

**EVEL**

2

**USER'S MANUAL**

**FOR**

**VASCOMP II**

**THE V/STOL AIRCRAFT SIZING  
AND PERFORMANCE COMPUTER PROGRAM**

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User oriented features of the program include minimized input requirements, diagnostic capabilities, and various options for program flexibility.

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27 August 1980  
8-1162-6666

Department of the Navy  
Naval Air Development Center  
Warminster, Pennsylvania 18974

Attention: Code 6051

Subject: Contract N62269-79-C-0706, "VASCOMP II Computer Program" - Submittal of VASCOMP II User's Manual

Enclosure: (1) VASCOMP II User's Manual (Five Copies)  
(2) DD Form 250, Material Inspection and Receiving Report (One Copy)

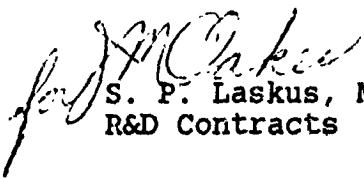
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1. In accordance with Data Sequence Item A002 of the subject contract Data Requirements List, Boeing Vertol submits Enclosure (1), the VASCOMP II User's Manual.

2. It is requested that you execute the enclosed DD Form 250 and return it to the undersigned at your earliest convenience.

3. With this action, all direct activity required under the subject contract is completed and administrative close-out action is being initiated necessary to preparation and submittal of the final invoice

Very truly yours,

  
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**VASCOMP II**  
**USER'S MANUAL**

**6**  
**USER'S MANUAL FOR VASCOMP II,  
THE V/STOL AIRCRAFT SIZING AND PERFORMANCE  
COMPUTER PROGRAM.** *Volume VI*

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By A. H. SCHOEN, H. ROSENSTEIN, K. A. STANZIONE and  
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## FOREWORD

VASCOMP, the V/STOL Aircraft Sizing and Performance Computer Program, was originally written during the period June 1966 to March 1967 under NASA Contract NAS2-3142, Mod. 1. From September 1967 to March 1968, a major modification to the computer program led to the development of VASCOMP II under Contract NAS2-3142, Mod. 2. A second modification to the program conducted during the period January 1971 to October 1971 under NASA Contract NAS2-6107, Mod. 1, led to Revision 1 of this document in October 1971.

Past modifications involved updating and expanding the statistical weight trends data and incorporating the weight trends documentation, Reference 2, directly into this document. This revision was conducted under NASA Contract NAS2-6107, Mod. 7, between April and September 1973.

The most recent modifications included a general performance subroutine, a transmission sizing option, accessory horsepower inputs, and additional engine sizing inputs for specified fraction of power and vertical rate of climb.

Numerous comment cards have been added in the Fortran code as an aide to the troubleshooter. Also, where possible, named commons have been used to pass variables among a few subroutines.

Recognizing that in time the program will change to reflect new thinking and grow to include more sophisticated methods of simulating advanced V/STOL systems, the User's Manual is loose-leaf bound to facilitate updating of the program documentation.

Inquiries regarding the program should be directed to the authors.

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NOTE

Section 5.3 contains a definition of program input variables and indicators; section 6.2 lists the major diagnostic error printouts and describes their probable cause. For ease of reference, these sections are printed on blue and green paper, respectively.

## 1.0 INTRODUCTION

### 1.1 BACKGROUND

VASCOMP II is an improved version of VASCOMP, the V/STOL Aircraft Sizing and Performance Computer Program, described in Reference 1. The purpose of the program is to aid comparative design studies of V/STOL aircraft systems by rapidly providing airplane size and mission performance data. The program can be used to define design requirements such as weight breakdown, required propulsive power, and physical dimensions of aircraft which are designed to meet specified mission requirements. The program is also useful in sensitivity studies involving both design trade-offs and performance trade-offs.

During formulation of the program, the following guidelines have been followed:

1. Maintain generality and flexibility:

A program of this type must be comprehensive and flexible in order to permit an accurate simulation of virtually any V/STOL configuration. It must be capable of approximating the design process involved in layout and sizing of a wide variety of V/STOL aircraft and synthesizing the performance of these aircraft.

2. The program should be easy to use:

In order to minimize hand computation of input data, the input to the program consists primarily of a series of single point values specifying, for example, the aspect ratio, taper ratio, etc. of the wing and tail surfaces, the geometry of the fuselage, the type of propulsion system, a description of the mission profile, and weights of fixed equipment, fixed useful load and payload. Where necessary to adequately describe certain functional relationships, the input is in tabular form. However, since preparation of data for tabular input is generally more cumbersome and time consuming, this form of input has been kept to a minimum.

3. Minimize computation time:

In order to minimize computation time, the program makes ample use of optional computation

paths. To eliminate large quantities of null arithmetic, the program avoids calculations which do not apply to the particular aircraft being studied. This is accomplished by means of a series of input indicators that specify the calculations to be performed.

4. The program should be well balanced:

The program should not be extremely sophisticated in one detail and yet extremely simple in another. To offset the possibility of this occurrence, great care has been taken to examine methods used to describe the aircraft and its operation. As an example, the program does not calculate actual airplane takeoff performance since too many detailed factors are required for this purpose. Rather, the program calculates the power and fuel flow required to satisfy specified thrust to weight requirements. The thrust to weight required is calculated in a separate program and is dictated by the specific aircraft being considered.

1.2 APPLICATION

The program has two primary independent applications, a third which is a combination of the first two, and a fourth option used for obtaining aircraft weight only. The program may be used for the sizing of aircraft for which the type of aircraft and the mission profile are specified. Alternatively, the program may be used for mission calculations for aircraft for which sizing details (gross weight, fuel available, engine power and fuel consumption, etc.) are known. As a combination of these two capabilities, the program may be used to first size an airplane for a given mission and then calculate the off-design-point performance for other missions. The option of calculation to be used is specified to the program by means of an input "option indicator".

The program has been written in a manner to make it directly applicable to sensitivity studies to determine the effect of variations in weight, drag, engine characteristics, etc. This is accomplished by use of incremental multiplicative and additive factors applied to the gross weight, component drag and fuel required equations. For the most part, the multiplicative factors are nominally equal to unity and the additive factors are nominally equal to zero. However, to determine the effect, for example, of a 10 percent increase in drive system weight, the appropriate multiplicative factor can be set to 1.10 and the sizing program rerun.

The program contains size trends equations which reflect the variation of aircraft dimensions with gross weight, detailed statistical weight trends equations, a routine for sizing of engines to match airframe requirements, a comprehensive library of engine cycle data, and a variety of optional procedures for calculating propeller performance for turboprop airplanes.

The program can be used to study any aircraft which uses fixed wing lift for primary cruise flight. It is not intended to be used for analysis of aircraft which employ rotary wing lift for forward flight.



## 2.0 SPECIFICATION OF AIRCRAFT CHARACTERISTICS

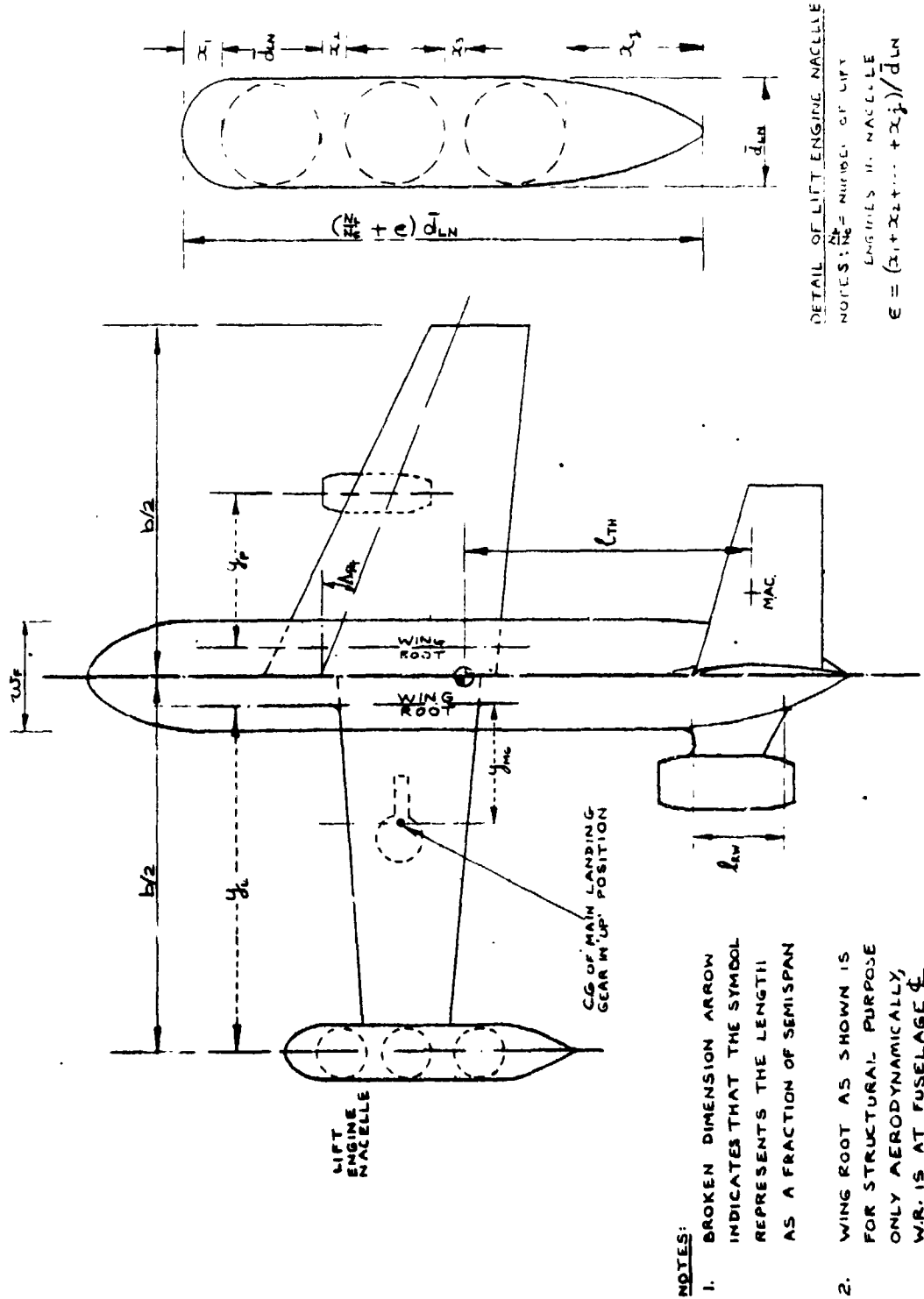
Specification of aircraft characteristics to the program is made in a variety of ways: through use of input indicators which specify the types of calculations to be made, through use of weights factors and constants, aerodynamics data, propulsion information, and through use of mostly nondimensional geometric information.

### 2.1 AIRCRAFT GEOMETRY

It is assumed that a typical sizing analysis starts with known payload characteristics, both in terms of payload weight and volume requirements. The volume requirements are usually reflected in length, height, and width of the constant diameter (cabin) section of the airplane. Adding a nose and tail section of reasonable fineness ratio onto the cabin section completes the fuselage geometry and leads to a body of known dimensions. A special option of the program permits the fuselage geometry to be calculated to match known passenger requirements for commercial applications. Wing geometry may be dictated by the requirements to accommodate multiple propellers while maintaining reasonable wing chord to propeller diameter ratios, as in the case of a tilt wing airplane, or it may be dictated by required wing loading-aspect ratio combinations. Tail surface geometry is usually dictated by requirements on tail volume coefficients. Since the fuselage length is generally known and fixed in length, the tail moment arms may be approximated and input as fixed quantities. Alternatively, if the tail surface size is a known value, it may be input to the program as a fixed constant. Primary engine nacelle size is set by type of engine and by engine size (which, in turn, is dictated by power requirements). Lift engine size is set by type of engine, engine size, and by the number of engines which may be clustered together.

Figure 2-1, Parts 1 and 2, of a hybrid V/STOL airplane illustrates the type of information concerning the aircraft geometry which may be required of the user of the program. These data specify nondimensional distances from the aircraft centerline to the engines, to the main gear, and to concentrated loads, propeller overlap and clearance factors, and other parameters which specify the geometric layout of the aircraft. A list of these input variables is included in Section 5.3.1.





DETAIL OF LIFT ENGINE NACELLE  
 $N_L$  = NUMBER OF LIFT ENGINES IN NACELLE  
 $\epsilon = (x_1 + x_2 + \dots + x_j) / d_{LN}$

- NOTES:
1. BROKEN DIMENSION ARROW INDICATES THAT THE SYMBOL REPRESENTS THE LENGTH AS A FRACTION OF SEMISPAN
  2. WING ROOT AS SHOWN IS FOR STRUCTURAL PURPOSE ONLY AERODYNAMICALLY, W.R. IS AT FUSELAGE  $l_{mc}$

Figure 2-1. Typical Aircraft Geometry (Part 2 of 2).

## 2.2 PROPULSION SYSTEM

This program permits the use of either a single, primary propulsion system or a combination of a primary system and lift propulsion system. For the primary system, turboshaft, turbofan, turbojet or convertible cycles may be used. Lift fan and lift turbofan cycles are used to represent the lift propulsion system. The program includes a standard library of eighty-one different generalized engine cycles, as shown in Table 2-1. The user of the program may either select the desired engine cycle(s) from the standard library or input the characteristics of any arbitrary engine cycle he may choose.

The library engines are unrestricted in performance over their operating system range (dictated by power setting limits). However, the user, at his discretion, may include limits on engine operation by setting maximum values of fuel flow, torque, or gas generator or power turbine shaft rpm. In addition, nonlinear scaling effects of real engines may be included by input of Reynolds number-based correction factors. Degradation in performance of turbo-shaft engines operating at nonoptimum power turbine speed will be calculated by the program at the option of the user. The library engine cycles may thus be used with no additional input or, by appropriate additional input, may be made to include the effects of multiple operating restrictions and other factors characteristic of real engine cycles.

During a sizing calculation, the engine cycles may be "scaled" or fixed in size. That is, if the user desires, the program will calculate the engine size required to meet the mission requirements, or alternatively, he may input engines of specified size. In the case of aircraft employing multiple propulsion systems, the primary system may be used to provide part of the lift thrust or power, and the lift engines will be sized to provide the remaining required thrust or power.

## 2.3 AIRCRAFT WEIGHT SUMMARY

A detailed aircraft weight summary is provided by the program through use of statistical weight trend equations. A description of, and justification for, these equations is

TABLE 2-1.  
LIST OF ENGINE CYCLES

	1970	INTERMED- IATE	ADVANCED
<u>PRIMARY PROPULSION</u>			
TURBOSHAFT			
ENGINE PRESS. RATIO	13, 16	13, 16, 19	13, 16, 19, 22
TURB. INLET TEMP.	2600°R	2900°R	3200°R
TURBOJET			
ENGINE PRESS. RATIO	13, 16	13, 16, 19	13, 16, 19, 22
TURB. INLET TEMP.	2600°R	2900°R	3200°R
TURBOFAN			
ENGINE PRESS. RATIO	16, 20	16, 20, 24	16, 20, 24, 28
TURB. INLET TEMP.	2600°R	2900°R	3200°R
FAN BYPASS RATIO	2, 4, 6	2, 4, 6	2, 4, 6
<u>LIFT PROPULSION</u>			
LIFT ENGINES			
ENGINE PRESS. RATIO	7	7	7
TURB. INLET TEMP.	2400°R	2700°R	3000°R
FAN BYPASS RATIO	2, 4, 6	2, 4, 6	2, 4, 6
LIFT FANS			
ENGINE PRESS. RATIO	13, 16	13, 16, 19	13, 16, 19, 22
TURB. INLET TEMP.	2600°R	2900°R	3200°R
FAN BYPASS RATIO	8, 11, 14	8, 11, 14	8, 11, 14

given in Reference 2. Three major categories of weights are calculated: the propulsion group, the structures group, and the flight controls group. The weight trends subroutine is described in detail in section 4.9.

#### 2.4 AERODYNAMIC CHARACTERISTICS

The aerodynamic data which are calculated by the program are the airplane drag and lift curve slope. The lift curve slope is used for calculation of gust load factor and for calculation of angle of attack required during climb and descent. Drag data may be input to the program in a variety of forms ranging from input of a single point value of either drag coefficient or of flat plate area to input of a detailed drag summary. Scaling effects on drag based upon Reynolds number corrections are included. The program will automatically calculate the compressibility drag rise on the basis of an approximate semi-empirical technique. If the user prefers, he may input tabulated values of the drag rise. Spanwise loading efficiency (Oswald's factor) may be either input to the program or may be internally calculated by the program.

## 3.0 PROGRAM OPERATION

### 3.1 GENERAL

#### 3.1.1 The Option Indicator

As previously described, the program has two major options and a third which is a combination of these two. The specific option to be used is selected by means of an input "option indicator" abbreviated OPTIND.

##### OPTIND = 0

This is an iterative routine which determines only the aircraft weight, dimensions, and power.

##### OPTIND = 1

This is an iterative routine which determines the aircraft weight, dimensions and required power to satisfy a prescribed mission flight profile. In addition to the flight profile, certain characteristics describing the type of aircraft are specified such as the wing aspect ratio, thickness ratio, the wing loading or disc loading, the engine cycle, etc.

##### OPTIND = 2 or 3

These options are used to calculate the flight performance of an aircraft for which the size is fixed. In addition to the aircraft characteristics described above, the power available, aircraft dimensions, etc. are input to the program. A flight profile is also specified. The program then calculates the performance history of the aircraft for the specified mission.

If OPTIND = 2 is selected, the aircraft gross weight is input and the fuel required to fly the specified mission is determined. This option is useful for solving many different performance problems where it is desired to constrain gross weight such as calculating climb performance, cruise performance, or payload-range capability.

If OPTIND = 3 is selected, the operating-weight-empty is input and takeoff gross weight and required fuel load is determined. This option is useful for calculating various overload off-design weights and for determining ferry performance.

### Combined Option

This option permits the user to size an aircraft for a "design-point" mission and then to calculate the off-design-point performance of the sized aircraft for a variety of additional missions. Basically, this option causes the program to run option number one (OPTIND = 1), save the sizing data generated in that option, and then input this information into the performance option (OPTIND = 2).

### 3.1.2 Description of Mission Profile

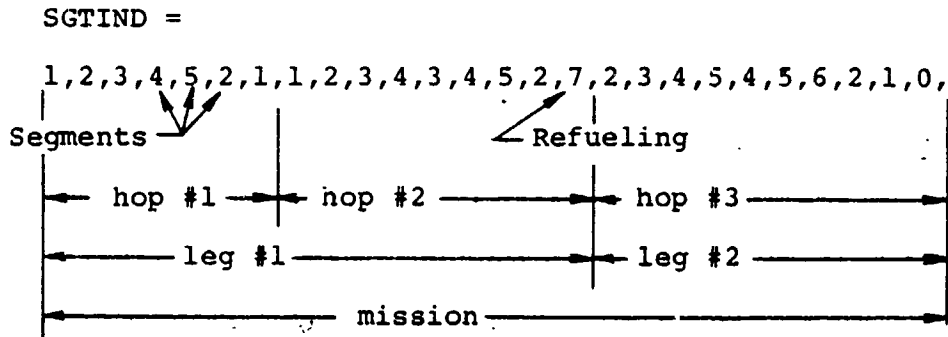
The performance calculation subprogram in VASCOMP II, consisting of nine individual subroutines, permits the simulation of aircraft performance for virtually any mission flight profile. A typical performance analysis is made up of a series of elements which, in building block fashion, allows the user of the program to perform a wide variety of studies. The elements of a typical performance analysis are:

- a. Segment - A segment of a mission profile is a unique portion of the mission such as a cruise or a climb. A segment starts with a set of initial conditions of one or more of the variables of state (altitude, range, weight, etc.) and ends when a terminal condition (or conditions) has been satisfied.
- b. Hop - A hop is defined as a set of segments ending at some logical terminal locations (such as ground level at the desired range). Thus, a hop might consist of flying from location "A" to location "B" by means of combining the following segments: taxi, takeoff, climb, cruise, descent, landing, and taxi.
- c. Leg - A leg of a mission is herein defined as a set of hops ending in a re-fueling of the aircraft. Thus, a leg might consist of flying from location "A" to "B", then to "C", at which point the aircraft is refueled.
- d. Mission - A mission is defined in this program as a set of legs (or hops or segments) which satisfy some specific operational requirement. In this program, the mission is the basic element for which the aircraft is sized.

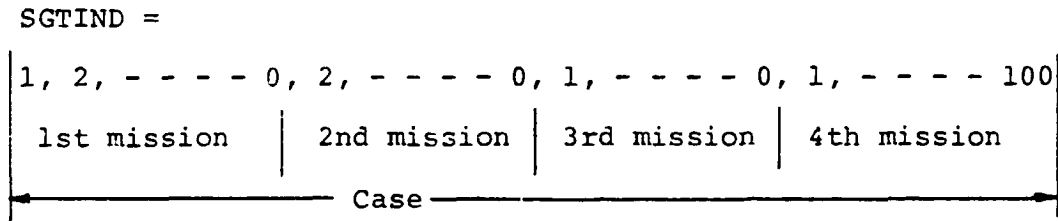


- e. Case - A case is a consecutive series of missions for the same aircraft. This program permits the user to analyze a case which consists of a mission for which an aircraft is sized, followed by a different mission which the now-sized aircraft performs, followed by yet additional missions.

The performance calculations subprogram consists of ten individual performance segments, specified by means of an input indicator, SGTIND. The segments are taxi (SGTIND = 1), hover (SGTIND = 2), climb (SGTIND = 3), cruise (SGTIND = 4), descent (SGTIND = 5), loiter (SGTIND = 6), an increment in weight of fuel (SGTIND = 7) or payload (SGTIND = 8), a transfer of altitude (SGTIND = 9), and general performance (SGTIND = 11). The end of the mission is specified by an input SGTIND = 0. An array of segment indicators is input to the program to specify the mission being studied. Thus, a typical array might be:



At the end of any leg, the sum of segment fuel required to perform that leg is stored in the computer. At the end of the mission, the largest of these stored values is used to determine the aircraft sizing requirements when OPTIND = 1. An end of a case is specified by an input SGTIND = 100. Since an end-of-case is also always an end-of-mission, it is not necessary to end a case by a SGTIND = 0 followed by SGTIND = 100. SGTIND = 100 always takes precedence over SGTIND = 0. The distinction between a mission and a case is most useful when it is desired to size an aircraft for a specified mission followed by analysis of the off-design-point performance of the "sized" aircraft on other missions. As an example, with OPTIND = 1 (sizing option) the following array of SGTIND might be used:



The program will size the aircraft for the first mission and then analyze the performance of the "sized" aircraft for the second, third and fourth missions. Up to 50 consecutive segments may be included in a single case, arranged in any arbitrary series of hops, legs, and missions. Up to 10 of any specific segment may be included in any case. Thus, a case might consist of several missions, each mission having several different cruise segments.

Each segment is a discrete element of the mission, independent of any other segment with the exception of the influence on the altitude, range, weight, and time. That is, the first cruise of a case might be at cruise power at standard atmospheric conditions and the second cruise could be at best specific range for a nonstandard day.

At the start of a case, the user inputs values for initial conditions of altitude, range, weight, and time. The first segment of the case uses these values as initial boundary conditions and the segment ends at a specified terminal condition. The final values of altitude, range, weight, and time then become, in turn, the initial values for the following segment.

The final, or terminal, condition varies depending upon the segment. Terminal conditions for each segment, input by the user, are:

Taxi - increment in time

Takeoff, Hover, and Landing - increment in time

Climb - altitude at end of climb

Descent - altitude at bottom of descent and, for certain options, range at end of descent

Loiter - increment in time

Change of Fuel Weight - increment in weight and increment in time

Change of Payload Weight - increment in weight and increment in time

Transfer Altitude - final altitude

General Performance - increment in velocity

Segments 2 through 6 (takeoff, hover, and landing through loiter) and segment 11 (general performance require, in addition to terminal conditions on one of the variables of state, an input value for the step size to be used in the calculations. The step size specifies both the increment in the primary variable which is used in the calculations and the increment between successive printouts. Printouts occur at even integral multiples of the primary variable. Thus, if an aircraft is required to climb from a starting value of altitude of 6300 feet to a final value of 29,500 feet, and the step size is specified as 1000 feet, the program will calculate and print at 6300 feet, 7000 feet, 8000 feet, - - - - - 28,000 feet, 29,000 feet, 29,500 feet. As the step size is decreased, the program accuracy improves, but the computing time lengthens.

Atmospheric conditions may vary from segment to segment. For example, the first segment, a climb, may be for a standard atmosphere; the second segment, a cruise, may use a constant increment in temperature above standard;

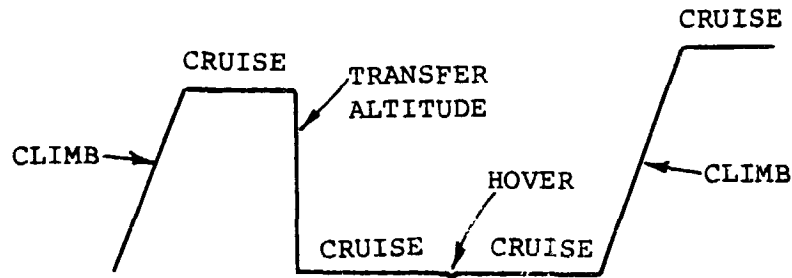
and the third segment, another climb, may use a nonstandard temperature versus altitude table. The third atmosphere option requires a tabular input of temperature ratio versus altitude. Only one nonstandard tabular atmosphere may be used in a single case.

### 3.1.3 Special Flight Path Control Options

Two special options on flight path control aid in doing certain types of studies. These are:

- a.  $V_{LIMIND}$  - This limiting-speed indicator will permit the user to fly a mission with a speed constraint such that at altitudes of 10,000 feet or less the airplane is restricted from flying at equivalent airspeeds greater than 250 knots in conformance with federal regulations. The mission may be made up of any arbitrary order of segments such as climb, cruise and descent.
- b.  $h_{OPTIND}$  - This indicator will permit the user to fly a mission at the optimum altitude for best fuel consumption. The program will automatically determine the best altitude for any cruise segment which is preceded by either a climb segment or a transfer of altitude. If the cruise is preceded by a climb, the program will determine the flight altitude which minimizes the sum of the fuel for climb and cruise. If the cruise is preceded by a transfer altitude, the program will determine the altitude for the best fuel consumption during cruise only.

In addition to specifying that optimum altitude flight is desired during the mission, the user may specify a maximum altitude permitted for each cruise segment. This is specified by means of the  $h_{MAX}$  input for the preceding climb or the  $h_{FINAL}$  input for the preceding transfer altitude. The maximum altitude specification is useful in studying missions for which some of the cruise segments are to be optimized while other cruise segments are to be flown at known altitude such as the high-low-low-high mission shown on the next page in which the low altitude segments represent sea level dashes. For this mission, the user specified  $h_{FINAL} = 0$  for the transfer altitude segment.



### 3.1.4 Propulsive Efficiency

Propeller efficiency can be calculated in three different ways for aircraft with turboshaft engines. The option chosen is specified by means of a propulsive efficiency indicator,  $npIND$ . The options range from (a) input of a set of point values of efficiency to (b) input of a prop map table to (c) automatic calculation of propeller performance. The option chosen will depend on the type of problem being studied as each of the means of calculating prop performance has features which may be desirable under certain conditions. These options are described in more detail in Section 4.5.

A fourth propulsive option available to the user is to input a fan map table of Mach number versus thrust for fan propelled aircraft.

A value for the propulsive efficiency may also be input for jet engines during the takeoff, hover, and landing segment ( $SGTIND = 2$ ). This efficiency may be used to simulate turning efficiency for a jet engine during takeoff. Similarly, a value for efficiency for lift engines in takeoff, hover, or landing may be input. This is discussed in more detail in Section 4.10.

### 3.2 PROGRAM OPTIONS

Flexibility of operation and generality of approach have been accomplished by use of many optional computation paths. The path to be used is selected by the user through use of a series of input indicators. Besides the option indicator, previously described, the program indicators fall into seven categories:

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propulsion indicators, aerodynamics indicators, size trends indicators, mission performance indicators, flight path control indicators, an atmosphere indicator, and an optional print indicator. The indicators and their use are described below. A summary list of all indicators and their values is included in Section 5.3.2.

### 3.2.1 Propulsion Indicators

- a. ENGIND - Three different classes of cruise engines are included in the program. They are "horsepower producing" engines, "thrust producing" engines, and convertible engines. The horsepower producing engines which are included in the standard engine library are turboshaft engine cycles. The thrust producing engines in the engine library are either turbojet or turbofan engines. Convertible engine cycles can be simulated by selecting a cruise turbofan cycle, plus properly setting the engine indicator, ENGIND. If ENGIND is input as zero, a power producing cycle is selected. If ENGIND is input as 1, a thrust producing cycle is selected. If ENGIND is input as 2, a fan (thrust producing) cycle will be selected and the program flow will simulate operation of a convertible engine cycle.
- b. LFTIND - A primary (or cruise) engine cycle is selected for each aircraft. In addition, a lift engine cycle may be selected. The selection of separate lift propulsion is specified to the program by means of the indicator, LFTIND. LFTIND = 0 indicates only cruise propulsion is selected while LFTIND = 1 indicates both cruise propulsion and lift propulsion systems are included on the aircraft.
- c. FIXIND - Engines selected for aircraft being studied in the program may be either "fixed" in size or "rubberized." If the engines are "rubberized," the engine sizing subroutine calculates the maximum power or thrust of the engines required to satisfy certain specified criteria. If the engines are fixed in size, the user inputs the level of maximum power or thrust for the engines and the engine sizing subroutine is bypassed. The user specifies the option of calculation by means of the input indicator, FIXIND. If FIXIND is set to

zero, the engines are fixed in size. If FIXIND is set to unity, the engine sizing subroutine is used to calculate the size of the "rubberized" engines.

- d. ESZIND - For aircraft which do not contain separate lift propulsion, the program permits the user to size the primary engines either for takeoff conditions only or for the more critical choice of takeoff or cruise. This is specified by means of the engine sizing indicator, ESZIND. If ESZIND is input to zero, the program will size the engines for takeoff conditions only. If ESZIND is input as unity, the program will size the engines for takeoff, then cross-check the engine size required for cruise conditions, and pick the more critical of the two conditions.
- e. WDTIND, QIND, N1IND, N10IND, N2IND - These indicators specify to the program that the primary engine performance is restricted by a maximum level of fuel flow, torque, gas generator shaft rpm, gas generator referred shaft rpm, or power turbine (output) shaft rpm. An input zero value for these indicators will permit operation restricted only by power setting (turbine temperature) limits. A unity input for any of the indicators will cause the engine operation to also be restricted by a maximum level of the appropriate variable. More than one of these indicators may be set to unity at the same time, thus simulating performance of an engine operating with multiple restrictions. N2IND has a third possible value which the user may input for turboshaft engines, N2IND = 2. This input specifies that the engine is operating at a known discrete value of output shaft speed (in general, not the optimum value). If this option is used, the user inputs the level of  $N_{II}$  for each flight segment, and the program will calculate the effect on engine performance.
- f. LWDIND, LN1IND, LN2IND - These indicators are similar to those described in (e.) above except that they apply to the lift propulsion system. A unity input for any of these indicators will cause the lift engines to be restricted in performance by a maximum level of fuel flow,  $N_I$ , or  $N_{II}$ . Since the lift

engines are either lift fans or lift turbofans, they are assumed to always operate at optimum  $N_{II}$ , and therefore there is no option for the lift engines similar to the previously described  $N2IND = 2$ .

- g. RNOIND - The performance of real engines is sensitive to scaling effects. That is, doubling the maximum static power of the engine at sea level for standard atmospheric conditions by increasing the physical size of the engine will not cause a corresponding doubling of the power at other operating conditions. This nonlinear behavior is due to the influence of variations in the Reynolds' number at the compressor inlet. RNOIND permits these effects to be accounted for on turboshaft engines through use of an input table of a correction factor on power available. If the indicator is set to unity, the tabulated correction factor may be input and will be used by the program to account for scaling effects. A zero input for the indicator will cause the program to assume that perfect scaling occurs.
- h. POWIND - This indicator specifies the limiting power setting to be used in climb, cruise, and for engine sizing at cruise conditions: maximum (POWIND = 0), military (POWIND = 1), and normal (POWIND = 2). A separate value of this indicator is input with each climb and cruise and for engine sizing.
- i.  $\eta_p$ IND - This indicator permits the user to select one of the four different methods for predicting propeller performance for turbo-prop airplanes. If  $\eta_p$ IND is input equal to zero, the user can specify a set of point value efficiencies for each of takeoff, climb, and descent and a table of efficiency vs. Mach number for cruise and loiter. An input of  $\eta_p$ IND = 1 will permit the user to load in a propeller performance map to be used during takeoff, climb, cruise, and loiter while an input of  $\eta_p$ IND = 2 will permit use of an automatic subroutine within the program for calculating prop performance. For  $\eta_p$ IND = 3 the user inputs a fan performance map. It is anticipated that this latter option will be used for the majority of sizing and performance studies. The input prop map



option will typically be used in cases where detailed test data is available on prop performance and it is desired to closely represent a specific propeller. The first option, permitting input of point values, is most useful for sensitivity studies or where propeller choice has not yet been made and only representative values of efficiency are desired. A more detailed discussion of these options is contained in Section 4.5.

### 3.2.2 Aerodynamics Indicators

- a. DRGIND - The aerodynamics calculations subroutine includes a set of semi-empirical equations to calculate drag rise due to compressibility effects. If specific information about the drag rise of the aircraft being studied is known, this may optionally be input to the program by means of an input table. The method of calculating compressibility drag is specified to the program by means of the indicator DRGIND. If DRGIND is input as zero, the program uses the semi-empirical equations to calculate an approximate drag rise. If DRGIND is input as unity, the user may input a three-dimensional table of compressibility drag coefficient as a function of lift coefficient and Mach number.
- b. OSWIND - The span loading efficiency factor (Oswald's efficiency factor) may be calculated by the program from an approximate relationship as a function of wing aspect ratio. If the user prefers, he may input a fixed value of the efficiency factor to the program. An input of OSWIND = 0 permits the user to input a fixed value for efficiency. An input of OSWIND = unity will cause the program to use the approximate equation to calculate the value for efficiency.

### 3.2.3 Size Trends Indicators

- a. FDMIND - The fuselage dimension indicator permits optional calculations of fuselage dimensions. The user studying an aircraft with known fuselage length and wetted area may input these values to the program by setting FDMIND = 0. However, the user, knowing only

the length of the cabin (or constant diameter) section of the aircraft, may have the program calculate the total aircraft length and wetted area for him by inputting  $FDMIND = 1$  and the values for nose and tail section fineness ratios. A third option,  $FDMIND = 2$ , will permit the user to size the fuselage to accommodate known passenger requirements for commercial service. The user inputs the number of passengers, the unit seat width, seat pitch, number of aisles, aisle width, and number of seats abreast for tourist class and also for first class service. He also specifies certain data on galley size and lavatory size requirements by means of the indicators described below.

- b. GALLEY INDICATOR - This indicator will permit the user to directly input the galley area required by setting this indicator to 1.0 or will permit use of a trend equation based on number of passengers carried by inputting a value of zero for the indicator. Input of the GALLEY INDICATOR is required only if  $FDMIND = 2$ .
- c. LAVATORY INDICATOR - This indicator will permit the user to directly specify the number of lavatories ( $LAVATORY INDICATOR = 1$ ) or to use a trend equation based on number of passengers ( $LAVATORY INDICATOR = 0$ ). It is assumed by the program that each lavatory is 16 sq ft in floor area. If the user desires smaller lavatories he may represent that by input of a fractional number of lavatories. This indicator is required only when  $FDMIND = 2$ .
- d. WDMIND - The wing dimension indicator permits the user to calculate wing dimensions in one of two ways. The wing dimensions may be dictated by either input value of wing loading and aspect ratio ( $WDMIND = 0$ ) or by propeller geometry as in the case of a tilt wing aircraft ( $WDMIND = 1$  or  $2$ ).
- e. HTIND, VTIND - These indicators permit the user to input fixed-size tail surfaces to the program or, optionally, to have the program calculate the tail surface size based upon input volume coefficients.

If a unity value is input, the program will calculate the size based upon tail volume

coefficient. If either HTIND or VTIND is set to two (2.0), the horizontal or vertical tail (or both) may be input as fixed size surfaces.

- f. PDMIND - The prop dimension indicator, PDMIND, permits the user to define the major propeller dimensions - diameter and chord - in various ways. The diameter may be directly input to the program (PDMIND = 1 or 3) or may be calculated from an input of the disc loading (PDMIND = 2 or 4). The chord, represented by activity factor or solidity may be calculated from an input activity factor (PDMIND = 1 or 2) or from an input thrust coefficient to solidity ratio,  $C_T/\sigma$  (PDMIND = 3 or 4). Depending upon which of the four values of the indicator is chosen, any combination of the methods for predicting chord and diameter may be selected.

#### 3.2.4 Mission Performance Indicators

- a. SGTIND - The mission profile flown by the aircraft may be made up of an arbitrary sequencing of nine discrete profile segments. The segment selected is specified by means of the segment indicator, SGTIND. The segments are: taxi (SGTIND = 1), takeoff, hover and landing (SGTIND = 2), climb (SGTIND = 3), cruise (SGTIND = 4), descent (SGTIND = 5), loiter (SGTIND = 6), a change of fuel weight (SGTIND = 7), a change of payload weight (SGTIND = 8), a transfer of altitude (SGTIND = 9), and general performance (SGTIND = 11). By appropriate sequencing of the input values for the segment indicator, the mission profile may be made up of any arbitrary combination of these discrete elements. The mission is terminated by an input value for segment indicator = 0.
- b. TOLIND - The indicator TOLIND is input with each takeoff, hover, and landing segment and dictates the manner in which power is calculated. TOLIND = 1 may be used with airplanes which have double propulsion systems (primary and lift) or which have primary propulsion alone. A required thrust-weight ratio is input to the program. If the airplane has lift engines, as much thrust as is necessary will be taken from the lift engine system up to maximum thrust level. If maximum lift engine thrust is insufficient, the available lift engine thrust will be augmented with primary engine thrust. TOLIND = 2 may be used only for airplanes which have both primary and lift engine systems. This option is similar to TOLIND = 1 in the sense that a required thrust-weight ratio is input to the program. The

difference lies in the fact that equal percentages of available thrust are taken from primary and lift systems. TOLIND = 3 is used if the user wants to specify the percentage of maximum power being used from the engine system(s). The resultant thrust-weight ratio is calculated by the program.

- c. CLMIND - Four types of climb calculations are permitted: maximum rate of climb (CLMIND = 1), constant equivalent airspeed (CLMIND = 2), constant Mach number (CLMIND = 3), and constant true airspeed (CLMIND = 4).
- d. CRSIND - Six types of cruise missions are included in the program. They are: cruise at fixed cruise power (CRSIND = 1), cruise at constant true airspeed (CRSIND = 2), cruise at airspeed for best specific range (CRSIND = 3), cruise at the speed for 99% of best specific range (CRSIND = 4), cruise-climb (constant  $W/\delta$ ) at the speed for best specific range (CRSIND = 5), or cruise-climb at the speed for 99% of best specific range (CRSIND = 6).
- e. DESIND - Eight different descent paths may be calculated by the program. They are of four types: descent at maximum speed, (DESIND = 1,2), descent at idle power (DESIND = 3,4), descent at constant equivalent airspeed (DESIND = 5,6) and descent at constant Mach number (DESIND = 7,8). The odd-numbered values are used when it is desired to specify the terminal range at the end of descent, the even numbered values when it is not so desired.
- f. LTRIND - The loiter segment may be used to simulate an additional requirement for reserve fuel, or may be included as part of the mission fuel. In either case, the fuel required for loiter would be used as part of the total fuel required to size the aircraft. However, if the fuel is to be used for reserve purposes only, the aircraft weight will not be reduced by the amount of loiter fuel. The option is specified to the program by means of the input indicator LTRIND. If LTRIND is input as zero, the program will assume the loiter fuel is part of reserves. If LTRIND is input as unity, the loiter fuel will be included in the mission fuel.

- g. WGTIND - The change fuel and change payload segments may be used to simulate refueling, unloading or loading of passengers, or a fuel drop. There is no restriction on the amount of fuel or payload which may be removed at any point in the mission. However, during a sizing run, it would be undesirable to increase the airplane weight (by adding fuel or payload) to a value which exceeds the initial gross weight of the airplane. This is because the design gross weight, upon which the subsystem weights depend, is assumed to be the same as the initial gross weight at the start of the mission. During a performance run (OPTIND = 2) this restriction does not apply and the user is given the option of overloading the airplane at any point of the mission. If WGTIND is input as zero the program will not permit the maximum weight to exceed the design gross weight. This is useful if it is desired to refuel to capacity at some point in the mission. If WGTIND is input as unity (and if the performance option is being run) the program will permit the airplane weight to exceed the design gross weight. This is useful for parametric performance studies. For example, the user can specify an array of SGTIND = 7, 4, 0, 7, 4, 0, 7, 4, 0, -----7, 4, 100. When this is done, the program will calculate the performance in cruise at a series of different aircraft weights. The "7" segment is used to increment the design gross weight to any value of weight desired for the following cruise.
- h. XMSNIND - Indicator that controls drive system transmission sizing. When XMSNIND = 0.0 the transmission will be sized at an input fraction (LOC 0258) of the primary installed power. If XMSNIND = 1.0 the transmission is sized at a specified fraction of power required to hover or cruise at design conditions (more critical of the two conditions is selected).

For both XMSNIND conditions the designed transmission torque is used in the weight trends subroutine to determine transmission weight.

### 3.2.5 Flight Path Control Indicators

- a. V<sub>LIM</sub>IND - Setting this indicator to a value of 1.0 will automatically limit the flight speed at altitudes below 10,000 feet to 250 knots EAS or less. If V<sub>LIM</sub>IND is input as zero, no such constraint on equivalent airspeed will occur.

- b.  $h_{OPTIND}$  - By inputting  $h_{CPTIND} = 1.0$ , the program will automatically determine the cruise altitude for minimum fuel consumption for any cruise which is preceded by a climb or a transfer altitude. For cruise segments which are preceded by a climb the program will find the cruise altitude for which the sum of climb fuel and cruise fuel is minimized. The user can also specify a maximum permissible altitude for each cruise segment. If  $h_{OPTIND} = 0$  is input, the program will not do an optimum altitude search for the cruise segments.

### 3.2.6 Atmosphere Indicator

- a. ATMIND - The atmosphere for each individual mission profile segment and for the engine sizing calculations may be either a standard or non-standard atmosphere. Thus, the climb may be run on a nonstandard atmosphere followed by a cruise for standard day conditions. Three options (one for standard atmosphere, the other two for a nonstandard atmosphere) are available. For the performance calculations, the type of atmosphere to be used is specified to the program by means of the atmosphere indicator, ATMIND. If ATMIND is input as zero, the program will use a standard atmosphere. ATMIND = 1 specifies a nonstandard, constant increment in temperature above standard while ATMIND = 2 specifies a nonstandard atmosphere requiring a tabular input of temperature ratio versus altitude.

3.2.7 Optional Print Indicator - Two different forms of print-out are available for the mission performance data. By setting OPTIONAL PRINT INDICATOR = 0 a standard print-out will occur. This consists of time, range, fuel used, aircraft weight, pressure altitude, true airspeed, engine turbine temperature, an engine code which specifies the condition which is dictating the engine operating point, and a power fraction which is the instantaneous fraction of maximum power which is being used. These data are printed for all performance segments. In addition, depending upon which segment is being used, the standard printout will include such parameters as rate of climb, equivalent airspeed, specific range, flight path angle, etc.

More detailed data may be obtained by setting the OPTIONAL PRINT INDICATOR = 1.0. The data printed will then include airplane lift and drag in pounds, fuel flow rate, actual horsepower or thrust,  $C_L$ ,  $C_D$ , propeller  $C_p$ ,  $J$ , and  $C_T$ , etc.

The printout available from the program is described in more detail in Section 6.

PROGRAM FLOW

Figure 3-1 indicates, conceptually, the operation of the program. Program flow is monitored by a general control loop which controls the operation of a series of peripheral programs. These include twelve minor subroutines, four major subroutines, a major subprogram, and a library of engine cycle data. The characteristics of these routines are summarized in Table 3-1.

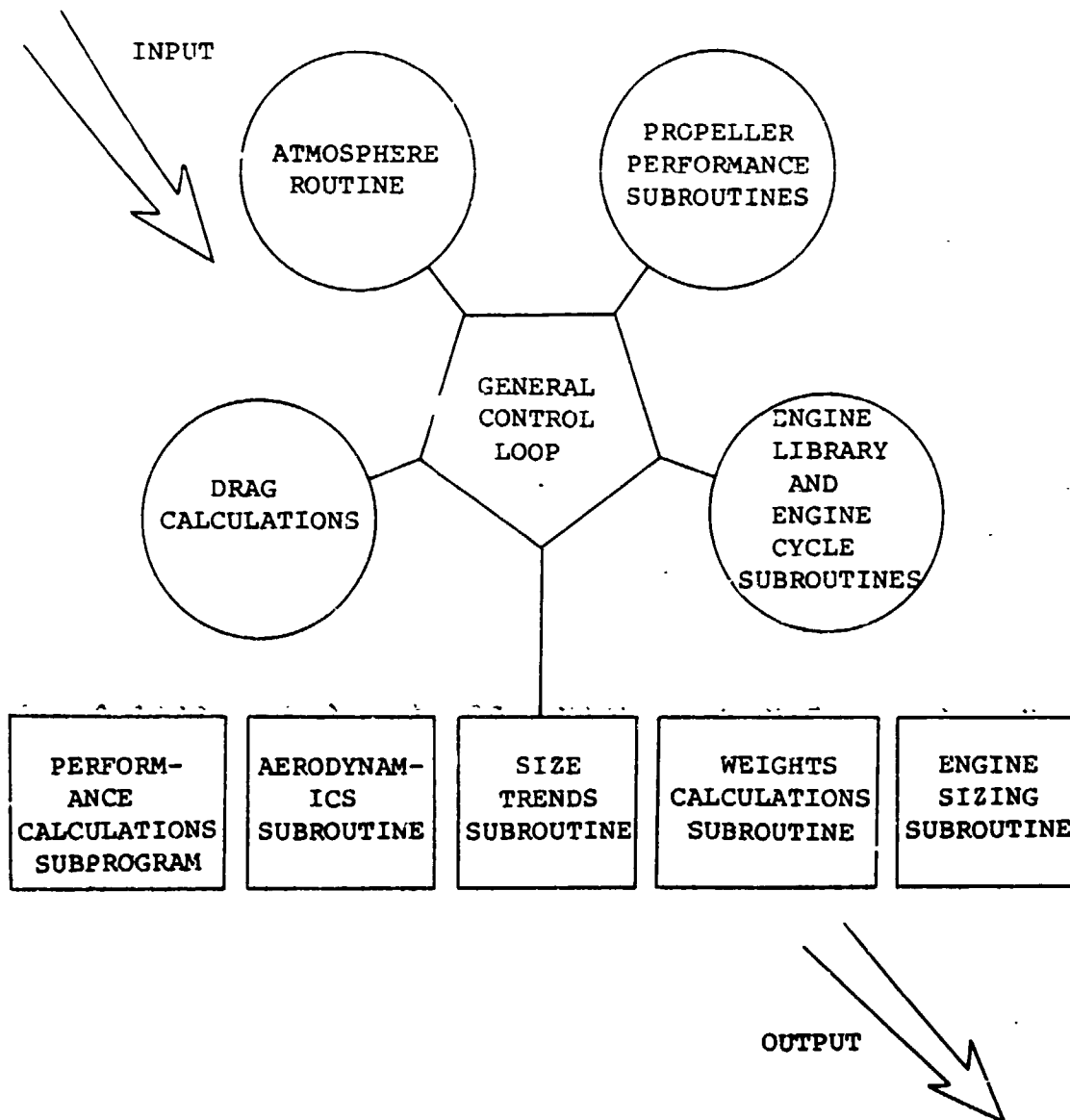


Figure 3-1. Sketch of Program Geometry.

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TABLE 3-1  
SUMMARY OF SUBROUTINES

ROUTINE	CALLED BY	PURPOSE
Main Control Loop	---	Monitor program operations, check convergence and calculate gross weight during iterative sizing option (OPTIND = 1)
Minor Subroutines: Drag Calculations	Performance Sub-routines with SGTIND = 1-6, and Engine Sizing	Calculate airplane drag coefficient
Atmosphere	Performance sub-routines with SGTIND = 1-6, Engine Sizing, and Size Trends	Calculate atmospheric density, pressure, temperature, and speed of sound
POWAVL	Performance sub-routines with SGTIND = 1-6, Engine Sizing and Size Trends	Calculate power and fuel flow available for turboshaft engines by determining most critical operating restriction
POWREQ	Same as POWAVL	Calculate fuel flow for turboshaft engines when power required is less than power available.
ENG 1	POWREQ, POWAVL	Calculate power available for turboshaft engines at any specified turbine temperature including effects of Reynolds' number and operation at nonoptimum N II



TABLE 3-1  
(CONTINUED)

ROUTINE	CALLED BY	PURPOSE
THR AVL	Same as POW AVL	Calculate thrust and fuel flow available for turbofan and turbojet engines by determining most critical operating restriction
THR REQ	Same as POW AVL	Calculate fuel flow for turbofan and turbojet engines when thrust required is less than thrust available
LTHR AV	Taxi, Takeoff/Hover/ Land, Engine Sizing, and Size Trends	Same as THR AVL except applies to lift engines
LTHR EQ	Same as LTHR AV	Same as THR REQ except applies to lift engines
POWER	Performance subrou- tines with SGTIND = 2, 3, 4, & 6 and Engine Sizing and Size Trends	Calculate propeller power required when thrust and advance ratio are known
THRUST	Same as FOWER	Calculate propeller thrust available when power and advance ratio are known
SCRIBE	Performance subrou- tines with SGTIND = 3, 4, 5, & 6.	Controls printout when detailed print option is desired (OPTIONAL PRINT INDICATOR = 1.0).

TABLE 3-1  
(CONTINUED)

ROUTINE	CALLED BY	PURPOSE
<u>Major Subroutines:</u> Engine Sizing	Main	Calculates engine size (power or thrust) required to meet mission requirement
Weight Trends	Main	Calculates aircraft weight summary including propulsion, structures, flight controls and fuel available
Size Trends	Main	Calculates aircraft dimensions which are required for weight estimate and drag calculation
Aerodynamics	Main	Calculates lift curve slope, spanwise loading efficiency, and a series of coefficients which are used by the drag subroutine to calculate aircraft drag
<u>Major Subprogram:</u> Performance Calculations	Main	Monitors program flow during calculation of mission performance and calculates total fuel required at end of mission
<u>General Performance Calculations</u>	Performance Subprogram	Calculate power required, fuel flow, and other variables for given aircraft, starting at $V = 0$ to input $V_{max}$
<u>Performance Subroutines:</u> Taxi	Performance Subprogram	Calculate taxi performance
Takeoff, Hover, and Landing	Performance Subprogram	Calculate takeoff, hover, or landing performance

TABLE 3-1  
(CONTINUED)

ROUTINE	CALLED BY	PURPOSE
<u>Performance Subroutines (continued):</u>		
Cruise	Performance Subprogram	Calculate cruise performance
Descent	Performance Subprogram	Calculate descent performance
Loiter	Performance Subprogram	Calculate loiter performance
Change Fuel Weight	Performance Subprogram	Add (or subtract) fuel to aircraft
Change Payload	Performance Subprogram	Add (or subtract) payload to aircraft
Transfer Altitude	Performance Subprogram	Changes altitude

### 3.4 SUBROUTINE CROSS REFERENCE

#### MAIN:

calls:	LOADER	SIZTR	AERO
	ENGSZ	WGHTR	LOADER
	ATMOS		

#### AERO

does not call any other subroutine

#### ATMOS

does not call any other subroutine

#### CHGPL

does not call any other subroutine

#### CHGFW

does not call any other subroutine

#### CLIMB

calls:	AERO	DRAG	POWAVL
	THRUST	THRAVL	DRAG
	POWER	POWREQ	THRREQ
	CRUS 1	CRUS 2	CRUS 3

#### CRUS 1

calls:	ATMOS	DRAG	POWER
	POWAVL	POWREQ	THRAVL
	THRREQ		

#### CRUS 2

calls:	ATMOS	DRAG	POWER
	POWAVL	POWREQ	THRAVL
	THRREQ	CRUS 1	

#### CRUS 3

calls:	ATMOS	DRAG	POWAVL
	POWER	THRAVL	POWREQ
	THRREQ		

DSCEX

calls: ATMOS                    DRAG                    POWAVL  
         THRAVL                    THRREQ                    POWREQ  
         SCRIBE

DSCNT

calls: ATMOS                    DRAG                    POWAVL  
         THRAVL                    POWREQ                    THRREQ  
         SCRIBE

ENGSZ

calls: ATMOS                    LIFAVL                    DRAG  
         THRAVL                    POWAVL                    THRUST

ENGL

does not call any other subroutine

LIFAVL

does not call any other subroutine

LOIT

calls: ATMOS                    DRAG                    POWAVL  
         POWER                    POWREQ                    THRAVL  
         SCRIBE                    THRREQ

LIFREQ

does not call any other subroutine

PAYL

calls: ENG 1                    ENG 2

PLOTXY

calls: LOADER

POWER

calls: POWAVL                    POWREQ                    THRUST

PRFRM

calls:	LOADER	TAXI	TOHL
	CLIMB	CRUS 1,3	DSCNT
	DSEX	LOITER	CHGFW
	CHGPI	TRALT	PLOT XY

PRFRP

calls:	ATMOS	THRREQ	LIFAVL
	POWAVL	POWREQ	LIFREQ
	POWER	THRAVL	DRAG
	CRUS 1, 3	LOITR	

SCRIBE

calls:	POWAVL	POWREQ	THRAVL
--------	--------	--------	--------

SIZE

calls:	ATMOS	POWAVL	THRUST
	THRAVL	LIFAVL	

THRAVL

calls: does not call any other subroutine

TAXI

calls:	ATMOS	THRAVL	THRAVL
	POWAVL	LIFAVL	

THRUST

does not call any other subroutine

TOHL

calls:	ATMOS	POWAVL	POWER
	THRREQ	POWREQ	THRAVL
	LIFAVL	LIFREQ	THRUST

TRALT

calls:	CRUS 1	CRUS 2	CRUS 3
--------	--------	--------	--------

THRREQ

does not call any other subroutine

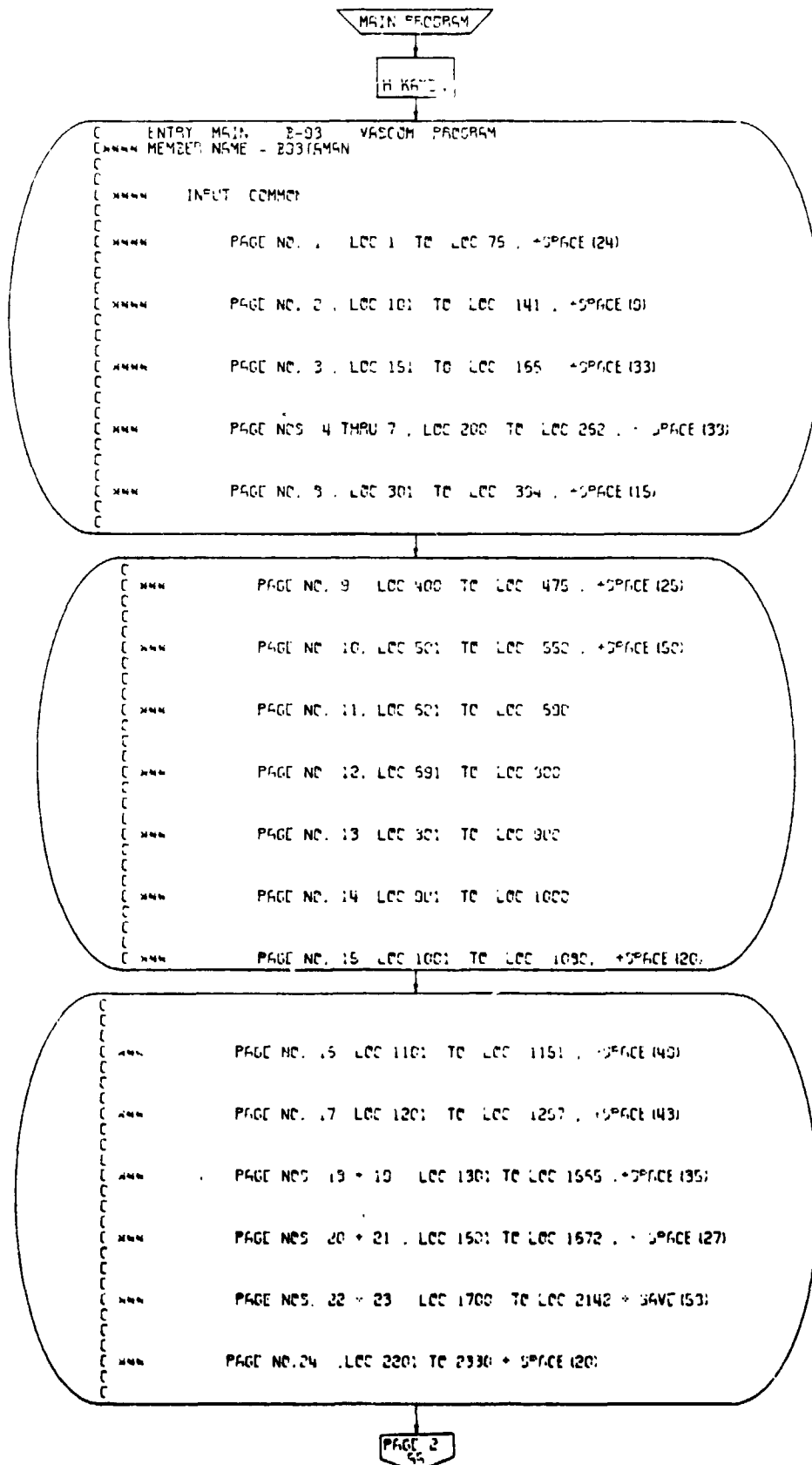
WGTR

does not call any other subroutine

## 4.0 DETAILED PROGRAM DESCRIPTION

### 4.0 MAIN CONTROL LOOP

Figure 4-1 is a flow chart of the main control loop for the computer program. For aircraft weights and size data only (OPTIND = 0), the user inputs a gross weight and some preliminary aircraft dimensions. The program will not iterate the weights and size, and no performance data will be printed out. In the sizing routine (OPTIND = 1), the program iterates on the aircraft gross weight until the fuel available and the fuel required are equivalent within a specified tolerance. If OPTIND = 2 or 3, the program bypasses the size trends, engine sizing, and weight trends subroutines. If OPTIND = 3, the program iterates to determine the takeoff weight and fuel required to fly a specified mission.



PAGE 1  
MAIN PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 1 of 25)





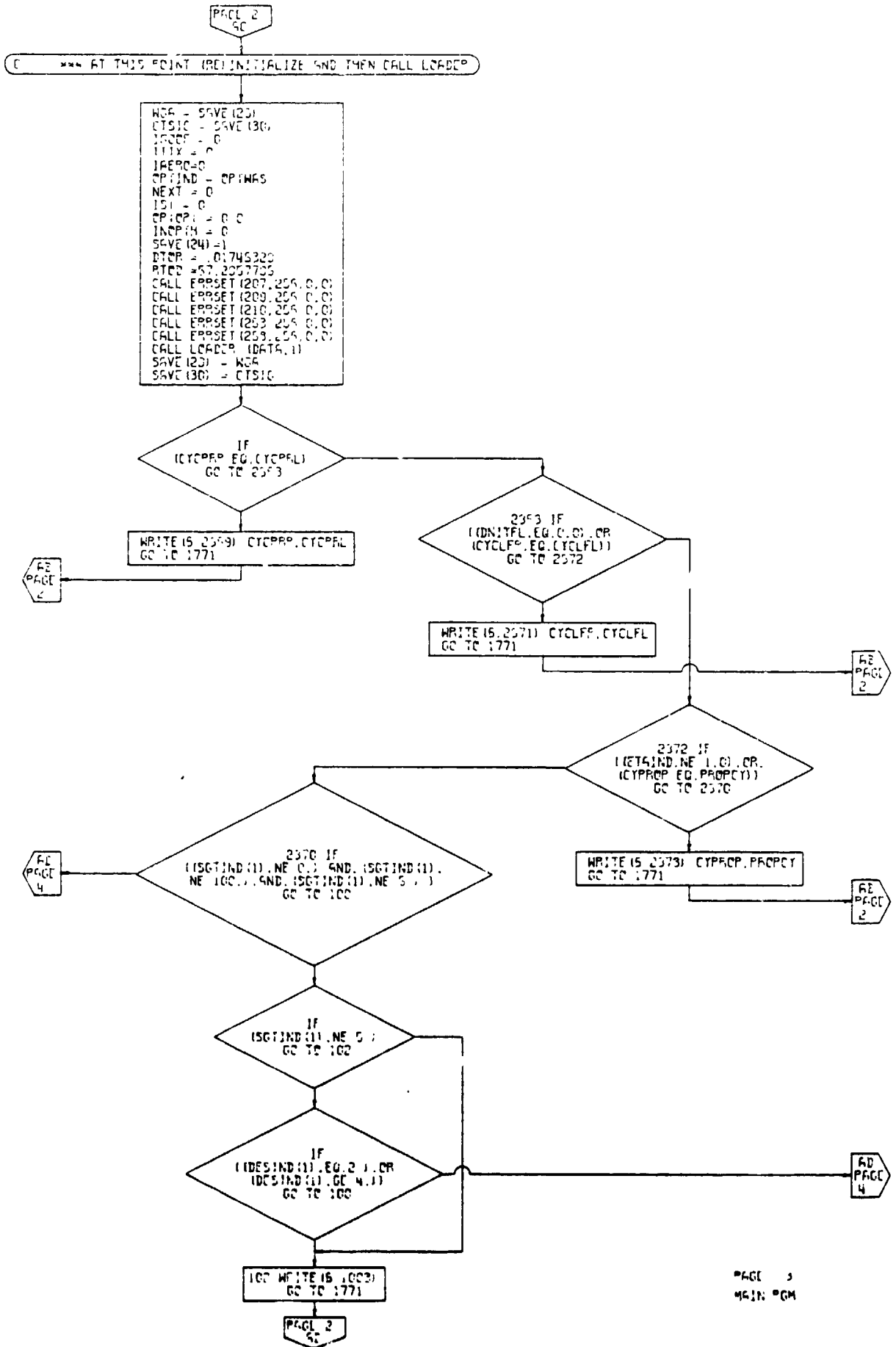


Figure 4-1. Main Control Loop, Flow Chart  
(Part 3 of 25)

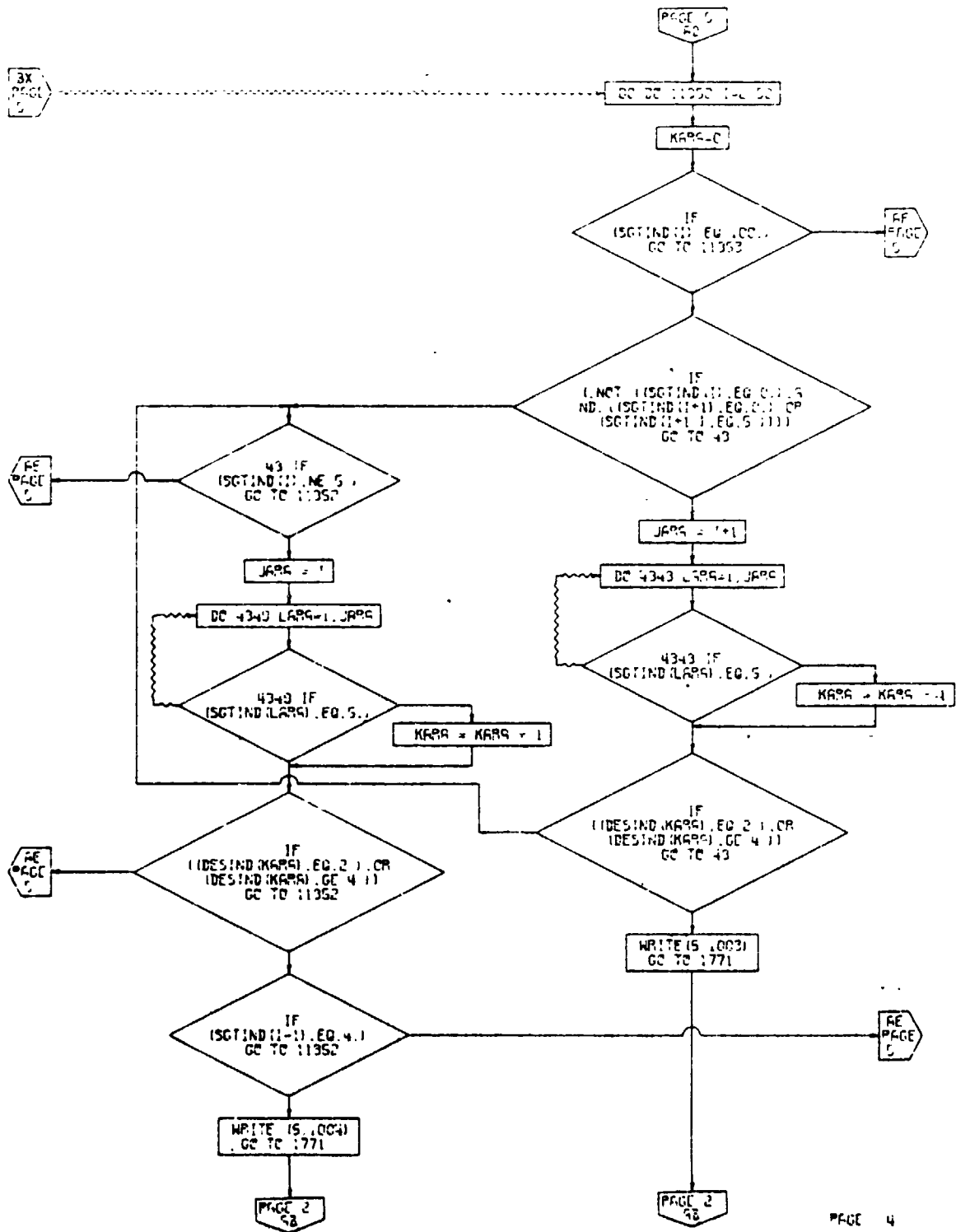
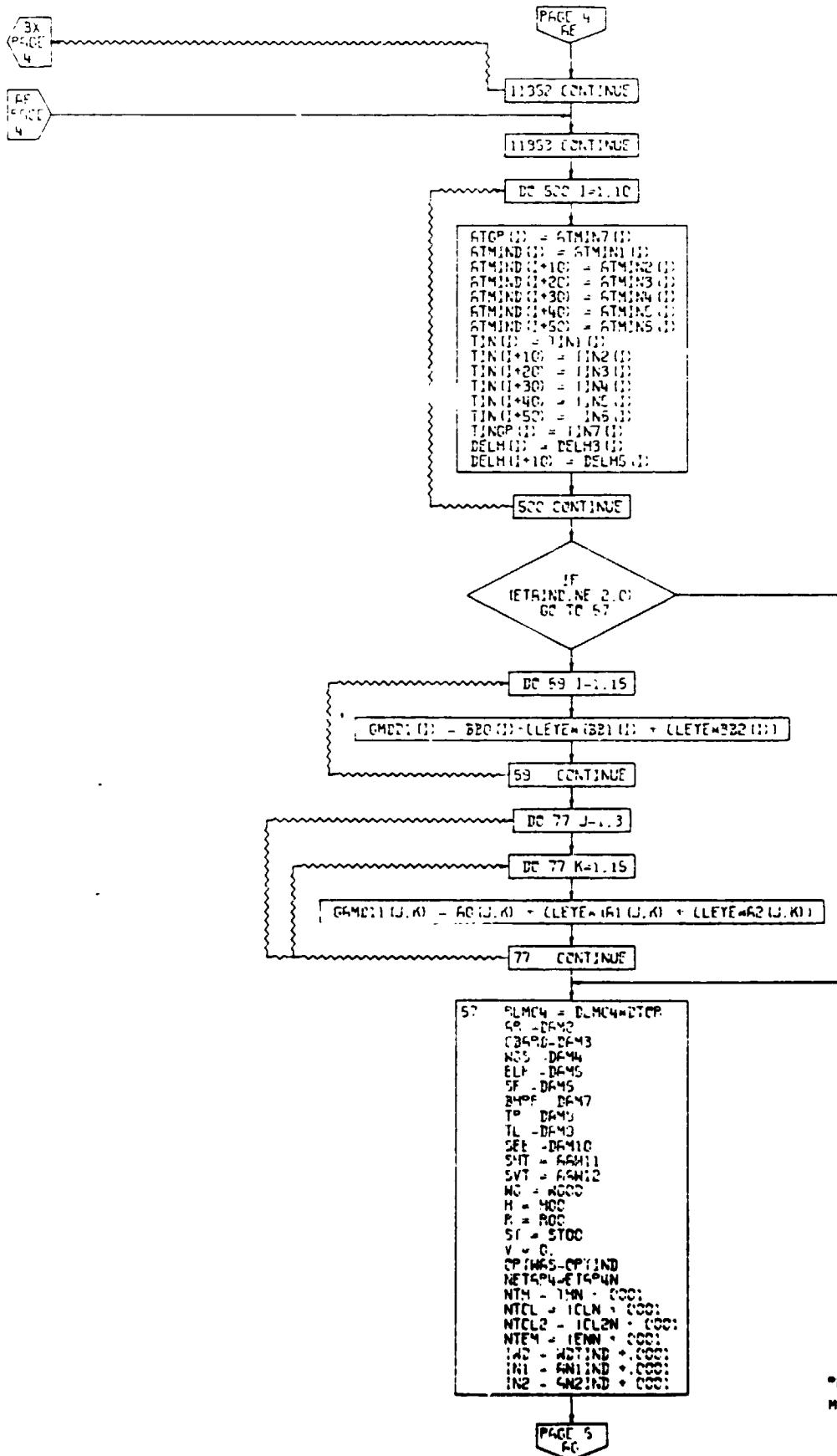


Figure 4-1. Main Control Loop, Flow Chart  
(Part 4 of 25)



PAGE 5  
MC:R PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 5 of 25)



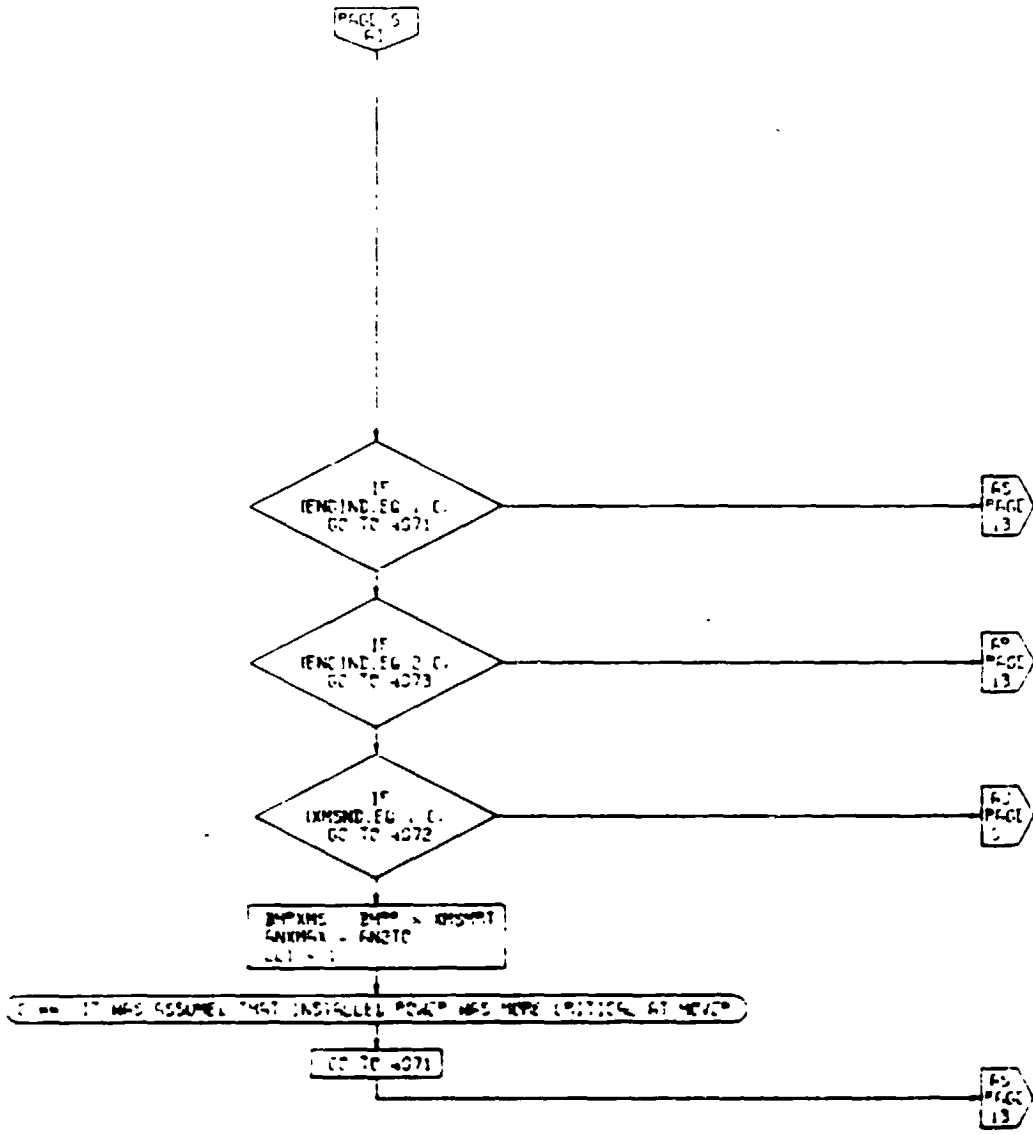


Figure 4-1. Main Control Loop, Flow Chart  
(Part 7 of 25)

```

4372 MM = YES
    YALE22 = 1.0
    CALL ATNCS (MM, YALE22, TINT)
    DSMPFC = MC * V/PC/ 10000. * CRPC
    BHPRT = SORT (SENE = 2) AND SORT (MCA) / (550. * 20000 * 2000 * CTAT * CTSP)
    I = (DSMPFC + DSMPFC) / (540 * C)
    MM = MC
    CALL ATNCS (MM, YALE22, STMT)
    V = VC
    R = 1.42535 * RMC * V * W
    CL = A / (SN * C)
    EM = V / 54
    CALL DRAG
    P = ANZCP * ANZCP * VT
    CALL PRGVL (TMAX, O, J)
    SLP = SLP
  
```

IF  
RETAIN EQ 0.0  
GO TO 2003

END PAGE 12

TMPFC CD = 24 = 3

IF  
RETAIN EQ 2.0  
GO TO 91

END PAGE 10

REALJ = .539 \* P1 = 1/P  
CCT = (TMPFC \* ANZCP) \* 3 / (10.003507 \* 210 \* C \* P \* 2 \* W \* C)

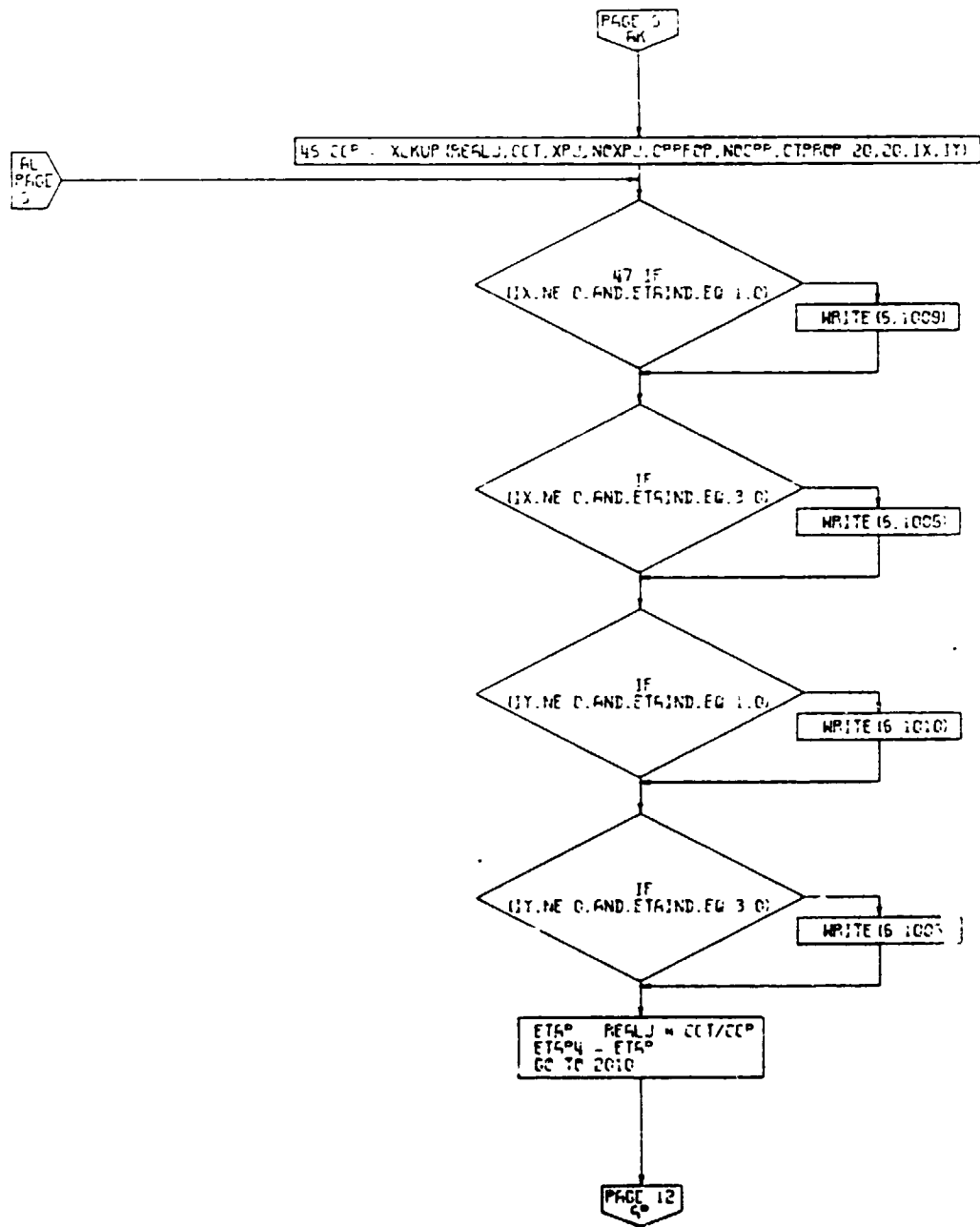
IF  
RETAIN EQ 3.0  
GO TO 45

END PAGE 3

EM = V / 54  
TORG = (TMPFC \* WCA / WCA \* DELTA)  
HPACTM = XLNUP (EM, TORG, A, P, WCA \* P, C \* P \* P \* WCA \* P \* CT \* P \* 20.00 \* 14.17)  
CCT = HPACTM \* 54 \* WCA \* 55 \* 2 / (P \* STRETA) \* 3  
GO TO 47

PAGE 1  
NOVA 804

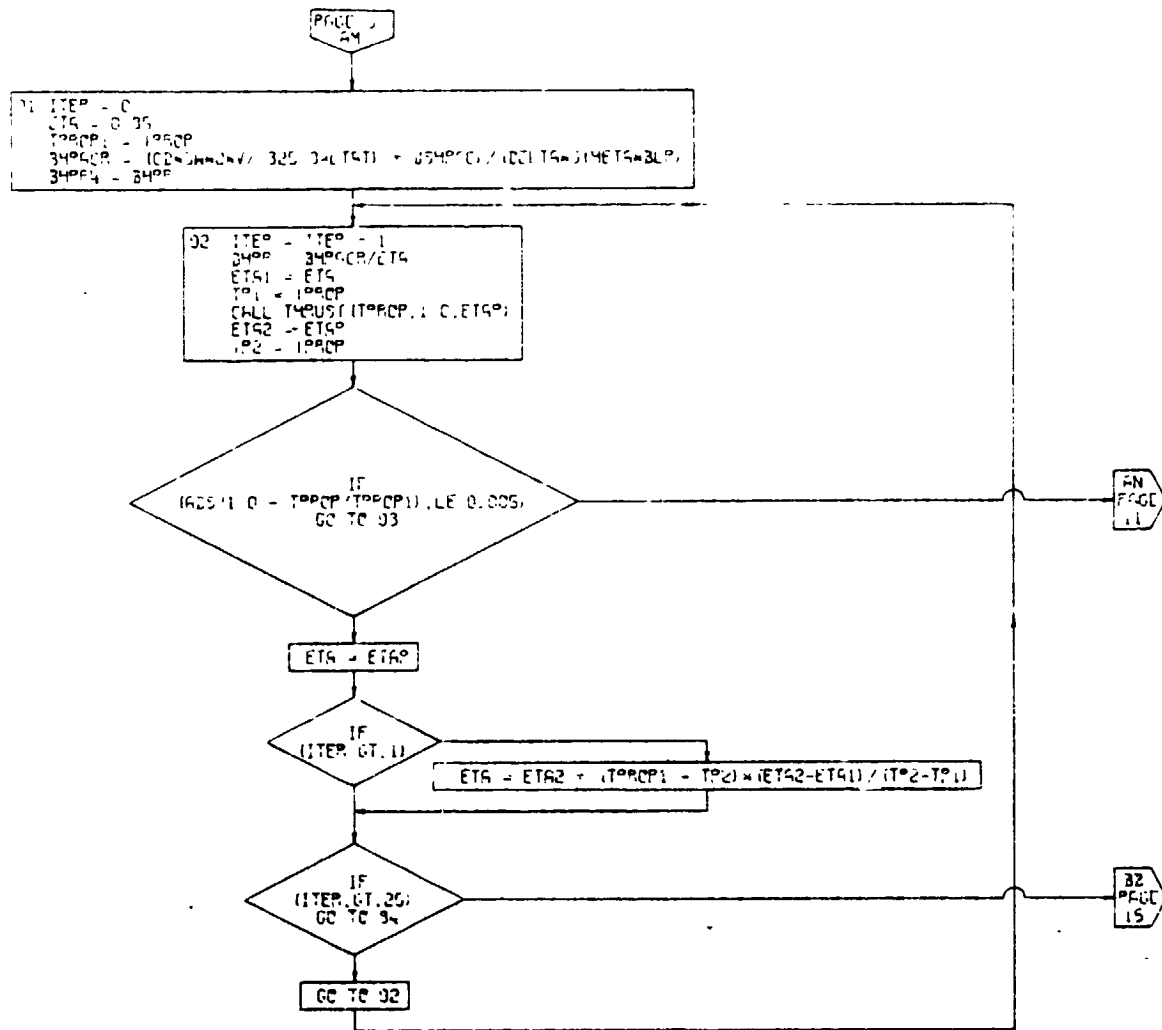
Figure 4-1. Main Control Loop, Flow Chart (Part 8 of 25)



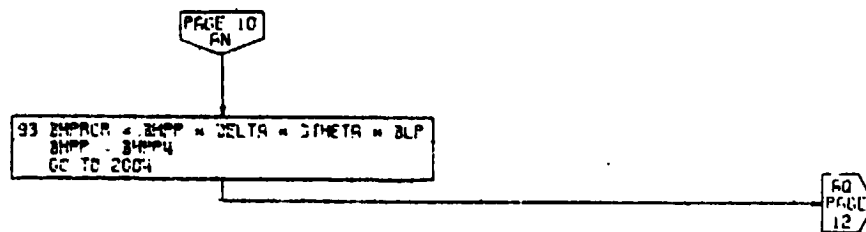
PAGE 3  
MAIN PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 9 of 25)



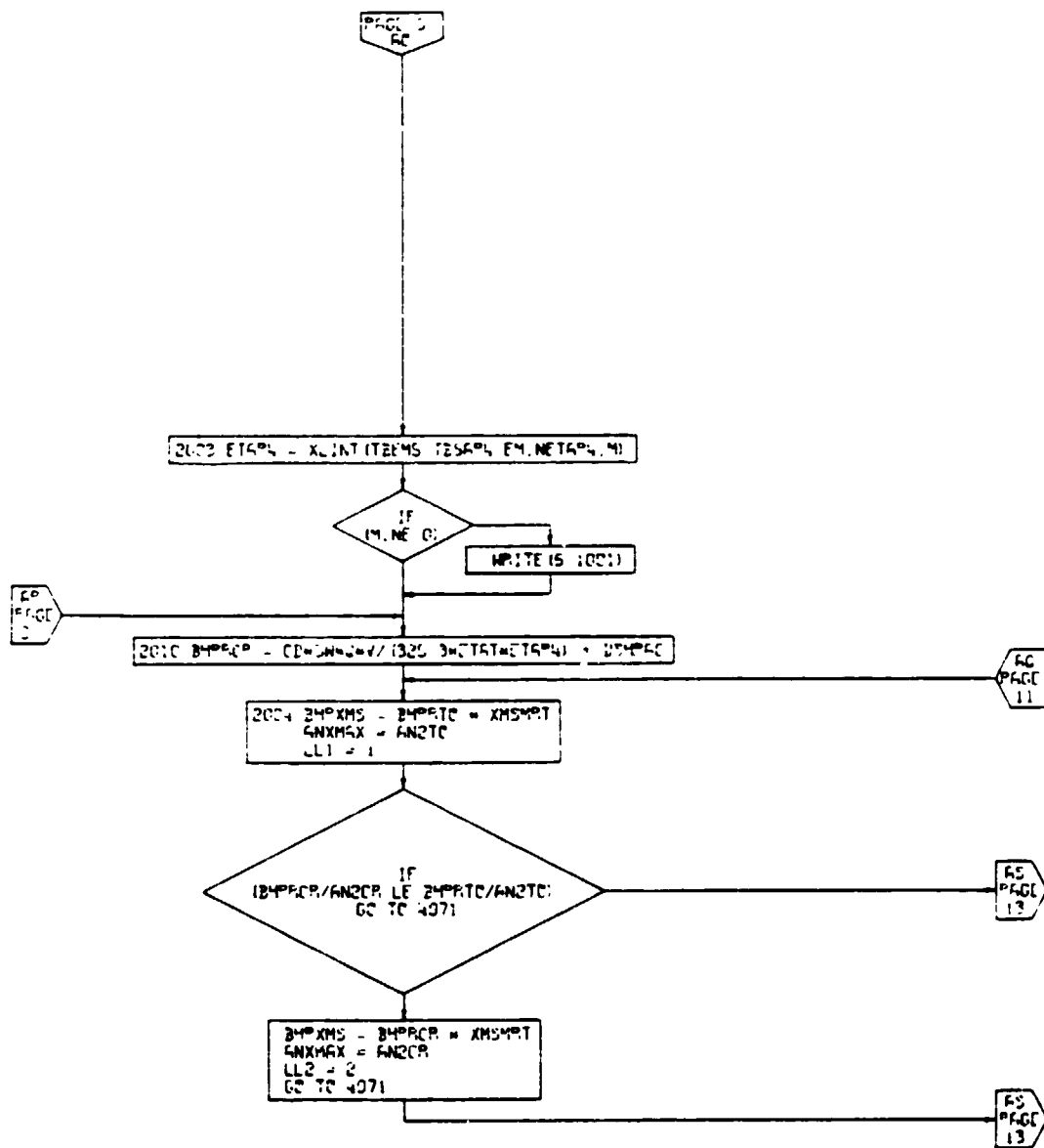


PAGE 10  
MAIN PGM



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MAIN PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 10 of 25)



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16-10-68

Figure 4-1. Main Control Loop, Flow Chart  
(Part 11 of 25)

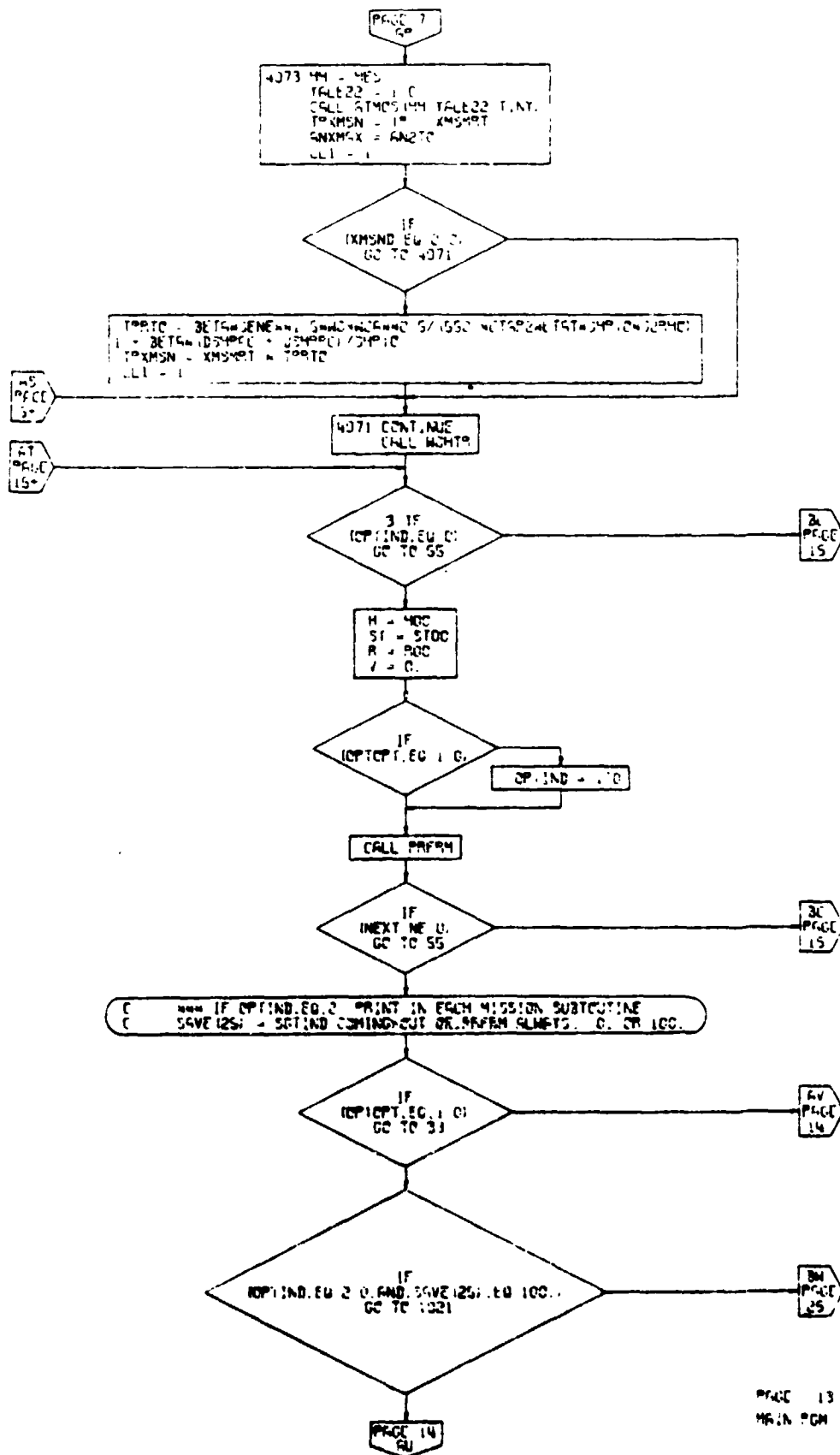
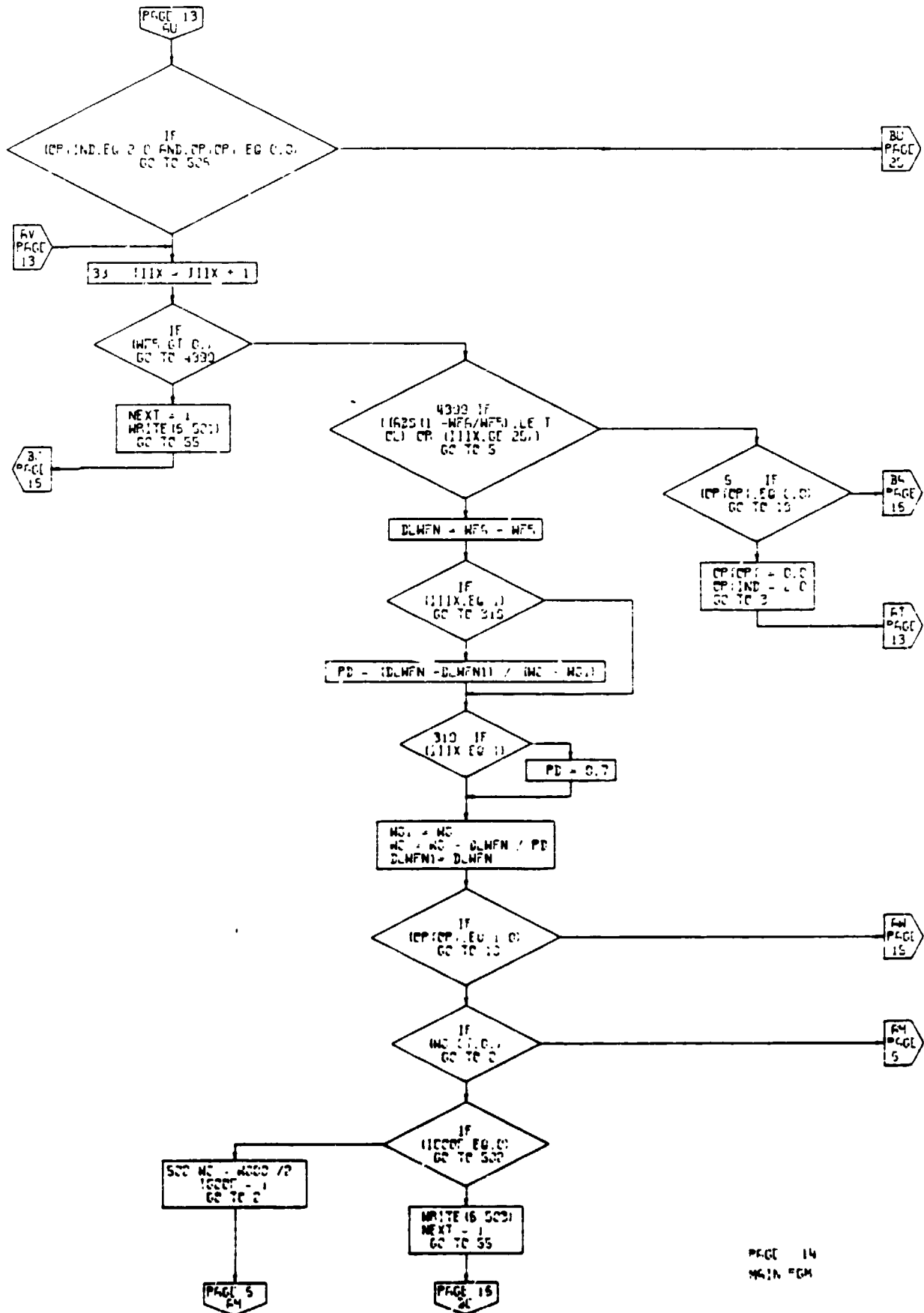
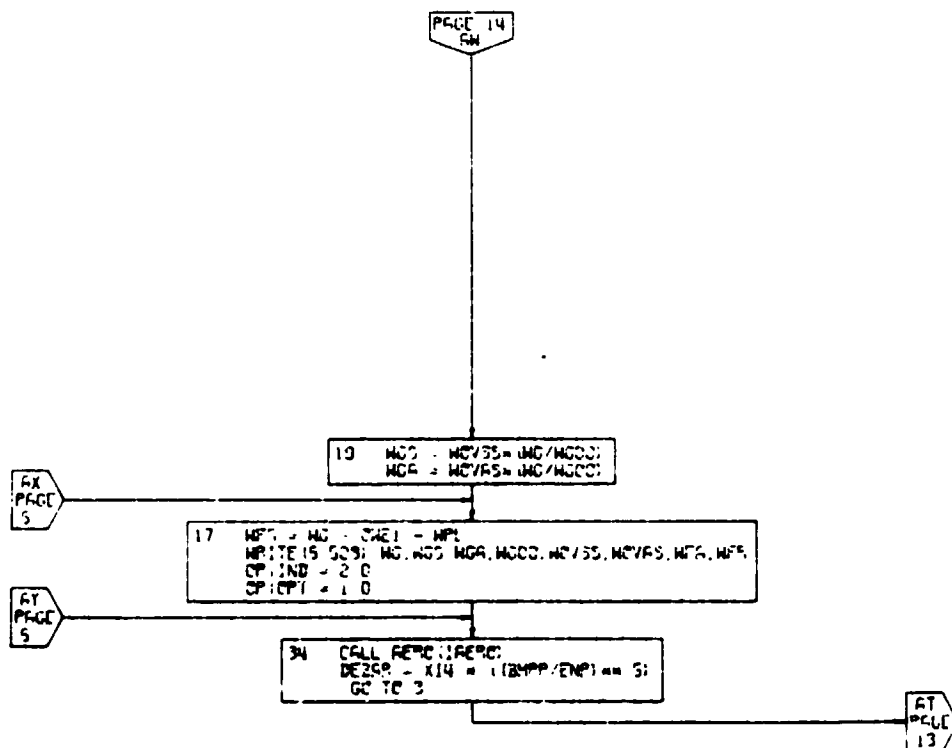


