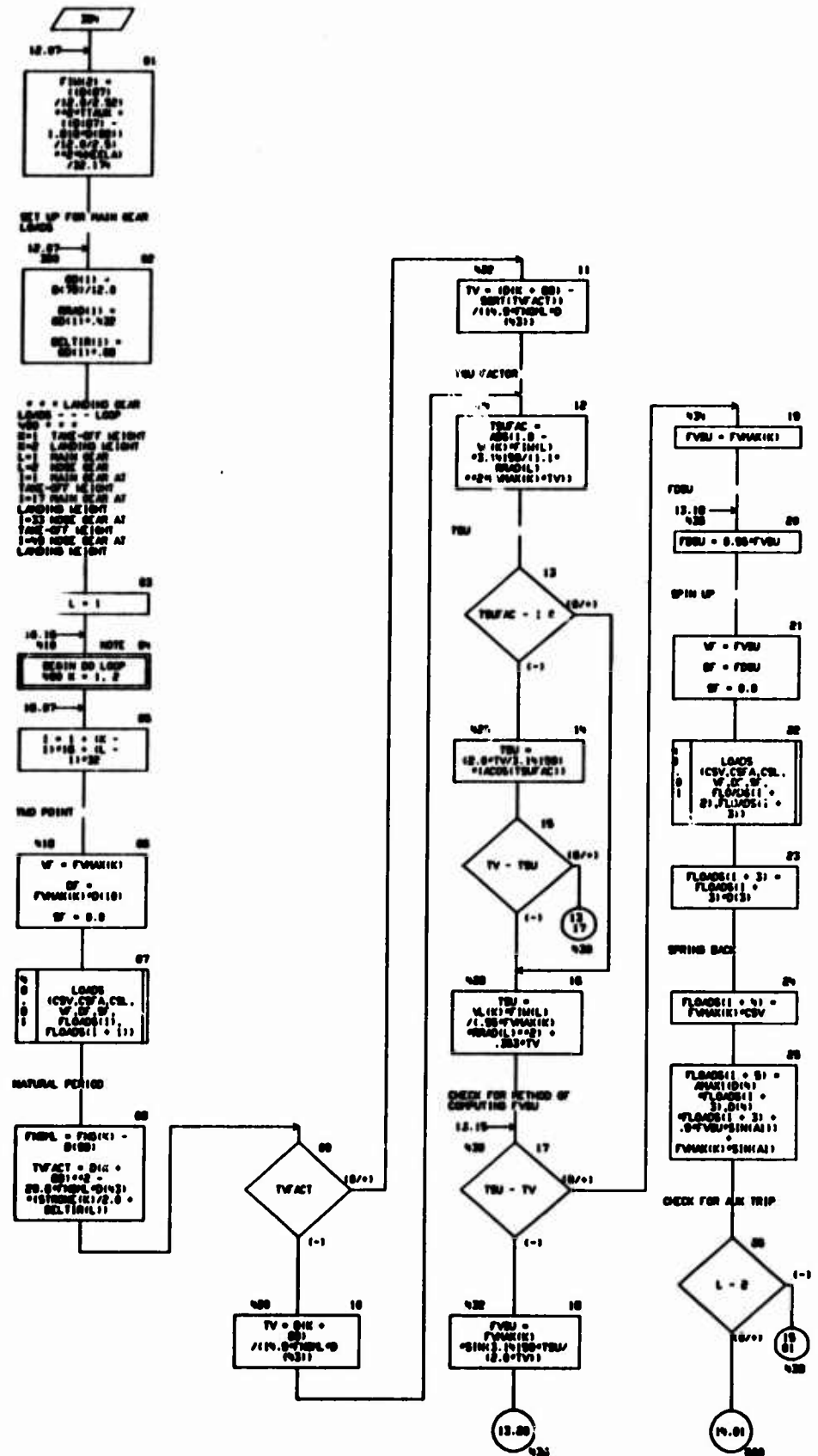


CHART TITLE - SURROUTINE LOCAL

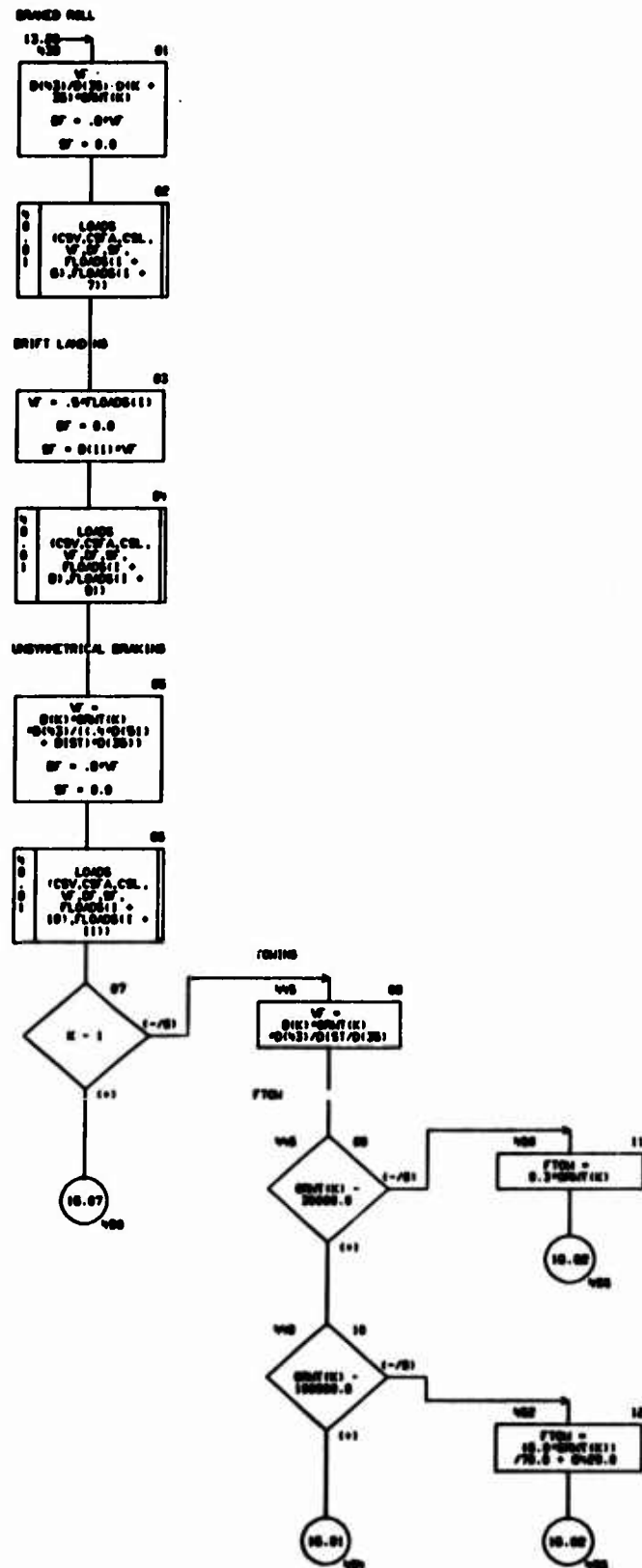
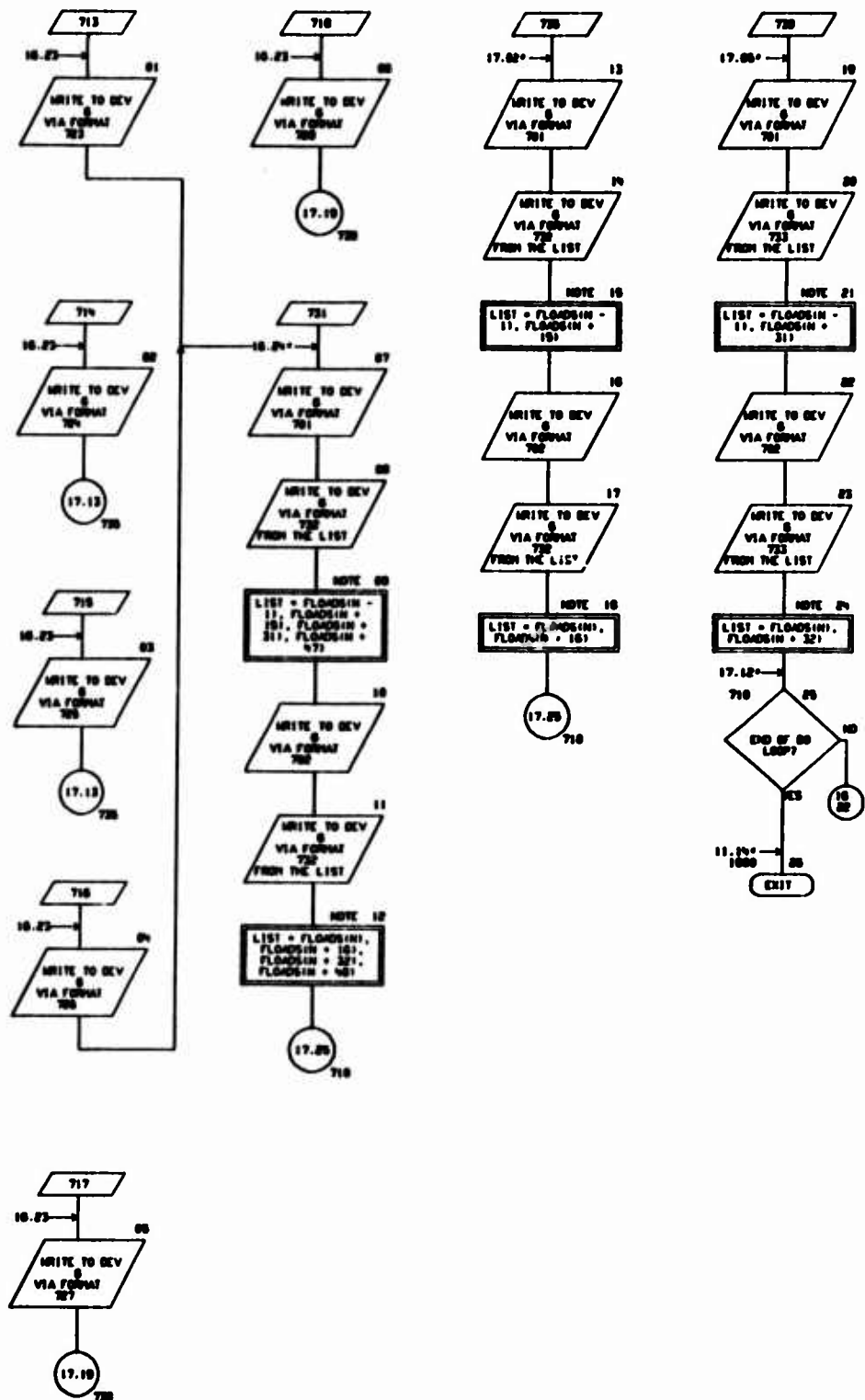


CHART TITLE - SUBROUTINE LOCAL



05/07/74

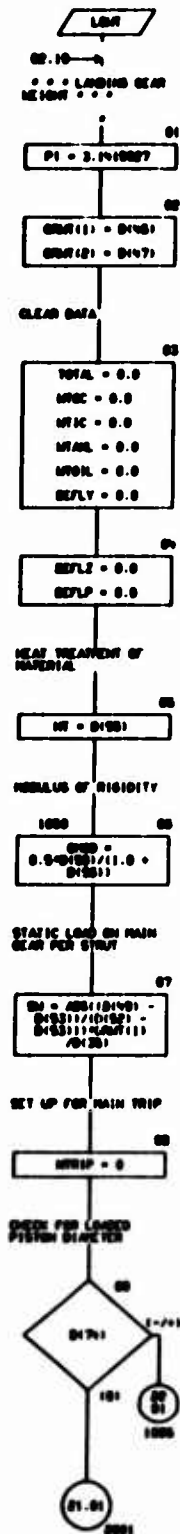
REFUEL CHART SET - DEEP LANDING GEAR HANDLE

PAGE 10

CHART TITLE - INTRODUCTION COMMENTS

.....
SUBMIT THE LOG
.....