Figure 4-1. Main Control Loop, Flow Chart  
(Part 12 of 25)



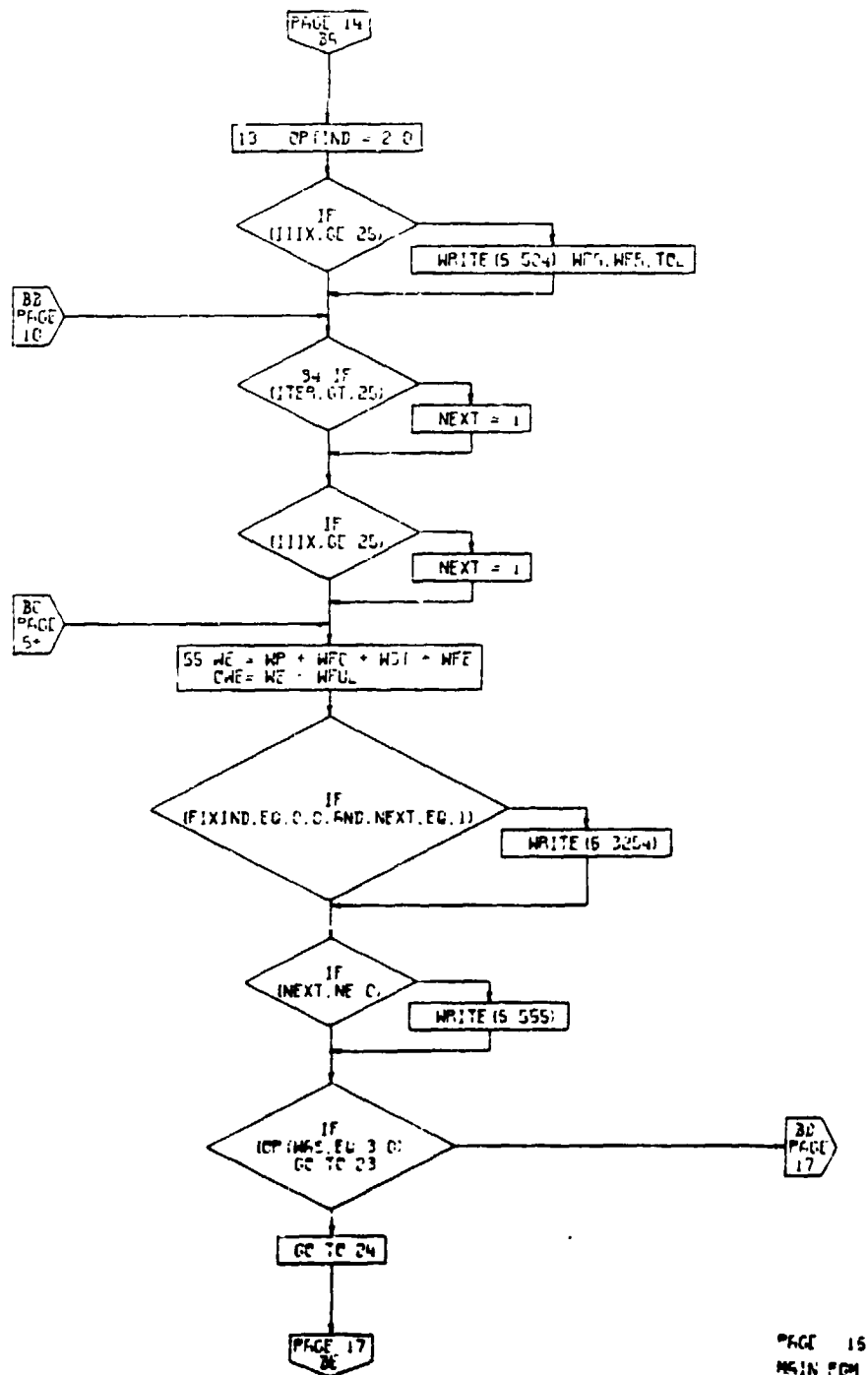
PAGE 14  
MAIN PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 13 of 25)  
4-14



PAGE 15  
MAIN PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 14. of 25)



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MAIN FOR

Figure 4-1. Main Control Loop, Flow Chart  
(Part 15 of 25)

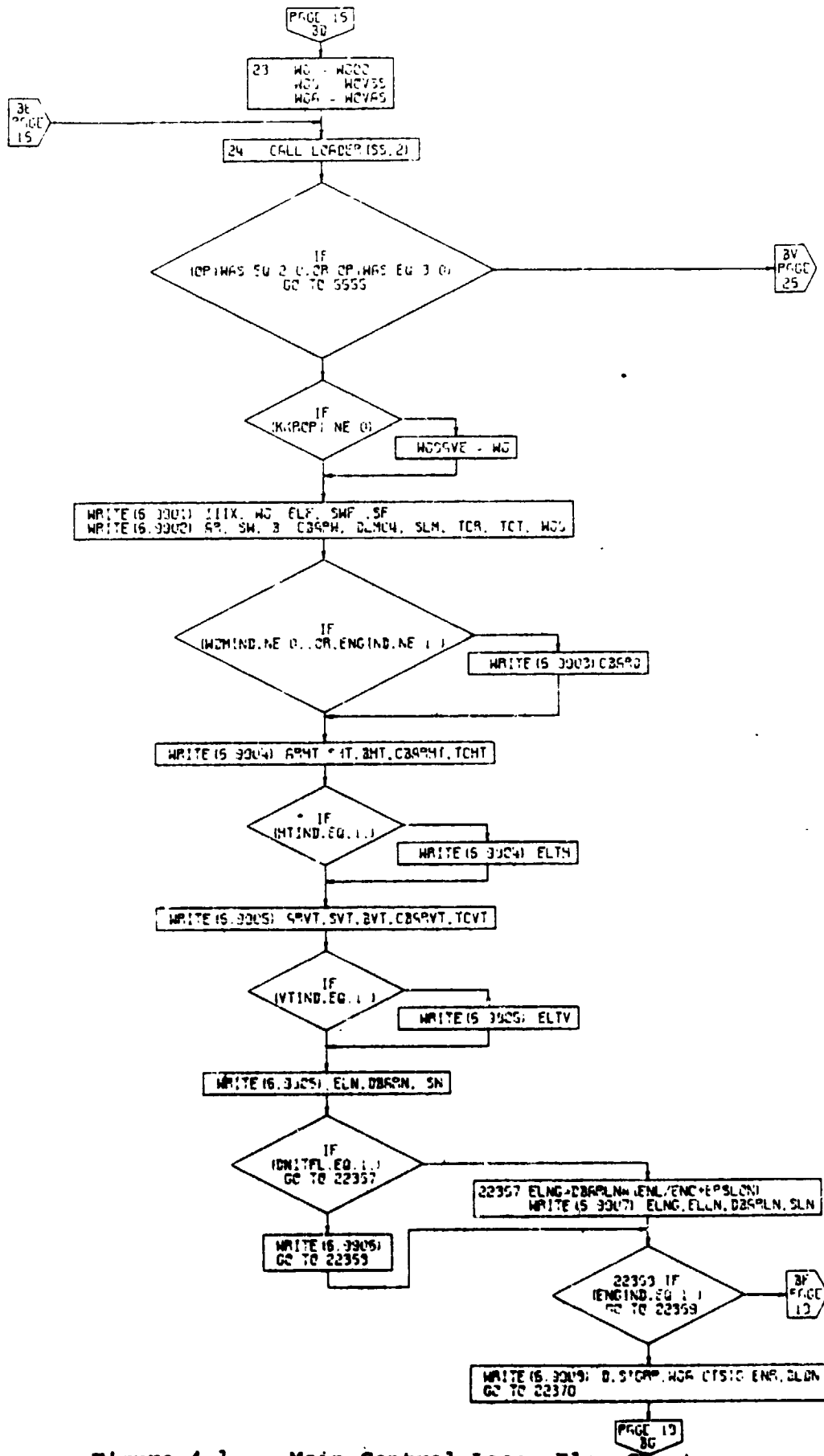
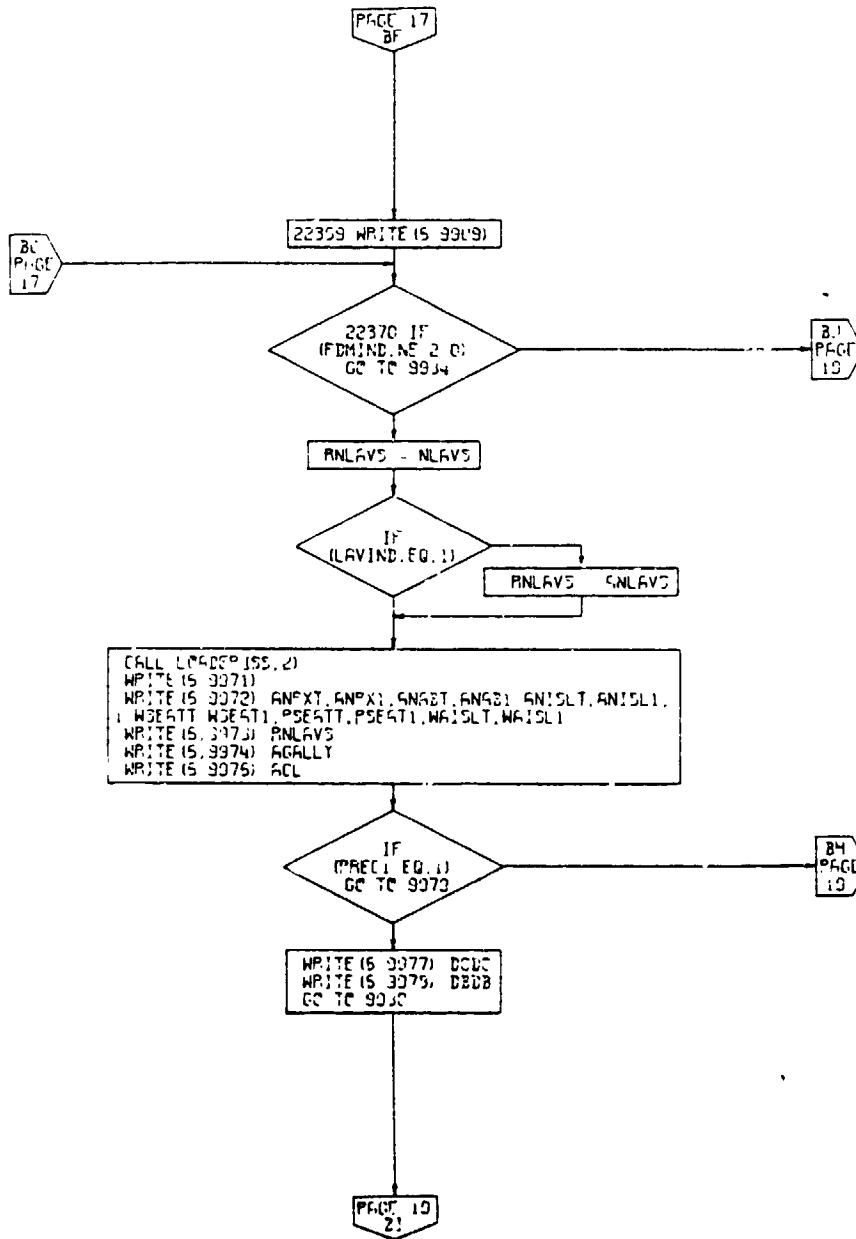


Figure 4-1. Main Control Loop, Flow Chart  
(Part 16 of 25)  
4-17



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MAIN PGM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 17 of 25)



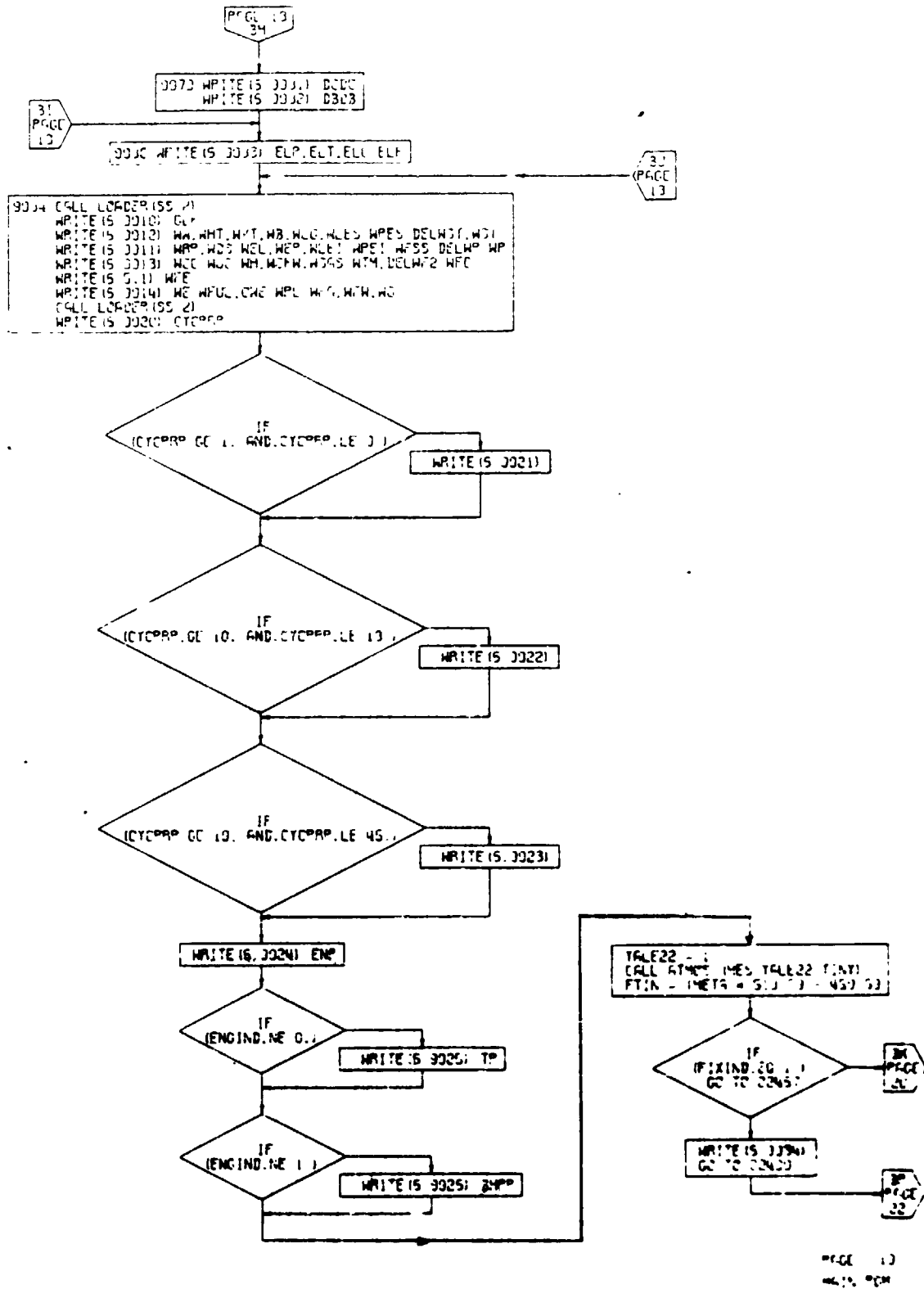


Figure 4-1. Main Control Loop, Flow Chart (Part 18 of 25)

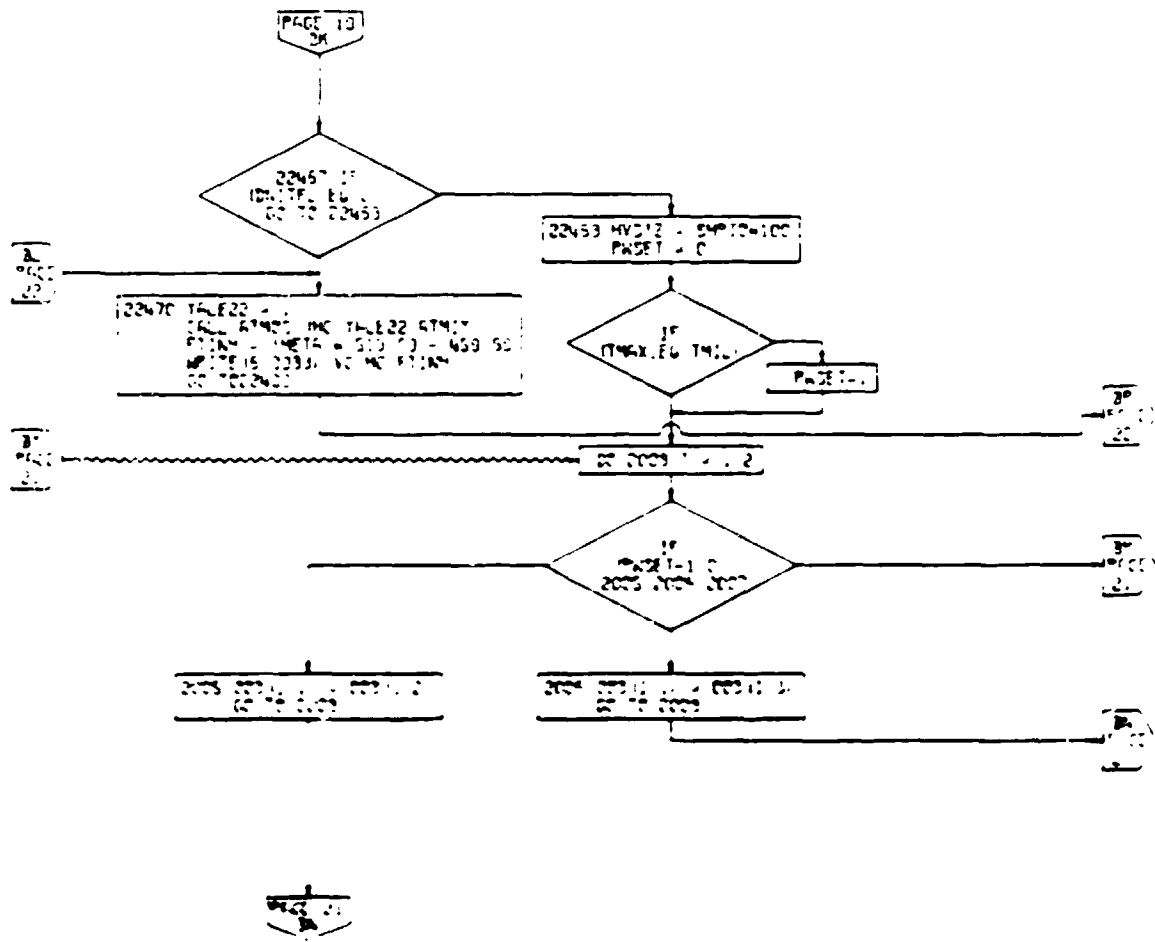
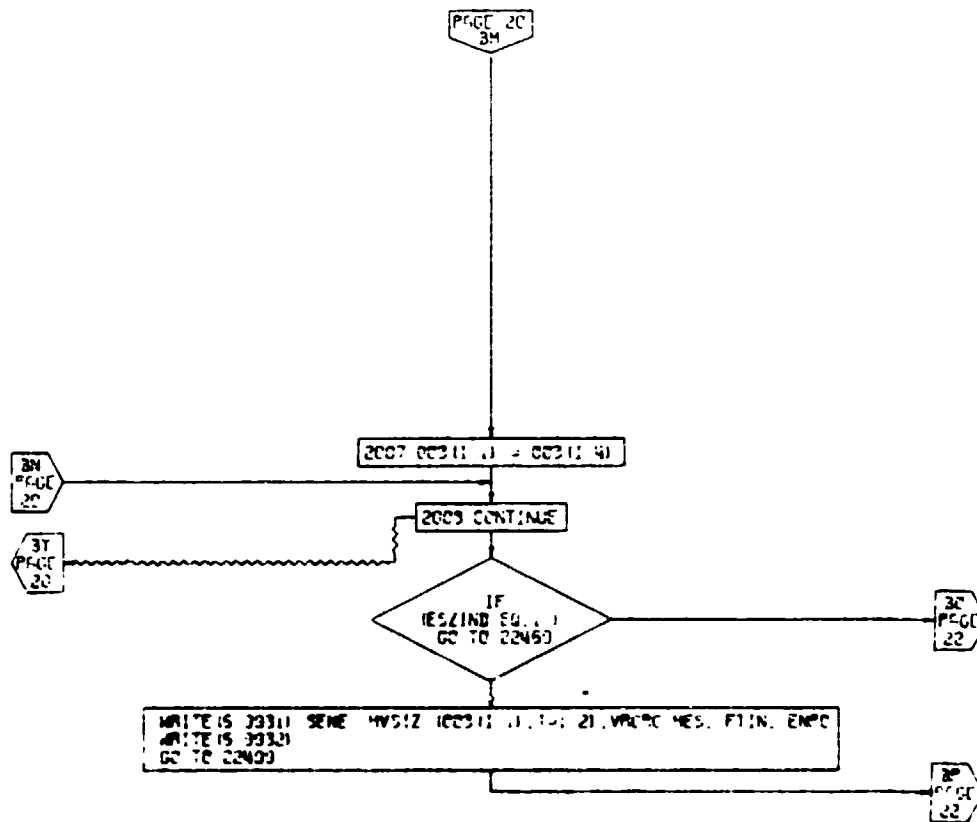


Figure 4-1. Main Control Loop, Flow Chart  
(Part 19 of 25)



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4-21

Figure 4-1. Main Control Loop, Flow Chart  
(Part 20 of 25)

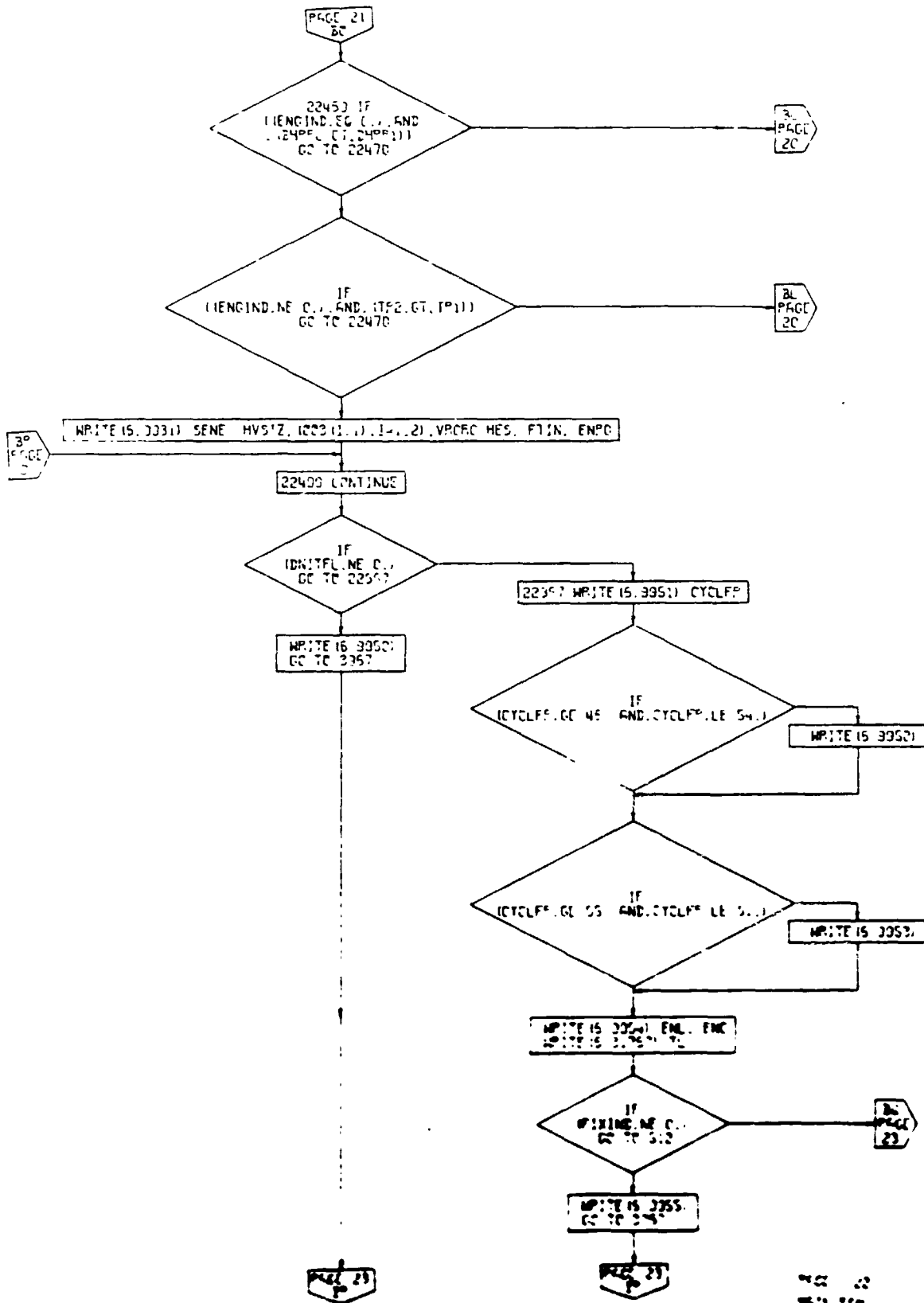


Figure 4-1. Main Control Loop, Flow Chart  
(Part 21 of 25)

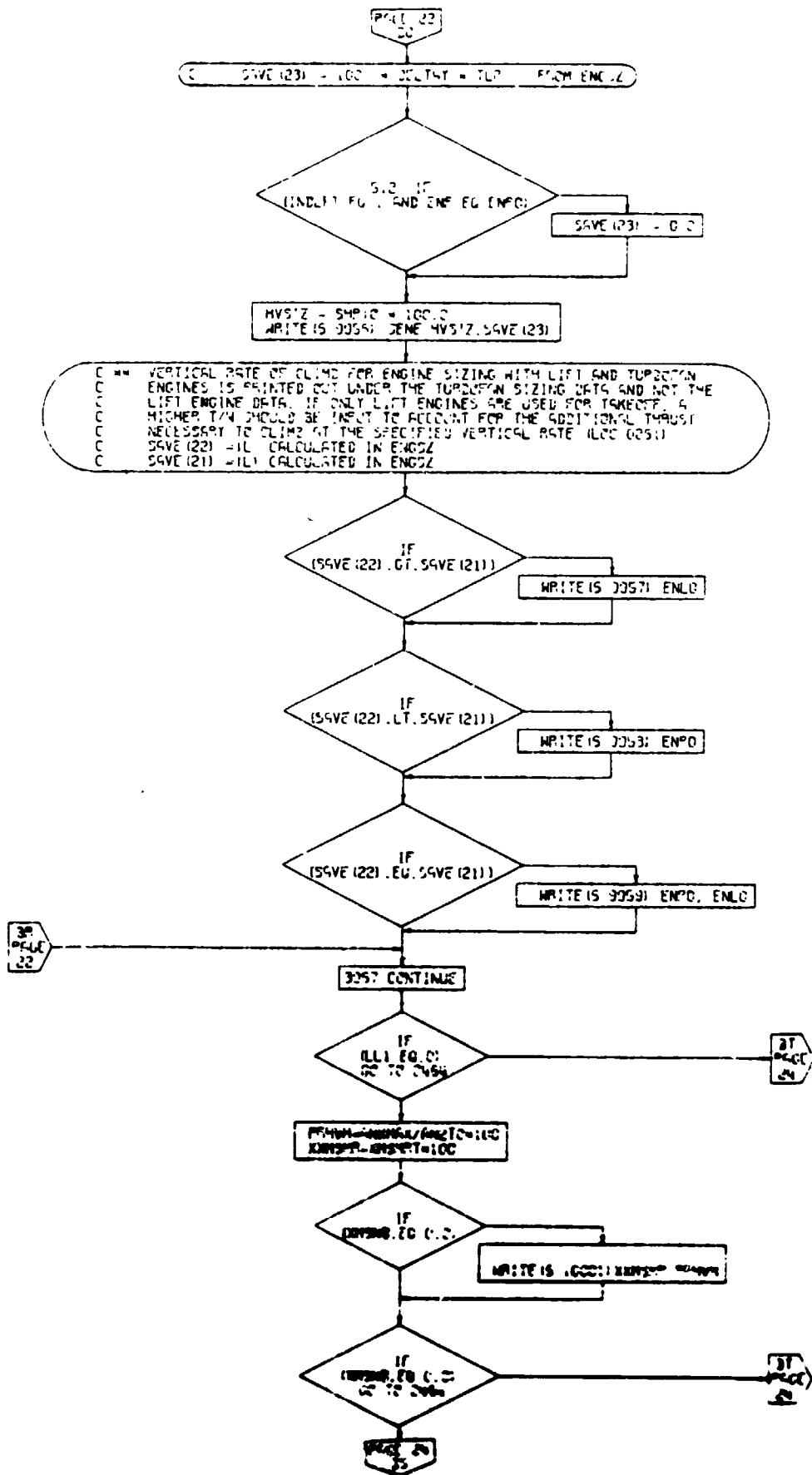


Figure 4-1. Main Control Loop, Flow Chart  
(Part 22 of 25)

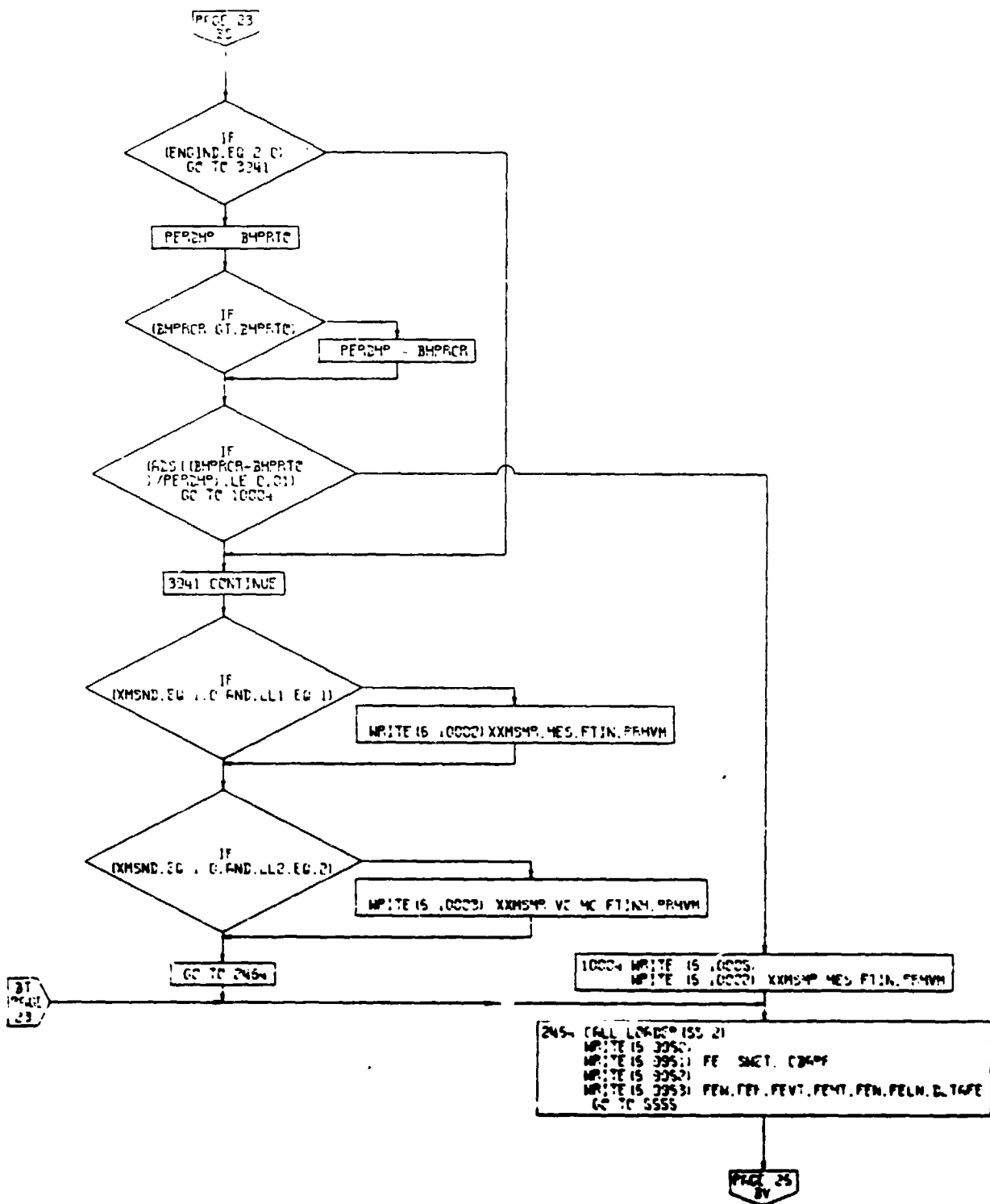


Figure 4-1. Main Control Loop, Flow Chart  
(Part 23 of 25)

PAGE 14  
BU

C SAVE (24) = NO. OF TIMES ENTERING PREFM WITHIN ONE RUN

50% SAVE (24) = SAVE (24) \* 1 0  
OPTION = 2 0  
GO TO 3

AT  
PAGE  
13

PAGE 25  
MAIN PCM

Figure 4-1. Main Control Loop, Flow Chart  
(Part 24 of 25)

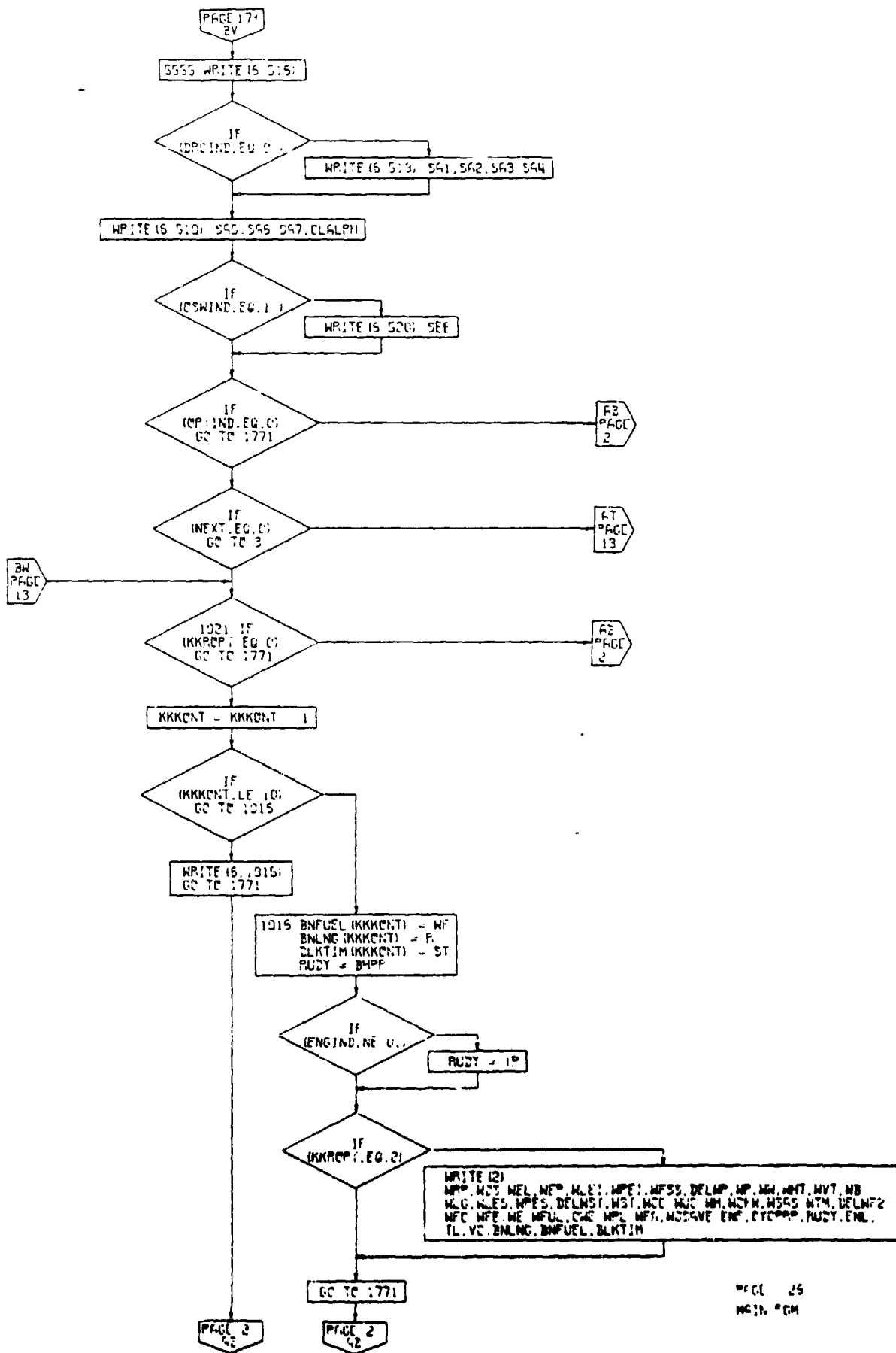


Figure 4-1. Main Control Loop, Flow Chart  
(Part 25 of 25)



#### 4.2 ATMOSPHERE SUBROUTINE

The atmosphere subroutine will calculate the atmospheric density, pressure, and temperature as a function of altitude. Three options included below are available. These are specified by means of an input indicator, ATMIND, which is input individually for the performance data and the engine sizing data. Thus, the atmosphere can be calculated differently for each segment of the flight profile and for the engine sizing.

The options are:

ATMIND = 0: Standard atmosphere

ATMIND = 1: Constant increment in temperature above standard temperature

ATMIND = 2: Nonstandard temperature distribution as a function of altitude

The flow chart for the atmosphere subroutine is shown in Figure 4-2.

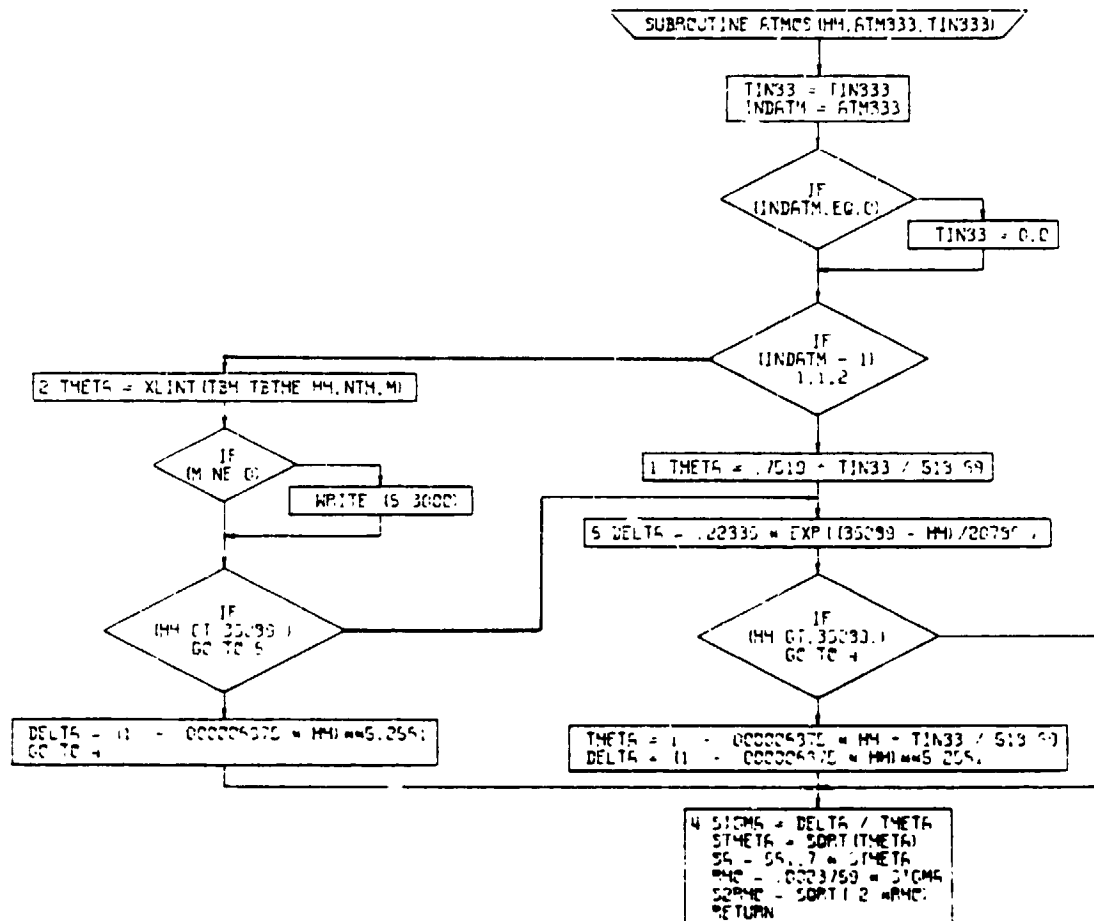


Figure 4-2. Atmosphere Subroutine, Flow Chart

#### 4.3 DRAG CALCULATIONS SUBROUTINE

The drag calculations subroutine uses the factors  $a_1$  through  $a_7$ , as determined by the aerodynamics calculations subroutine, to calculate the drag of the airplane (see Section 4.7). Aircraft  $C_D$  is calculated as a function of  $C_L$  and Mach number. Since the calculation of compressibility drag is based upon a semi-empirical technique, it is limited in accuracy to a specific Mach number range. For analysis of aircraft flying at Mach numbers beyond that range, a calculation option is provided. By setting a drag indicator (DRGIND) equal to unity, a tabular compressibility drag (function of  $C_L$  and  $M$ ) may be used. This option requires preparation and input of a three-dimensional table. The subroutine flow chart is shown in Figure 4-3.

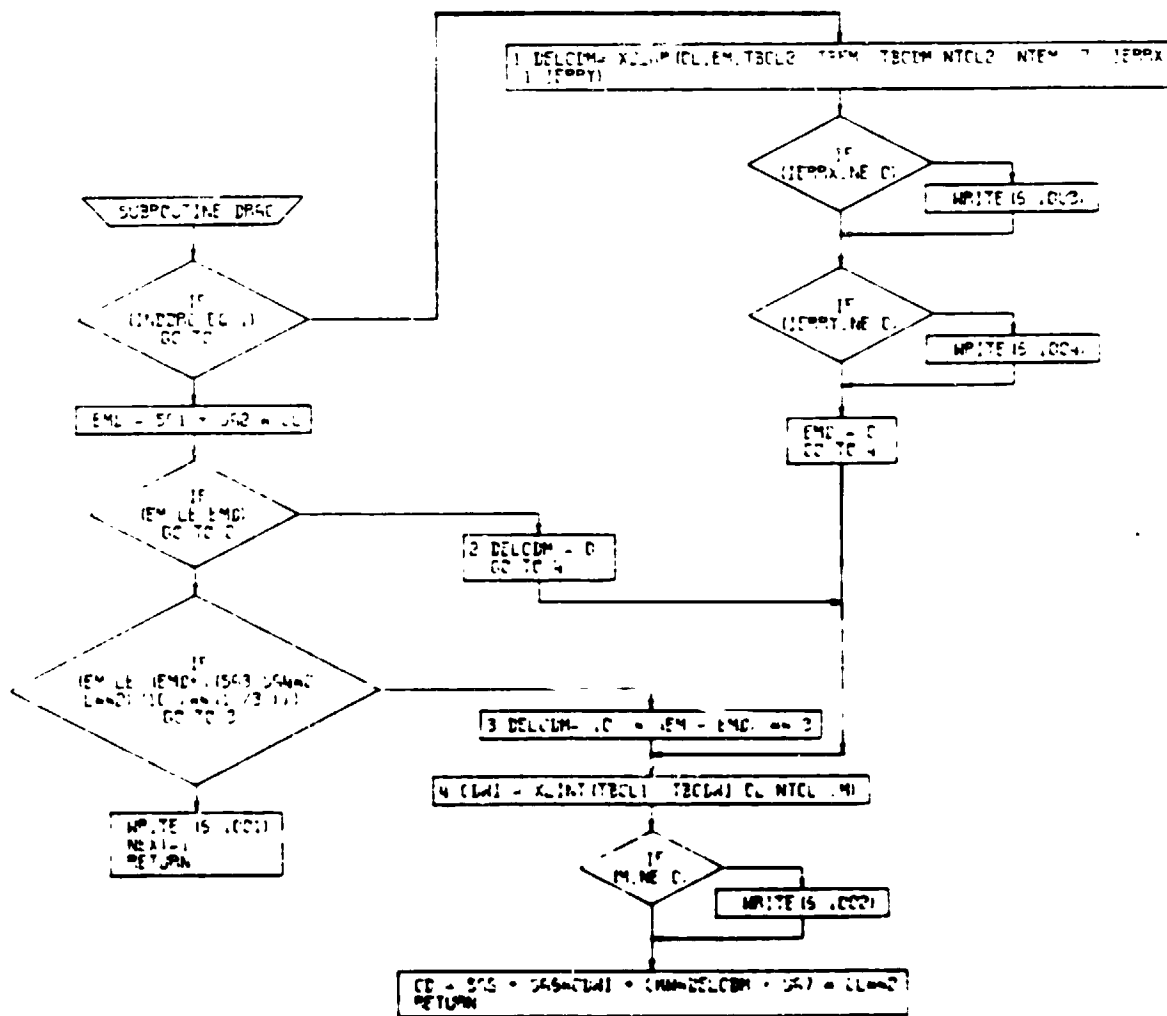


Figure 4-3. Drag Calculations Subroutine, Flow Chart

#### 4.4 ENGINE LIBRARY AND ENGINE CYCLE SUBROUTINES

The basic cycle performance data consists of tabulated values of four variables:

1. referred thrust or horsepower  
 $F_N / \delta F_N^*$  or  $SHP / \delta \sqrt{\theta}$  SHP\*  
input locations 1326-1373
2. referred fuel flow  
 $W_f / \delta \sqrt{\theta} F_N^*$  or  $W_f / \delta \sqrt{\theta}$  SHP\*  
input locations 1390-1437
3. referred gas generator shaft RPM  
 $N_I / \sqrt{\theta} N_I^*$   
input locations 1454-1501
4. referred power turbine shaft RPM  
 $N_{II} / \sqrt{\theta} N_{II}^*$   
input locations 1518-1565

For the primary engine cycles, these tables are functions of Mach number and referred turbine inlet temperature. For lift engine cycles, the tables are functions only of referred turbine inlet temperature. All data are in referred, normalized format as shown in Table 4-1.

The standard engine cycle library consists of forty-five different generalized engine cycles shown in Table 4-2. The data for each cycle is punched in card form, accessible for input with the remainder of the input data for a given case. Each cycle is numbered; and, to guard against selection of an incorrect cycle, the cycle number is checked against a similar number input to the program by the user.

The fuel flow of the basic engine cycle should correspond to the manufacturer's specification data. Adjustments to the fuel flow level may be made by means of the input multiplier,  $K_{FF}$ .

Because of the normalized, referred format, all data are valid for any ambient temperature, standard or nonstandard. With the exception of referred power, none of the tables are dependent upon power turbine speed. Usually  $N_{II}$  Loc (1238), is set equal

to 1.0 in order to determine  $\frac{N_{II}}{N_{II}^{MAX}}$  through the relationship  $\frac{N_{II}}{N_{II}^{OPT}}$

Table 4.1 Engine Cycle Data Format

VARIABLE	SYMBOL	REFERRED, NORMALIZED FORM
Thrust	$F_N$	$F_N / \delta F_N^*$
Power	SHP	$SHP / \delta \sqrt{\theta} SHP^*$
Gas Generator rpm	$N_I$	$N_I / \sqrt{\theta} N_I^*$
Power Turbine rpm	$N_{II}$	$N_{II} / \sqrt{\theta} N_{II}^*$
Fuel Flow	$\dot{W}_f$	$\begin{cases} \dot{W}_f / \delta \sqrt{\theta} F_N^* \\ \dot{W}_f / \delta \sqrt{\theta} SHP^* \end{cases}$
Turbine Inlet Temperature	$T$	$T / \theta$

Where:

- \* = Max. Power Setting, Static, Sea Level, Standard Day
- $\theta$  = Ambient Temperature ( $^{\circ}R$ ) Divided by  $518.69^{\circ}R$
- $\delta$  = Ambient Pressure (psia) Divided by 14.696 psia

$$\frac{N_{II}}{N_{II\text{OPT}}} = 1.0 = \frac{\left(\frac{N_{II}}{N_{II\text{MAX}}}\right) \left(\frac{N_{II\text{MAX}}}{N_{II}^*}\right)}{\left(N_{II\text{OPT}} / N_{II} \sqrt{\theta}\right)} \frac{1}{\sqrt{\theta}}$$

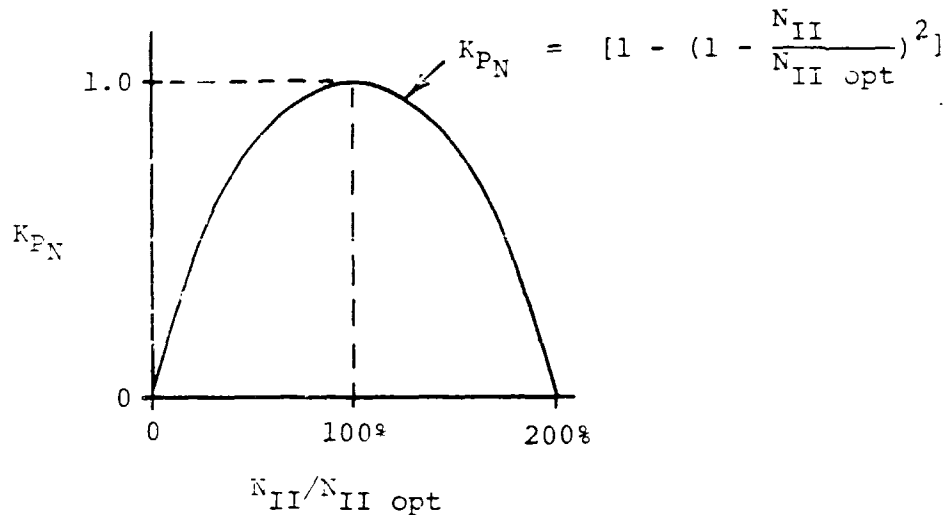
where  $\frac{N_{II\text{MAX}}}{N_{II}^*}$  is input into Loc (1223). If  $\frac{N_{II}}{N_{II\text{MAX}}}$  is determined to be an unsatisfactory value, greater than 1.0, then set  $\frac{N_{II}}{N_{II\text{MAX}}} = 1.0$  for specific segment and calculate  $\frac{N_{II}}{N_{II\text{OPT}}}$ . Changes in  $\frac{N_{II}}{N_{II\text{OPT}}}$  directly affect  $\frac{N_{II}}{N_{II\text{MAX}}}$  and indirectly affect operating tip speed through

$$V_T \text{ operating} = \left(\frac{N_{II}}{N_{II\text{MAX}}}\right) \left(\frac{N_{II\text{MAX}}}{N_{II}^*}\right) V_T$$

	Engine Cycle Number	Max. Turbine Inlet Temper- ature - °R	Compressor Design Pres- sure Ratio	Fan Bypass Ratio	
PRIMARY CRUISE ENGINES	1	2600	13		
	2	2600	16		
	3	2900	13		
	4	2900	16		
	TURBOSHAFT ENGINES				
	5	2900	19		
	6	3200	13		
	7	3200	16		
	8	3200	19		
	9	3200	22		
	TURBOJET ENGINES				
	10	2600	13		
	11	2600	16		
	12	2900	13		
	13	2900	16		
	14	2900	19		
	15	3200	13		
	16	3200	16		
17	3200	19			
18	3200	22			
TURBOFAN ENGINES	19, 20, 21	2600	16	2, 4, 6	
	22, 23, 24	2600	20	2, 4, 6	
	25, 26, 27	2900	16	2, 4, 6	
	28, 29, 30	2900	20	2, 4, 6	
	31, 32, 33	2900	24	2, 4, 6	
	34, 35, 36	3200	16	2, 4, 6	
	37, 38, 39	3200	20	2, 4, 6	
	40, 41, 42	3200	24	2, 4, 6	
	43, 44, 45	3200	28	2, 4, 6	
	46, 47, 48	2400	7	2, 4, 6	
	INDEPENDENT LIFT ENGINES				
	49, 50, 51	2700	7	2, 4, 6	
52, 53, 54	3000	7	2, 4, 6		
GAS COUPLED LIFT FANS	55, 56, 57	2600	13	8, 11, 14	
	58, 59, 60	2600	16	8, 11, 14	
	61, 62, 63	2900	13	8, 11, 14	
	64, 65, 66	2900	16	8, 11, 14	
	67, 68, 69	2900	19	8, 11, 14	
	70, 71, 72	3200	13	8, 11, 14	
	73, 74, 75	3200	16	8, 11, 14	
	76, 77, 78	3200	19	8, 11, 14	
79, 80, 81	3200	22	8, 11, 14		

Table 6.2 VASCOMP II Engine Library

where  $V_1$  is input Loc (C181). By setting  $N2IND = 1$  Loc (104), turboshaft engine power at nonoptimum  $N_{II}$  will be calculated by the program by multiplying power at optimum  $N_{II OPT}$  by a correction factor,  $K_{PN}$ , which is a function of  $N_{II}/N_{II OPT}$ . The factor  $K_{PN}$  is normally calculated by the program and obeys a second order relationship:



Most, but not all, turboshaft engines will obey this relationship. For engine cycles whose performance is not properly represented by the above curve, the user may input a table of  $K_{PN}$  versus  $N_{II}/N_{II OPT}$  locations 1238-1257. The program uses input  $N_{II}/N_{II MAX}$  for each flight segment and  $N_{II MAX}/N_{II}^*$  for the engine cycle. The program uses this information to establish the value of  $N_{II}/N_{II OPT}$  for each point of flight.

By setting  $N2IND = 0$  or  $1$ , the program will assume that the power turbine is always operating at optimum speed and no correction will be applied.  $N2IND = 0$  will simulate an engine cycle which is operating at optimum  $N_{II}$ , and for which no upper limit has been placed on  $N_{II}$ . For many applications, this option will be perfectly adequate for preliminary sizing studies. The adequacy of this assumption can be determined by consideration of the following factors:

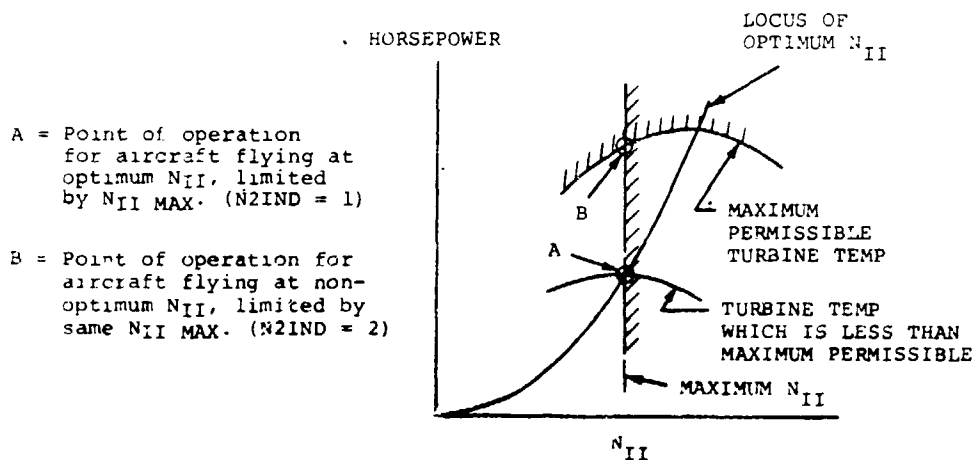
1. It may be desirable (e.g., as in the case of a tilt-rotor aircraft) to reduce the main rotor RPM in cruise flight.
2. For some applications this may, in turn, force the engine to operate at a very inefficient  $N_{II}$ . In general, the optimum  $N_{II}$  increases as output power increases relative to the maximum level.



Consider the following case:

Low disc loading aircraft will require a higher percentage of maximum power to fly at a specified airspeed than will high disc loading aircraft, assuming that engine power is dictated by a hover requirement. The low disc loading aircraft, therefore, will require a higher  $N_{II}$  for optimum engine performance than will the high disc loading aircraft. As a result, the low disc loading aircraft may be more severely compromised with respect to engine performance if the propeller rpm is reduced.

$N2IND = 1$  will simulate operation of an engine cycle at optimum  $N_{II}$ , but with the restriction of a maximum value for  $N_{II}$ . This type of operation is characteristic of airplanes employing fixed pitch propellers. Care should be taken in using this option because it may lead to a significant reduction in power available as shown by the sketch below:



$N2IND = 2$  is similar to  $N2IND = 1$  except the operational flying point is located at a nonoptimum  $N_{II}$ .

Limitations on engine cycle operation may be input to the program on any combination of the following:

- fuel flow  $W2IND$  Loc (1201) =
  - 0. = no fuel flow cutoff
  - 1. = fuel flow cutoff specified by  $W_{MAX}/W^*$  Loc (1220).
- gas generator speed,  $N1IND$  Loc (1202) =
  - 0. = no gas generator speed cutoff
  - 1. = gas generator speed cutoff specified by  $N_1$  MAX Loc (1221)

- gas generator referred RPM, N1@IND Loc (1203) =
  - 0. = no referred RPM cutoff
  - 1. = referred RPM cutoff specified by
 
$$\frac{N_1}{N_1^*} \quad \text{Loc (1222)}$$
  
- output shaft speed N2IND Loc (1204) -
  - 0. = no output shaft speed cutoff
  - 1. = output shaft speed cutoff specified by optimum  $\frac{N_{II\text{MAX}}}{N_{II}^*}$  Loc (1223).
  - 2. = output shaft speed cutoff specified by nonoptimum  $\frac{N_{II\text{MAX}}}{N_{II}^*}$  Loc (1223).
  
- torque, QIND Loc (1205) =
  - 0. = no torque limit
  - 1. = torque limit imposed on main and tail rotor transmission specified by  $\frac{Q_{\text{MAX}}}{Q^*}$  Loc (1224).
  - 2. = torque limit imposed on auxiliary propulsion transmission specified by  $\frac{Q_{\text{MAX}}}{Q^*}$  Loc (1224).

Engine ratings (power settings) are dictated by turbine temperature. Five discrete values of that parameter are input for the primary engine cycles, one for each of the following power settings: maximum, military, normal, flight idle, and ground idle.

The program will print out, during the mission, the value of turbine temperature and a code that designates which condition is governing the engine performance at that point: power or thrust required, turbine temperature, torque limit,  $N_1$  limit, referred  $N_1$  limit,  $N_{II}$  limit, or fuel flow limit.

Manufacturer's data on some engines show significant variations in both referred power ( $\text{shp}/\delta\sqrt{\theta}$ ) and lapse rate with respect to changes in altitude. These variations are due to Reynolds' number effects. It has been found that these effects can be accounted for by means of a multiplicative factor on power available which is a function of the Reynolds number based on compressor inlet conditions, compressor blade geometry, and tip speed. Figure 4-4 shows a typical curve for a real engine. The correction factor  $K_{PR}$  is input to the program as a function of the Reynolds' parameter

$$\frac{N_I}{N_I^*} \frac{D}{v_1}$$

TURBOSHAFT ENGINE 'A'

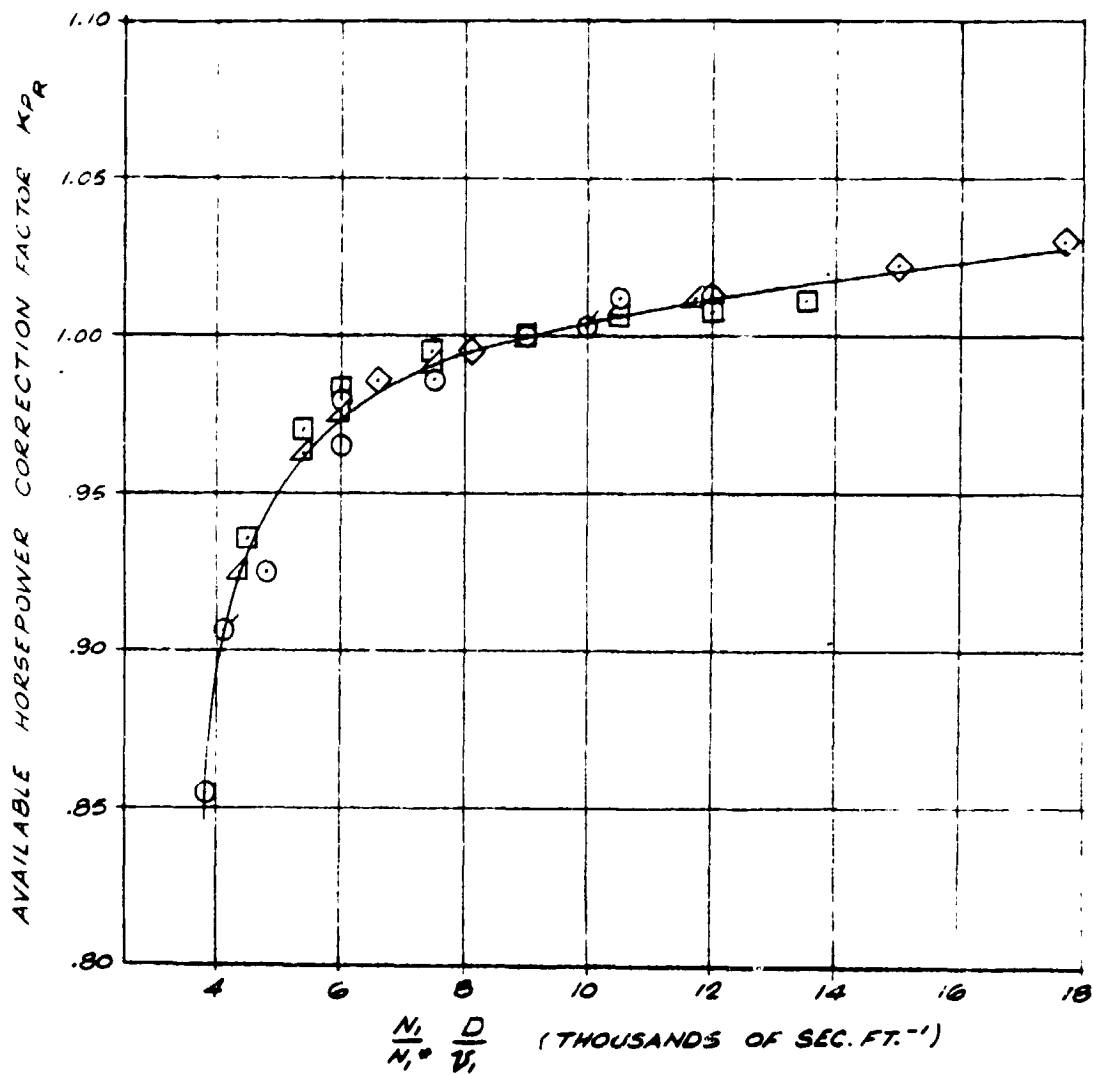


Figure 4-4. Typical Reynolds' Number Correction Factor for a Turboshaft Engine Cycle.

The tabular input of power, fuel flow,  $N_I$ , and  $N_{II}$  for engines which require Reynolds number corrections should be input to the program at a nominal fixed value of the Reynolds number parameter. The KPR correction factor will then give the power at other values of the Reynolds number parameter. In the example shown in Figure 4-4, the nominal value of the parameter was chosen as 9000 seconds/foot.

The referred  $N_I$  limit is a constraint on the value of  $N_I/\sqrt{\theta_1}$  where  $\theta_1$  is the temperature ratio at the compressor face. This limit simulates a restriction on compressor speed. The user inputs a maximum value of  $N_I/N_I^*\sqrt{\theta_1}$ .

The engine dry weight and dimensions are calculated by means of the input parameters  $k_3, k_{3I}, k_4, k_{4I}, \xi_4$  and  $\xi_{4I}$ :

$$\left. \begin{array}{l} \text{Primary} \\ \text{engines} \end{array} \right\} \begin{array}{l} \text{weight (lb)} = k_3 \frac{F^* N}{N_P} + k_4 \text{ or } k_3 \frac{\text{SHP}^*}{N_P} + k_4 \\ \text{diameter (ft)} = \xi_4 \left[ \frac{F^* N}{N_P} \right]^{1/2} \text{ or } \xi_4 \left[ \frac{\text{SHP}^*}{N_P} \right]^{1/2} \\ N_P = \text{number of primary engines} \end{array}$$

$$\left. \begin{array}{l} \text{Lift} \\ \text{engines} \end{array} \right\} \begin{array}{l} \text{weight (lb)} = k_1 \frac{F^* N_L}{N_L} + k_2 \\ \text{diameter (ft)} = \xi_1 \left[ \frac{F^* N_L}{N_L} \right]^{1/2} \\ \text{length (ft)} = \xi_2 + \xi_3 \left[ \frac{F^* N_L}{N_L} \right]^{1/2} \\ N_L = \text{number of lift engines} \end{array}$$

It has been found that the VASCOMP program can react in an extremely sensitive manner to "bumps" in the engine cycle data. Extreme care should be taken to ensure that the engine data which is input is smooth and continuous. In a particular example which was studied extremely erratic climb profiles resulted during maximum rate of climb mission segments. The speed for maximum rate of climb for example, jumped from 200 KTAS at 12,000 feet to 330 KTAS at 13,000 feet, during a climb from sea level to 25,000 feet in 1,000 foot increments. These anomalies were traced to inflections in the engine cycle curves of referred  $N_I$  versus turbine temperature and Mach number. (See Figure 4-5).

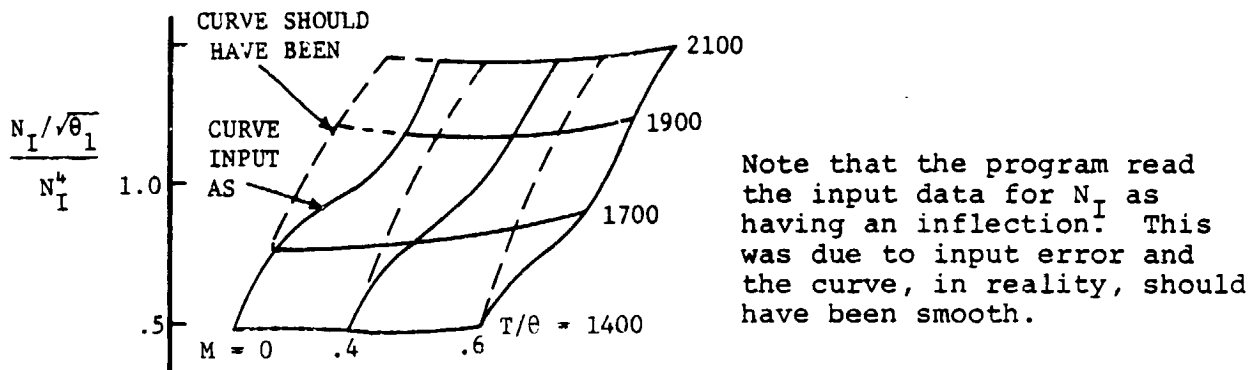


Figure 4.5 Referred  $N_I$  as a Function of Mach No. and Temperature

The interpolation routine used with the engine data is a second-order curve-fitting method using the point closest to the desired value and the points immediately above and below to generate a second-order curve to obtain the intermediate values. As a result, when the independent variable is in the region of an inflection, a discontinuity occurs in the dependent variable. For example, Figure 4-6 shows the variation of turbine temperature,  $T$ , with Mach number,  $M$ , as calculated for the referred  $N_I$  limit at 13,000 feet.

Points 1 through 4 have been calculated using the discrete values of  $M$  ( $M= 0, .4, .6, .8$ ) input to the test case. Curve A is the interpolation curve using points 1, 2, and 3, while curve B uses 2, 3 and 4. When  $M$  becomes greater than about .5, a sudden jump in  $T$  results, as curve B is then considered more valid than curve A;  $M$  is then closer to 0.6 than to 0.4. The solid line indicates the intended variation of  $T$  with  $M$ .

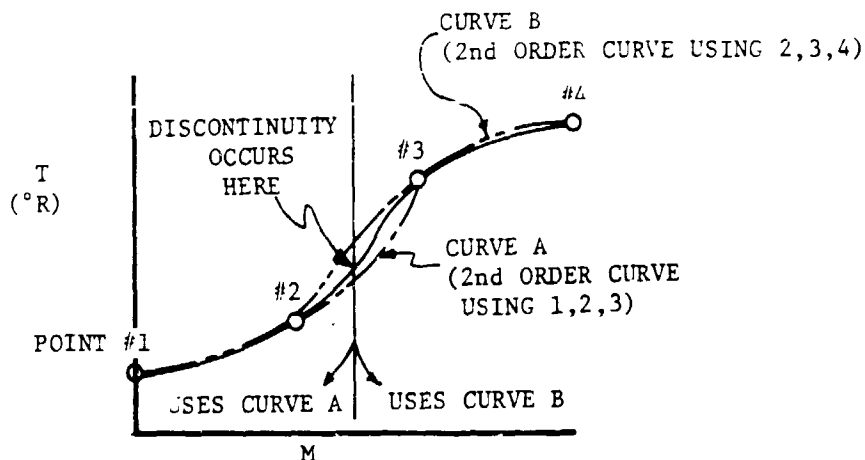


Figure 4-6. Variation of Turbine Temperature vs. Mach Number

This sudden change in  $T$  causes a corresponding jump in available horsepower and rate of climb. This causes a local peak in the variation of R/C with speed, and can cause an erroneous maximum rate of climb speed. This is because the program is searching for maximum rate of climb by working from high speed ( $V_{MO}$ ) to lower speeds. In Figure 4-7, we see that at altitudes greater than 13,000 feet

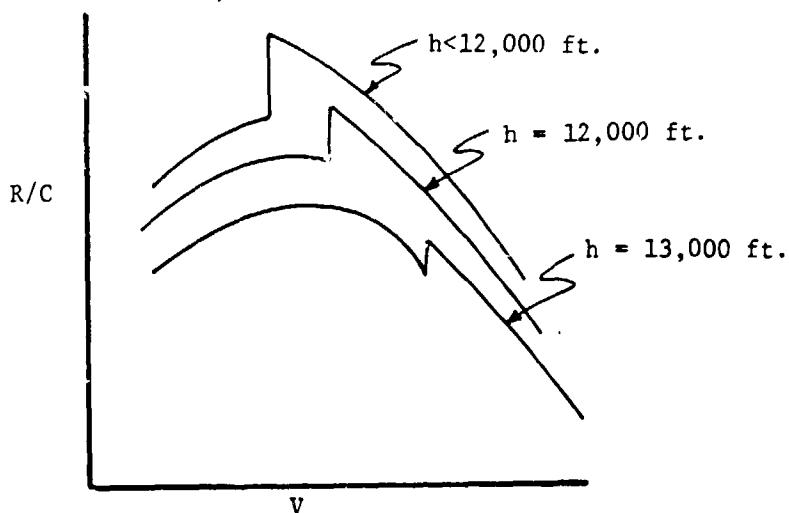


Figure 4-7. Variation of Rate of Climb vs. Velocity

the climb routine would pick up this local peak and we see a dramatic change in speed for a small change in altitude because of engine cycle curves with inflections. Such data may well be incorrect, and may cause inexplicable discontinuities in the output.

Figures 4-8 through 4-14 are flow charts of the engine cycle subroutines. The purpose of these subroutines is described in Table 3-1.

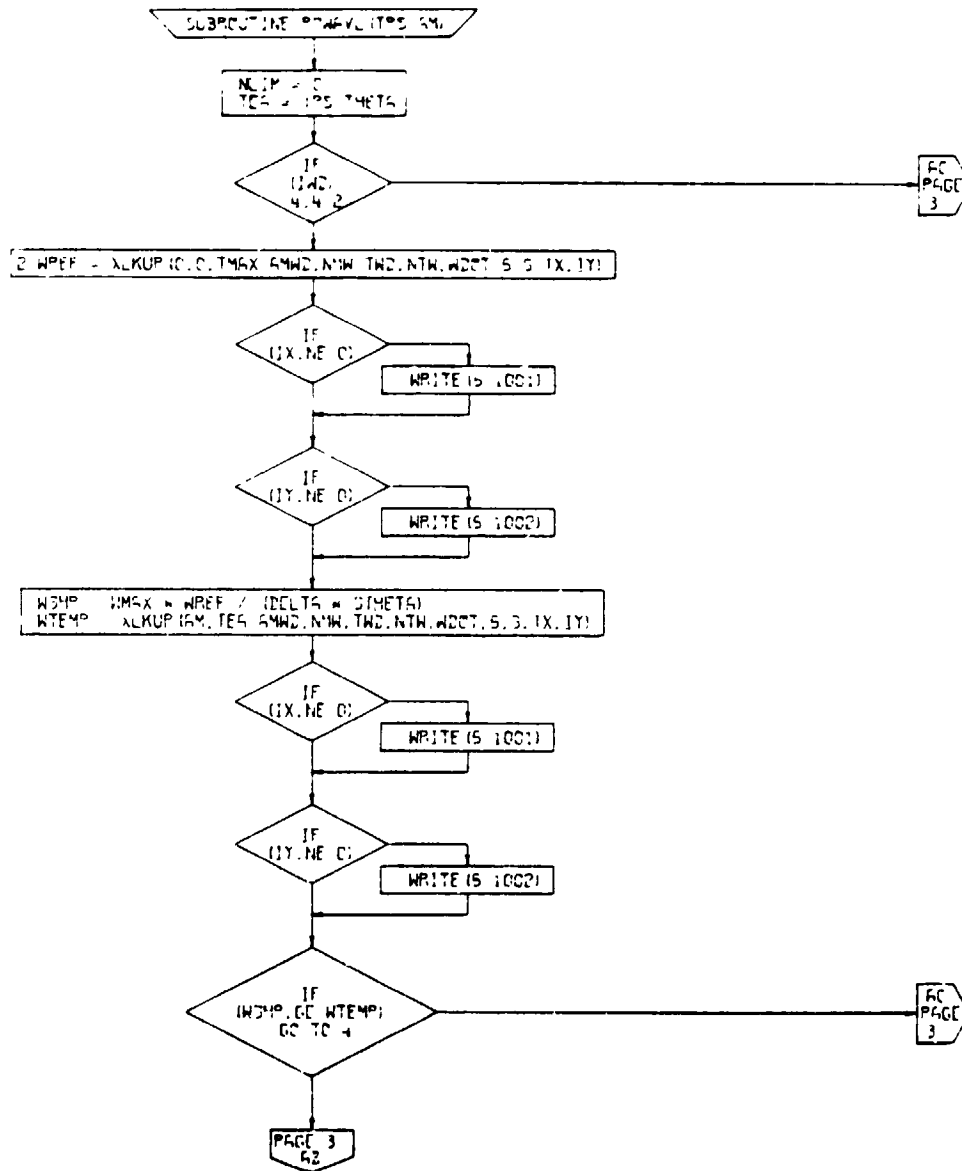


Figure 4-8. POWAVL Subroutine, Flow Chart (Part 1 of 7)

PAGE 2  
POWAVL



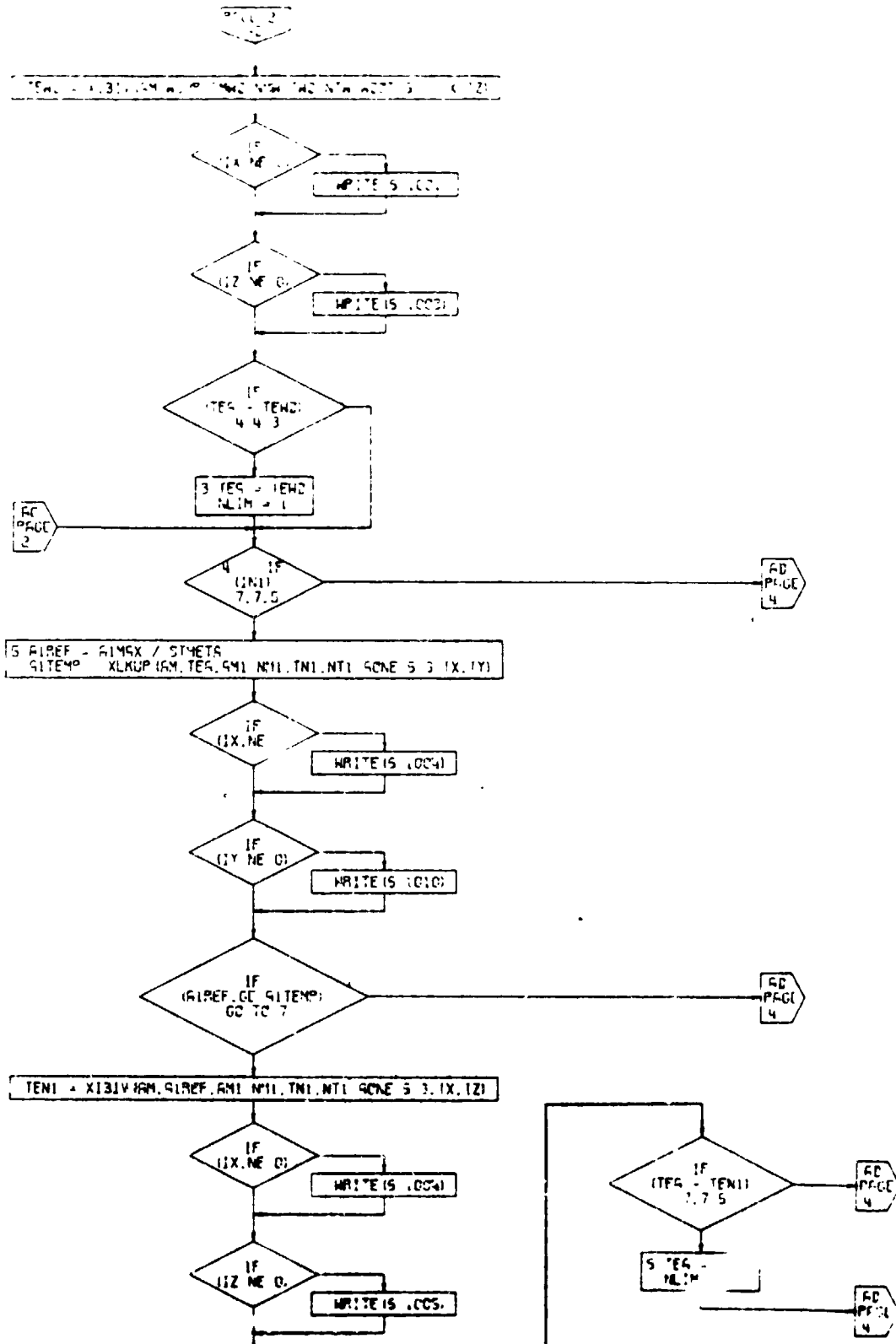


Figure 4-8. POWAVL Subroutine, Flow Chart (Part 2 of 7)

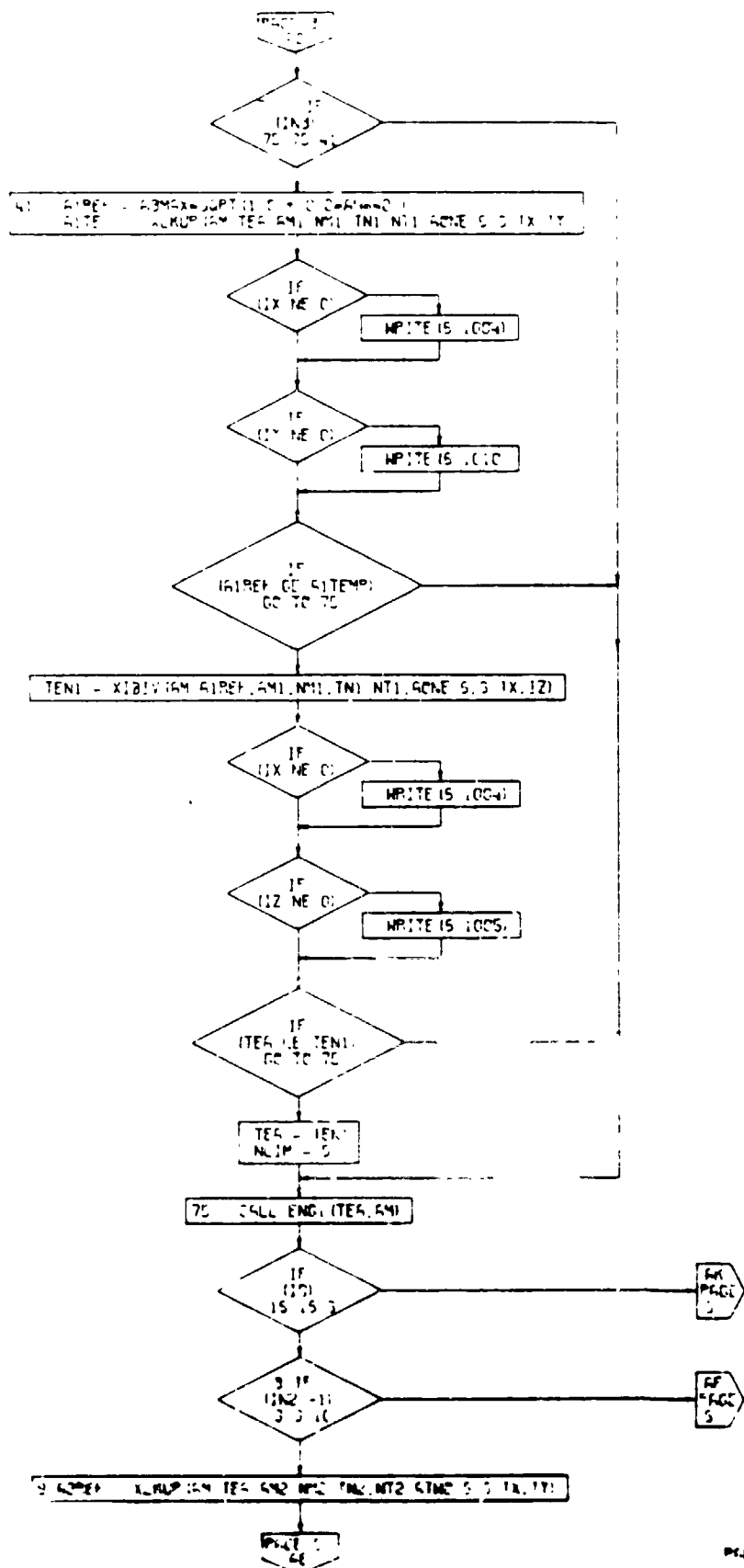


Figure 4-8. PMAVL Subroutine, Flow Chart (Part 3 of 7)

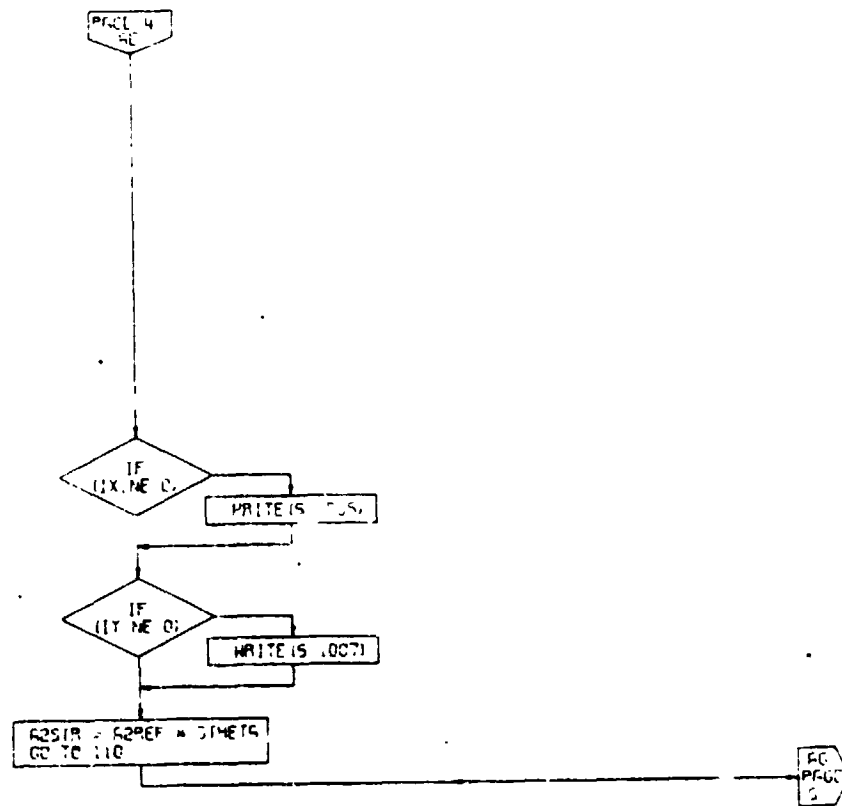


Figure 4- . POWAVL S: subroutine, Flow Chart  
(Part 4 of 7)

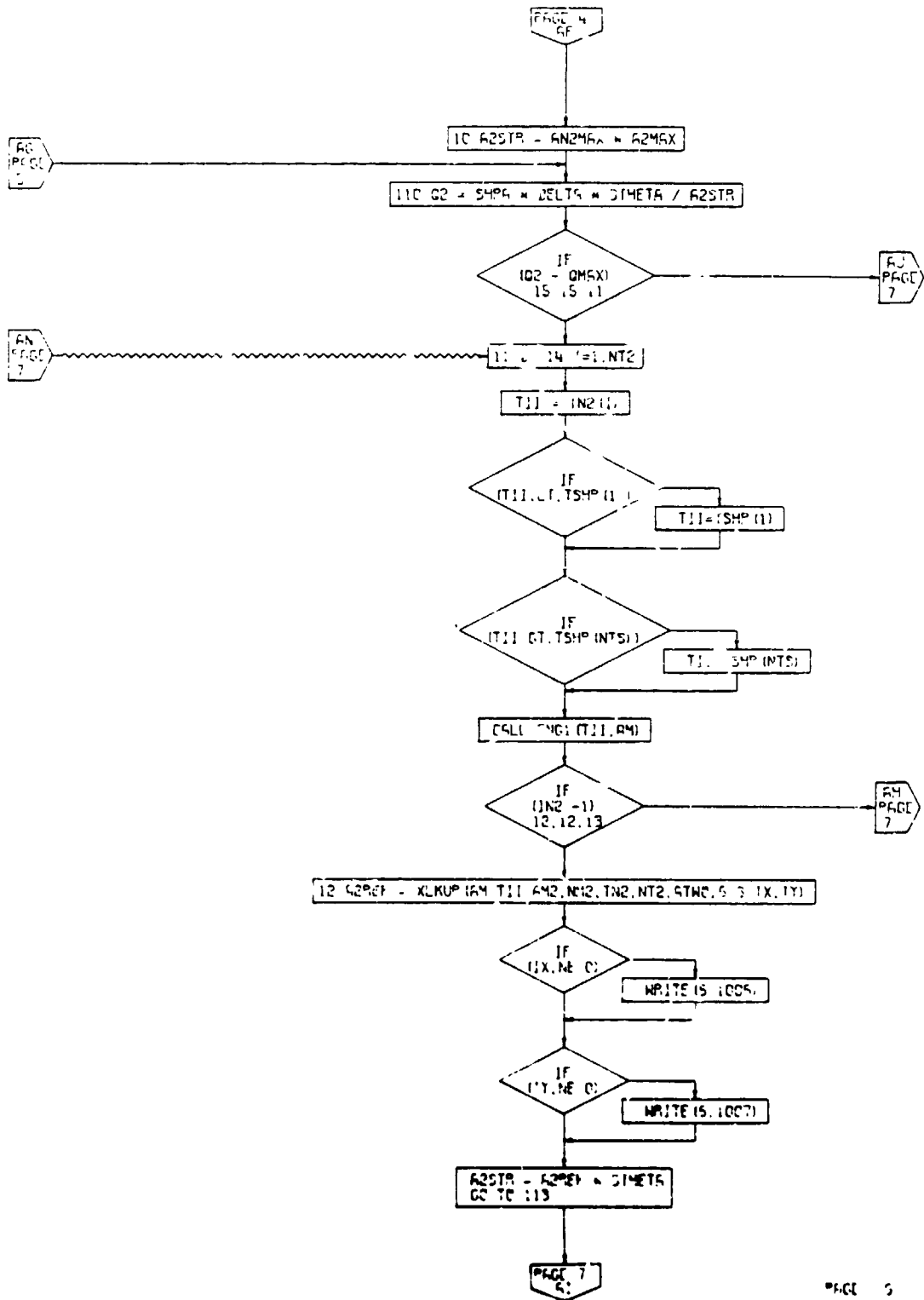
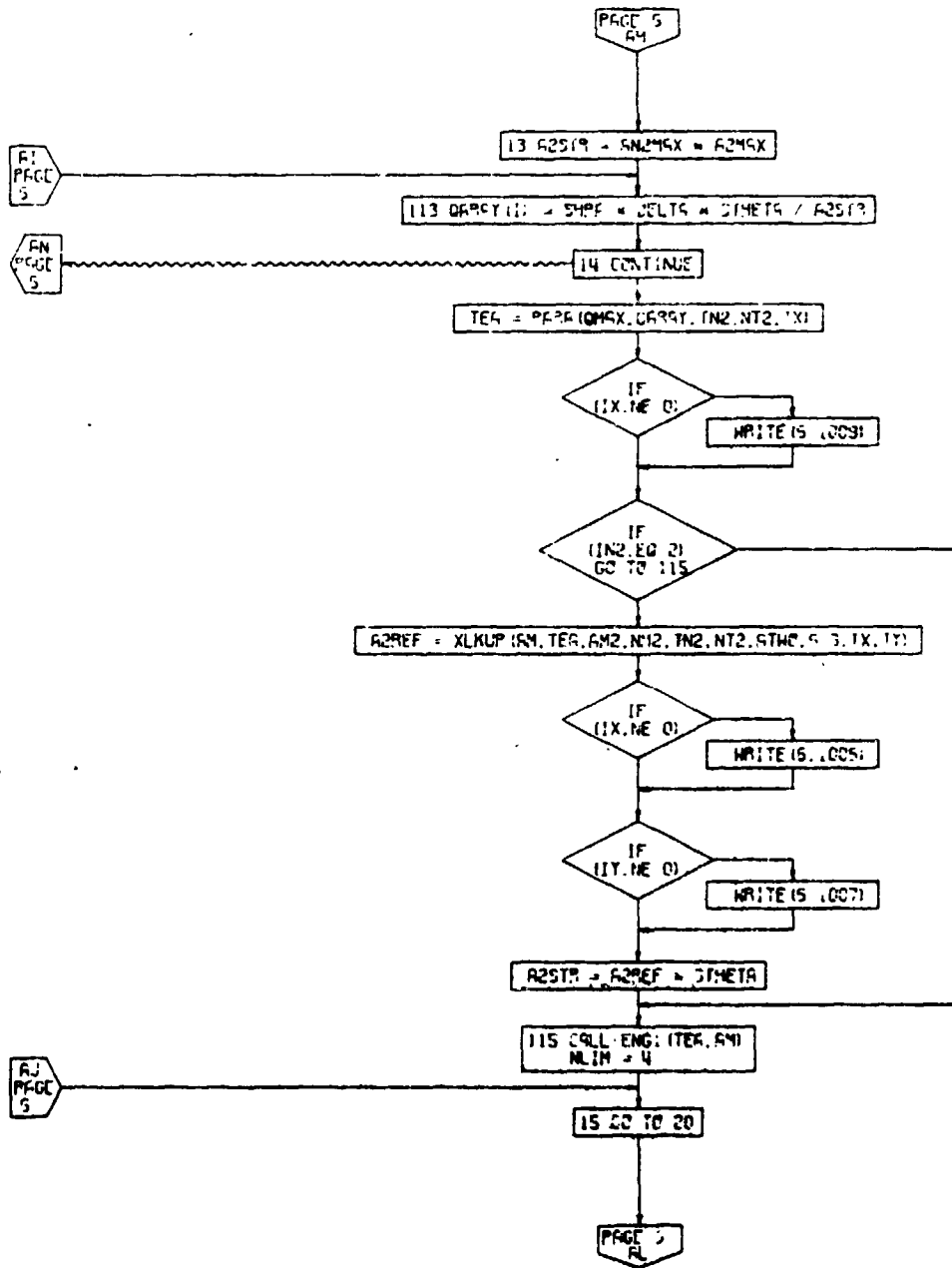


Figure 4-8. POW/VL Subroutine, Flow Chart (Part 5 of 7)



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POWAVL

Figure 4-8. POWAVL Subroutine, Flow Chart  
(Part 6 of 7)

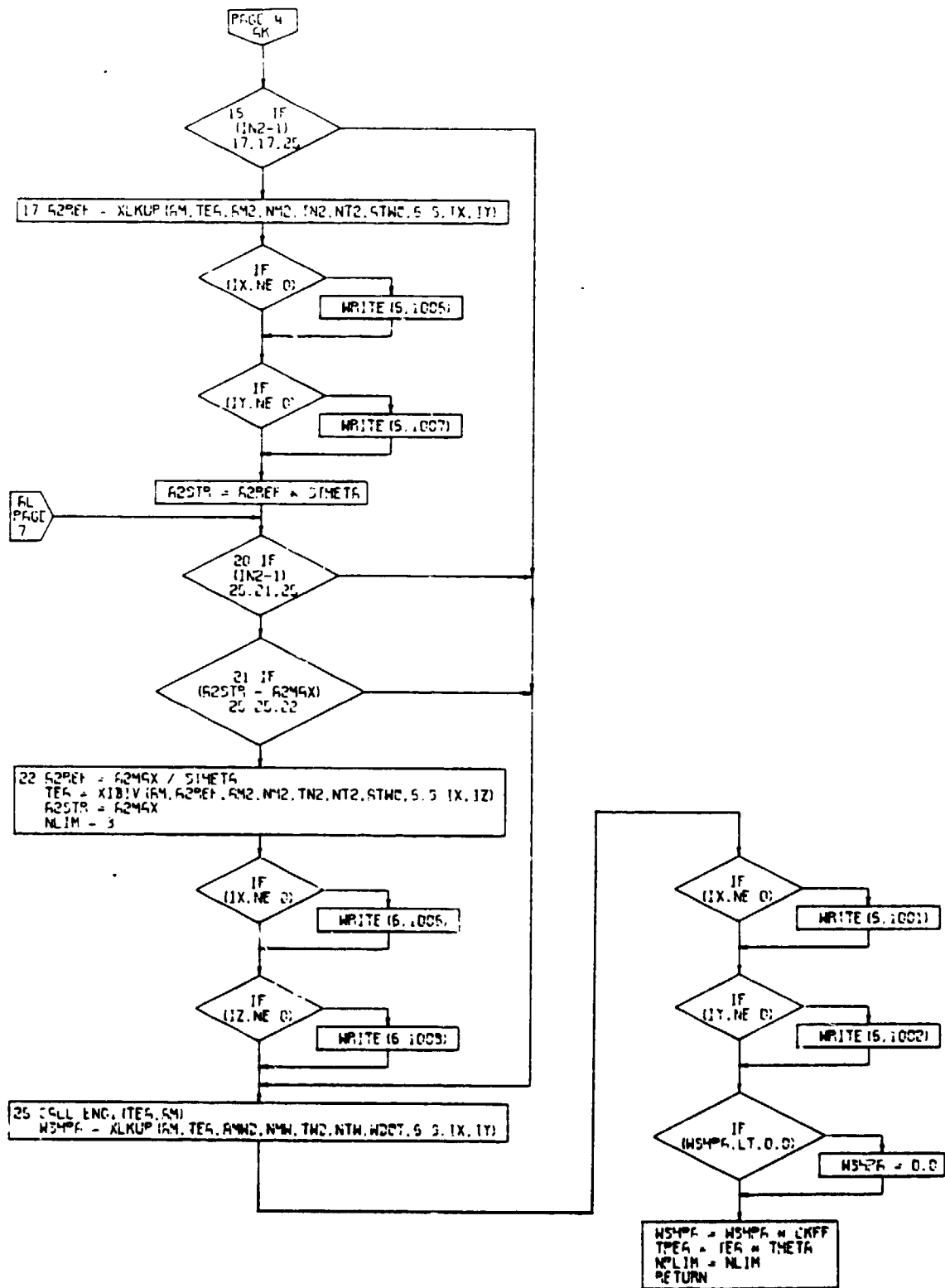
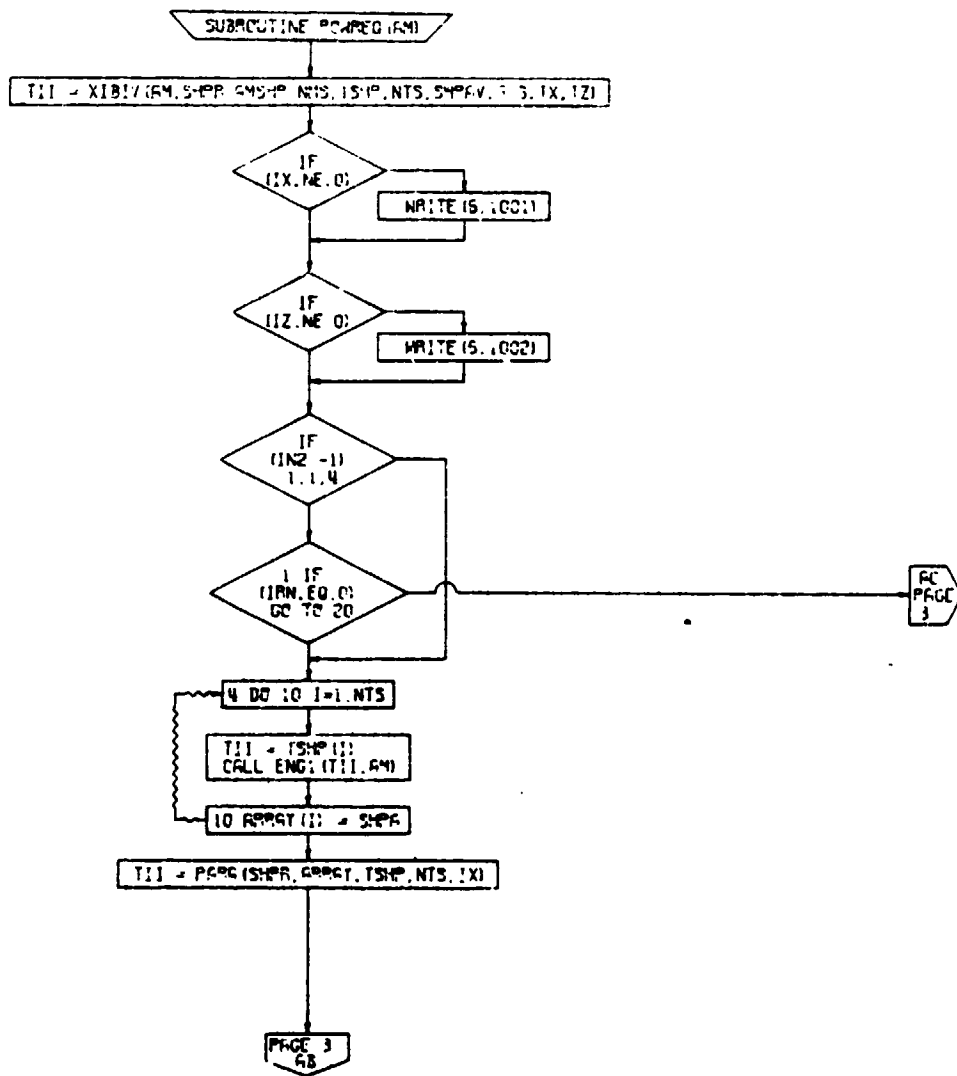


Figure 4-8. POWAVL Subroutine, Flow Chart (Part 7 of 7)

PAGE 3  
POWAVL



PAGE 2  
POWREQ

Figure 4-9. POWREQ Subroutine, Flow Chart (Part 1 of 2)

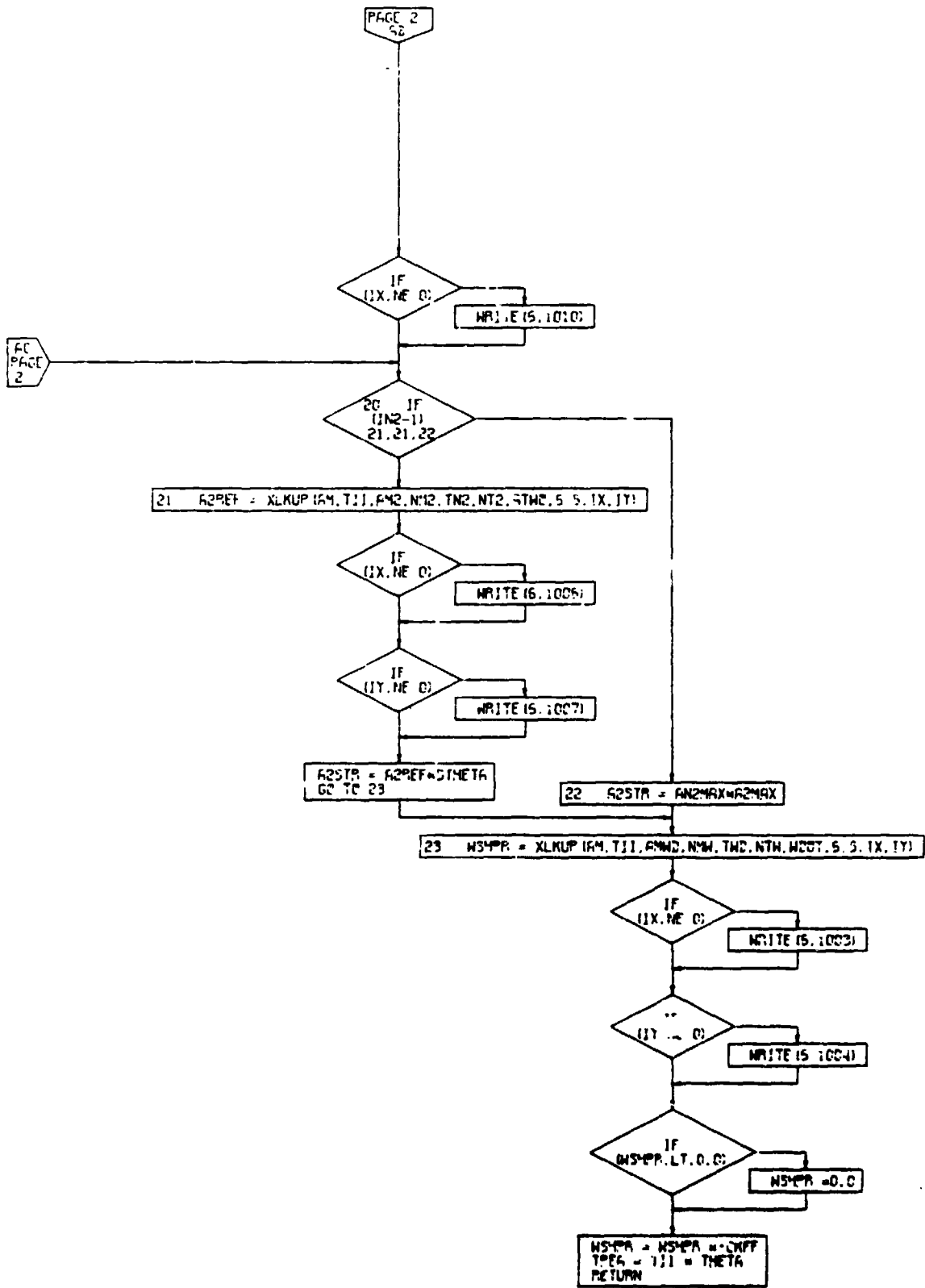
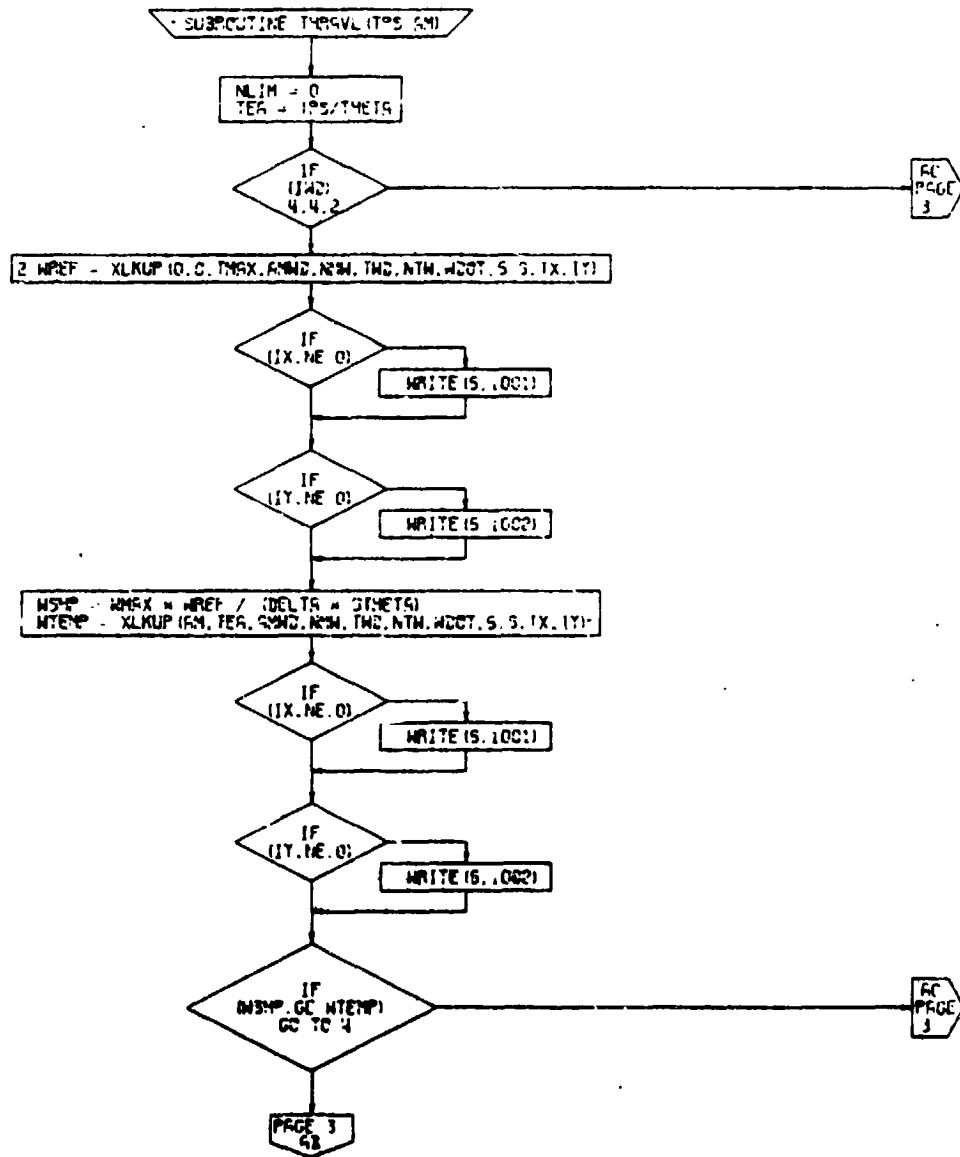


Figure 4-9. POWREQ Subroutine, Flow Chart  
(Part 2 of 2)

PAGE 3  
POWREQ





PAGE 2  
THR AVL

Figure 4-10. THR AVL Subroutine, Flow Chart  
(Part 1 of 4)

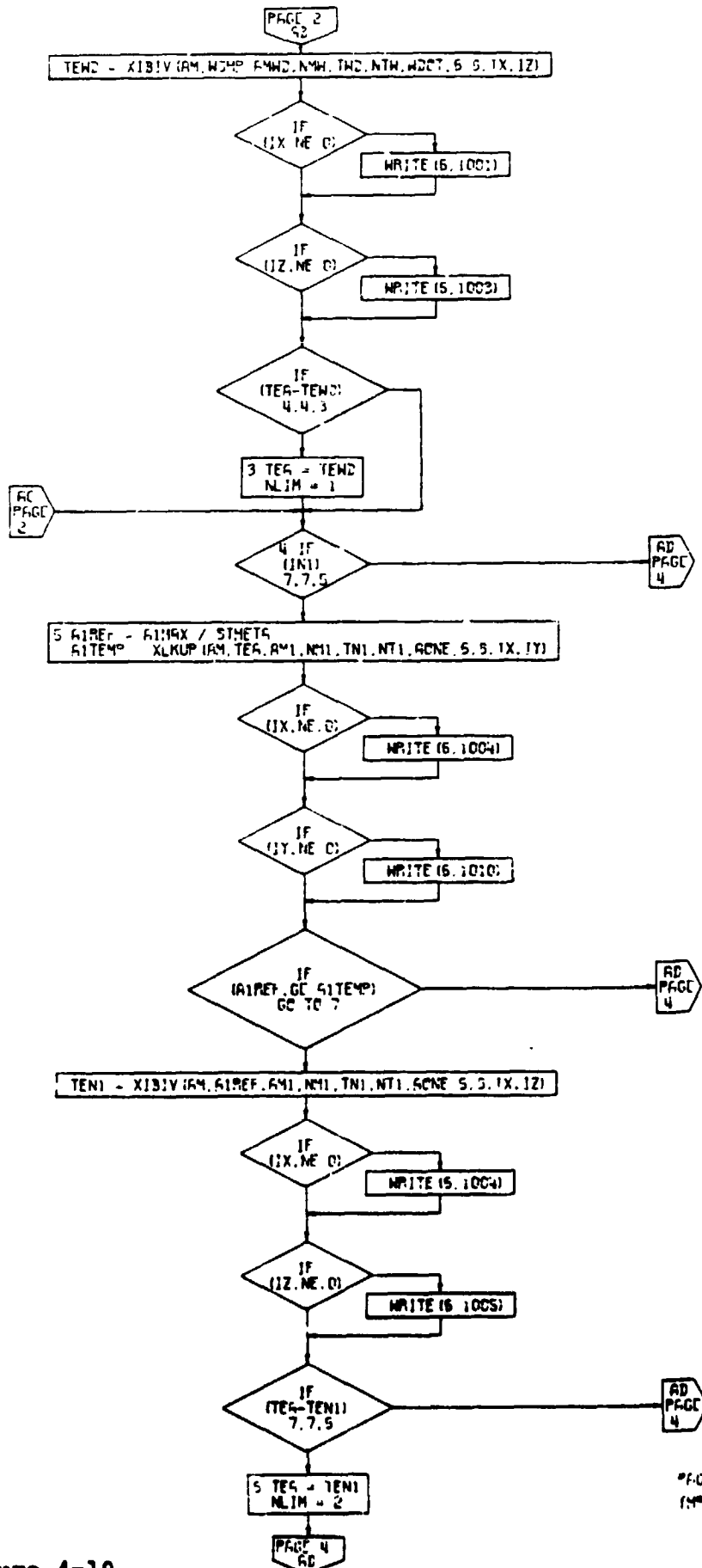


Figure 4-10. THRVL Subroutine, Flow Chart (Part 2 of 4)

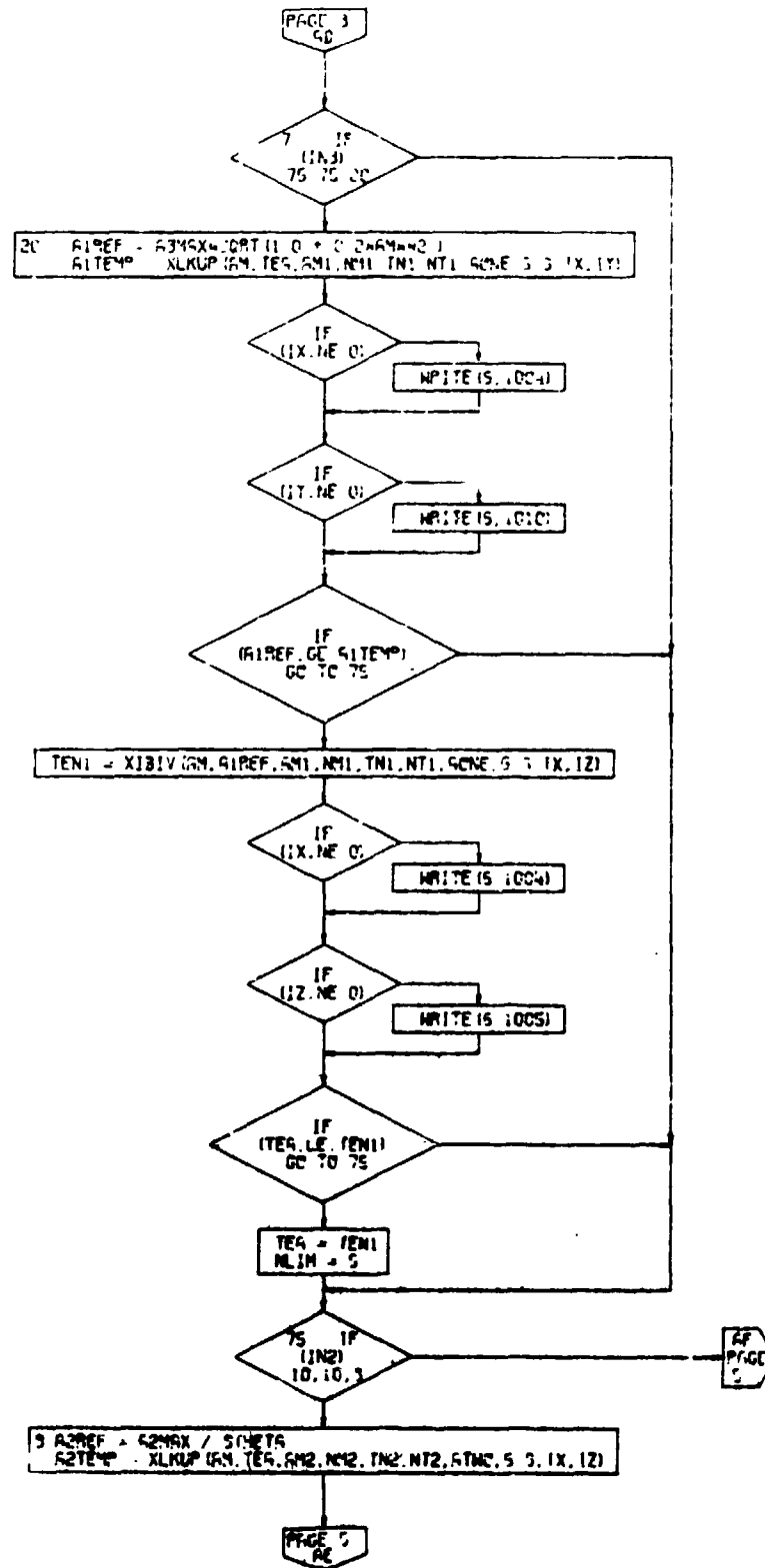


Figure 4-10. THR AVL Subroutine, Flow Chart  
(Part 3 of 4)

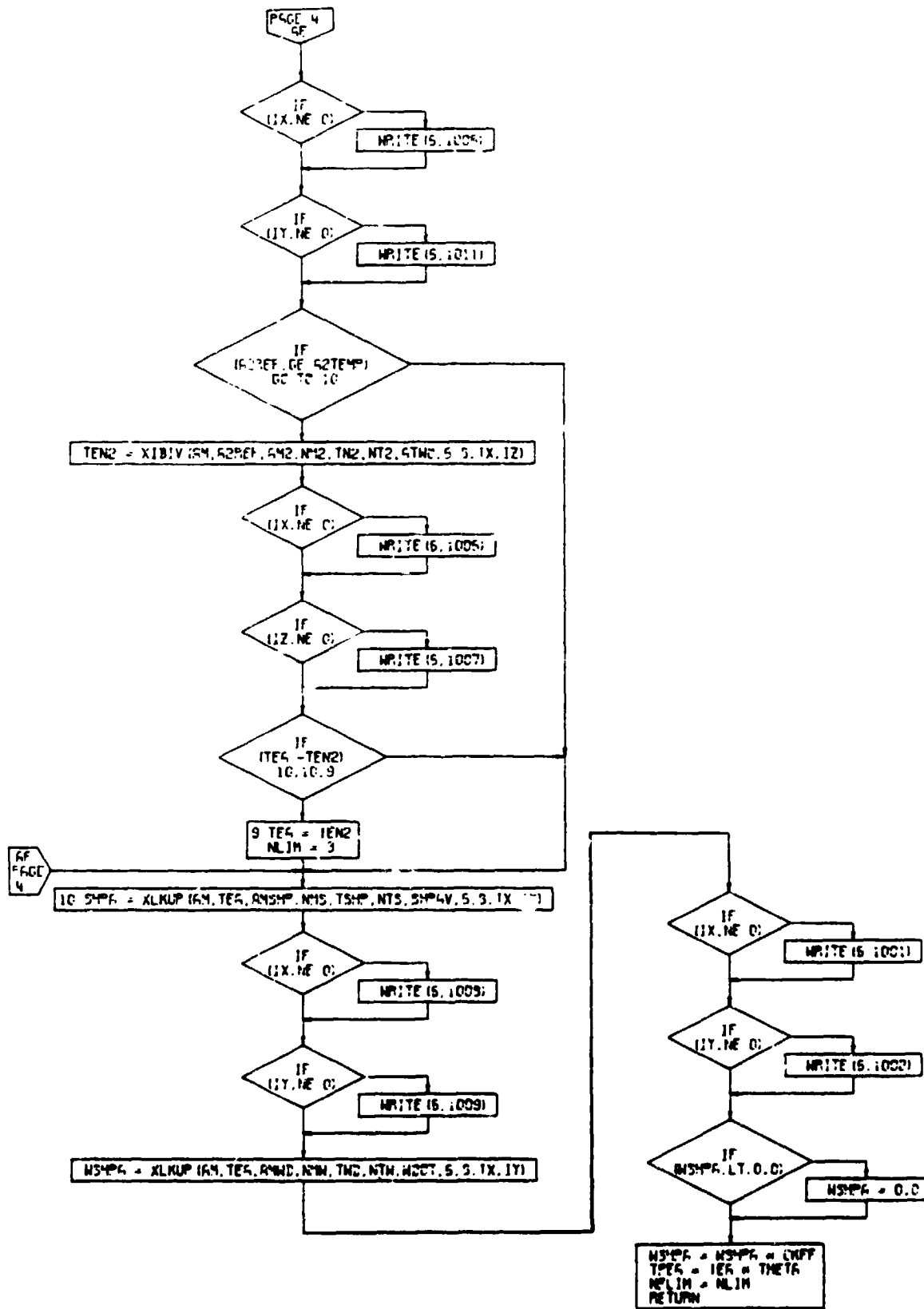


Figure 4-10. THRVL Subroutine, Flow Chart  
(Part 4 of 4)

PAGE 5  
THRVL

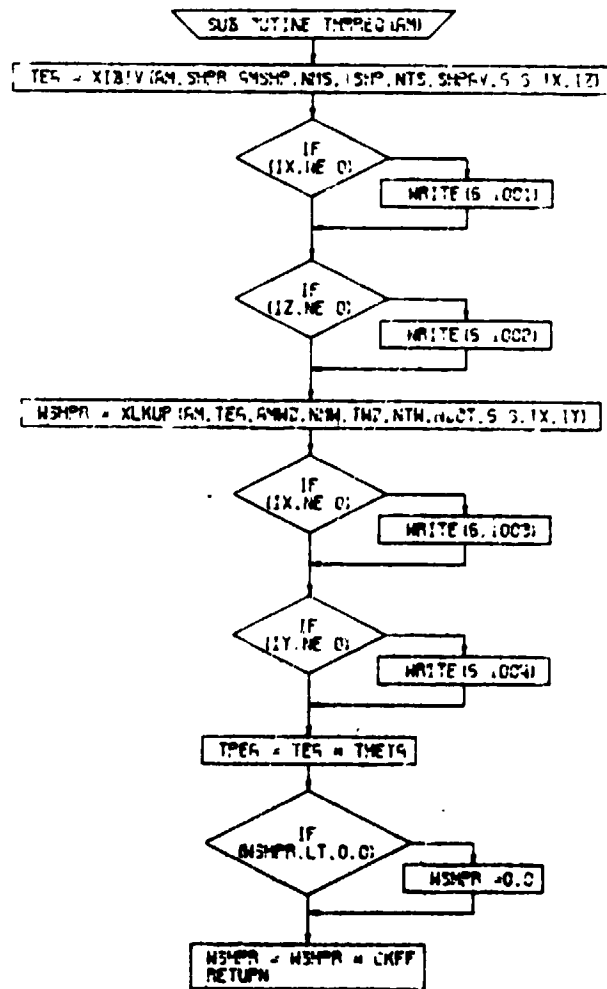


Figure 4-11. THREEQ Subroutine, Flow Chart

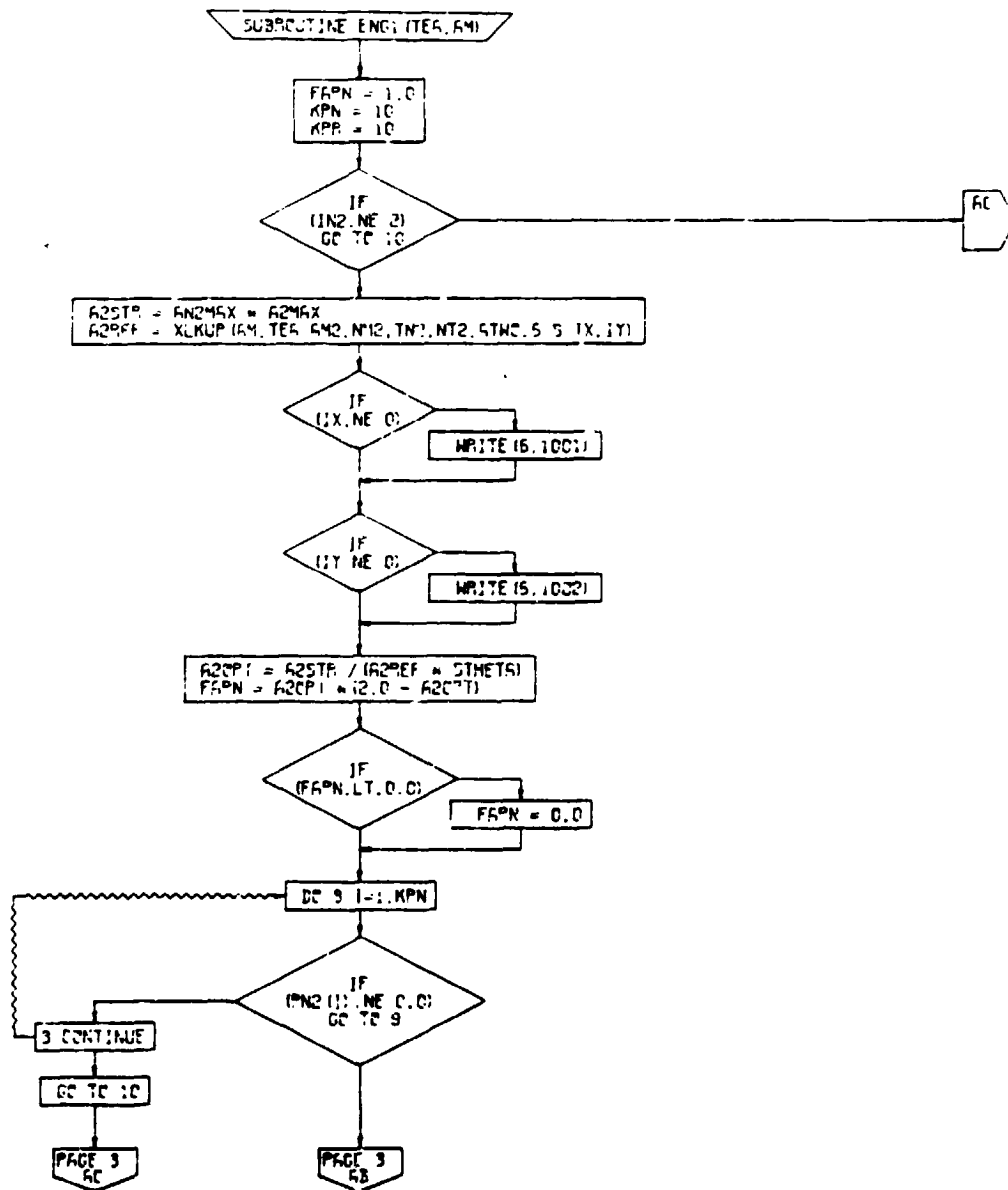


Figure 4-12. ENGL1 Subroutine, Flow Chart  
(Part 1 of 2)

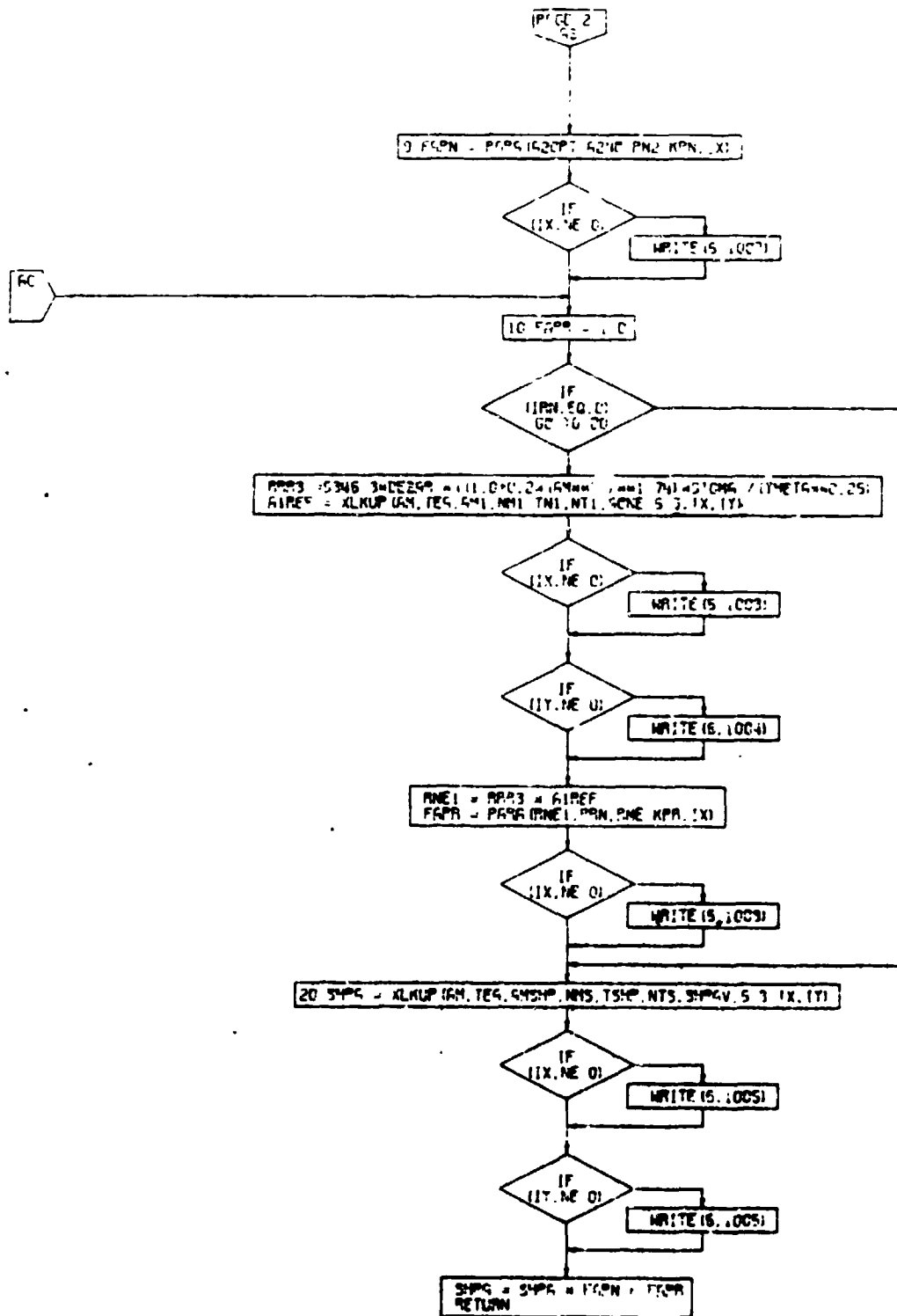


Figure 4-12. ENGI Subroutine, Flow Chart  
(Part 2 of 2)

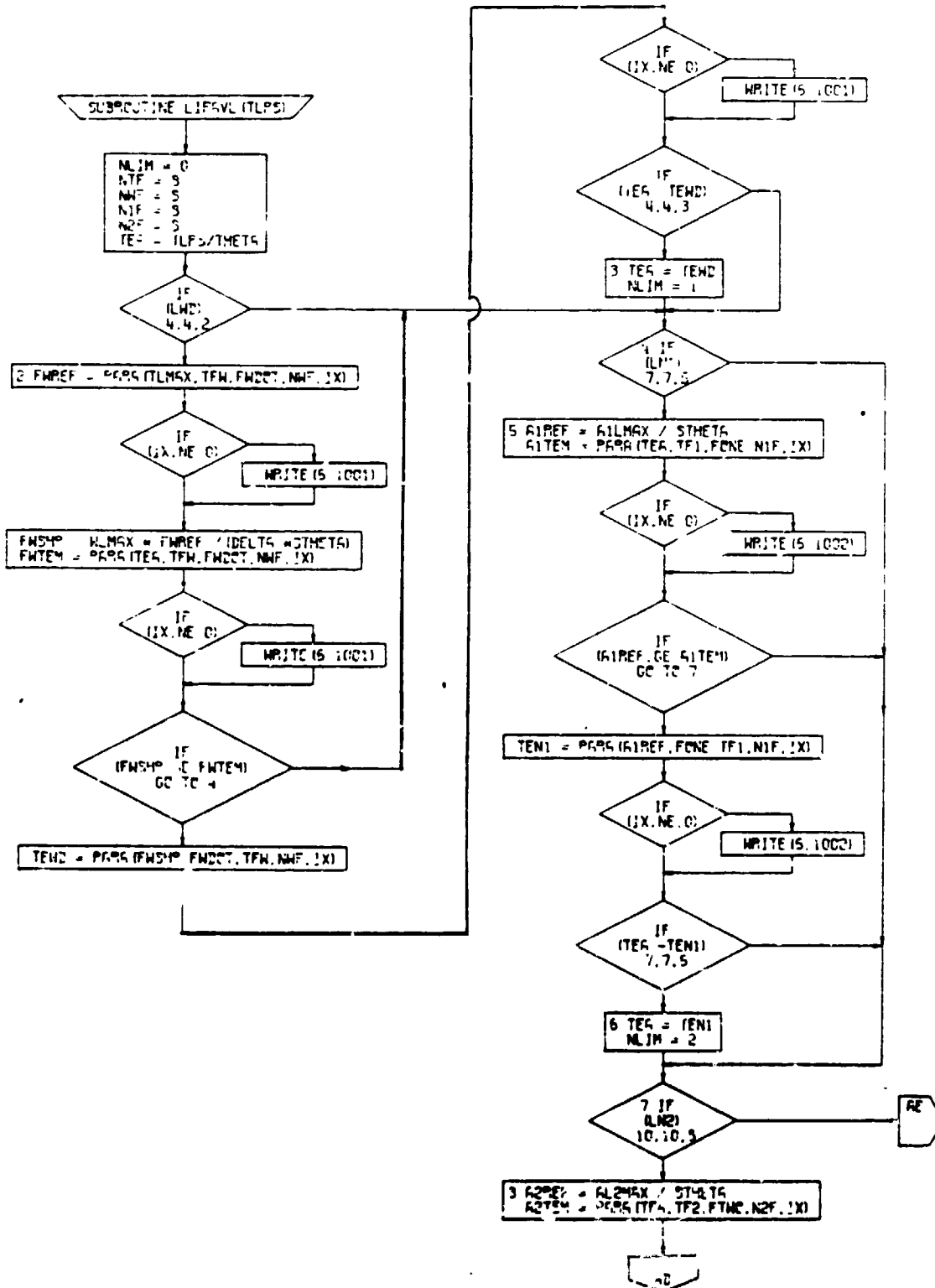


Figure 4-13. Lift Available Calculations Subroutine, Flow Chart (Part 1 of 2)



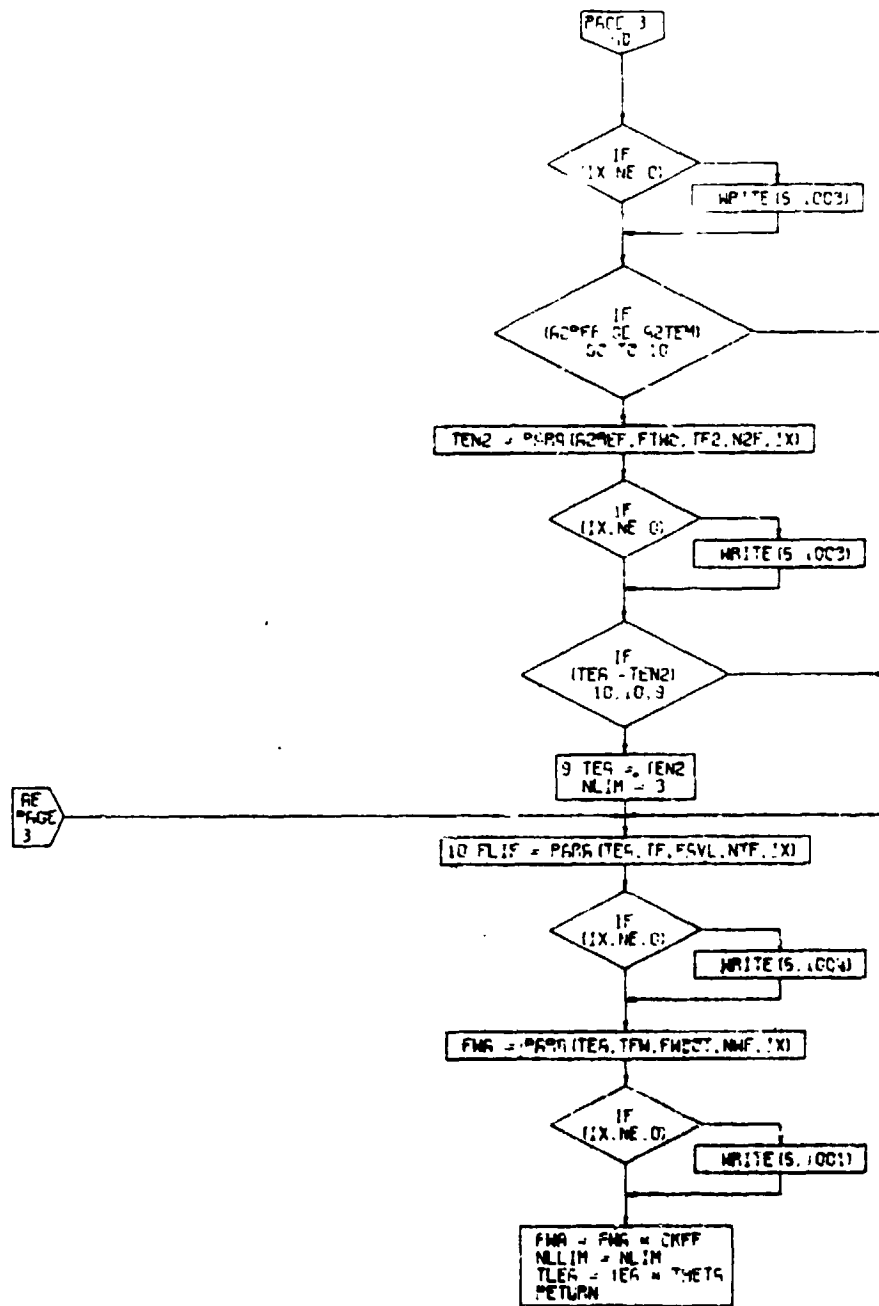


Figure 4-13. Lift Available Calculations Subroutine, Flow Chart (Part 2 of 2)

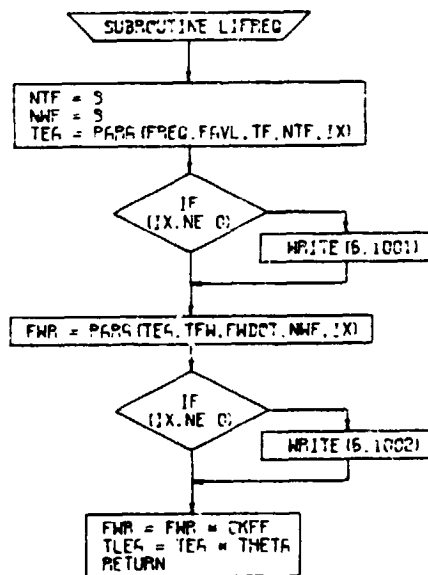


Figure 4-14. Lift Required Subroutine,  
Flow Chart

#### 4.5 PROPELLER PERFORMANCE CALCULATIONS

Four different options are available for representing the performance of propellers when using turboshaft engines (ENGIND=0). The option to be used is specified to the program by means of a prop efficiency indicator - " $\eta_p$ IND".

$\eta_p$ IND=0 The user inputs a set of point values for the prop efficiency for the performance segments of takeoff, climb, and descent and a table of efficiency as a function of flight Mach number for cruise and loiter. The following input is required:

$\eta_{p2}$  - The static propeller efficiency (Figure of Merit) to be used in calculation of Takeoff, Hover and Landing (SGTIND=2) is input as a single point value. It should be noted that  $\eta_{p2}$  is also a required input for jet engines (ENGIND=1) or for convertible engines (ENGIND=2). In the former case  $\eta_{p2}$  may be used to represent the turning efficiency of jet engines being used with turning vanes. In the latter case it represents the Figure of Merit of the props or rotors being used with the convertible engines.

$\eta_{p3}$  - A single point value is input for the prop efficiency during climb (SGTIND=3).

$\eta_{p4}$  - A table is input of prop efficiency during cruise (SGTIND=4) and Loiter (SGTIND=6) as a function of flight Mach number.

$\eta_{p5}$  - A single point value is input representing the prop efficiency during Descent (SGTIND=5).

The primary advantage of this option of propeller performance representation is that it permits rapid evaluation of the sensitivity of aircraft performance and size to changes in propeller performance. For example, a series of runs with different values of  $\eta_{p2}$  and  $\eta_{p4}$  will quickly show the tradeoff between Figure of Merit and cruise efficiency for a family of propellers. It may also prove desirable to use this option in early conceptual studies when a specific prop has not been picked and it is desired to use "reasonable" values of efficiency.

TABLE 4-3  
PROPELLER CHARACTERISTIC SUMMARY

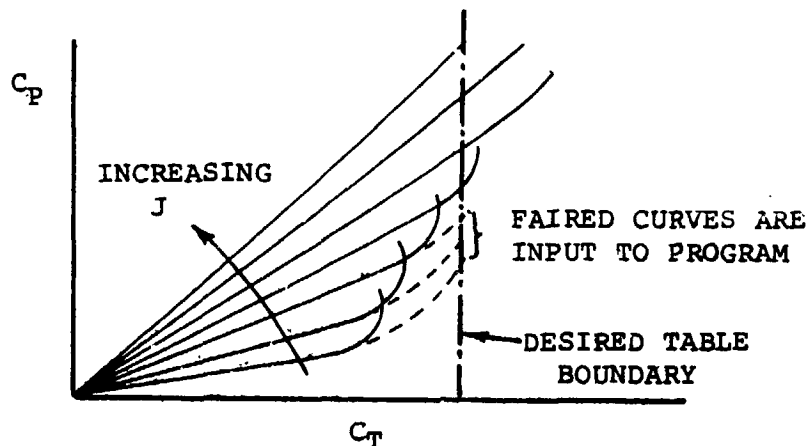
ALL PROPELLERS ARE 3-BLADED, CONSTANT SPEED

MANUFACTURER	DESIGNATION	INTEGRATED DESIGN $C_L$	ACTIVITY FACTOR PER BLADE	APPLICATION
HARTZELL PROPELLERS, INC.	T10282H	0.555	114 (118)*	TWIN OTTER SKYVAN
HARTZELL PROPELLERS, INC.	10173-8	0.62 (0.7)*	104 (107)*	KINGAIR BEECH 99
HAMILTON STANDARD DIVISION, UAC	33LF 1033A-0	0.424	127	HAWK COMMANDER
HAMILTON STANDARD DIVISION, UAC	33LF 1027A-0	0.5	110	
HAMILTON STANDARD DIVISION, UAC	33LF 1013A-0	0.483	97	

NOTE: VALUES IN PARENTHESES ARE QUOTED BY HARTZELL PROPELLERS.  
THE VALUES NOT IN PARENTHESES ARE CONSISTENT WITH THE  
BLADE GEOMETRIC DATA SUPPLIED BY HARTZELL.

Table 4.3 Propeller Characteristic Summary

$\eta_p \text{IND}=1$  - This option permits the user to input a table representing the performance of the propeller throughout the flight envelope with the exception of DESCENT (SGTIND=5) for which a value of  $\eta_p$  is input as before. For all other performance segments the table, input in the format of  $C_p$  (prop power coefficient) as a function of  $C_T$  (prop thrust coefficient) and  $J$  (advance ratio) is used. The table which is prepared must include all compressibility losses for the known tip speed at which the propeller is intended to operate. The user is cautioned that the tabular values must be monotonic. That is, the table cannot include the maximum in  $C_T$  which reflects blade stall at high values of  $C_p$ . This must be faired out as shown in the sketch below:



The advantage of this option is that it permits the user to input the performance of a real propeller as determined from test data.

A previous NASA contract for the modification of VASCOMP II required the preparation of propeller performance data for five general aviation propellers. These data are in the form of card decks and are for use with the  $\eta_p \text{IND} = 1.0$  option for propeller calculations.

The characteristics and applications of each of these propellers are summarized in Table 4-3. The propeller table number (INPUT LOCATION 0256) to be specified is indicated in the table. These propeller decks are available for use with VASCOMP II. In addition to specifying the "propeller table number" in his input, the user should also indicate on his job required card that the particular propeller deck is required.

<u>Propeller Designation</u>	<u>Table Number</u>
Hartzell T10282H	10282.3
Hartzell 10173-8	101738.3
Hamilton Standard 33LF 1033A-O	1033.3
Hamilton Standard 33LF 1027A-O	1027.3
Hamilton Standard 33LF 1013A-O	1013.3

In each of the above Table Numbers the 3 after the decimal point indicates that a 3 bladed propeller is represented by the data in the table.

Hover data was previously input by specifying various propeller power coefficients for  $J=0$  (Loc 1702) and an input  $C_T$  (Loc 1723). The current modification enables the user to directly input Figure of Merit for specified  $C_T/\sigma$  and Tip Mach Number. Values of  $C_T/\sigma$  are input locations 2352-2361.  $M_{Tip}$  is input locations 2363-2368, and Figure of Merit is tabularized in locations 2369-2428. The user will no longer input the first advance ratio (Loc 1702) as  $J=0$ , or an error message will be printed out.

$n_{pIND}=2$  - Through use of this option the program will automatically calculate the performance of a wide variety of V/STOL propellers. The user need only specify the number of blades (3 or 4), the activity factor per blade, and the integrated lift coefficient,  $CL_i$ . The method used for the calculation of propeller performance is the "short method" originated at the Curtiss-Wright Corporation's Propeller Division (Reference 6). The method involves the use of a set of equations which can be developed from strip theory. These equations permit the propeller performance maps ( $C_p$ ,  $C_T$ ,  $J$ ) to be transformed into an "equivalent" lift-drag polar for the propeller. Conversely, the lift-drag polars, once developed, can be used with the equations to predict the propeller performance. For incompressible flow, the "equivalent" lift-drag polar which is used depends only on the value of  $CL_i$  being considered. That is, for a given  $CL_i$  the same polar can be used to accurately represent the performance of props with a wide variation in activity factor and number of blades and for a wide range of  $C_p$  and  $J$ . For compressible flow conditions, the curves correlate very well on the basis of the value of helical Mach number at the 3/4 radial station. The equivalent lift-drag polars which are contained in the program were developed from detailed strip analysis calculations for cruise and from calculations using an explicit vortex-influence technique in hover. These detailed calculations covered the following range of parameters:

No. of blades: 3 and 4  
Activity factor/blade: 60 + 220  
Integrated lift coefficient,  $CL_i$ : 0.15 + 0.7

Although the user is permitted to input values of activity factor and  $CL_i$  greater than (or less than) those shown above, the level of confidence in the predictions is reduced when values for those parameters are outside the range used in the detailed calculations.

Figures 4-15 and 4-16 are characteristic of the level of accuracy obtained from the short method when compared to the detailed calculations.

This option will calculate the propeller performance for all mission performance segments except Descent (SGTIND=5). For Descent, the user inputs a value for  $\eta_{p5}$ . Figure 4-17 is a flow chart of subroutine THRUST which calculates the propeller thrust available for known values of power and flight speed. Figure 4-18 is a flow chart for subroutine POWER in which the power required for specified thrust and flight speed is calculated. These subroutines make use of propeller equivalent lift-drag polars, as mentioned above, to calculate the performance of the propeller. The polars are developed in the main control loop for the particular value of integrated lift coefficient,  $CL_i$ , being studied from the following equations:

$$\gamma = \tan^{-1} (C_D/C_L) = \text{function of } M_H, C_L, CL_i$$

$M_H$  = helical Mach no. @ 3/4 r/R  
 $C_L$  = equivalent lift coefficient at which prop is operating  
 $CL_i$  = integrated lift coefficient of prop

For cruise

$$\gamma = a_0 + a_1 CL_i + a_2 CL_i^2$$

$a_0$ ,  $a_1$ , and  $a_2$  are coefficients stored in the program and are functions of  $M_H$  and  $C_L$

For hover:

$$\gamma = b_0 + b_1 CL_i + b_2 CL_i^2$$

$b_0$ ,  $b_1$ , and  $b_2$  are coefficients stored in the program and are functions of  $C_L$ .

The coefficients  $a_0$ ,  $a_1$ ,  $a_2$ ,  $b_0$ ,  $b_1$ ,  $b_2$  are listed in Table 4-3.

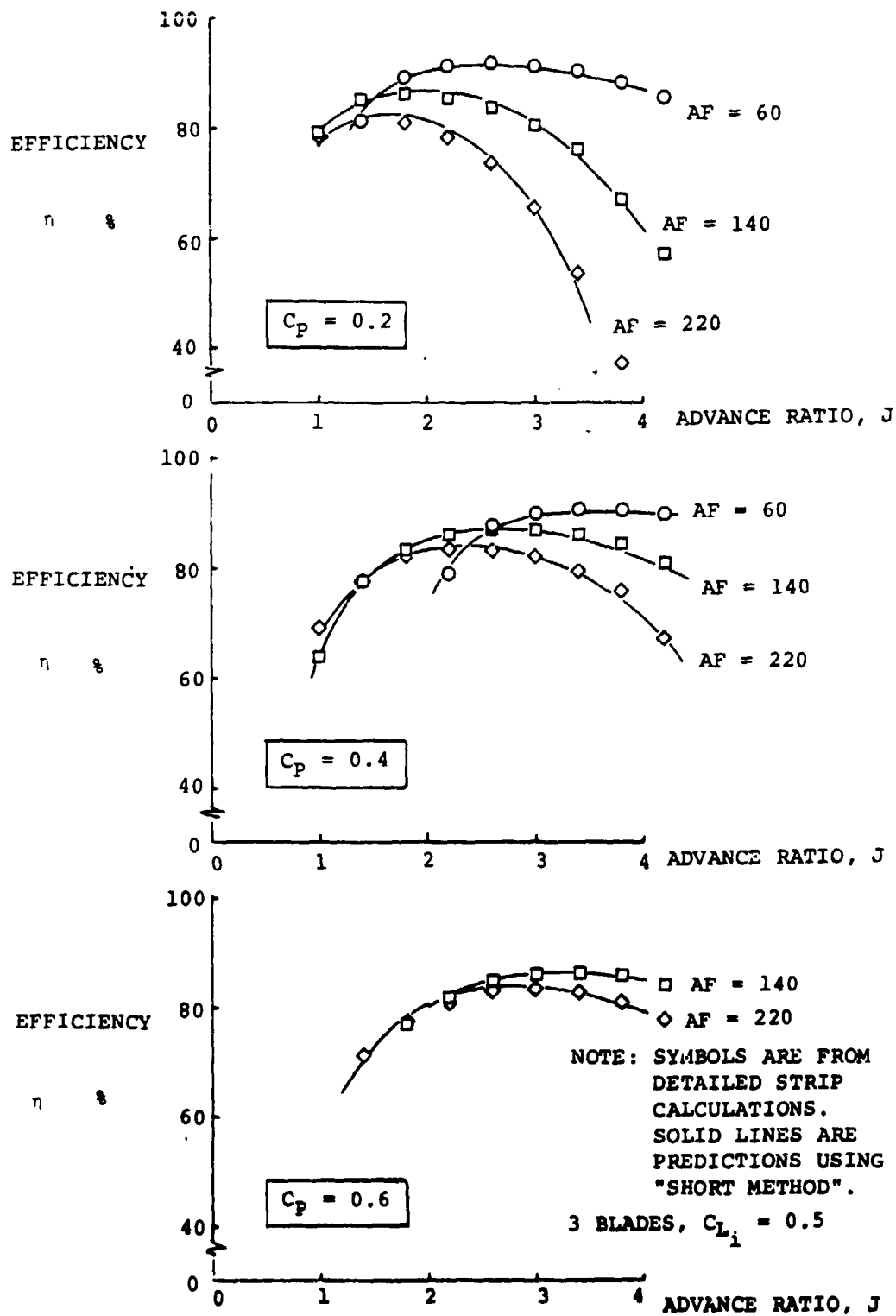


Figure 4-15. Comparison of "Short Method" and Detailed Calculations for Propeller Cruise Efficiency.



FIGURE OF  
MERIT

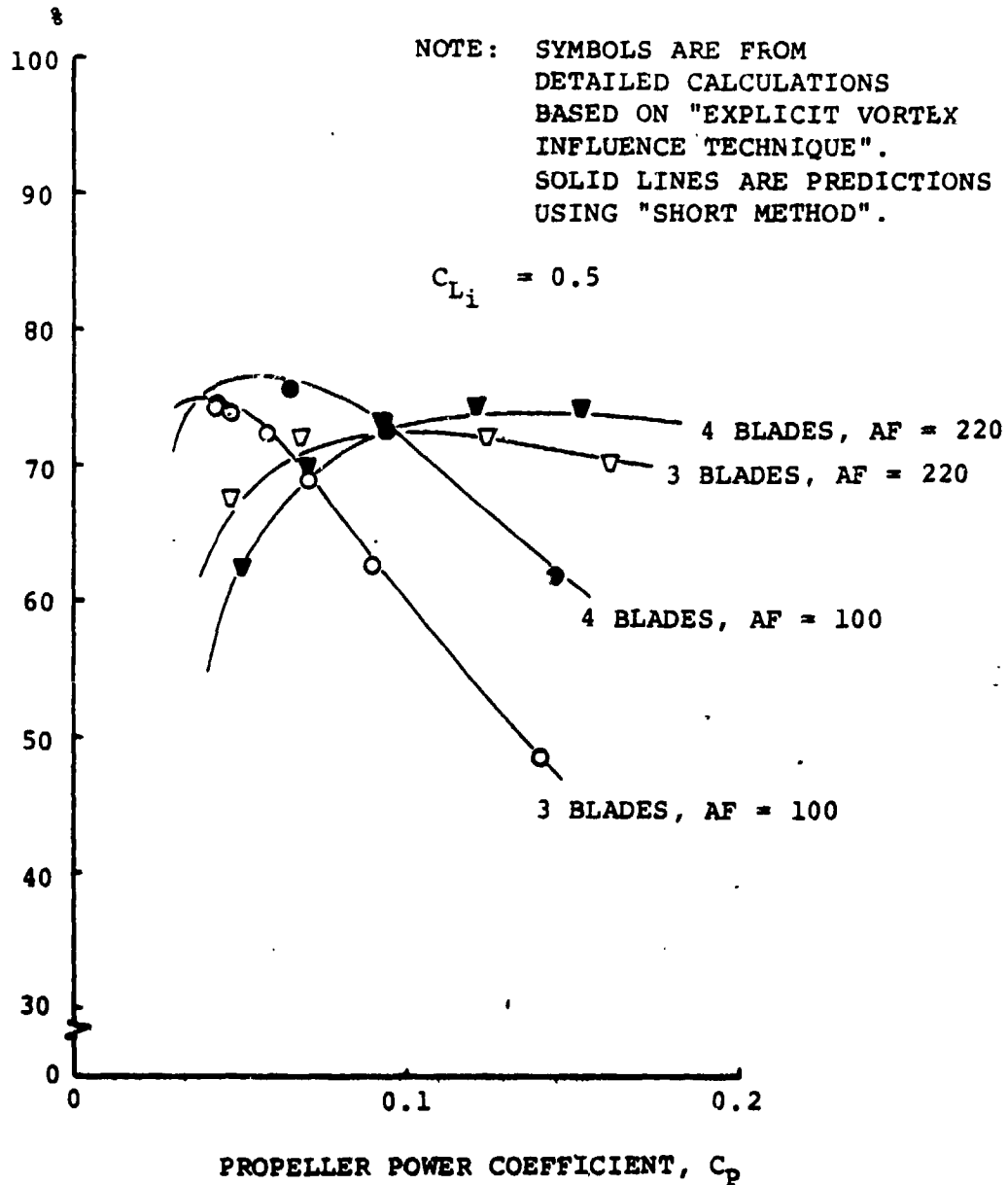
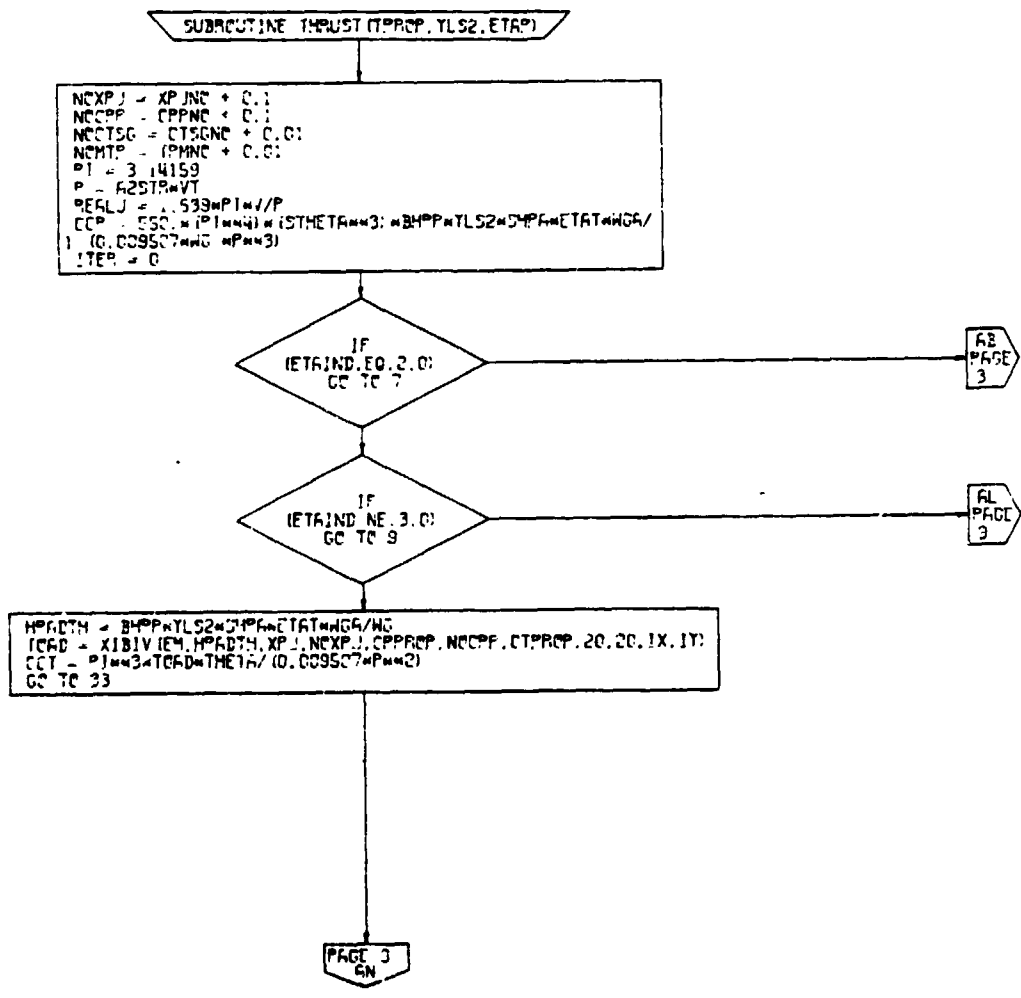


Figure 4-16. Comparison of "Short Method" and Detailed Calculation for Propeller Rover Efficiency.



PAGE 2  
THRUST

Figure 4-17. THRUST Subroutine, Flow Chart (Part 1 of 7)

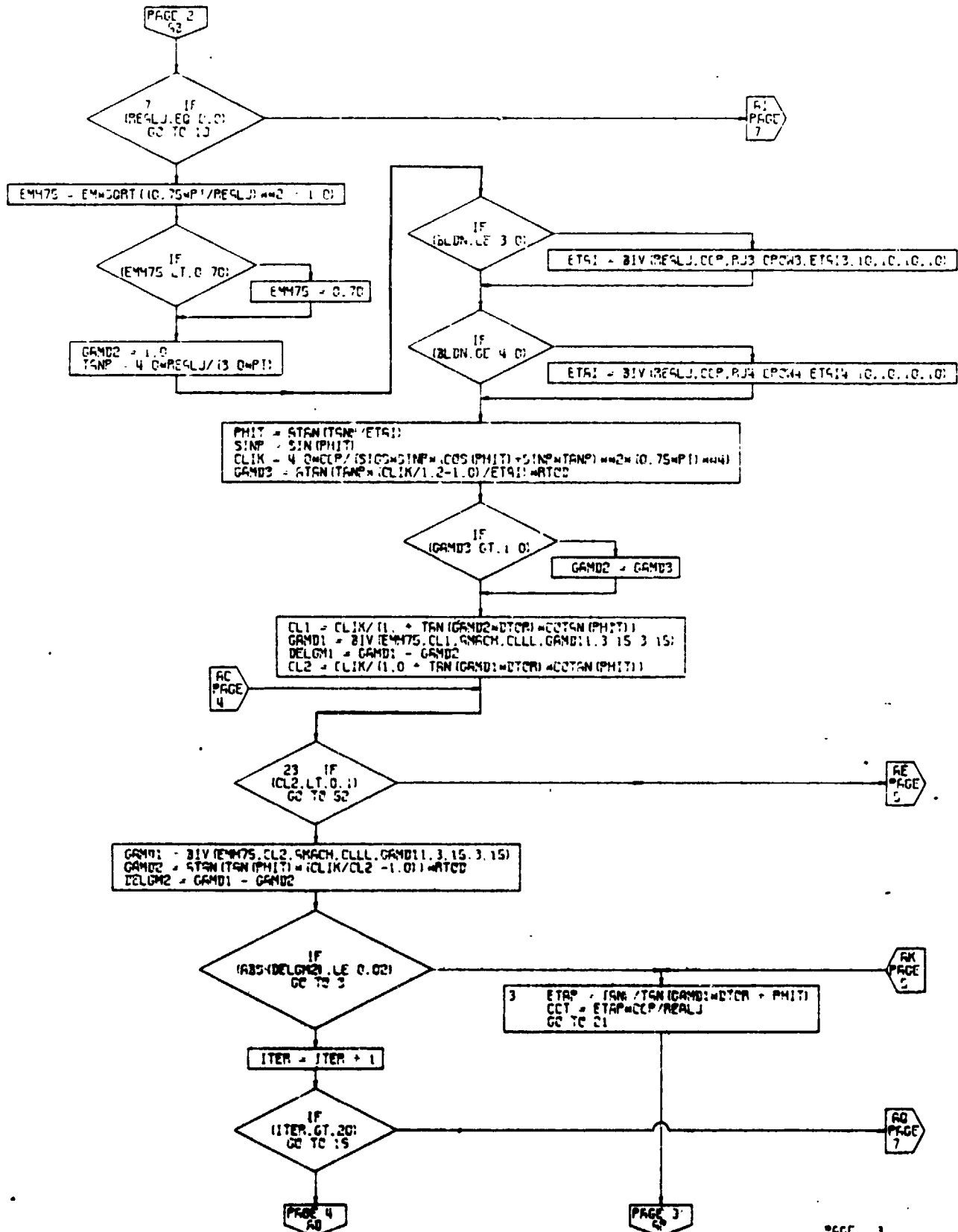
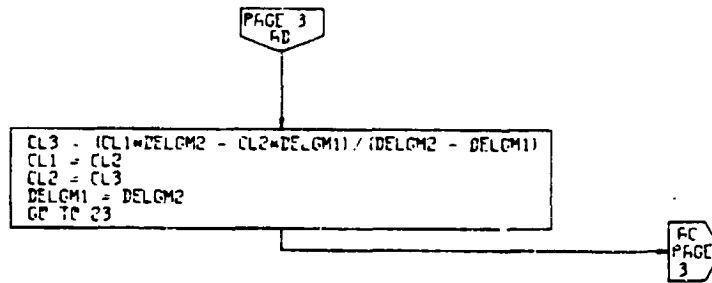
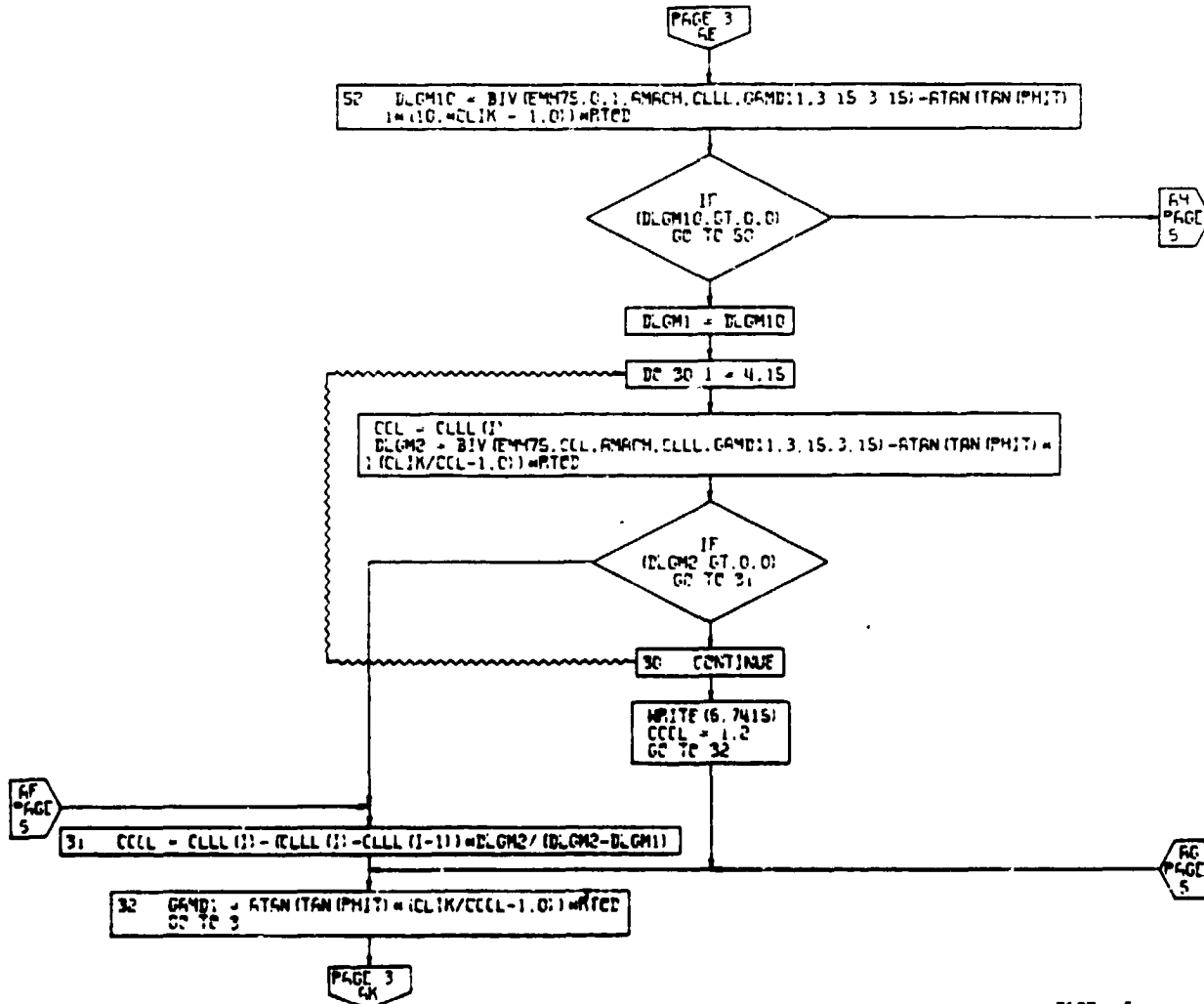


Figure 4-17. THRUST Subroutine, Flow Chart (Part 2 of 7)

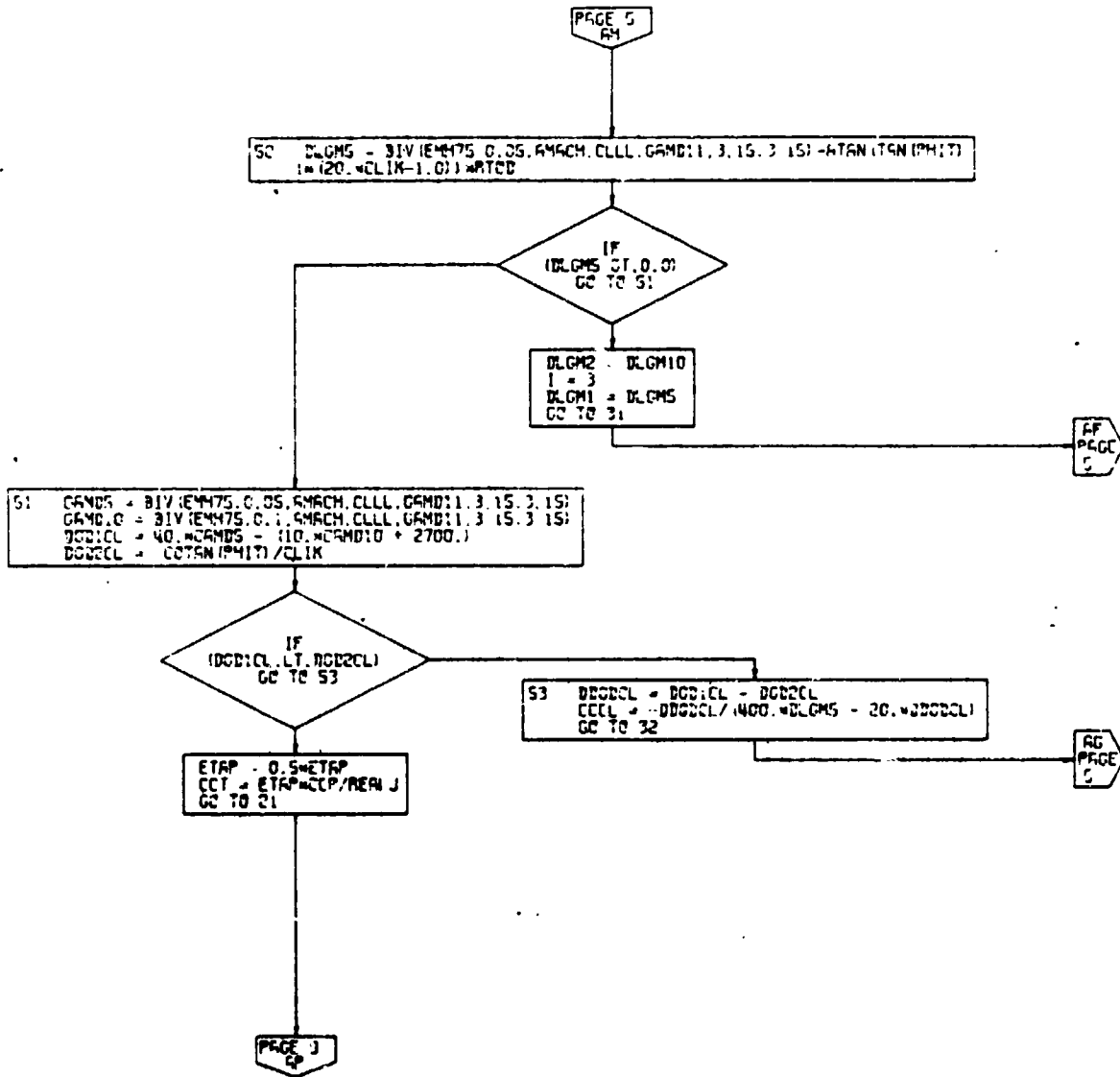


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Figure 4-17. THRUST Subroutine, Flow Chart  
(Part 3 of 7)



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THRUST

Figure 4-17. THRUST Subroutine, Flow Chart  
(Part 4 of 7)

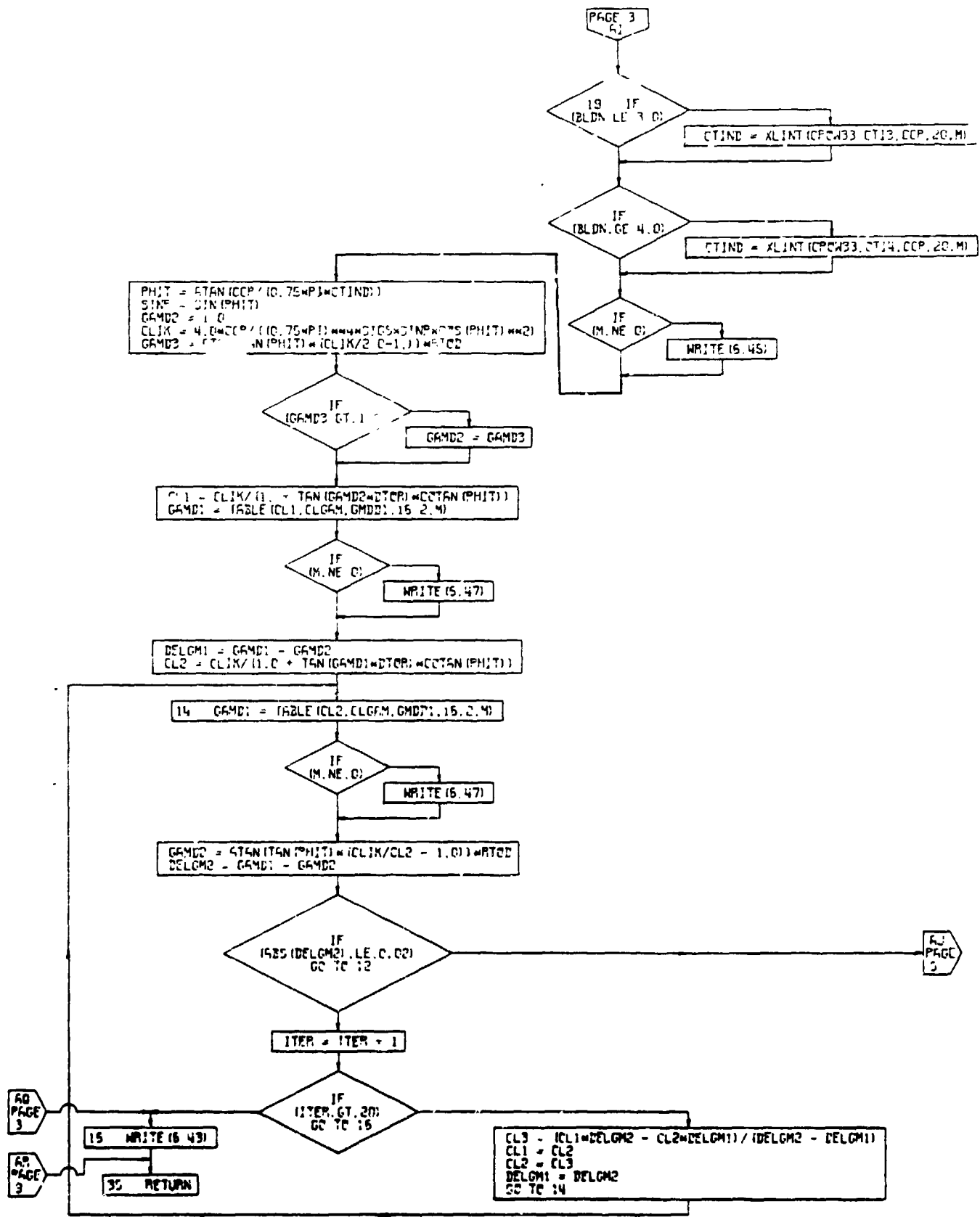


Figure 4-17.