CHART TITLE - SUBROUTINE LGH



**CALCULATE PISTON
DIAMETER, DP, FOR
STATIC HEIGHT, SH**

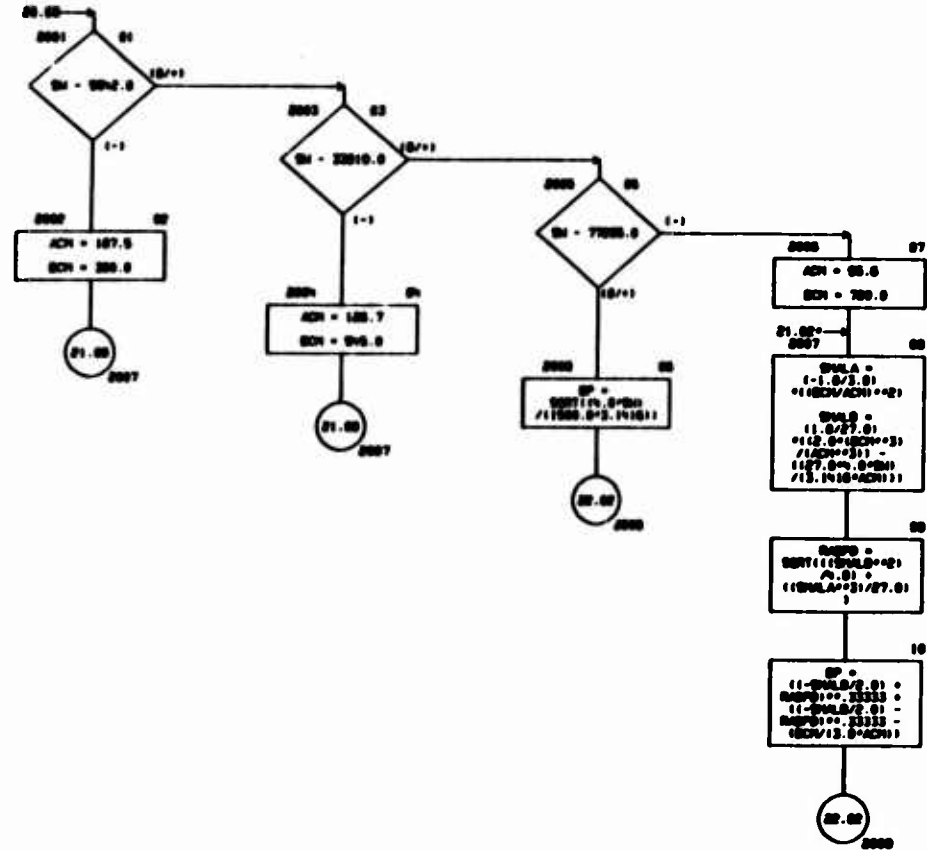
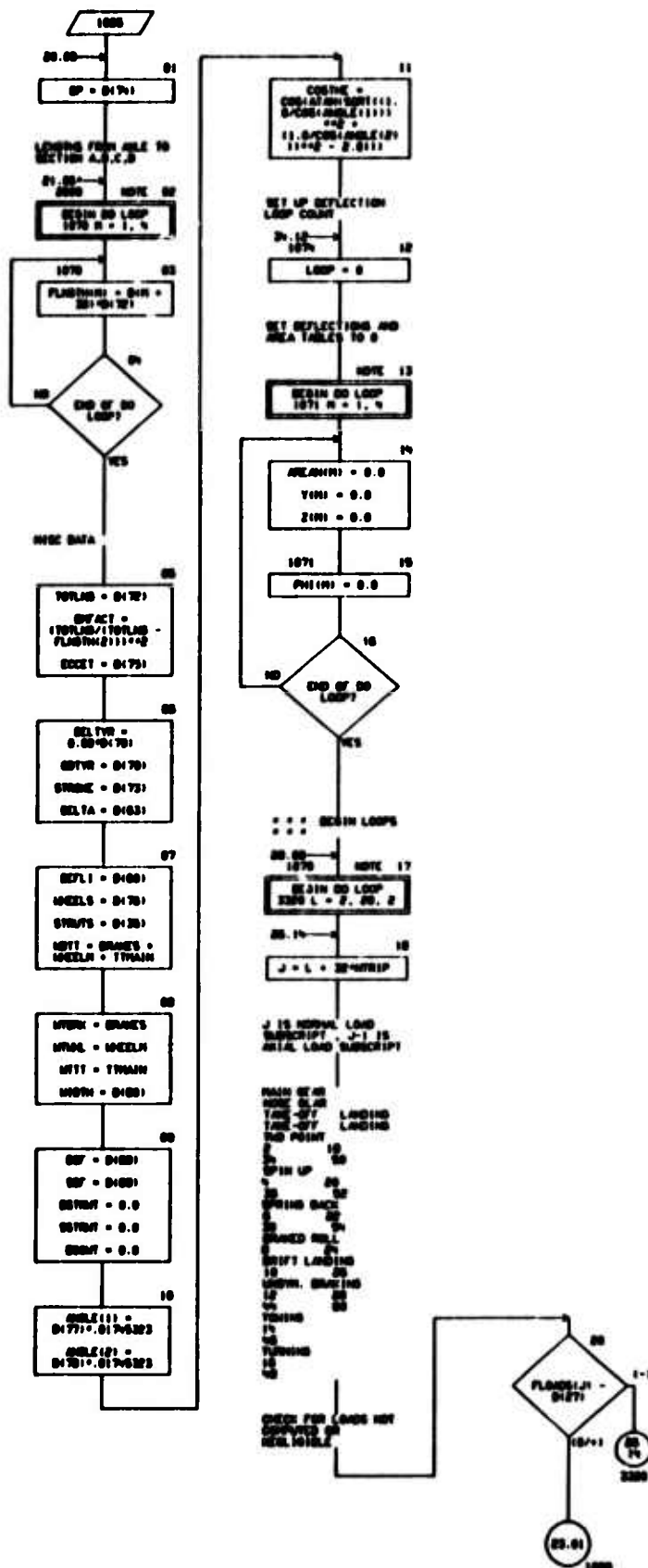


CHART TITLE - DERIVATIVE LOG



610

612

CHART TITLE - SUBMITTING UNIT



CHART TITLE - SUBROUTINE LOW

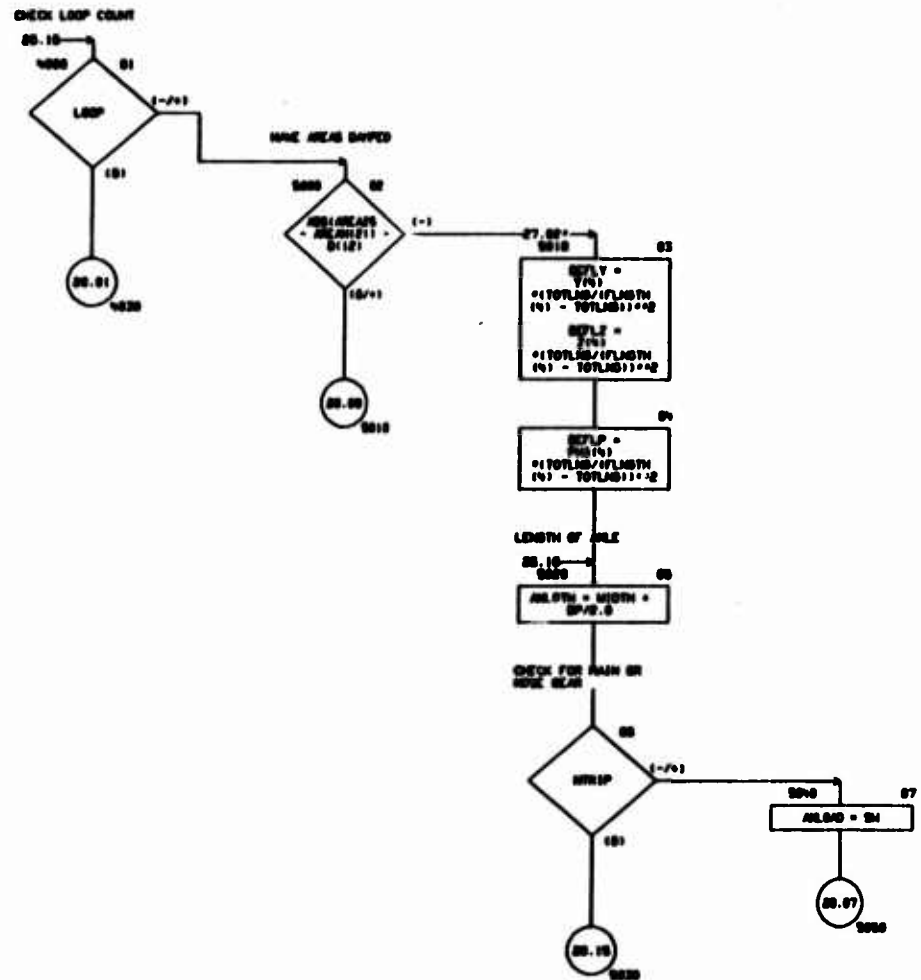
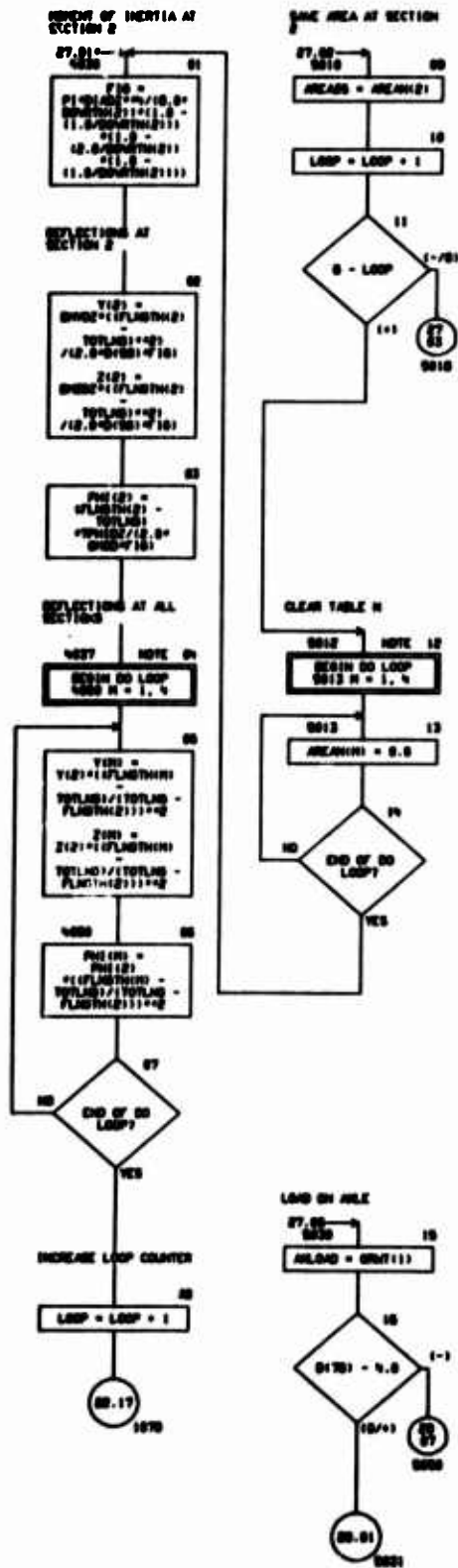
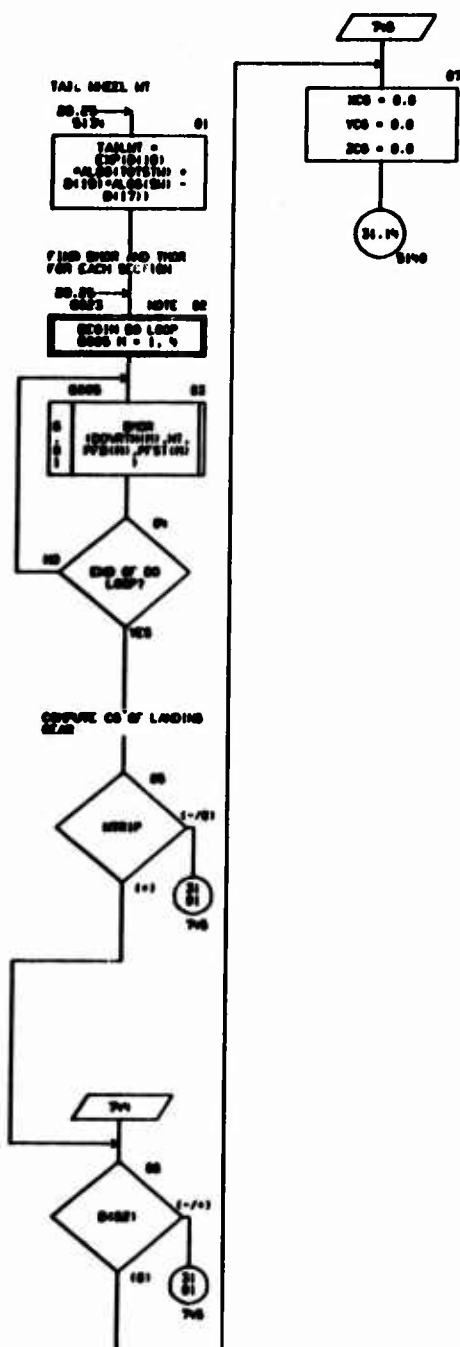


CHART TITLE - SUBROUTINE LGMT





CURT TITLE - SUBROUTINE LOW

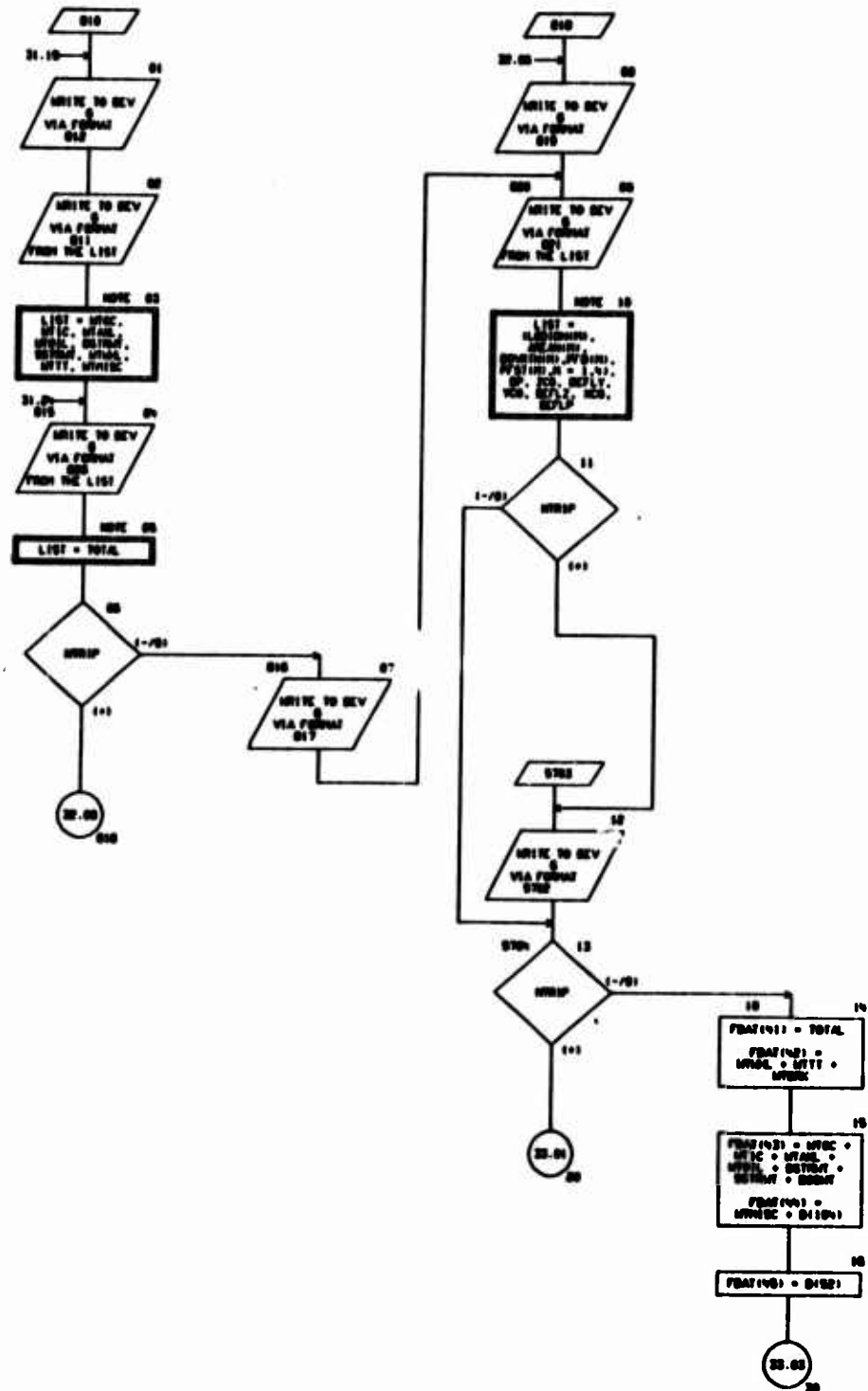


CHART TITLE - SUBROUTINE LOW

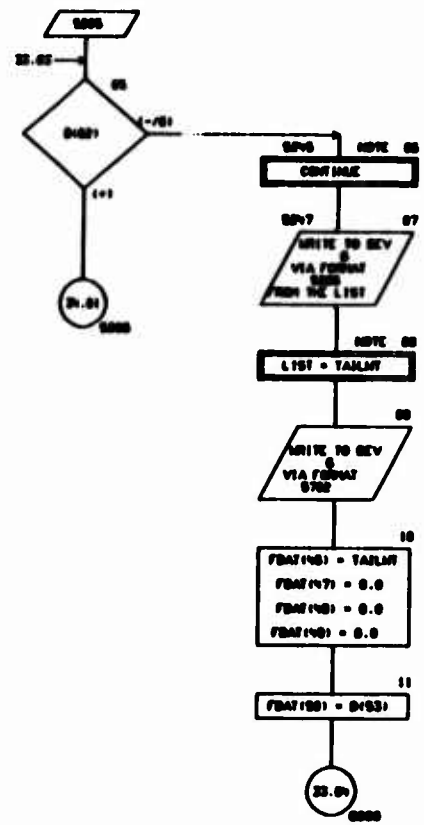
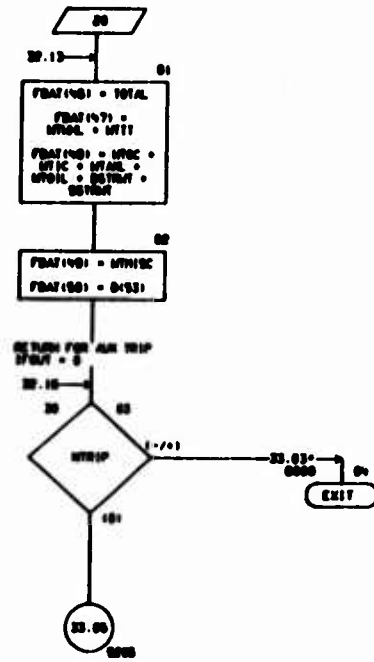
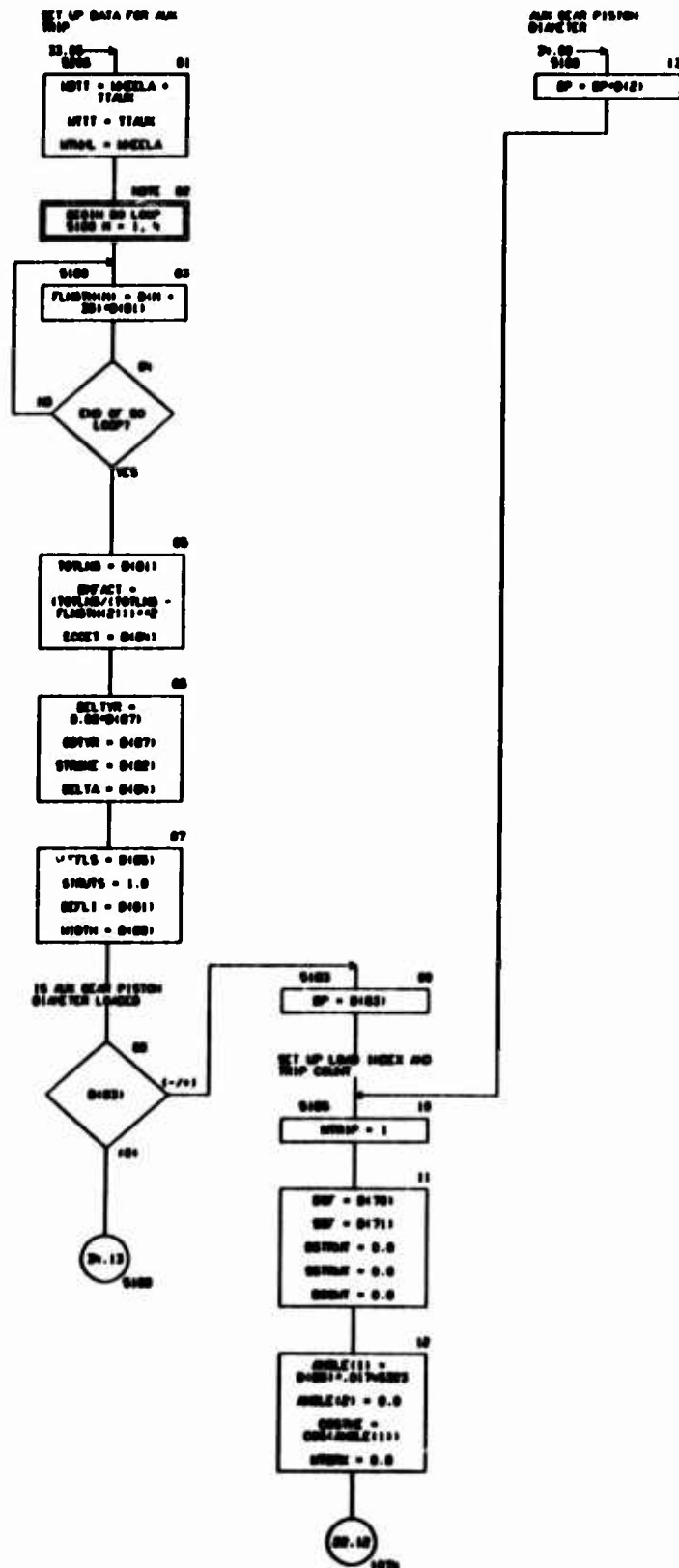


CHART TITLE - SUBROUTINE LBN



[illegible]

05/07/74

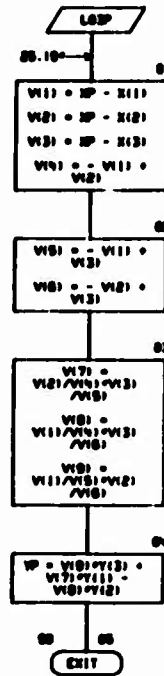
ATPFLN CHRT 01 - DEEP LANDING BEAR HEDLE

PAGE 25

CHRT TITLE - INTRODUCTORY COMMENTS

.....
SUBROUTINE LAP
.....