THRUST Subroutine, Flow Chart  
(Part 5 of 7)

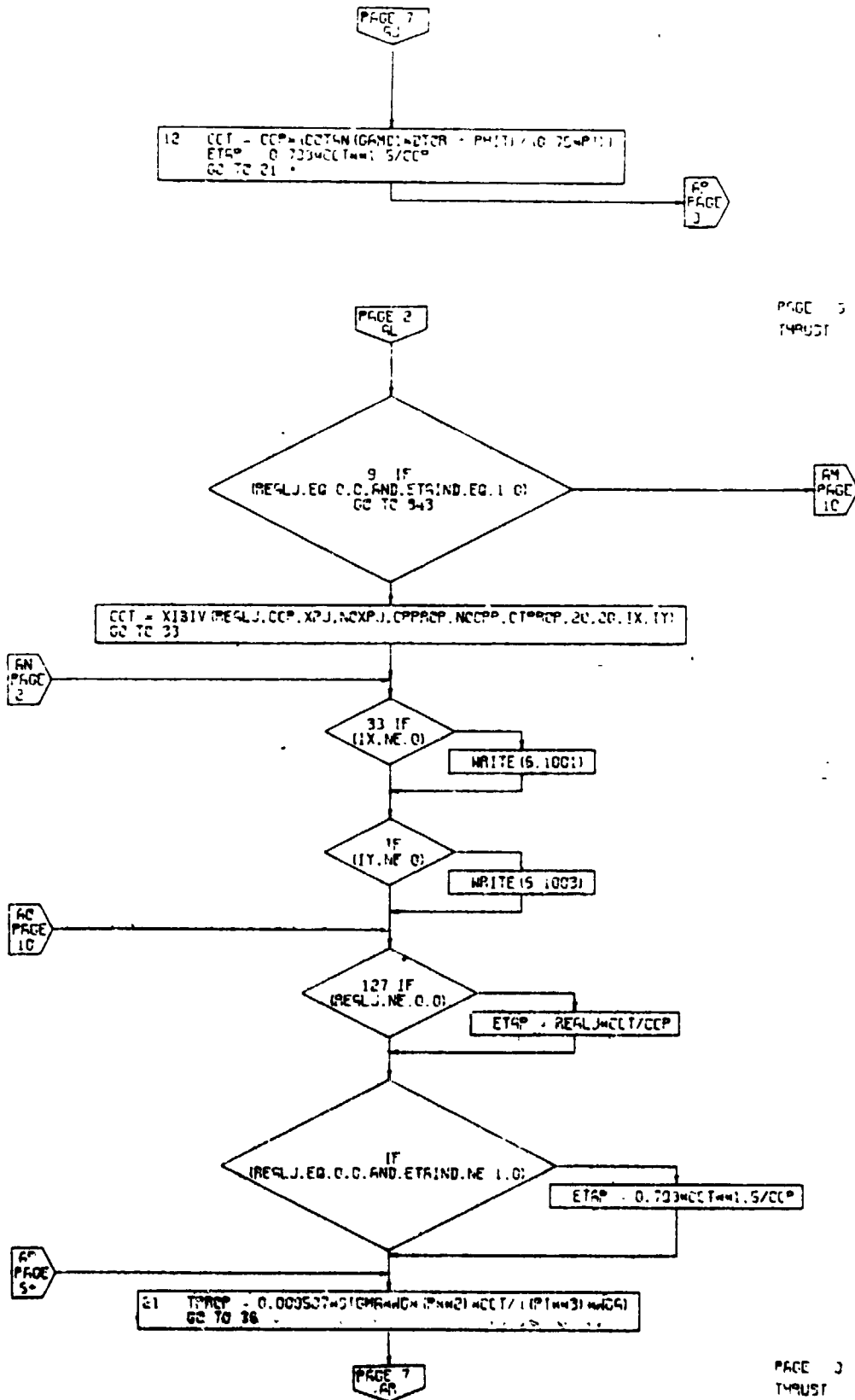
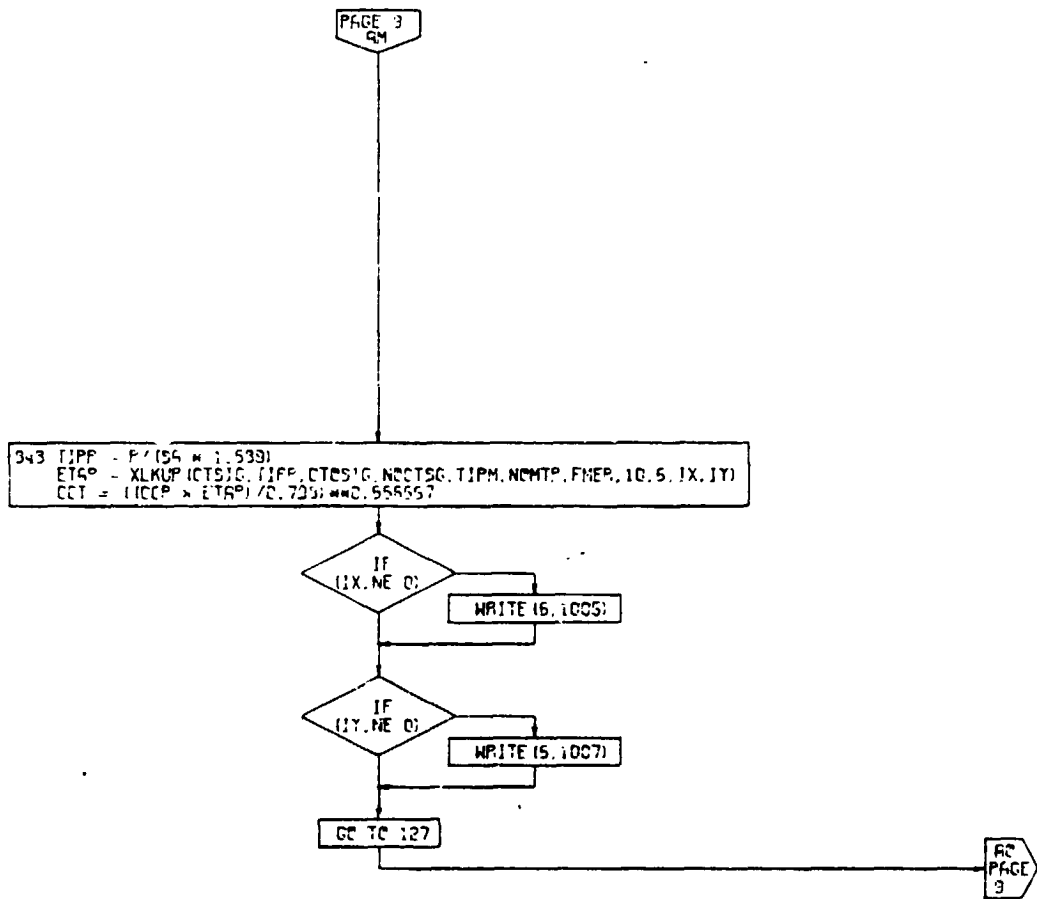


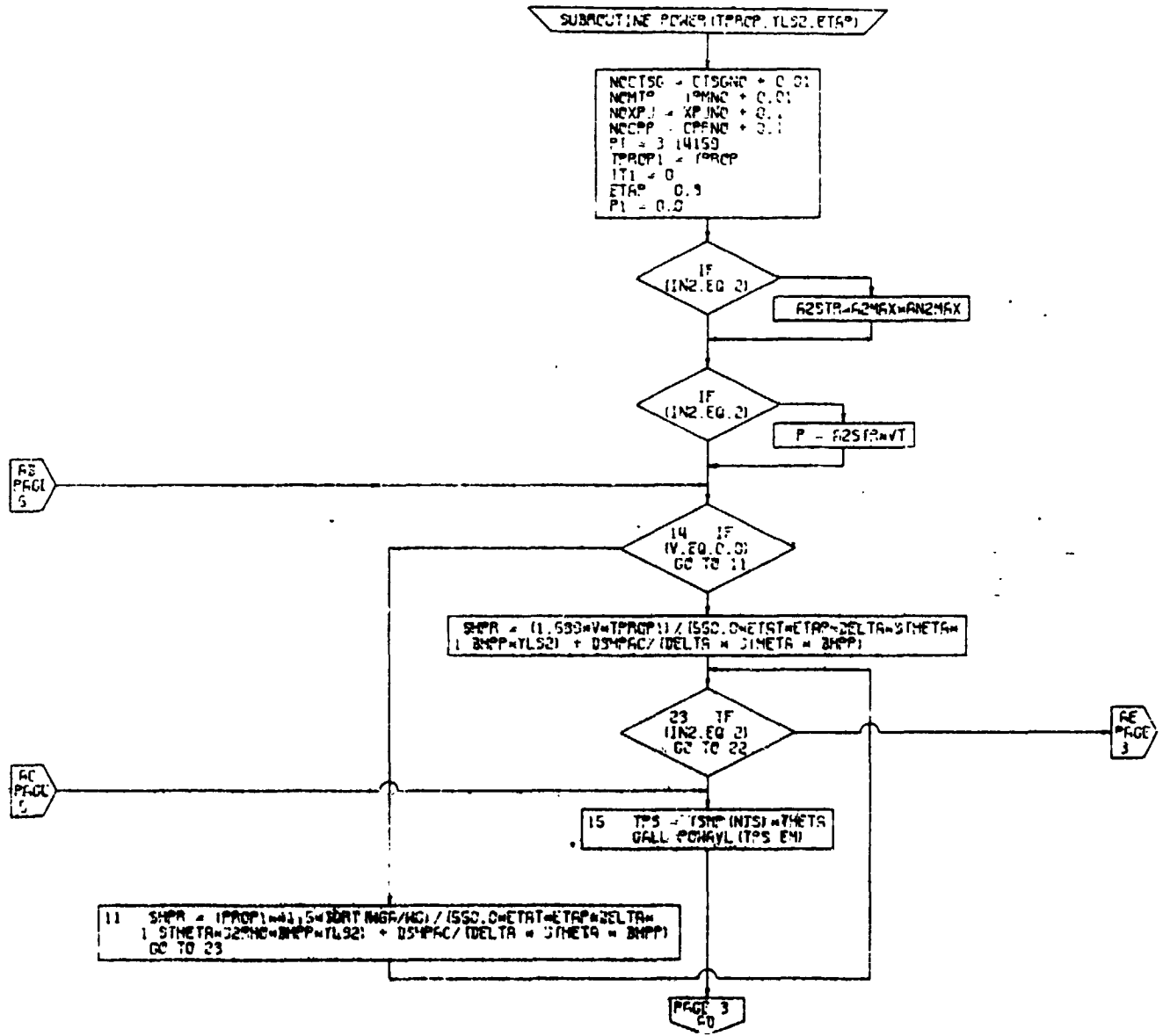
Figure 4-17. THRUST Subroutine, Flow Chart  
(Part 6 of 7)



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THRUST

Figure 4-17. THRUST Subroutine, Flow Chart  
(Part 7 of 7)

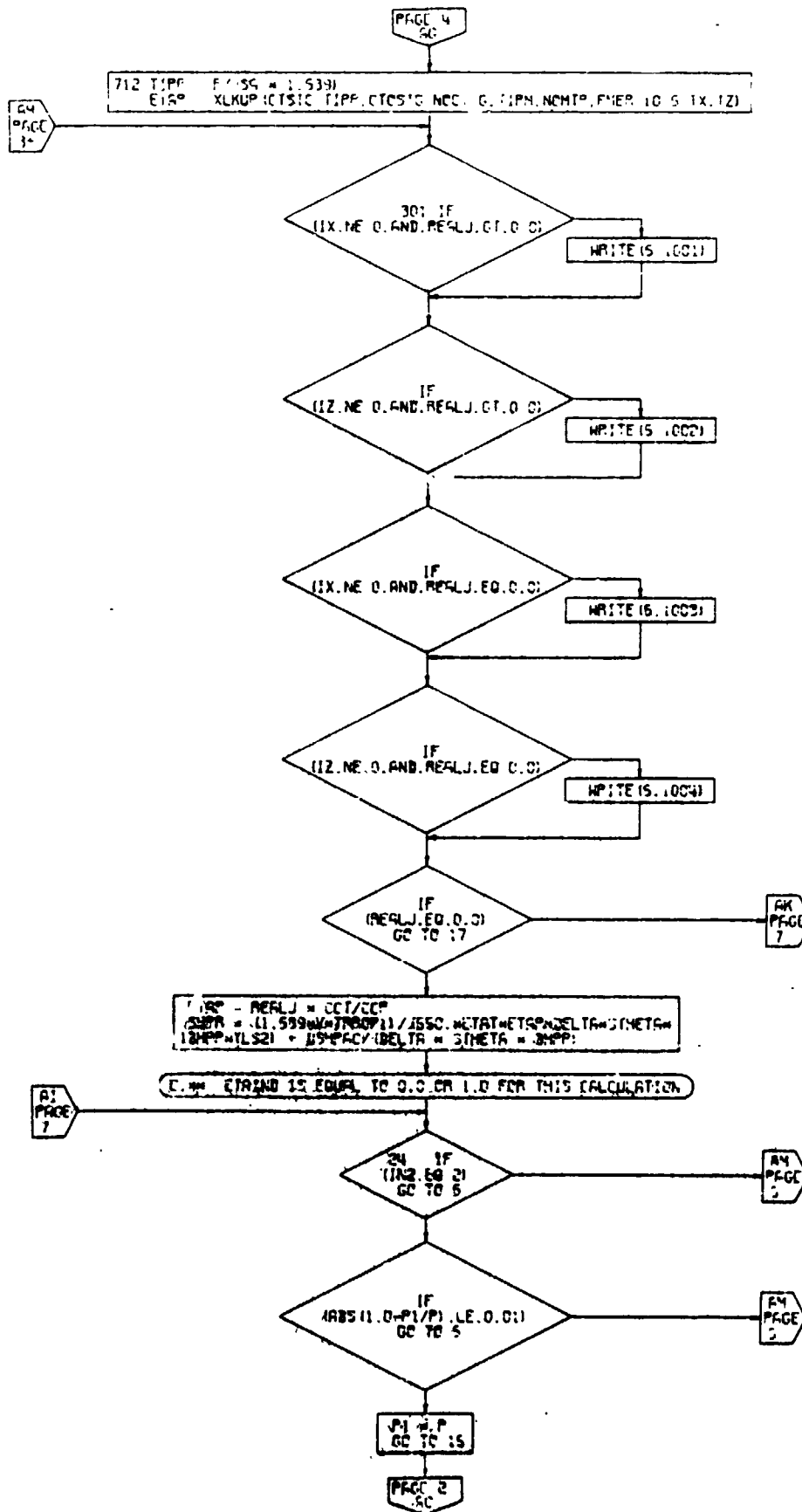




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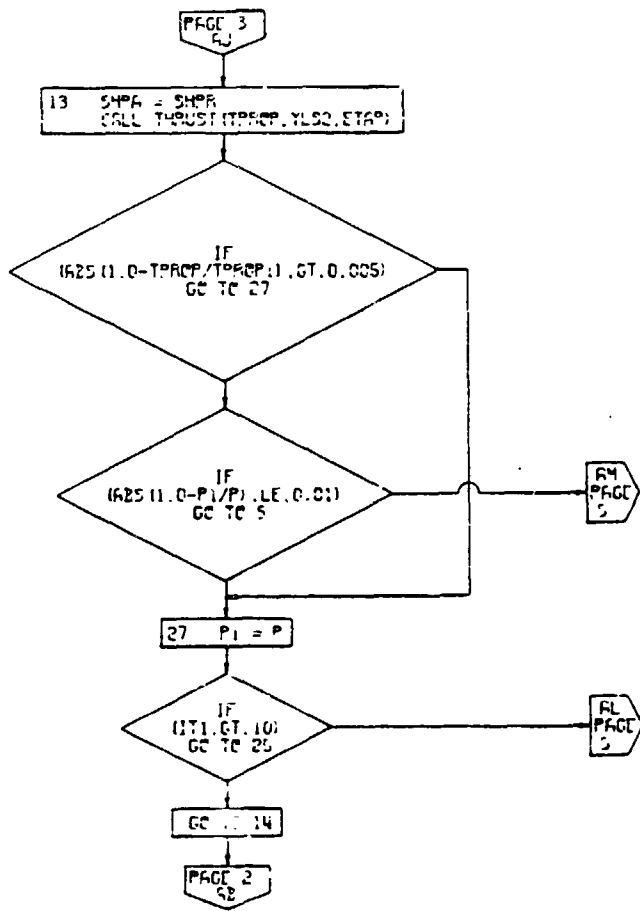
Figure 4-18. POWER Subroutine, Flow Chart (Part 1 of 5)



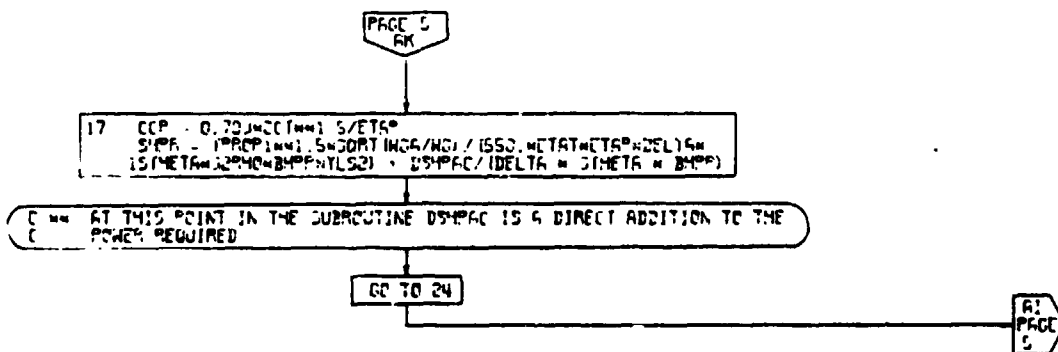


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POWER

Figure 4-18. POWER Subroutine, Flow Chart  
(Part 3 of 5)



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POWER



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POWER

Figure 4-18. POWER Subroutine, Flow Chart  
(Part 4 of 5)

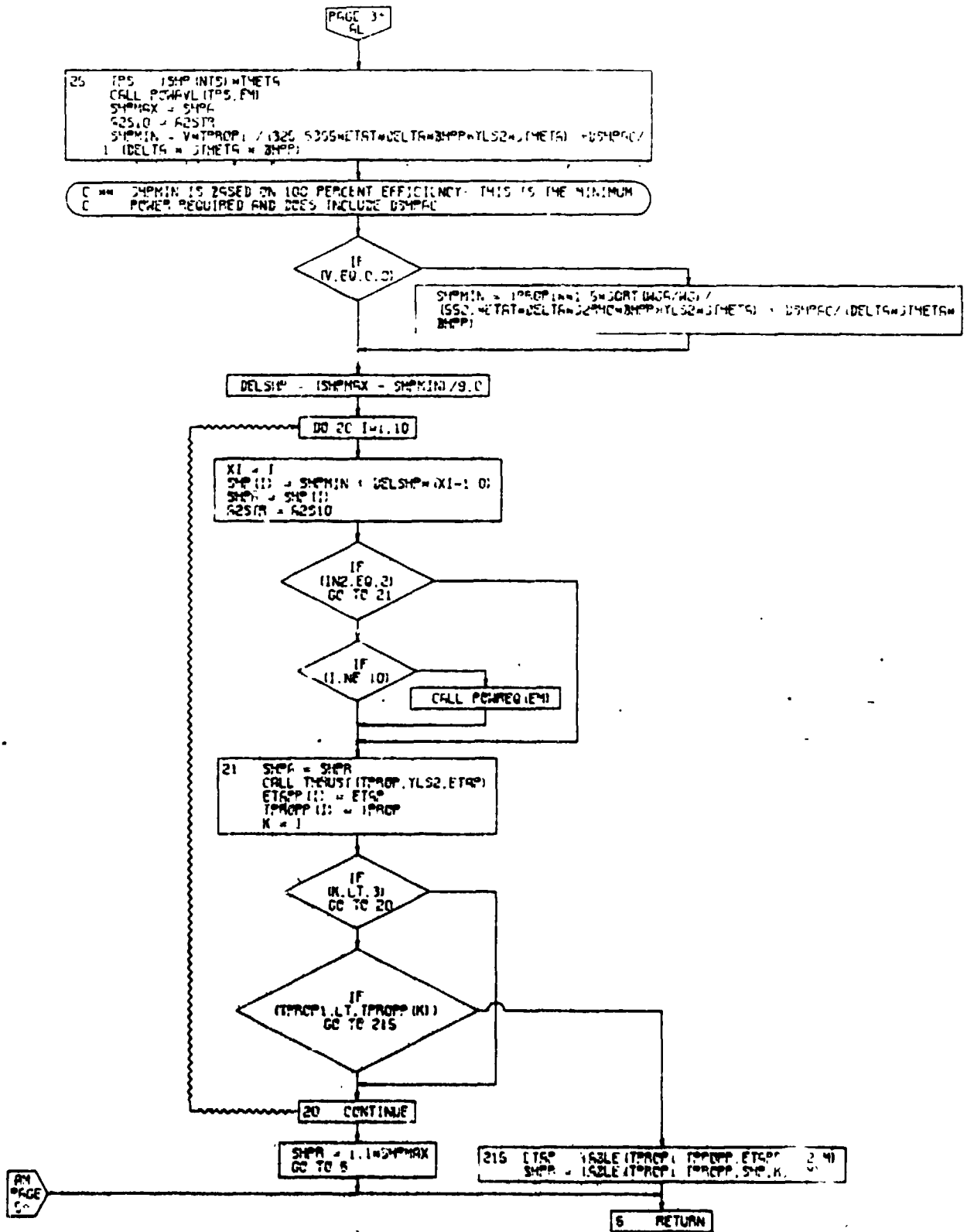


Figure 4-18. POWER Subroutine, Flow Chart (Part 5 of 5)

TABLE 4-4

COEFFICIENTS FOR PROPELLER EQUIVALENT POLARS

COEFFICIENTS FOR HOVER:

C <sub>L</sub>	b <sub>1</sub>	b <sub>2</sub>	b <sub>3</sub>
0	90	0	0
.15	2.68	-5.4836	13.5125
.2	1.9141	-2.9393	8.012
.3	1.513	-2.7523	5.8118
.4	1.5304	-3.0648	4.8132
.5	1.9611	-4.5374	5.3846
.6	2.7089	-6.8293	6.8072
.7	3.8237	-10.0965	9.3267
.8	5.051	-12.558	10.7333
.9	7.3796	-18.5171	15.8002
1.0	9.13	-19.35	15.5

COEFFICIENTS FOR CRUISE:

C <sub>L</sub>	M <sub>H</sub>	a <sub>0</sub>	a <sub>1</sub>	a <sub>2</sub>	M <sub>H</sub>	a <sub>0</sub>	a <sub>1</sub>	a <sub>2</sub>	M <sub>H</sub>	a <sub>0</sub>	a <sub>1</sub>	a <sub>2</sub>
0	0.7	90.	0.	0.	0.8	90.	0	0	0.9	90.	0.	0.
.05	0.7	7.0392	-1.9949	61.2416	0.8	10.2148	2.4433	86.4731	0.9	11.3227	40.9515	21.9481
.10	0.7	4.8350	-4.1639	19.2195	0.8	8.3106	-22.6338	56.0	0.9	11.3355	-14.062	52.0142
.15	0.7	3.2218	-1.7030	8.291	0.8	5.4623	-14.9997	35.3636	0.9	8.3676	-12.2425	36.0889
.20	0.7	2.7551	-2.5322	7.0366	0.8	4.0458	-9.9337	23.0606	0.9	6.5856	-9.574	25.9573
.3	0.7	2.481	-4.5422	7.3774	0.8	3.9439	-13.0524	22.0028	0.9	5.3862	-8.9808	18.0439
.4	0.7	2.4521	-5.4949	7.4251	0.8	3.6769	-11.7146	17.3803	0.9	5.2054	-9.3153	16.4063
.5	0.7	2.8149	-7.092	8.3401	0.8	3.8766	-12.0044	16.0882	0.9	6.1902	-14.7567	23.2672
.6	0.7	3.875	-10.861	11.4678	0.8	4.5901	-13.8756	17.2451	0.9	8.153	-25.0375	39.117
.7	0.7	5.6653	-16.2691	15.8093	0.8	6.1044	-18.2607	21.8349	0.9	10.1745	-30.7342	51.0509
.8	0.7	8.5799	-24.8115	22.6773	0.8	8.9031	-26.0958	30.7056	0.9	13.0822	-33.2211	58.1494
.9	0.7	12.25	-33.6185	28.7271	0.8	12.2042	-29.4588	34.1515	0.9	16.5344	-34.9378	64.3529
1.0	0.7	17.0496	-43.061	33.8798	0.8	17.0398	-37.3809	43.697	0.9	20.8089	-40.6314	76.3927
1.1	0.7	21.8332	-47.8821	33.6322	0.8	22.784	-47.3791	55.5455	0.9	25.6453	-49.145	94.4326
1.2	0.7	31.7062	-49.6246	26.4923	0.8	28.7851	-57.8217	68.2121	0.9	33.5049	-77.6449	144.4176

The calculations of propeller performance for  $\eta_{pIND} = 1$  and 2 are based on the assumption that the engines are interconnected by a cross shaft. That is, if engines are shut down during cruise and loiter the remaining power is evenly distributed to all of the propellers.

#### Accuracy of Propeller Performance Calculation for $\eta_{pIND} = 2.0$

The propeller performance calculation subroutine using the Curtiss-Wright (modified) Short Method has a data base derived from extensive detailed calculations for a family of high disc loading V/STOL propellers. In order to confirm that the subroutine accurately represents the performance of this type of propeller, the comparison of Figure 4-19 was made between the "short method" calculation and detailed calculations for the propeller of the Vertol Model 170-544P tilt wing transport airplane. The prediction is very good and properly reflects the compromise between hover and cruise performance.

Figure 4-20 shows a comparison between the subroutine and a comparable data base for propellers specifically designed for cruise applications. The data were obtained from the Hamilton Standard "Red Book." Such propellers would be designed with a greater amount of twist than a V/STOL propeller and consequently the data base of the propeller calculation subroutine may not be expected to give accurate predictions in this case. However, as shown in Figure 4-20, the subroutine predicts cruise efficiency only slightly lower than the Red Book and exhibits the same trends.

As an additional comparison, the subroutine has been used in an attempt to predict the performance of a low disc loading prop-rotor. Because of the relatively small amount of blade twist associated with the low disc loading prop-rotor the data base used in the subroutine does not result in accurate performance predictions. This is shown in Figure 4-21 where the subroutine calculations are compared with detailed calculations. As might be expected, the subroutine underpredicts hover performance and overpredicts the cruise performance for this propeller.

The data base for the subroutine was derived from detailed calculations for a family of moderate to high disc loading V/STOL propellers. A similar set of data could be prepared for other propellers, such as the low disc loading prop-rotor, which would allow accurate performance predictions by the subroutine for these propellers.

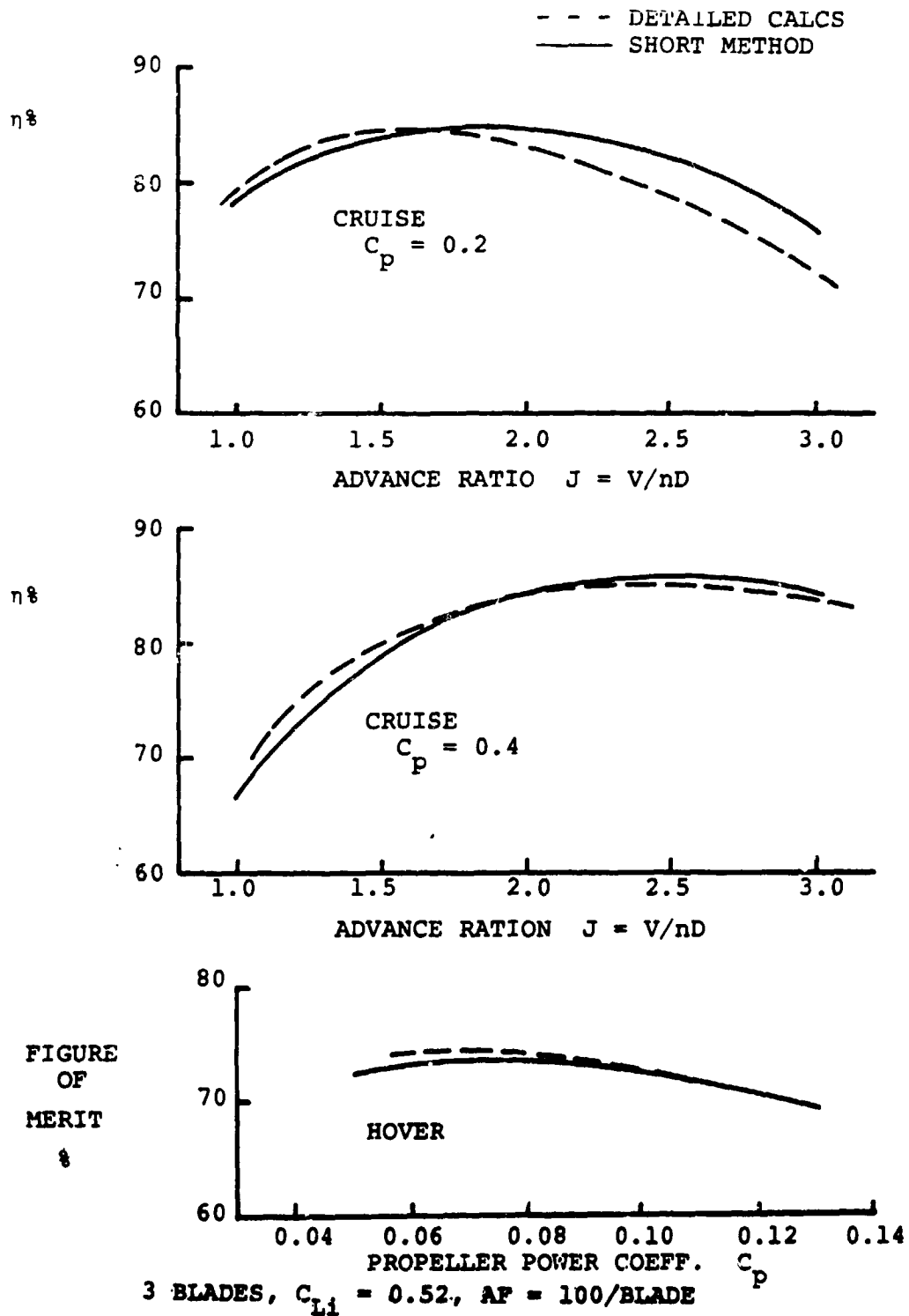
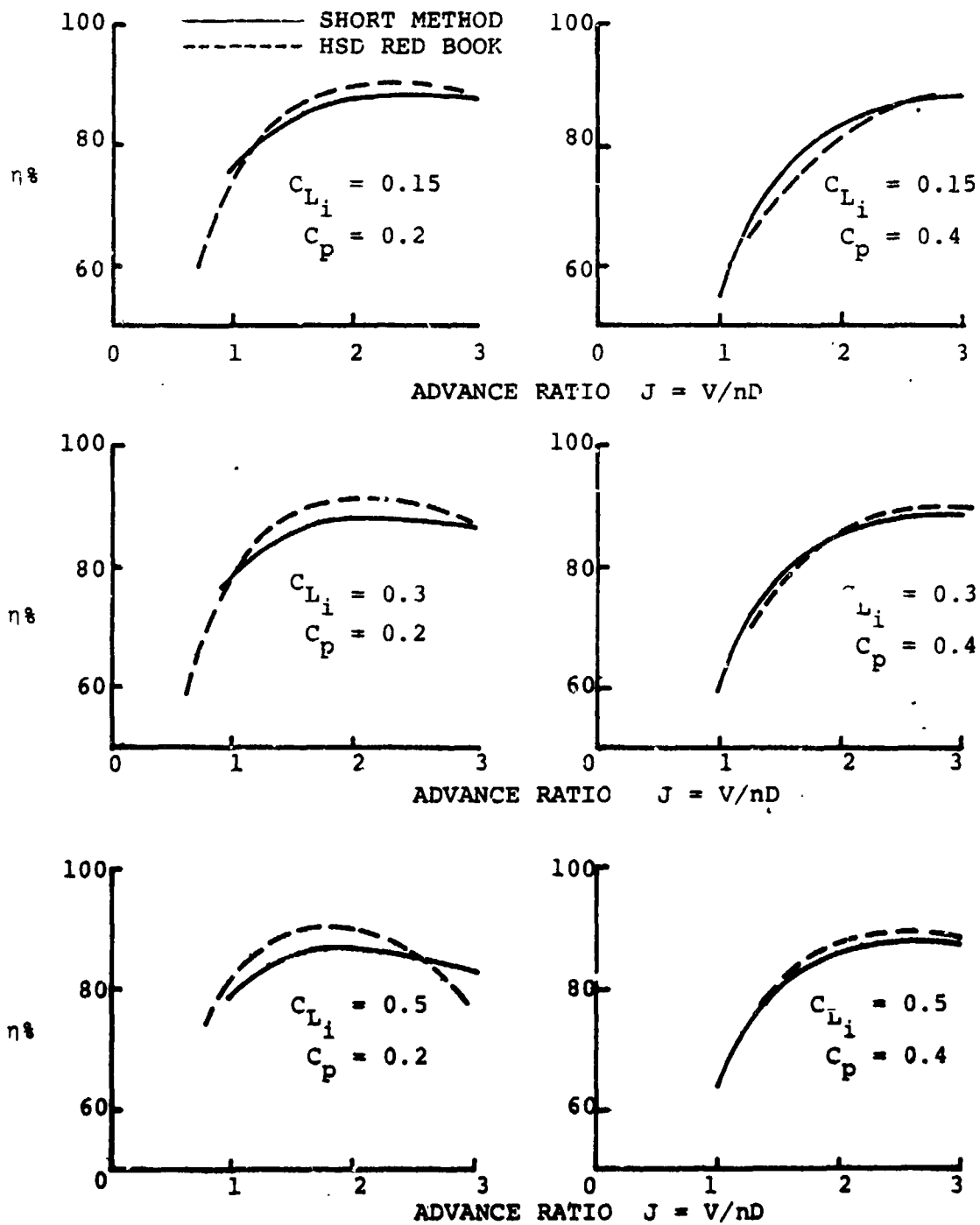


Figure 4-19.  
V/STOL PROP FOR VERTOL MODEL 170- 544P TILT WING

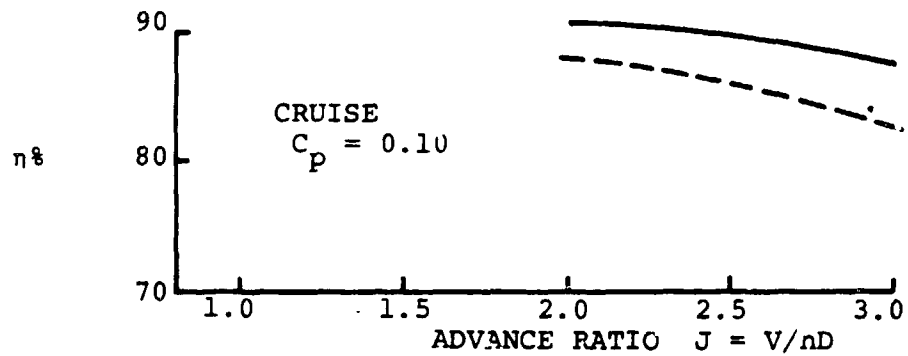
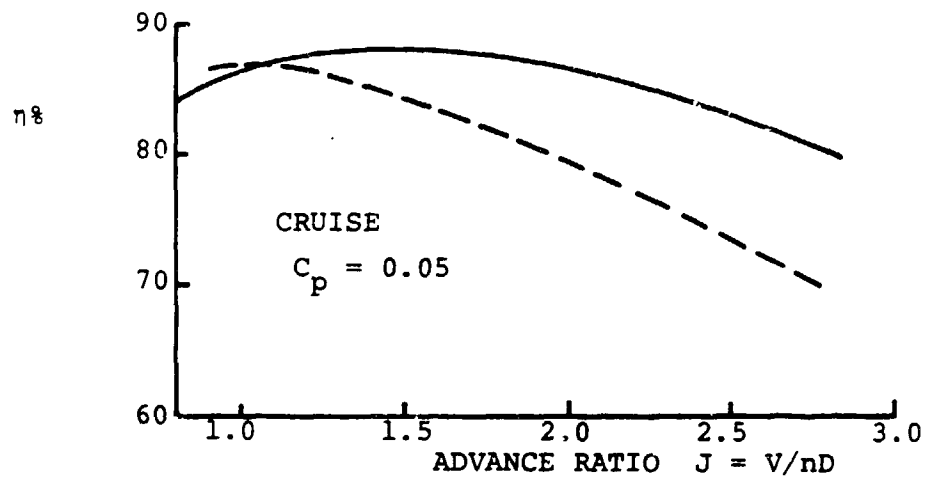




4 BLADES, ACTIVITY FACTOR = 100/BLADE

Figure 4-20. Comparison of Short Method vs Hamilton Standard Red Book Data

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PROP ROTOR -----  
 DES. DISC LDG = 10 PSF  
 $C_{L_i} = 0.22$ , 3 BLADES  
 AF = 64 PER BLADE  
 SHORT METHOD -----

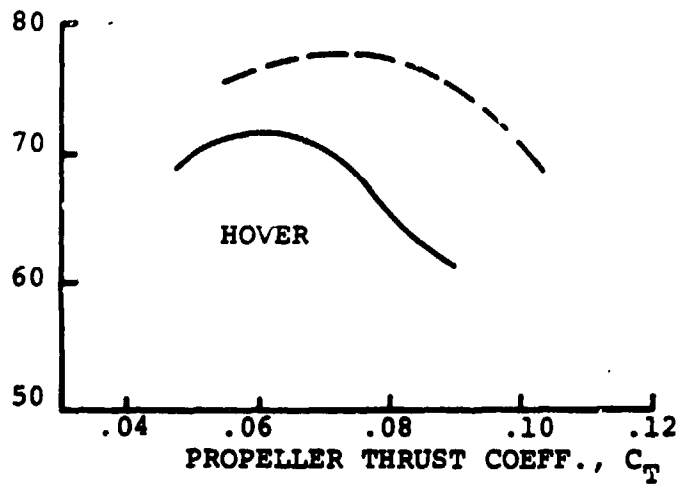


Figure 4-21. Performance Predictions of Low Disc/Loading Prop/Rotors

$\eta_p \text{IND} = 3.0$  This option allows the user to input a fan performance table similar to the propeller performance table used for  $\eta_p \text{IND} = 1.0$ . The ducted fan performance is supplied to the program in the form of a table of referred power as a function of forward flight Mach Number and referred thrust:  $\text{SHP}/A_2 \delta \sqrt{\theta} = (M, \text{TA}_2 \delta)$  where  $A_2$  is the annulus area of the fan.

To use the ducted fan option, the user must provide the following inputs:

- $\eta_p \text{IND} = 3.$  in LOCATIONS 0200
- Fan Table Number in LOCATIONS 1700, 0256
- Number of Mach Numbers in LOCATION 1701
- Number of Referred Thrusts in LOCATION 1722
- Tabulated Values of Mach Number in LOCATIONS 1702 through 1721
- Tabulated Values of  $T/A_2 \delta$  in LOCATIONS 1723 through 1742
- Tabulated Values of  $\text{SHP}/A_2 \delta \sqrt{\theta}$  in LOCATIONS 1743 through 2142
- A zero input of  $k_{R/p}$  in LOCATION 0457
- An appropriate value of  $k_{TM}$  in LOCATION 0408

The above data may be input using the Propeller/Fan data input sheets, and the Weights input sheet provided in Chapter 5.

No changes have been incorporated to calculate the weight of ducted fan systems and it is considered that the weight equations associated with the propeller inputs would give an inaccurate estimate. To avoid using the propeller weight equations,  $k_{R/p}$ , LOCATION 0457, should be input as zero. The weight of a ducted fan system can be calculated by use of the variable input  $k_{TM}$ , which is nominally the weight factor for the tilt mechanism on a tilt wing or tilt rotor aircraft. This constant calculates a weight which is proportional to the aircraft gross weight. Since the weight of a ducted fan is approximately proportional to the design thrust and the design thrust is determined by a design thrust to weight ratio, choice of a suitable value for  $k_{TM}$  allows the user to obtain a reasonable estimate of the weight of the ducted fan system.

In propeller or rotor calculations within VASCOMP, the reference area employed is the total disc area and is calculated from inputs of either disc loading or diameter and the number of propellers or rotors. In order to obtain accurate values of  $A_2$  for ducted fan calculations, the user must either (i) scale the fan performance data so that the reference area is  $A$  (the disc area) rather than  $A_2$ , the annulus area, or (ii) use input values of disc loading or diameter that will ensure that the calculated reference area is equal to the annulus area. Two options are available. When  $\text{PDMIND}$  (Location 0005) is 1 or 3, the user must input a "Diameter" in Location 0226. To make the reference area  $A (= N \pi D^2 / 4)$  equal to the annulus area of the fan, a value of  $D = N(D_T^2 - D_R^2)$  must be used, where  $D_T$  and  $D_R$  are the tip and root diameters of the fan, respectively.

In cases where PDMIND is 2 or 4, the user must input the "fan loading" ( $= W_G/A_2$ ) in Location 0225 rather than disc loading. The calculated value of diameter will be the effective value,  $N(DT^2 - DR^2)$ .

#### DISCUSSION OF PROPULSION EFFICIENCY

The final selection of a propeller blade design to best suit a given V/STOL aircraft mission is a rather arduous task because the suboptimization of many considerations such as propeller efficiency, propeller weight, power transmission system weight, powerplant performance, and others is required for each mission segment followed by an overall mission optimization. A single propeller design does not satisfy the requirements for optimum performance in every mission segment. That is, the design optimized for best hovering performance is not also the best climb or cruise segment design.

The basic problem faced in evolving a single propeller design to satisfy all flight conditions is that of achieving the optimum blade loading for each of the flight conditions. This is virtually impossible due to the degree and manner in which thrust required and power available vary with engine and vehicle speeds. From an aerodynamic viewpoint, this basic problem manifests itself in terms of problems associated with blade chord, twist and design  $C_{Lj}$  distributions, engine-propeller performance matching, and compressibility.

Propeller blade loading is a function of the spanwise distribution of blade twist, blade chord, and blade section design lift coefficient. These three parameters must be employed so as to yield the optimum propeller performance at a given flight condition. This will occur when each section of the blade is adjusted to operate at or near its maximum lift-drag ratio while maintaining an optimum spanwise load distribution. As the operating conditions vary, the degree to which near optimum conditions can be maintained changes for a fixed blade geometry. Therefore, some compromise must take place, and best efficiency cannot be achieved at each and every operating condition.

As one can appreciate, with fixed blade geometry the attainment of overall propeller optimization is somewhat limited with regard to what can be aerodynamically achieved with twist, solidity, and design lift coefficient. Furthermore, changing these variables results in variations in blade centrifugal twisting moment, hub centrifugal loads, blade pitch control loads, and numerous other items which result in either operational envelope limitations or weight constraints. Variable blade geometry can result in aerodynamic improvements, but these may well be offset by increased weight and cost. Variable geometry

propeller blade development and application, furthermore, have been quite limited.

The ability to alter propeller speed in cruise with respect to hover will help the designer cope with blade loading problems and result in better mission efficiency. This can be done either by using a multiple speed power transmission system between the engine and propeller or by exercising the variable output shaft speed capability of free turbine powerplant. The former method is generally not used due to weight penalties, while the latter method is extensively employed. Engine-propeller matching, though, is not as simple as it may sound, and transmission torque requirements and weight increase with reduced turbine speed.

The combination of vehicle speed, propeller speed, diameter and altitude produce a constraint in the form of Mach number. Exceeding a helical tip Mach number of about 0.95 appears to significantly reduce propeller efficiency.

Current state of the art regarding propeller aerodynamics appears to permit very accurate appraisal of a given propeller design's performance over most of the flight envelope. Performance prediction capability is generally inadequate in the following areas: (1) static thrust (e.g., relating to the pure hovering flight mode), (2) at moderate to high propeller shaft angles of attack (say 30 to 90 degrees), and (3) under the "mixed" flow conditions where the blade sections are in neither wholly subsonic nor wholly supersonic flows. For purposes of preliminary design, however, the short methods for predicting propeller performance available from propeller manufacturers (e.g., Curtiss-Wright and Hamilton Standard) generally produce acceptable results, and should certainly be given consideration.

Whenever possible, the aircraft designer should consult the propeller manufacturers and his own propeller staffs early in the preliminary design phase. Lacking this, he should freely exercise the methodology published by propeller manufacturers. These methods require only several minutes to manually compute a propeller performance point and are well worth the effort. Too many preliminary aircraft designs have proceeded too far assuming propeller efficiencies in excess of the ideal induced (i.e., zero drag) value.

4.6 SIZE TRENDS SUBROUTINE

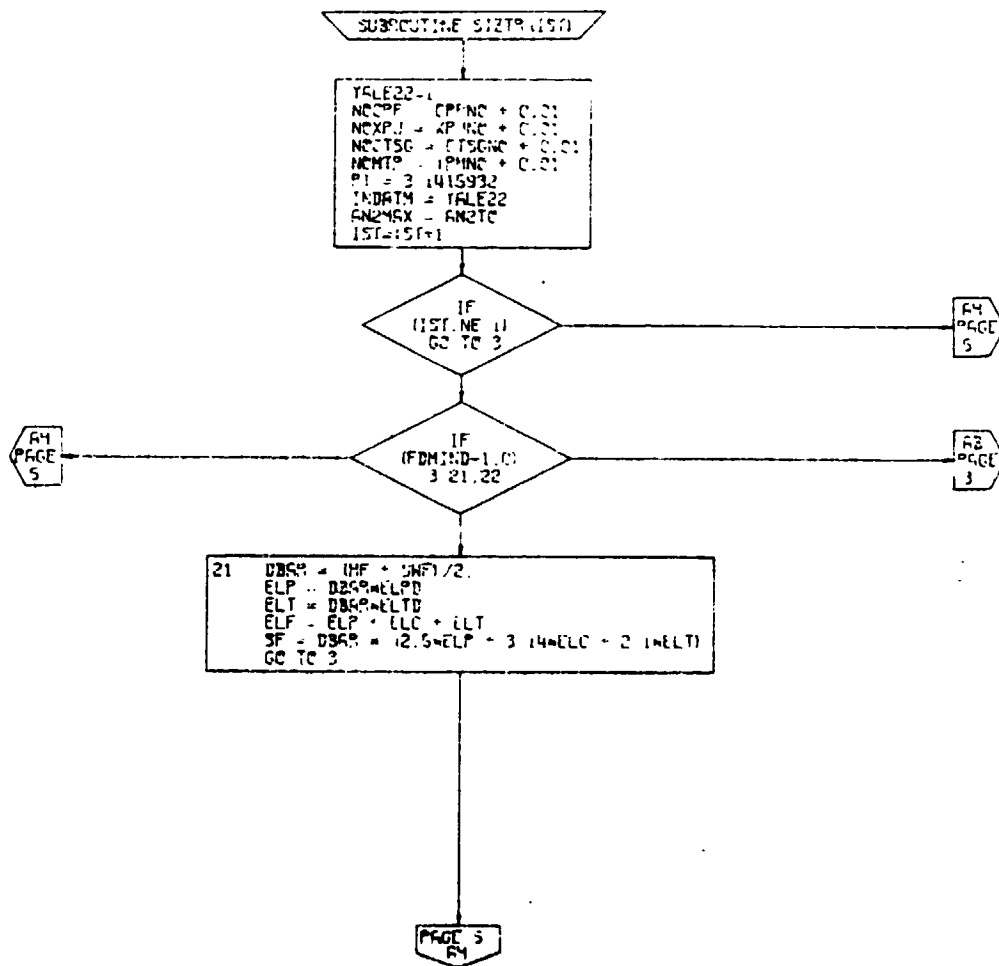
The size trends subroutine calculates the trends of the aircraft geometric dimensions as the weight of the aircraft changes throughout the iterative sizing loop. Figure 4-22 displays a flow chart showing the several options available within the size trends subroutine. The first of these is an option concerning the calculation of fuselage dimensions. The fuselage dimension option is specified by means of the input indicator FDMIND, the fuselage dimension indicator. This option permits the user to either input the length and wetted area of the fuselage or to have the program calculate these factors. If FDMIND = 1, the computer program will calculate the length and wetted area of the fuselage based upon input values of the cabin length, the cabin mean diameter, and the fineness ratio of the pilot's section and the tail section. If FDMIND = 0, the length of the fuselage and wetted area are input to the program by the user. This option is included in the program so that the user studying an aircraft of known fuselage dimensions can input the exact dimensions to the program.

If the fuselage dimension indicator is set to 2, the airplane fuselage will be sized to accommodate specified passenger requirements. The user inputs the required number of passengers, seats abreast, number of aisles, unit seat width, seat pitch, and aisle width. This data can be input for both first class and tourist service. Two different options are available for galleys and lavatories. Each is specified by means of an input indicator. Setting the galley indicator and/or lavatory indicator to 1 will permit the user to directly specify the galley area and/or the number of lavatories. A zero (0) input will force the program to use the following built-in trends:

Lavatories

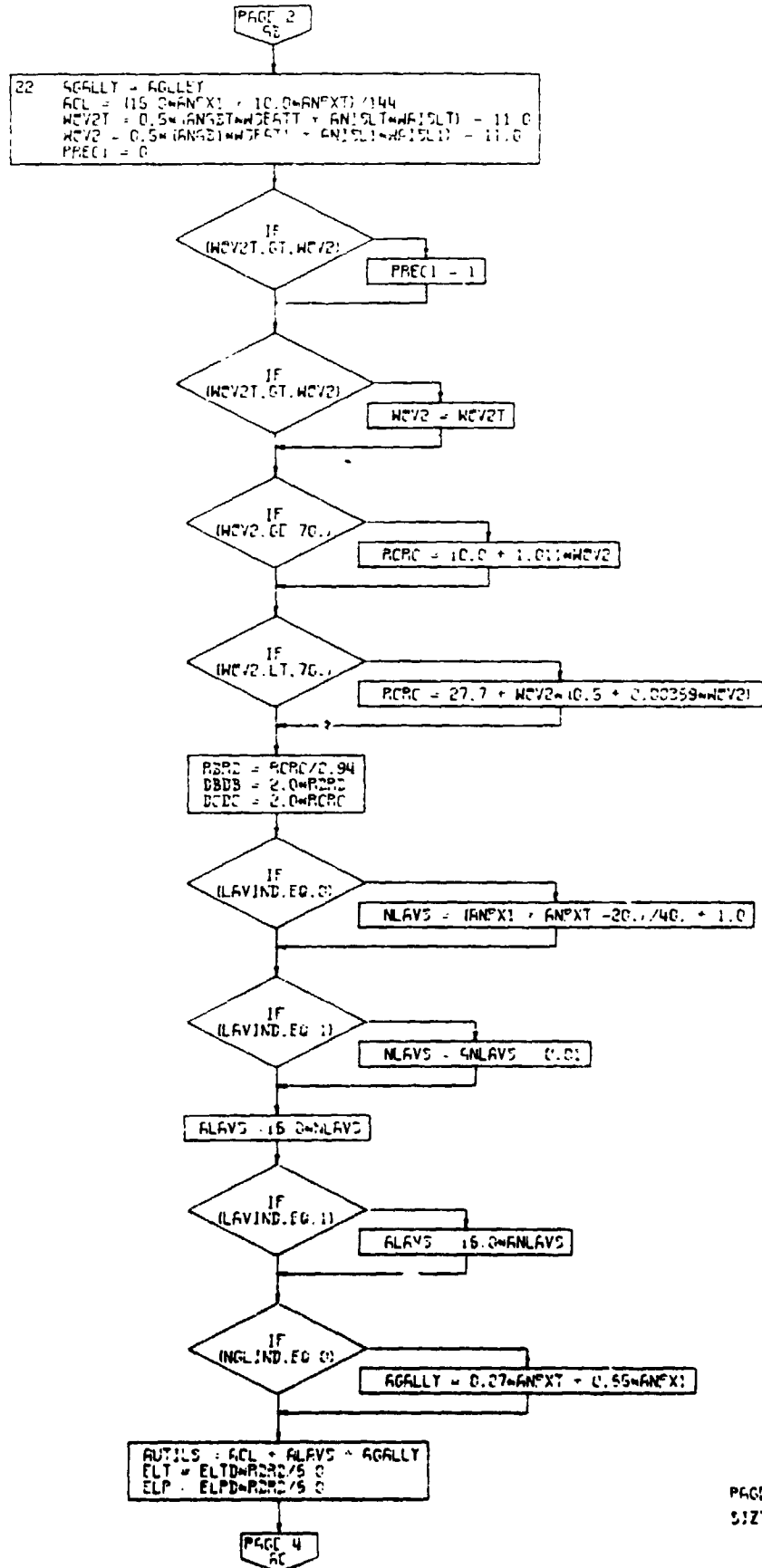
<u>No. of Passengers</u>	<u>No. of Lavatories</u>
0 + 59	1
60 + 99	2
100 + 139	3
140 + 179	4
etc.	etc.

The floor area required for lavatories is calculated at 16 square feet per lavatory.



PAGE 2  
SIZTR

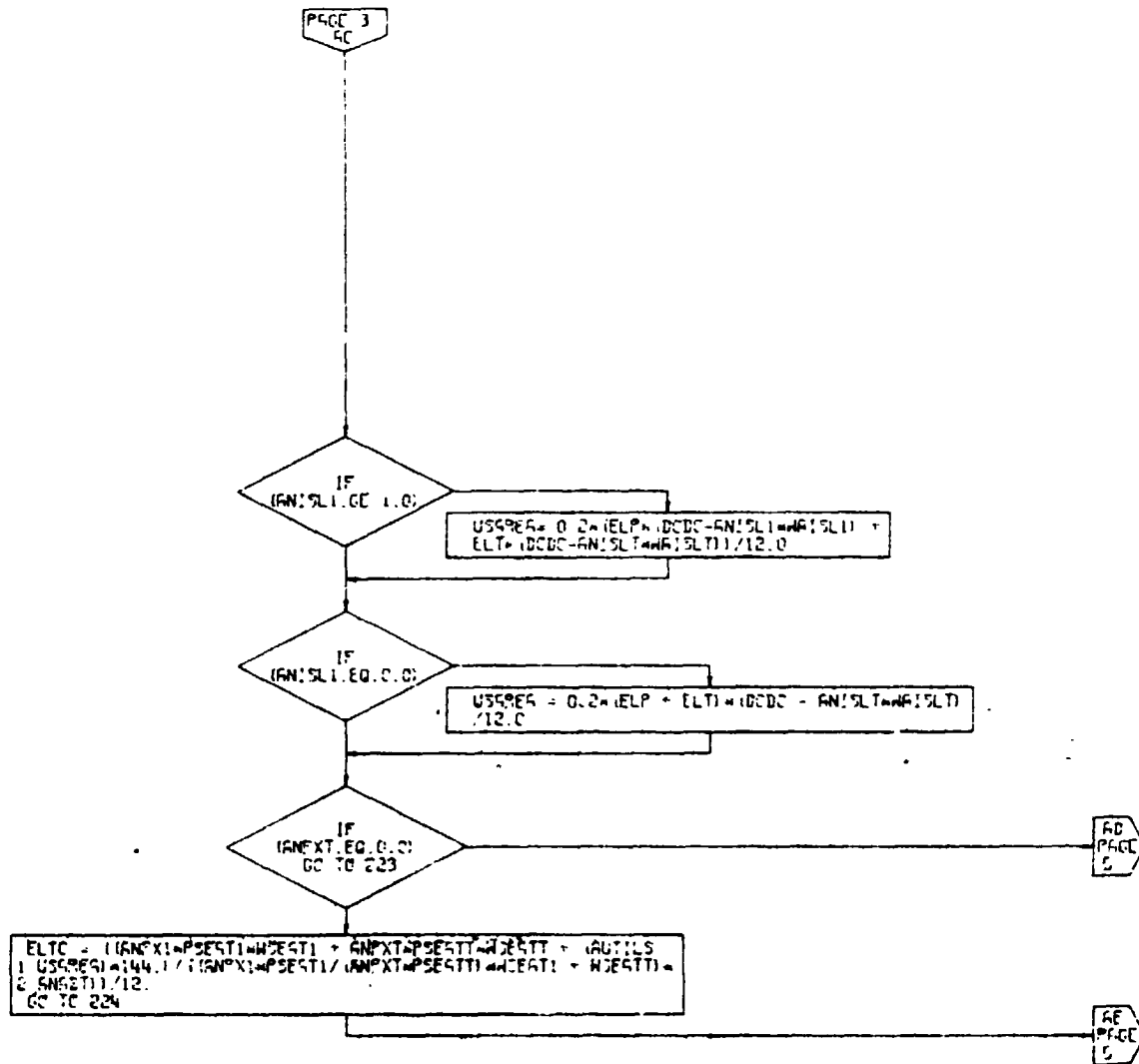
Figure 4-22. Size Trends Subroutine, Flow Chart  
(Part 1 of 13)



PAGE 3  
SIZTR

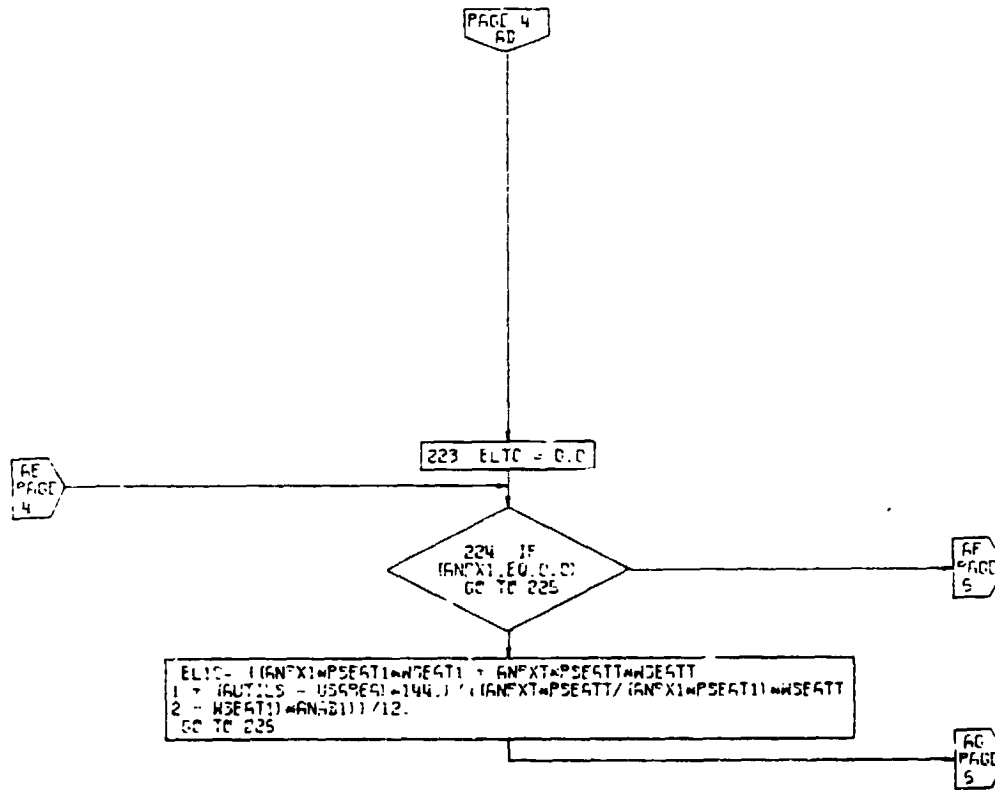
Figure 4-22. Size Trends Subroutine, Flow Chart (Part 2 of 13)  
4-90





PAGE 4  
SIZTR

Figure 4-22. Size Trends Subroutine, Flow Chart  
(Part 3 of 13)



PAGE 5  
SIZE

Figure 4-22. Size Trends Subroutine, Flow Chart  
(Part 4 of 13)

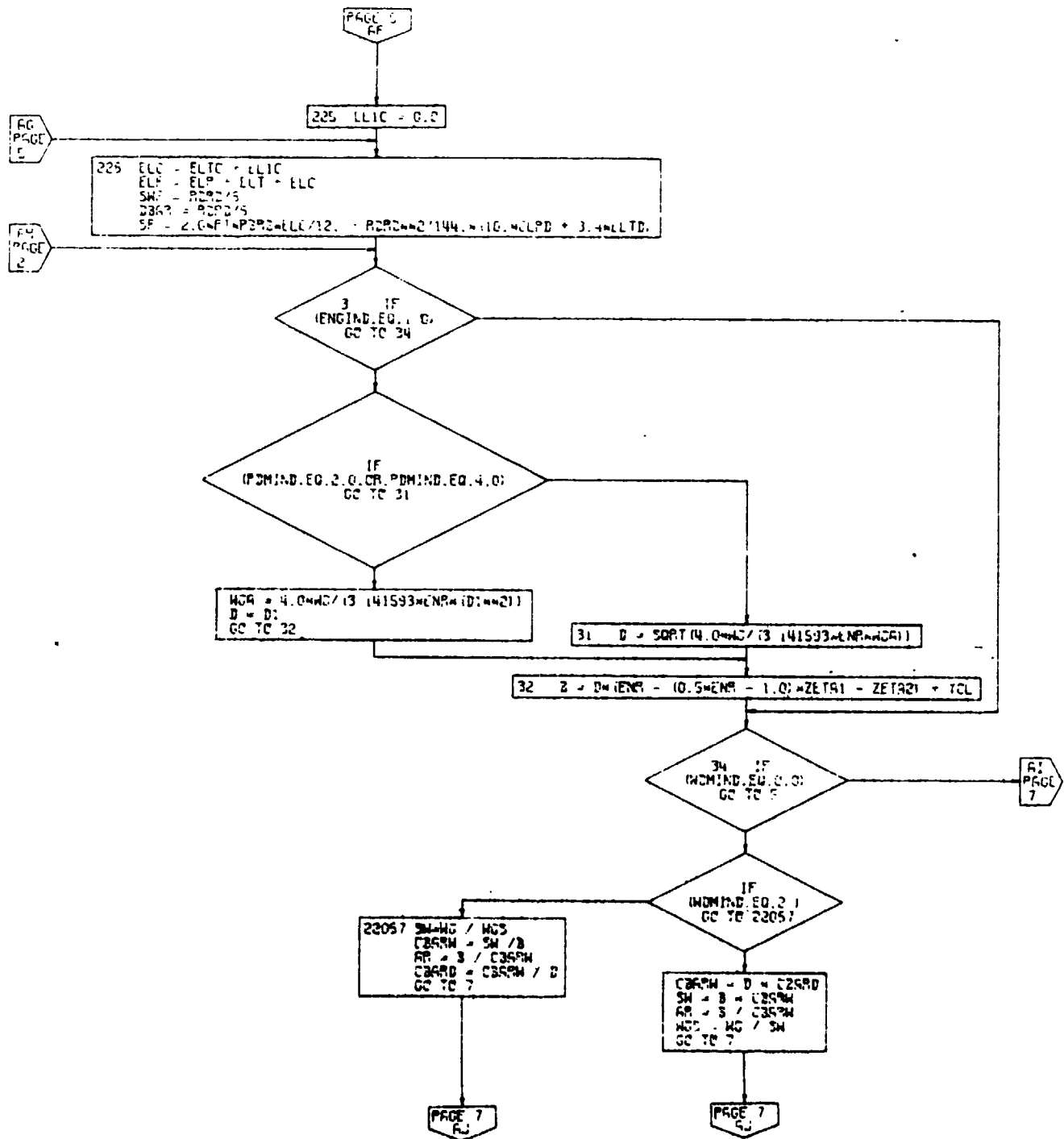
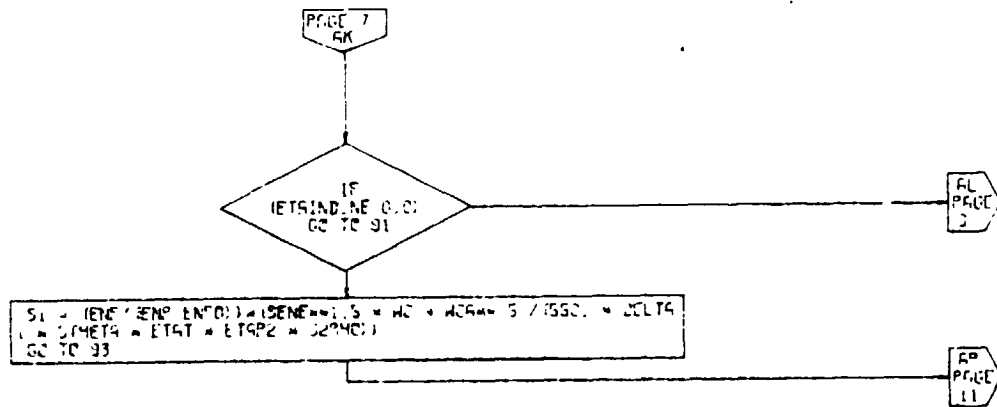


Figure 4-22.

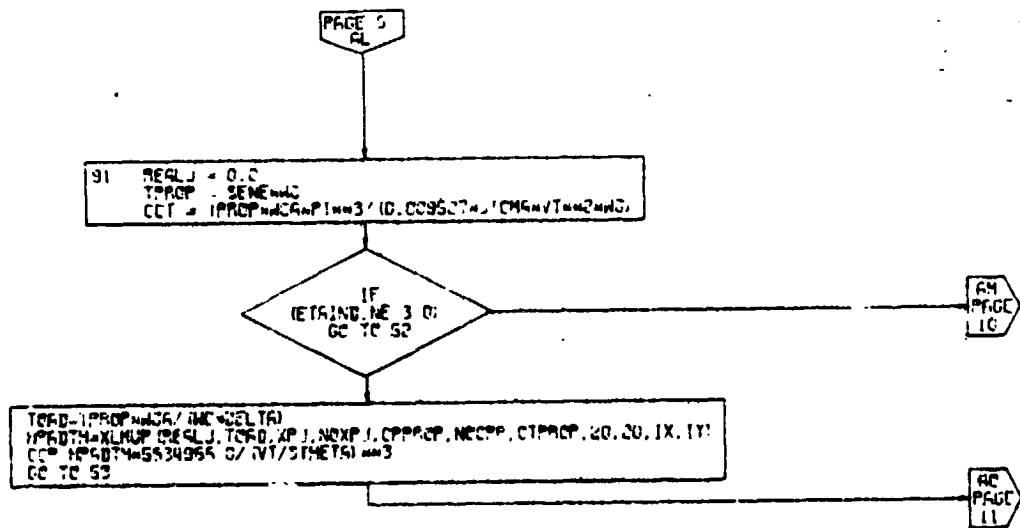
Size Trends Subroutine, Flow Chart  
(Part 5 of 13)

PAGE 5  
51279



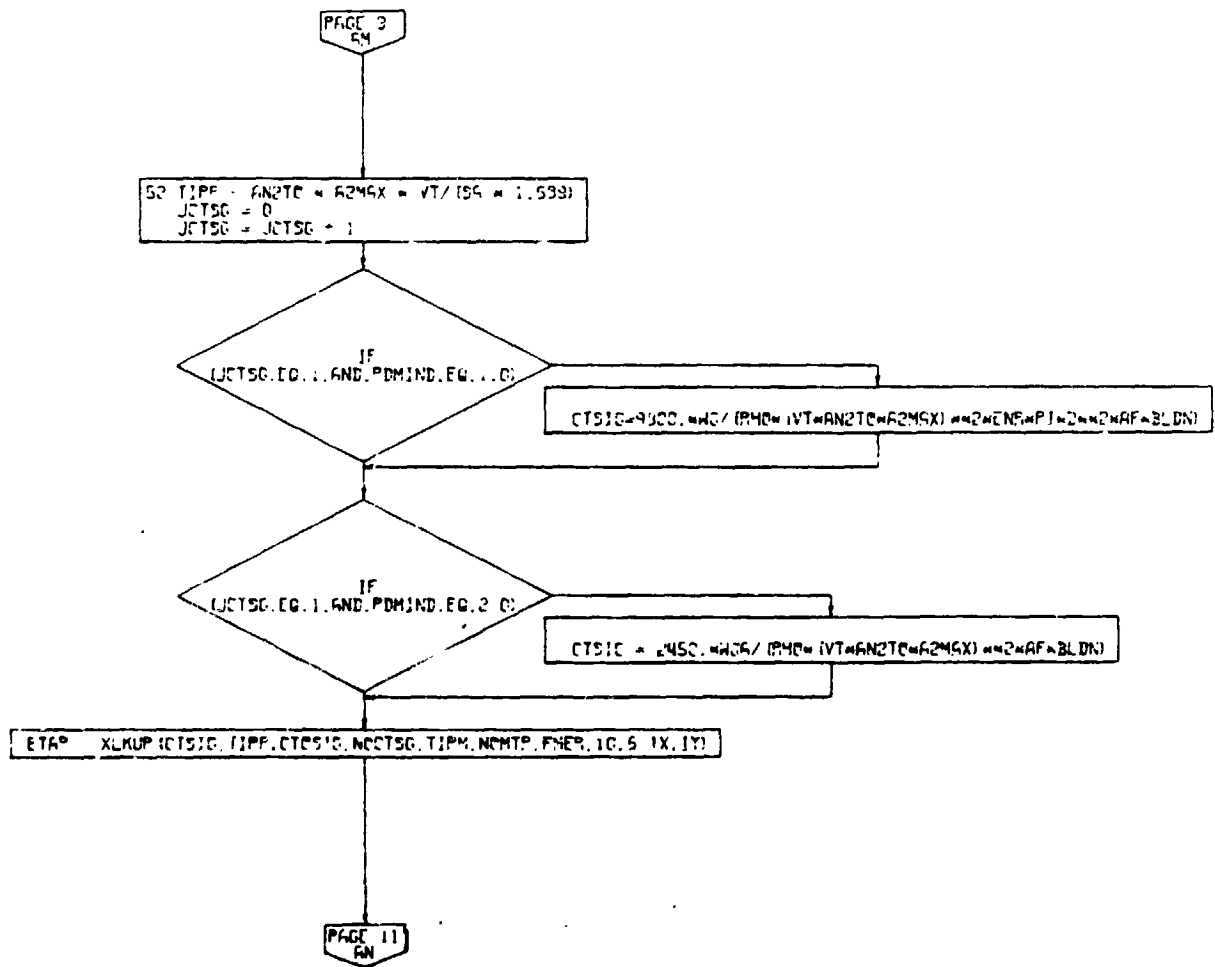


PAGE 2  
S1ZTR



PAGE 3  
S1ZTR

Figure 4-22. Size Trends Subroutine, Flow Chart  
(Part 7 of 13)



PAGE 10  
S12TR

Figure 4-22. Size Trends Subroutine, Flow Chart  
(Part 8 of 13)

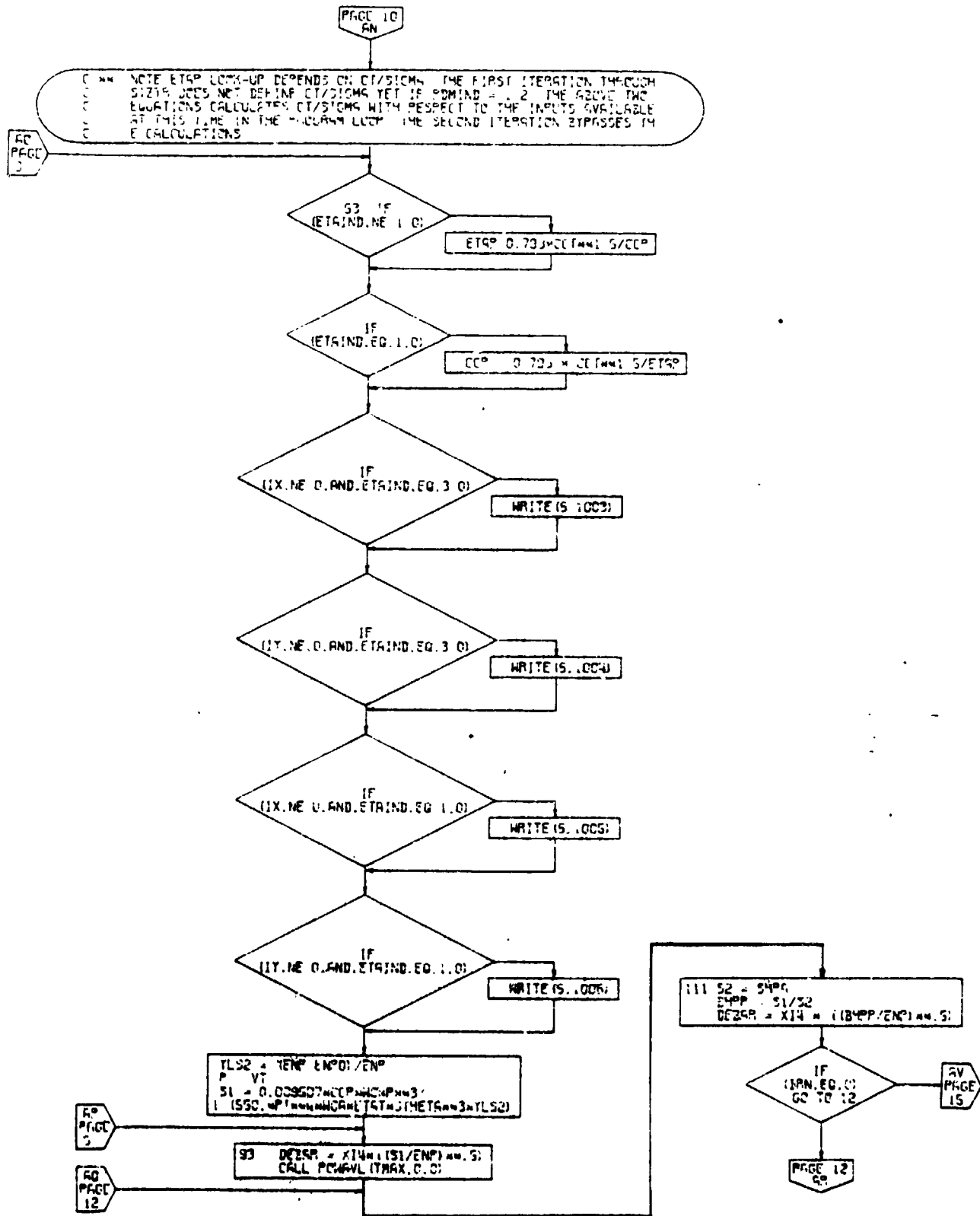
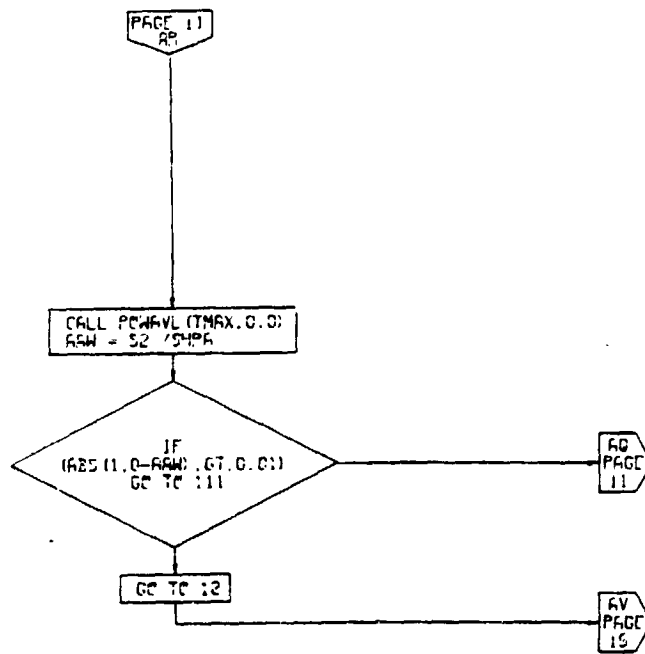


Figure 4-22. Size Trends Subroutine, Flow Chart (Part 9 of 13)

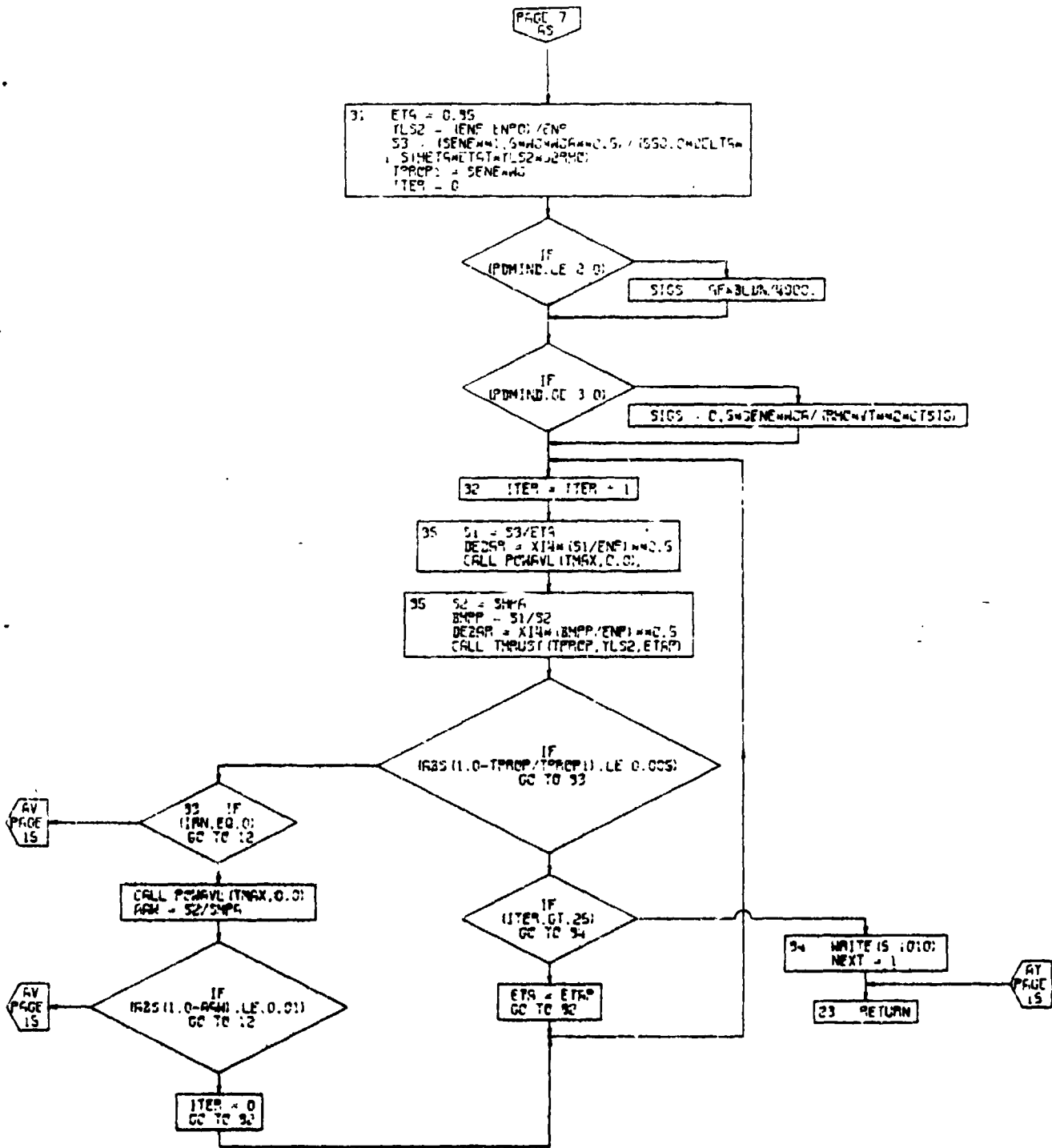
PAGE 11  
SIZTR



PAGE 12  
SIZTR

Figure 4-22. Size Trends Subroutine, Flow Chart  
(Part 10 of 13)  
4-98





PAGE 13  
SIZTR

Figure 4-22. Size Trends Subroutine, Flow Chart (Part 11 of 13)

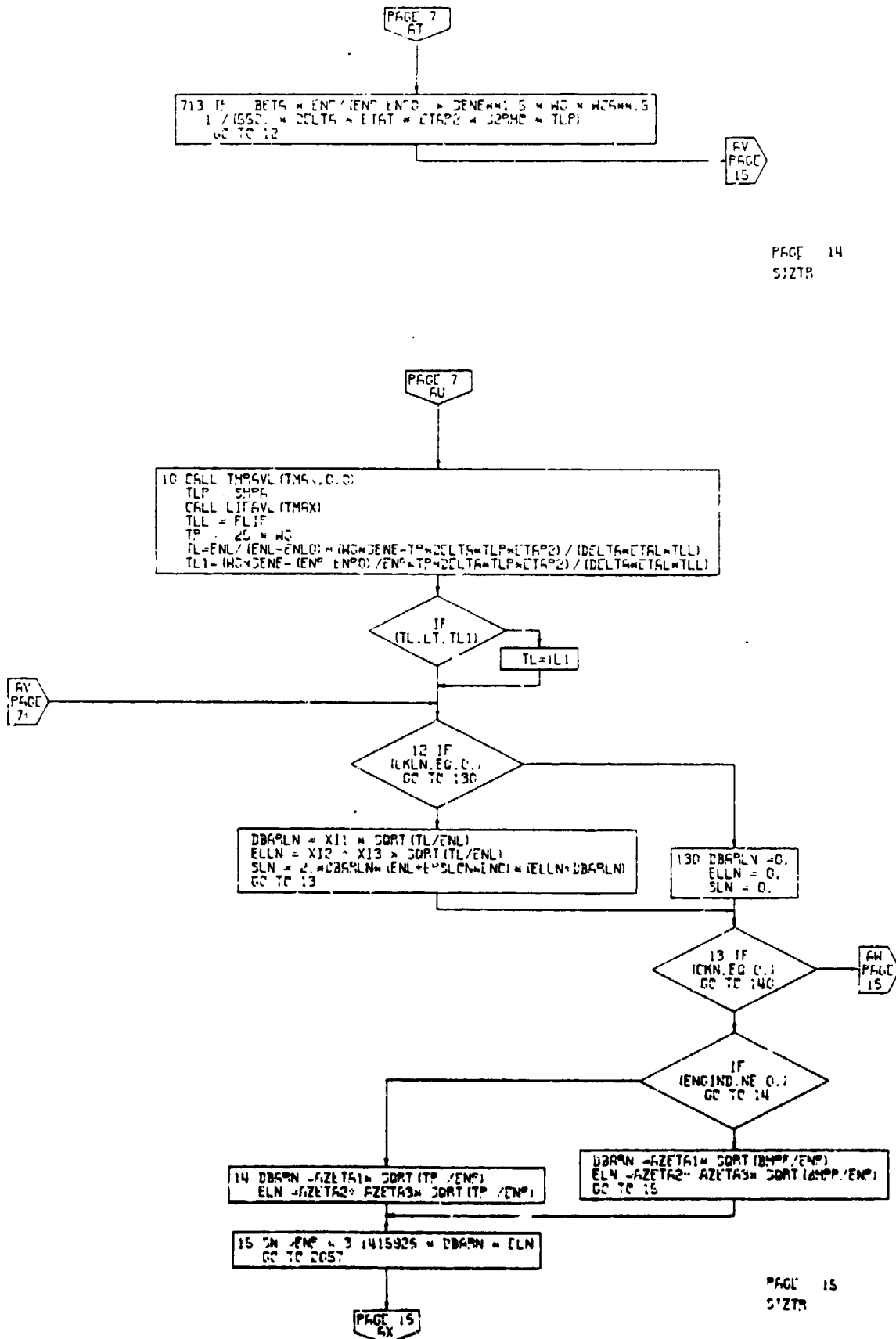


Figure 4-22. Siza Trends Subroutine, Flow Chart (Part 12 of 13)

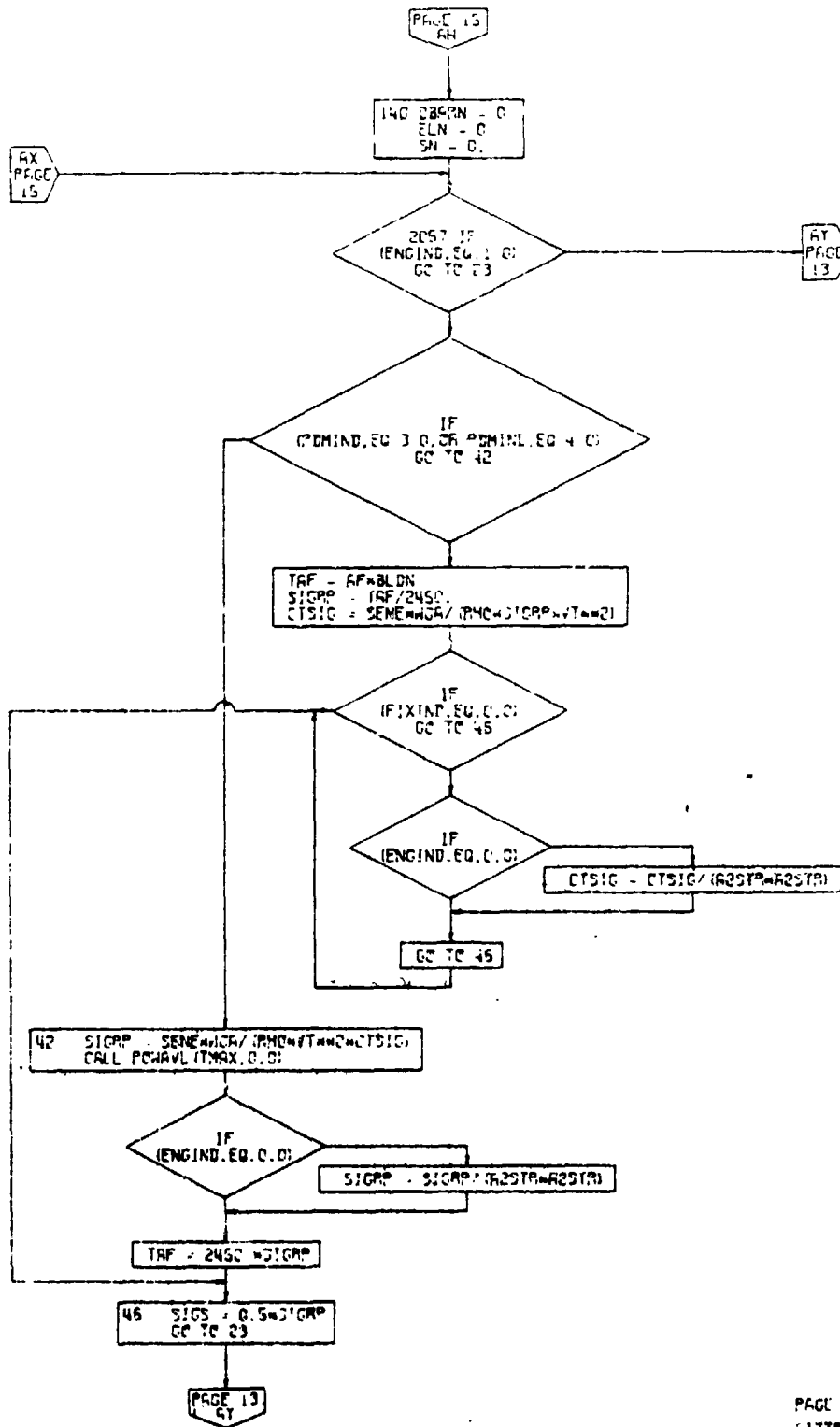


Figure 4-22. Size Trends Subroutine, Flow Chart (Part 13 of 13)

### Galleys

The floor area required for galleys is 0.27 square feet per tourist passenger and 0.65 square feet per first class passenger.

The body is assumed to be circular in cross-section. The cabin diameter (I.D.) is determined by the number of seats abreast, unit seat width, number of aisles, aisle width, plus a requirement that adequate clearance be maintained between the window seat passenger and the inside cabin wall. The clearance requirements define a set of sidewall control points, shown in Figure 4-23. By using these control points, an empirical equation for the cabin radius has been developed (shown in Figure 4-24). The body radius (O.D.) is calculated from (cabin radius)  $\div$  0.94. A comparison between predicted and actual body radius for six different commercial aircraft is shown in Figure 4-25.

The body length is made up of a nose section, a constant diameter section, and a tail section. The user specifies the fineness ratio of the nose and tail. Typical values for fineness ratios for commercial aircraft are  $(l/d)_{\text{NOSE}} = 1.5 + 2.0$  and  $(l/d)_{\text{TAIL}} = 2.5 + 3.5$ . The closet floor plan area is calculated by the program from a trend equation and contributes to the determination of fuselage length. The closet area is 15 square inches per first class passenger and 10 square inches per tourist passenger. The body length is determined by setting the floor plan area required for passengers and services (galleys, lavatories and closets) equal to the area available in nose, tail, and constant diameter sections. The assumption has been made that 1/5th of the nose and tail can be used for passengers and services. A comparison between predicted and actual fuselage length for six different commercial aircraft is shown in Figure 4-26.

An option is available for calculation of wing dimensions. By use of this option the wing dimensions may be dictated by either wing loading or by propeller geometry as in the case of a tilt-wing aircraft. This option is specified to the program by the user through use of a wing dimension indicator, WDMIND. If WDMIND = 1 or 2, the wing geometry is dictated by propeller characteristics. The user inputs a disc loading, a clearance from inboard propeller tip to inboard propeller tip, propeller to propeller overlap, and wing tip position relative to the outboard propeller. If ENGIN = 1.0 (turbofan engine), do not set WDMIND.

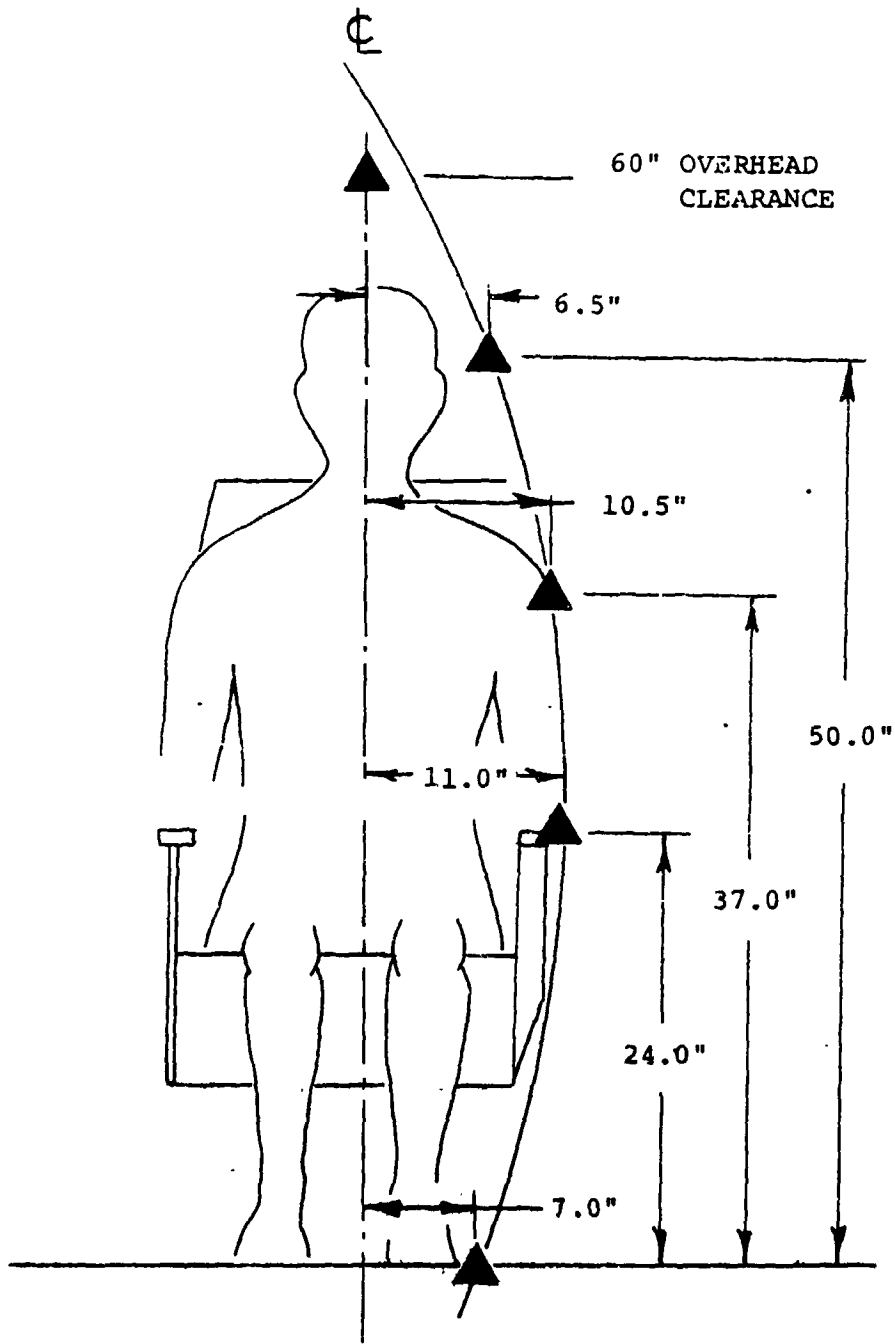


Figure 4-23. Definition of Sidewall Control Points for Fuselage Sizing.

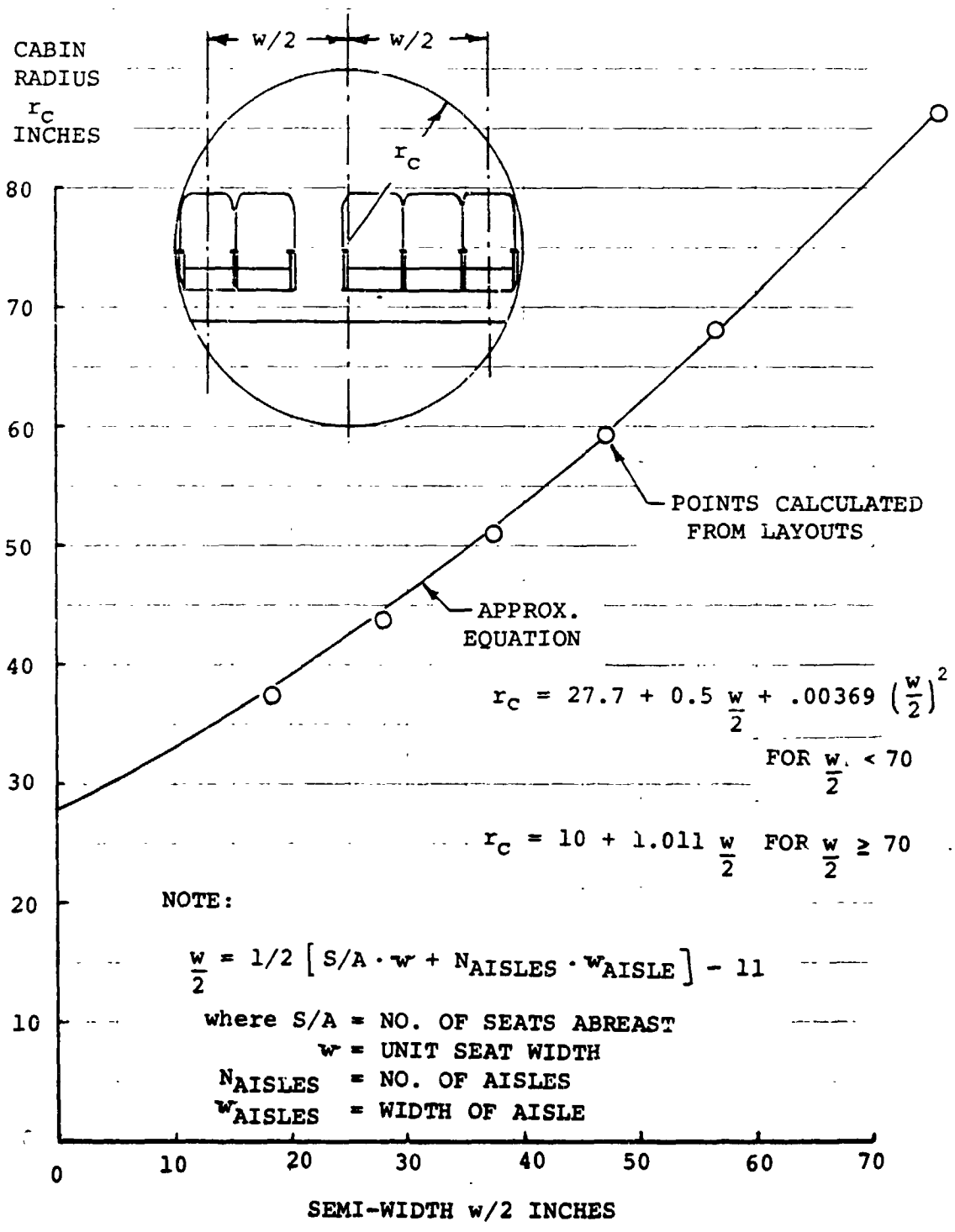


Figure 4-24. Empirical Relationship for Cabin Radius.

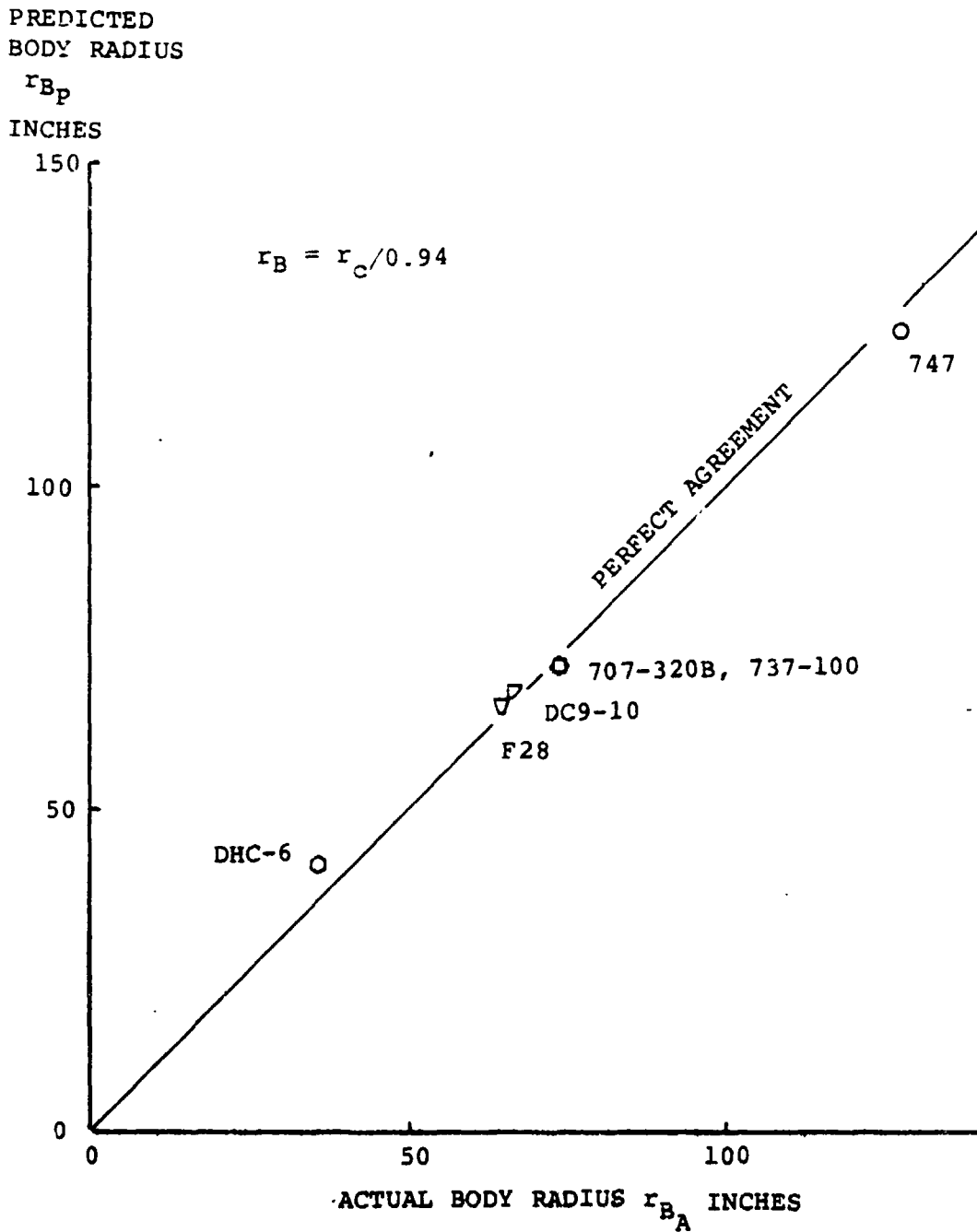


Figure 4-25. Comparison of Predicted Body Radius with Actual Body Radius for Six Commercial Aircraft.

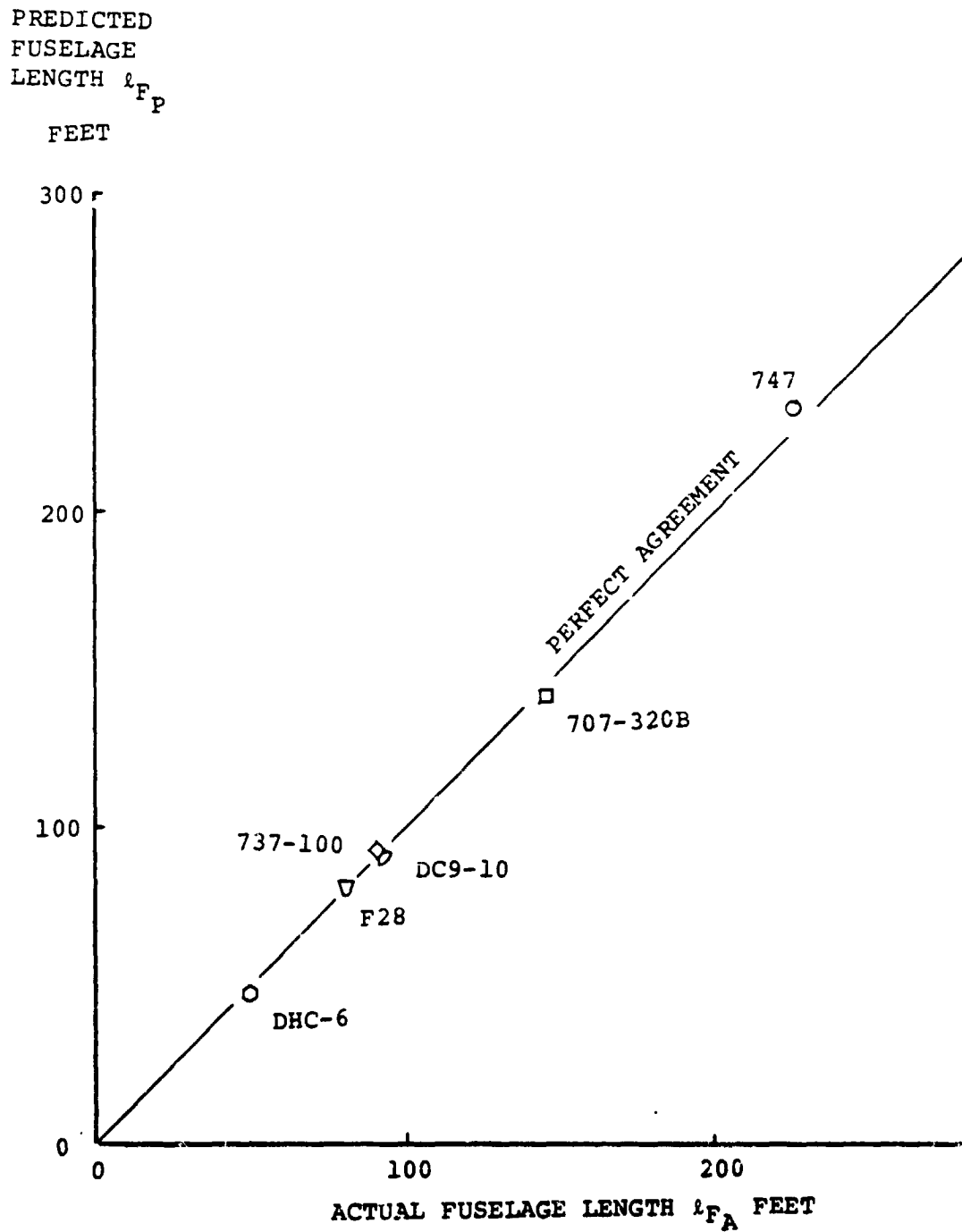


Figure 4-26. Comparison of Predicted Fuselage Length With Actual Fuselage Length for Six Commercial Aircraft.



If WDMIND = 1, the user also inputs a mean chord to diameter ratio and the program calculates wing loading. If WDMIND = 2, the user inputs wing loading and the program calculates mean chord to diameter ratio. In either case the program calculates the mean chord of the wing, the wing span, the wing area, and the aspect ratio. If WDMIND = 0, the wing geometry is dictated by wing loading. The user inputs a wing loading and aspect ratio of the wing. The program then calculates the wing area, span and mean chord. In addition, if turboshaft or convertible engines (ENGIND = 0, or 2) are used, the program calculates a mean chord-to-diameter ratio.

The important propeller dimensions are the diameter and the blade chord (or activity factor or solidity). The diameter may either be input directly or calculated from an input value for the disc loading. The chord may be specified by an input for the activity factor per blade or calculated from an input thrust coefficient-to-solidity ratio. The following choices are available, specified by an input prop dimension indicator, PDMIND:

<u>PDMIND</u>	<u>Input</u>
1	Diameter and activity factor
2	Disc loading and activity factor
3	Diameter and $C_T/\sigma$
4	Disc loading and $C_T/\sigma$

These options can only be used if the option indicator, OPTIND = 1. If the option indicator is 2 or 3 and it is desired to calculate the propeller performance by the automatic subroutine option ( $\eta_pIND=2$ ), the user must input the disc loading and activity factor per blade.

The dimensions of the tail surfaces are next calculated. The areas of the horizontal and/or vertical surfaces may be input as fixed constants by setting the indicator HTIND and/or VTIND to 2.0. Otherwise, by inputting the indicator(s) as unity the program will calculate the tail area(s) from input tail volume coefficient(s). The aspect ratio of each tail surface is also input. The program then calculates the span and mean geometric chord of each tail surface.