CHART TITLE - SUBROUTINE LOOP(X,Y,WP)



03/27/74

ALPHEON CHART SET - SHEEP LANDING GEAR MIDDLE

PAGE 20

CHART TITLE - NON-PROCEDURAL STATEMENTS

DIMENSION X(3),Y(3),V(3)

CHART TITLE - INTRODUCTORY COMMENTS

 SLIPSTREAM LOSS

CHRT TITLE - SUBROUTINE LOADS(CV,CFA,CL,V,BF,BF,AL,OAD,LOAD)



FORTRAN LISTING
OF
LANDING GEAR MODULE

FORTRAN MODEL ALIST,AUTOCB1

```

CARD NO      ****      COMMENTS      ****
1            C
2            C *****
3            C      PROGRAM LOADER
4            C *****
5            C
6            C      PROGRAM LOADER
7            C
8            C      OPEN /ALDATA/01101, /LOAD01001, ITAN, ITMAIN, WHEEL, WHEELN, BRNCS
9            C
10           C      OPEN /PRINT/1P100)
11           C
12           C      DD DD N=1,101
13           C      DD DIM = 0.0
14           C
15           C      CALL READ01(1,011),110,05)
16           C
17           C      IF(1P100)10001,0001,0002
18           C      0001 CONTINUE
19           C
20           C      WRITE(6,001)(DIM),04N=20),N=05,04)
21           C      001 FORMAT(1H1,2H1,2H1** VARIABLE LANDING GEAR DATA ***,10H1,
22           C      1 2H1** LOADER - 1P100) ***
23           C      * 10H,20H 40 TAKE-OFF HEIGHT .F12.2,
24           C      * 10H,20H 01 NOSE GEAR LENGTH .F12.2/
25           C      * 10H,20H 47 LANDING HEIGHT .F12.2,
26           C      * 10H,20H 02 NOSE GEAR STROKE .F12.2/
27           C      * 10H,20H 40 ABORTED TAKE-OFF DELTA MT .F12.2,
28           C      * 10H,20H 03 NOSE GEAR PISTON DIAMETER .F12.2/
29           C      * 10H,20H 40 AIRCRAFT CG AT TAKE-OFF .F12.2,
30           C      * 10H,20H 04 NOSE GEAR ECCENTRICITY .F12.2/
31           C      * 10H,20H 00 AIRCRAFT CG AT LANDING .F12.2,
32           C      * 10H,20H 00 NOSE GEAR WHEELS/STRT .F12.2/
33           C      * 10H,20H 01 AIRCRAFT CG TO GROUND .F12.2,
34           C      * 10H,20H 00 STRUT ANGLE (FORE-AFT) .F12.2/
35           C      * 10H,20H 02 MAIN GEAR FUELAGE STATION.F12.2,
36           C      * 10H,20H 07 NOSE GEAR TIME CD .F12.2/
37           C      * 10H,20H 03 NOSE GEAR FUELAGE STATION.F12.2,
38           C      * 10H,20H 00 NOSE GEAR TIME WIDTH .F12.2/
39           C      * 10H,20H 04 DIST BETWEEN STRUTS .F12.2,
40           C      * 10H,20H 00 TAKE-OFF HEIGHT SINK SPEED.F12.2)
41           C
42           C      WRITE(6,002)(DIM),04N=35),N=05,03)
43           C      002 FORMAT(
44           C      * 10H,20H 00 HEAT TREATMENT OF MATERIAL .F12.2,
45           C      * 10H,20H 00 LANDING HEIGHT SINK SPEED .F12.2/
46           C      * 10H,20H 00 POISSONS RATIO .F12.2,
47           C      * 10H,20H 01 TAKE-OFF MT LANDING SPEED .F12.2/
48           C      * 10H,20H 07 FCY .F12.2,
49           C      * 10H,20H 00 LANDING MT LANDING SPEED .F12.2/
50           C      * 10H,20H 00 MODULUS OF ELASTICITY .F12.2,
51           C      * 10H,20H 00 TAKE-OFF MT LND FACTOR .F12.2/
52           C      * 10H,20H 00 DENSITY OF MATERIAL .F12.2,
53           C      * 10H,20H 04 LANDING HEIGHT LND FACTOR.F12.2/
54           C      * 10H,20H 00 MAIN DEFLECTION INDICATOR .F12.2,
55           C      * 10H,20H 00 CL AT TAKE-OFF HEIGHT .F12.2/
56           C      * 10H,20H 01 NOSE DEFLECTION INDICATOR .F12.2,
57           C      * 10H,20H 00 CL AT LANDING HEIGHT .F12.2/
58           C      * 10H,20H 00 AUXILIARY GEAR INDICATOR .F12.2,
59           C      * 10H,20H 07 WING AREA .F12.2/
60           C      * 10H,20H 03 MAIN GEAR HEIGHT COEFF .F12.2,
61           C      * 10H,20H 00 WING LIFT COEFFICIENT .F12.2)
62           C
63           C      WRITE(6,003)(DIM),04N=35),N=05,02)
64           C      003 FORMAT(
65           C      * 10H,20H 04 NOSE GEAR HEIGHT COEFF .F12.2,
66           C      * /
67           C      * 10H,20H 00 OUTER CYL HEIGHT COEFF .F12.2,
68           C      * 10H,20H 00 MAIN GEAR WHEEL HEIGHT .F12.2/
69           C      * 10H,20H 00 INNER CYL HEIGHT COEFF .F12.2,
70           C      * 10H,20H 01 MAIN GEAR MERTIA .F12.2/

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05/07/74      INPUT LISTING      ALPHALAM CHART SET - SHEEP      LANDING GEAR MEASLE

CARD NO      ****      COMMENTS      ****

71      * 10K,20H 07 BOSSIE HEIGHT CORCT      /12.2.
72      * 10K,20H 08 MAIN GEAR TIRE HEIGHT      /12.2/
73      * 10K,20H 09 MAIN BRAD STRUT MT CORCT      /12.2.
74      * 10K,20H 05 BRADIE HEIGHT      /12.2/
75      * 10K,20H 06 MAIN SIDE STRUT MT CORCT      /12.2.
76      * 10K,20H 04 MISCELLANEOUS HEIGHT      /12.2/
77      * 10K,20H 70 NRESE BRAD STRUT MT CORCT      /12.2.
78      * 10K,20H 09 NRESE GEAR WHEEL HEIGHT      /12.2/
79      * 10K,20H 71 NRESE SIDE STRUT MT CORCT      /12.2.
80      * 10K,20H 08 NRESE GEAR TIRE HEIGHT      /12.2/
81      * 10K,20H 72 MAIN GEAR LENGTH      /12.
82      * 10K,20H 07 MAIN GEAR AL (FORE-AFT)      /12.2/
83      C
84      WRITE(6,40H) (01N1,01N2,01N3),N=73,001
85      40H FORMAT:
86      * 10K,20H 73 MAIN GEAR STROKE      /12.2.
87      * 10K,20H 08 MAIN GEAR RL (FORE-AFT)      /12.2/
88      * 10K,20H 74 MAIN GEAR PISTON DIAMETER      /12.2.
89      * 10K,20H 09 MAIN GEAR AL (DRIFT LAND)      /12.2/
90      * 10K,20H 75 MAIN GEAR ECCENTRICITY      /12.2.
91      * 10K,20H 10 MAIN GEAR RL (DRIFT LAND)      /12.2/
92      * 10K,20H 76 MAIN GEAR WHEELS/STRUT      /12.2.
93      * 10K,20H 11 MAIN GEAR AL (TURNING)      /12.2/
94      * 10K,20H 77 STRUT ANGLE (FORE-AFT)      /12.2.
95      * 10K,20H 12 MAIN GEAR RL (TURNING)      /12.2/
96      * 10K,20H 78 STRUT ANGLE (LATERAL)      /12.2.
97      * 10K,20H 13 NRESE GEAR AL (FORE-AFT)      /12.2/
98      * 10K,20H 79 MAIN GEAR TIRE SD      /12.2.
99      * 10K,20H 14 NRESE GEAR RL (FORE-AFT)      /12.2/
100      * 10K,20H 80 MAIN GEAR TIRE WIDTH      /12.2.
101      * 10K,20H 15 NRESE GEAR AL (TURNING)      /12.2/
102      C
103      WRITE(6,400H) (110)
104      400 FORMAT:
105      * 00K,20H 16 NRESE GEAR RL (TURNING)      /12.2/
106      C
107      BOSS CONTINUE
108      C
109      CALL LGEAR
110      C
111      CALL LGMT
112      C
113      S CONTINUE
114      END
115      C
116      C (((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((
117      C SUBROUTINE SPGR
118      C (((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((
119      C
120      C SUBROUTINE SPGR(OT,MT,BVAL,TYER)
121      C
122      2=MT/1000.0
123      B=OT
124      C
125      AFB=1.0010007E0+2-.001251+2+14.21870
126      BFB=-.0040075+2+2-003.125
127      CFB=1-3.242107E0+2+2003.1251+2-142000.02E0
128      C
129      BVAL=(AFB*BFB)*%*CFB
130      C
131      AST=1.0010007E0+2-.0000701+2+47.5
132      BST=1.00+2-27.251+2+1700.0
133      CST=400.4075+2+20700.5
134      C
135      TYER=(AST*BST)*%*CST
136      C
137      RETURN
138      END
139      C
140      C (((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((
141      C SUBROUTINE LGEAR

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631

03/27/74	INPUT LISTING	AUTOLAN CHART SET - SHEEP	LOADING GEAR MODULE
CARD NO	****	CONTENTS	****
013	C	COMPUTE EFFECTIVE STROKES	LOC70000
014	DO 00 330 N=1,2		
015	330 STROKE(N)=D(173) * D(1002) /12.0		
016	C		
017	C	ARE LOAD FACTORS LOADED	LOC70030
018	IF (D(103)) 1337,330,337		
019	337 DO 330 N=1,2		LOC70060
020	330 FMS(N)=D(1002)		
021	GO TO 340		LOC70070
022	C		
023	C	COMPUTE LOAD FACTORS	LOC70080
024	330 DO 340 N=1,2		
025	340 FMS(N)=(1.0- D(1)) * (1+D(1002)) * (2/34+1+1.0-D(1001))		
026	1 * (1- D(1)) * STROKE(N) * D(115) * D(170) /12.011/ 1		
027	1 * D(101) * STROKE(N) * 1-D(1001)		
028	C		
029	C	FVPAK	LOC70090
030	340 FVPAK(1) = D(143) * (FMS(1)-D(1001)) * (D(171)-D(140)) / D(170)		
031	FVPAK(2) = D(143) * (FMS(2)-D(1001)) * (D(172)-D(140)) / D(170)		
032	C		
033	C	GROUND CONSTANTS A,B,DIST	
034	DIST = ABS(D(152) - D(153))		
035	DO 352 N=1,2		
036	AIN(N)=ABS(D(1004B) - D(152))		
037	352 BIN(N)=ABS(D(1004B) - D(153))		
038	C		
039	C	COMPUTE MTT IF NOT GIVEN	LOC71000
040	350 IF (D(100)) 1370,350,370		
041	C		
042	C	WHEEL, TIRE AND TUBE	LOC71040
043	350 MTTHAL=D(170) * D(100) * .425+.000623*(D(170)+D(100)/100.0)**2		
044	C		
045	C	IF TAIL WHEEL SKIP AIR GEAR MTT	LOC71070
046	IF (D(102)) 1352,354,352		
047	352 MTALH=D(107) * D(100) * .4+.000623*(D(107)+D(100)/100.0)**2		
048	C		
049	354 BRAMS=D(170) * (D(171)+1.1)**2 * .010703		
050	WHEELA=D(1004B)*MTTHAL * D(170) * D(170)		
051	WHEELA=D(1004B)*MTTHAL * D(100)		
052	TTHAIN=1.0002*(WHEELA)		LOC71140
053	TALH=1.0002*(WHEELA)		LOC71150
054	GO TO 370		LOC71160
055	C		
056	C	SHIFT GIVEN MTT	LOC71170
057	370 WHEELA=D(100)		
058	TTHAIN=D(100)		
059	BRAMS=D(100)		
060	WHEELA=D(100)		
061	TALH=D(100)		
062	C		
063	C	IF T.O. SINK SPEED IS 0, GO TO HEIGHTS	LOC71230
064	370 IF (D(100)) 1380,1000,384		
065	C		
066	C	COMPUTE MOMENT OF INERTIA OF MTT AND ROTATING BRAM	LOC71250
067	380 FIM(1) = D(101)		
068	IF (D(101)) 1383,382,383		
069	C		
070	C	IN TIRES AND TUBES-MAIN WHEELS	LOC71260
071	380 FIM(1) = (D(170)/12.0/2.52)**2 * TTHAIN + (D(170)-1.010-D(1001))		
072	* /12.0/2.51**2 * 1.05*BRAMS + WHEELA / 32.174 / D(100)		
073	C		
074	383 IF (D(102)) 1384,380,384		
075	C		
076	384 FIM(2) = (D(107)/12.0/2.52)**2 * TALH + (D(107)-1.010-D(1001))		
077	* /12.0/2.51**2 * WHEELA / 32.174		
078	C		
079	C	SET UP FOR MAIN GEAR LOADS	LOC71300
080	380 GD(1) = D(170) / 12.0		
081	GRAD(1) = GD(1) * .430		
082	DELTH(1) = GD(1) * .00		
083	C		

05/07/74	INPUT LISTING	AUTOFLOW CHART SET - SHEEP	LANDING GEAR MODULE
CARD NO	*****	COMMENT	*****
001	C		
002	C	*** LANDING GEAR LOADS *** - - - LOOP 400 ***	
003	C	K=1 TAKE-OFF HEIGHT	
007	C	K=2 LANDING HEIGHT	
008	C	L=1 MAIN GEAR	
009	C	L=2 NOSE GEAR	
010	C	I=1 MAIN GEAR AT TAKE-OFF HEIGHT	
011	C	I=17 MAIN GEAR AT LANDING HEIGHT	
012	C	I=35 NOSE GEAR AT TAKE-OFF HEIGHT	
013	C	I=40 NOSE GEAR AT LANDING HEIGHT	
014	C	L = 1	
015	C		
016	C	410 00 400 K=1,2	
017	C		
018	C	I = 1 + (K-1)*10 + (L-1)*20	
019	C		
020	C	THIS POINT	LAE71040
021	C	410 W = F*WAKE	
022	C	W = F*WAKE + 0.110	
023	C	W = 0.0	
024	C	CALL LBRG+CDV,CFA,CBL,W,W,W,FLRDS(1),FLRDS(1+1)	
025	C		
026	C	NATURAL PERIOD	LAE71070
027	C	FREQ = FREQ(K) - 0.100	
028	C	TVACT = 0.4K*0.1**2 - 20.0*FREQ*(43)*(STROKE(K)/2.0*DELTIME(L))	
029	C	W (TVACT)*0.00,0.00,0.00	LAE71000
030	C	420 TV = 0.4K*0.01 / ((14.0*FREQ*(43))	
031	C	00 TO 424	LAE71710
032	C	422 TV = 0.4K*0.01 - 0.001(TVACT)/((14.0*FREQ*(43))	
033	C		
034	C	TSU FACTOR	LAE71720
035	C	424 TSU*AC = ABS(1.0-0.4K*(F*HML)*3.14159/(1.1*0.0041)*0.2*F*WAKE)	
036	C	0 * TV1)	
037	C		
038	C	TSU	LAE71730
039	C	W (TSU*AC - 1.0)*0.00,0.00,0.00	
040	C	426 TSU = (2.0*TV / 3.14159)*(ACOS(TSU*AC))	
041	C	W (TV - TSU) 14.00,0.00,0.00	
042	C	428 TSU = 0.4K*(F*HML)/(1.00*F*WAKE)*(0.0041)**2) + .303*TV	
043	C		
044	C	CHECK FOR METHOD OF COMPUTING FREQ	LAE71010
045	C	430 W (TSU - TV) 14.00,0.00,0.00	
046	C	432 FREQ = F*WAKE*(SINH(3.14159*TSU / (2.0*TV))	
047	C	00 TO 435	LAE71040
048	C	434 FREQ = F*WAKE	
049	C		
050	C	FREQ	LAE71000
051	C	436 FREQ = 0.00*FREQ	
052	C		
053	C	SPIN UP	LAE71000
054	C	W = FREQ	
055	C	W = FREQ	
056	C	W = 0.0	
057	C	CALL LBRG+CDV,CFA,CBL,W,W,W,FLRDS(1+2),FLRDS(1+3))	
058	C	FLRDS(1+3) = FLRDS(1+3) + 0.1	
059	C		
060	C	SPRING BACK	LAE71010
061	C	FLRDS(1+4) = F*WAKE + CDV	
062	C	FLRDS(1+5) = 0.4K*(0.41*FLRDS(1+3) + 0.41*FLRDS(1+3)	
063	C	0 * (0.4*FREQ*(SINH(1)) + F*WAKE*(SINH(1))	
064	C		
065	C	CHECK FOR AIR TRIP	LAE71040
066	C	IF L = 0.1420,000,000	
067	C		
068	C	REMAINING NOSE GEAR LOADS	
069	C		
070	C	GEOMETRICAL BRAKING	LAE71070
071	C	000 W = (LAK) + (4*0.4K*(0.41/0.15) + 0.041K) + 0.143) / 0.101	
072	C	W = 0.4K*(0.41*W + 0.4K) + 0.143) + 0.041K) + 0.143) / (4.0*0.15**2)	
073	C	W = 0.0	
074	C	CALL LBRG+CDV,CFA,CBL,W,W,W,FLRDS(1+10),FLRDS(1+11))	

03/27/74	INPUT LISTING	AUTOFLY CHART SET - SHEEP	LANDING GEAR MODULE
CARD NO	CONTENTS		
305	C		
306	WTS IF IK=1530,530,400		
307	C		
308	C TONING		LOC70050
309	530 W = AIK1 / DIST * GRNT(K) * D(43)		
310	WF = FTM * D(43)		
311	WF = 0.0		
312	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+12),FLDAS(1+13))		
313	C		
314	C TURNING		LOC70060
315	W = AIK1 / DIST * GRNT(K) * D(43)		
316	WF = 0.0		
317	WF = ANIM(1.5, .5 * D(1) * D(5) / DIST / D(5)) * W		
318	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+14),FLDAS(1+15))		
319	GO TO 400		
370	C		
371	C BRAKED ROLL		LOC70100
372	430 W = D(43)/D(35) * D(1+35) * GRNT(K)		
373	WF = .0 * W		
374	WF = 0.0		
375	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+6),FLDAS(1+7))		
376	C		
377	C BRIFT LANDING		LOC70150
378	W = .5 * FLDAS(1)		
379	WF = 0.0		
380	WF = D(11) * W		
381	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+8),FLDAS(1+9))		
382	C		
383	C UNSYMMETRICAL BRAKING		LOC70180
384	W = D(1) * (D(43) / (1.4 * D(5)) * DIST) * D(35)		
385	WF = .0 * W		
386	WF = 0.0		
387	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+10),FLDAS(1+11))		
388	C		
389	W IK=1445,445,400		
390	C		
391	C TONING		LOC70200
392	445 W = D(1) * GRNT(K) * D(43) / DIST / D(35)		
393	C		
394	C FTM		LOC70250
395	445 IF (GRNT(K)-30000.0) 450,450,445		LOC70260
396	445 IF (GRNT(K)-100000.0) 452,452,445		LOC70270
397	450 FTM = 0.3 * GRNT(K)		LOC70280
398	GO TO 400		LOC70290
399	452 FTM = 15.0 * GRNT(K) / 70.0 * D(29.0)		LOC70300
400	GO TO 400		LOC70310
401	454 FTM = 0.15 * GRNT(K)		LOC70320
402	455 WF = .75 * FTM * D(43)		
403	WF = 0.0		
404	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+12),FLDAS(1+13))		
405	C		
406	C TURNING		LOC70340
407	FW = ANIM(1.5, .5 * D(1) * D(5) / DIST / D(5))		
408	W = GRNT(K) * (.5 * D(1) / DIST * FW * D(5) / D(5)) * D(43)		
409	WF = 0.0		
410	WF = FW * W		
411	CALL LOADS(CSV,CFA,CBL,W,WF,FLDAS(1+14),FLDAS(1+15))		
412	C		
413	400 CONTINUE		LOC70400
414	C		
415	C IS MORE GEAR DONE		
416	IF IL = 21400,534,534		
417	C		
418	C IF TAIL GEAR SKIP MORE GEAR LOADS		
419	405 IF (D(52)) 1000,534,500		
420	C		
421	C SET UP FOR MORE GEAR LOADS		
422	500 DO 502 M=1,2		
423	500 STRENGTH(D(52)) * D(1+32) / 12.0		
424	C		
425	FWAN(1)=FWAN(1)+AI(1) * D(35) / DIST		

635

03/07/74	INPUT LISTING	AUTOFLOW CHART SET - SHEET	LANDING GEAR MODULE