The dimensions of the lift nacelle and primary nacelle are next calculated. These dimensions are dictated by the thrust or horsepower level of the engines. The size of the lift engine nacelle is assumed to be primarily dependent upon the physical size of the dry lift engines, the number of clusters of engines, and the gap between engines in a cluster (see Figure 2-1). The size of the

primary engine nacelles is more often dictated by the design of the transmission system and less often by the physical size of the dry engines. Separate input constants  $z_1$ ,  $z_2$ , and  $z_3$  are used to calculate the size of the primary engine nacelles:

$$\text{diameter (ft)} = z_1 \left[ \frac{\text{SHP}^*}{N_p} \right]^{1/2} \text{ or } z_1 \left[ \frac{F^*}{N_p} \right]^{1/2}$$

$$\text{length (ft)} = z_2 + z_3 \left[ \frac{\text{SHP}^*}{N_p} \right]^{1/2} \text{ or } z_2 + z_3 \left[ \frac{F^*}{N_p} \right]^{1/2}$$

$$\text{wetted area (ft}^2\text{)} = N_p \pi (\text{dia.}) (\text{length})$$

Correlation of data for nacelle size, within fixed categories of aircraft, show that this representation gives reasonable accuracy.

#### 4.7 AERODYNAMICS CALCULATIONS SUBROUTINE

The aerodynamics subroutine calculates the lift curve slope and a series of factors which are used for calculation of drag. The drag calculation has been written in the most general manner possible. The drag is assumed to be divided into profile drag, induced drag, and compressibility (wave) drag. The profile drag is further divided into a portion for each component of the aircraft. The wing profile drag is assumed to be a function of lift coefficient, as specified by an input table. The other portions of profile drag are single-value points. The profile drag is input at a reference Reynolds' number of  $10^7$ , and the program calculates a variation with Reynolds' number. Form factors for each component are input to the program. These factors can also be used to represent interference or for sensitivity studies. The fuselage drag is calculated as the sum of two terms: one proportional to wetted area and one which is constant. Therefore, if a known fuselage is being studied, the constant value can be input and the other term set to zero. Otherwise, the opposite can be done.

The drag is assumed to be equal to:

$$\begin{aligned}
 C_D = & \underbrace{C_{DWi} [f_W(Re)]}_{\text{Wing Profile}} + \underbrace{\left( \frac{.00287 K_F S_F + \Delta f_e}{S_W} \right) [f_F(Re)]}_{\text{Fuselage Profile}} \\
 & + K_{VT} \underbrace{\frac{S_{VT}}{S_W} C_{DVTi} [f_{VT}(Re)]}_{\text{Vert. Tail Profile}} + K_{HT} \underbrace{\frac{S_{HT}}{S_W} C_{DHTi} [f_{HT}(Re)]}_{\text{Hor. Tail Profile}} \\
 & + \underbrace{\Delta C_D}_{\text{Arbitrary}} + \underbrace{K_W \Delta C_{DM}}_{\text{Compressibility}} + \underbrace{C_L^2 / \pi e AR}_{\text{Induced}}
 \end{aligned}$$

The compressibility drag ( $\Delta C_{DM}$ ) is calculated according to a semi-empirical technique. The terms of the drag equation are combined in the following form:

$$C_D = a_5 + a_6 C_{DWi} + K_W \Delta C_{DM} + a_7 C_L^2$$

where

$$\begin{aligned}
 a_5 &= \left( \frac{.00287 K_F S_F + \Delta f_e}{S_W} \right) [f_F(Re)] \\
 &+ K_{VT} \frac{S_{VT}}{S_W} C_{DVTi} [f_{VT}(Re)] + \dots + \Delta C_D \\
 a_6 &= K_W [f_W(Re)] \\
 a_7 &= 1/\pi e AR
 \end{aligned}$$

The factors  $a_5$  through  $a_7$  (and  $a_1$  through  $a_4$ , for compressibility drag) are used in the drag calculations subroutine to calculate  $C_D$  as a function of  $C_L$  and  $M$ .

The terms  $f_W(Re)$ ,  $f_F(Re)$ ,  $f_{VT}(Re)$ , etc., are Reynolds' number functions for the wing, fuselage, vertical tail, etc., which reflect the variation of skin friction coefficient with Reynolds' number. The function which is used is a normalized form of the Prandtl-Schlichting turbulent flat plate skin friction equation:

$$f(Re) = \frac{C_f}{C_{f_{Re=10^7}}} = [1 + \frac{1}{7} \log_{10} \frac{Re}{10^7}]^{-2.6}$$

The program user inputs a value for average Reynolds number per foot for the mission and the program then calculates the Reynolds' number for each component of the aircraft and uses the Reynolds' number functions  $f_W(Re)$ ,  $f_F(Re)$ , etc., to determine the variation in component drag as the aircraft dimensions change during the iteration on gross weight. The individual profile drag coefficients,  $C_{DVTi}$ ,  $C_{DHTi}$ , etc., are input at a reference Reynolds' number of  $10^7$ .

The user inputs values for the profile drag coefficients ( $C_{DVTi}$ ,  $C_{DWTi}$ , etc.), for the interference factors ( $K_F$ ,  $K_W$ , etc.), for the mean Reynolds' number per foot,  $(R_e/l)$ , and for the efficiency factor,  $e$  (the program will calculate  $e$  if OSWIND is input as unity). The program then calculates the values for  $a_1$  through  $a_7$  for use in the drag calculations subroutine. The user also inputs the two dimensional lift curve slope, and the program calculates the three dimensional value for lift curve slope.

The drag routine may be used in many different ways. The four most common applications are:

1. Drag Build-up for a New Aircraft Design - This is best illustrated by first referring to the complete drag breakdown of a hypothetical airplane shown in Table 4-4. The input  $C_D$  for each component ( $C_{DWi}$ ,  $C_{DHTi}$ , etc.) may be used to represent the reference  $C_f$  at  $Re = 10^7$  and at the mean flight Mach number. Drag increases above the drag of a flat plate such as three dimensional effects, interference, roughness, and excrescences may be accounted for by the multiplying factors ( $K_W$ ,  $K_{HT}$ , etc.). Drag increments which are not proportional to skin friction can be summed and input as  $\Delta C_D$ . Examples of these increments are cooling momentum, trim, and airconditioning. The K factor for wings and tails should include a factor for relating the wetted area of the surface to the planform area. An example of the program input for the hypothetical airplane of Table 4-5, is shown in Table 4-6.
2. Study of the Sensitivity of Aircraft Size with Respect to the Component Drag or the Total Drag about a Certain Drag Level - Let the total drag of each component be contained in the drag coefficient of each component,  $C_{DWi}$ ,  $C_{DHTi}$ ,  $C_{DVTi}$ , etc. The change in drag of each component will then be determined by the values assigned to the component multiplying factor,  $K_W$ ,  $K_{HT}$ ,  $K_{VT}$ , etc. The fuselage drag change, however, will have to be represented by an incremental value of  $\Delta f_e$ .
3. Use of Component Drag Data from Wind Tunnel Test - Let the drag of each component (including interference) be contained in the component drag coefficient,  $C_{DWi}$ ,  $C_{DHTi}$ ,  $C_{DVTi}$ , etc. The skin friction drag must first be corrected to  $Re = 10^7$ . The drag increase due to items found only on the full scale airplane would then be represented by the factors and increments. Increases due to excrescences and roughness are represented by the factors,  $K_W$ ,  $K_{HT}$ ,  $K_{VT}$ , etc. Increments such as inlets, cooling, trim, and afterbody drag, can be summed and represented by  $\Delta C_D$ .
4. Simplified Drag Model for Parametric Studies - The program is often used to study the influence of variations of parameters such as wing loading and disc loading on the size of an aircraft. During these studies, the type of aircraft (such as four propeller tilt wing) is generally held constant. For studies of this type it may be possible to represent the total flat plate area

TABLE 4-5  
TYPICAL DRAG SUMMARY

DRAG BREAKDOWN FOR HYPOTHETICAL 4 PROP TILT-WING AIRCRAFT $R_e/ft = 3.0 \times 10^6$ , $M = .40$					
COMPONENT	Wetted Area	$C_f$	INCREMENT		$f_e$ FT <sup>2</sup>
			%	$\Delta f_e$	
FUSELAGE	2027.	.00185		3.75	7.08
3-Dimensional Effects			20.0	.75	
Excrescences			7.0	.31	
Canopy			5.0	.22	
Afterbody				2.05	
WING	1290.	.0024		3.17	5.25
3-D Effects			33.0	1.05	
Excrescences			4.0	.17	
Flaps, Slats, Ailerons, Spoilers			16.0	.63	
Body Interference			7.0	.23	
HORIZONTAL TAIL	477.	.00258		1.23	1.94
3-D Effects			20.6	.41	
Excrescences			8.6	.14	
Interference			10.0	.16	
VERTICAL TAIL	398.	.00235		.94	1.49
3-D Effects			33.0	.31	
Excrescences			8.6	.11	
Interference			10.0	.13	
INBOARD NACELLES	286.	.00228		.65	1.72
3-D Effects			35.0	.23	
Excrescences			20.0	.16	
Interference			88.0	.63	
Inlets				.05	
OUTBOARD NACELLES	331.	.00228		.76	1.70
3-D Effects			35.0	.27	
Excrescences			20.0	.21	
Interferences			40.0	.41	
Inlets				.05	
LANDING GEAR POD	338.	.00218		.74	1.46
3-D Effects			45.0	.34	
Excrescences			10.0	.11	
Interference			25.0	.27	
MISC.					1.56
Roughness (5.0% of $C_f A_{WET}$ )				.56	
Cooling				.50	
Trim				.30	
Air Conditioning				.20	
TOTALS	5147.				22.20
Notes: (1) Basic $f_e = (C_f A_{WET}) + (3-D \text{ Effects } \Delta f_e)$ (2) Excrescences & interference are % of basic $f_e$					



of the family of aircraft as a linear function of the wing area. This representation of drag can be input to the program by three values:  $\Delta f_e$  representing the drag at zero wing area,  $\Delta C_D$  representing the slope of the curve, and  $K_W = 1$ .

The three dimensional lift curve slope which is calculated is based upon the method of Reference 3, which accounts for aspect ratio, wing sweep, and Mach number effects. For the purpose of this program, the Mach number effects are not included. Rather, the value of lift curve slope is evaluated at a Mach number =  $.87M_{MO}$ , which gives a reasonably accurate value for use during climb and descent calculations.

Figure 4-27. is a flow chart of this subroutine.



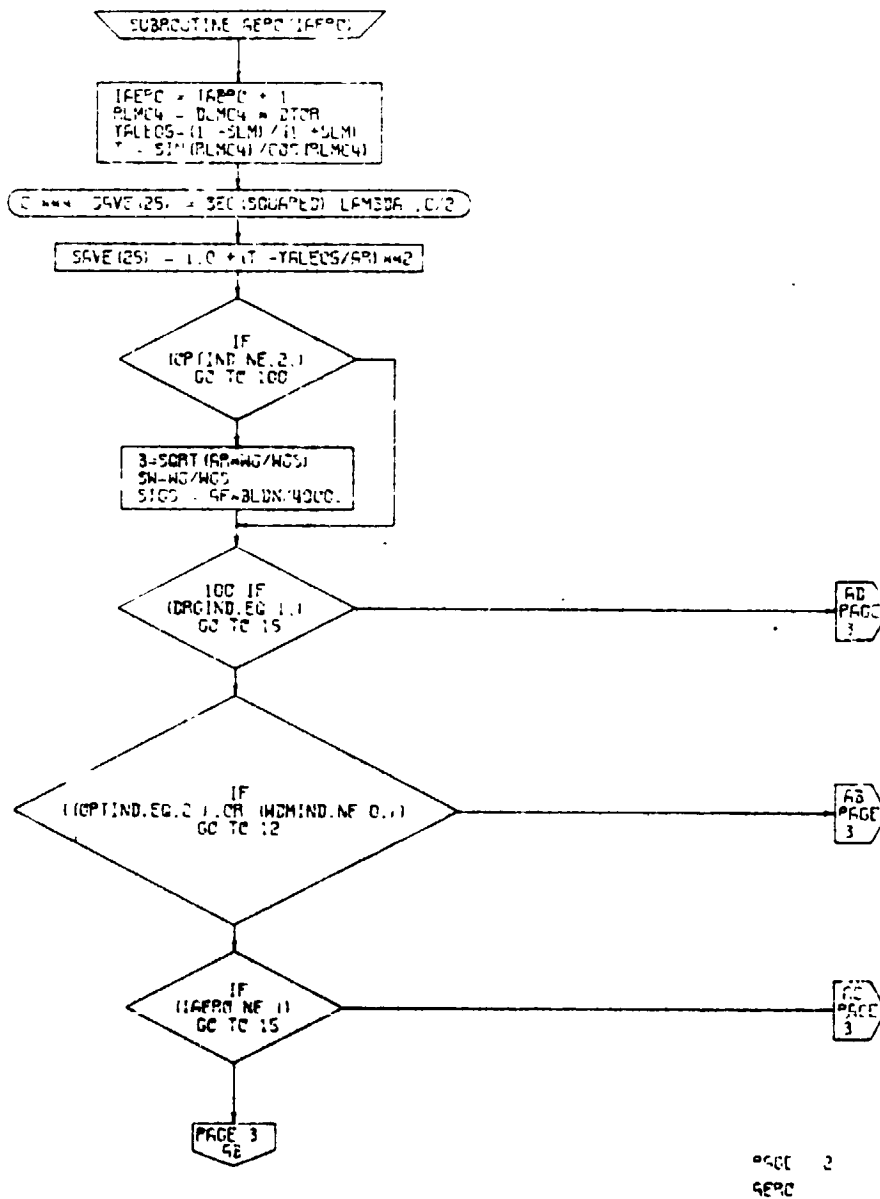


Figure 4-27. Aerodynamics Subroutine, Flow Chart  
(Part 1 of 4)

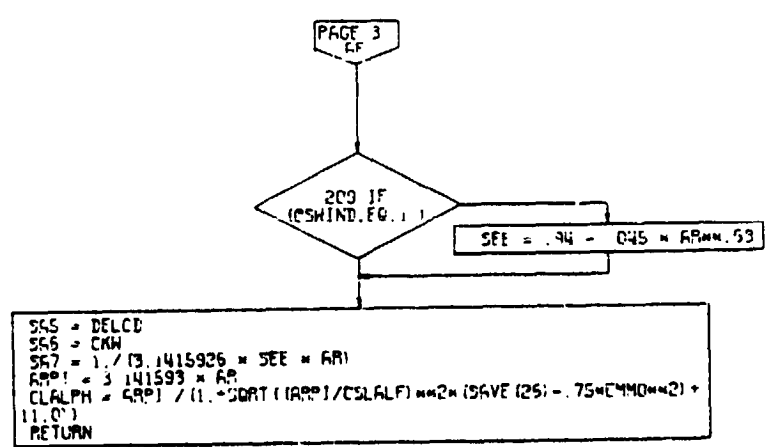
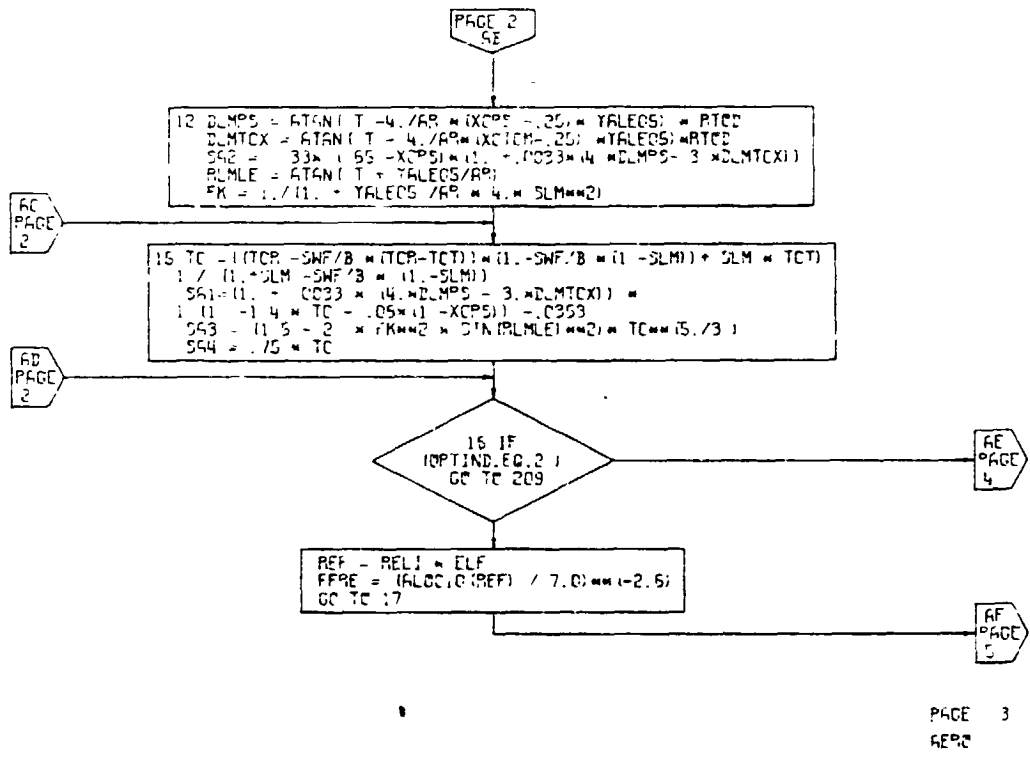


Figure 4-27. Aerodynamics Subroutine, Flow Chart (Part 2 of 4)

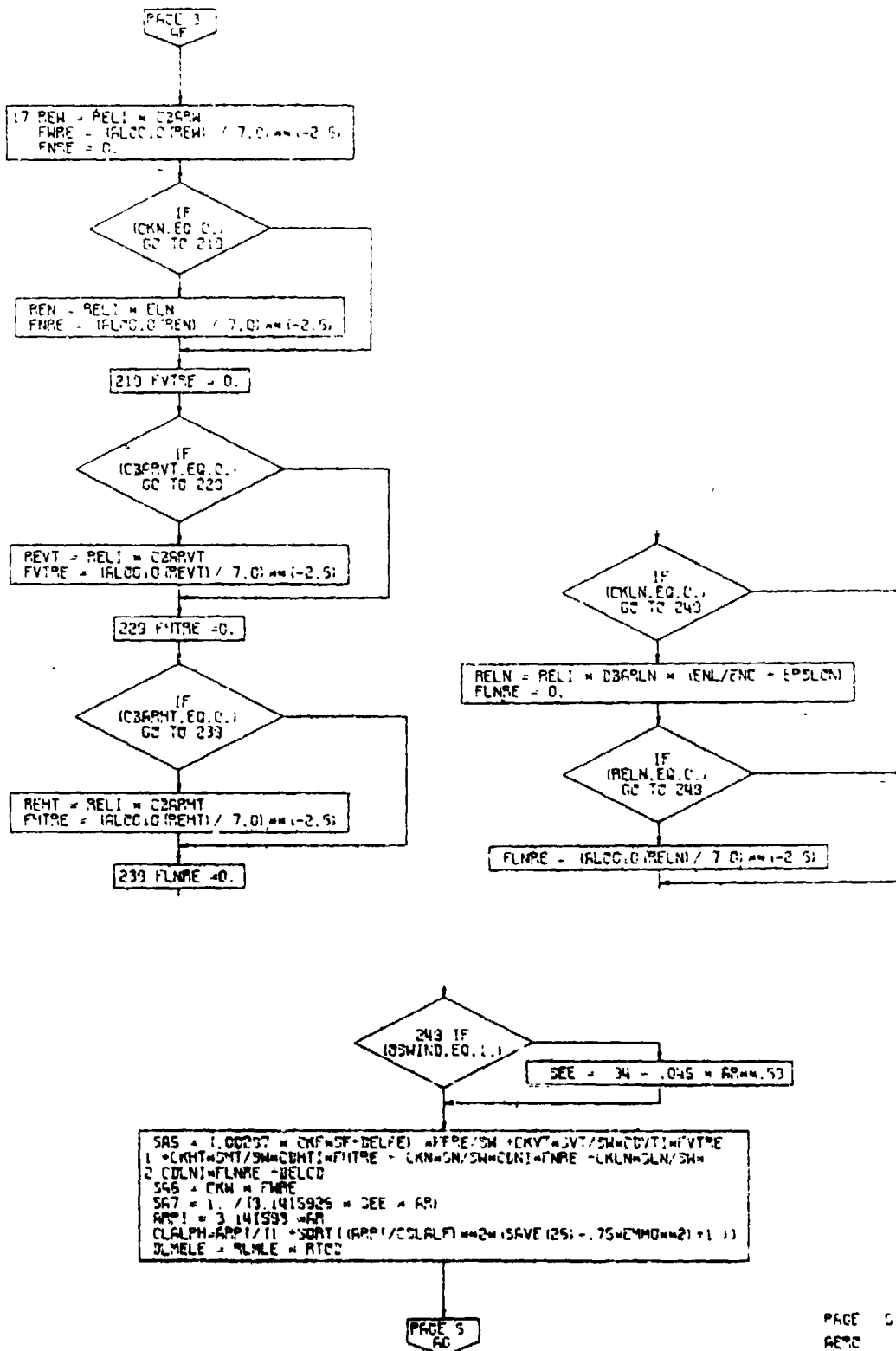
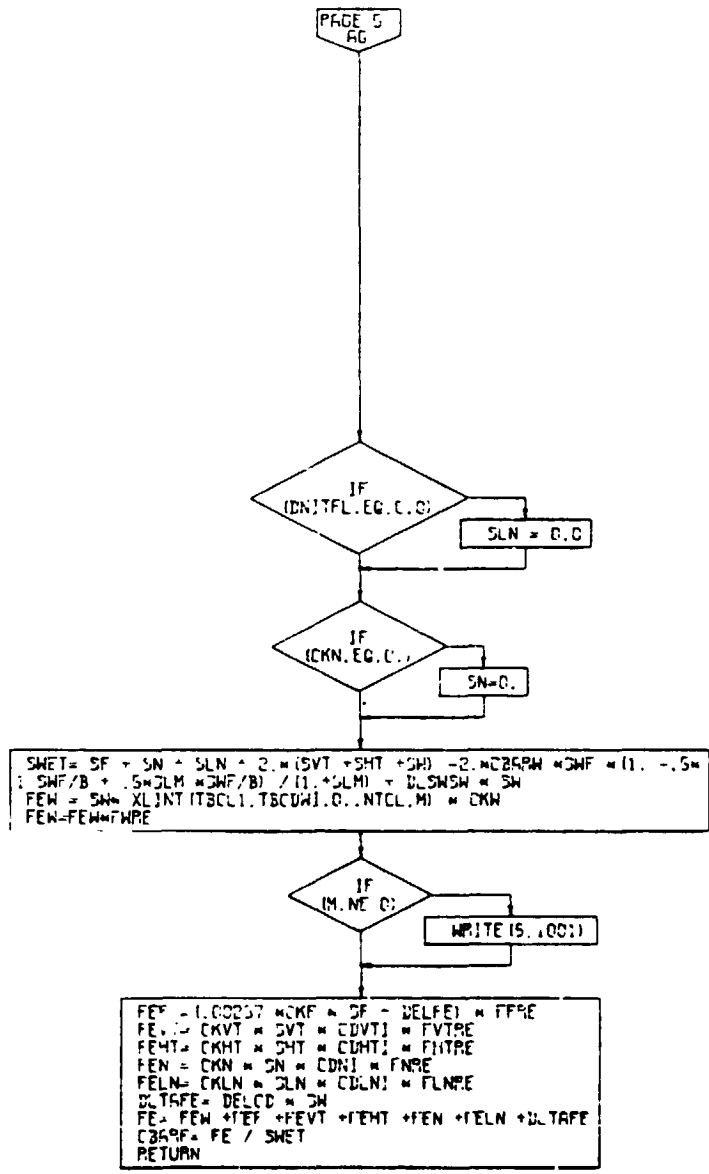


Figure 4-27. Aerodynamics Subroutine, Flow Chart  
(Part 3 of 4)



PAGE 5  
AERO

Figure 4-27. Aerodynamics Subroutine, Flow Chart (Part 4 of 4)

#### 4.8 ENGINE SIZING SUBROUTINE

The engine cycle performance data included in the engine library consists of detailed performance maps of power (or thrust), fuel flow,  $N_I$ , and  $N_{II}$ . The data, as shown in Table 4-1, is in normalized, referred format. In particular, horsepower is normalized with respect to the value of power at the maximum static rating at sea level, standard day conditions. Thrust is similarly normalized to the maximum static thrust at sea level, standard day.

The engine sizing subroutine calculates the value of the scaling factors; namely, the maximum static thrust or power (S.L., std.). The user is permitted to bypass this subroutine completely if he desires to study an aircraft with fixed rather than "rubberized" engines. This is accomplished by means of the input indicator FIXIND. If FIXIND = 0, the engine sizing subroutine is bypassed, and the user inputs the maximum power or thrust levels. If FIXIND is input as 1.0, the engine sizing subroutine is entered to calculate these values of maximum power or thrust.

A variety of different criteria are often applied to determine engine size requirements. These criteria, differing as they do, can generally be related by a single factor. For a takeoff condition this factor is the value of equivalent required thrust to weight ratio. Similarly, engine sizing requirements for forward flight can be related to a set of cruise conditions, namely, cruise altitude and true airspeed. Relationships used in this program to size the engines differ depending upon whether or not separate lift propulsion has been selected. Engine sizing requirements for V/STOL aircraft which do not contain separate lift propulsion are generally set by takeoff conditions, and less frequently by forward flight conditions. The program, therefore, permits the user two options of calculation for this type of aircraft. The first option will calculate engine size for takeoff conditions only; the second option will calculate engine size for both takeoff and forward flight conditions, compare the two, and pick the more critical condition. The engines are sized for takeoff to provide a required (input) equivalent thrust to weight ratio with a specified (input) number of engines inoperative.

Additional engine sizing parameters have been added for either the turboshaft (ENGIND = 0.0) or convertible (ENGIND = 2.0) engine. Expanded capabilities include a direct horsepower input to drive accessory options (LOC 0259), primary or lift engine sizing at a specified fraction of power (LOC 0260), and engine sizing for takeoff conditions at a specified vertical rate of climb (LOC 0261).

If separate lift propulsion is used, the cruise engines are first sized to meet specified forward flight conditions. The lift engines are then sized to provide sufficient additional thrust to meet the takeoff requirements. The lift engines are sized to provide this additional thrust with either a specified number of primary engines inoperative or a specified number of lift engines inoperative. The program calculates the thrust required to meet each of these conditions, compares them, and picks the more critical condition. Takeoff or cruise conditions or both may be set for standard or nonstandard atmosphere.

Cruise conditions are specified by means of altitude, ambient temperature, and true airspeed. In addition, the user may select the power setting to be used: maximum, military, or normal.

In addition to performing engine sizing, this subroutine calculates the drive system rating. The two options available to the user for this purpose are:

XMSNIND = 0.0            Transmission is sized at a specified  
(LOC 0257)            fraction of primary installed engine  
                         power

XMSNIND = 1.0            Transmission is sized at a specified  
                         fraction of power required to hover  
                         or cruise (program picks more  
                         critical condition)

It should be noted that when FIXIND (LOC 0010) = 0.0, fixed size engines, either transmission sizing option can be used. The Fortran coding that sizes the transmissions with fixed engines is found in the MAIN subprogram. The transmissions can be sized irregardless of the propeller performance option used (NPIND LOC 0200). If XMNSD = 1.0 is exercised for fixed size engines, the program will calculate the required powers, and size the transmission even if the required power is greater than the fixed sized input power.

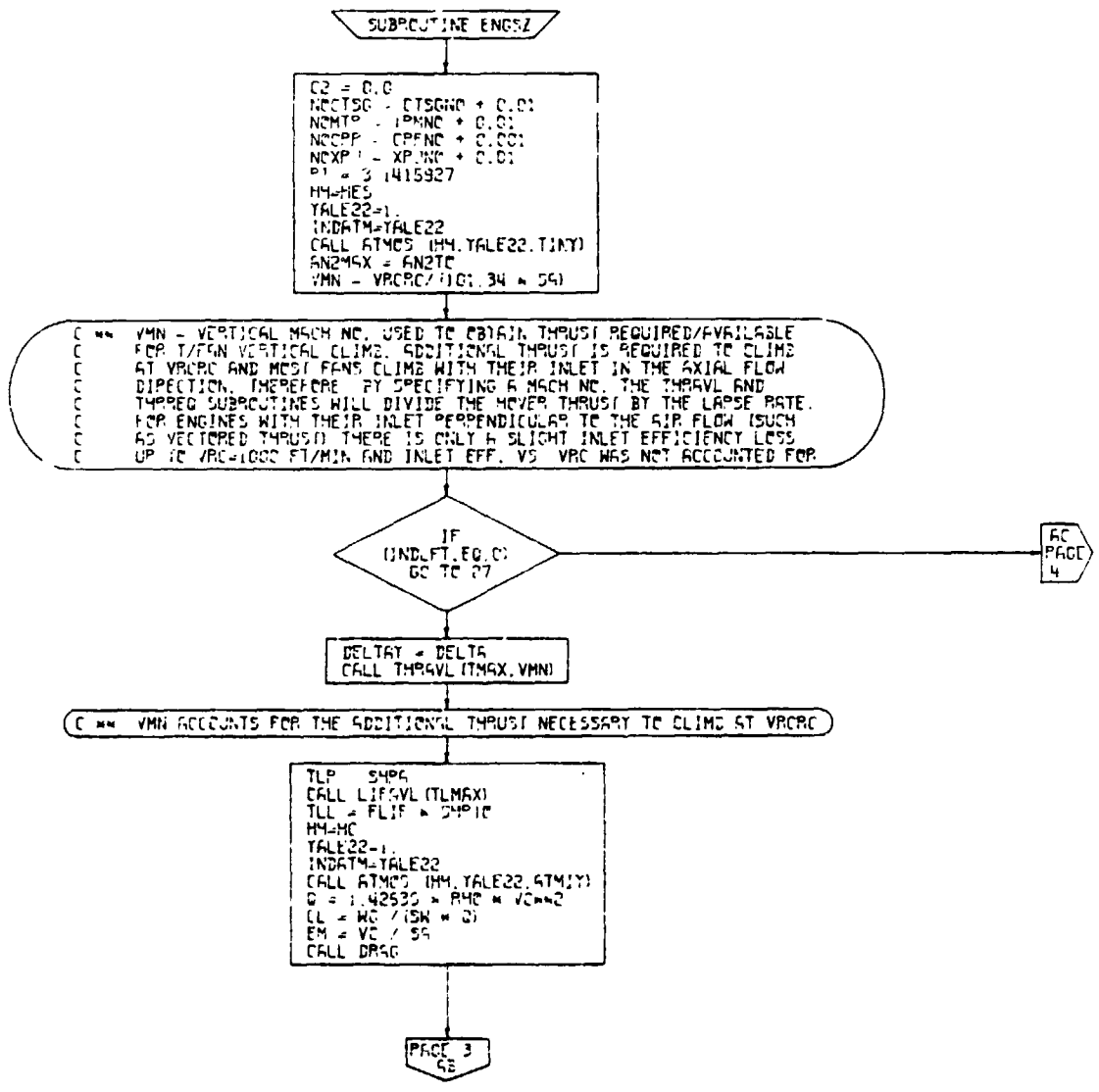
If  $ENGIND = 0$ , (LOC 0011), both transmission options are available to the user. For  $ENGIND = 1$ , transmission sizing is not possible, thus the program bypasses the transmission sizing inputs. For convertible engines,  $ENGIND = 2.0$ , the  $XMSNIND = 0$  option can be used without any constraints. Since convertible engines do not use a transmission for cruise,  $XMSNIND = 1.0$  cannot be used. If  $ENGIND = 2.0$  and  $XMSNIND = 1.0$ , the program will automatically apply the transmission limit as a specified fraction of installed takeoff power, and an informative message will be printed out.

The use of separate engines and transmission sizing options provides great flexibility in meeting conflicting engine/drive system requirements. As an example, if  $XMSNIND = 1.0$ , it is possible to size an aircraft's engines to meet an engine inoperative in hover requirement while sizing the transmission for the actual power required to hover at that design point, thus effecting a considerable saving in drive system weight. If  $XMSNIND = 0.0$ , it is possible to size the engines for cruise at 3000 ft/91.5°F, 250 Kts, but the transmission could be sized at 90% of the cruise power design point.

The transmission designed operating tip speed is passed from the engine sizing subroutine to the weight trend subroutine so that the prop/rotor system and the primary drive system weight reflect the actual operating tip speed.

The drive system ratings determined in the sizing process may be used to limit helicopter performance by setting  $Q_{IND}$  (LOC 1205) = 1.0, and inputting an appropriate value of  $Q_{MAX}/Q^*$ , LOC 1224. This option imposes a transmission torque limit in the performance calculations.

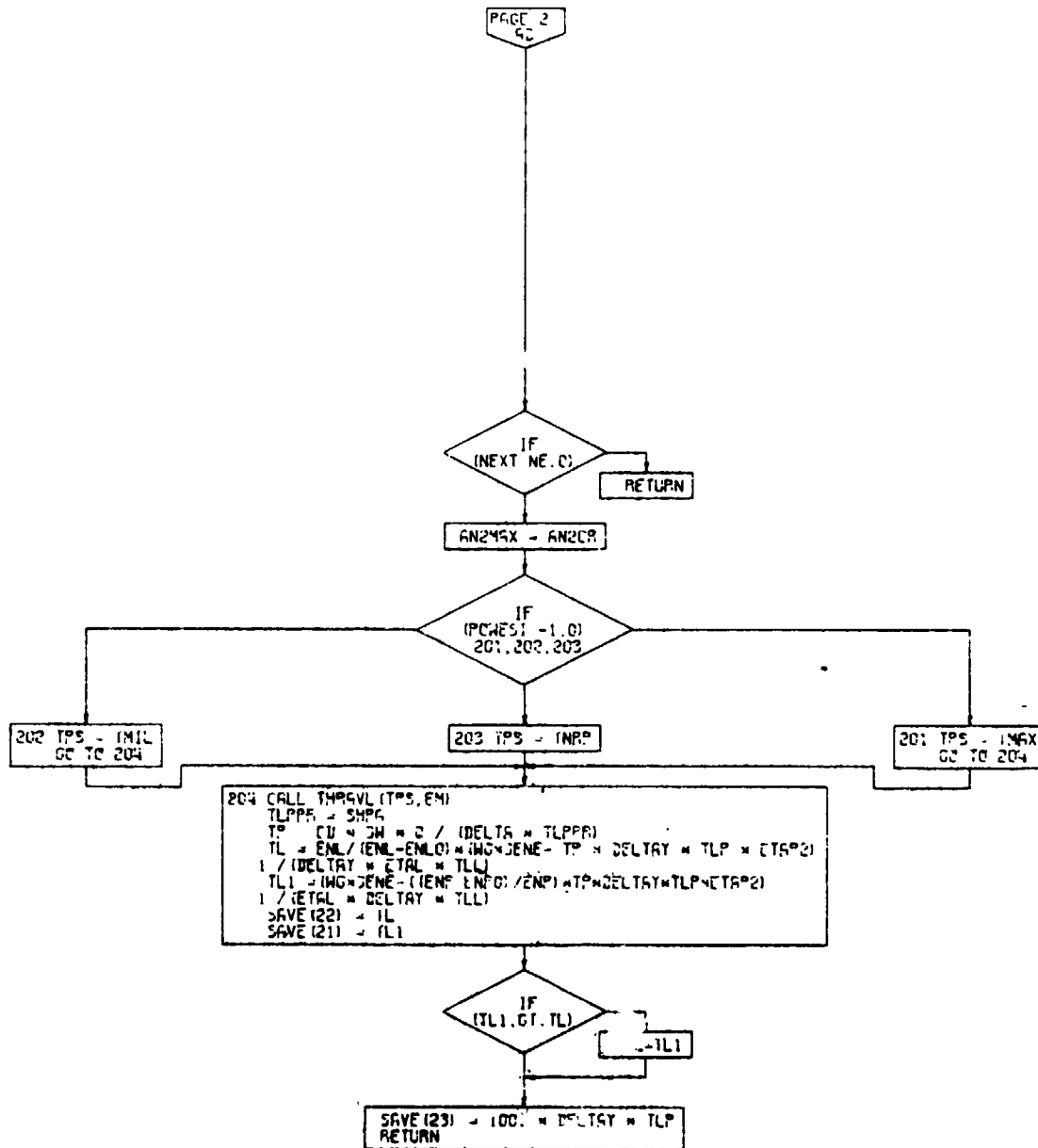
Figure 4-28 is a flow chart of the Engine Sizing Subroutine



PAGE 2  
ENGSZ

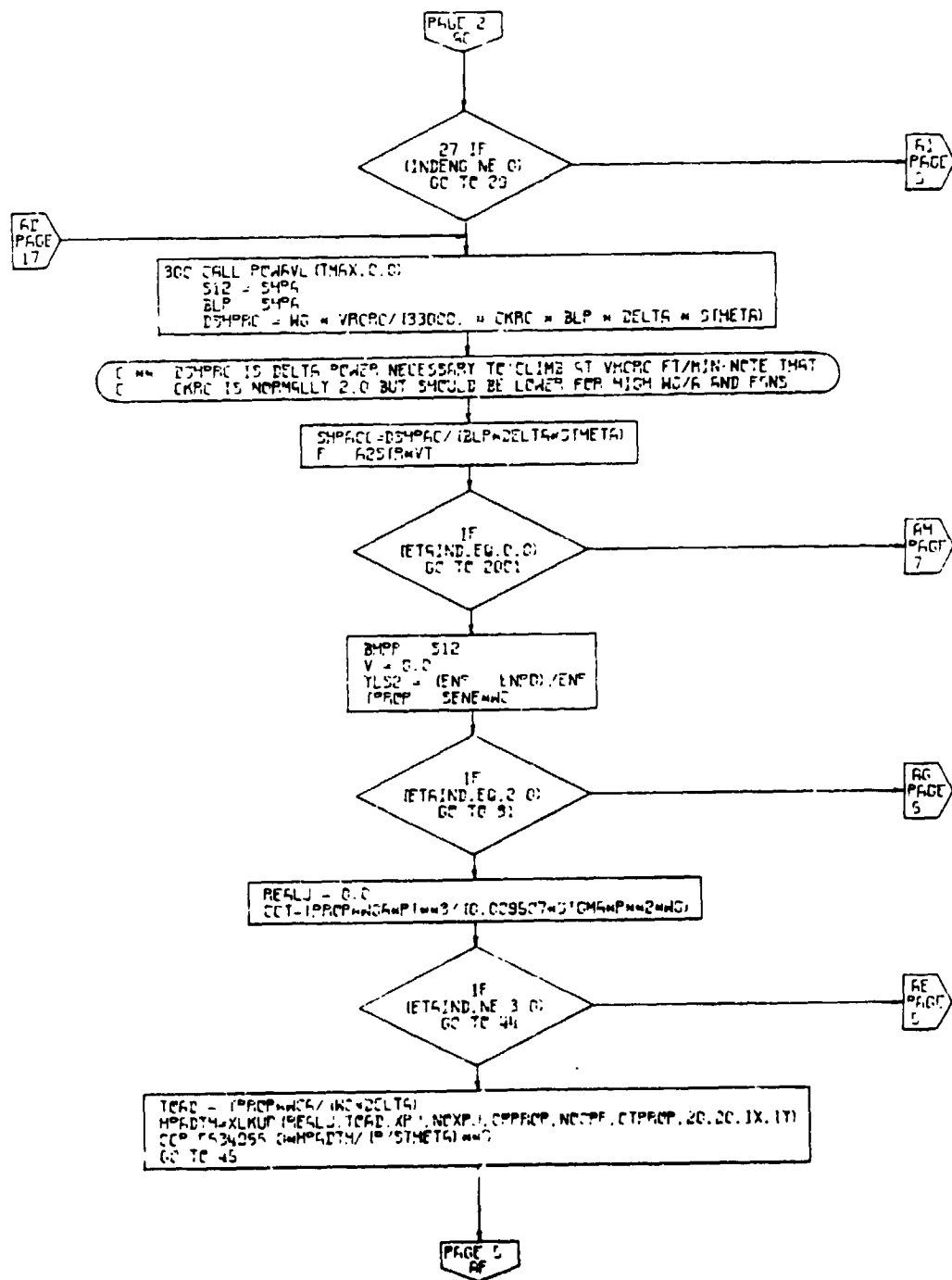
Figure 4-28. Engine Sizing Subroutine, Flow Chart (Part 1 of 12)





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ENGGZ

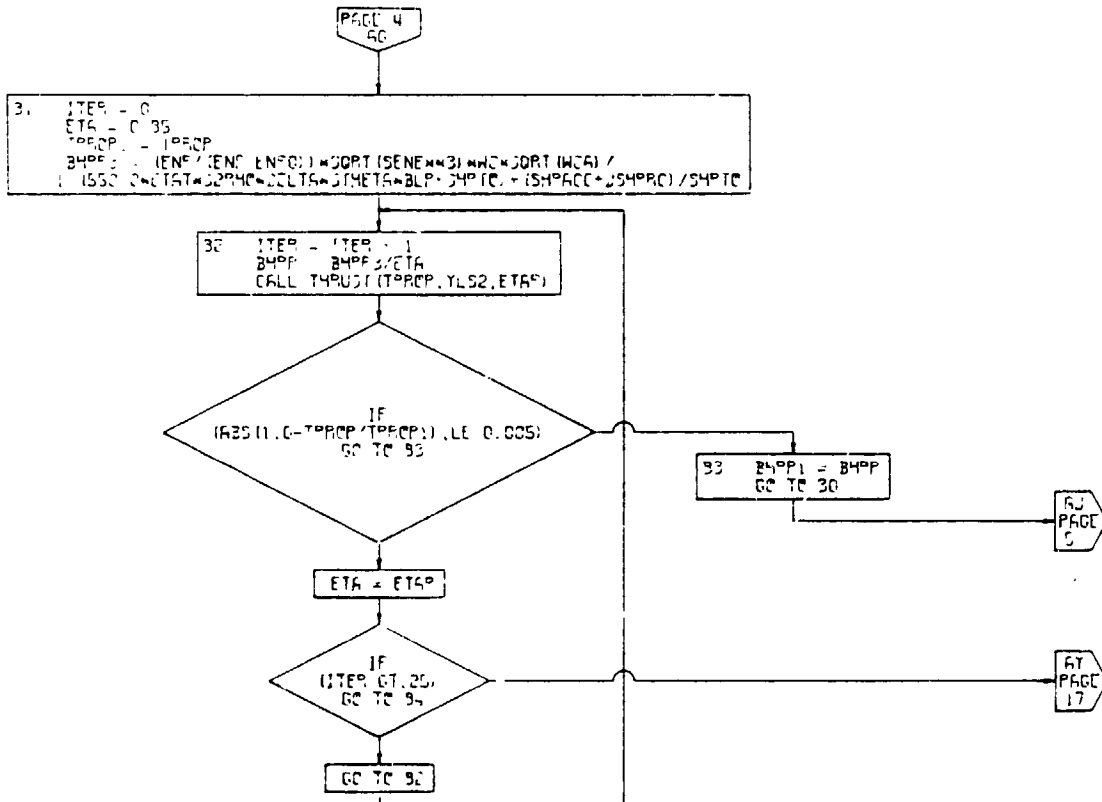
Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 2 of 12)  
4-123



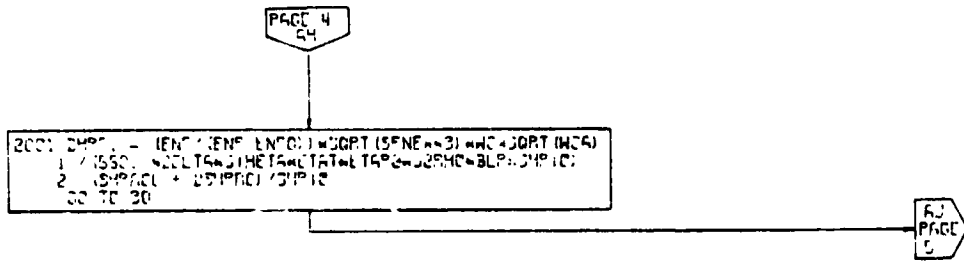
PAGE 4  
ENG52

Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 3 of 12)



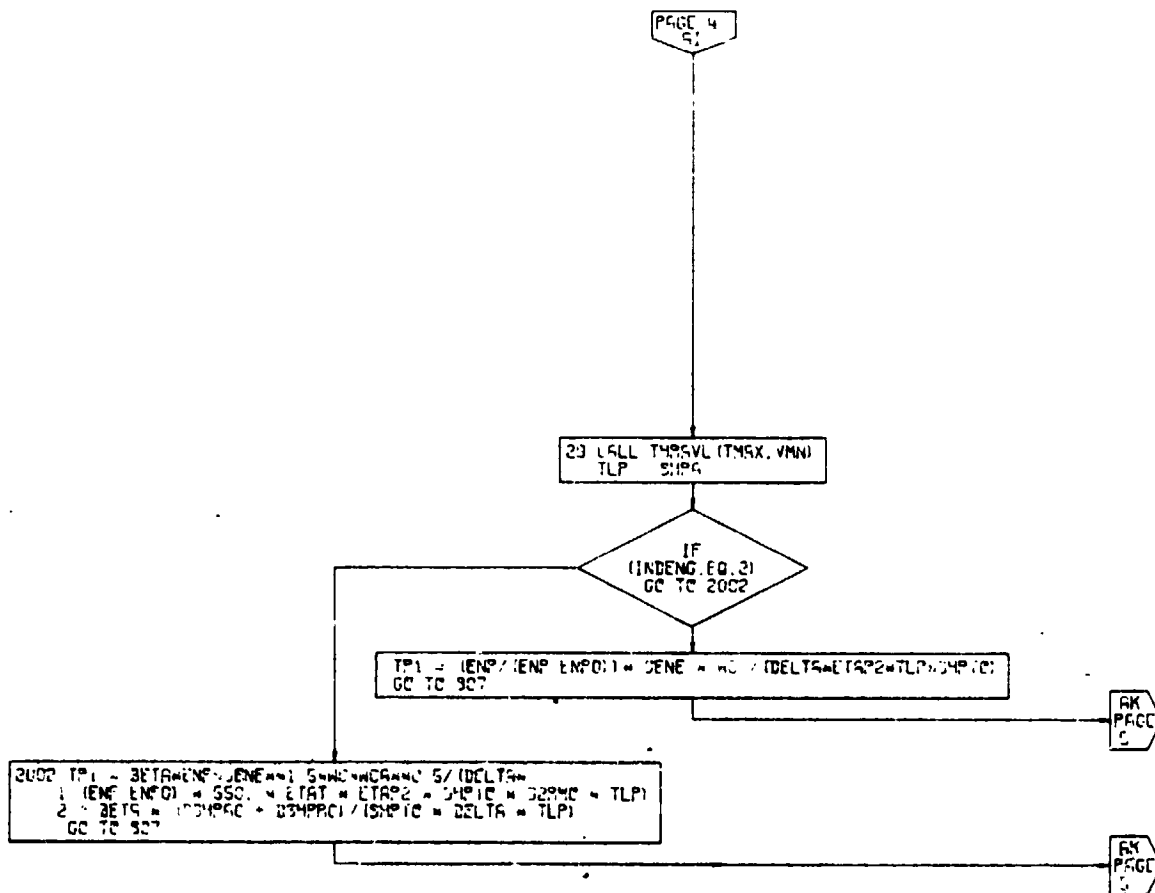


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ENGSZ



PAGE  
ENGSZ

Figure 4-28. Engine Sizing Subroutine, Flow Chart (Part 5 of 12)



PAGE  
ENGSZ

Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 6 of 12)

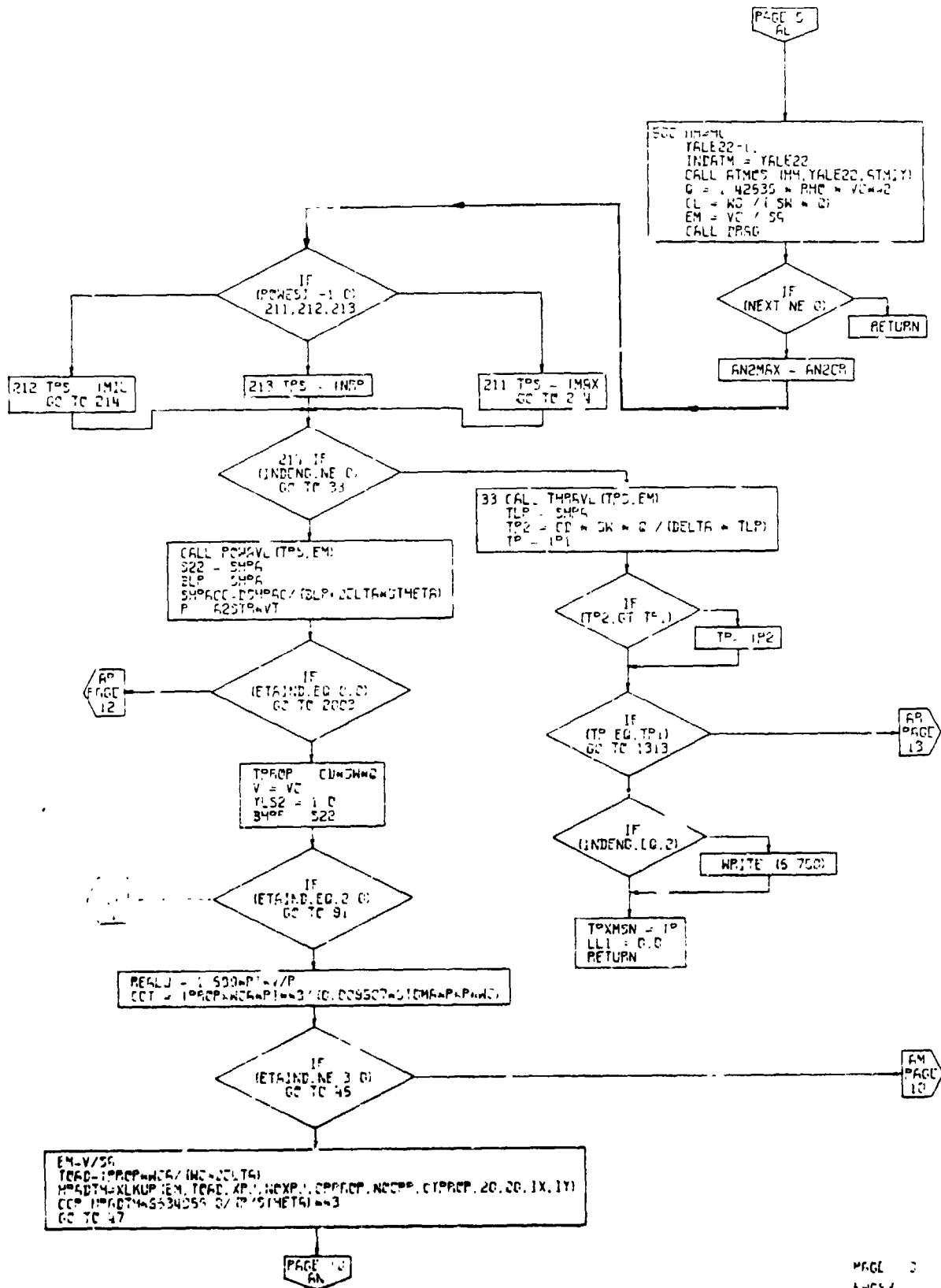
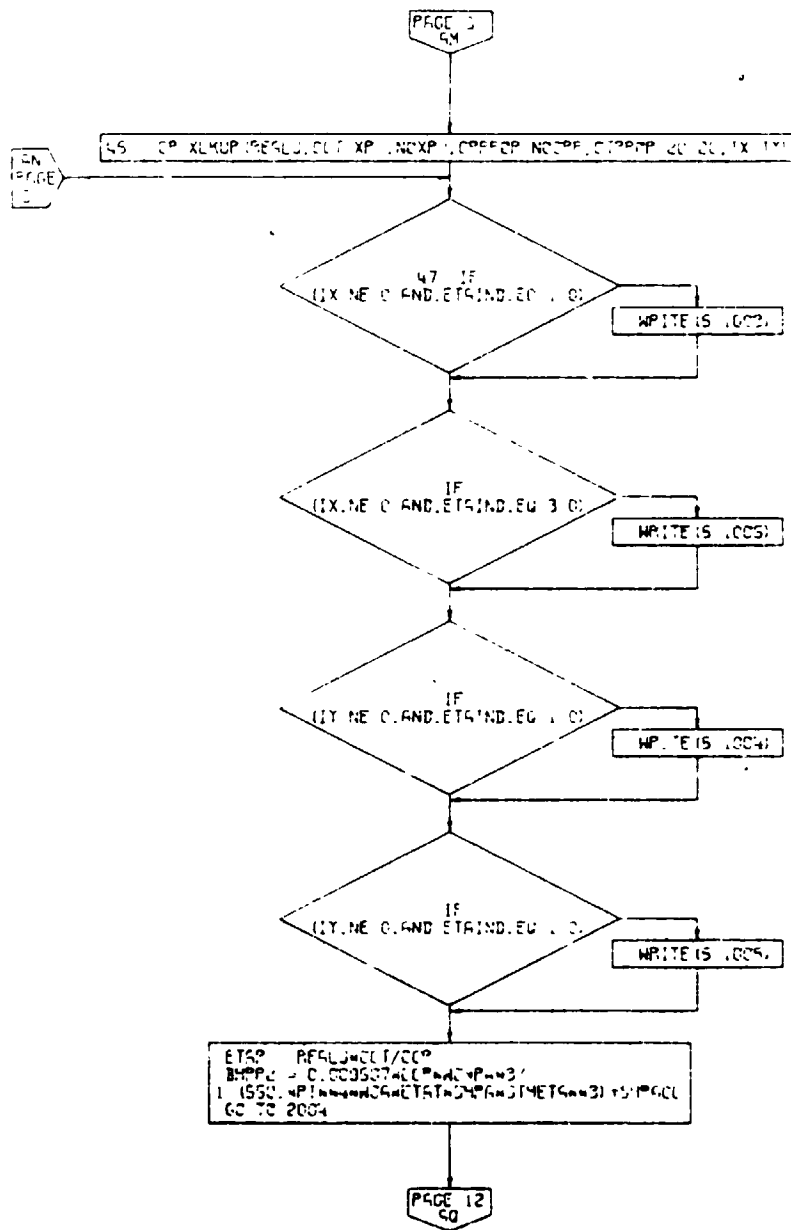


Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 7 of 12)

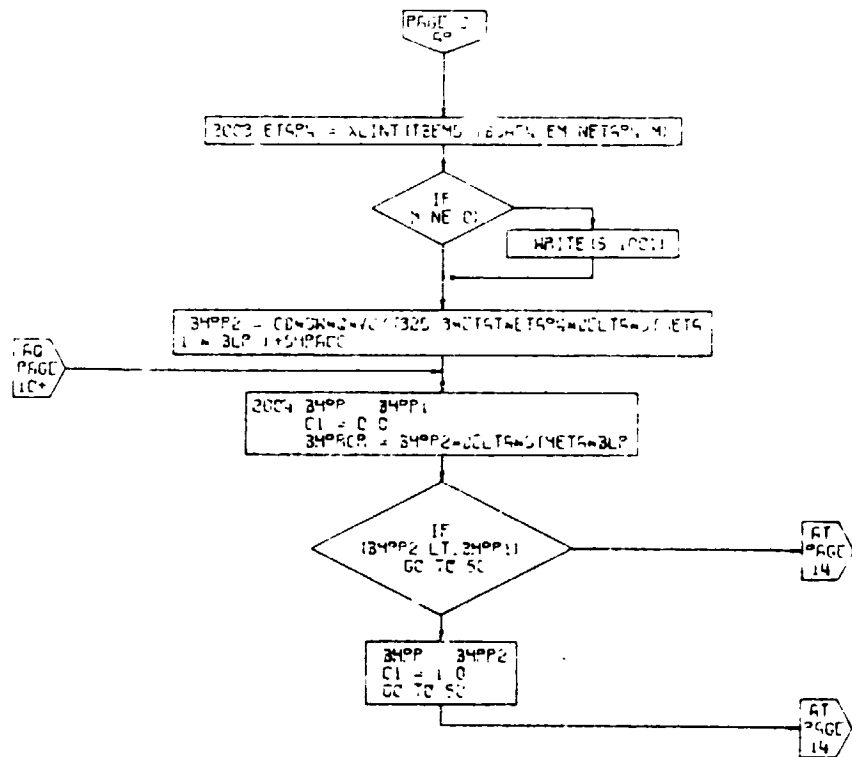


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ENCSZ

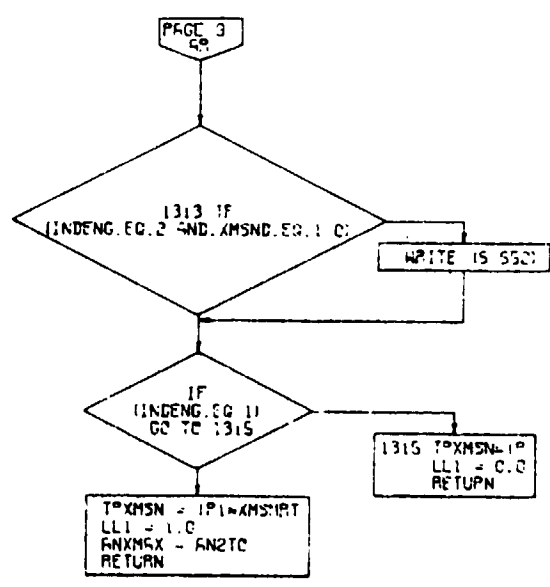
Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 8 of 12)





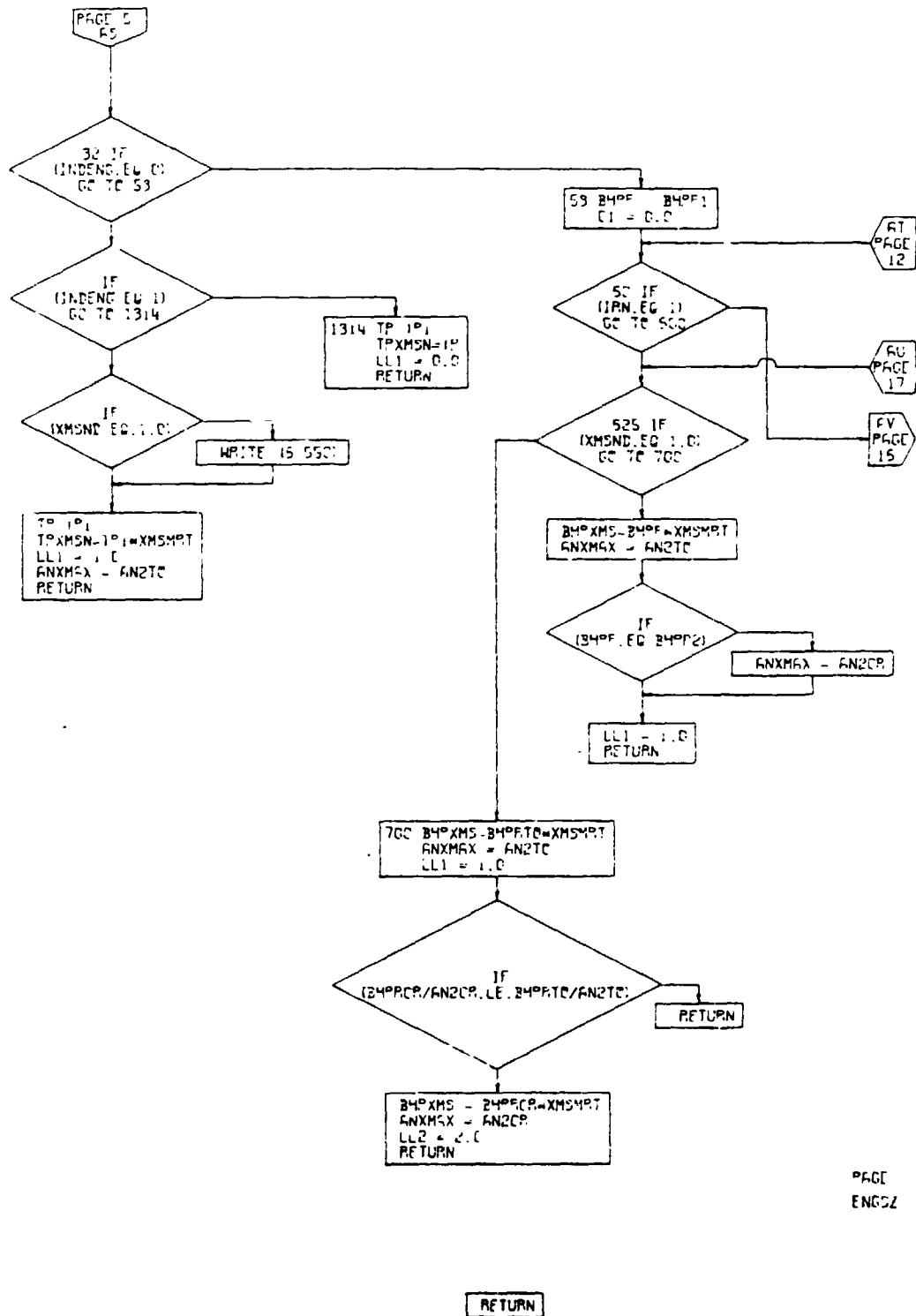


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ENG52



PAGE 13  
ENG52

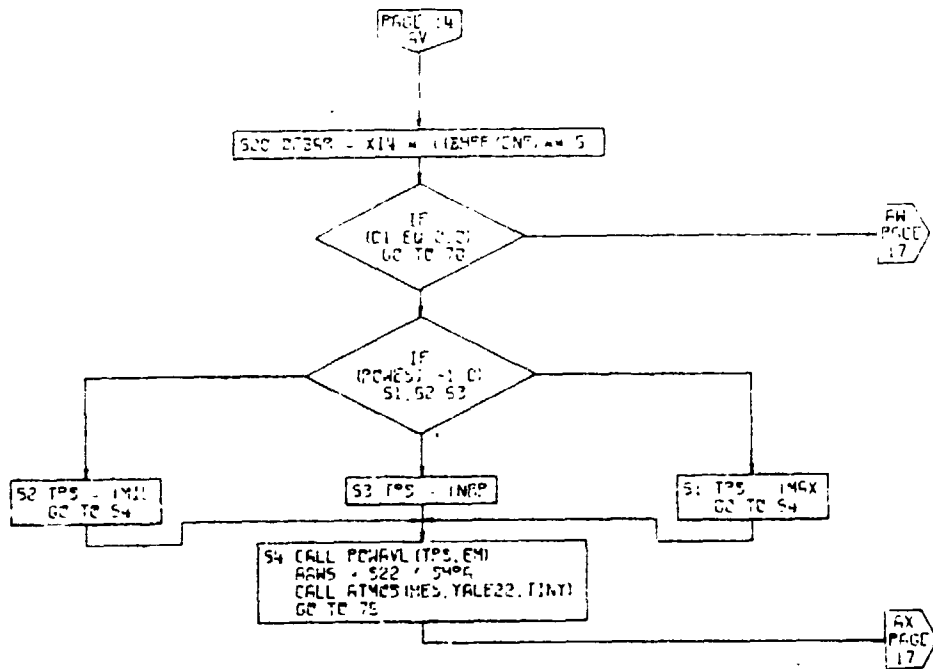
Figure 4-28. Engine Sizing Subroutine, Flow Chart (Part 10 of 12)



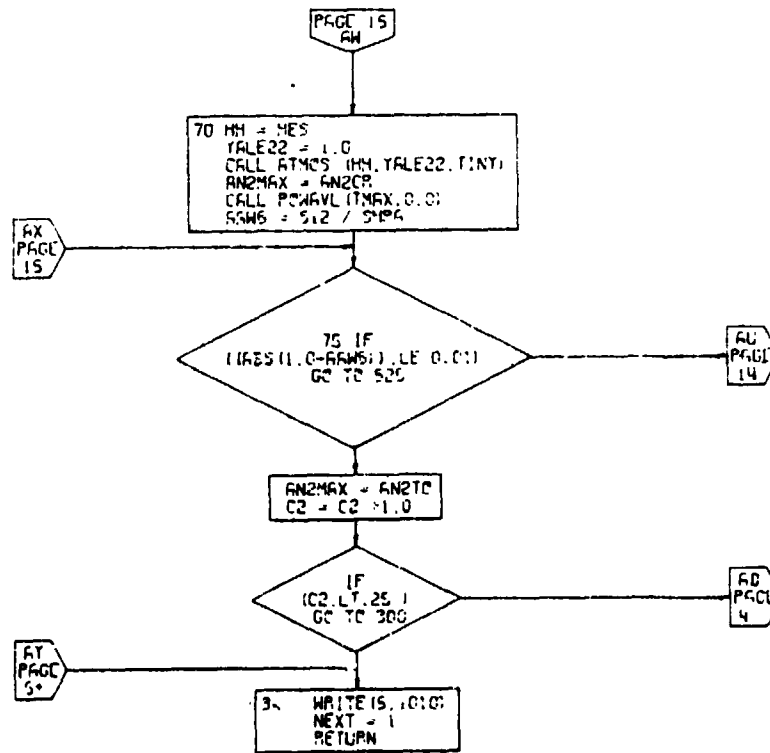
PAGE 14  
ENGGZ

PAGE 15  
ENGGZ

Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 11 of 12)



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ENG52



PAGE 17  
ENG52

Figure 4-28. Engine Sizing Subroutine, Flow Chart  
(Part 17 of 12)

#### 4.9 WEIGHT TRENDS SUBROUTINE

The weight trends subroutine calculates the group weights for the propulsion system, the structure system, and the flight control system. These weights are then combined with input values of the weight of fixed useful load, fixed equipment, and payload in order to determine the weight of fuel available (Figure 4-29). The subroutine uses detailed statistical weight equations as used at the Boeing Vertol Company. The group weights are not directly added, but rather are combined by the use of incremental multiplicative and additive weight factors; these factors are useful for sensitivity studies for the aircraft. For example, if it is desired to determine the effect of an additional 300 pounds of propulsion system weight, the factor  $\Delta W_D$  is input as 300. Similarly, if it is desired to investigate the effect of a 15-percent increase in the weight of the engines, the factor  $K_5$  is input as 1.15.

In order to calculate the weight of the aircraft structure, the weight trends subroutine must determine the limiting design load factor. It does this by comparing the magnitude of the input maneuver load factor with the value calculated for gust load factor. The gust load factor is evaluated at the altitude at which maximum operating equivalent airspeed ( $V_{MO}$ ) is equal to the speed for maximum operating Mach number ( $M_{MO}$ ) so long as the altitude falls in the band,

$$0 \leq h_{CRIT} \leq 20,000 \text{ feet} .$$

The gust load factor is calculated at the speed  $V_C$  (see Reference 4) which is taken to be equal to  $V_{MO}/M_{MO}$ . Modern aircraft which would be studied by VASCOMP II are seldom, if ever, gust-critical at either the  $V_B$  or  $V_D$  (Reference 4) conditions. If the user finds that his aircraft is gust-critical at other than the  $V_C$  condition, he must manually calculate the expected load factor and insert that value in the program as a dummy maneuver load factor.

##### 4.9.1 Weight Trend Data

The weights subroutine section of VASCOMP presented herein represents one approach for determining the individual and group weights which make up the weight empty of an aircraft. The aircraft weight is divided into the subgroups as shown in Table 4-7 and is in general accordance with the weight and balance data reporting procedures and forms for aircraft and rotorcraft described in Military Standard 1374. A copy of Part I (Group Weight Statement) is included at the end of this section. A flow chart describing the weights subroutine is shown in Figure 4-30.

WEIGHT TRENDS SUBROUTINE

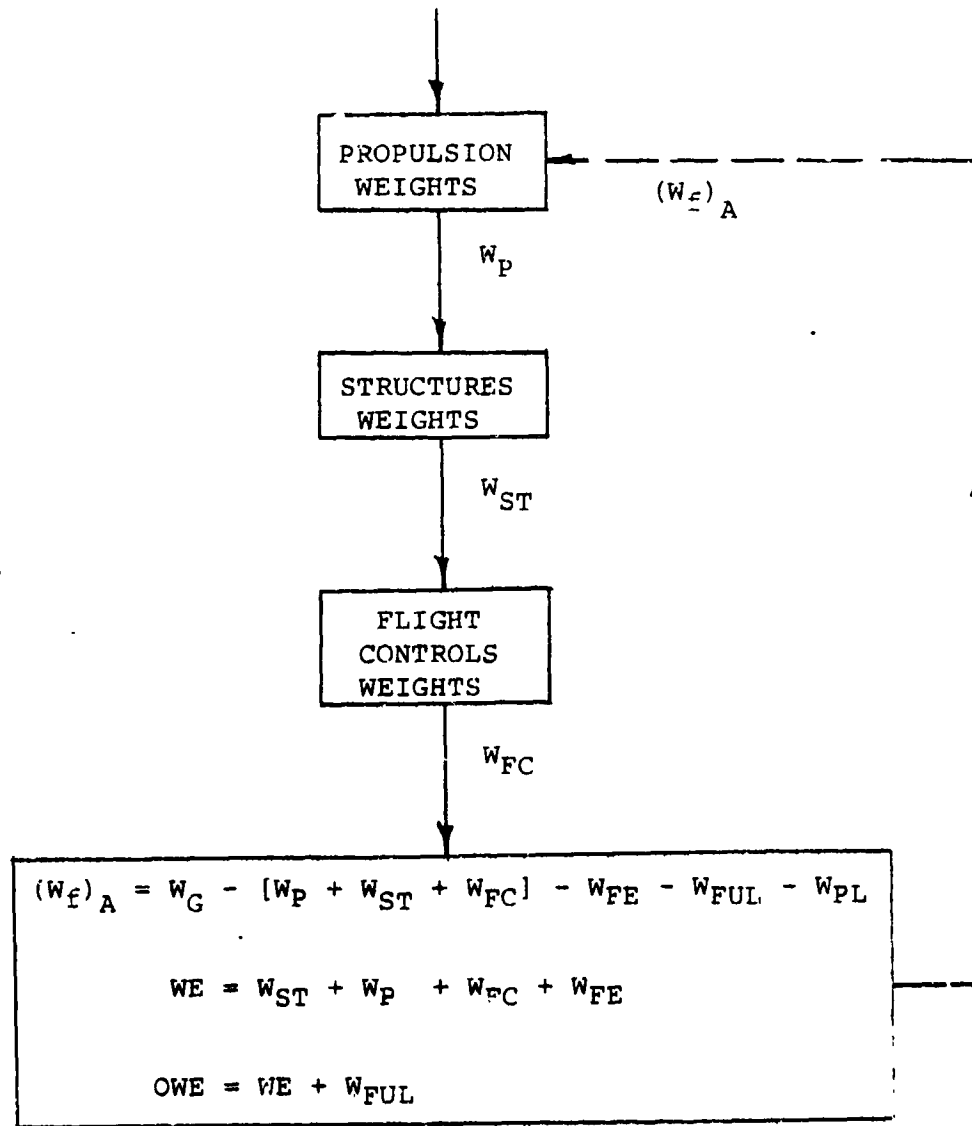
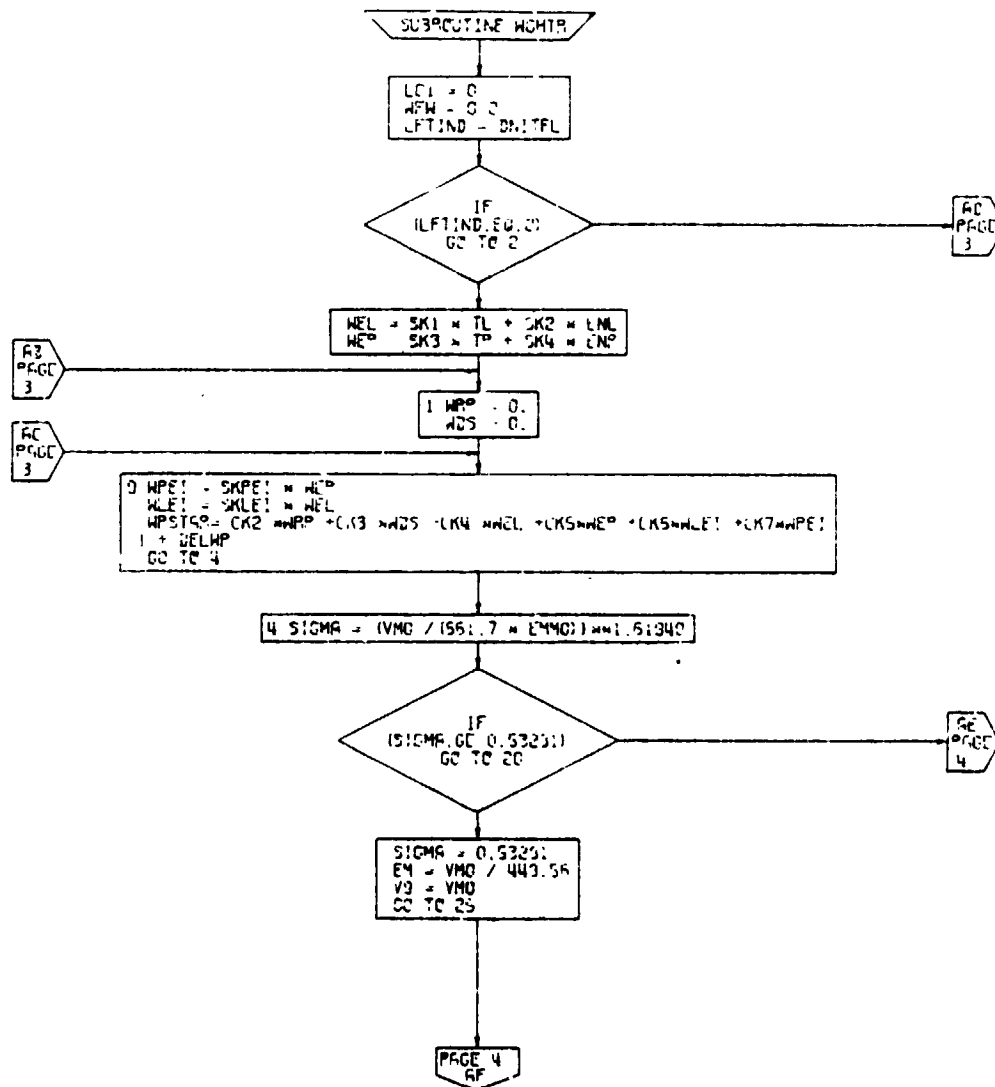


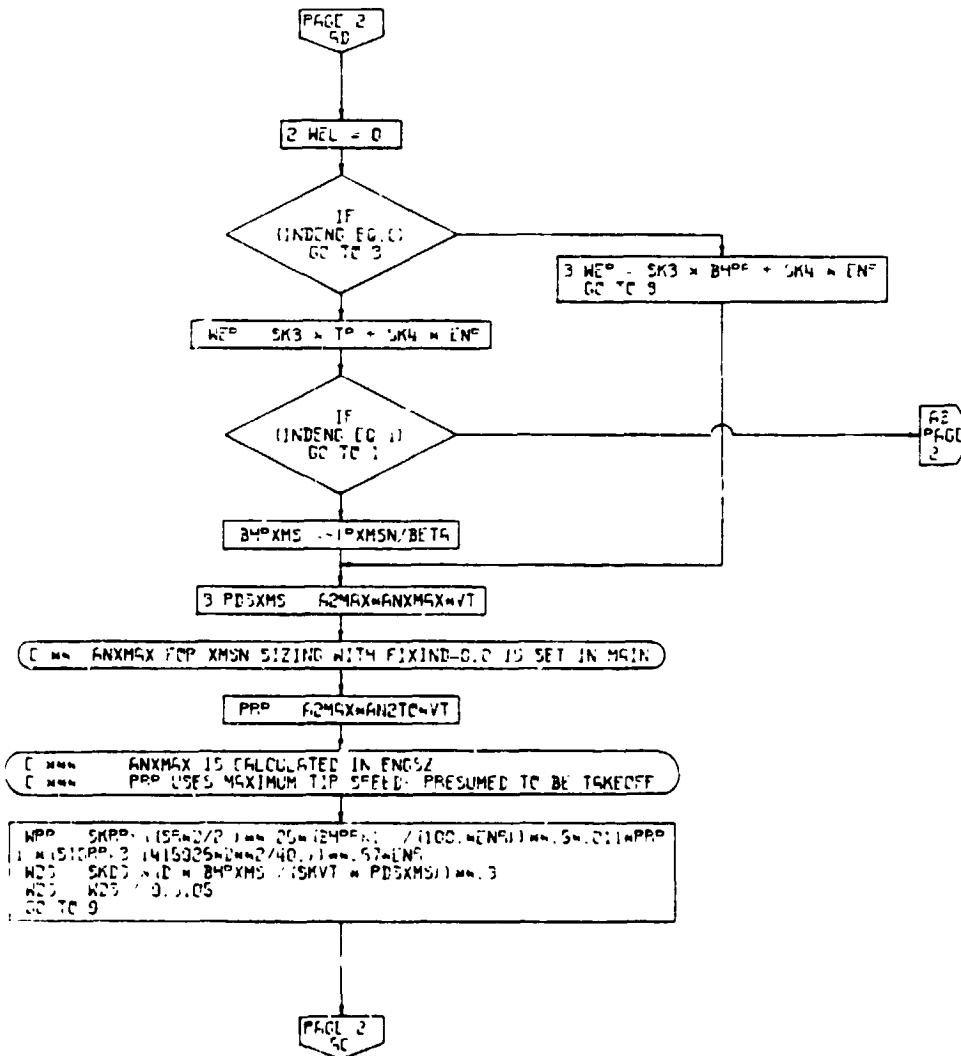
Figure 4-29. Weight Trends Schematic





PAGE 2  
WGMTR

Figure 4-30. Weight Trend Subroutine, Flow Chart  
(Part 1 of 4)



PAGE 3  
WOMTR

Figure 4-30. Weight Trend Subroutine, Flow Chart  
(Part 2 of 4)







The trend equations shown on the weights subroutine flow chart and those presented in the text produce the same results, although they are not necessarily written in the same form. The flow chart equations express the text trends in the terms used in other parts of the computer program.

The primary purpose of this weights subroutine is to provide a consistent method for rapidly estimating the operational weight empty and fuel available for the missions of various types of V/STOL aircraft. The results obtained from the trend equations will largely depend on engineering experience and the judgment exercised in selecting the various trend constants presented. The weight trend equations for the rotor, wing, tails, body, drive system, and pitch and yaw radius of gyration were developed by A. H. Schmidt of the Boeing Vertol Company over a span of 10 years. R. H. Swan, Chief Weight Engineer at Boeing Vertol, assisted in developing the rotor and wing equations. Accuracy of the trends is estimated to be within 5 percent of the actual values.

An explanation of the weight trends and instructions for completing the weight input sheet of VASCOMP are included in the text. As an additional aid for filling out the weight input sheet, the page numbers defining the various k terms are included with the respective terms on the weight input sheet, Table 4-8.

Weight trends developed at Boeing Vertol were used to determine the structure weights, Table 4-7, items 1, 3, and 6; flight control weights, item 22; and the propulsion system weights, items 2, 10, and 21. The trends were developed from existing aircraft and use design and geometric parameters to compute the weights of the various components. For aircraft on which limited information is available, such as in the case of the lift-fans, jet-lift, tilt-wing, etc., the trend constants have been adjusted to account for the design features typical of the particular configuration. Alighting gear weights are a function of the takeoff weight and are based on statistically derived percentages of the respective gross weights. Engine weights, item 13, were determined from information compiled from engine manufacturers. Engine section and engine installation weights, Table 4-7, items 10, 14, 15, 16, 17, and 19, are expressed as a percentage of the dry engine weight. Fixed equipment weights, items 24 through 41, are discussed later in the text.

Table 4-7 is representative of a typical weight summary form used for military aircraft. For this report the same general form will be used for commercial aircraft, with additions and revisions described in the group in which they occur. Definitions of some of the weight terms used are presented below.

WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

SHEET NO	CASE NO
06	

**AIRCRAFT WEIGHT INFORMATION**

VARIABLE	LOC	VALUE
* OWE	0400	Page 4-172
* W <sub>FE</sub> LBS	0401	Page 4-172
* W <sub>FULL</sub> LBS	0402	Page 4-172
** W <sub>PL</sub> LBS	0403	Page 4-174

**FLIGHT CONTROLS**

k <sub>CC</sub>	0404	Page 4-159
k <sub>FW</sub>	0405	Page 4-163
k <sub>H</sub>	0406	Page 4-159
k <sub>SAS</sub>	0407	Page 4-163
k <sub>TM</sub>	0408	Page 4-163
k <sub>UC</sub>	0409	Page 4-159

\* OWE IS NOT NECESSARY WHEN OPTIND = 1,2  
 \*\* W<sub>PL</sub> IS NOT NECESSARY WHEN OPTIND = 2

MULTIPLICATIVE FACTORS  
 NOMINALLY = 1.0

K <sub>15</sub>	0410	Page 4-176
K <sub>16</sub>	0411	Page 4-176
K <sub>17</sub>	0412	Page 4-176
K <sub>18</sub>	0413	Page 4-176
K <sub>19</sub>	0414	Page 4-176
K <sub>20</sub>	0415	Page 4-176

**ATMOSPHERE TEMPERATURE**

NO. OF PAIRS	0416
--------------	------

NOTE: THIS TABLE IS NOT NECESSARY IF ATMIND IS NEVER SET TO 2

Refer to Table 4-15 for a description of the multiplicative factors.

**TABLE 4-8**

INCREMENTAL GROUP WTS. NOM = 0

VARIABLE	LOC	VALUE
-W <sub>FC</sub> LBS	0417	Page 4-159
-W <sub>P</sub> LBS	0418	Page 4-174
-W <sub>ST</sub> LBS	0419	Page 4-174

**GROUP WEIGHT INFORMATION**

**STRUCTURAL**

k <sub>B</sub>	0420	Page 4-151
k <sub>LES</sub>	0421	Page 4-166
k <sub>LG</sub>	0422	Page 4-157
k <sub>MG</sub>	0423	Page 4-157
k <sub>TL</sub>	0424	Page 4-151
k <sub>WF</sub>	0425	Page 4-146
k <sub>WW</sub>	0426	Page 4-146
k <sub>Y</sub>	0427	Page 4-151
k <sub>Z</sub>	0428	Page 4-151
k <sub>PES</sub>	0429	Page 4-166
k <sub>MT</sub>	0430	Page 4-166
k <sub>NAC</sub>	0431	Page 4-166
Δ <sub>MT</sub>	0432	Page 4-166

VARIABLE	LOC	VALUE
-P P.S.I.	0450	Page 4-157
WC LBS.	0451	Page 4-146
Yc	0452	Page 4-146

**PROPULSION**

k <sub>DS</sub>	0453	Page 4-168
k <sub>FS</sub>	0454	Page 4-168
k <sub>LEI</sub>	0455	Page 4-166
k <sub>PEI</sub>	0456	Page 4-166
(†)k <sub>RIP</sub>	0457	Page 4-144
k <sub>V1</sub>	0458	Page 4-172

\* NOT NECESSARY WHEN LFTIND = 0  
 \*\* NOT NECESSARY WHEN ENGIN = 1  
 (†) INPUT AS 0 IF -PIND (LOC 0200) = 3  
 TO USE k<sub>MT</sub>, k<sub>NAC</sub>, & Δ<sub>MT</sub> INPUT k<sub>PES</sub>=0  
 IF k<sub>PES</sub> IS INPUT AS NON-ZERO, k<sub>MT</sub>, k<sub>NAC</sub>,  
 AND Δ<sub>MT</sub> ARE NOT REQUIRED.

K <sub>8</sub>	0433	Page 4-176
K <sub>9</sub>	0434	Page 4-176
K <sub>10</sub>	0435	Page 4-176
K <sub>11</sub>	0436	Page 4-176
K <sub>12</sub>	0437	Page 4-176
K <sub>13</sub>	0438	Page 4-176
K <sub>14</sub>	0439	Page 4-176

K <sub>2</sub>	0459	Page 4-176
K <sub>3</sub>	0460	Page 4-176
K <sub>4</sub>	0461	Page 4-176
K <sub>5</sub>	0462	Page 4-176
K <sub>6</sub>	0463	Page 4-176
K <sub>7</sub>	0464	Page 4-176
K <sub>21</sub>	0465	Page 4-176

h <sub>1</sub> FT	0440
h <sub>2</sub> FT	0441
h <sub>3</sub> FT	0442
h <sub>4</sub> FT	0443
h <sub>5</sub> FT	0444
h <sub>6</sub> FT	0445
h <sub>7</sub> FT	0446
h <sub>8</sub> FT	0447
h <sub>9</sub> FT	0448
h <sub>10</sub> FT	0449

θ <sub>1</sub>	0466
θ <sub>2</sub>	0467
θ <sub>3</sub>	0468
θ <sub>4</sub>	0469
θ <sub>5</sub>	0470
θ <sub>6</sub>	0471
θ <sub>7</sub>	0472
θ <sub>8</sub>	0473
θ <sub>9</sub>	0474
θ <sub>10</sub>	0475

Takeoff Gross Weight

Takeoff gross weight consists of the following subweights:

● Weight Empty

Weight empty includes a completely assembled aircraft ready to fly including the fluids required to operate the various systems such as in the transmissions and hydraulic systems. It does not include the trapped and unusable oil in the engine system or the trapped and unusable fuel in the fuel system.

● Fixed Useful Load

Crew and crew luggage (includes stewardesses)  
Trapped liquids (unusable fuel and oil)  
Engine oil  
Passenger service items (commercial aircraft)

- Water (wash and drink)
- Beverage
- Galley or coffee bar
- Toilet chemicals
- Food trays
- Emergency equipment (portable oxygen equipment, escape chute, smoke goggles, etc.)

● Payload

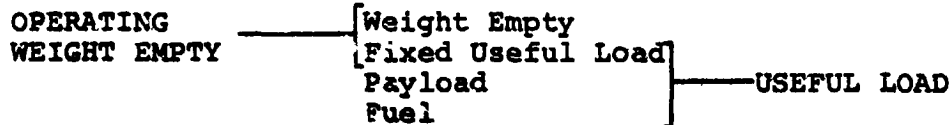
Gross weight less weight empty, fixed useful load, and fuel.

● Fuel

As required for mission.

Operating Weight Empty and Useful Load

Items included in the operating weight empty and the useful load are shown below:



The weight data and trend constants included herein are representative of the 1970-1975 time period. A description and explanation of the weight trends and other data required to complete the weights input portion of VASCOMP, Table 4-8, follow.

## Rotors or Propellers

The weight of the rotors or propellers is derived from the following equation:

$$W_R = 14.2 a (k)^{0.67},$$

$$\text{where } k = [r]^{0.25} \left[ \frac{HP_r}{100} \right]^{0.5} \left[ \frac{V_{t1}}{100} \right] \left[ \frac{R.b.c.}{10} \right] \left| \left[ \frac{R^{1.6}}{100K_d t} \right] \right|$$

Note: The last term is a droop factor, used only if the result is greater than 1.

## Legend

- $W_R$  = weight of rotor or propeller, pounds  
 $R$  = rotor radius, feet  
 $b$  = no. of blades per rotor  
 $c$  = blade chord (average), feet  
 $HP_r$  = horsepower (xmsn limit per rotor)  
 $V_{t1}$  = design limit tip speed, feet per second  
 $r$  = center line of rotation to average blade attachment point, feet
- $K_d$  = droop constant  
 $t$  = blade thickness at 0.25R, feet  
"a" = adjusting factor for type of system  
(see Figure 4-31)

In the trend equation the constant 14.2 is the average for the various rotor group weights presented in Figure 4-31. The expression "a" is the adjustment factor for the type of system, i.e., semirigid, pressure cycle, etc. To determine the value of  $k_{R/p}$  in the propulsion block of the weight input sheet, multiply the type of system desired "a" by the constant 14.2. Additional penalties must be added to the 14.2 "a" constant when blade folding and blade stowage are required. Increase the 14.2 "a" constant by an additional 50 percent if these features are included.

## Wing

The wing group includes the following general groups:

- Basic structure - upper and lower surfaces cover material, spars, ribs, joints, splices and fasteners
- Secondary structure - fixed leading and trailing edges, tips, nonstructural doors and panels, and wing fold items

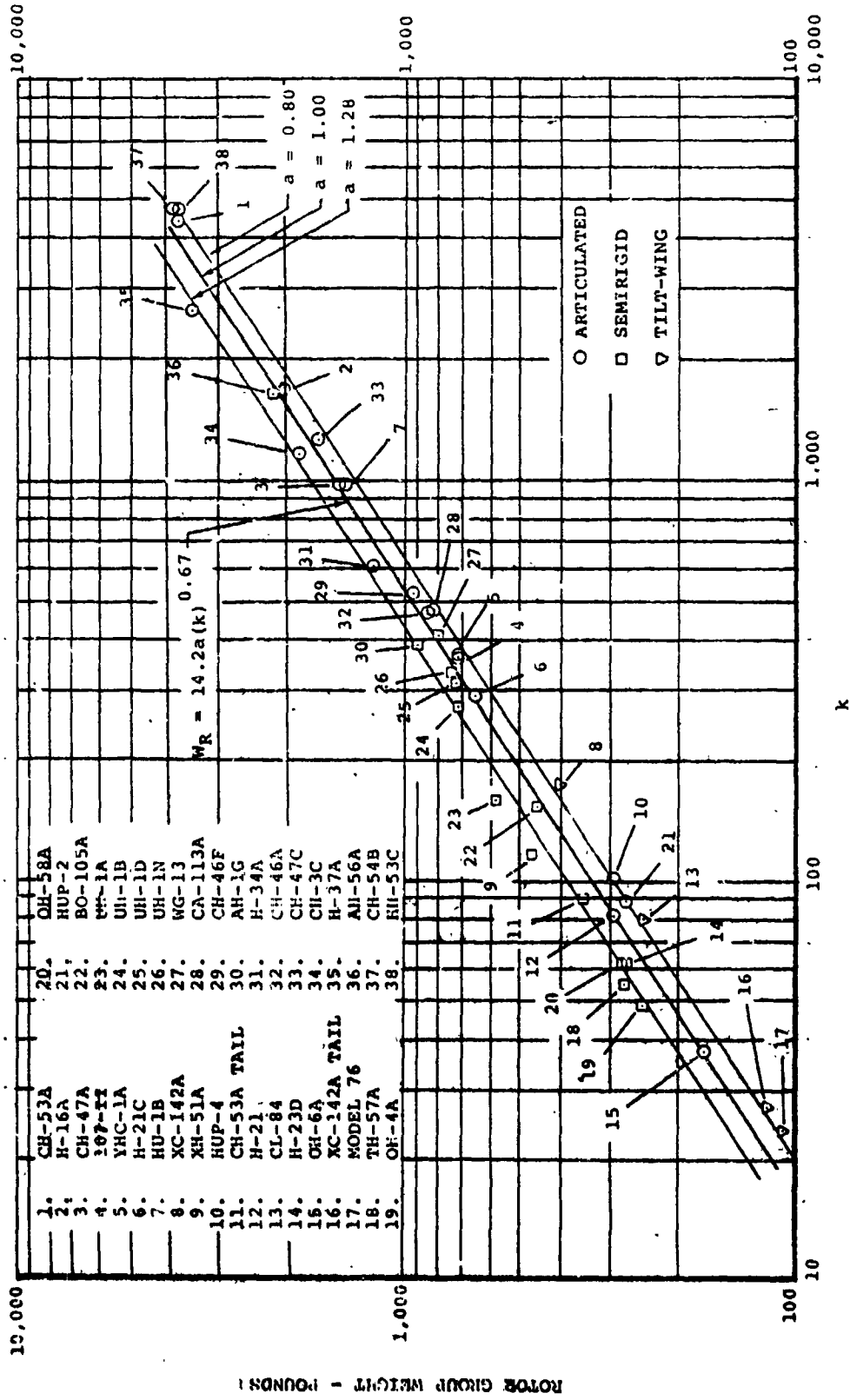


Figure 4-31. Rotor Group Weight Trend.