CARD NO	****	CONTENTS	****
007	WRITE(0,700)		
008	WRITE(0,703+FLD05(1),FLD05(1)+20)		
009	710 CONTINUE		
010	C		
011	1000 RETURN		
012	END		
013	C		
014	C (.....)		
015	C SUBROUTINE LOWT		
016	C (.....)		
017	C		
018	C SUBROUTINE LOWT		
019	C		
020	C * * * LANDING GEAR HEIGHT * * *		
021	C		
022	C OPEN /LSDATA/0(110),FLD05(00),TTALK,TTMAIN,WHEELA,WHEELM,SPRINGS		
023	C		
024	C OPEN /FBATT/ FBAT(00)		
025	C		
026	C DIMENSION FLADT(4),DIA(3),GRNT(2)		
027	C DIMENSION GST(3)		
028	C DIMENSION Y(4)		
029	C DIMENSION Z(4),PH(4)		LBH0120
030	C DIMENSION AREAM(4)		
031	C DIMENSION BOWTH(4),LEDS(4)		LBH0140
032	C DIMENSION AS(3),RA(3)		
033	C DIMENSION PTD(4)		
034	C DIMENSION PST(4),ANGLE(2)		
035	C		
036	C PI=3.1415927		
037	C		LBH70000
038	C GRNT(1) = 0(40)		
039	C GRNT(2) = 0(47)		
040	C		
041	C CLEAR DATA		LBH70000
042	C		
043	C TOTAL = 0.0		
044	C MTSC = 0.0		
045	C MTIC = 0.0		
046	C MTAH = 0.0		
047	C MTOIL = 0.0		
048	C BEFLY = 0.0		
049	C BEFLZ = 0.0		
050	C BEFLP = 0.0		
051	C		
052	C HEAT TREATMENT OF MATERIAL		
053	C HT=0(100)		
054	C		LBH71020
055	C MODULUS OF RIGIDITY		LBH70310
056	C 1000 GPCD=0.5*0(100) /((1.0*0(100))		
057	C		
058	C STATIC LOAD ON MAIN GEAR PER STRUT		LBH70330
059	C SM = ABS((0(40)-0(53))/((0(52)-0(53)))) * GRNT(1) / 0(30)		
060	C		
061	C SET UP FOR MAIN TRIP		LBH70400
062	C MTRIP=0		LBH70410
063	C		
064	C CHECK FOR LOADED PISTON DIAMETER		LBH70420
065	C IF 0(47) 11000,2001,1000		
066	C		
067	C CALCULATE PISTON DIAMETER ,DP, FOR STATIC HEIGHT ,SM		LBH70440
068	C 2001 IF (SM -2042.012002,2003,2003		LBH70400
069	C 2002 ACH=107.5		LBH70470
070	C BCH=200.0		LBH70400
071	C GO TO 2007		LBH70400
072	C 2003 IF (SM -2010.012004,2005,2005		LBH70500
073	C 2004 ACH=120.7		LBH70510
074	C BCH=240.0		LBH70500
075	C GO TO 2007		LBH70530
076	C 2005 IF (SM -7700.012006,2008,2008		LBH70540
077	C 2006 DP =GRNT(14,0*SM /((1000.0*3.1416))		LBH70500
078	C GO TO 2000		LBH70500

63-27774 INPUT LISTING AUTOTURN CHART SET - SHEET LANDING GEAR NOSE

CASE NO. CONTENTS

000 0000 ACH=0.0 LBN70070

001 0001 BCK=700.0 LBN70080

002 0002 SPALB=1.0/27.01*(1-BCK/ACH)**2 LBN70090

003 0003 SPALB=1.0/27.01*(1.0*(BCK**3)/(ACH**3))-1.27.0*4.0*BM 1/1 LBN70100

004 0004 (13.1416*ACH)**3 LBN70110

005 0005 RADPO=SPALB*(1+(SPALB**2)/4.01*(1+SPALB**3)/27.01) LBN70120

006 0006 OP = ((-SPALB/2.01)*RADPO)**.33333 + ((-SPALB/2.01)*RADPO)**.33333

007 0007 * - (BCK/(3.0*ACH))

008 0008 GO TO 2000

009 1000 OP = 0.171

010 C

011 C LENGTH FROM AXLE TO SECTION A,B,C,D LBN70130

012 0000 GO 1070 N=1,4

013 1070 FLASTHIN= 0.14*BM + 0.170

014 C

015 C MISC DATA LBN70170

016 1070 FLASTH=0.170

017 0001 SPACT=(TOTLMB/(TOTLMB-FLASTH(2)))**2

018 0002 ECCET=0.170

019 0003 DELTVR=0.00*0.170

020 0004 EDTVR=0.170

021 0005 STROKE=0.173

022 0006 DELTA=0.183

023 0007 DELT1 = 0.100

024 0008 WHEEL=0.170

025 0009 STRTVS= 0.130

026 0010 MFTT=STRTVS+WHEEL*TTMAIN LBN70200

027 0011 MFTVK=STRTVS LBN70210

028 0012 MFTVL=WHEEL*LBN70220

029 0013 MFTT=TTMAIN LBN70230

030 0014 WIDTH=0.100

031 C

032 0001 OP = 0.100

033 0002 SP = 0.100

034 0003 DISTMT = 0.0

035 0004 DISTMT = 0.0

036 0005 DISTMT = 0.0

037 C

038 0001 ANGLE(1) = 0.177 + .01745323

039 0002 ANGLE(2) = 0.170 + .01745323

040 0003 COSHE = COS(ATAN(SORT((1.0/COS(ANGLE(1))))**2 +

041 0004 (1.0/COS(ANGLE(2))))**2 - 2.0)))

042 C

043 C SET UP REFLECTION LOOP COUNT LBN71010

044 1070 LOOP = 0

045 C

046 C SET REFLECTIONS AND AREA TABLES TO 0 LBN71020

047 0001 GO 1071 N=1,4

048 0002 AREA(M)=0.0

049 0003 Y(M)=0.0

050 0004 Z(M)=0.0

051 1071 PM(M)=0.0

052 C

053 C * * * BEGIN LOOPS * * *

054 C

055 1070 GO 3100 L=2.00,2

056 C

057 J = L + 32*WTRIP

058 C

059 J IS NORMAL LOAD SUBSCRIPT, J-1 IS AXIAL LOAD SUBSCRIPT

060 C

	MAIN GEAR		NOSE GEAR	
	TAKE-OFF	LANDING	TAKE-OFF	LANDING
061 C TWO POINT	2	10	24	30
062 C SPIN UP	4	20	26	32
063 C SPRING BACK	6	22	28	34
064 C BRAKED ROLL	8	24		
065 C BRFT LANDING	10	26		
066 C 4-CHN. BRFT LND	12	28	34	36
067 C TURNING	14		36	
068 C TURNING	16		38	

03/27/74	MPW LISTING	AUTOFLOW CHART SET - SHEEP	LOADING BEAR MODALE
CARD NO	****	CONTENTS	****
030	C		
040	C	CHECK FOR LOADS NOT COMPUTED OR NEGLIGIBLE	
041		IF (LOADS(I)- D(27))320,1000,1000	
042	C		
043		1000 DO 3300 I=1,4	
044	C		
045	C	CHECK FOR DRIFT LANDING	LBH71200
046		IF IL-1012010,2015,2010	
047		2010 IF IL-2011001,2015,1001	
048	C		
049	C	FORE AND AFT BENDING MOMENT	LBH71230
050		1001 BW = (BWFACT*Y(2)+ABS(ECCET*SIN(PH(2)*BWFACT))-Y(1))*LOADS(I)-1	
051		11*LOADS(I)*FLGSTM(1)	LBH71260
052	C		
053	C	LATERAL BENDING MOMENT	LBH71270
054		BW = (BWFACT*Z(2)+ABS(ECCET*COS(PH(2)*BWFACT))-Z(1))*LOADS(I)-1	
055		11	LBH71280
056	C		
057	C	TORSIONAL MOMENT	LBH71300
058		1002 TPI = (FLGAS(I)/FLGAS(I)-1)*BW	
059		GO TO 2030	LBH71320
060	C		
061	C	DRIFT LAGO BW AND SET BW, TPI TO ZERO	LBH71330
062		2015 BLFNG = FLGSTM(1)+DOTY*0.5-DELTY	
063		IF (BLFNG / 10.0+ECCET)2010,2020,2020	
064		2010 FLGAS(I)=.75*FLGAS(I)	LBH71360
065		BW = 1-ECCET + Z(2)*BWFACT - Z(1) * FLGAS(I)-1	
066		• • BLFNG • FLGAS(I)	
067		GO TO 2032	LBH71380
068	C		
069		2020 BW = 1-ECCET + Z(2)*BWFACT - Z(1) * FLGAS(I)-1	
070		• • BLFNG • FLGAS(I)	
071	C		
072		2032 BW = 0.0	
073		TPI = 0.0	
074	C		
075	C	RESULTANT S.M.	LBH71400
076		2030 SWR =SQRT((BW**2)+(TPI**2))	
077	C		
078	C	CALC BRAG AND SIDE BRACES	LBH71630
079	C		
080		IF IL-1013001,3007,3001	
081		3001 IF IL-1013002,3007,3002	
082		3002 IF IL-1013004,3007,3004	
083	C		
084		3004 STRUT = MAX(10STRUT, STRUTS * D(50) * 2.3004 * TOTLNG	
085		1 • FLGAS(I) • SW / D(57))	
086		GO TO 2040	
087	C		
088		3007 STRUT = MAX(10STRUT, STRUTS * D(50) * 2.3004 * TOTLNG	
089		1 • FLGAS(I) • SW / D(57))	
090	C		
091	C	SET UP WORKING 0 OVER 1	LBH71470
092		2040 DO 2050 N=1,3	LBH71480
093		2050 DOT(N)= D(14-20)	
094	C		
095	C	SET RATIO CHECK COUNT	LBH71500
096		PAGE = 0.0	
097	C		
098	C	FIND STRUT DIAMETERS	LBH71520
099		2055 IF (1-4)2060,2060,2060	LBH71530
700		2060 DO 2070 N=1,3	
701		2070 DIAM(N)=((SW *0.675)/(DOT(N)-2.0))*DOT(N)	
702		GO TO 2080	LBH71570
703	C		
704		2080 DO 2081 N=1,3	LBH71580
705		2081 DIAM(N)=SW	
706		DIAM = SW	
707	C		
708		2086 DO 2089 N=1,3	
709	C		

03/27/74	INPUT LISTING	AUTOFLOW CHART SET - SHEEP	LOADING BEAR HEADLE
CARD NO	CONTENTS		
710	CALL OVER(DOT(N),MT,BNFR,TNFR)		
711	C		
712	C STRENGTH AREA		LEN71020
713	ASINI=0.0/DIAINI*(1.0+(1.0-0.0/DOT(N))**2)**.50711BNR / BNFR*LEN71030		
714	(1+0.17PH) / (2.0* TNFR)**2)+LOADS(J-1)/D(57)		
715	C		
716	C RATIO - STRENGTH AREA TO GEOMETRIC AREA		
717	2000 RATIO = ASINI / (PI * DIAINI**2 * (1.0 - 1.0/DOT(N)) / DOT(N))		
718	C		
719	C CHECK RATIO		LEN71000
720	IF (1.0-RATIO) 3030,3000,3000		LEN71000
721	3030 IF (1.0-RATIO) 3031,3031,3032		LEN71010
722	3031 IF (PASS) 3040,3040,3000		
723	3032 IF (PASS) 3050,3050,3000		
724	C		
725	3040 DO 3041 N=1,3		LEN71040
726	3041 DOT(N)= D(N+10) * 0.120)		
727	PASS = 1.0		
728	GO TO 2000		
729	C		
730	2000 CALL LOOP(RAT,DOT,1.0,DOTINT)		
731	C		
732	DO 3001 N=1,3		LEN71000
733	3001 DOT(N)= D(N+10) * DOTINT		
734	PASS = 1.0		
735	GO TO 2000		
736	C		
737	2000 CALL LOOP(RAT,DOT,1.0,DOTV)		
738	GO TO 2000		LEN70040
739	C		
740	2000 DOVT = D(31)		
741	GO TO 2000		LEN70000
742	C		
743	C		
744	C CHECK FINAL D/T, SECTION AND DIAMETER		LEN70000
745	3000 DOVT = ANINI(DOVT, D(31))		
746	3005 IF (1-1) 3230,3200,3230		LEN70120
747	3230 DIAM = ((DP +0.075)/(DOVT-2.0))*DOVT		
748	C		
749	C AREA FROM GEOMETRY-FINAL		LEN70140
750	3000 AREAC = PI * DIAM**2 / DOVT * (1.0 - (1.0/DOVT))		
751	C		
752	C CHECK PREVIOUS-CURRENT AREA		LEN70200
753	IF (AREAM)-AREAC 3300,3300,3300		
754	C		
755	C STORE IN TABLE N-AREA,D/T,LOAD ID		LEN70200
756	3010 AREAM()-AREAC		
757	DOVTN()-DOVT		LEN70400
758	LOADN() = L		
759	C		
760	C IF SECTION 2, SAME DESIGNING LOADS		
761	IF (1-2) 3300,3200,3300		
762	3005 DYNEX=DVT		
763	DYNEX=DVT		
764	TPHIDZ=TPH1		
765	DIAEZ=DIAM		
766	C		
767	C SAME AREA AT SECTION 2 IF LOOP=0		
768	IF (LOOP) 3600,3600,3300		
769	3600 AREAS = AREAC		
770	C		
771	3300 CONTINUE		LEN70430
772	C		
773	3300 CONTINUE		LEN70440
774	C		
775	C IF NO DEFLECTION, BYPASS DEFLECTION ANALYSIS		
776	IF (DEFL) 4000,4000,5000		
777	C		
778	C CHECK LOOP COUNT		LEN70470
779	4000 IF (LOOP) 5000,4030,5000		LEN70480
780	C		

05/87/74	INPUT LISTING	AUTOFLOW CHART SET - SHEET	LOADING GEAR MOBILE
CARD NO	CONTENTS		
701	C		
702	RECORD OF MERTIA AT SECTION 2		
703	4000 F10 = P1 * (DIAM**4 / (8.0*SQRTN(2))) * ((1.0-(1.0/SQRTN(2))))		
704	0 * ((1.0-(1.0/SQRTN(2))) * ((1.0-(1.0/SQRTN(2))))		
705	C		
706	DEFLECTIONS AT SECTION 2		
707	V(2) = (WDE * ((FLNTH(2)-TOTLND)**2) / (2.0*Q100*F10)		
708	Z(2) = (WDE * ((FLNTH(2)-TOTLND)**2) / (2.0*Q100*F10)		
709	PH(2) = (FLNTH(2)-TOTLND)*TPH(2)/(2.0*Q100*F10)		LEN7000
710	C		
711	DEFLECTIONS AT ALL SECTIONS		LEN7000
712	4037 DO 4038 N=1,4		
713	V(N) = V(2) * ((FLNTH(N)-TOTLND)/(TOTLND-FLNTH(2)))**2		
714	Z(N) = Z(2) * ((FLNTH(N)-TOTLND)/(TOTLND-FLNTH(2)))**2		
715	4000 PH(N) = PH(2) * ((FLNTH(N)-TOTLND)/(TOTLND-FLNTH(2)))**2		
716	C		
717	INCREASE LOOP COUNTER		
718	LOOP = LOOP + 1		
719	GO TO 1070		LEN7000
720	C		
800	C		
801	HAVE AREAS DAPPED		LEN7000
802	8000 IF (ABS(AREAS - AREAN(2))) - 0.12) 10010, 8010, 8010		
803	C		
804	SAME AREA AT SECTION 2		
805	8010 AREAS = AREAN(2)		
806	C		
807	LOOP = LOOP + 1		
808	IF (S - LOOP) 10010, 8010, 8012		
809	C		
810	CLEAR TABLE M		LEN7000
811	8012 DO 8013 N=1,4		
812	8013 AREAN(N)=0.0		
813	GO TO 4030		LEN7000
814	C		
815	8010 DEFL1 = V(N) * ((TOTLND/(FLNTH(N)-TOTLND)))**2		
816	DEFL2 = Z(N) * ((TOTLND/(FLNTH(N)-TOTLND)))**2		
817	DEFL3 = PH(N) * ((TOTLND/(FLNTH(N)-TOTLND)))**2		
818	C		
819	LENGTH OF AILE		
820	8020 AILENTH=HIGHTH*P / 2.0		LEN7000
821	C		
822	CHECK FOR MAIN OR MOBE GEAR		
823	IF (INTRIP) 8040, 8030, 8040		LEN7000
824	C		
825	8040 AILEAD=0		
826	GO TO 8050		
827	C		
828	LOAD ON AILE		LEN7000
829	8030 AILEAD=GRWT(1)		
830	C		
831	IF (Q170) - 4.0 10000, 8031, 8031		
832	C		
833	COMPUTE BOOLE HEIGHT WHEN 4 WHEELS/STRUT		
834	C		
835	8031 BOOL = BP * 1.1*Q170		
836	C		
837	8030 BOOL = ((8143) * Q17(1)) / STRUTS**2		
838	0 * ((8143) * .8*Q17(1)) / STRUTS**2)**2.5 * BOOL/2.0		
839	C		
840	700 = 8143) * .4 * Q17(1) * Q170 / STRUTS		
841	C		
842	CALL BPCR(8100, HT, WTS, WTT)		
843	C		
844	80 = ((32.0/P1) * ((800/WTS)**2) * (700/WTT)**2)**2		
845	0 / ((1.0 * ((8100)-2.0)/Q100)**2) / ((1.0 * ((8100)-2.0)/Q100)**2)		
846	0**23333		
847	C		
848	8030 BOOL = 8100*Q107/STRUTS*BOOL*IP1**2*(8100)-1.0/ 8100)**2)		
849	C		
850	WEIGHTS ON AILE		LEN7000
851	8000 WWT = 8143) * AILEAD / WWT(12.0/ 1.0 * ((8100)-2.0/STRUTS)		
852	WWT = 8143) * .8*AILEAD / WWT(11.0/ 1.0 * ((8100)-2.0/STRUTS)		

05/27/74	INPUT LISTING	AUTOLAN CHART SET - SHEEP	LANDING GEAR NOBLE
CARD NO	CONTENTS		
002	C		
003	C	MODULUS OF RUPT ON AXLE	LB/73100
004	C	CALL BPER: D(32),MT,BMED,THSD	
005	C		
006	C	AXLE DIAMETER	LB/73100
007	C	$DIAM = (1/32 * PI) * (BMD / (BMD * 2 + 1) * (THAN / (2 * THSD) + 2))^{.333}$	LB/73100
008	C		
009	C	VOLUME AXLE	LB/73200
010	C	$VOLAN = PI * (DIAM^2 * AXLES / 4 * 0.7854)$	LB/73210
011	C		
012	C	OIL VOLUME	LB/73340
013	C	$SOOS VOL OIL = PI * D^2 * L * STROKE * .375$	
014	C		
015	C	OUTER CYLINDER MT	LB/73300
016	C	$MTOC = ((AREAN(1) * 2 * AREAN(2) * AREAN(3)) / 4 * 0.7854 * (FLNGTH(1) * FLNGTH(2) * FLNGTH(3)) * STRUTS * 0.100) * 0.100$	LB/73370
017	C		
018	C		
019	C	INNER CYL MT	LB/73300
020	C	$SOOS MTIC = (PI * D^2 * L * (1.0 - (1.0 / 0.100))) * (FLNGTH(2) * FLNGTH(3)) * (AREAN(4) * FLNGTH(3)) * STRUTS * 0.100) * 0.100$	
021	C		
022	C		
023	C	MT. AXLE OIL	LB/73330
024	C	$SOOS MTAL = STRUTS * 0.100 * VOLAN$	
025	C	$MT OIL = VOL OIL * STRUTS * 0.100$	
026	C		
027	C	TOTAL STRUT MT	LB/73300
028	C	$TOTSTM = MTOC + MTIC + MTAL + MTOIL + MBTT + MBTTT + MBTTT$	
029	C	$+ SOOSMT$	
030	C		
031	C	TOTAL CALCULATED HEIGHT	LB/73300
032	C	$TOTCAL = TOTSTM + MBTT$	LB/73400
033	C		
034	C	MAIN OR ALX TRIP MISC MT	LB/73410
035	C	IF (MTRIP) 5110,5100,5110	LB/73420
036	C		
037	C	MAIN	LB/73430
038	C	$5100 MTHISC = 0.100 * TOTSTM * 0.100 * TOTCAL * 0.100 * 0.100$	
039	C	GO TO 5120	LB/73400
040	C		
041	C	ALX	LB/73400
042	C	$5110 MTHISC = 0.100 * TOTSTM * 0.100 * TOTCAL * 15.0$	
043	C		
044	C	DELTA	
045	C	$5120 TOTAL = DELTA * (TOTSTM + MTHISC - MBTT) + MBTT$	
046	C	$MTHISC = TOTAL - TOTSTM$	
047	C		
048	C	MAIN OR ALX TRIP	LB/73420
049	C	IF (MTRIP) 5120,5121,5130	LB/73430
050	C		
051	C	ADD MISC HEIGHT	LB/73400
052	C	$5121 TOTAL = TOTAL * 0.100$	
053	C		
054	C	STATIC HEIGHT FOR ALX GEAR	LB/73430
055	C	$5130 SM = (MBTT(1) * 1 - 100 * 0.100) * 0.100$	
056	C		
057	C	TAIL WHEEL CHECK, 0-TW	LB/73400
058	C	$5132 IF (0.100) 1000,5134,0000$	
059	C		
060	C	TAIL WHEEL MT	LB/73470
061	C	$5134 TAILMT = EXP(0.100 * LOG(TOTSTM) * 0.100 * LOG(50) - 0.100)$	
062	C		
063	C		
064	C	FIND BPER AND THEN FOR EACH SECTION	LB/73400
065	C	$0000 DO 0000 N=1,4$	
066	C	$0000 CALL BPER(BPER(MTH),MT,PT(BH),PT(ST(M))$	
067	C		
068	C	COMPUTE CG OF LANDING GEAR	
069	C		
070	C	IF (MTRIP) 740,740,744	
071	C		
072	C	$744 IF (0.100) 740,740,740$	

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00107/74 INPUT LISTING AUTOFLIGHT SET - SHEEP LANDING GEAR MODEL
CARD NO **** CONTENTS ****
003 C
004 TWS H20 = 0.0
005 V20 = 0.0
006 ZC0 = 0.0
007 GO TO 0140
008 C
009 C
010 TWS ZC0C = (AREAM2) * (FLNTH1-FLNTH2)**2 / 2.0
011 * (AREAM1-AREAM2)/2.0 * (FLNTH1-FLNTH2)**2 / 3.0
012 * AREAM3 * (FLNTH2-FLNTH3)
013 * (FLNTH1) - (FLNTH2+FLNTH3)/2.0 *
014 * (AREAM2-AREAM3)/2.0 * (FLNTH2-FLNTH3)
015 * (FLNTH1) - (2.0*FLNTH2+FLNTH3)/3.0 * COSTH
016 * / (FLNTH1-FLNTH3) * (AREAM1+2.0*AREAM2+AREAM3)/4.0)
017 C
018 H20C = ZC0C * TANHANGLE(1)
019 V20C = ZC0C * TANHANGLE(2)
020 C
021 ZC01C = ((P1 * BP**2 / 0.125)) * ((1.0 - 1.0/0.125))
022 * (FLNTH1) - (FLNTH2+FLNTH3)/2.0)
023 * (FLNTH2-FLNTH3) * AREAM4 * FLNTH3)
024 * (FLNTH1) - (FLNTH3+FLNTH4)/2.0) * COSTH
025 * / ((P1 * BP**2 / 0.125)) * ((1.0 - 1.0/0.125))
026 * (FLNTH2-FLNTH3) * AREAM4 * FLNTH3)
027 C
028 H201C = ZC01C * TANHANGLE(1)
029 V201C = ZC01C * TANHANGLE(2)