- Control surfaces - spoilers and ailerons
- High-lift devices - slats, leading and trailing-edge flaps, and boundary-layer-control nozzles and ducting

Wing weights are derived from the following equation:

$$W_W = 220a(k)^{0.585},$$

$$\text{where } k = \left[ \frac{R_m W_x}{10^4} \right] \left[ \frac{S_w}{10^2} \right] \left[ \log \frac{b}{B} \right] \left[ \sqrt{\frac{1+\lambda}{2k_r}} \right] \left[ \sqrt{N} \right] \left[ \log_{10} V_D \right] \left[ \log_{10} AR \right]$$

#### Legend

- $W_W$  = weight of wing, pounds  
 $S_w$  = planform area of wing (taken from  $C_L$  of aircraft), square feet  
 $b$  = wingspan, feet  
 $B$  = maximum fuselage width, feet  
 $\lambda$  = taper ratio  
 $N$  = ultimate load factor  
 $V_D$  = dive velocity, knots  
 $AR$  = aspect ratio  
 $k_r$  = wing root thickness  $\div$  root chord  
 $W_x$  = gross weight less wing and items on/in wing, pounds  
 $R_M$  = relief term =  $1 - \frac{(\text{dead wt in and on wing}) (d_2)}{(W_G - \text{wing wt} - \text{wing fuel wt}) (d_1)}$   
 $d_1$  = spanwise dimension from side of body to wing MAC, feet  
 $d_2$  = spanwise dimension from side of body to center of concentrated load, feet  
 $W_G$  = takeoff gross weight, pounds  
 $"a"$  = adjusting factor for type of wing (see Figure 4-32)

This wing weight equation represents the results of the wings analyzed in Figure 4-32. The 220 constant is an average for the spectrum of aircraft presented on the graph. The "a" factor adjusts the trend accordingly for the type of wing configuration being weighed. The value of  $k_{WW}$  to be placed in the structural box of the weight input sheet is the result of "a" times the constant 220. Typical examples of the value "a" are shown in Figure 4-32. When concentrated loads such as auxiliary fuel tanks, bombs, or other external loads are intended to be suspended from the wing, the  $W_C$  and  $Y_C$  portions of the incremental block must be filled in.  $W_C$  is the total weight of the applied loads and  $Y_C$  is its distance, in feet, from the side of the body. The  $k_{WF}$  term on the weight input sheet is included to account for the wing bending relief moment resulting from carrying fuel in the wing. The value of  $k_{WF}$  will vary between 0 and 0.7 depending on the amount of fuel estimated



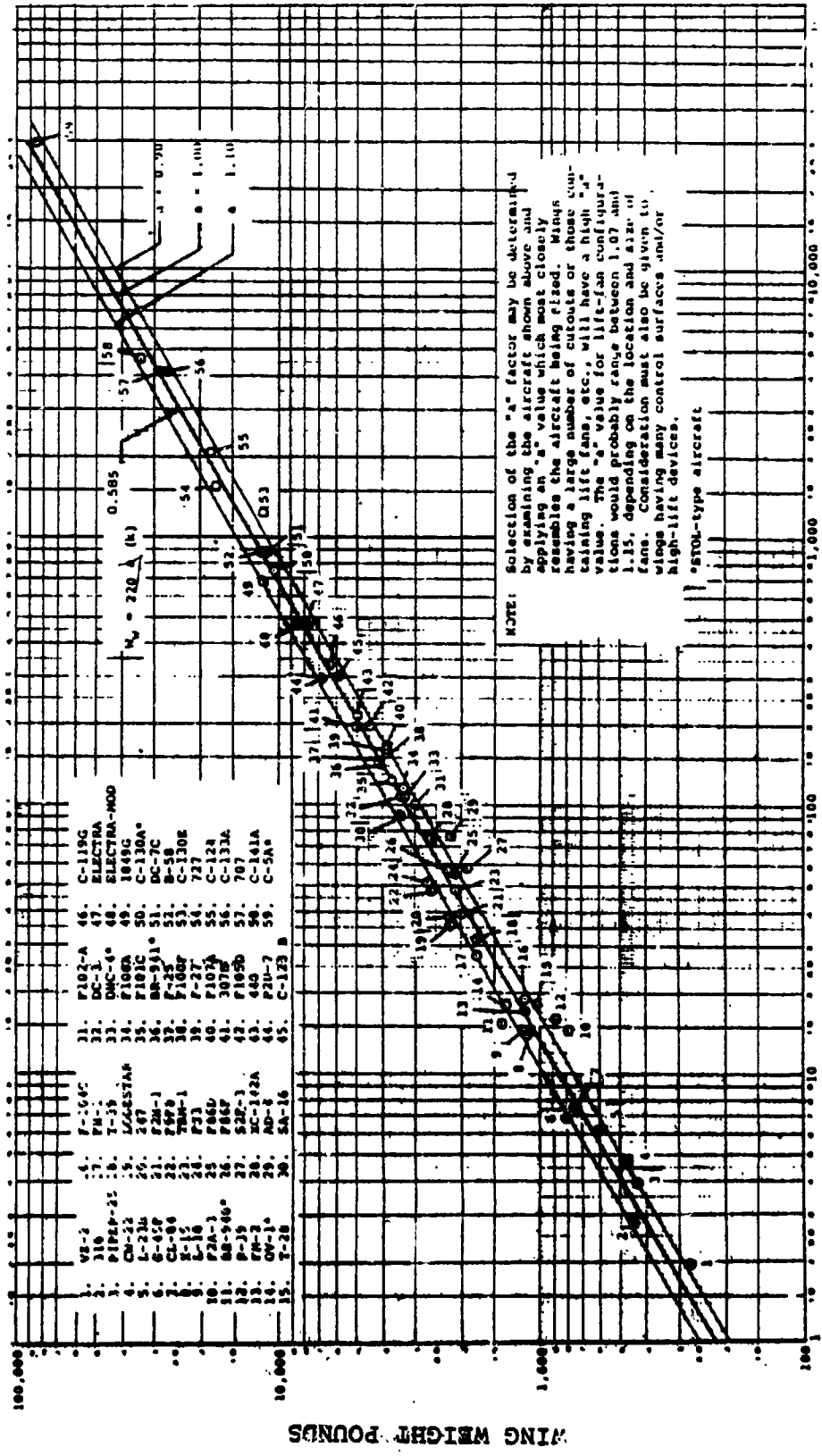


Figure 4-32. Wing Weight Trend.

to be in the wing. The following equation may be used to determine the value of  $k_{WF}$ :

$$k_{WF} = \frac{\text{Estimated wing fuel}}{(S_W)^{1.5}}$$

It should be noted that the program will never permit the fuel carried in the wing to be greater than the total fuel available and therefore, if it is desired to carry all the fuel in the wing, the user should simply input a large value for  $k_{WF}$ .

Aircraft designed specifically for STOL operation (running takeoff and landing over a 50-foot obstacle within 500 to 2,500 feet) normally require a large number of high-lift devices on the wing. The weight penalty associated with the high-lift devices will vary with the aircraft's performance goals, load factor, speed, and surface area of the lift device being employed. To aid in selecting  $k_{WW}$  for a STOL configuration, refer to Figure 4-32. This illustration includes and identifies a number of STOL aircraft. Selection of  $k_{WW}$  should be based on the Figure 4-32 aircraft which most closely compares to the configuration being analyzed. If the wing being analyzed is not similar to one of those on Figure 4-32, the following alternate method can be used: a) Input  $k_{WW} = 200$  into location 0426 on the weight input sheets; b) calculate a high lift factor to account for the type of high lift system being used. The high lift factor (HLF), calculated from the following equation, should be input to location 0433 (wing multiplicative factor) on the weight input sheet.

$$HLF = 1 + \frac{S_{HLS}}{S_W} \quad (TF)$$

where HLF = high-lift factor  
 $S_W$  = planform area of wing taken from  $\mathcal{G}$  of aircraft, square feet  
 $S_{HLS}$  = retracted planform area of high-lift surface, square feet  
 TF = high-lift type factor from Table 4-9

The HLF must be placed in location 0433 (wing multiplicative factor) on the weight input sheet.

Figure 4-32 presents the weights of conventional wings designed primarily by airloads resulting from forward flight. The term  $R_{MWx}$  in the trend equation indicates the magnitude of the resultant wing shear and bending loads located at the semispan center of lift in forward flight. In tilt-rotor-type aircraft where the propulsion and dynamic components (engine and prop/rotor installations, drive system, nacelle, etc.) are located at the wingtips, the wing design requirements result from

TABLE 4-9  
HIGH-LIFT FACTORS -  
WING CONTROL SURFACES

Lift Device and Hinge	Type Factor (TF)
Simple flap	0.0
Standard or simple Fowler	0.585
Fowler with variable droop (track + hinge)	0.741
Fixed double slot, simple hinge	0.585
Fixed double slot, extended hinge	0.741
Double slot, 2 simple hinges	0.741
Double slot, track + simple hinge	1.000
Triple slot, track + 2 simple hinges	1.270
Triple slot, 2 tracks + simple hinge	1.460
Slat (with simple track)	0.585
Slat with track	0.810
Droop LE, simple hinge	0.490
Spoiler-brake comb., simple hinge	0.390
Krueger, simple hinge	0.490
Krueger, extended hinge (707 type)	0.666
Blown flap-hot, single slot, simple hinge	0.666
<p>For aircraft employing combinations of the above devices, the appropriate type factors should be summed.</p>	

vertical flight and transitional modes and the term  $R_M W_X$  is interpreted by locating the center of lift at the thrust line of the rotor and  $W_X$  is redefined as the aircraft gross weight less the weight of the nacelle and contents. The computer subroutine does not relocate the center of thrust for tilt rotor type aircraft. This must be analyzed separately and the wing K adjusted accordingly.

### Tails

The weights of the horizontal and vertical tails are determined from the weight trend equations presented below.

#### Horizontal Tail

$$W_{HT} = 350(k)^{0.54}, \text{ where}$$

$$k = \left[ F_H \right] \left[ \frac{S_H}{10^2} \right] \left[ \frac{\log V_D}{TMA \times t} \right] \text{ and } F_H = \left[ \frac{W_G}{10^4} \right] \left[ \frac{k_y}{10} \right] \left[ \frac{b_H}{10} \right] \left[ \frac{1+2\lambda_H}{1+\lambda_H} \right] \left[ k_{TL} \right]$$

#### Vertical Tail

$$W_{VT} = 360(k)^{0.54}, \text{ where}$$

$$k = \left[ F_V + \frac{a F_H}{2 b_V} \right] \left[ \frac{S_V}{10^2} \right] \left[ \frac{\log V_D}{TMA \times t} \right] \text{ and } F_V = \left[ \frac{W_G}{10^4} \right] \left[ \frac{k_z}{10} \right] \left[ \frac{b_V}{10} \right] \left[ \frac{1+2\lambda_V}{1+\lambda_V} \right]$$

### Legend

$W_G$  = design gross weight, pounds  
 $k_y$  = pitch radius of gyration, feet  
 $k_z$  = yaw radius of gyration, feet  
 $b$  = tailspan, feet

$\lambda$  = taper ratio,  $\frac{(\text{chord at tip})}{(\text{chord at root})}$

$S$  = planform area, square feet  
 $F$  = tail load parameter  
 $V_D$  = dive velocity, knots  
 $TMA$  = tail moment arm (measured from wing 1/4 chord to tail 1/4 chord), feet  
 $t$  = root thickness, feet  
 $a$  = height of horizontal tail attachment to vertical tail (measured from root of vertical tail), feet  
 $H$  = subscript H denotes horizontal tail  
 $v$  = subscript v denotes vertical tail  
 $k_{TL}$  = tail load factor

The trends consider the tail loads which are a function of the gross weight, span, radius of gyration, and point of load application (distance of the mean aerodynamic chord from the

point of support). The "a" term in the vertical tail equation accounts for T-tail configurations. Figures 4-33 and 4-34 present the aircraft used to develop the trends. Refer to Figures 4-35 and 4-36 to determine the values of  $k_y$  and  $k_z$  to be placed in the structural box of the weight input sheet.

The term  $k_{t1}$  in the structural box of the weight input sheet is nominally 1. It is included to provide a means for penalizing the weight of the horizontal tail when loads incurred from carrier deck landings become a design consideration. The value of  $k_{t1}$  under these conditions would vary between 1.1 and 1.2 depending on the magnitude of the design loads.

### Body Group

The weight of the body structure is determined from the following equation:

$$W_{BG} = 124a(k)^{.508}, \text{ where}$$

$$k = \left[ \frac{W_x}{10^4} \right]^{0.7} \left[ \frac{Sf}{10^3} \right]^B (Lf + L_{RW})^{0.5} \left[ \log_{10} V_D \right] (\Delta P + 1)^{0.2} (N)^{0.3}$$

### Legend

- $W_{BG}$  = weight of body group, pounds
- $W_x$  = weight of fuselage and contents (includes empennage), pounds
- $Sf$  = wetted area of fuselage, square feet
- $B$  = maximum fuselage width, feet
- $Lf$  = length of fuselage, feet
- $L_{RW}$  = length of ramp well, feet
- $L_{EB}$  = length of engine bay (in lieu of or added to  $L_{RW}$ , depending on configuration), feet
- $V_D$  = dive velocity, knots
- $\Delta P$  = limit differential cabin pressure, pounds per square inch
- $N$  = ultimate load factor
- "a" = body adjustment factor

Figure 4-37 indicates the relative body weight variation between different families of aircraft. Commercial, military, cargo, carrier-based, and land-based aircraft represent the different families. Other factors which affect the weight of the fuselage include such things as number of cutouts, type of entrance doors and stairs, ramp design, pressurized versus unpressurized, etc.

A mean line of 124 has been selected as an average for all the aircraft shown in Figure 4-37. The body adjustment factor "a" corrects the 124 constant in accordance with the family being

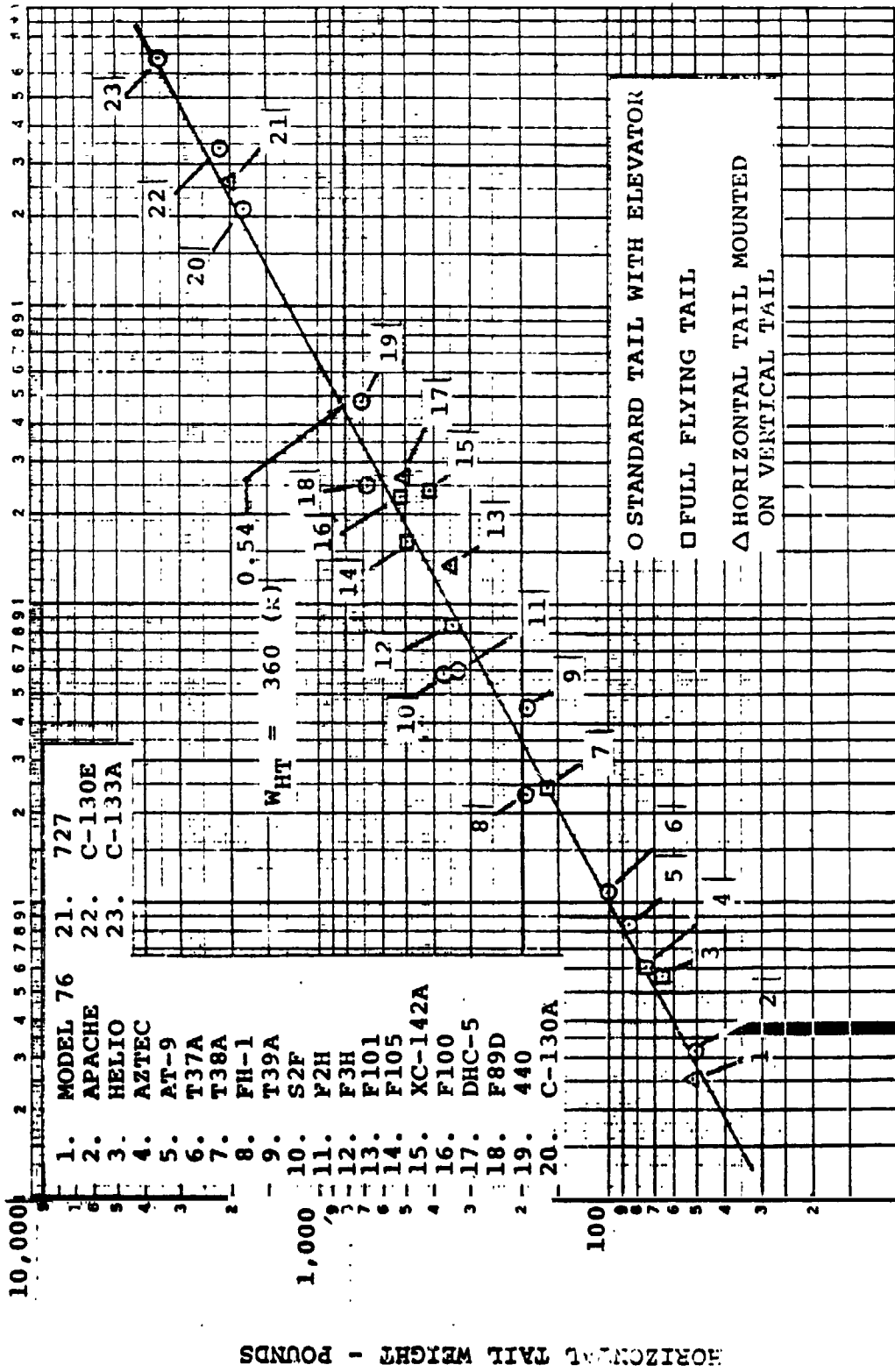


Figure 4-33. Horizontal Tail Weight Trend

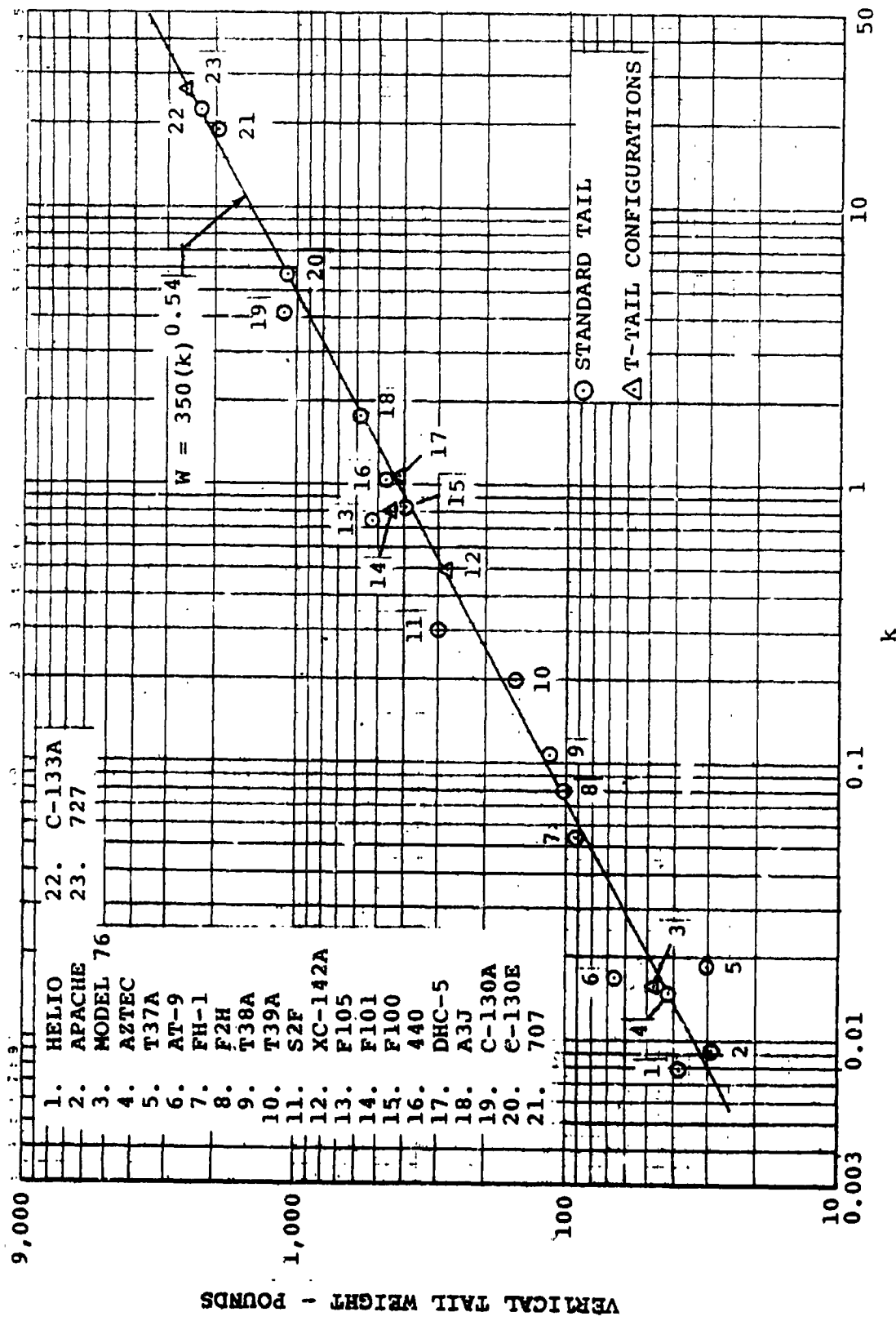


Figure 4-34. Vertical Tail Weight Trend.

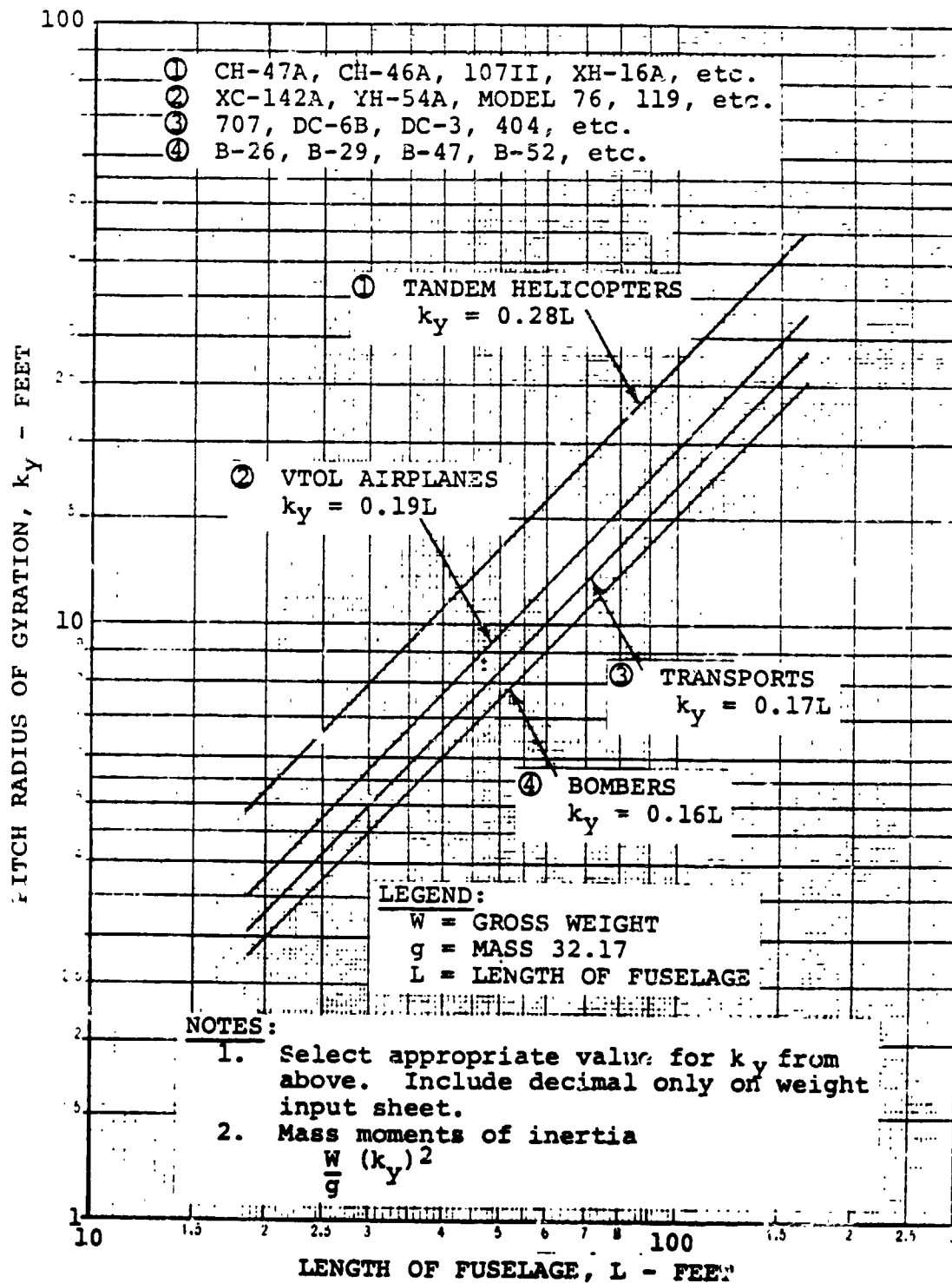


Figure 4-35. Radius of Gyration Trend - Pitch.



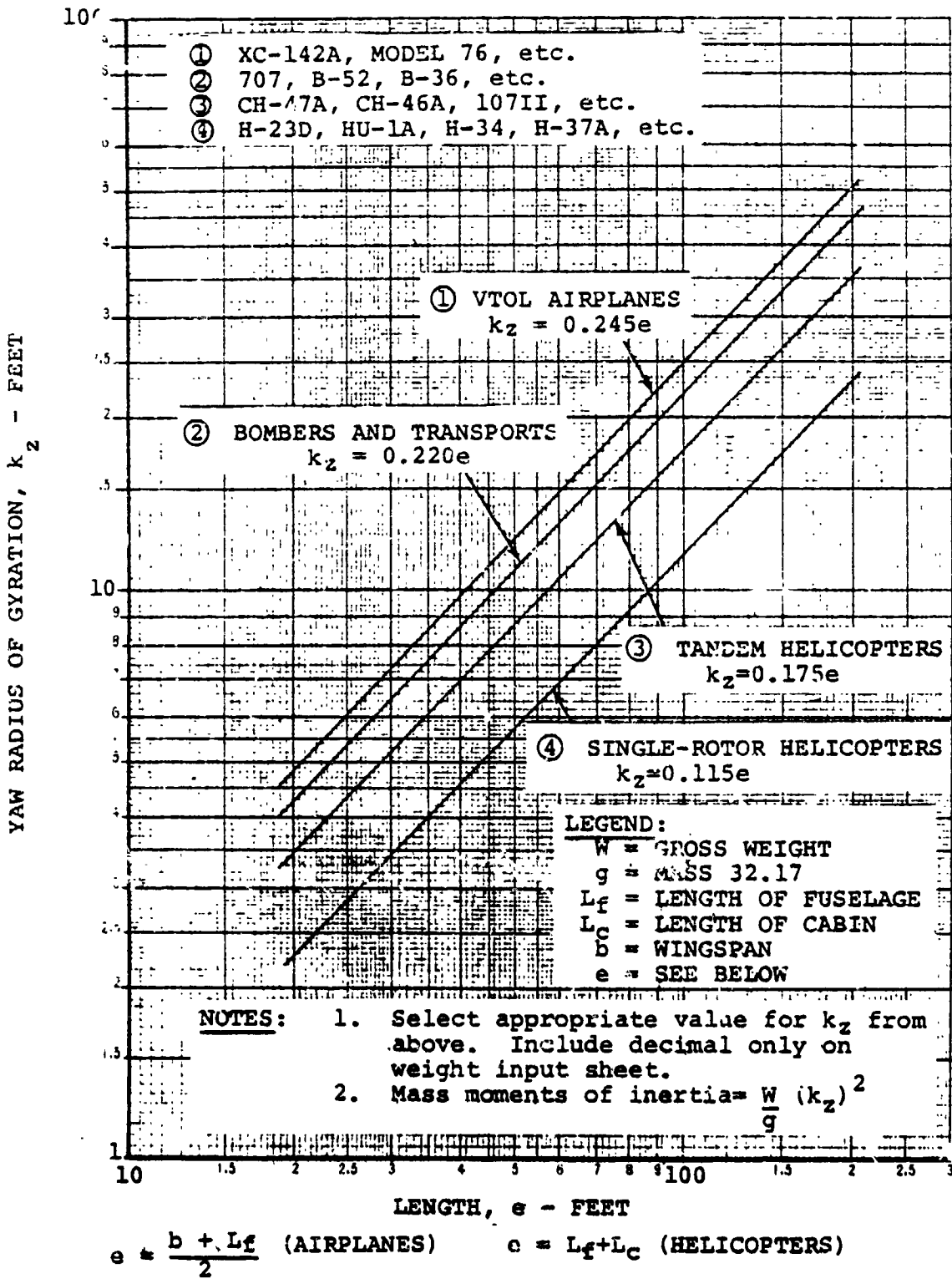


Figure 4-36. Radius of Gyration Trend - Yaw.

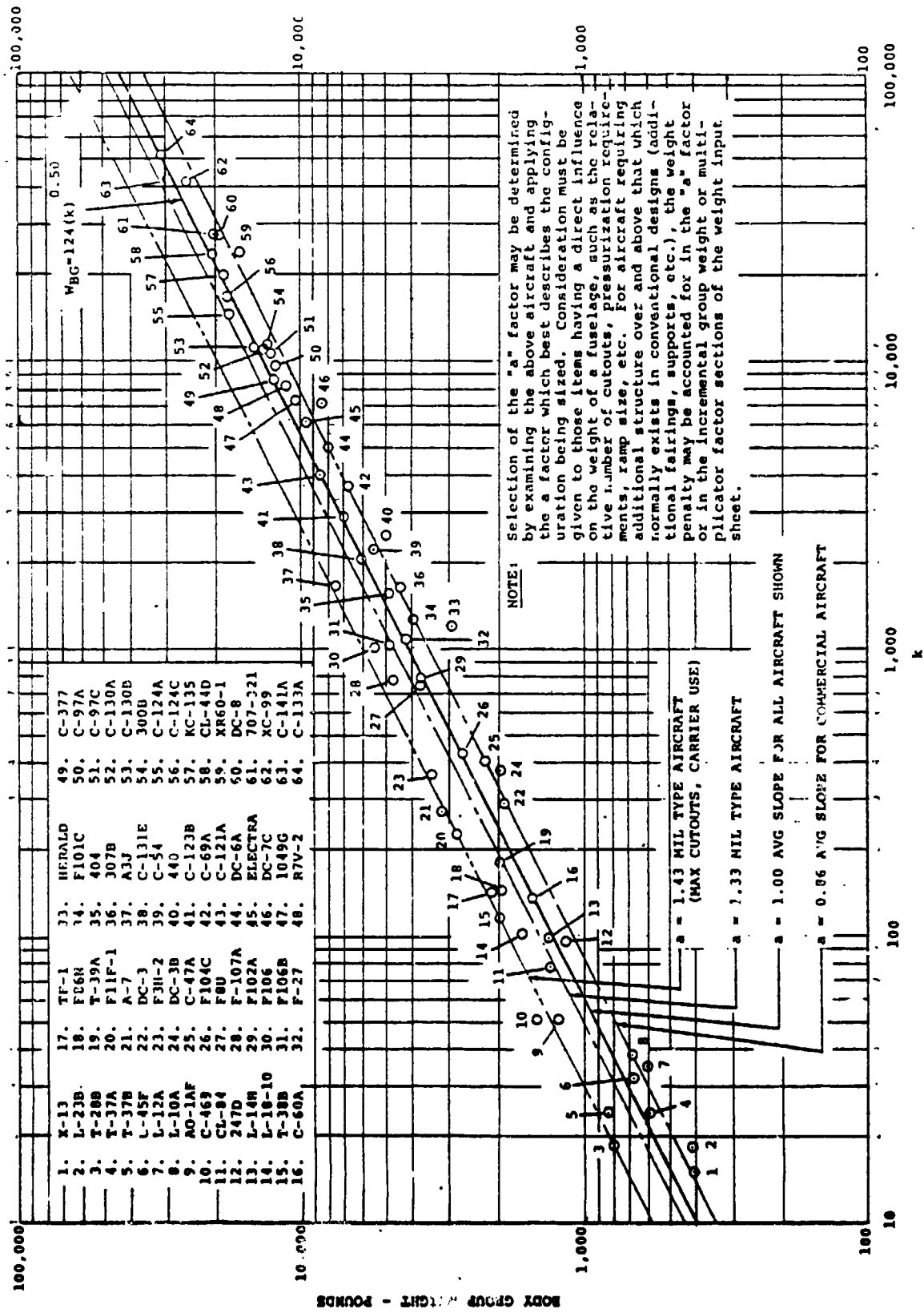


Figure 4-37. Body Group Weight Trend.

configured. For aircraft having engines, gas generators, fans, etc., on top of the fuselage, an additional penalty must be added to the 124 "a" constant to account for the additional supports, fairings, etc., required to support and enclose these components. Refer to Figure 4-37 to determine the "a" factor which best describes the configuration. The revised constant, 124 "a", is the  $k_B$  term to be inserted in the appropriate box of the weight input sheet. The limit differential cabin pressure ( $\Delta P$ ) must also be placed in the proper location in the incremental block of the weight input sheet.

### Alighting Gear

For the normal tricycle gear geometry, the total landing gear weight including the running gear (wheels, tires, brakes, etc.), structure (shock struts, drag struts, support structure, etc.), and controls (retraction, steering, systems, etc.) is expressed as a percentage of the design gross weight where:

$$W_{LG} = (k_{LG}) W_g$$

where  $W_{LG}$  = total weight of the landing gear

$$k_{LG} = \frac{\text{landing gear}}{\text{gross weight}}$$

$W_g$  = design gross weight

The percentage will vary between 0.015 and 0.080 depending on the complexity and design loads of the system. Conventional landing gear with retracting systems, operating on improved runways, normally run between 0.025 and 0.037. STOL-type systems operating on rough runways require longer and larger alighting gear components to accommodate the aircraft's higher rotational angle and sink speeds required to operate at the shorter field lengths.  $k_{LG}$  for the STOL aircraft will normally vary between 0.035 and 0.08. The main gear usually weighs about 80 percent of the total gear weight. The  $k$  term in the weight expression above is the value that must be placed in the  $k_{LG}$  box of the weight input sheet. The weight of the main gear is included by placing 0.80 in the  $k_{MG}$  location on the weight input sheet.

Table 4-10 is included as a guide in selecting  $k_{LG}$ . It includes the total gear weight as a percentage of the gross weight for a sampling of military, commercial, and VTOL aircraft.

### Flight Controls

The weight of the flight controls will vary depending on the type of control system required (manual, power boost, etc.) and the type of aircraft being considered (tilt-wing,

TABLE 4-10  
LANDING GEAR WEIGHTS

Aircraft	Gross Weight (lb)	Total Gear Weight (lb)	Percent of Gross Weight
<u>Military</u>			
DHC-4*	28,500	1,398	0.049
F-27	42,000	1,884	0.045
Breguet 941*	46,000	2,626	0.057
DHC-5*	41,000	1,800	0.044
C-123B	54,000	2,331	0.043
C-118	107,000	3,895	0.036
C-130B*	135,000	4,824	0.036
C-130E*	155,000	4,939	0.032
C-124C	185,000	11,700	0.063
C-133A	275,000	10,635	0.039
C-141	318,000	10,357	0.033
C-5A	732,000	32,711	0.045
<u>Commercial</u>			
Gulfstream	35,100	1,237	0.035
Convair 440	49,100	2,158	0.044
Boeing 737-100	102,000	4,372	0.043
Boeing 727-100	161,000	7,211	0.044
Convair 880	184,500	6,933	0.038
Boeing 707-320	336,000	12,982	0.038
<u>VTOL</u>			
XV-5A	12,500	482	0.038
XV-4B	12,500	389	0.031
CL-84	12,600	369	0.029
X-22A	15,980	449	0.028
XC-142A	37,500	1,266	0.034
*STOL-type aircraft			

tilt-rotor, fixed-wing, etc.). Aircraft control systems requiring power boost and those having high-lift devices and many control surfaces will normally weigh more than those having a manual system and few control surfaces. Consideration must be given to these factors when determining the flight control constants to insert on the weight input sheet.

An equation defining the weight of the flight controls of a tilt-wing configuration is used as a base for the controls of all aircraft since it includes factors which can be isolated and applied to other types of configurations. Values for the various k factors listed below must be inserted in the flight control blocks of the weight input sheet. A description of the items comprising each of the control subgroups is included along with a sample of the k input values. Refer to the referenced trend curves, included for each of the major control groups, as an aid in selecting the respective k values.

#### Tilt-Wing

$$W_{FC} = k_{CC} \left( \frac{W_G}{1000} \right)^{0.41} + k_{UC} W_{RTOTAL} + k_H \left( \frac{W_{RTOTAL}}{100} \right)^{0.84} + k_{FW} W_G + k_{SAS} + k_{TM} W_G$$

#### Legend

$k_{CC}$  = constant for cockpit controls = 26

Cyclic and collective control sticks and linkages, pedals, cables and rods (Figure 4-38).

$k_{UC}$  = constant for upper controls = 0.30

All components from and including the power actuators up through the pitch links. Major items included are the actuators, swashplate, and pitch links (Figure 4-39).

$k_H$  = constant for systems and hydraulics = 40

All components between the cockpit controls and the rotor controls including actuators, artificial feel system, mechanical programmer, bell-cranks, rods, idlers, etc.

Main hydraulic systems including pumps, reservoirs, accumulators, filters, valves, lines, fluid, and supports (Figure 4-40).

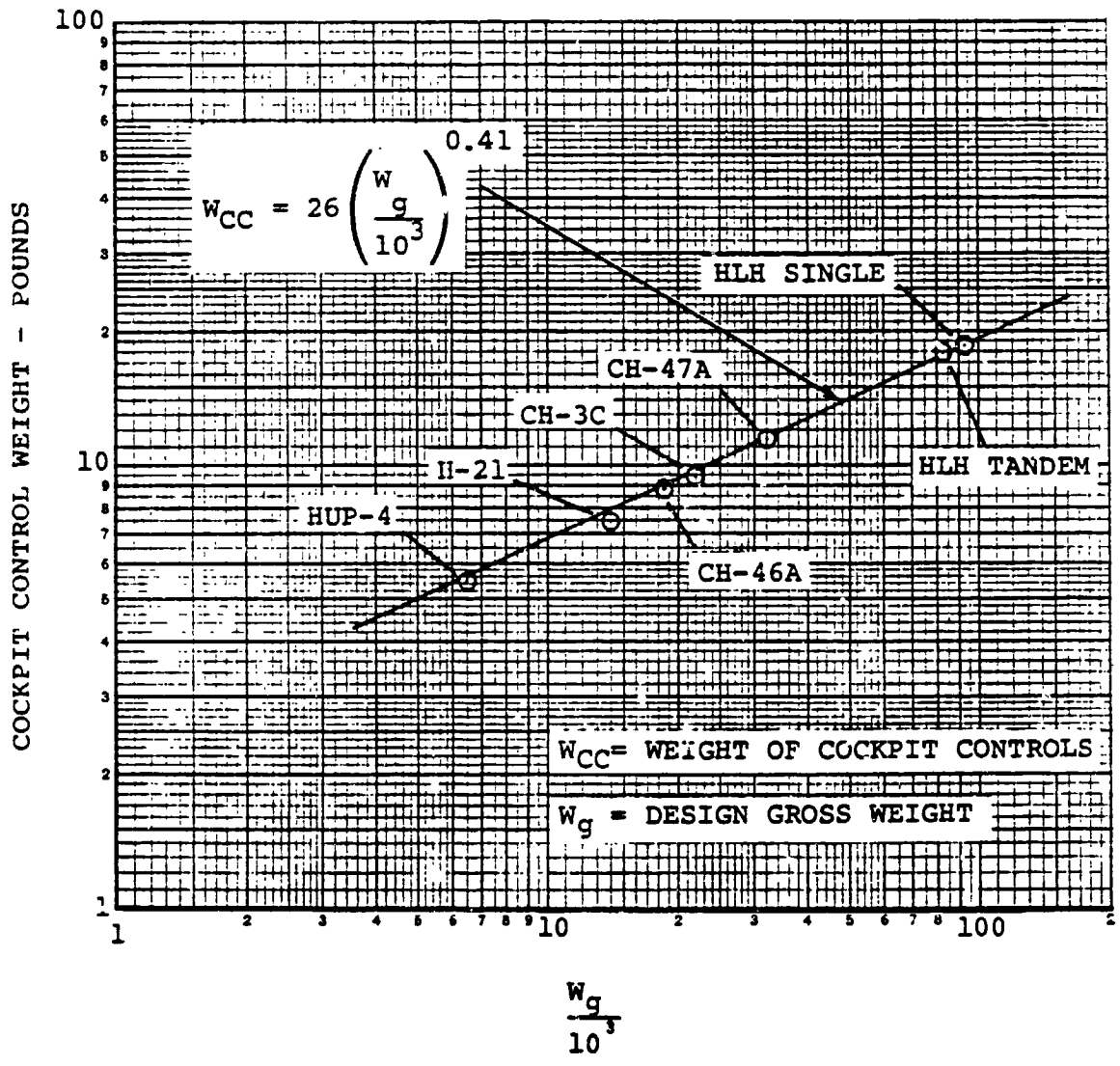


Figure 4-38. Cockpit Controls Weight Trend.

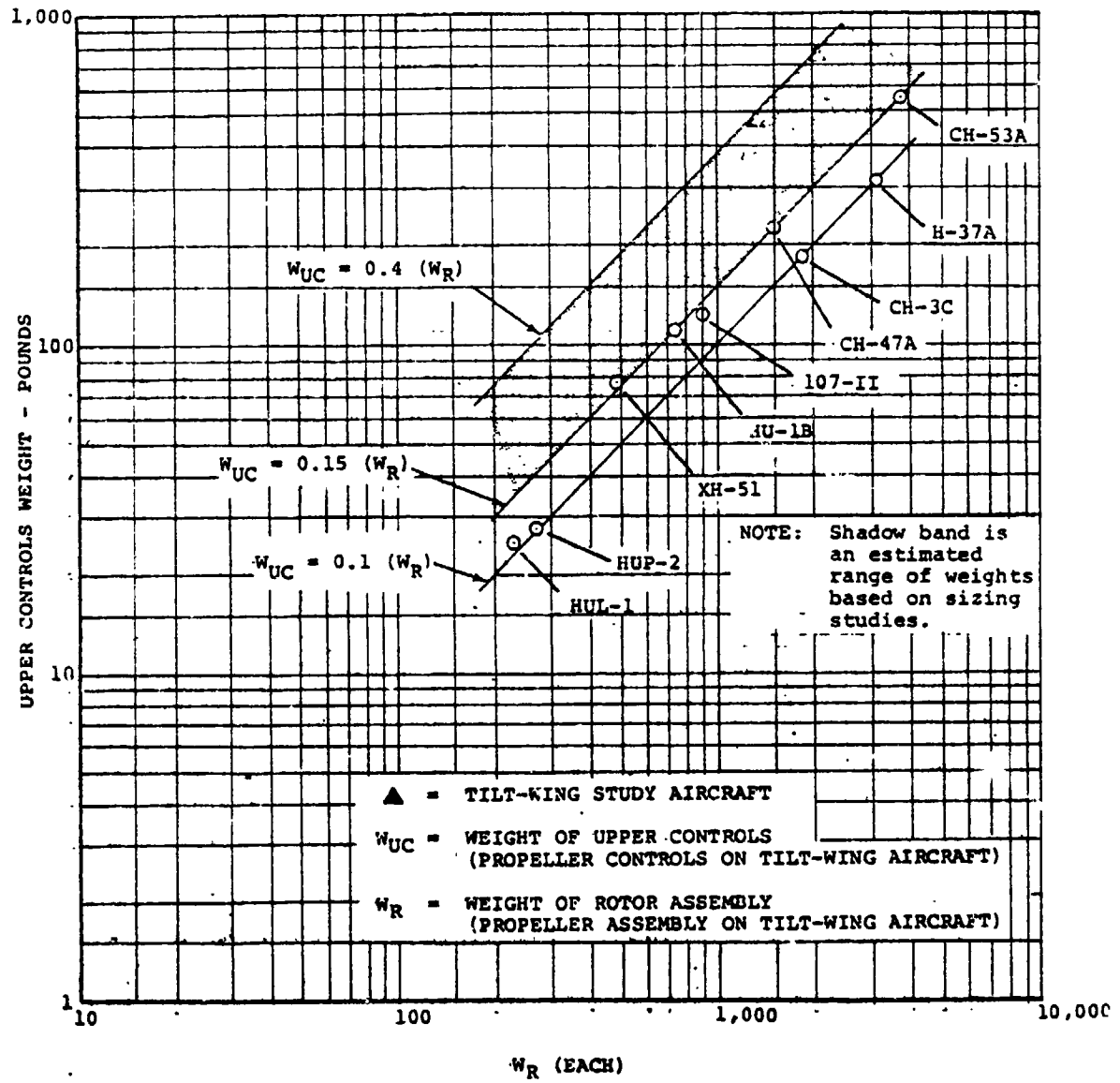


Figure 4-39 . Upper Controls Weight Trend.

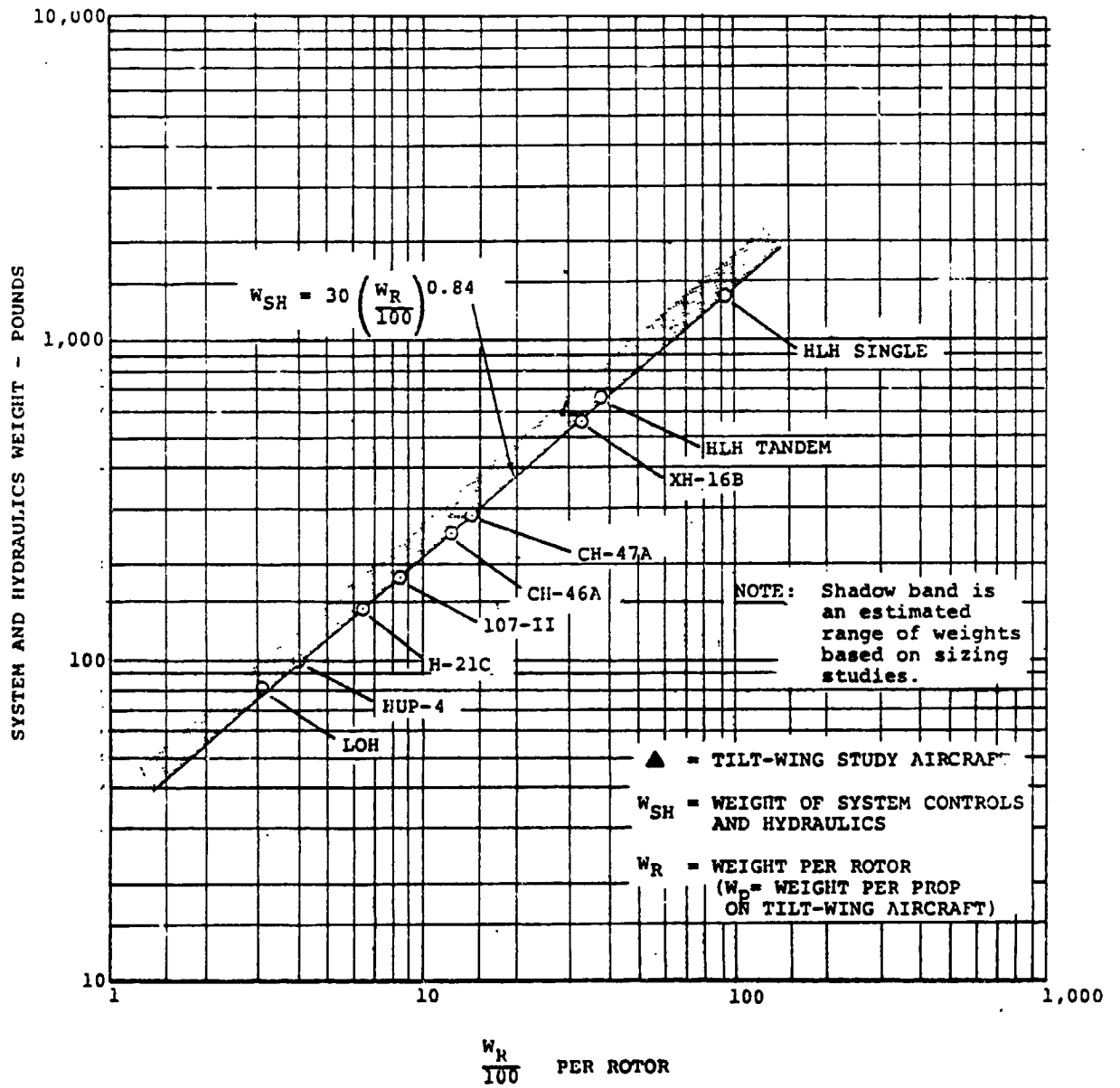


Figure 4-40. System and Hydraulics Weight Trend.



$k_{FW}$  = constant for conventional fixed-wing controls = 0.015

All components, actuators, and supports associated with moving the control surfaces - LE umbrellas, flaperons, spoilers, and tail surfaces, (including variable-incidence horizontal stabilizer), excluding those items common to the system quoted above. The constant for STOL aircraft employing a large number of high-lift devices will vary between 0.02 and 0.04 depending on the size and complexity of the surface (Table 4-11).

$k_{SAS}$  = constant for stability-augmented system and mixing units = 175

Includes black boxes and mechanical mixing units.

$k_{TM}$  = constant for tilting mechanism = 0.005

All components and supports required to tilt the wing or nacelle including actuators, power control units, mechanical system, fittings, and hardware (Figure 4-41).

#### Fixed-Wing

When sizing propeller-driven fixed-wing aircraft, use  $k_{UC}$  and  $k_{FW}$  only.

For aircraft requiring tailfans or rotors for pitch and/or yaw control, delta weight must be added in the incremental group block of the weight input sheet,  $\Delta W_{FC}$ . Other factors may be taken from the tilt-wing equation as before. An estimate of the weight of the fans or rotors may be made by using the rotor group and drive system trends described on pages 4-144 and 4-168 and adding an additional allowance for the weight of the structure, cross-shaft, and controls necessary to complete the installation. Aircraft requiring reaction controls must also be accounted for in the  $\Delta W_{FC}$  of the incremental block. No attempt is made to describe the weight of these controls since their weight will depend on the type (puff-pipes, compressors, turbines, etc.) and the amount of control power and response rate necessary to meet specified requirements.

#### Engines, Gas Generators, and Fans

The weight of the lift engines, cruise engines, gas generators, and lift fans is determined as part of the engine sizing routine considered elsewhere in the program. There is no provision for determining their weights on the weight input sheet. The  $\Delta W_p$  and  $k_5$  blocks of the input sheet provide a method for adding weight to the engines, etc., if desired. The weights

TABLE 4-11  
 FLIGHT CONTROL SURFACE  
 ACTUATION SYSTEMS DATA

Aircraft	① Flight Design Weight (lb)	② Flight Control Weight* (lb)	② ÷ ① **	Control Surfaces					
				Ailerons	LE Flaps or Slats	TE Flaps	Elevator or UHT	Rudder	Spoiler or Deflector
OV-10	15,421	552	0.035	M	-	M	M	M	H
DHC-4	28,500	467	0.016	M	-	M	M	M	-
DHC-5	41,000	610	0.015	M	-	M	M	M	-
Breguet 941	46,000	1,056	0.023	H/M	-	H	H/M	H/M	-
F-28	50,000	1,009	0.020	H	-	H	H	H	-
C-123B	54,000	599	0.011	M	-	H	M	M	-
737-200	100,000	2,192	0.022	H/M	H/E	H/E	H/M	H	H
B-47B	125,000	2,047	0.016	H/M	H	H/E	H/M	M	-
C-130B	135,000	1,645	0.012	H	H	H	H	H	-
727-100	161,000	2,996	0.019	H/E	H/E	H/E	H/M	H	H
C-124C	185,000	1,493	0.008	H/M	-	H	M	M	-
720-022	203,000	2,199	0.011	M	H	H/E	M	H/M	H
C-133A	275,000	1,804	0.009	M	-	H	M	M	-
C-5A	728,000	6,543	0.009	H	H	H	H	H	H

\*Reported flight control weight  
 \*\*This figure to be placed in location  
 0405 on weight input sheet

M = mechanically operated  
 H = hydraulically operated  
 E = electrically operated

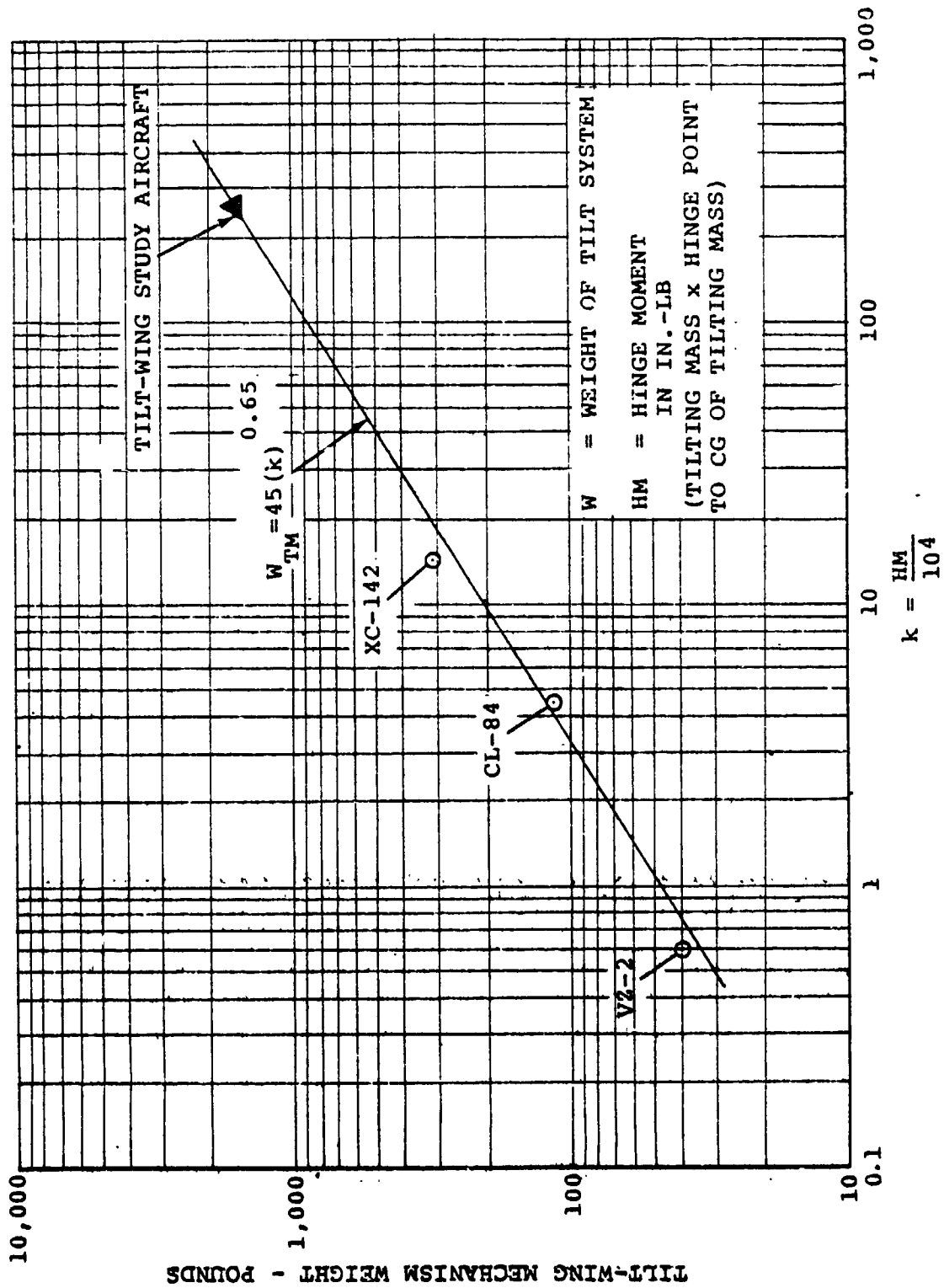


Figure 4-41. Tilt-Wing Mechanism Weight Trend.

of the ducting and other items associated with lift-fan aircraft are considered in the lift engine section and lift engine installation ( $k_{ES}$  and  $k_{LEI}$ ) blocks of the weight input sheet.

#### Engine Section and Engine Installation

The engine section and engine installation weights are determined from the dry weight of the engines. The engine section weight is part of the weight empty and appears as item 10 in Table 4-7. It is basically the engine mounts, nacelle structure, firewall, and support pylons or struts. The engine installation weight is also part of weight empty and includes items 14, 15, 16, 17 and 19 in Table 4-6.

The weights of these two groups will vary greatly between aircraft depending on the type and powerplant arrangement of the configuration being sized. No attempt is made here to describe all the various approaches that may be used or to evaluate their weights, but instead a simple method of taking a percentage of the weight of the dry engines and/or fans, generators, etc., is used to define the weight of the engine section and its installation. The percentages applied will depend on the judgment of the user.

Examples of some typical values are presented in Table 4-12 and described as  $k_{PEI}$  and  $k_{PEI}$  for the primary engines, and  $k_{LES}$  and  $k_{LEI}$  for the lift engines on the weight input sheet. The weights of thrust reversers, deflectors, and/or sound suppression systems are not included in the k factors and, if required, must be added to the multiplicative factor section of the weight input sheet. ( $K_4$  for lift engines and  $K_5$  for primary engines - see Table 4-12.)

A secondary method is included for determining the weight of the engine section. Equations are presented for the mounts, nacelle, and firewall. Pylons or strut weights are not included; these must be estimated and added separately and their weights included in the  $\Delta$  structure box.  $k_{MT}$ ,  $k_{NAC}$ , and  $l_{MT}$  can be determined from the data given below and inserted in the proper location on the weight input sheet.

The weight of the engine section using the secondary method is determined from the following equations:

$$W_{MT} = \frac{W_P}{10^3} (2 + l_m l_n) n k_{mt}$$

$$W_{NAC} = \frac{1}{2} (\log_{10} V_D k_S S_N k_{NAC})$$

$$W_{FW} = D^2 N_{PE}$$

TABLE 4-12  
ENGINE SECTION AND  
INSTALLATION FACTORS

Turbofan	Turbojet	Turboprop Turbojet	Lift Jet	Lift Fan
See Note 1				
$k_{PES} = 0.40$ $k_{PEI} = 0.14$	$k_{PES} = 0.33$ $k_{PEI} = 0.14$	$k_{PES} = 0.45$ $k_{PEI} = 0.14$	$k_{LES} = 0.70^*$ $k_{LEI} = 0.30^*$	$k_{LES} = 0.35$ $k_{LEI} = 0.25$
			*For pod-mounted engines	
See Note 2				
$K_5 = 1.15$  (Primary engine thrust reverser)	$K_5 = 1.10$  (Primary engine thrust reverser)	$K_5 = 1.15$  (Primary engine thrust reverser)	$K_4 = 1.25$  (Lift engine thrust reverser)	
	$K_5 = 1.03$  (Primary engine sound suppression)	$K_5 = 1.03$  (Primary engine sound suppression)	$K_4 = 1.03$  (Lift engine sound suppression)	
<b>NOTES:</b>				
1. These values must be placed in their proper location in the flight control, structure, or propulsion sections of the weight input sheet.				
2. If thrust reversers and/or sound suppression are required, these values must be placed in the multiplicative factor section of the weight input sheet. When both thrust reversers and sound suppression are required, add the individual values for each together and place the total in the proper box. <u>Example:</u> Turbojet requiring both thrust reversers and sound suppression - $K_5$ value would be $1.10 + 0.03$ or $1.13$ .				
3. All values represent a percentage of the dry engine or fan weights.				

### Legend

- $W_{MT}$  = weight of engine mounts, pounds  
 $W_p$  = weight of propulsion group plus upper controls less fuel system, pounds  
 $l_m$  = distance from engine cg to closest structural attachment point between nacelle and wing, as a percentage of nacelle length  
 $\eta$  = ultimate load factor  
 $k_{mt}$  = nacelle type factor - from chart  
 $V_p$  = dive velocity, knots  
 $k_s$  = nacelle weight factor, from Figure 4-42  
 $S_N$  = nacelle wetted area per aircraft, square feet  
 $k_{NAC}$  = factor  $k_{mt} \times k_{dr}$  from Table 4-13  
 $W_{FW}$  = weight of firewall, pounds  
 $D$  = average nacelle diameter or equivalent diameter, foot  
 $N_{PE}$  = number of primary engines

### Fuel System

The weight of the fuel system, defined as  $k_{fs}$  in the propulsion block of the weight input sheet, will vary depending on the capacity, type, and complexity of the system required. For commercial aircraft having simple fuel systems in the wing, the value for  $k_{fs}$  would range between 0.02 and 0.07; for aircraft requiring self-sealing tanks with more complex systems, the value would range between 0.10 and 0.15.

### Drive System

The weight of the drive system including shafting, lubrication, etc., is derived from the following equation:

$$W_{DS} = 300 a(k)^{0.8} \quad \text{where } k = \left[ \frac{HP_{Total} \times 1.1}{RPM_{Rotor}} \right]$$

### Legend

- $W_{DS}$  = weight of drive system, pounds  
 $HP_{Total}$  = total aircraft horsepower  
 $RPM_{Rotor}$  = rotor design rpm  
 $"a"$  = drive system adjustment factor

The factor "a" is an adjustment factor used to account for the type, number of boxes, and special features, etc., included in the drive system. Figure 4-43 gives typical examples of the "a" factor. To determine the  $k_{DS}$  value to place on the weight input sheet, multiply the 300 constant by your selection of "a".

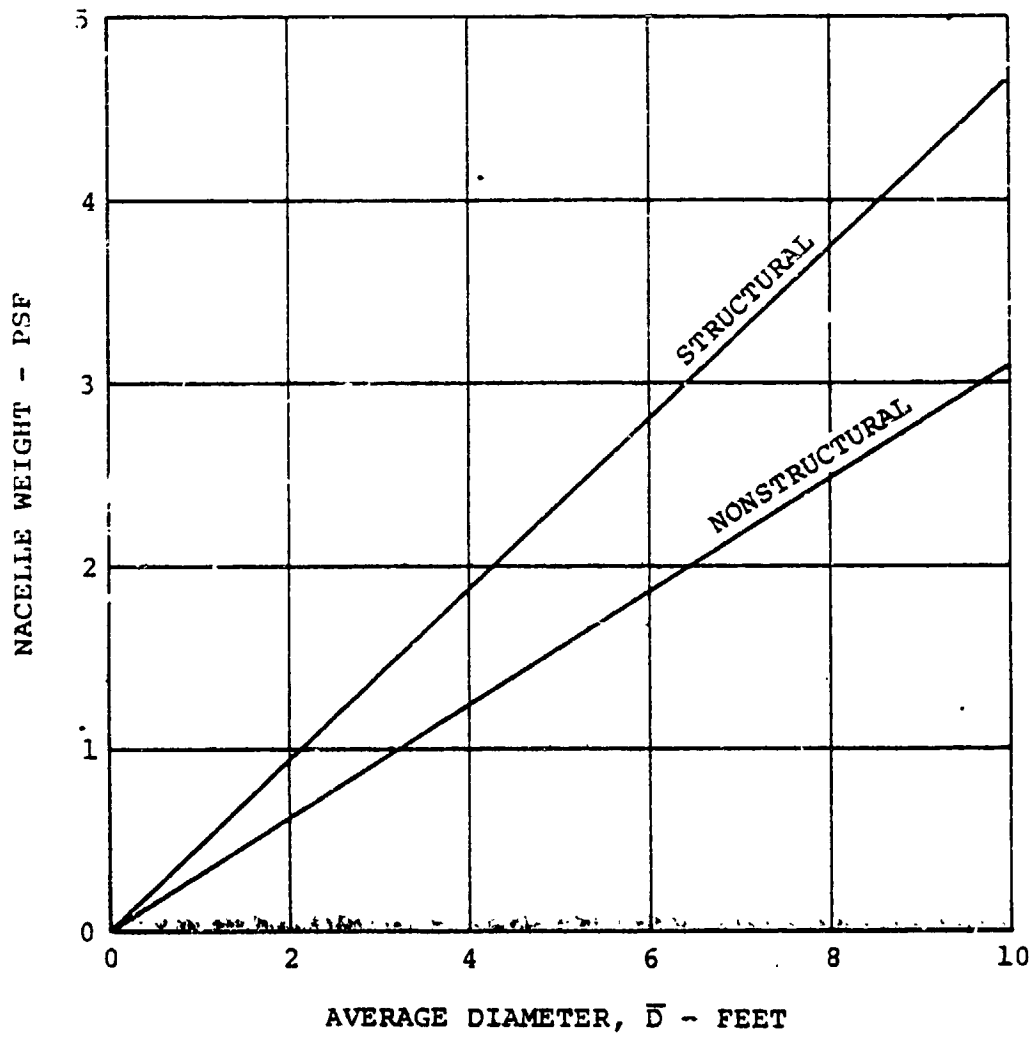


Figure 4-42. Engine Nacelle Weight Trend,  $k_s$ .

TABLE 4-13  
ENGINE NACELLE FACTORS

Parameter	Factor
Type of Nacelle	$k_{mt}$
Through wing	0.9
Standard (including pylon type)	1.0
Fanjet = $1 + \frac{l_f}{3 \times l_n}$	-
Structural nacelle = $1 + \frac{l_s}{l_n}$	-
Type of Engine	$k_{et}$
Jet or fan	1.0
Turboprop	1.1
Piston (including vibration absorbers)	1.2
Doors, Cowl Flaps, and Work Platforms	$k_{dr}$
Minimum doors	0.8
Standard	1.0
Radial engine cowl flaps	1.1
Split and hinged engine cowl	1.2
Hinged cowl with work platform	1.3
- High wing	1.2
- Low wing	1.1
These factors should be assessed on basis of size of cowl versus total nacelle.	



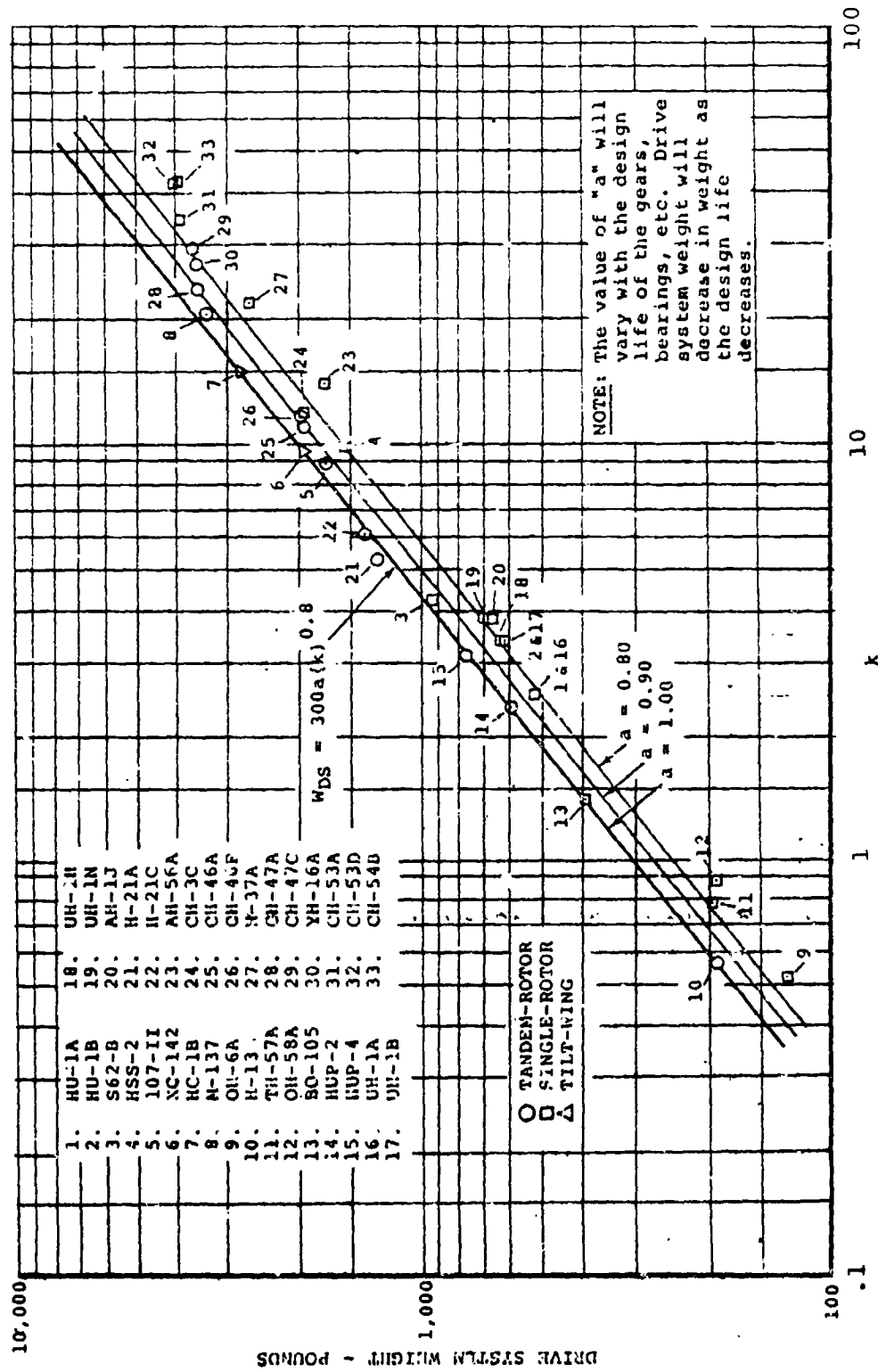


Figure 4-43. Drive System Weight Trend.

The  $k_{VT}$  term in the propulsion block of the weight input sheet is provided to allow for variations in the drive system weight when the hover tip speed and transmission tip speed or the maximum power and the transmission design power are not the same. The nominal value for  $k_{VT}$  is 1 when these parameters are similar. The value of  $k_{VT}$  will change accordingly when tip speed and power vary as indicated by the following expression:

$$\left[ \frac{\text{Design tip speed}}{\text{Hover tip speed}} \right] \left[ \frac{\text{Maximum power}}{\text{Design power}} \right]$$

#### Fixed Equipment

The weight of the fixed equipment is included in the weight empty and consists of the following groups: auxiliary powerplant, instruments and navigation, electrical, electronics, armament, furnishings and equipment, air conditioning and deicing, photographic, and auxiliary gear (see Table 4-7).

The weight of the fixed equipment will vary with the type and requirements of the aircraft under study. It will weigh more in passenger aircraft than it does in the cargo type; it will be heavier in propeller aircraft than it is in jet-powered aircraft; and in the pressurized aircraft of each type it will be heavier than those that are unpressurized. Table 4-14 gives some typical examples of the fixed-equipment weights for a military cargo aircraft and commercial passenger configurations. The cargo plane would be similar to a C-123; the passenger aircraft is similar to a Boeing 737 or a Douglas DC-9. An airbus version of the passenger aircraft is also included for comparison. The major difference in the airbus configuration is in the weight of the furnishings and equipment group, where passenger comfort level is the predominant factor.

The total weight of the fixed equipment,  $W_{FE}$ , must be placed in the  $W_{FE}$  block of the weight input sheet.

#### Fixed Useful Load

The weight of the fixed useful load represents a portion of the useful load and includes the crew, trapped liquids, engine oil, and other items that are required, except for fuel, which make the aircraft operational (refer to page 4-143). Typical weights for fixed-useful-load items are listed below. Graphs are included as a guide for determining the weights of the trapped liquids and engine oil. The total weight of the items below must be placed in the  $W_{FUL}$  block of the weight input sheet.



### Military

- Crew (200 pounds per crewman)
- Unusable fuel and oil (see Figure 4-44)
- Engine oil (see Figure 4-45)

### Commercial

- Crew and crew luggage (200 pounds per crewman)
- Stewardesses and luggage (140 pounds per stewardess)
- Unusable fuel and oil (see Figure 4-44)
- Engine oil (see Figure 4-45)
- Passenger service items (refer to page 4-80 for detailed list of items)

The weight of passenger service items depends on the passenger comfort level desired and the range of the mission. A tabulation of some typical values for various aircraft is shown below. The total weight of the passenger service items is the product of the number of passengers times the selection of the weight per passenger presented below.

<u>Long-Range</u>		<u>Medium-Range</u>		<u>Short-Range</u>	
<u>Config</u>	<u>Wt/Pass.</u>	<u>Config</u>	<u>Wt/Pass.</u>	<u>Config</u>	<u>Wt/Pass.</u>
707-121	37	880	28	727	18
707-321	36	720	25	BAC-111	14
VC-10	33	Electra	23	DC-9	12

### Payload

The weight of the payload is determined by the mission requirements. The total weight of the payload must be put in the  $W_{PL}$  block of the weight input sheet.

### Incremental Group Weights

The incremental group weights section of the weight input sheet is provided to enable the user to add fixed increments of weight where desired. Definitions and values for some of the items in this group have already been discussed.  $\Delta W_{FC}$ ,  $\Delta W_P$ , and  $\Delta W_{ST}$  represent incremental weights of the flight controls group, propulsion group, and structural group respectively. Any value inserted in the incremental group weight section

( )

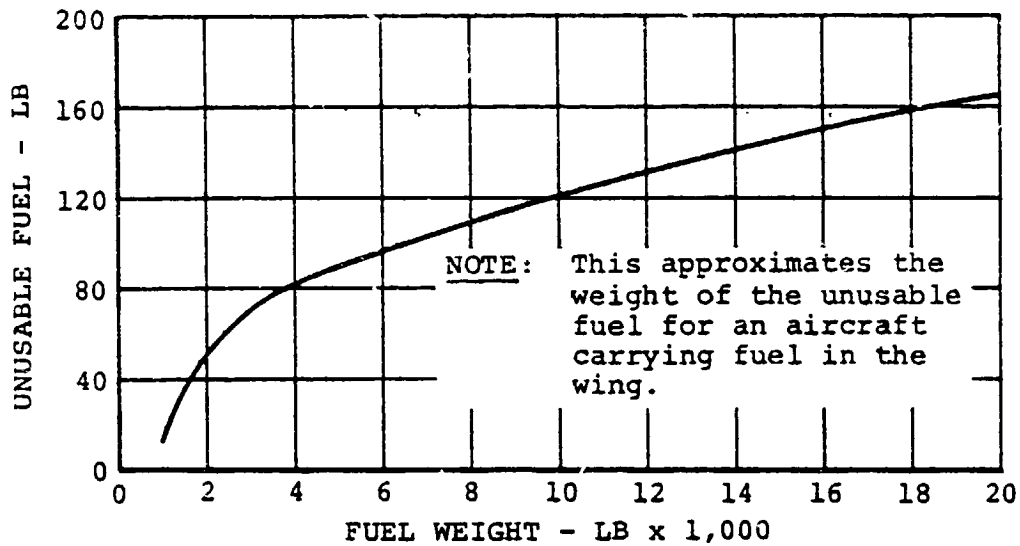


Figure 4-44 . Maximum Fuel Versus Unusable Fuel Weight Trend.

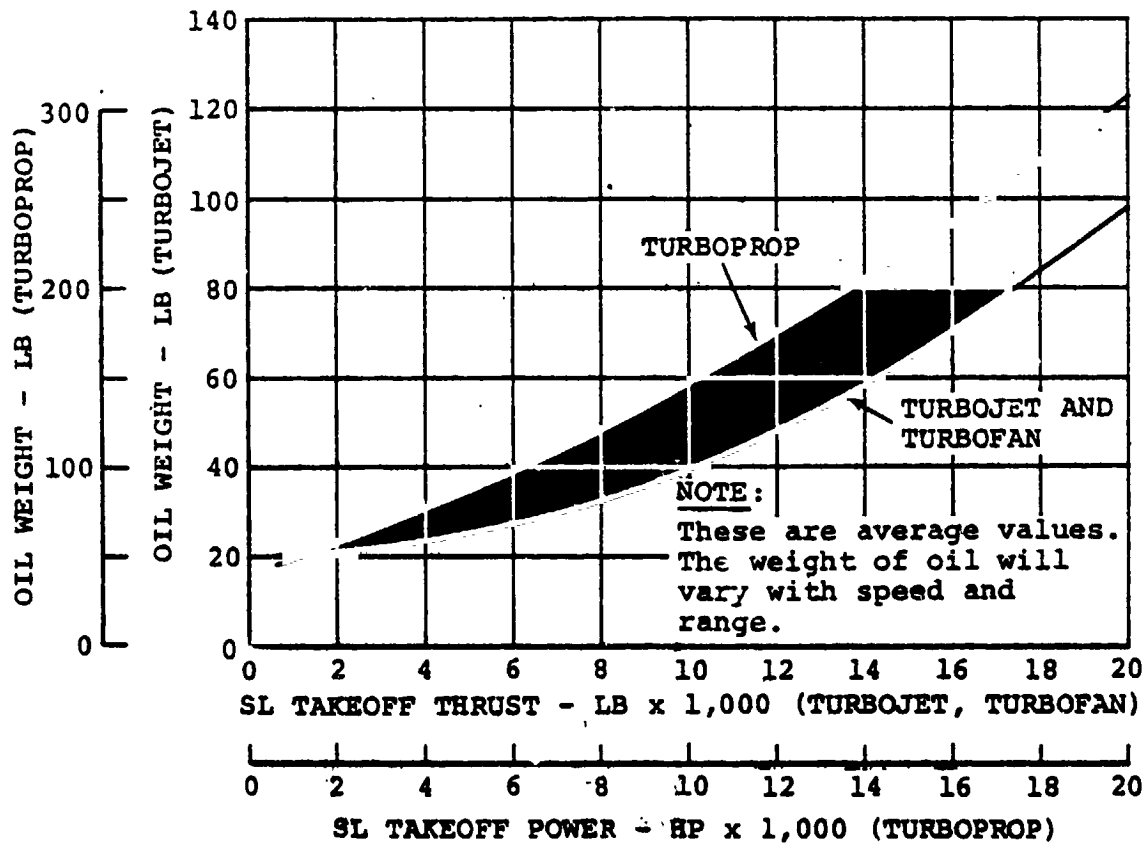


Figure 4-45. Engine Oil Weight Trend.

TABLE 4-15  
MULTIPLICATIVE FACTORS

K	Location	Letter Code	Description
K <sub>2</sub>	0459	W <sub>R/P</sub>	Weight of rotors or propellers
K <sub>3</sub>	0460	W <sub>DS</sub>	Weight of drive system
K <sub>4</sub>	0461	W <sub>EL</sub>	Weight of lift engines
K <sub>5</sub>	0462	W <sub>EP</sub>	Weight of primary engines
K <sub>6</sub>	0463	W <sub>LEI</sub>	Weight of lift-engine installation
K <sub>7</sub>	0464	W <sub>PEI</sub>	Weight of primary engine installation
K <sub>8</sub>	0433	W <sub>W</sub>	Weight of wing
K <sub>9</sub>	0434	W <sub>HT</sub>	Weight of horizontal tail
K <sub>10</sub>	0435	W <sub>VT</sub>	Weight of vertical tail
K <sub>11</sub>	0436	W <sub>B</sub>	Weight of body
K <sub>12</sub>	0437	W <sub>LG</sub>	Weight of landing gear
K <sub>13</sub>	0438	W <sub>LES</sub>	Weight of lift-engine section
K <sub>14</sub>	0439	W <sub>PES</sub>	Weight of primary engine section
K <sub>15</sub>	0410	W <sub>CC</sub>	Weight of cockpit controls
K <sub>16</sub>	0411	W <sub>UP</sub>	Weight of upper controls
K <sub>17</sub>	0412	W <sub>H</sub>	Weight of hydraulics and vertical system
K <sub>18</sub>	0413	W <sub>FW</sub>	Weight of fixed-wing controls
K <sub>19</sub>	0414	W <sub>SAS</sub>	Weight of SAS and mixing unit
K <sub>20</sub>	0415	W <sub>TM</sub>	Weight of tilt mechanism
K <sub>21</sub>	0465	W <sub>FS</sub>	Weight of fuel system

remains constant regardless of gross weight. The nominal value for any block in this section is 0. All blocks must be filled in.

#### Group Weight Information

The nominal value for items in this section of the weight input sheet is 0. All blocks must be filled in. Definitions and constants for the various k factors have been previously discussed in the respective subgroup definitions.

#### Multiplicative Factors

The multiplicative factors described as  $K_8$  thru  $K_{21}$  on the weight input sheet provide the capability of performing weight sensitivity studies. The factors are nominally 1. All blocks must be filled in. To vary the weight of any subgroup ( $K_{CC}$ ,  $K_B$ ,  $K_{DS}$ , etc.), insert the desired value in the appropriate box. Refer to Table 4-15 below to relate the various K factors with their respective groups. Inserting a value of 1.1 would increase the weight of the respective group by 10 percent, a value of 0.9 would decrease it by 10 percent, etc. The values in this group will vary with gross weight.

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## GROUP WEIGHT STATEMENT

### AIRCRAFT

(INCLUDING ROTORCRAFT)

ESTIMATED - CALCULATED - ACTUAL

(Cross Out Those Not Applicable)

CONTRACT NO. \_\_\_\_\_

AIRCRAFT, GOVERNMENT NO. \_\_\_\_\_

AIRCRAFT, CONTRACTOR NO. \_\_\_\_\_

MANUFACTURED BY \_\_\_\_\_

		MAIN	AUX
ENGINE	MANUFACTURED BY		
	MODEL		
	NO.		
	TYPE		

PAGES REMOVED	PAGE NO.



GROUP WEIGHT STATEMENT  
WEIGHT EMPTY

Page \_\_\_\_\_

Name \_\_\_\_\_

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1	WING GROUP				
2	BASIC STRUCTURE - CENTER SECTION				
3	- INTERMEDIATE PANEL				
4	- OUTER PANEL				
5	- GLOVE				
6	SECONDARY STRUCTURE (Incl. Wing Fold Weight) (lbs.)				
7	AILERONS (Incl. Balance Weight) (lbs.)				
8	FLAPS - TRAILING EDGE				
9	- LEADING EDGE				
10	SLATS				
11	SPOILERS				
12					
13					
14	ROTOR GROUP				
15	BLADE ASSEMBLY				
16	HUB & HINGE (Incl. Blade Fold Weight) (lbs.)				
17					
18					
19	TAIL GROUP				
20	BASIC & SECONDARY STRUCT. - STABILIZER				
21	- FIN (Incl. Dorsal)				
22	VENTRAL				
23	ELEVATOR (Incl. Balance Weight) (lbs.)				
24	RUDDERS (Incl. Balance Weight) (lbs.)				
25	TAIL ROTOR - BLADES				
26	- HUB & HINGE				
27					
28	BODY GROUP				
29	BASIC STRUCTURE - FUSELAGE or HULL				
30	- BOOMS				
31	SECONDARY STRUCTURE - FUSELAGE or HULL				
32	- BOOMS				
33	- SPEEDBRAKES				
34	- DOORS, RAMPS, PANELS, & MISC.				
35					
36					
37	LAUGHING GEAR GROUP (Type)				
38	LOCATION	Running Gear*	Arrest Gear*	Structure	Controls
39					
40					
41					
42					
43					
44					
45	ENGINE SECTION or NACELLE GROUP				
46	BODY - INTERNAL				
47	- EXTERNAL				
48	WING - INBOARD				
49	- OUTBOARD				
50					
51					
52	AIR INDUCTION SYSTEM				
53	DOORS, PANELS, & MISC.				
54					
55					
56					
57	TOTAL STRUCTURE (to be brought forward)				

\*Change to Flare & Strut for Water Type Gear.

GROUP WEIGHT STATEMENT  
WEIGHT EMPTY

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Page \_\_\_\_\_

Name \_\_\_\_\_

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		Auxiliary	Main	
1	PROPULSION GROUP			
2	ENGINE INSTALLATION			
3				
4	ACCESSORY GEAR BOXES & DRIVE			
5				
6	EXHAUST SYSTEM			
7	ENGINE COOLING			
8	WATER INJECTION			
9	ENGINE CONTROL			
10	STARTING SYSTEM			
11	PROPELLER INSTALLATION			
12	SMOKE ABATEMENT			
13	LUBRICATING SYSTEM			
14	FUEL SYSTEM			
15	TANKS - PROTECTED			
16	UNPROTECTED			
17	PLUMBING, etc			
18	DRIVE SYSTEM			
19	GEAR BOXES, LUB SY & ROTOR BRK			
20	TRANSMISSION DRIVE			
21	ROTOR SHAFTS			
22	JET DRIVE			
23				
24	FLIGHT CONTROLS GROUP			
25	COCKPIT CONTROLS (Autopilot Lbs.)			
26	SYSTEMS CONTROLS			
27				
28				
29	AUXILIARY POWER PLANT GROUP			
30	INSTRUMENTS GROUP			
31	HYDRAULIC & PNEUMATIC GROUP			
32				
33	ELECTRICAL GROUP			
34				
35	AVIONICS GROUP			
36	EQUIPMENT			
37	INSTALLATION			
38				
39	ARMAMENT GROUP Incl. Passive Prot. Lbs.)			
40	FURNISHINGS & EQUIPMENT GROUP			
41	ACCOMMODATION FOR PERSONNEL			
42	MISCELLANEOUS EQUIPMENT			
43	FURNISHINGS			
44	EMERGENCY EQUIPMENT			
45				
46	AIR CONDITIONING GROUP			
47	ANTI-ICING GROUP			
48				
49	PHOTOGRAPHIC GROUP			
50				
51	LOAD & HANDLING GROUP			
52	AIRCRAFT HANDLING			
53	LOAD HANDLING			
54				
55	MANUFACTURING VARIATION			
56	TOTAL FROM PAGE 2			
57	WEIGHT EMPTY			

**GROUP WEIGHT STATEMENT  
USEFUL LOAD AND GROSS WEIGHT**

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Page \_\_\_\_\_

Name \_\_\_\_\_

Model \_\_\_\_\_

Date \_\_\_\_\_

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1	LOAD CONDITION				
2					
3	CREW (No )				
4	PASSENGERS (No )				
5	FUEL	Location	Type	Gal.	
6	UNUSABLE				
7	INTERNAL				
8					
9					
10					
11	EXTERNAL				
12					
13					
14	OR				
15	TRAPPED				
16	ENGINE				
17					
18	FUEL TANKS (Location )				
19	WATER INJECTION FLUID ( Gal.)				
20					
21	BAGGAGE				
22	CARGO				
23					
24	GUN INSTALLATIONS				
25	GUNS	Location	Fix. or Flex	Quantity	Caliber
26					
27					
28	AMMO.				
29					
30					
31	SUPPTS				
32	WEAPONS INSTALL. (Incl. Submarine Detection Expendables)				
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46	EQUIPMENT				
47					
48	SURVIVAL KITS & LIFE RAFTS				
49					
50	OXYGEN				
51					
52					
53					
54					
55	TOTAL USEFUL LOAD				
56	WEIGHT EMPTY				
57	GROSS WEIGHT				

\*If applicable and specified as Useful Load.  
 \*\*List Stores, Miscels, Bombs, etc. Followed by Buckle, Launchers, Chutes, etc. Max Part of Weight Empty.  
 List Identification, Location, and Quantity for All Items Shown including installation.





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GROUP WEIGHT STATEMENT

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AIRFRAME WEIGHT

The Airframe Weight to be entered on line 57 of page 5 of the Group Weight Statement should be derived here in detail showing those items deducted from weight empty as required by the document "Cost Information Reports (CIR) for Aircraft, Missiles, and Space Systems" dated 21 April, 1966, or subsequent revisions thereto. Airframe weight is the same as previously called AMPR and DCPR and is not to be confused with "Work Breakdown Structure (WBS) Airframe Cost Definition."

WEIGHT EMPTY  
DEDUCT THE FOLLOWING ITEMS  
(ITEMIZE)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

AIRFRAME WEIGHT

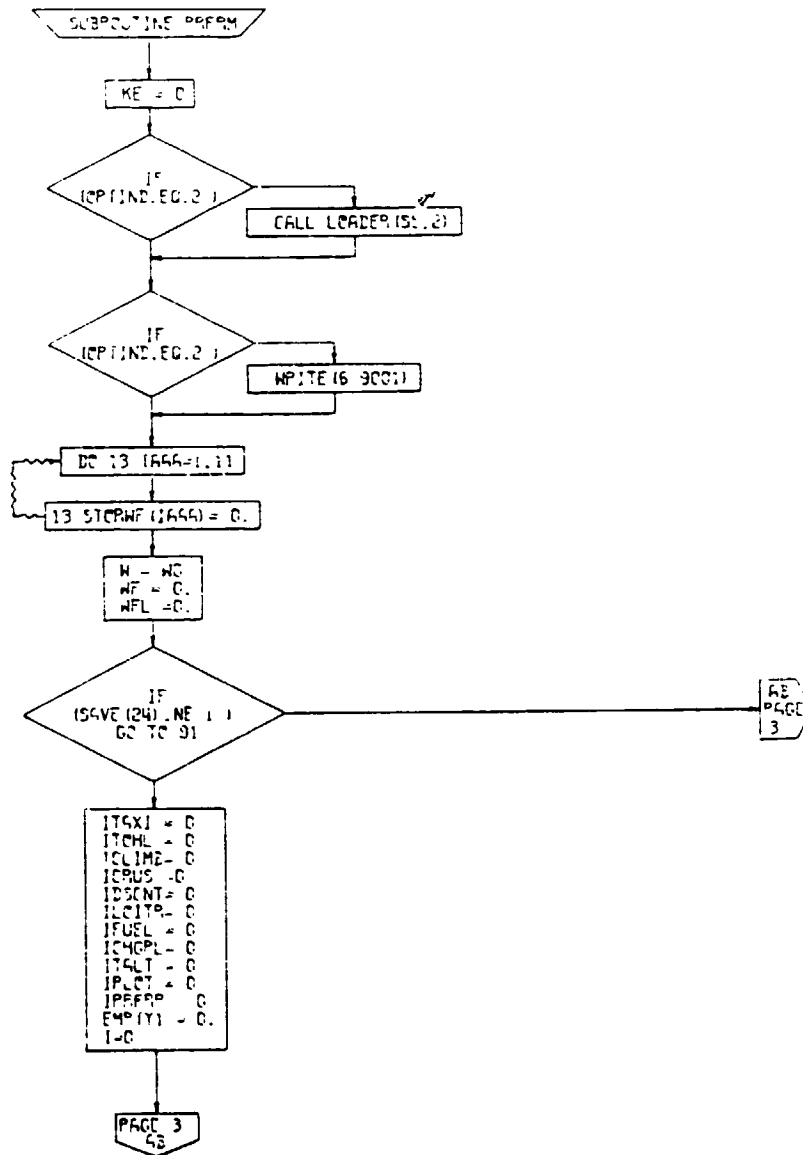
#### 4.10 PERFORMANCE CALCULATIONS SUBPROGRAM

The flow chart of the control loop for the performance calculations subprogram is shown in Figure 4-46. This routine monitors the flow during calculation of mission performance data and calculates the total fuel required at the end of the mission.

##### 4.10.1 Taxi Calculations Subroutine

The taxi calculations subroutine (specified by SGTIND = 1), calculates the fuel required to taxi at ground idle engine setting for a specified period of time. For aircraft which have independent lift propulsion systems (LFTIND = 1), the program will calculate taxi performance for either primary engines operating alone, or both primary and lift engines operating. This is accomplished by means of the input constant  $k_{FL}$ . If  $k_{FL}$  is input as 0, the program will consider only primary engines in operation in determining fuel flow rates. If  $k_{FL}$  is input as unity, the program will include both primary and lift propulsion systems in calculating the fuel flow rates and the corresponding reduction in aircraft gross weight. Figure 4-47 is a flow chart of this subroutine.

Input to this subroutine consists of the time for taxi, value of  $k_{FL}$ , and atmospheric conditions.