030 C
031 ZC001L = (FLNTH1) - FLNTH2) * COSTH
032 H2001L = ZC001L * TANHANGLE(1)
033 V2001L = ZC001L * TANHANGLE(2)
034 C
035 ZC00S = .375 * FLNTH1) * COSTH
036 H200S = 3.0**5 * FLNTH1) / 0.0
037 V200S = 0.0
038 C
039 ZC00S = .375 * FLNTH1) * COSTH
040 H200S = 0.0
041 V200S = - 3.0**5 * FLNTH1) / 0.0
042 C
043 ZANTR0 = FLNTH1) * COSTH
044 XANTR0 = ZANTR0 * TANHANGLE(1)
045 YANTR0 = ZANTR0 * TANHANGLE(2) - ECCET
046 C
047 C
048 ZC0 = (MTC*ZC0C + MTC*ZC01C + MTOIL*ZC001L + DSTRUT*ZC00S
049 * +DSTRUT*ZC00S + ZANTR0*MTAIL*MTAIL*MTT*MTBRK*BOOMT) / TOTSTM
050 XC0 = (MTC*H20C + MTC*H201C + MTOIL*H2001L + DSTRUT*H200S
051 * +DSTRUT*H200S + XANTR0*MTAIL*MTAIL*MTT*MTBRK*BOOMT) / TOTSTM
052 YC0 = (MTC*V20C + MTC*V201C + MTOIL*V2001L + DSTRUT*V200S
053 * +DSTRUT*V200S + YANTR0*MTAIL*MTAIL*MTT*MTBRK*BOOMT) / TOTSTM
054 C
055 0140 CONTINUE
056 C
057 0141 IF (0.001) 0204, 0204, 0202
058 C
059 0204 GO 0205 N=1,4
060 0205 LOD101H) = 0
061 C
062 0202 IF (INTRIP) 0203, 0203, 010
063 C
064 0203 WRITE(6,001)
065 001 FORMAT(1H,4X,3HMAIN LANDING GEAR HEIGHTS (POUNDS),2X,
066 1 10**6 LBS) **
067 C
068 WRITE(6,01) MTC,MTC,MTAIL,MTOIL,DSTRUT,DSTRUT,MTAIL,
069 * MTT,MTMTC
070 011 FORMAT(1H,4X,10HENTER CYLINDER,2X,F0.1/4X,0HPISTON,11X,F0.1/
071 * 4X,0HOLE,12X,F0.1/ 4X,0HOLE,14X,F0.1/
072 * 4X,10HCRAB STRUT,7X,F0.1/ 4X,10HSIDE STRUT,7X,F0.1/
073 * 4X,0HHEELS,11X,F0.1/ 4X,0HTIRES,12X,F0.1/

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03/27/74	INPUT LISTING	AUTOFLEX CHART SET - SHEEP	LANDING GEAR MODULE
CARD NO	CONTENTS		
004	• 40X,120MISC (CALC.),5X,70.1)		
005	C		
006	WRITE(0,011)MTORX,BOOMT,0104)		
007	011 FORMAT(40X,0.000000E,11X,70.1/40X,0.000000E,12X,70.1/		
008	• 40X,120MISC (INPUT),5X,70.1)		
009	GO TO 015		
1000	C		
1001	010 WRITE(0,012)		
1002	012 FORMAT(11X,40X,3.000000E LANDING GEAR HEIGHTS (POUNDS),25X,		
1003	1 10M** LMT **)		
1004	C		
1005	WRITE(0,011)MTC,MTIC,MTAL,MTOL,OSTRT,OSTRT,MTAL,		
1006	• MTT,MTMISC		
1007	C		
1008	010 WRITE(0,000)TOTAL		
1009	000 FORMAT(10X,40X,0.000000E,12X,70.1/)		
1010	C		
1011	IF(M - IP)010,010,010		
1012	C		
1013	010 WRITE(0,017)		
1014	017 FORMAT(10X,7X,2.000000E LANDING GEAR DESIGN DATA)		
1015	GO TO 025		
1016	C		
1017	010 WRITE(0,019)		
1018	019 FORMAT(10X,7X,2.000000E LANDING GEAR DESIGN DATA)		
1019	C		
1020	020 WRITE(0,021)LEDDIN(M),AREAN(M),DOVTHIN(M),PFBIN(M),PFBTIN(M),P=1,4),		
1021	• SP,200,DEFLV,YC0,DEFLZ,NC0,DEFLP		
1022	021 FORMAT(10X,40X,0.000000E,5X,4.000000E,5X,0.000000E,4X,0.000000E,		
1023	• 2X,0.000000E/ 50X,0.000000E,5X,0.000000E,11X,7X,0.000000E,		
1024	• 0.000000E,4X,0.000000E/ 40X,0.000000E,12X,0.000000E,5X,		
1025	• 0.000000E,5X,0.000000E/ 51X,0.000000E,10X,0.000000E,4X,0.000000E,		
1026	• 12X,0.000000E,12X,0.000000E,10X,12.0,0.0,0.0,0.0,		
1027	• 20X,0.000000E,7X,12.0,0.0,0.0,0.0,		
1028	• 20X,0.000000E,7X,12.0,0.0,0.0,0.0,		
1029	• 12X,0.000000E (20 PCT OF LENGTH FROM AXLE),4X,12.0,0.0,0.0,		
1030	• 0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,		
1031	• 5X,0.000000E - BOUN TRUNION POINT,10X,0.0,		
1032	• 10X,0.000000E DEFLECTION (INCHES),0.0,		
1033	• 5X,0.000000E - OUTBOARD (INBOARD) FROM TRUNION POINT,0.0,		
1034	• 10X,0.000000E DEFLECTION (INCHES),0.0,		
1035	• 5X,0.000000E - AFT (FORWARD) FROM TRUNION POINT, 5X,0.0,		
1036	• 10X,0.000000E OF TWIST (RADIANS),0.0,		
1037	C		
1038	IF(NTIP)5704,5704,5703		
1039	C		
1040	5703 WRITE(0,5702)		
1041	5702 FORMAT(10X,		
1042	• 40X,0.000000E DESIGN LOAD CONDITION INDICATORS/		
1043	• 47X,0.000000E HEIGHT,5X,0.000000E LANDING HEIGHT/		
1044	• 20X,0.000000E,10X,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,		
1045	• 20X,0.000000E,10X,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,		
1046	• 10X,0.000000E/ 20X,0.000000E LANDING,11X,0.0,0.0,0.0,		
1047	• 20X,0.000000E,10X,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,		
1048	• 20X,0.000000E,10X,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,		
1049	• 0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,		
1050	• ON LOADS WERE GIVEN IN THE INPUT DATA)		
1051	C		
1052	5704 IF(NTIP)10,10,20		
1053	C		
1054	10 F0AT(41) = TOTAL		
1055	F0AT(42) = MTAL + MTT + MTOR		
1056	F0AT(43) = MTC + MTIC + MTAL + MTOL + OSTRT + OSTRT + BOOMT		
1057	F0AT(44) = MTHISC + 0104)		
1058	F0AT(45) = 0102)		
1059	GO TO 30		
1060	C		
1061	20 F0AT(46) = TOTAL		
1062	F0AT(47) = MTAL + MTT		
1063	F0AT(48) = MTC + MTIC + MTAL + MTOL + OSTRT + OSTRT		
1064	F0AT(49) = MTHISC		

05/27/74	INPUT LISTING	AUTOFLOW CHART SET - DEEP	LANDING GEAR MODULE
CARD NO	****	CONTENTS	****
1005		FBA1(50) = D(53)	
1006	C		
1007	C	RETURN FOR ALN TRIP IF OUT = 0	
1008		30 IF (INTRIP) 0000, 5205, 5000	
1009	C		
1070		5205 IF (D(52)) 5245, 5245, 5205	
1071	C		
1072		5245 CONTINUE	
1073	C		
1074		5247 WRITE(6, 5205) TAILMT	
1075		5000 FORMAT(1H, 10H, 11H TAIL HEIGHT, F8.1, 7H, 10H** LENT ****)	
1076	C		
1077		WRITE(6, 5702)	
1078	C		
1079		FBA1(45) = TAILMT	
1080		FBA1(47) = 0.0	
1081		FBA1(48) = 0.0	
1082		FBA1(49) = 0.0	
1083		FBA1(50) = D(53)	
1084		GO TO 0000	
1085	C		
1086	C	SET UP DATA FOR ALN TRIP	
1087		5205 MT1=40EXLA-TTALX	
1088		MT1=TTALX	
1089		MTN1=40EXLA	
1090	C		
1091		DO 5100 N=1,4	
1092		5100 FLNTH(N)= D(N*30) + D(51)	
1093	C		
1094		TOTLAD=D(51)	
1095		EFAC = (TOTLAD / (TOTLAD - FLNTH(2)))**2	
1096		SCCT=0(54)	
1097		DELTA=0.00+D(57)	
1098		SDTN=0(57)	
1099		STRKE=0(52)	
1100		DELTA=0(54)	
1101		MXLS=0(55)	
1102		STRTS=1.0	
1103		SEFL = 0(51)	
1104		MIGN=0(55)	
1105	C		
1106	C	IS ALN GEAR PISTON DIAMETER LOADED	
1107		IF (D(53)) 15103, 5100, 5103	
1108	C	ALN GEAR PISTON DIAMETER	
1109		5100 SP =0P + D(2)	
1110		GO TO 5105	
1111		5103 SP =0(53)	
1112	C		
1113	C	SET UP LOAD INDEX AND TRIP COUNT	
1114		5100 NTRIP=1	
1115	C		
1116		SW = 0(70)	
1117		SW = 0(71)	
1118		SDTN=0.0	
1119		SDTN=0.0	
1120		SDTN = 0.0	
1121	C		
1122		AMLE(1) = 0(56) + .017+5323	
1123		AMLE(2) = 0.0	
1124		COSME = COS(AMLE(1))	
1125		WTRK = 0.0	
1126	C		
1127		GO TO 1074	
1128	C		
1129		0000 P	
1130			
1131	C		
1132	C		
1133	C	ROUTINE LSP	
1134	C		
1135	C		

CARD NO	INPUT LISTING	AUTOFLON CHART SET - SHEEP	LANDING GEAR HODDLE
1136	SUBROUTINE LOBP(X,Y,WP,VP)		
1137	C		L6370010
1138	DIMENSION X(3),Y(3),V(6)		
1139	C		
1140	V(1)=WP-X(1)		
1141	V(2)=WP-X(2)		
1142	V(3)=WP-X(3)		
1143	V(4)=-V(1)+V(2)		
1144	V(5)=-V(1)+V(3)		
1145	V(6)=-V(2)+V(3)		
1146	C		L6370140
1147	V(7) =V(2)/V(4)+V(3)/V(5)		
1148	V(8) =V(1)/V(4)+V(3)/V(5)		
1149	V(9) =V(1)/V(5)+V(2)/V(6)		
1150	C		
1151	VP = V(8)*Y(3) + V(7)*Y(1) - V(9)*Y(2)		
1152	C		
1153	GO RETURN		L6370330
1154	END		L6370340
1155	C		
1156	C		
1157	C		
1158	SUBROUTINE LOADS		
1159	C		
1160	C		
1161	C		
1162	SUBROUTINE LOADS(CSV,CFA,CBL,W,DF,W,AILOAD,PLDAD)		
1163	C		
1164	RLDAD = (W**2 + DF**2 + W**2)**.5		
1165	C		
1166	CRV = W/RLDAD		
1167	CFA = DF/RLDAD		
1168	CBL = W/RLDAD		
1169	C		
1170	ANG = ACOS(ANINI(CSV*CRV + CFA*CFA + CBL*CBL , 1.0))		
1171	C		
1172	AILOAD = RLDAD * COS(ANG)		
1173	PLDAD = RLDAD * SIN(ANG)		
1174	C		
1175	RETURN		
1176	END		