PAGE 2  
PPFM

Figure 4-46. Performance Calculations Subroutine, Flow Chart (Part 1 of 6)



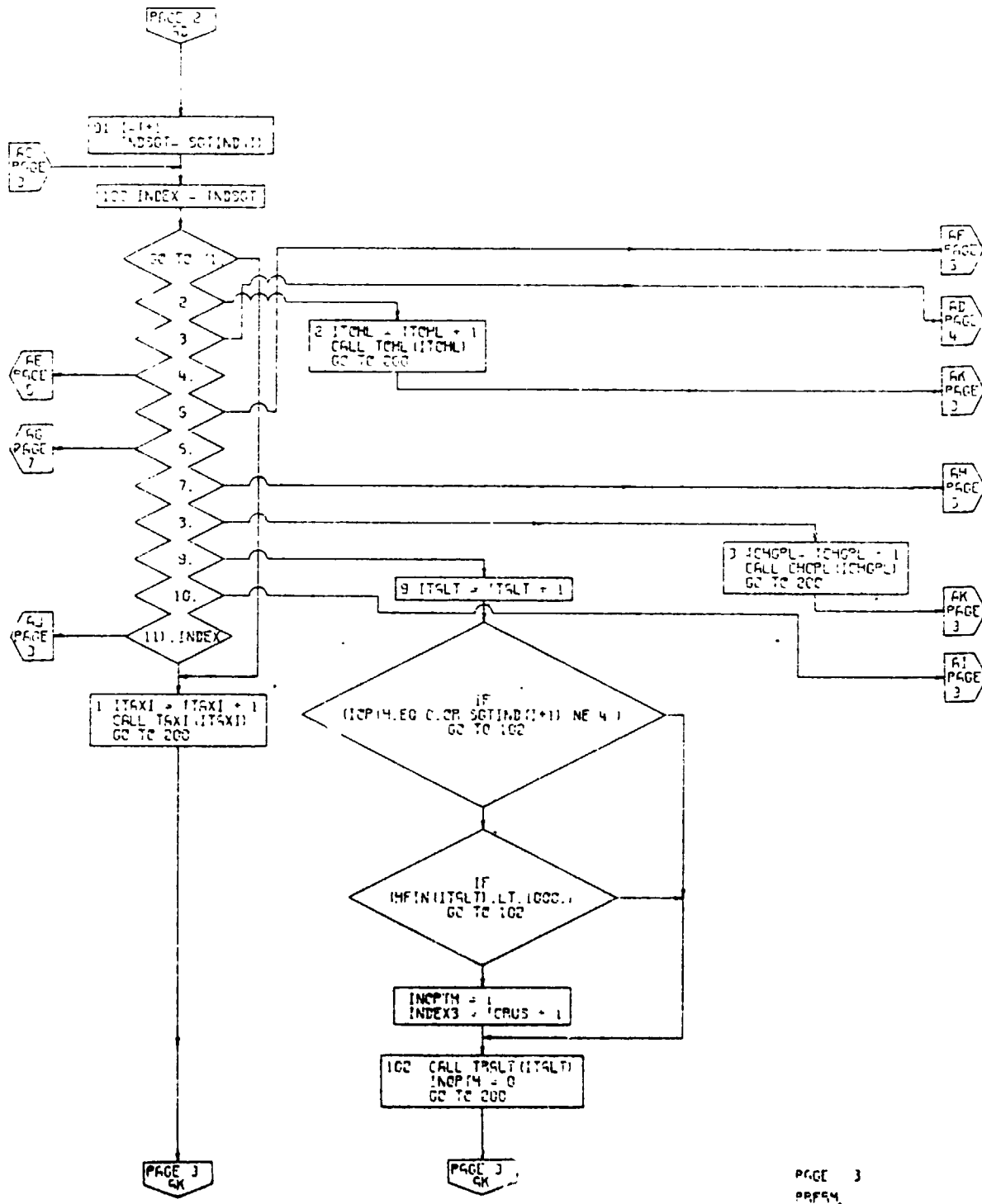
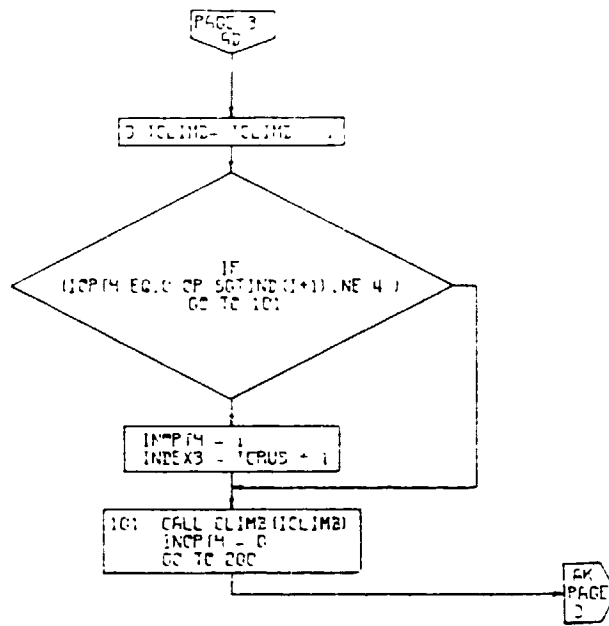
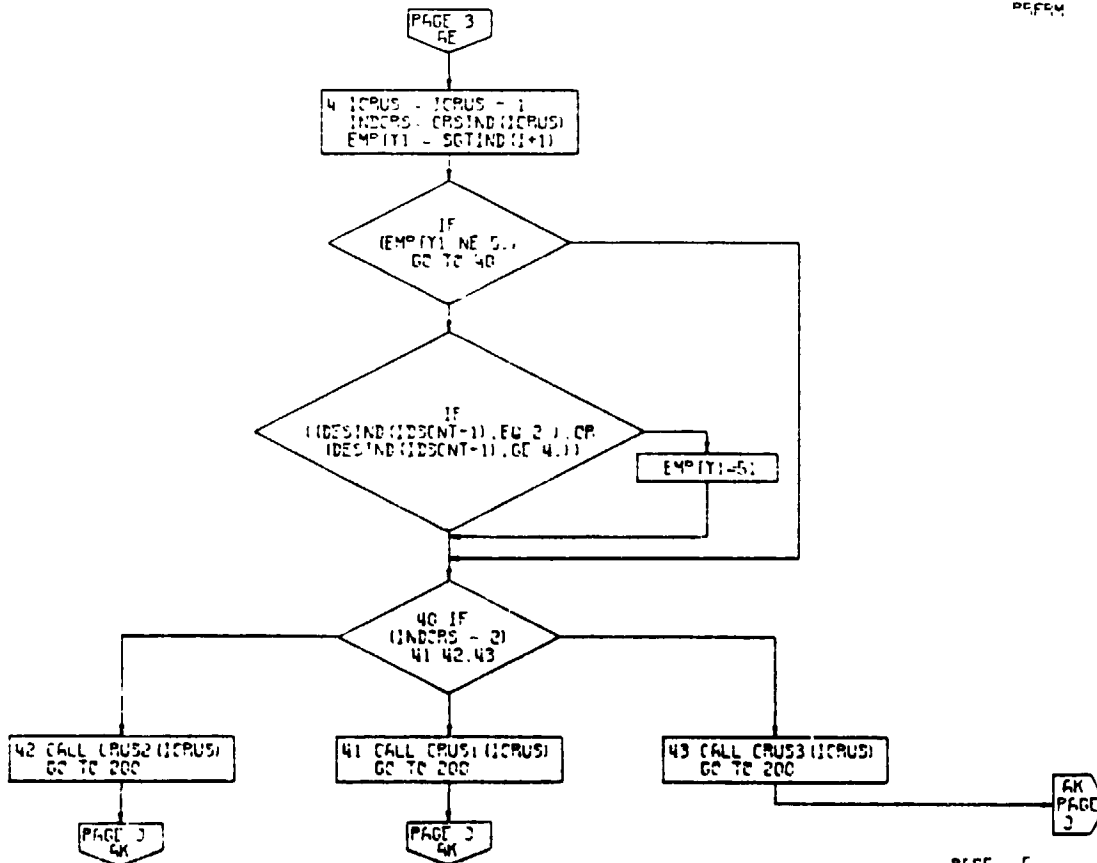


Figure 4-46. Performance Calculations Subroutine, Flow Chart (Part 2 of 6)

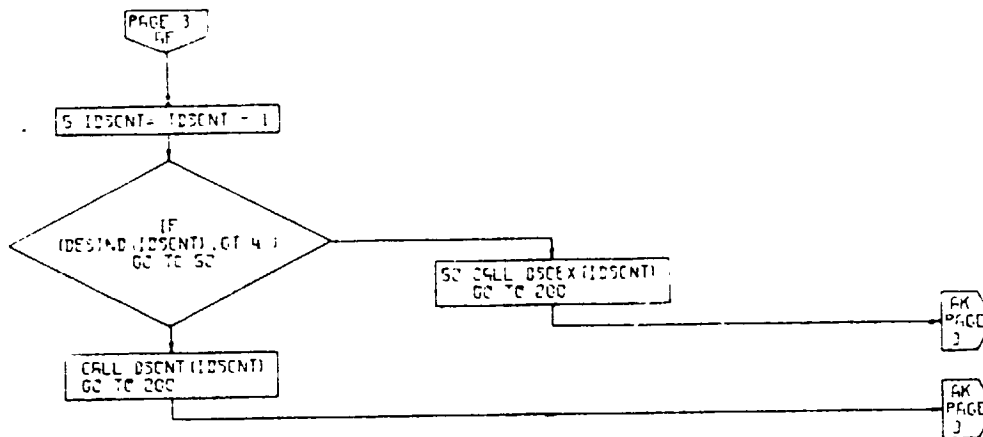


PAGE 4  
REFEM

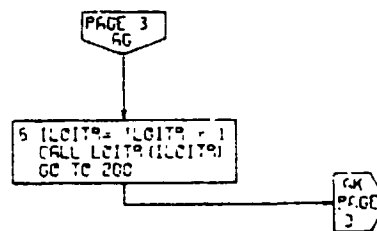


PAGE 5  
PRFEM

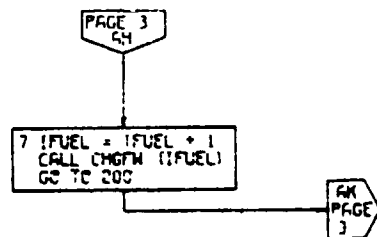
Figure 1-46. Performance Calculations Subroutine, Flow Chart (Part 3 of 6)



PAGE 5  
PRFEM



PAGE 7  
PRFEM



PAGE 5  
PRFEM

Figure 4-46. Performance Calculations Subroutine, Flow Chart (Part 4 of 6)

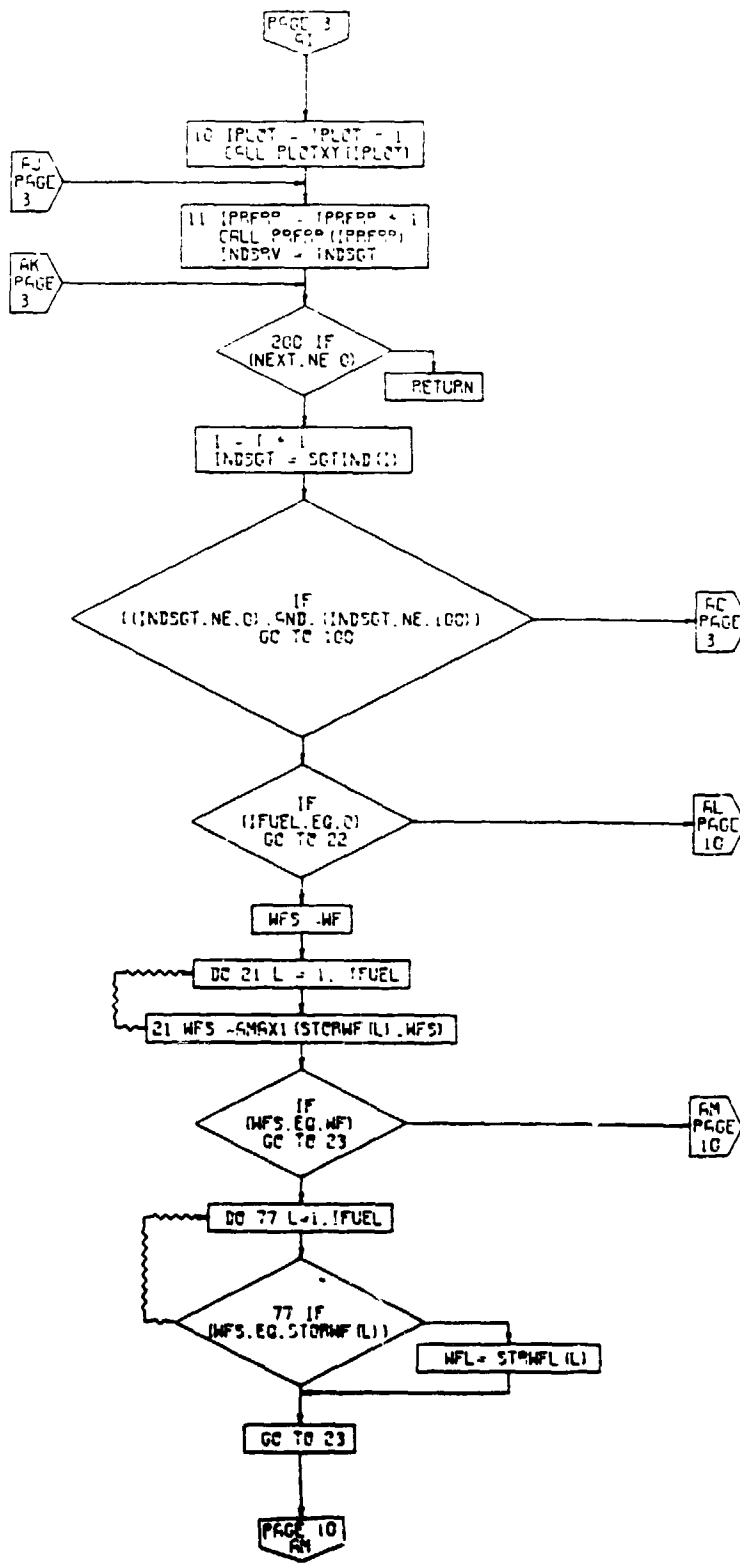
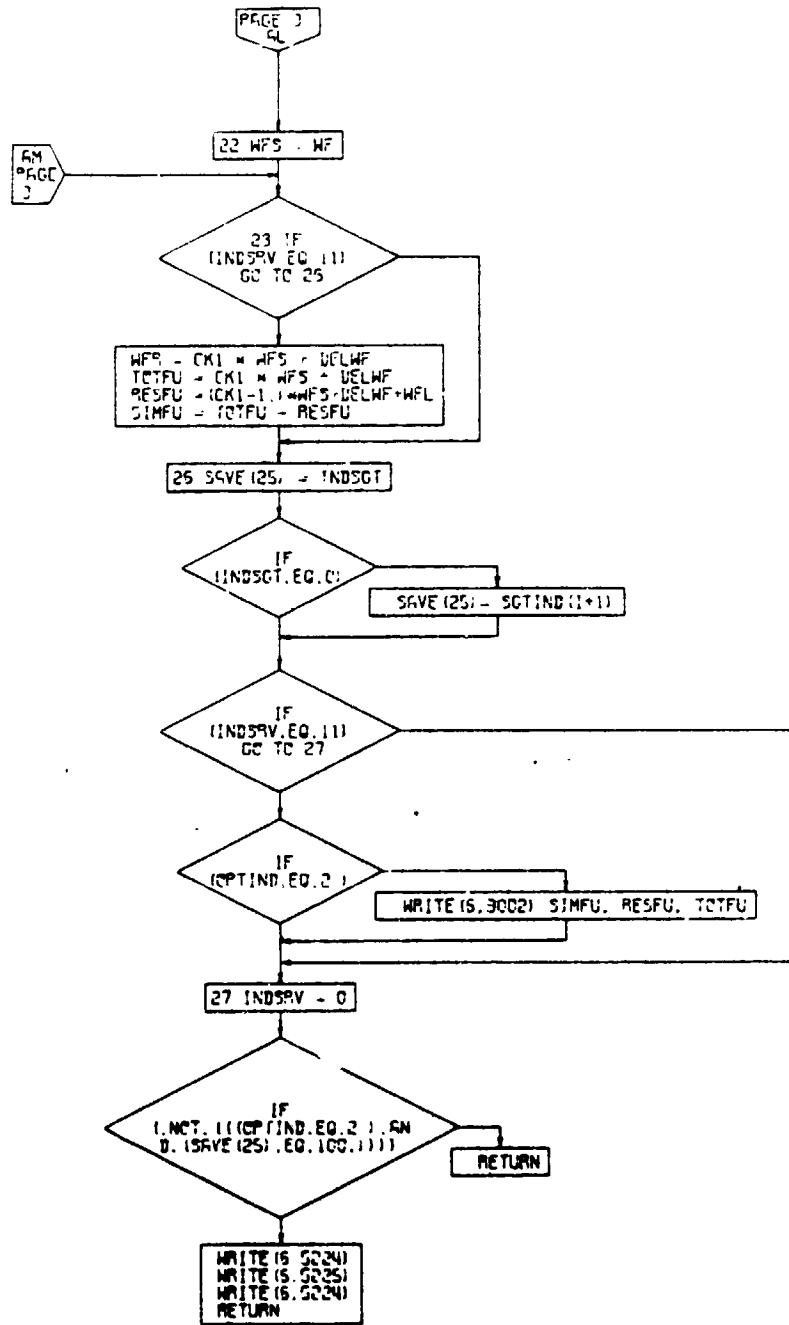


Figure 4-46. Performance Calculations Subroutine, Flow Chart (Part 5 of 6)

PAGE 3  
PRFP



PAGE 10  
PAGE 4

Figure 4-46. Performance Calculations Subroutine,  
Flow Chart (Part 6 of 6)

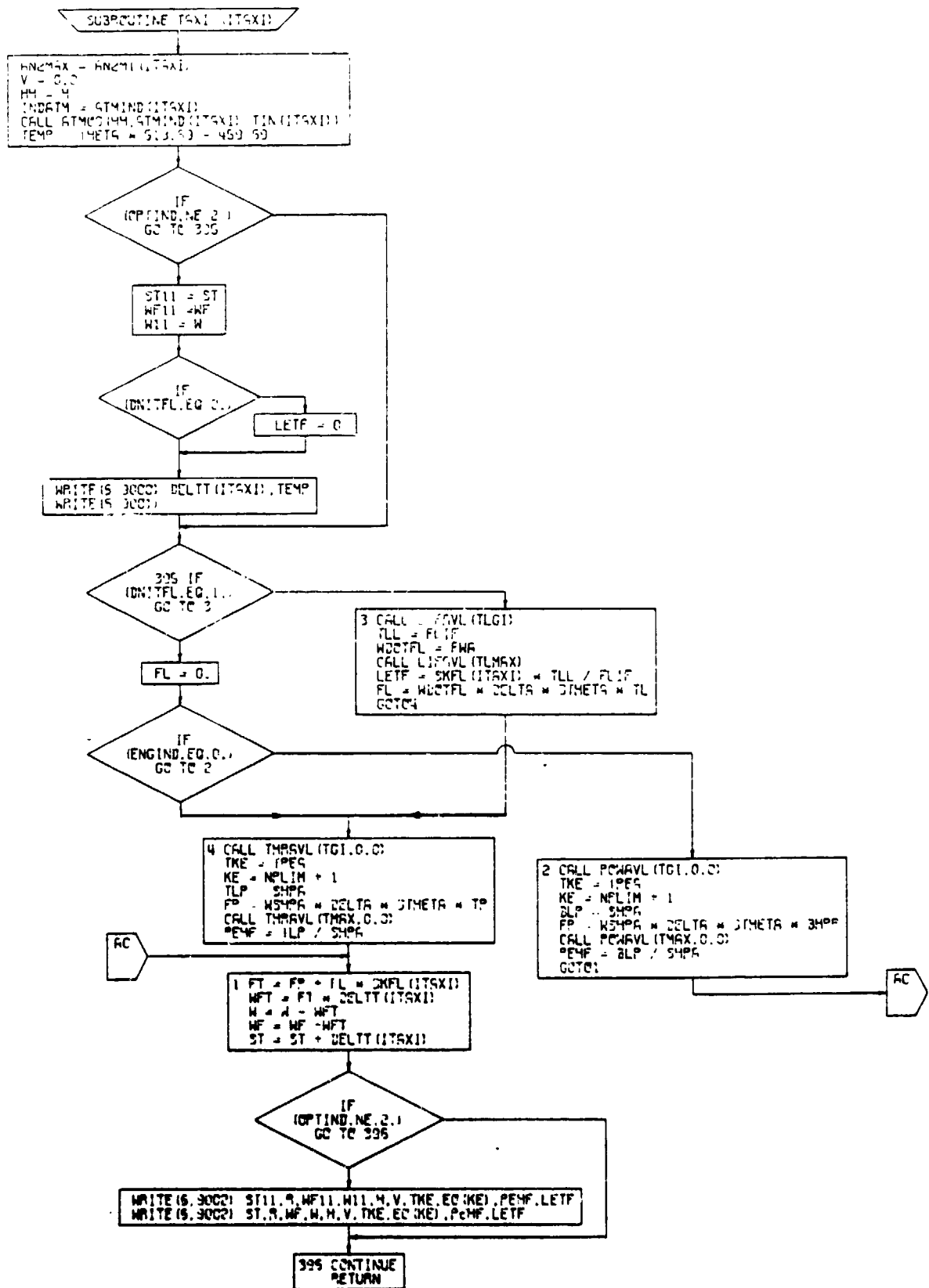


Figure 4-47. Taxi Calculations Subroutine, Flow Chart

#### 4.10.2 Takeoff, Hover, and Landing Calculations Subroutine

The takeoff, hover, and landing calculations subroutine (specified by SGTIND = 2) will calculate the thrust or power required and corresponding fuel flow rates during simulated takeoff/hover/landing operations. Three options are available, specified by the input indicator TOLIND:

TOLIND = 1 - Input required thrust-weight ratio. Program will use maximum thrust from lift engines before augmenting with primary engines (if necessary). If only primary engines are on aircraft (LFTIND = 0), required thrust level will be taken from primary engines.

TOLIND = 2 - This option must not be used if LFTIND = 0. Input required thrust-weight ratio. Program will take an equal fraction of power available from lift engines and primary engines.

TOLIND = 3 - Input required power fraction (fraction of maximum available power) for primary engines and/or lift engines. Program will calculate thrust-weight ratio.

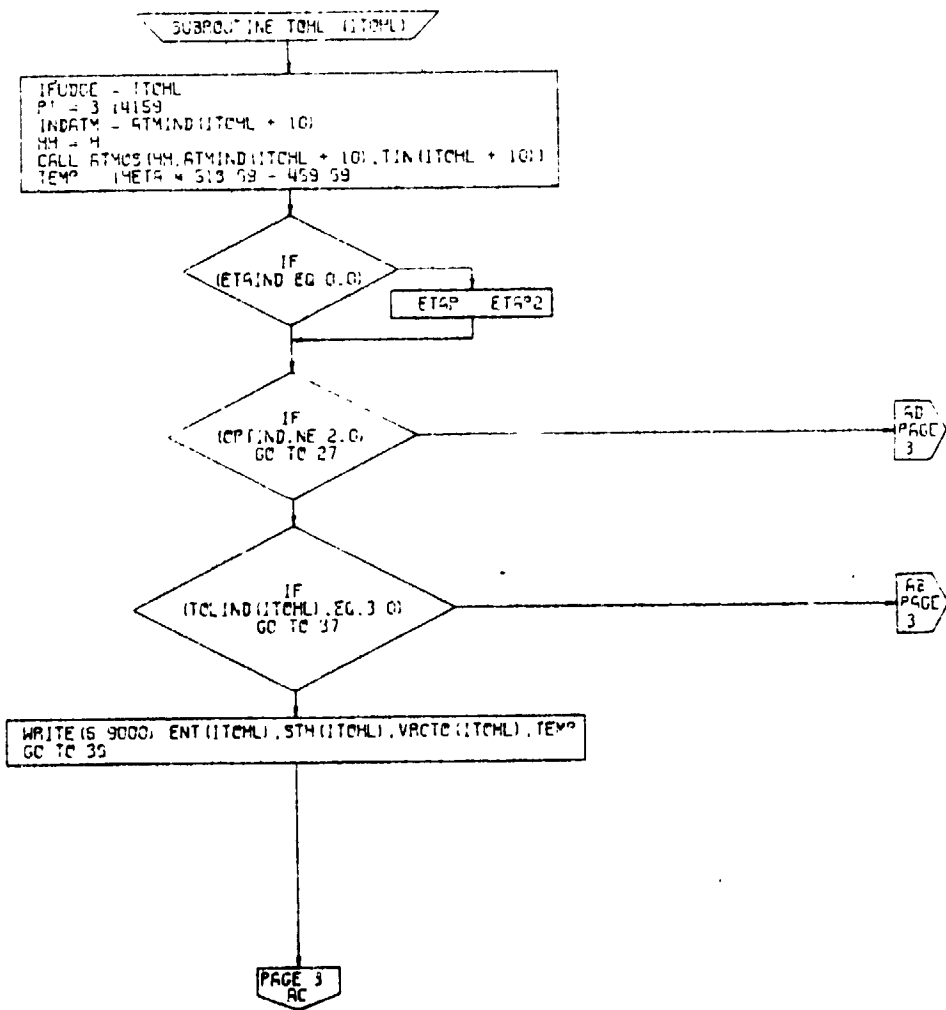
In all cases, the program will print out the power fraction and thrust-weight ratio. The program will permit operation at power fractions greater than 1.0 (more than 100 percent of available power) in order to make it easier to perform studies in which engine power is being varied parametrically to satisfy specified takeoff or landing requirements at a remote site. The program will, however, print a cautionary note that power fraction exceeds 100 percent.

Propulsive efficiencies for both primary and lift propulsion systems can be input to this subroutine. The value of efficiency relates to the percentage of thrust or power which is doing useful work in the vertical direction. Thus, the primary engine efficiency  $\eta_{p2}$ , when used with a thrust producing engine (ENGINEB = 1) is interpreted as the ratio of thrust of the primary engines in the vertical direction to total engine thrust, and may be used to simulate a turning efficiency of jet engines being used with turning vanes. Similarly, the lift engine efficiency,  $\eta_L$ , may be used to simulate the effect of

control losses on lift engine thrust. If the primary engines being used are turboshaft (ENGIND = 0) or convertible (ENGIND = 2) engines, the primary propulsive efficiency,  $\eta_{p2}$ , is defined in the more normal manner as a power ratio (rather than a thrust ratio).

Figure 4-48 is a flow chart for this subroutine.





PAGE 2  
TCHL

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 1 of 12)

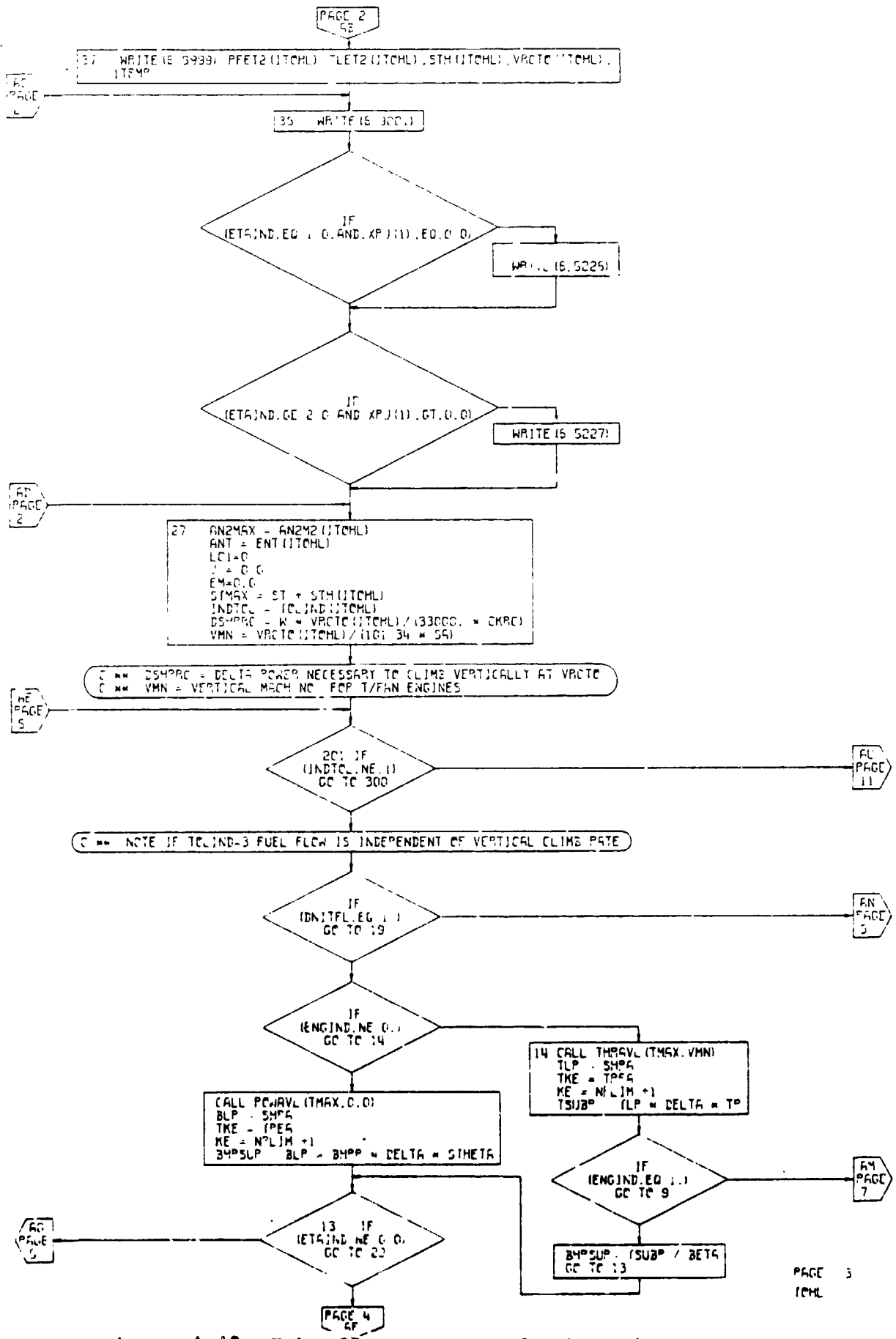
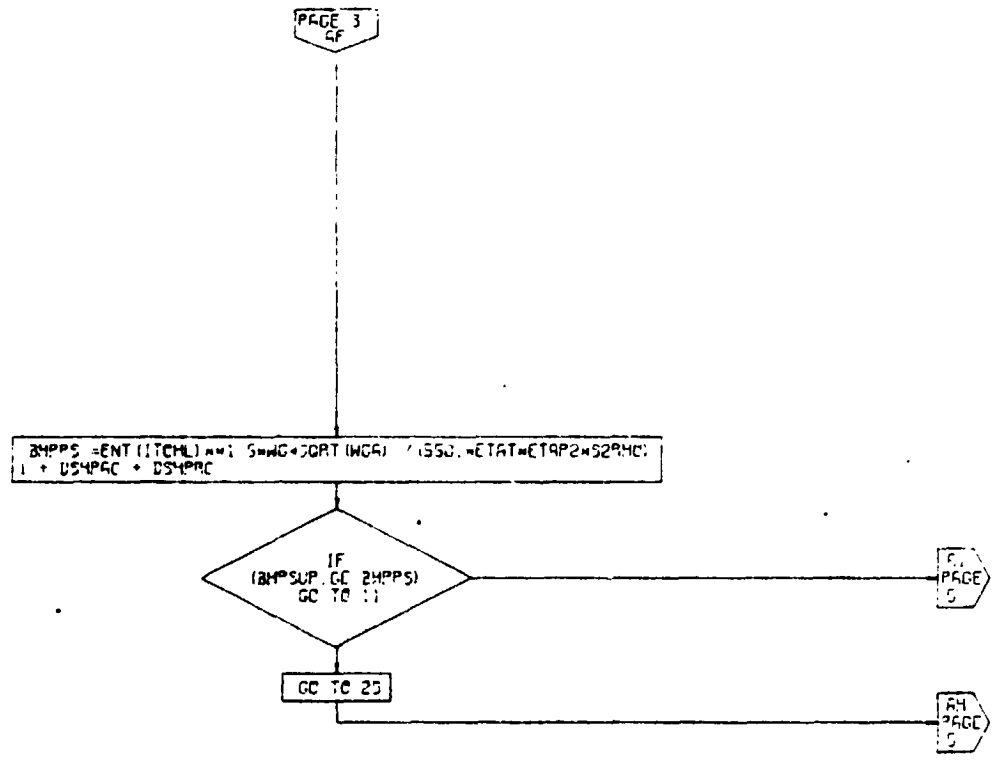


Figure 4-48. Takeoff, Hover, Land Subroutine, Flow Chart (Part 2 of 12)  
4-196



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TCML

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 3 of 12)

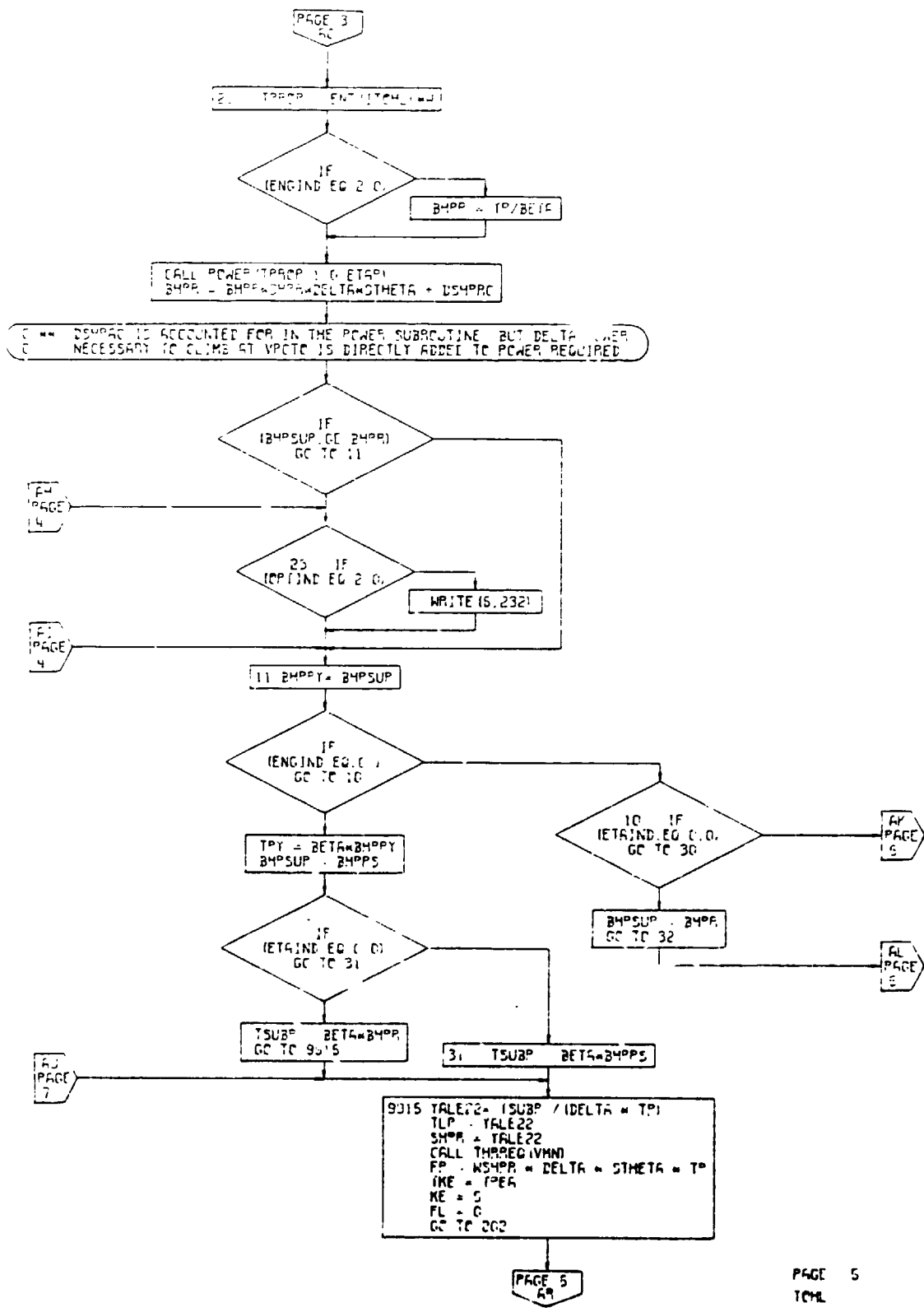
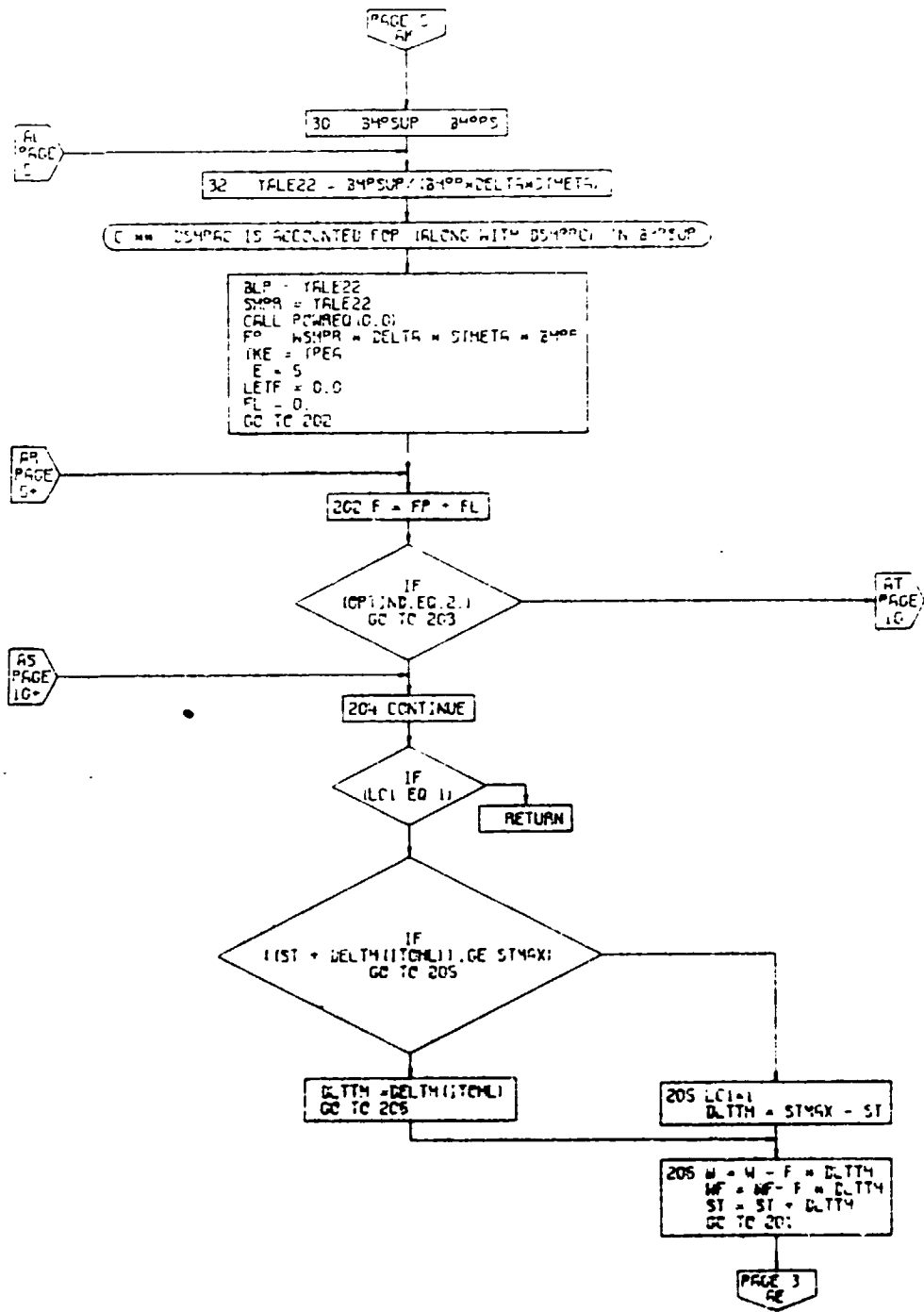
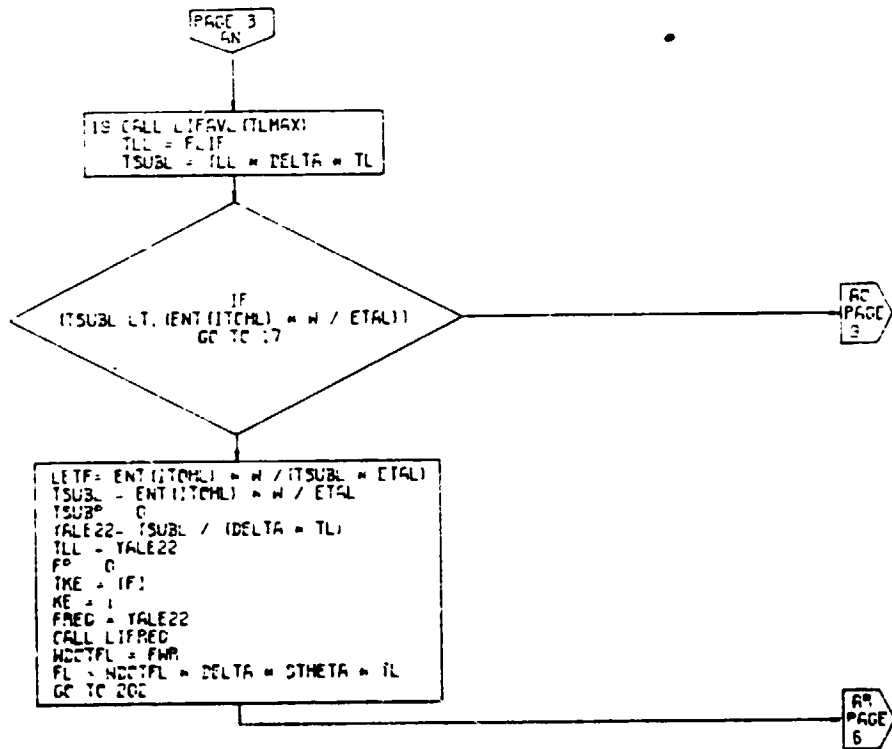
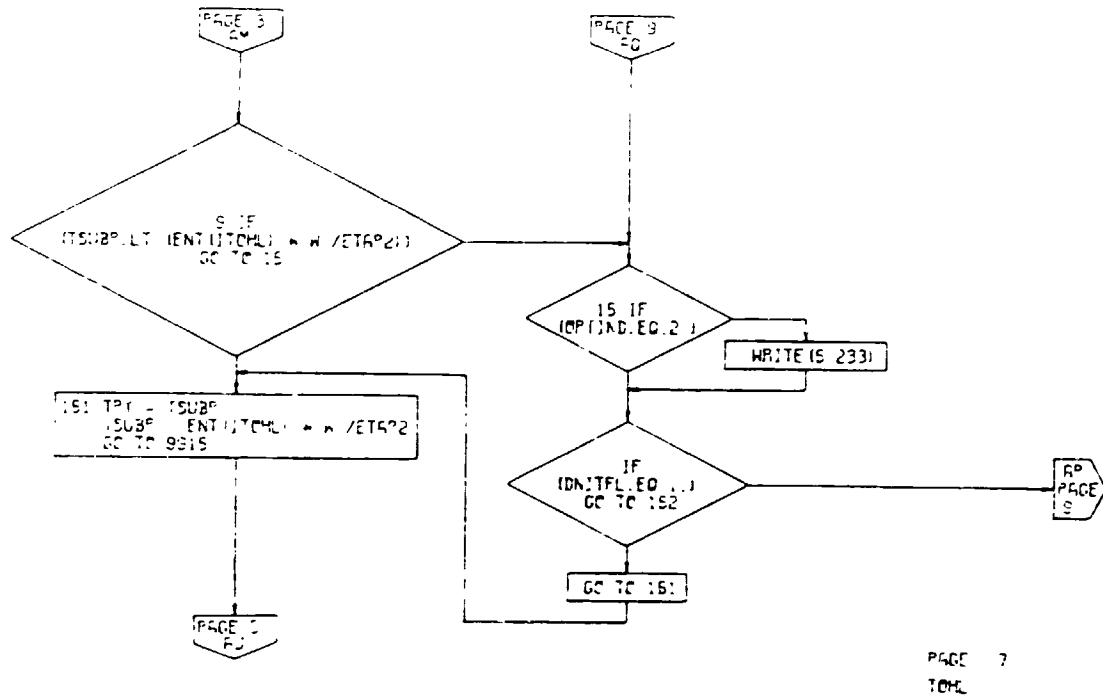


Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 4 of 12)



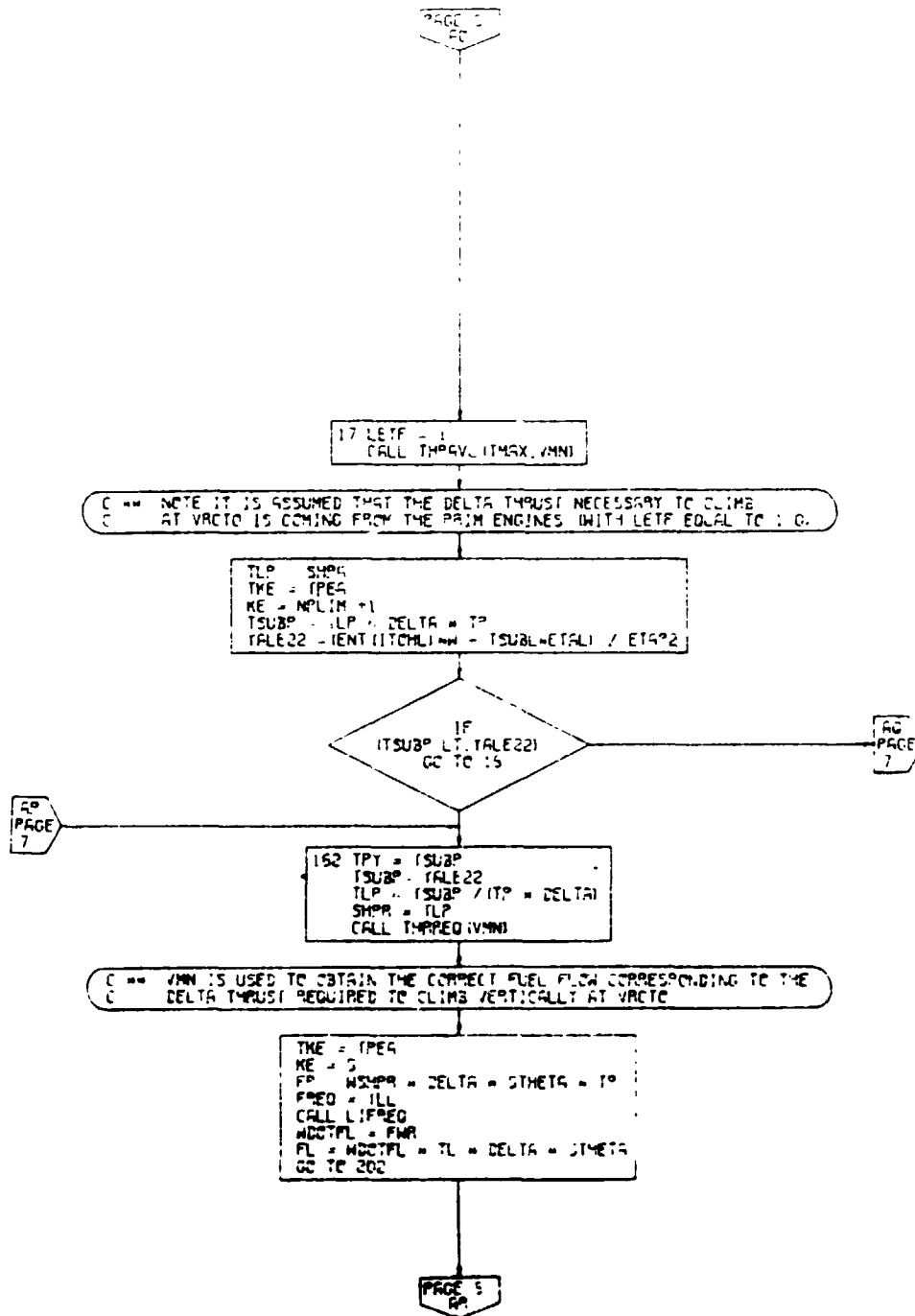
PAGE 5  
TML

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 5 of 12)



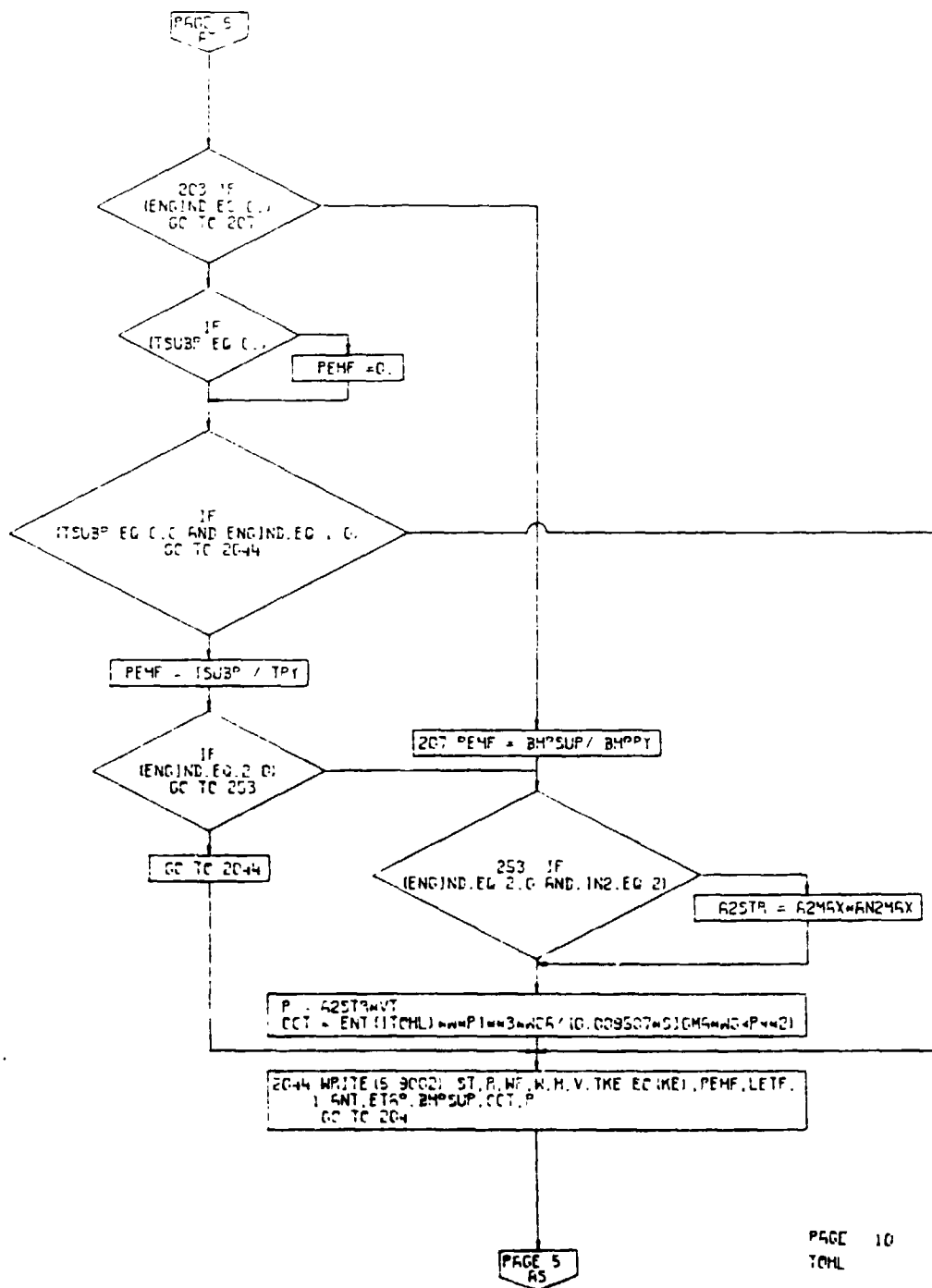
PAGE 3  
TOML

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 6 of 12)



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TOML

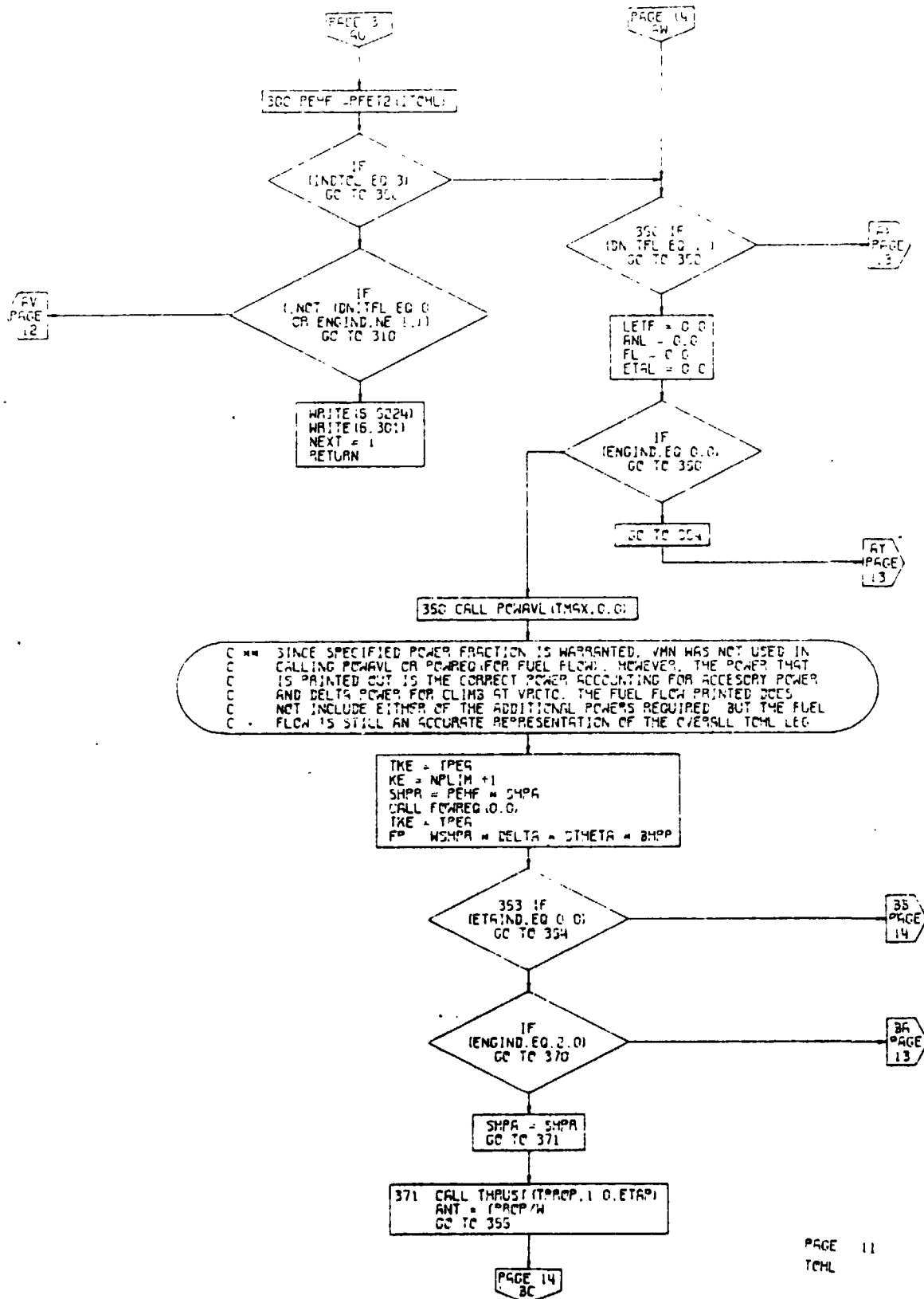
Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 7 of 12)



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TCHL

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 8 of 12)





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TCHL

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart: (Part 9 of 12)

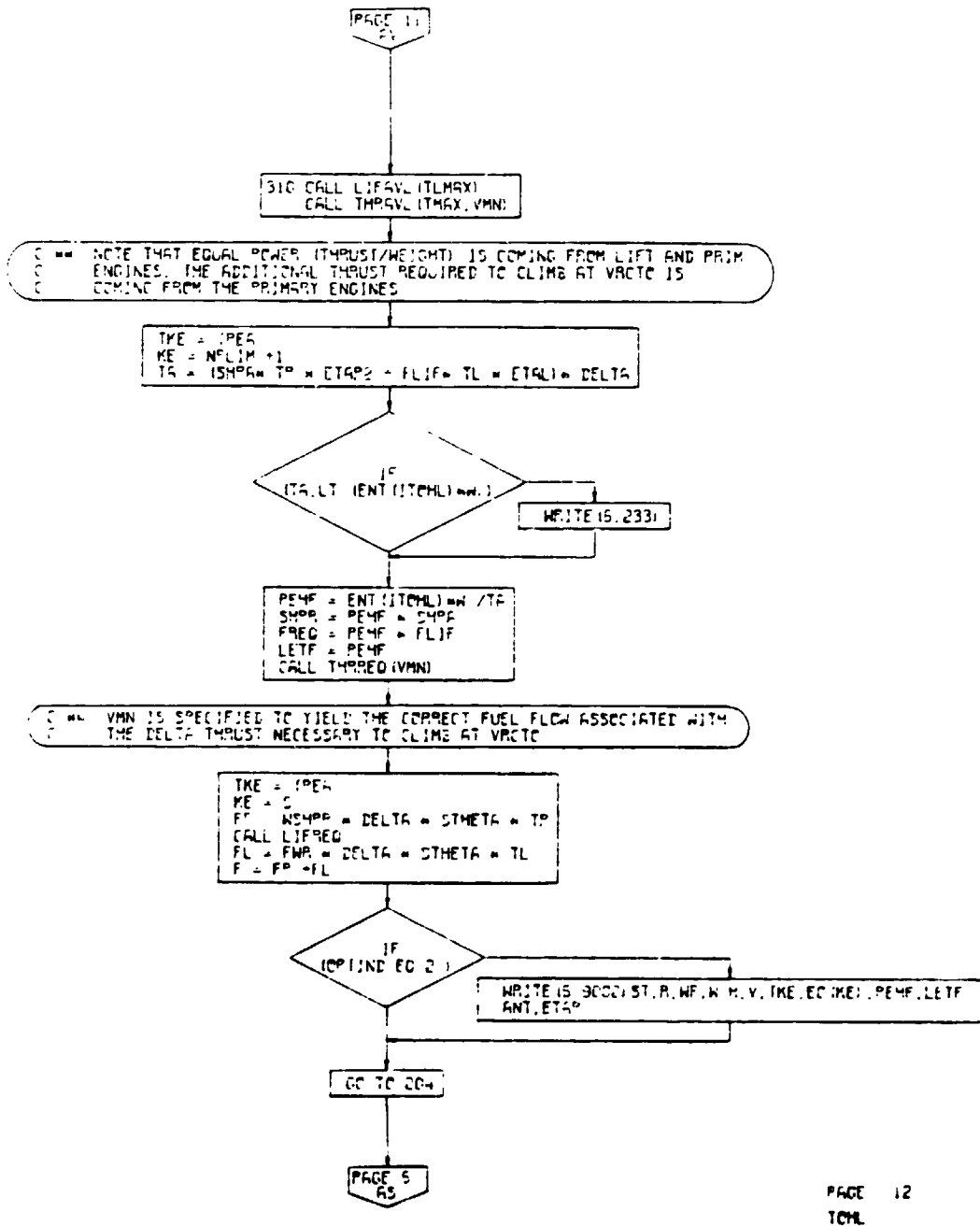


Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 10 of 12)

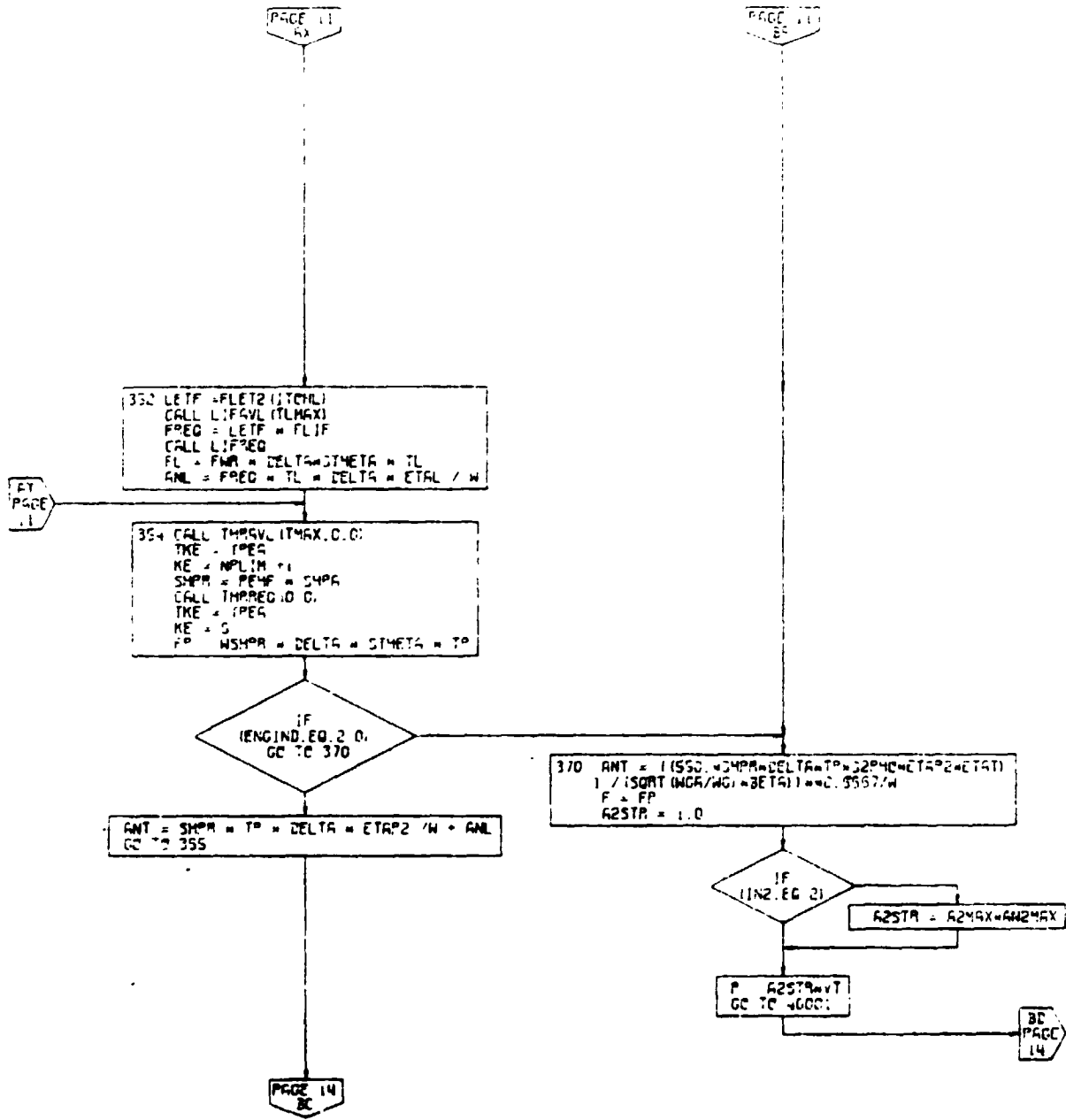
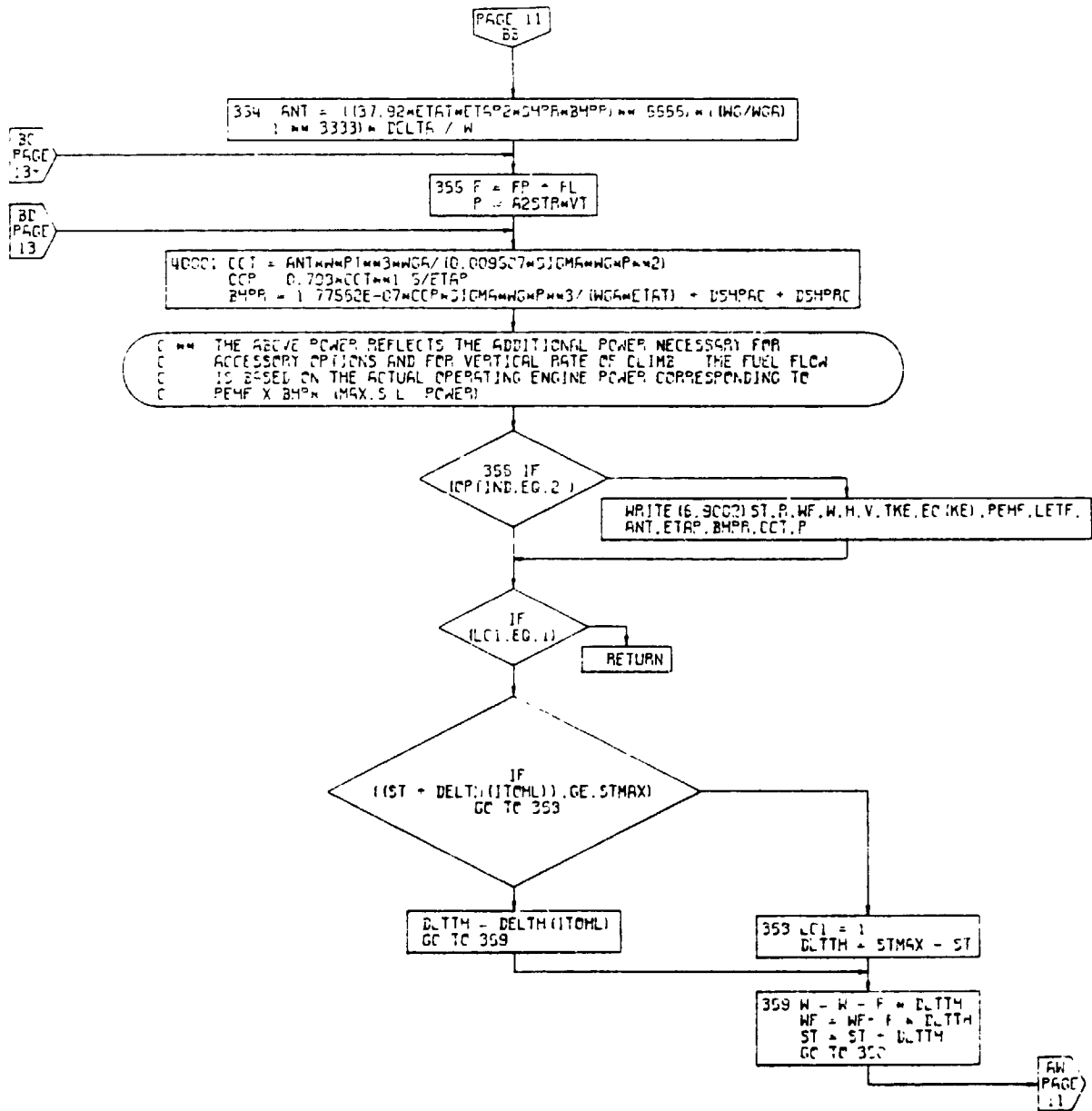


Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 11 of 12)



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TOML

Figure 4-48. Takeoff, Hover, Land Subroutine Flow Chart (Part 12 of 12)

#### 4.10.3 Climb Calculations Subroutine

The third performance segment is a calculation of climb performance. Four options are available, specified by the indicator CLMIND:

CLMIND = 1 - The program calculates performance of the aircraft in a maximum rate of climb ascent limited by maximum operating airspeed, maximum operating Mach number, and maximum body attitude angle. If, at the conditions for best rate of climb, the attitude angle of the aircraft fuselage is greater than the input maximum, the airspeed is increased until the attitude angle restriction is satisfied. In no event will the aircraft be required to fly at an airspeed greater than the input maximum operating airspeed. In the unlikely event that at  $V_{MO}$ ,  $M_{MO}$ , the aircraft rate of climb is sufficiently high to cause the aircraft fuselage attitude angle to exceed the maximum value, the engine power will be reduced to that level necessary to satisfy the attitude angle constraint. The aircraft will then climb at  $V_{MO}$ ,  $M_{MO}$ , at reduced power rating.

CLMIND = 2 - The program calculates the climb performance of the aircraft at specified constant equivalent airspeed limited, as before, by  $M_{MO}$ ,  $V_{MO}$ , and maximum body attitude angle. If the attitude angle exceeds the input maximum, the power level will be reduced.

CLMIND = 3 - Climb performance is calculated at constant specified Mach number. Otherwise, the option is similar to CLMIND = 2.

CLMIND = 4 - Climb will be calculated at constant true airspeed with the same constraints as for CLMIND = 2.

For all options, the user may input the power setting of the engines which will be considered to be the maximum permissible rating. This is accomplished by means of the indicator POWIND:

POWIND = 0: Maximum	}	engine rating
POWIND = 1: Military		
POWIND = 2: Normal		

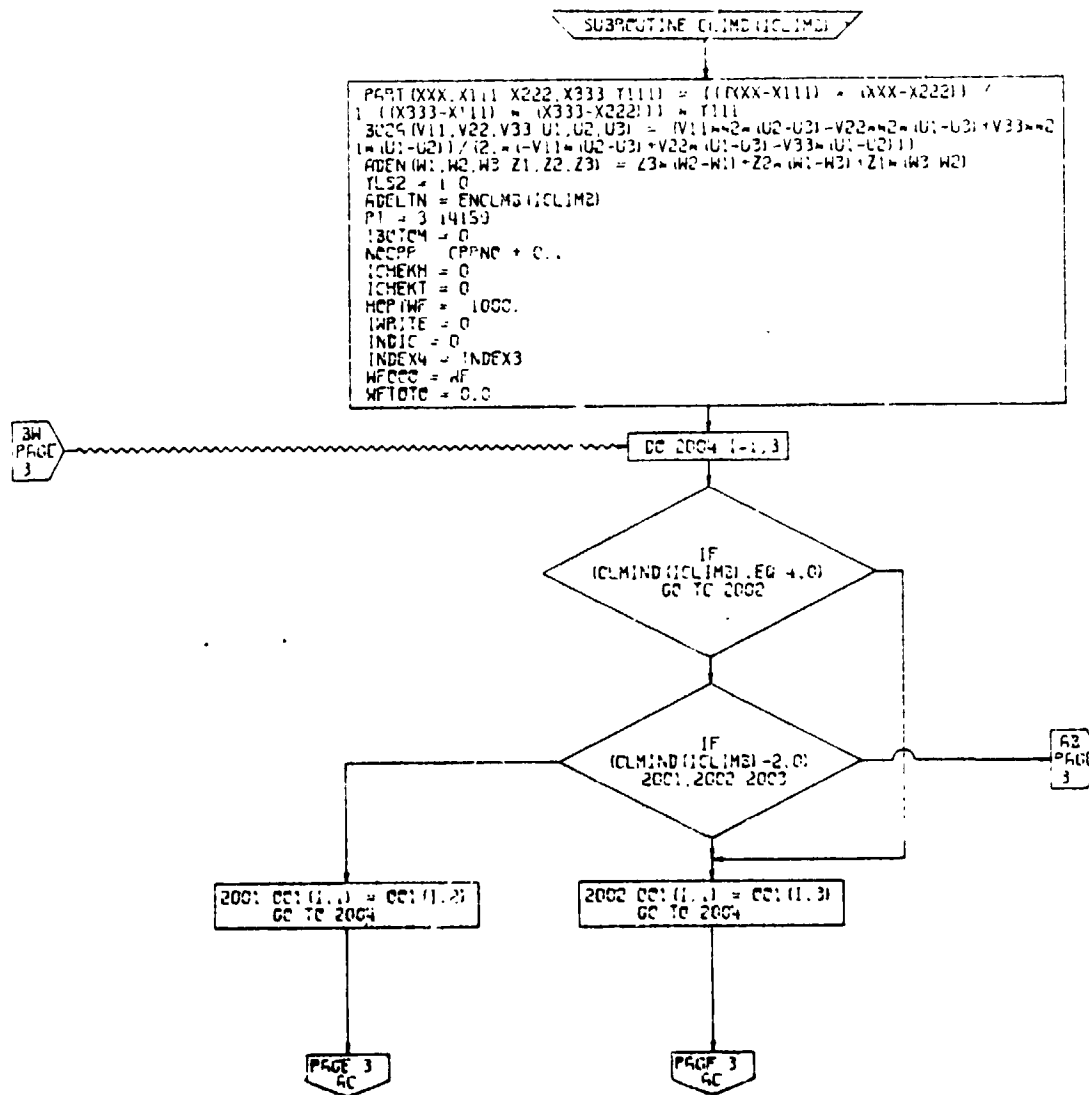
If the limiting speed option ( $V_{LIMIND} = 1$ ) is used, the climb speed calculated by the program or specified by the user will be automatically monitored by the program to ensure that it does not exceed 250 knots equivalent airspeed at altitudes of 10,000 feet or less.

The climb segment may be used to make energy-maneuverability calculations. To calculate the specific excess power ( $P_s$ ) at a given value of altitude and true airspeed (or Mach number) and at a desired level of normal load factor, the user may run a climb segment at constant Mach number (CLMIND=3) or constant true airspeed (CLMIND=4). The normal load factor is specified to the program by an input for  $\Delta n_{CLIMB}$ . This input represents the airplane normal load factor in excess of 1 g. For conventional climbs, this parameter should be input as zero. The program printout for rate of climb in feet per minute may be interpreted as the specific excess power ( $P_s$ ) and converted to units of feet per second, ordinarily used in energy-maneuverability charts.

The user may specify a value for incremental drag coefficient during climb,  $\Delta C_{DCLIMB}$  to represent variations in store drag.

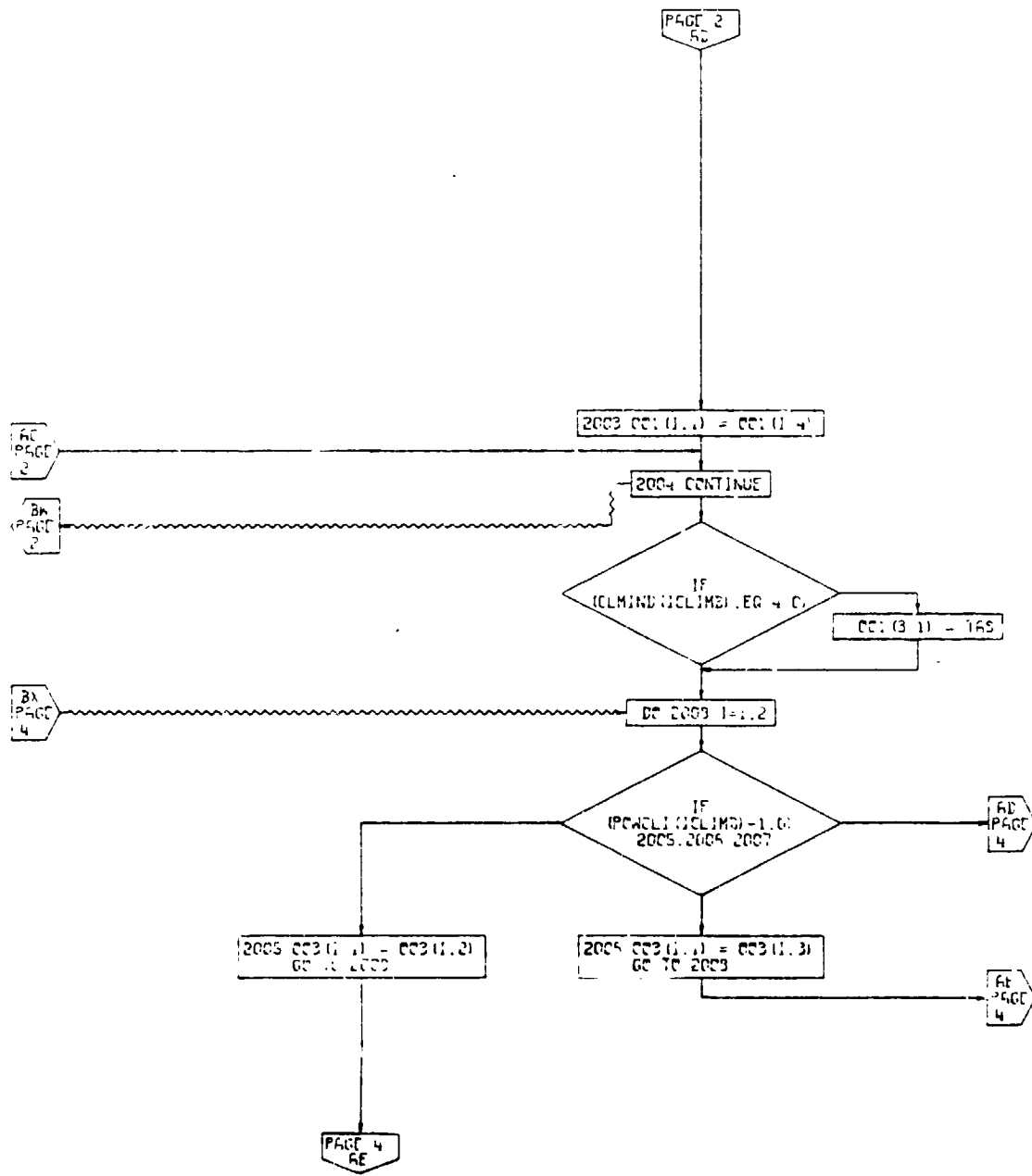
The input  $h_{max}$  has two applications. If  $h_{OPTIND} = 1$  (optimum altitude search) and the climb is followed by a cruise, the input value of  $h_{max}$  will be interpreted as the maximum flight altitude for the following cruise. If the optimum cruise altitude is determined by the program to be at an altitude less than  $h_{max}$ , the climb will terminate at the lower altitude. If an optimum altitude search is not being used or if the following segment is other than a cruise, the input  $h_{max}$  is interpreted as the final altitude for the climb segment.

Figure 4-49 is a flow chart for this subroutine.



PAGE 2  
CLIMD

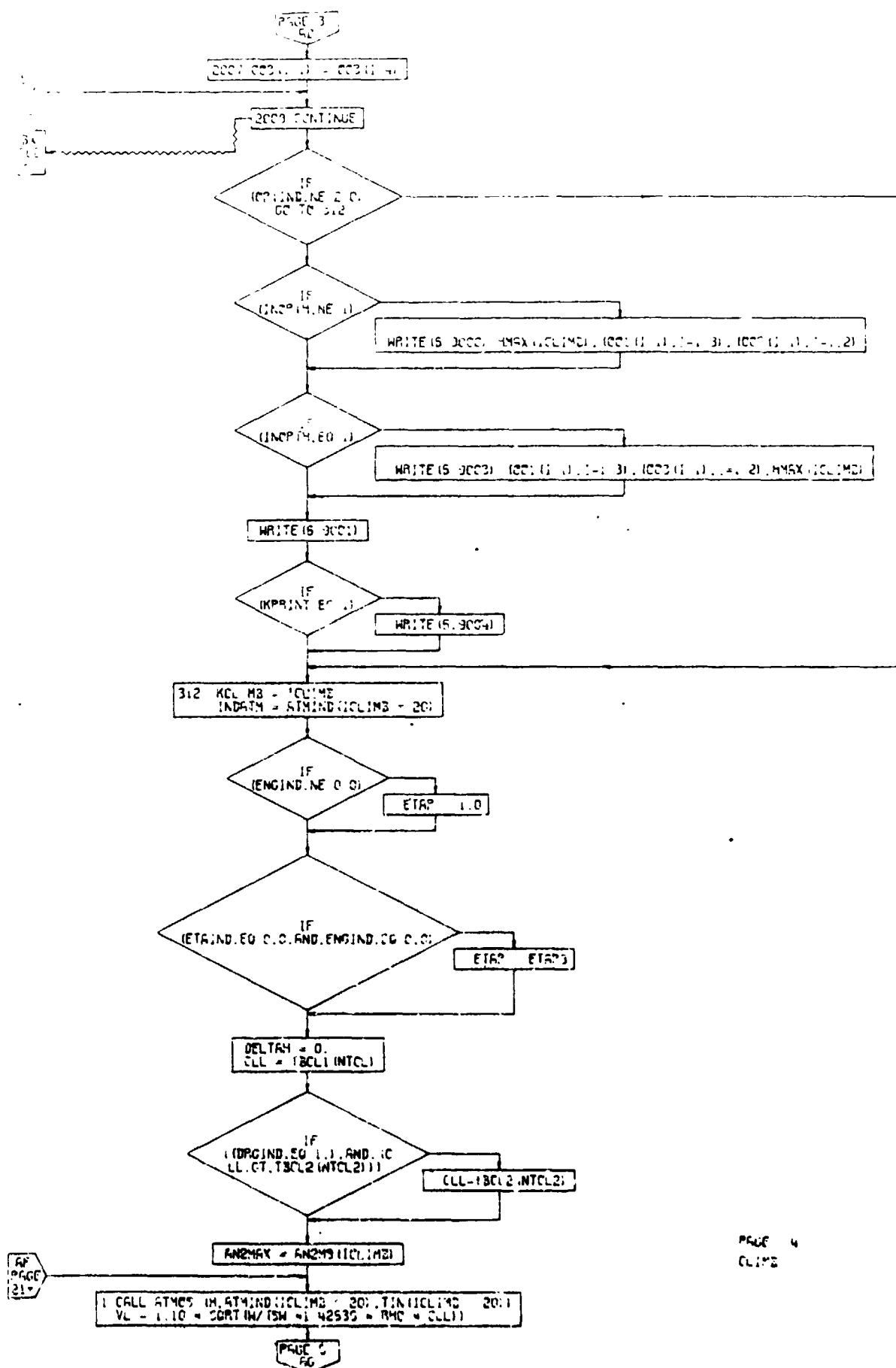
Figure 4-49. Climb Subroutine, Flow Chart (Part 1 of 22)



PAGE 3  
CLIMB

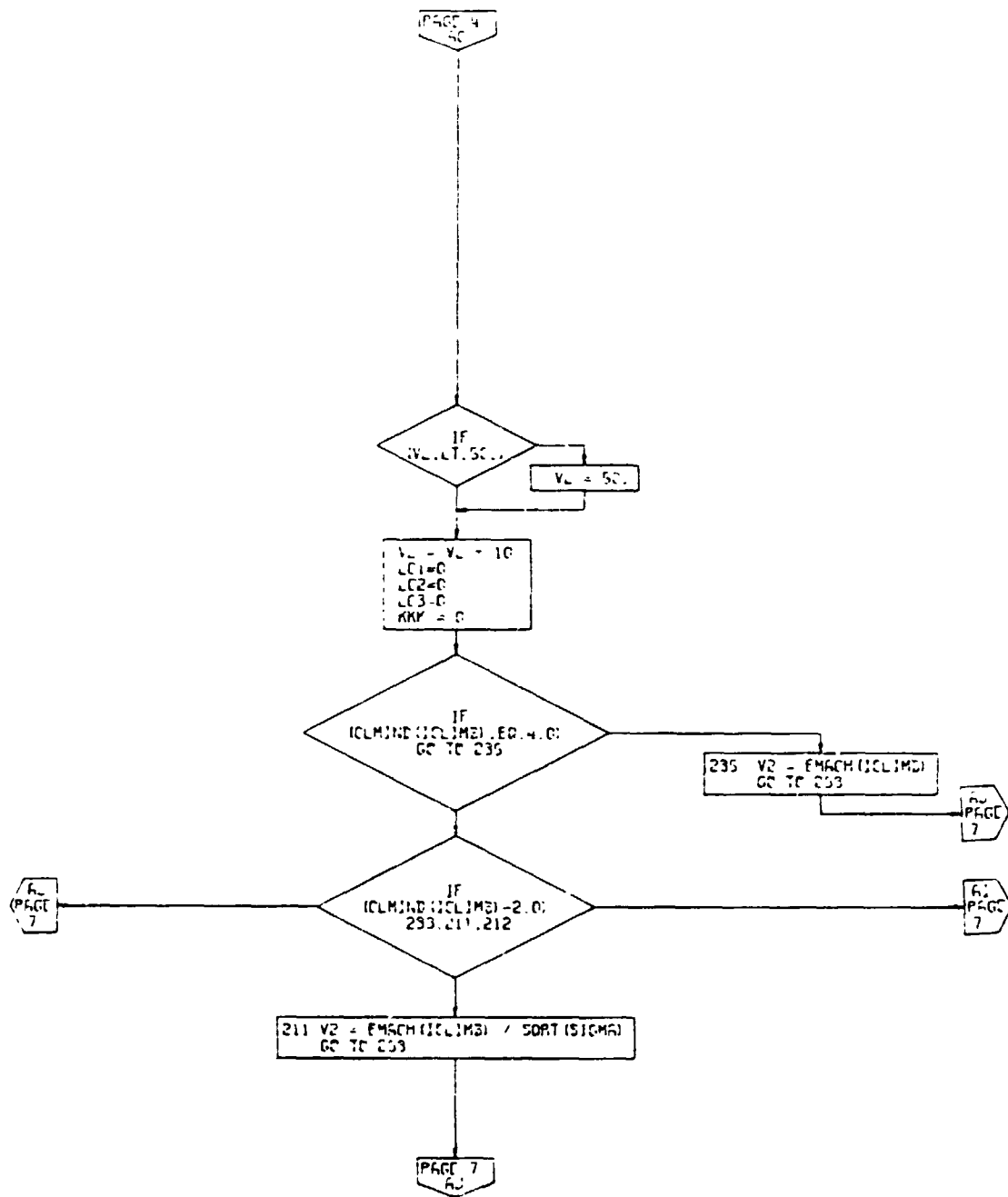
Figure 4-49. Climb Subroutine, Flow Chart  
(Part 2 of 22)





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CLIMB

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 3 of 22)  
4-211



PAGE 5  
CLIMB

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 4 of 22)



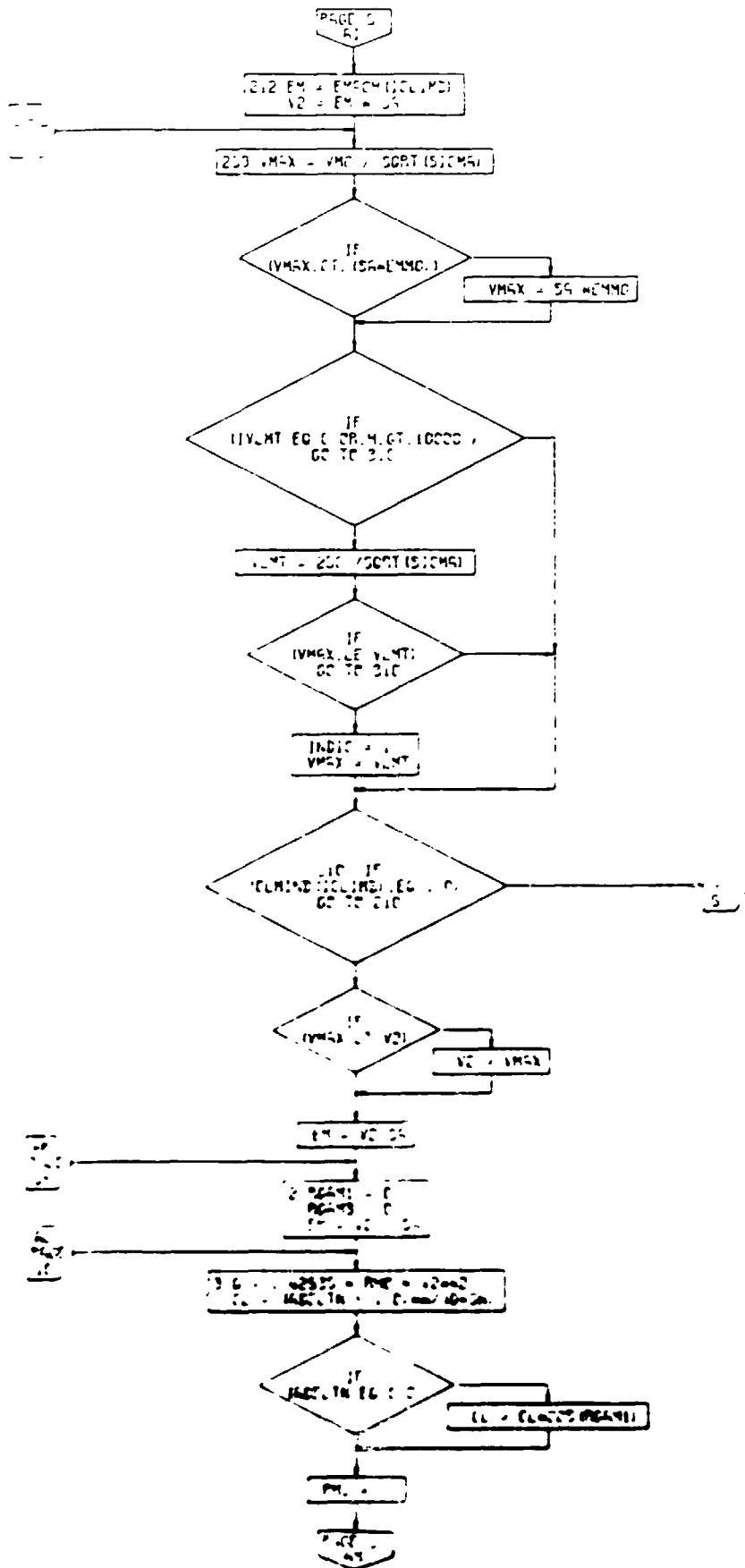
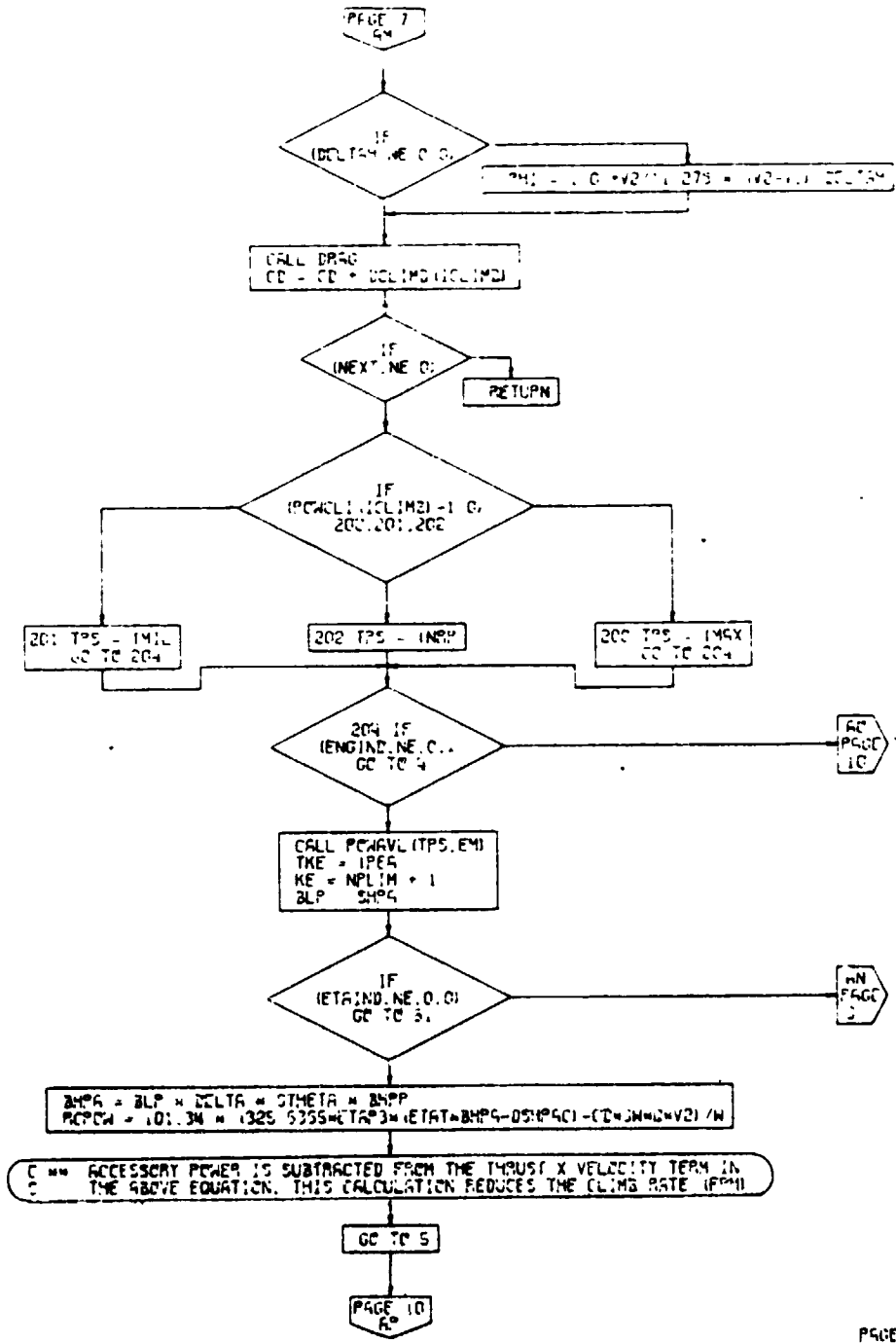


Figure 4-49. Climb Subroutine, Flow Chart  
(Part 6 of 22)



PAGE 3  
CLIMD

Figure 4-49. Climb Subroutine, Flow Chart (Part 7 of 22)

PAGE 8  
AN

```
15. V = VC  
CALL THRUST (TRP, YL52, FTAP)  
RPPC = VC * 34 - V * (TRP * (L * D * C) / W)  
GO TO 5
```

PAGE 9  
CLIMB

PAGE 9  
CLIMB

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 8 of 22)

4-216

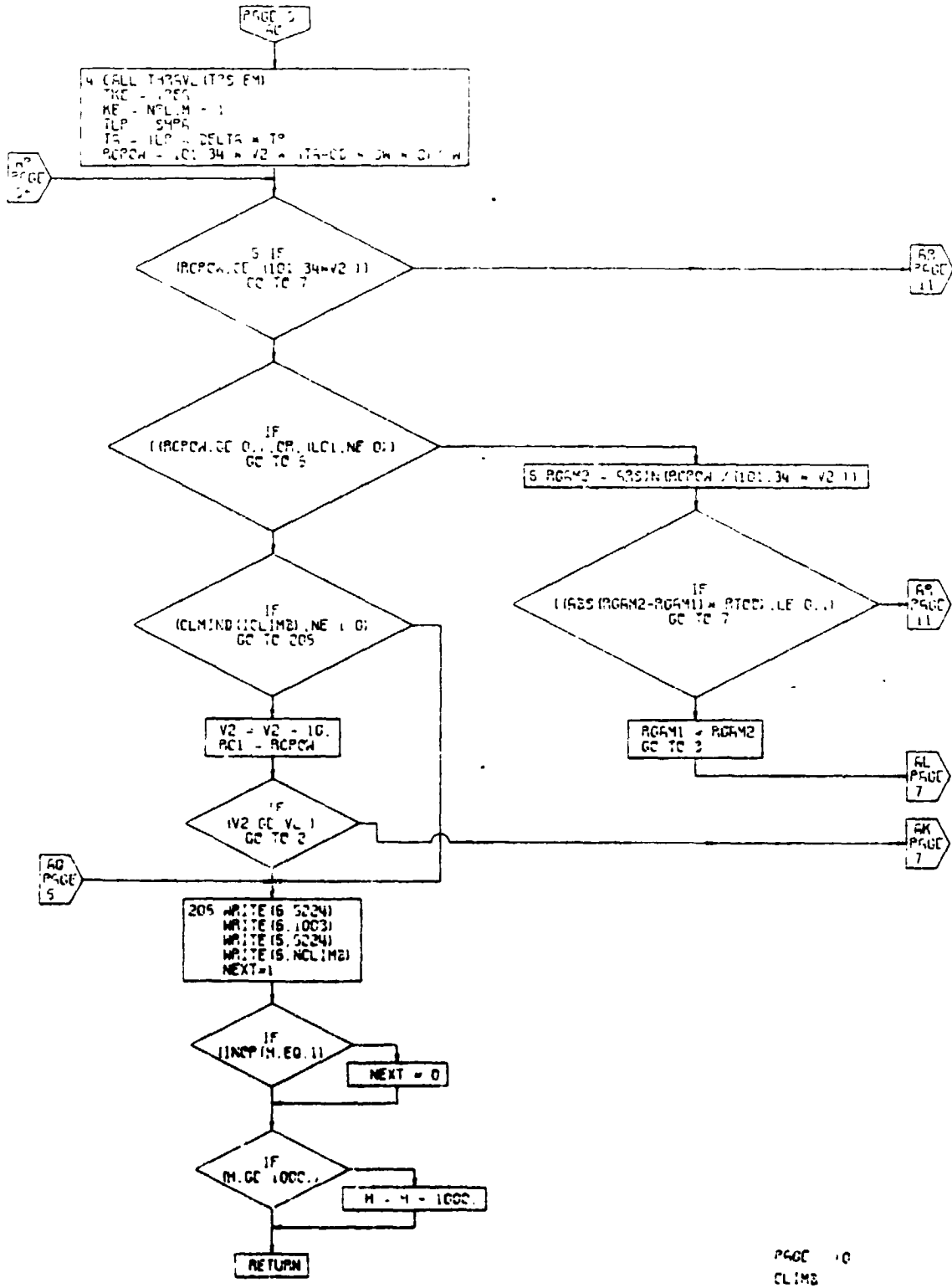
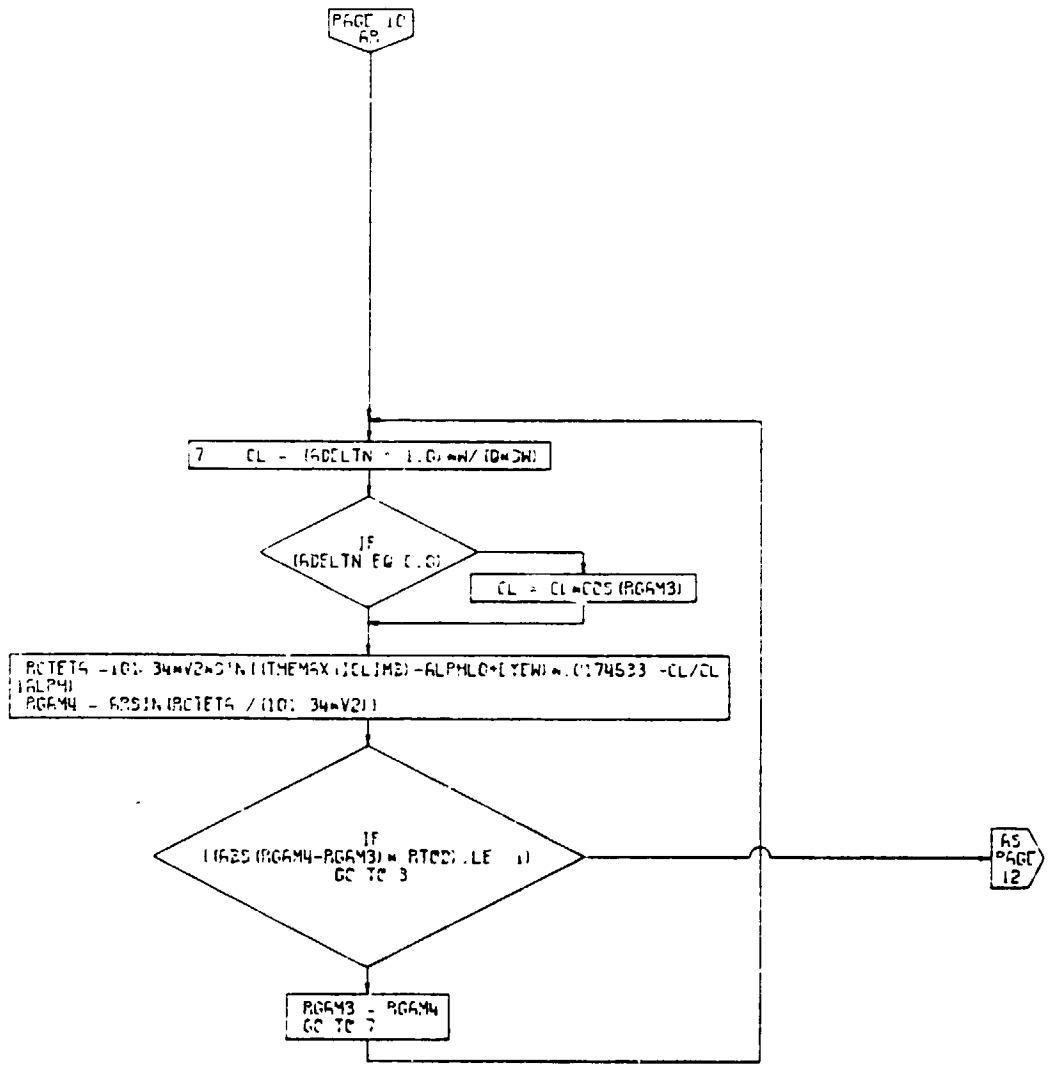


Figure 4-49. Climb Subroutine, Flow Chart (Part 9 of 22)



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CLIMB

Figure 4-49. Climb Subroutine, Flow Chart (Part 10 of 22)





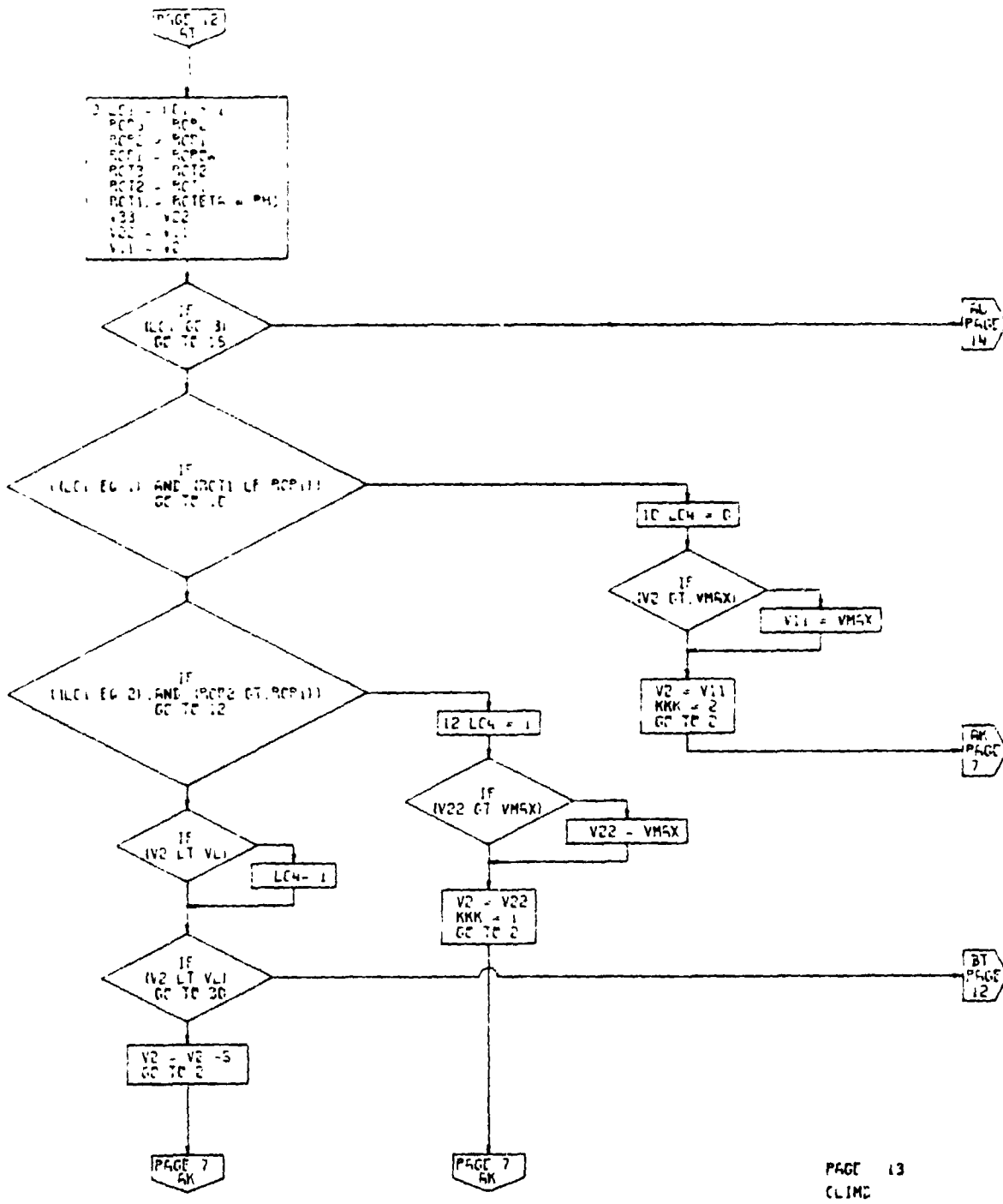
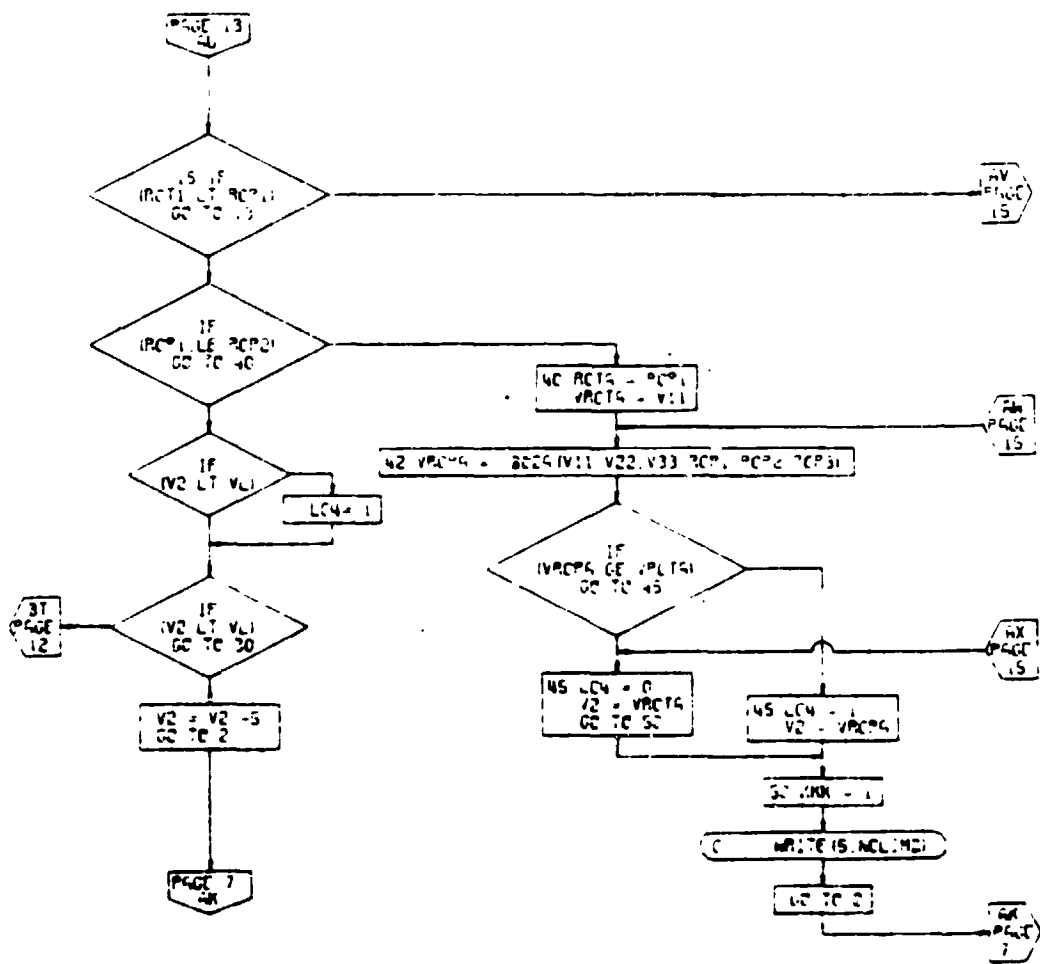
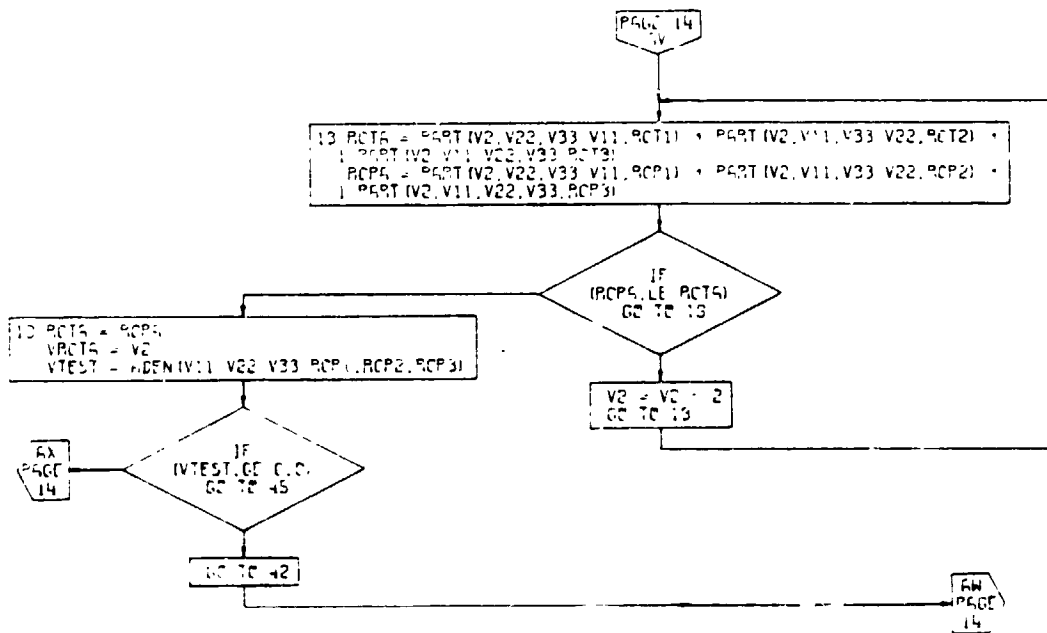


Figure 4-49. Climb Subroutine, Flow Chart (Part 12 of 22)

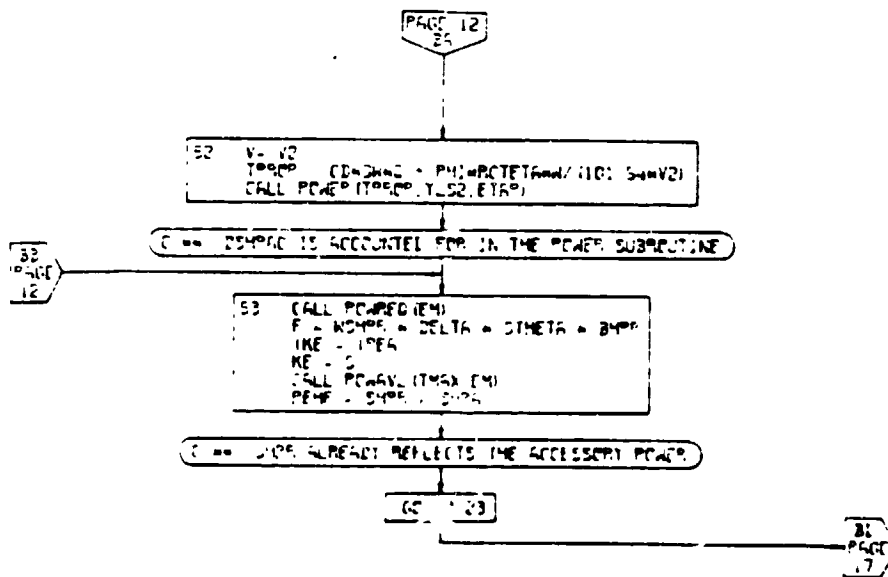


PAGE 14  
CLIMB

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 13 of 22)  
4-221

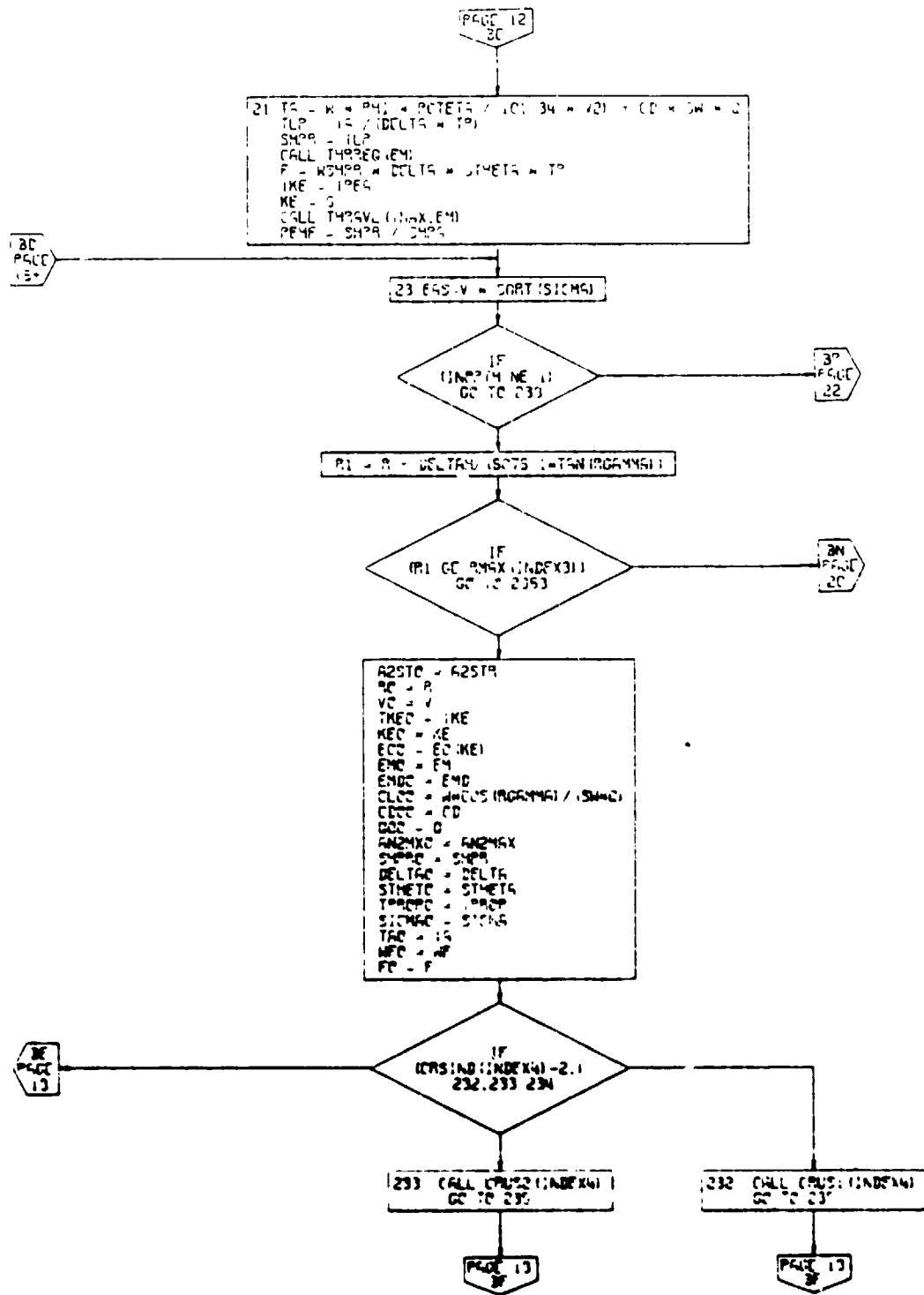


PAGE 15  
CLINE



PAGE 15  
CLINE

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 14 of 22)



PAGE 17  
CLIND

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 15 of 22)

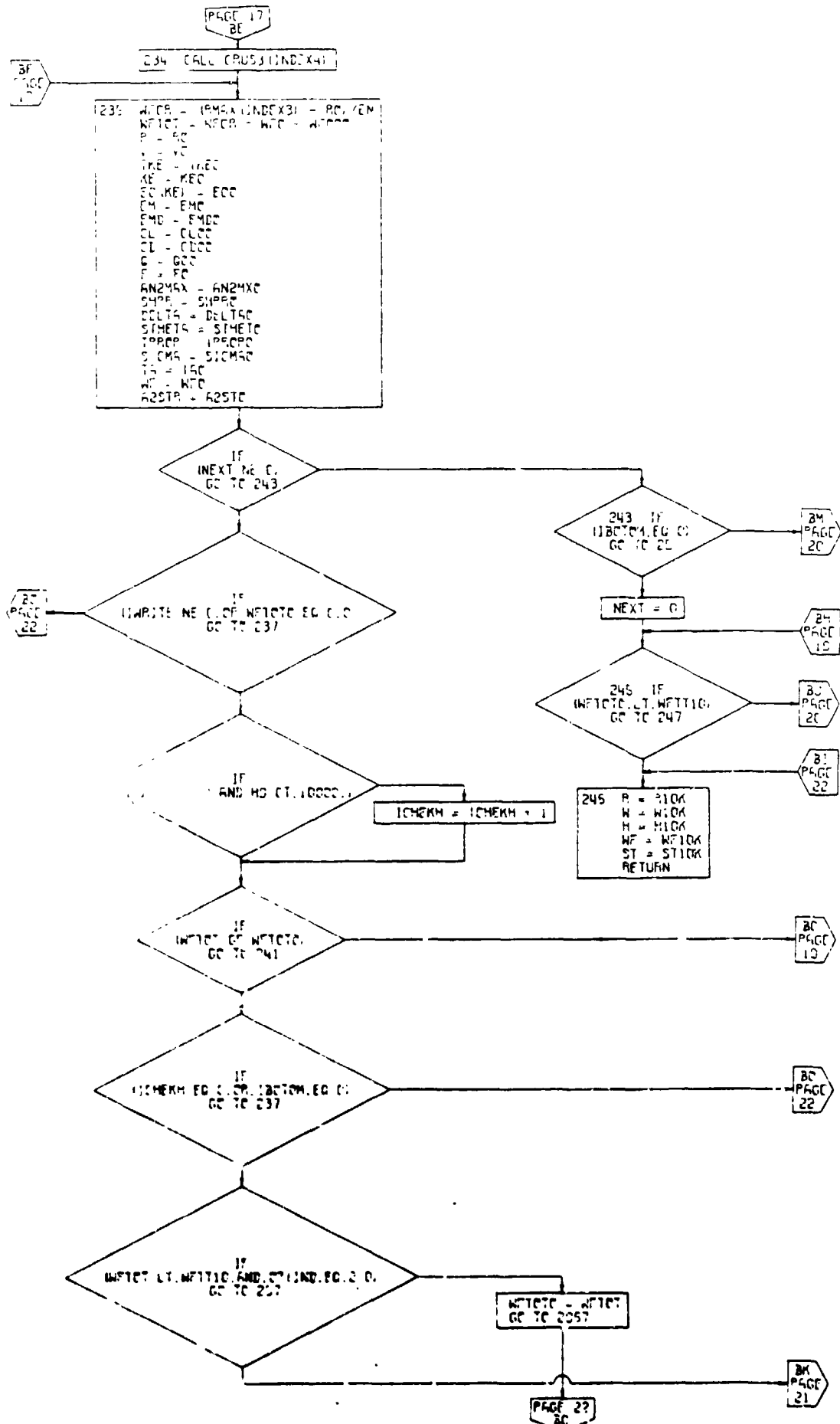
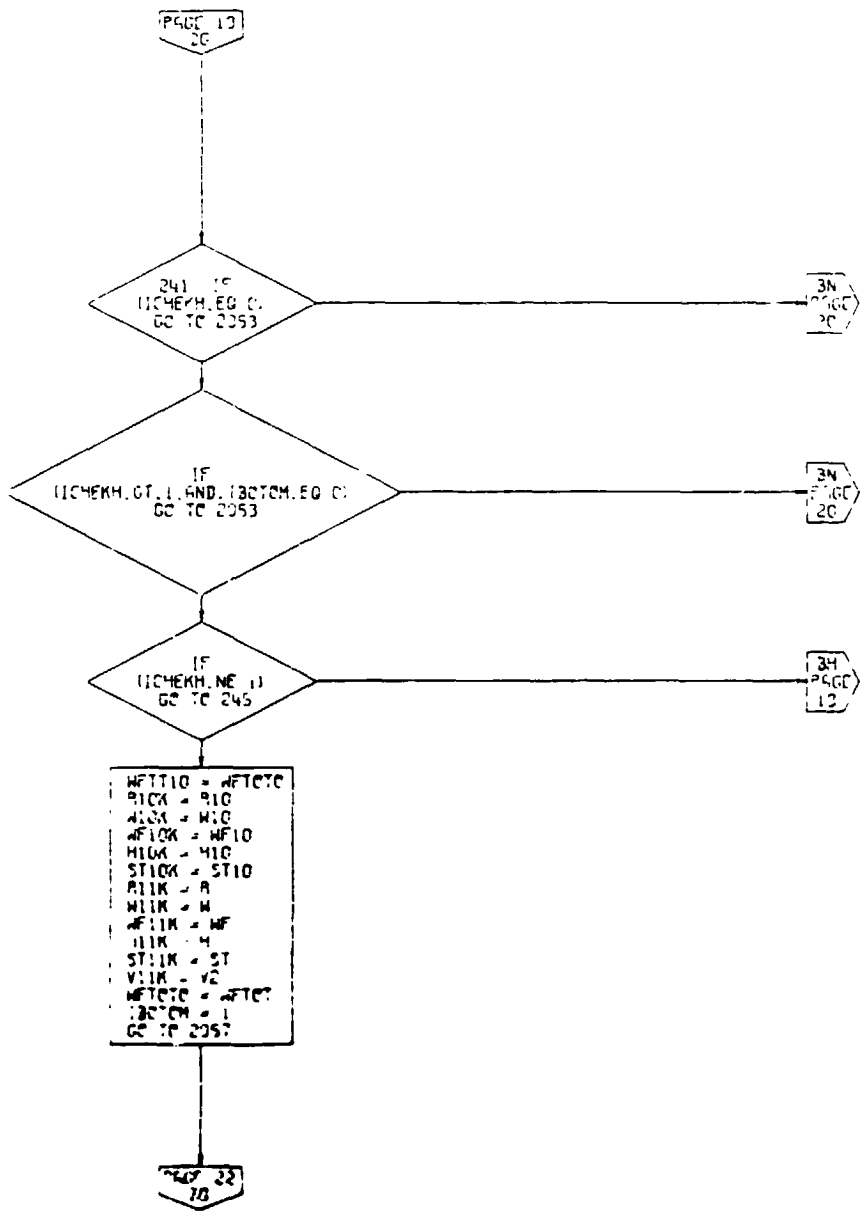


Figure 4-49. Climb Subroutine, Flow Chart (Part 16 of 22)



PAGE 12  
20, 22

Figure 4-49. Clixb Subroutine. Flow Chart  
(Part 17 of 22)

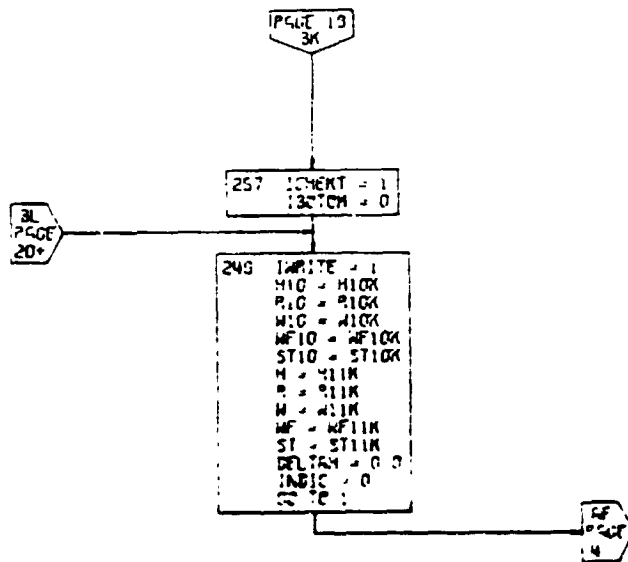
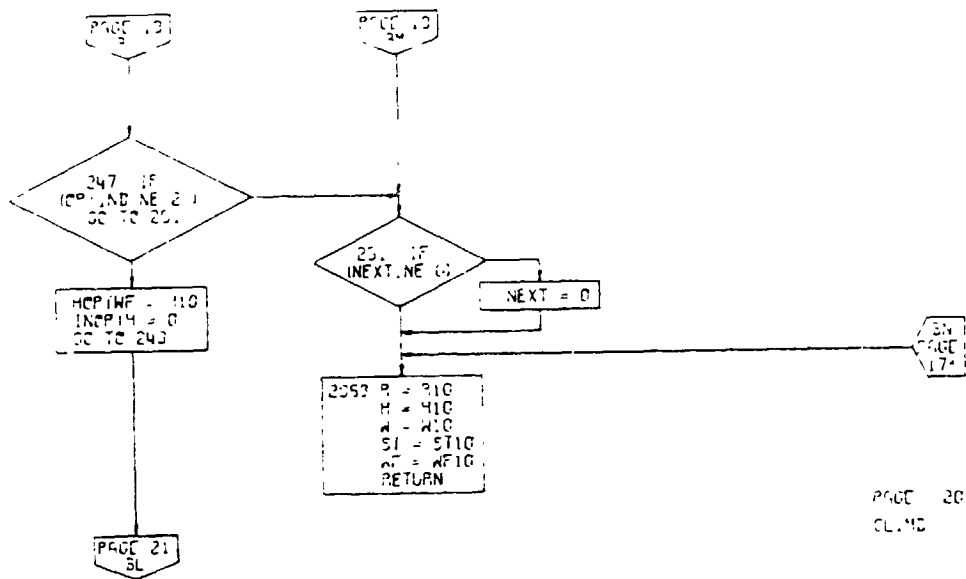
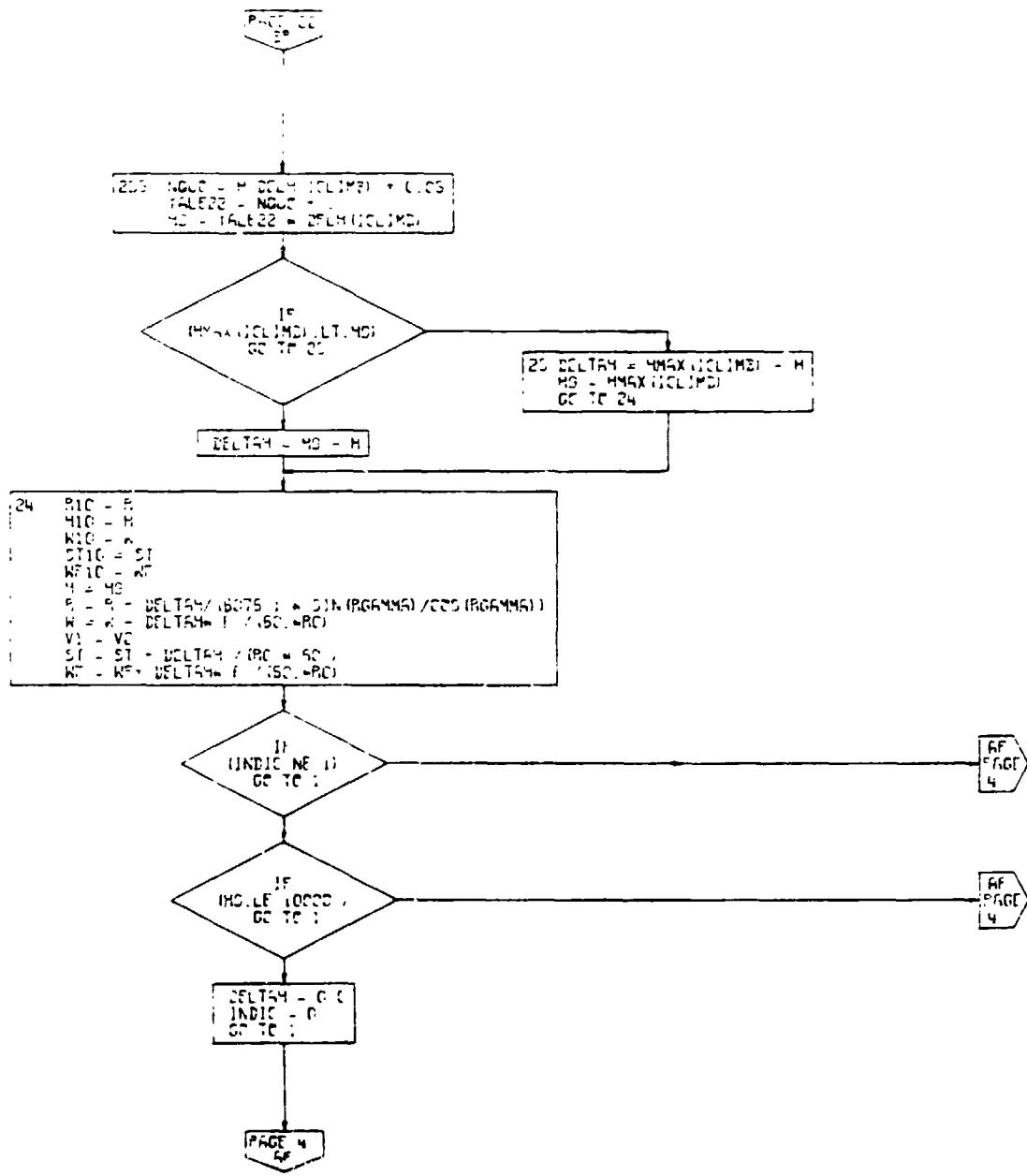


Figure 4-49. C'imb Subroutine, Flow Chart (Part 18 of 22)

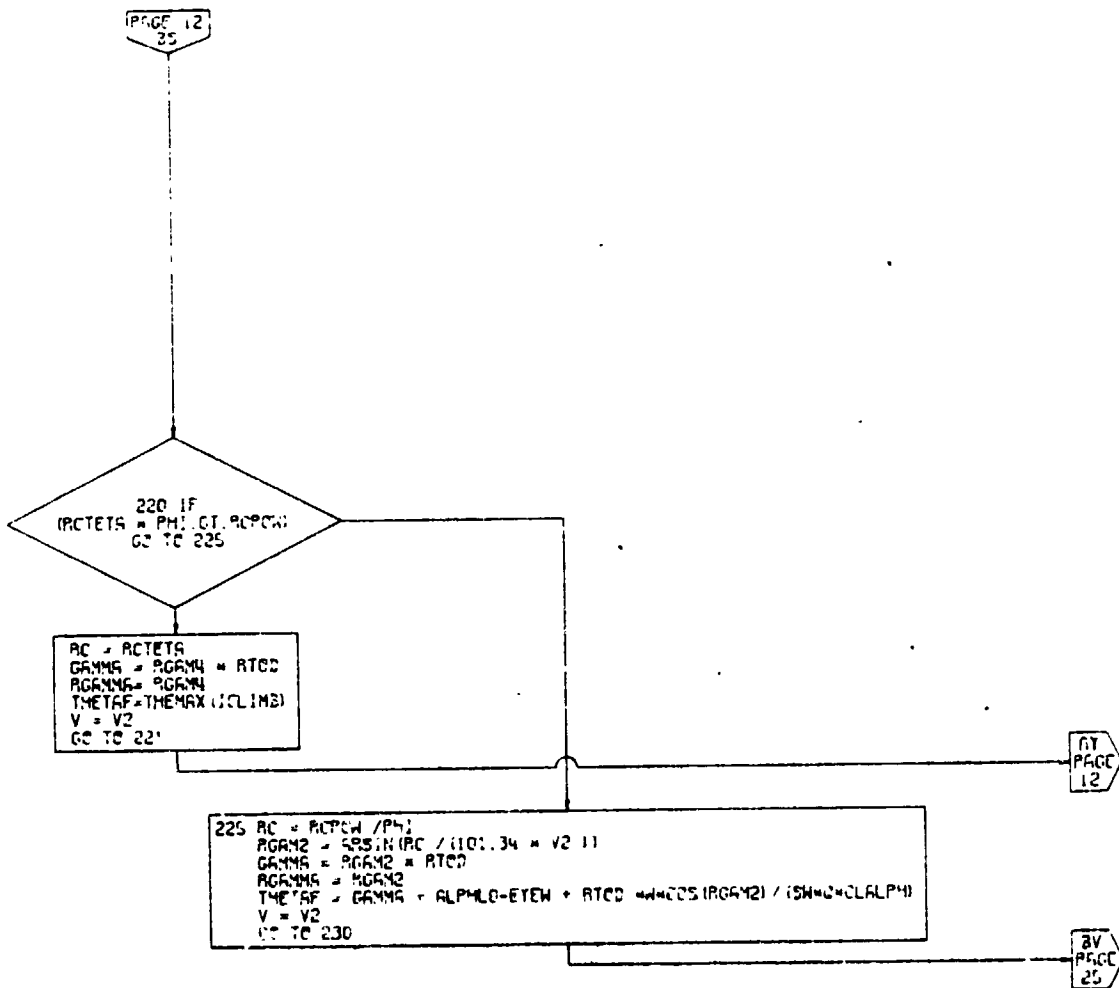






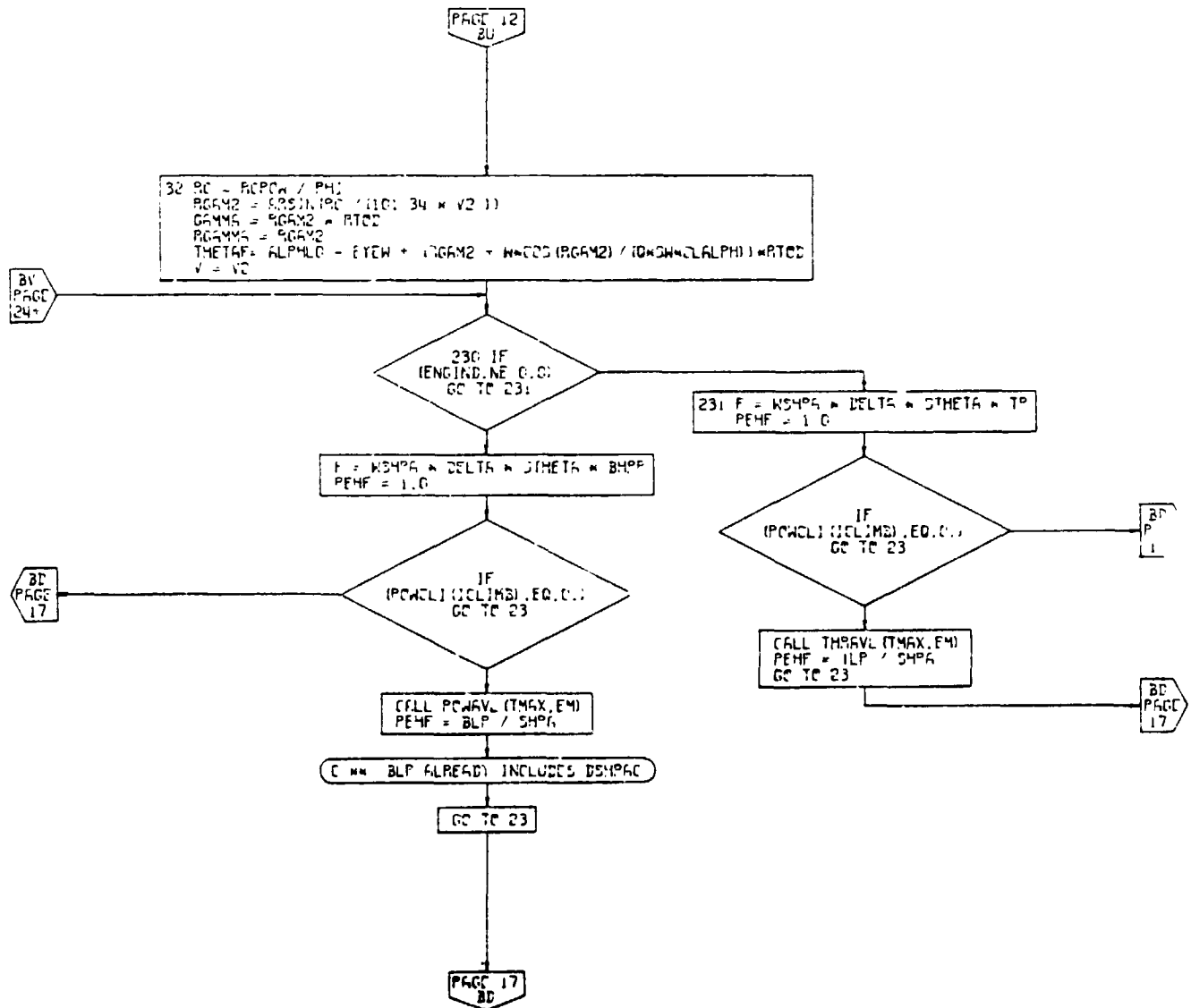
PAGE 23  
CLIMB

Figure 4-49. Climb Subroutine, Flow Chart (Part 20 of 22)



PAGE 24  
CLIMB

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 21 of 22)



PAGE 25  
CLIMB

Figure 4-49. Climb Subroutine, Flow Chart  
(Part 22 of 22)

#### 4.10.4 Cruise Calculations Subroutine

The fourth performance segment is the calculation of cruise performance. The cruise performance calculation contains six separate options specifying the type of cruise for the aircraft. This option is determined by an input indicator, CRSIND.

CRSIND = 1 - This is a calculation of aircraft cruise performance at a fixed cruise power setting and at a constant altitude, constrained by limiting airspeed and Mach number. This option calculates the true airspeed, Mach number, specific range, and reduction in gross weight during cruise.

CRSIND = 2 - This option will calculate the cruise performance of the aircraft at constant true airspeed, constant altitude, and constrained by cruise power and by limiting airspeed and Mach number. The program will calculate the power setting required, true airspeed, specific range, and corresponding reduction in gross weight of the aircraft during cruise.

CRSIND = 3 - This option calculates the airspeed during cruise required for best specific range, constrained by normal power setting and by limiting airspeed and Mach number. Flight is at constant altitude.

CRSIND = 4 - This option will calculate the "long range cruise" condition - that is, cruise at speed for 99% of best specific range. Flight is constrained by normal power setting, limiting airspeed and Mach number and is at constant altitude.

CRSIND = 5 - This option is a calculation for a cruise-climb at a constant value of  $W/\delta$  (airplane weight to ambient pressure ratio). The airspeed will be the speed for best specific range.

CRSIND = 6 - This is a calculation for a cruise climb (constant  $W/\delta$ ) at the speed for 99% of best specific range.

Cruise power setting as discussed above is defined by user input to be maximum (POWIND = 0), military (POWIND = 1), or normal (POWIND = 2) engine rating.

This subroutine permits simulation of cruise performance of an aircraft with an arbitrary number of engines shut down. The program user specifies the number of

engines shut down and a corresponding increment in airplane drag coefficient.

The user may also specify a desired value of headwind when CRSIND = 3 through 6.

The input for the subroutine consists of the final range for cruise, the step size (incremental range), number of engines shut down, increment in drag coefficient, atmospheric conditions, required true airspeed (if CRSIND = 2) the headwind (if CRSIND = 3, 4, 5, or 6) and the settings for CRSIND and POWIND. Figure 4-50 is a flow chart of this subroutine.

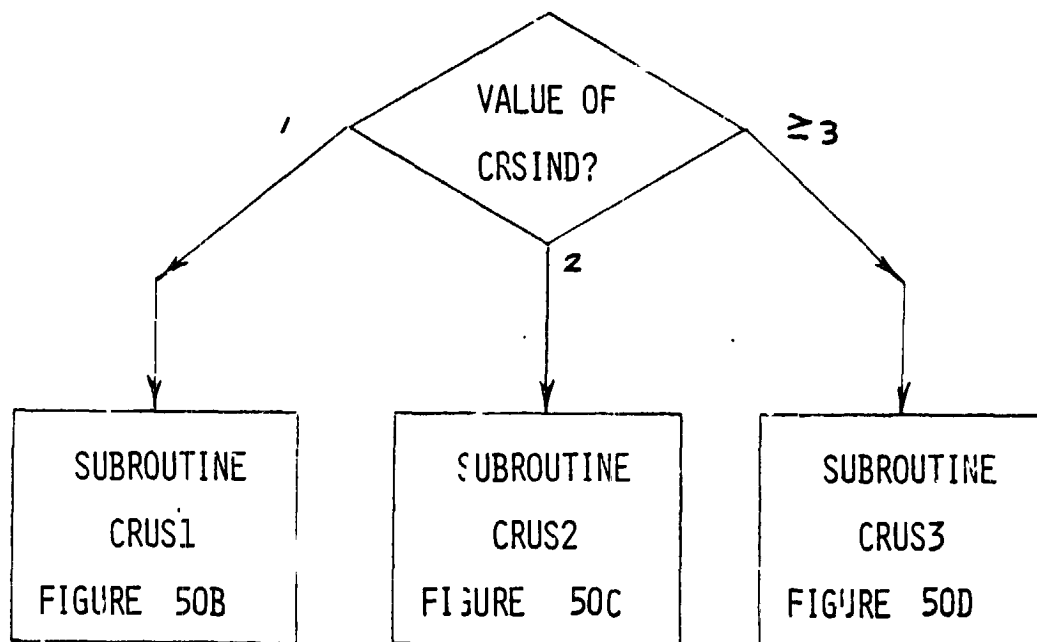
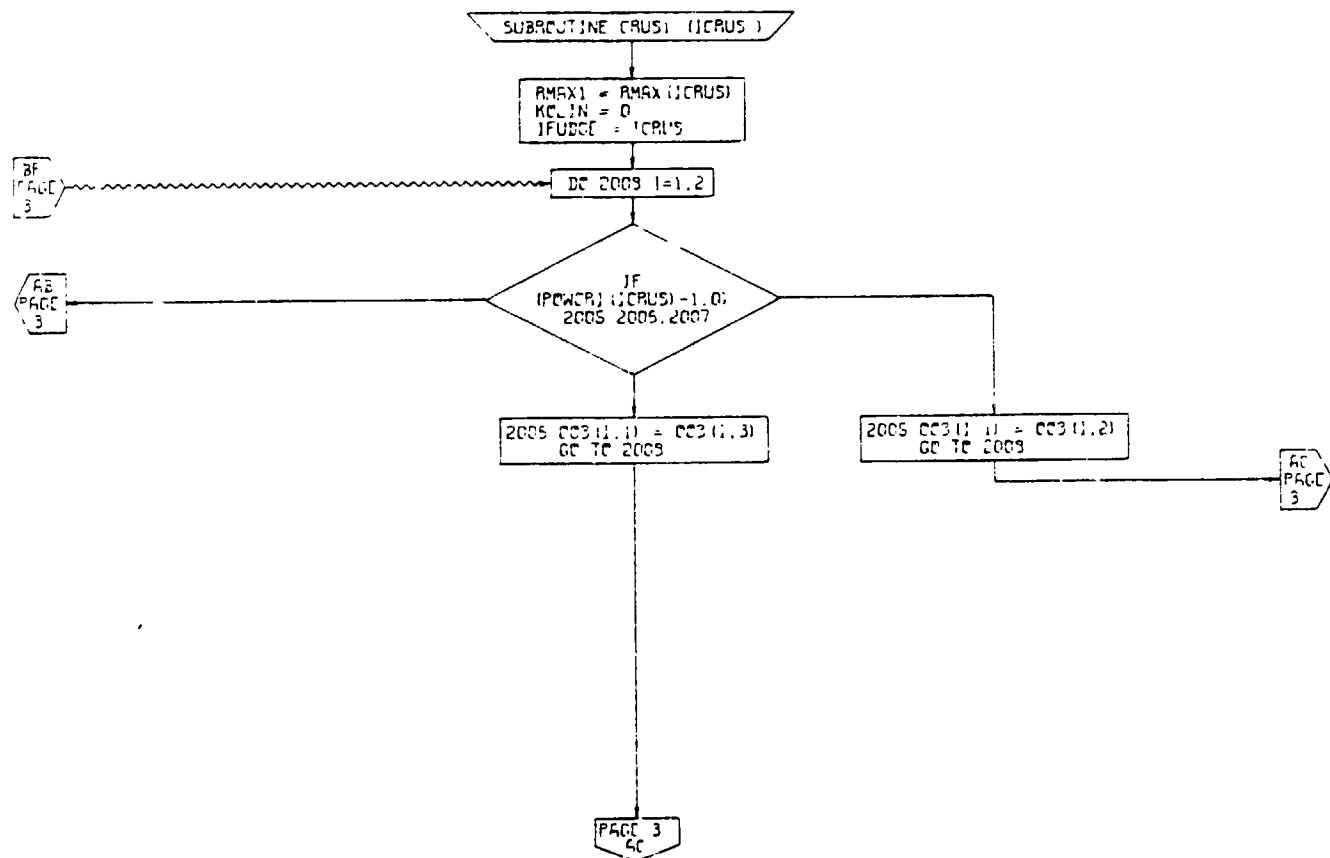


Figure 4-50a. Cruise Calculations Subroutine, Flow Chart.



PAGE 2  
CRUS1

Figure 50B . CRUS1 Calculations Subroutine, Flow Chart (Part 1 of 10)



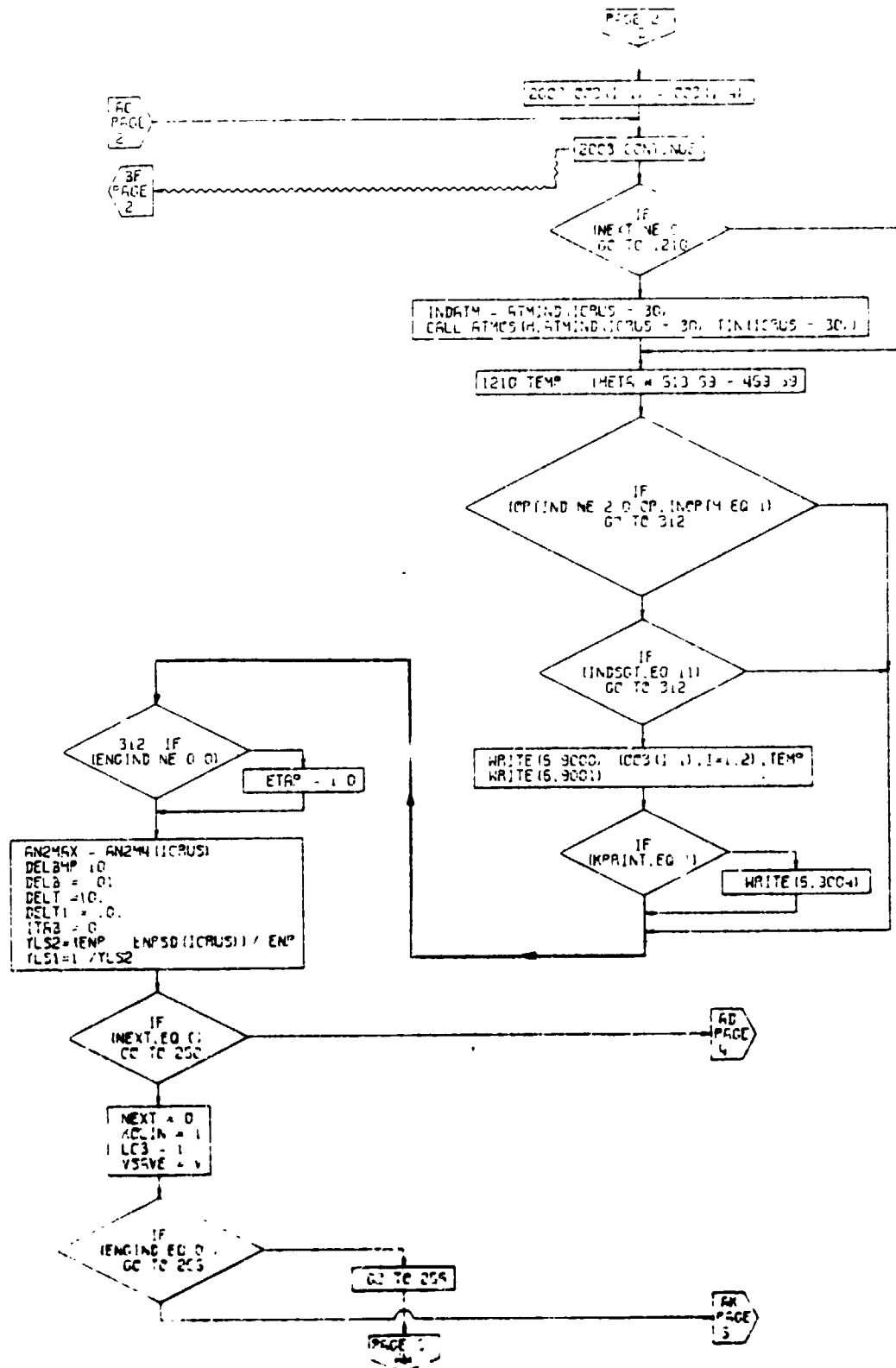
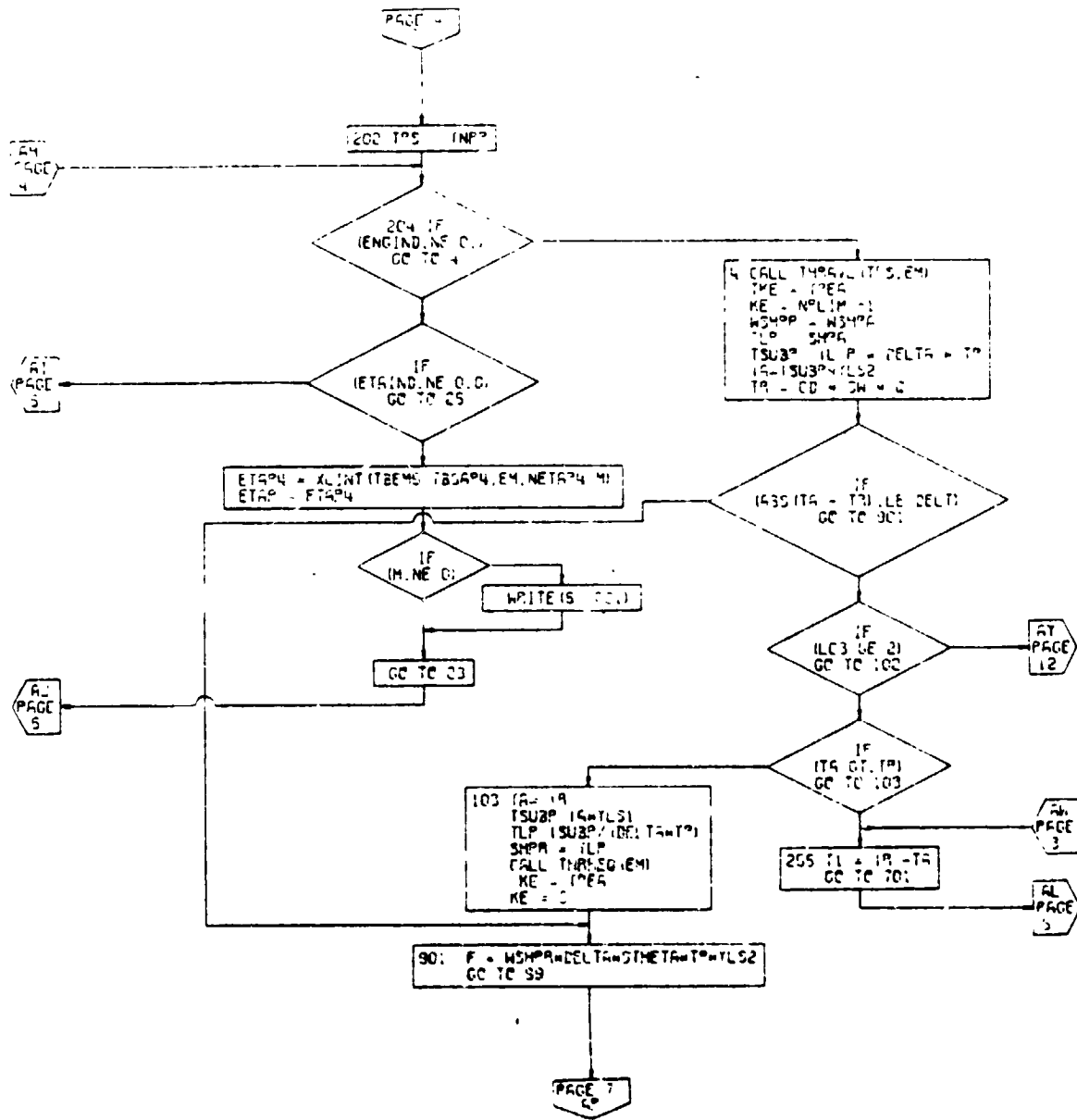


Figure 50B. CRUS1 Calculations Subroutine, Flow Chart (Part 2 of 10)

PAGE 3  
CRUS1





PAGE 4  
CRUS1

Figure 50B. CRUS1 calculation, Subroutine, Flow Chart (Part 4 of 10)

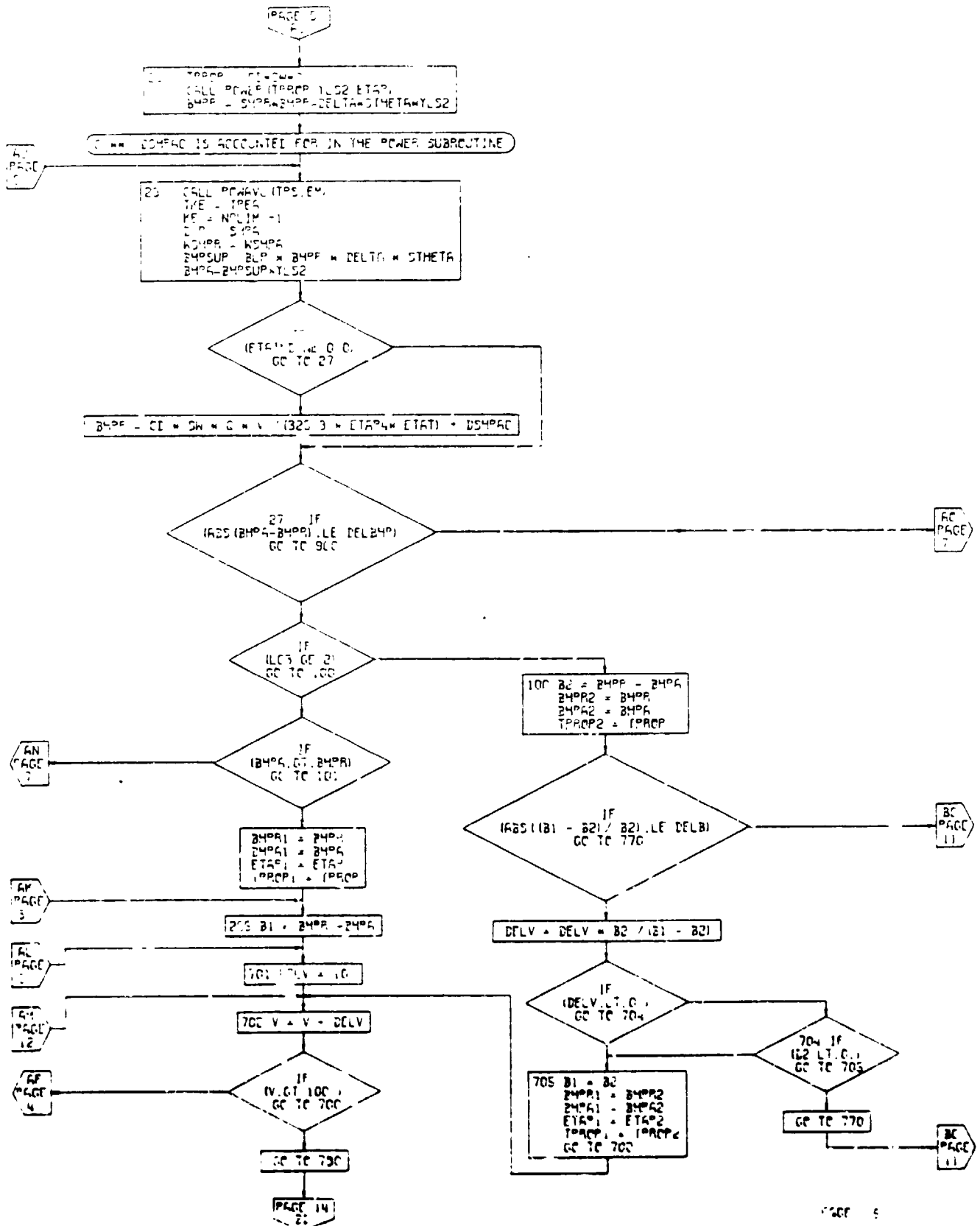
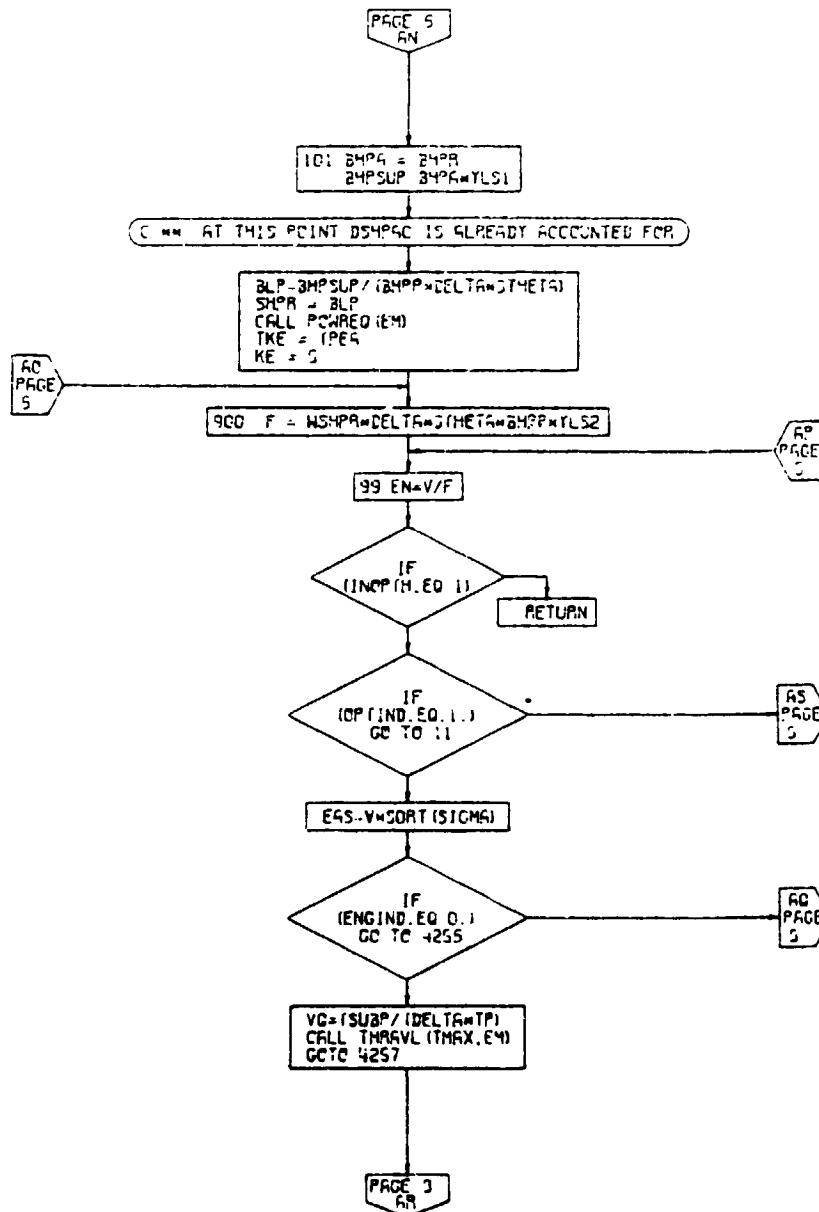


Figure 50B. CRUS) Calculations Subroutine, Flow Chart (Part 5 of 10)  
4-238



PAGE 7  
CRUS1

Figure 50B. CRUS1 Calculations Subroutine, Flow Chart (Part 6 of 10)

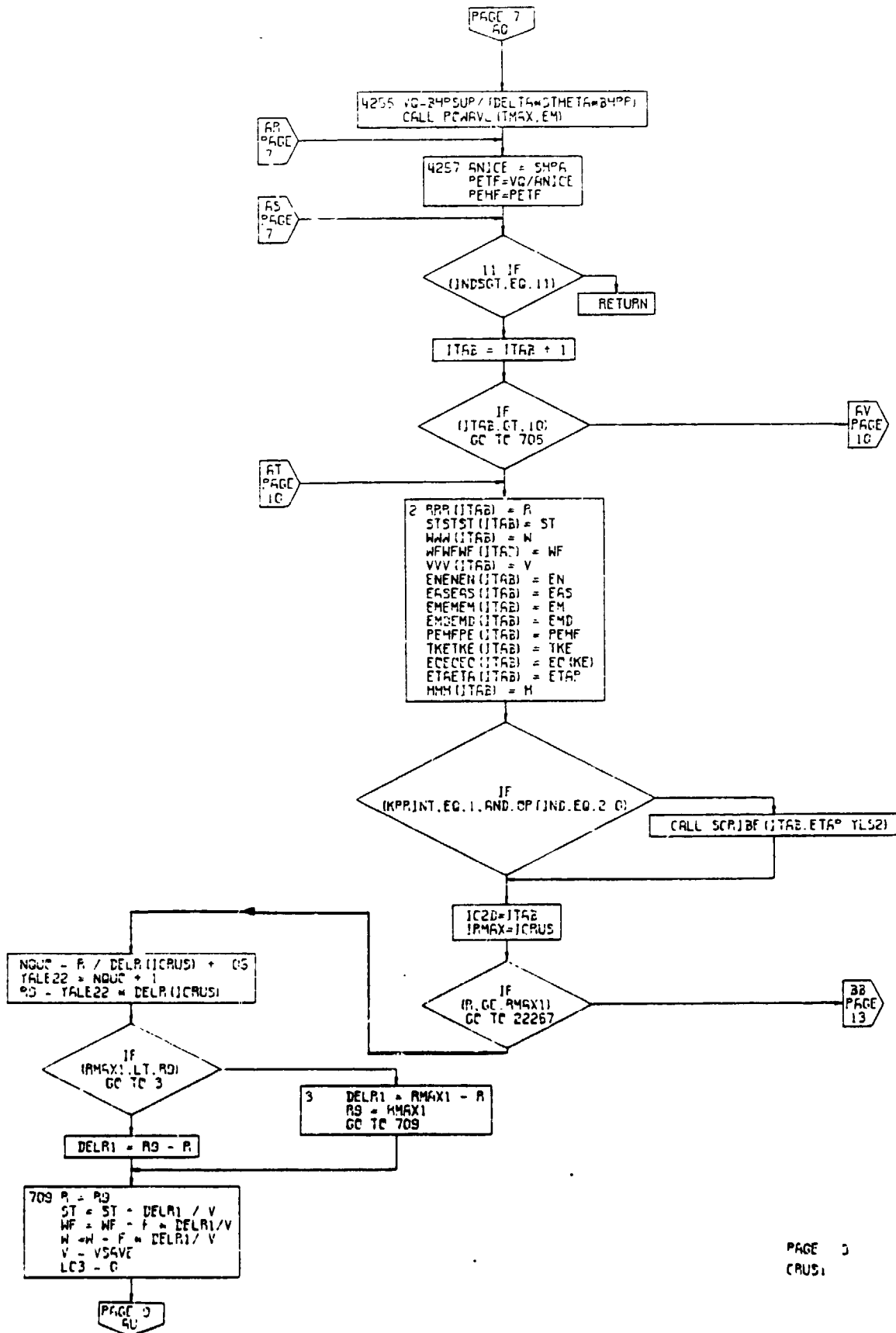
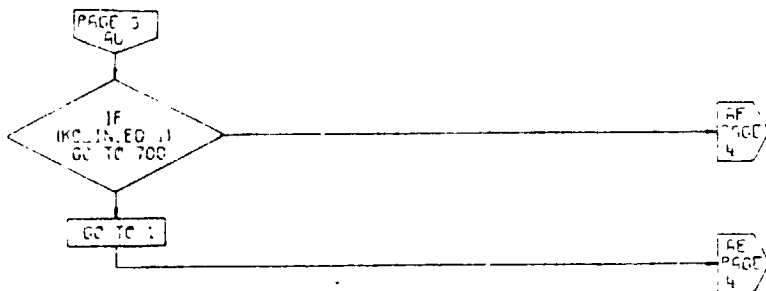
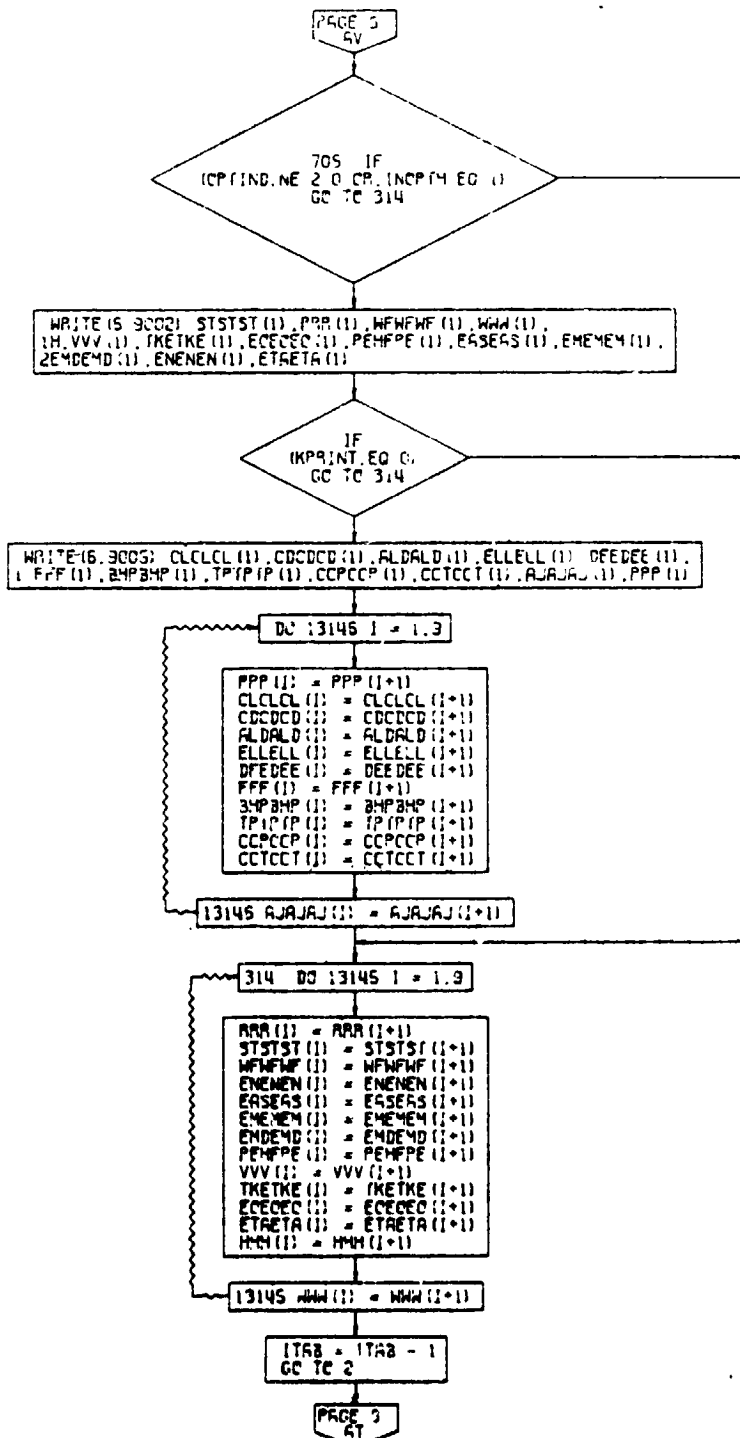


Figure 50B. CRUS1 Calculations Subroutine, Flow Chart (Part 7 of 10)

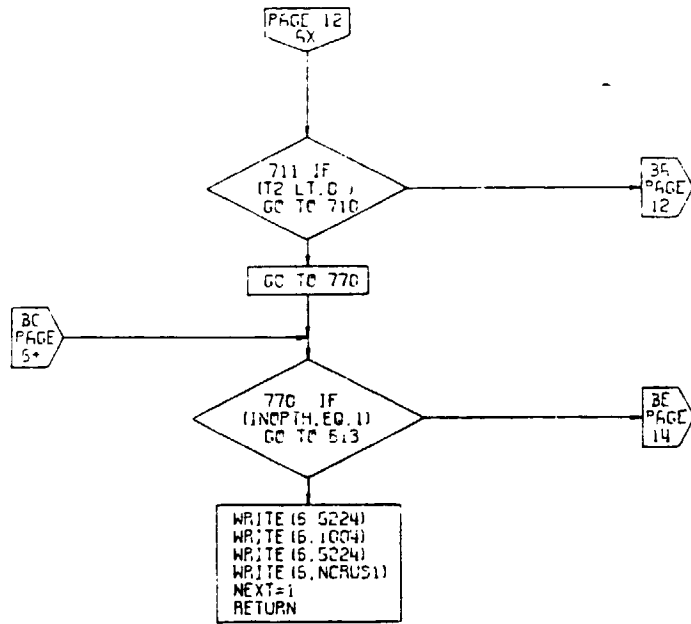


PAGE 3  
CRUS1

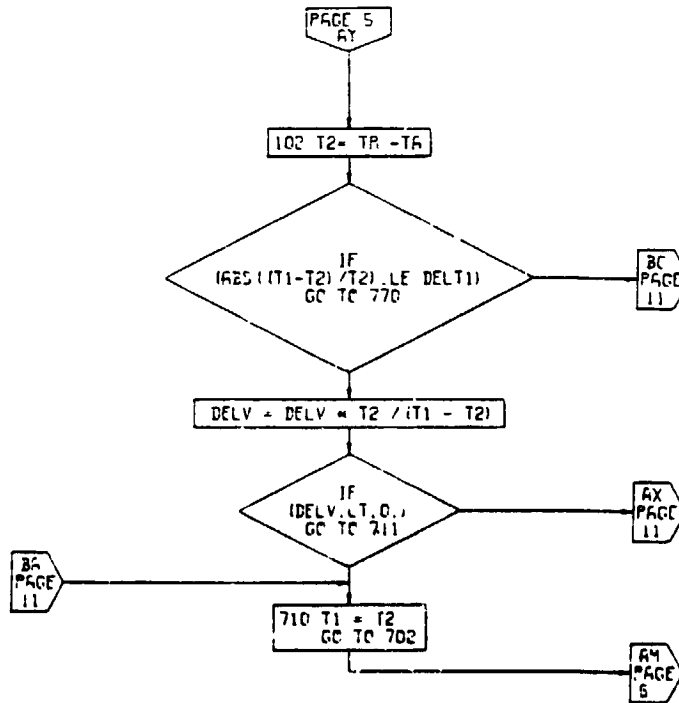


PAGE 10  
CRUS1

Figure 50B. CRUS1 Calculations Subroutine, Flow Chart (Part 8 of 10)



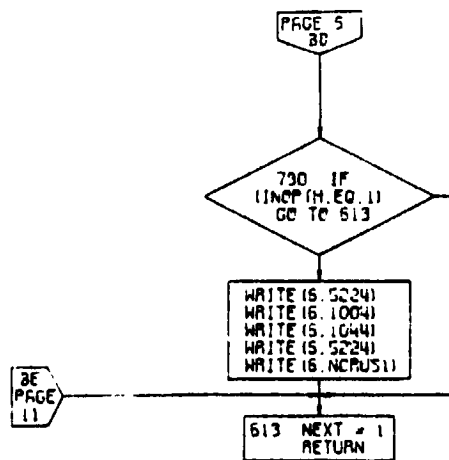
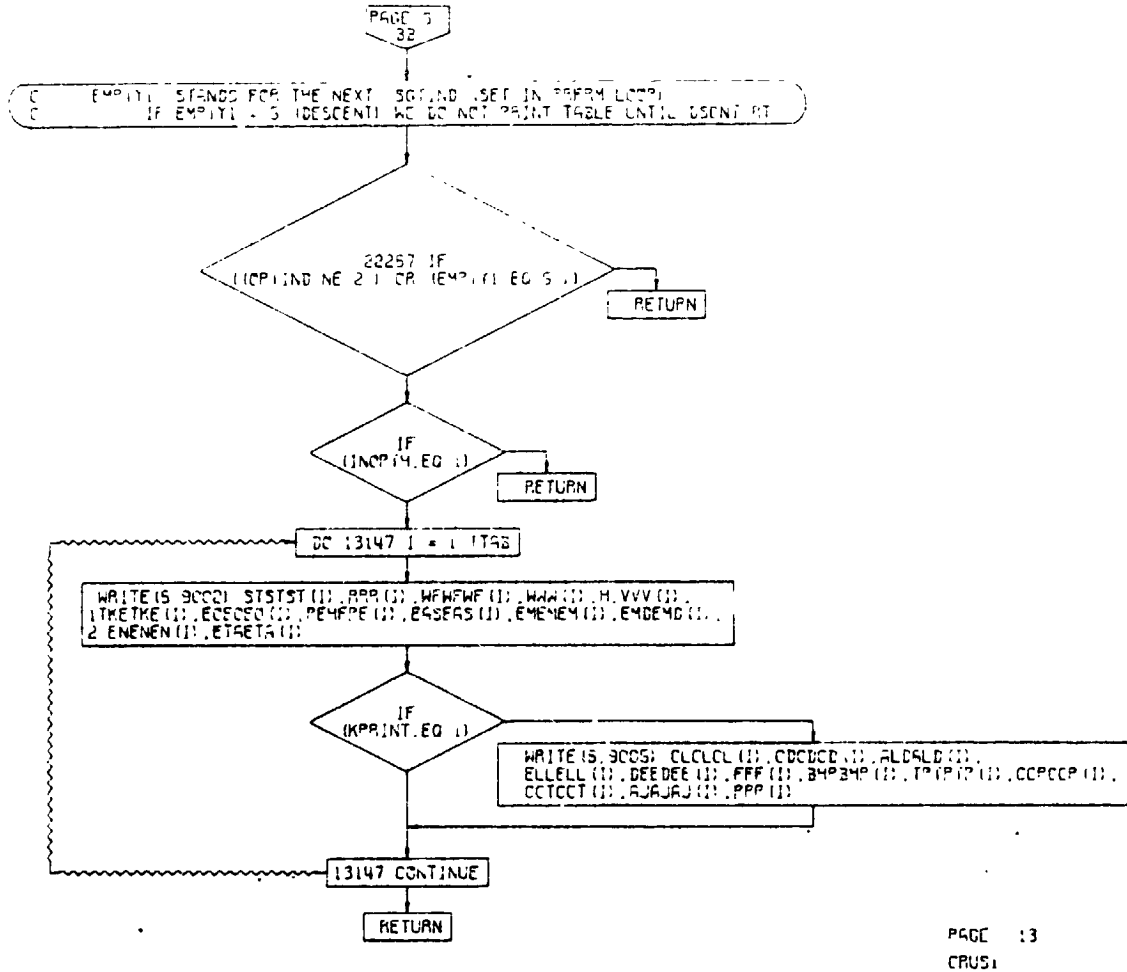
PAGE 11  
CRUS1



PAGE 12  
CRUS1

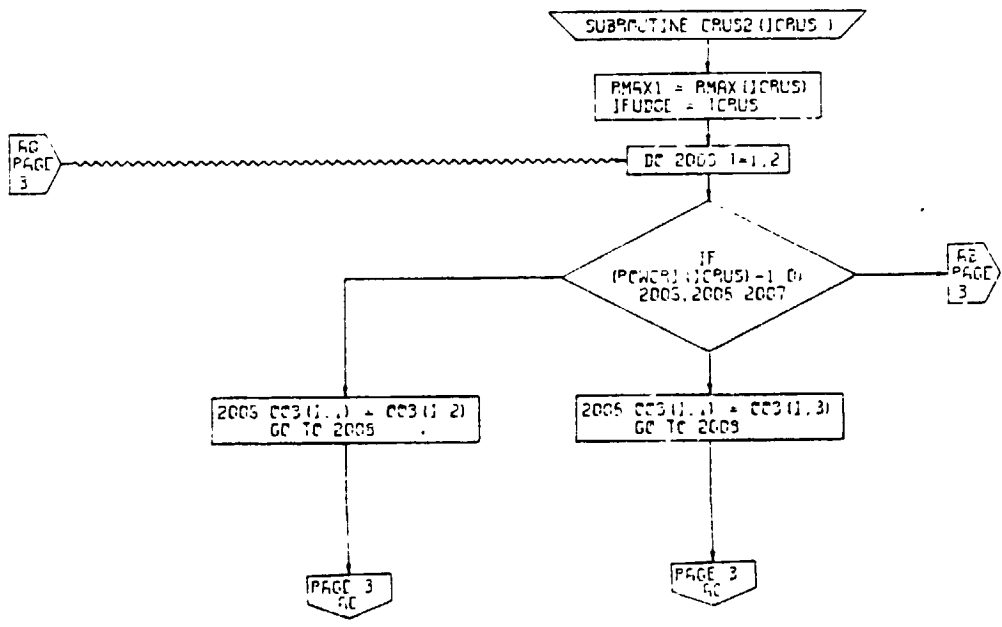
Figure 50B. CRUS1 Calculations Subroutine, Flow Chart (Part 9 of 10)





PAGE 14  
CRUS1

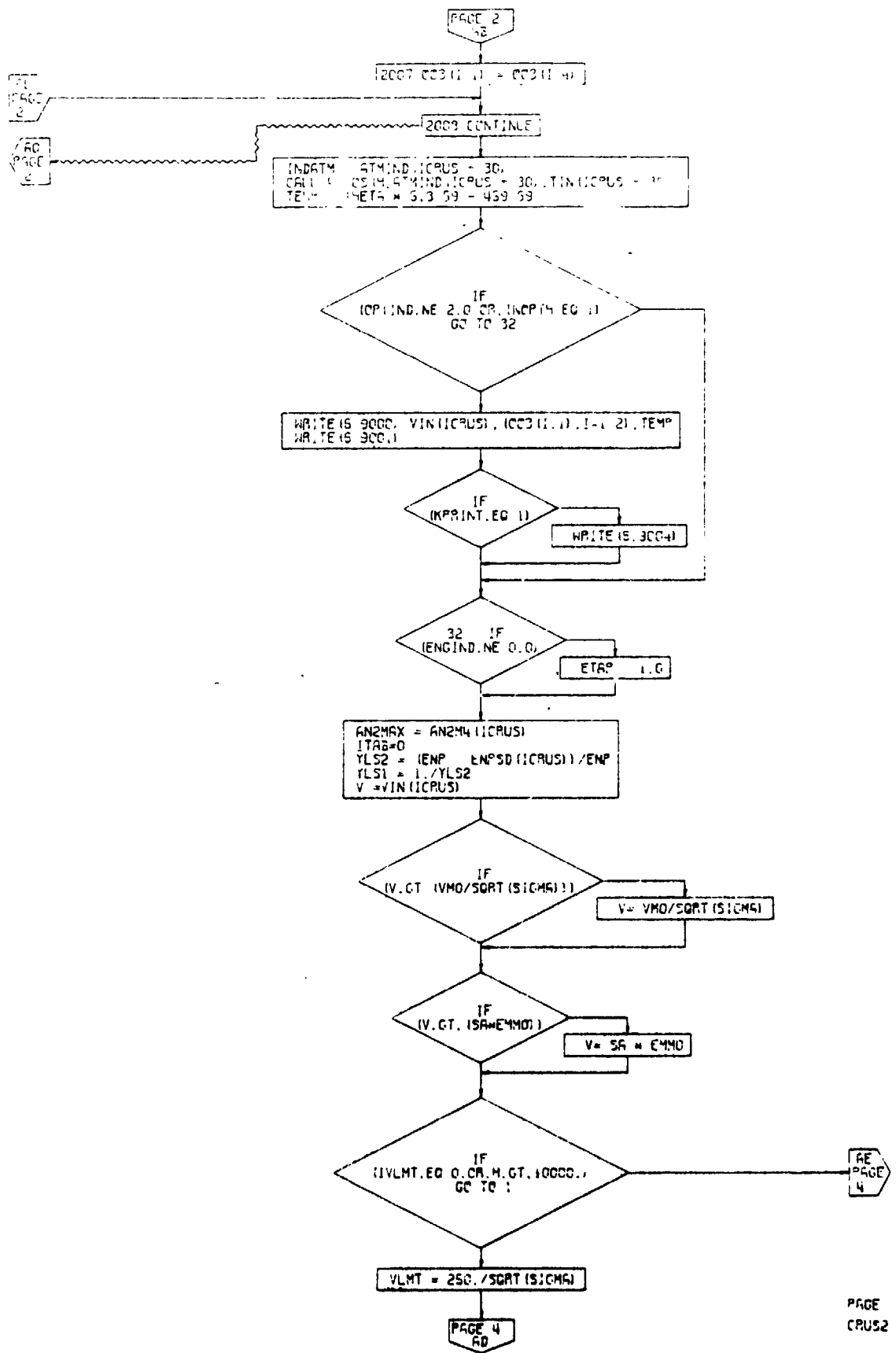
Figure 50B. CRUS1 Calculations Subroutine, Flow Chart (Page 10 of 10)



PAGE 2  
CRUS2

Figure 50C . CRUS2 Calculations Subroutine, Flow Chart (Part 1 of 8)

( )



PAGE 3  
CRUS2

Figure 50C. CRUS2 Calculations Subroutine, Flow Chart (Part 2 of 8)  
4-245

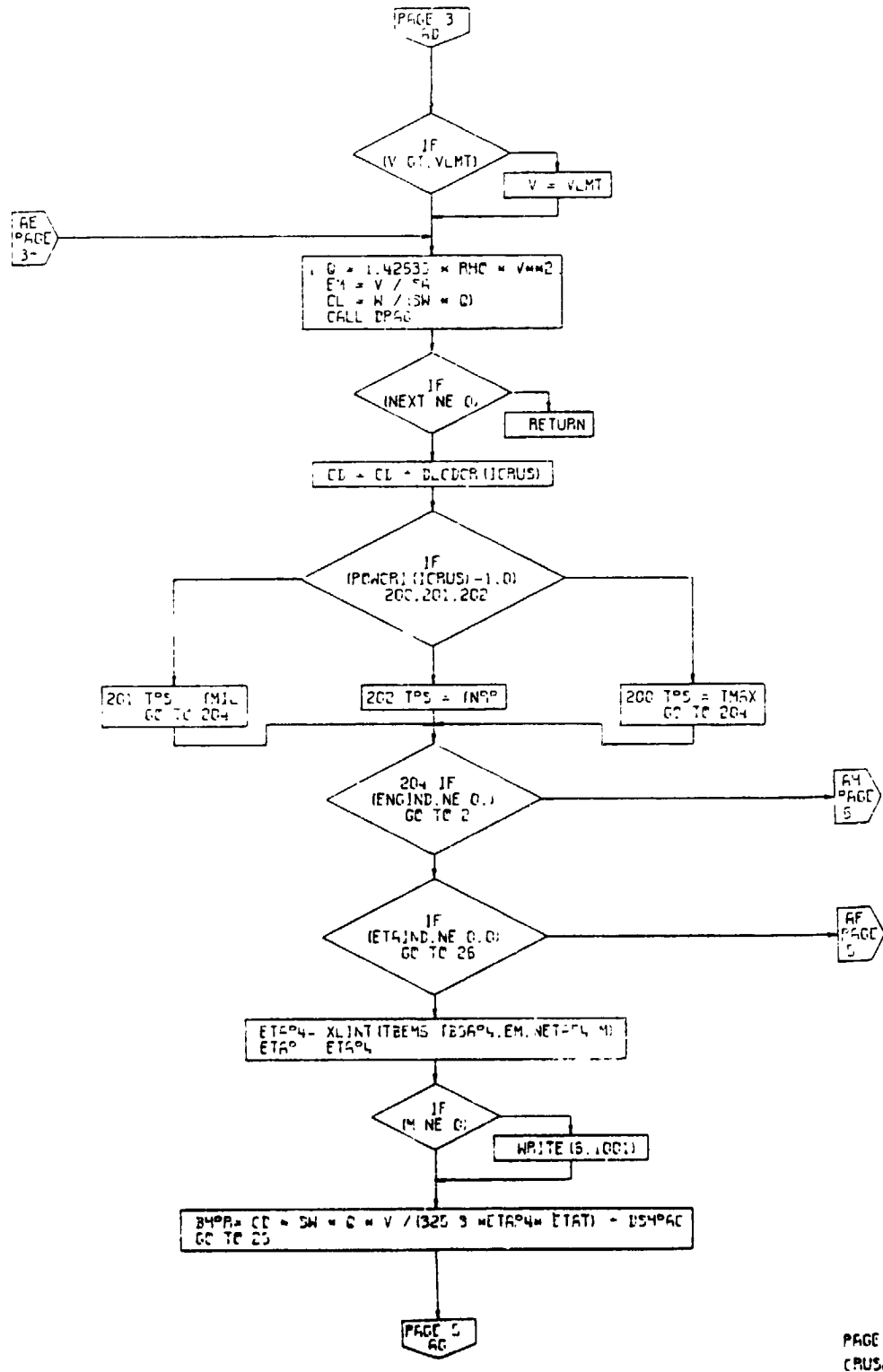
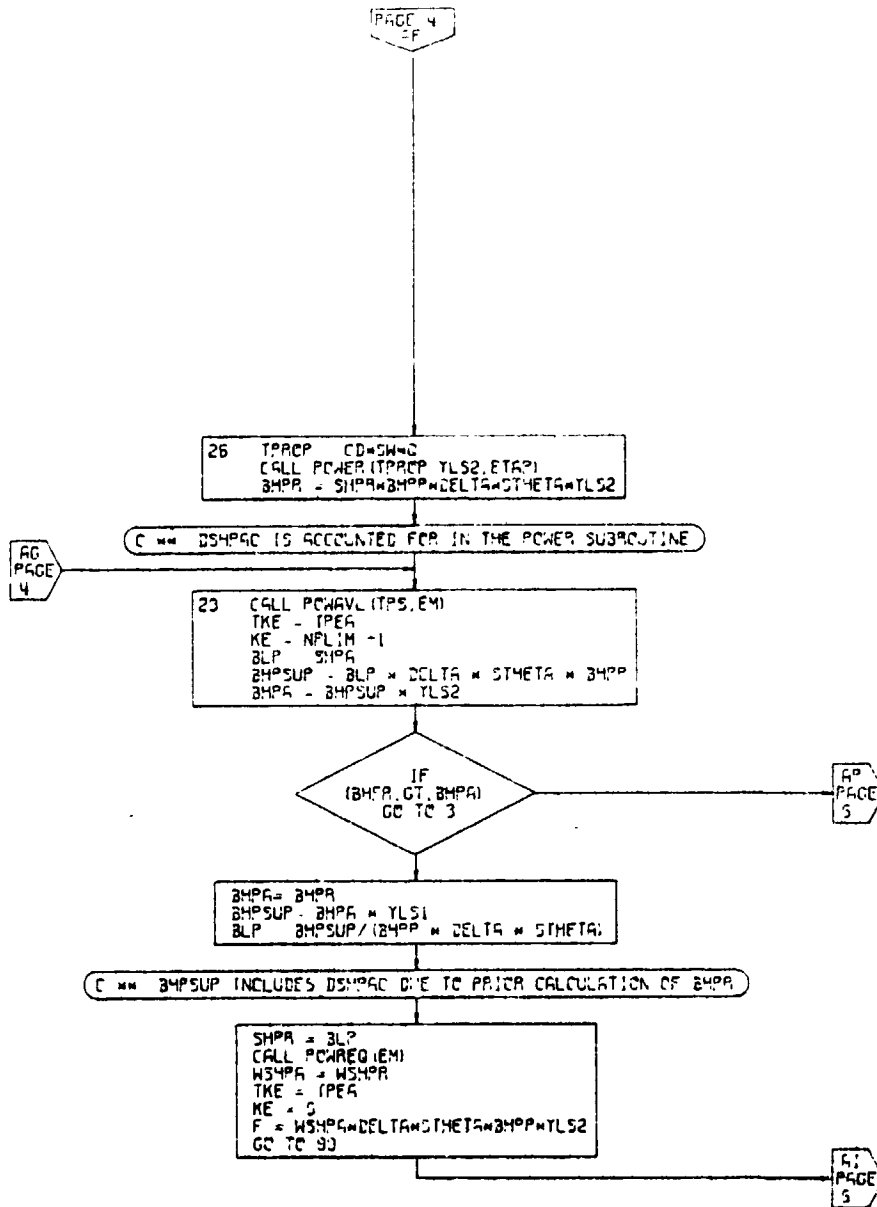


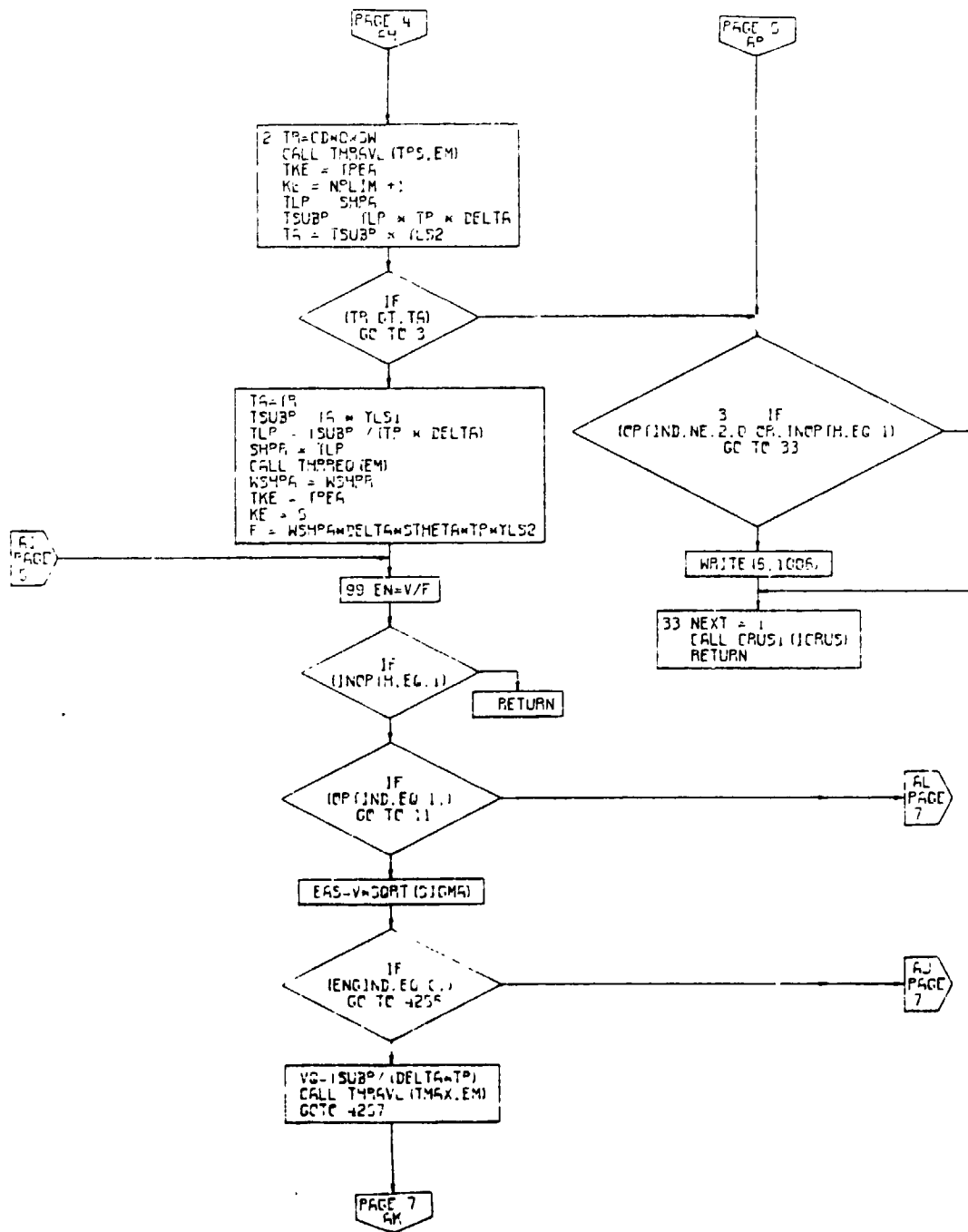
Figure 50C. CRUS2 Calculations Subroutine, Flow Chart (Part 3 of 8)



PAGE 5  
CRUS2

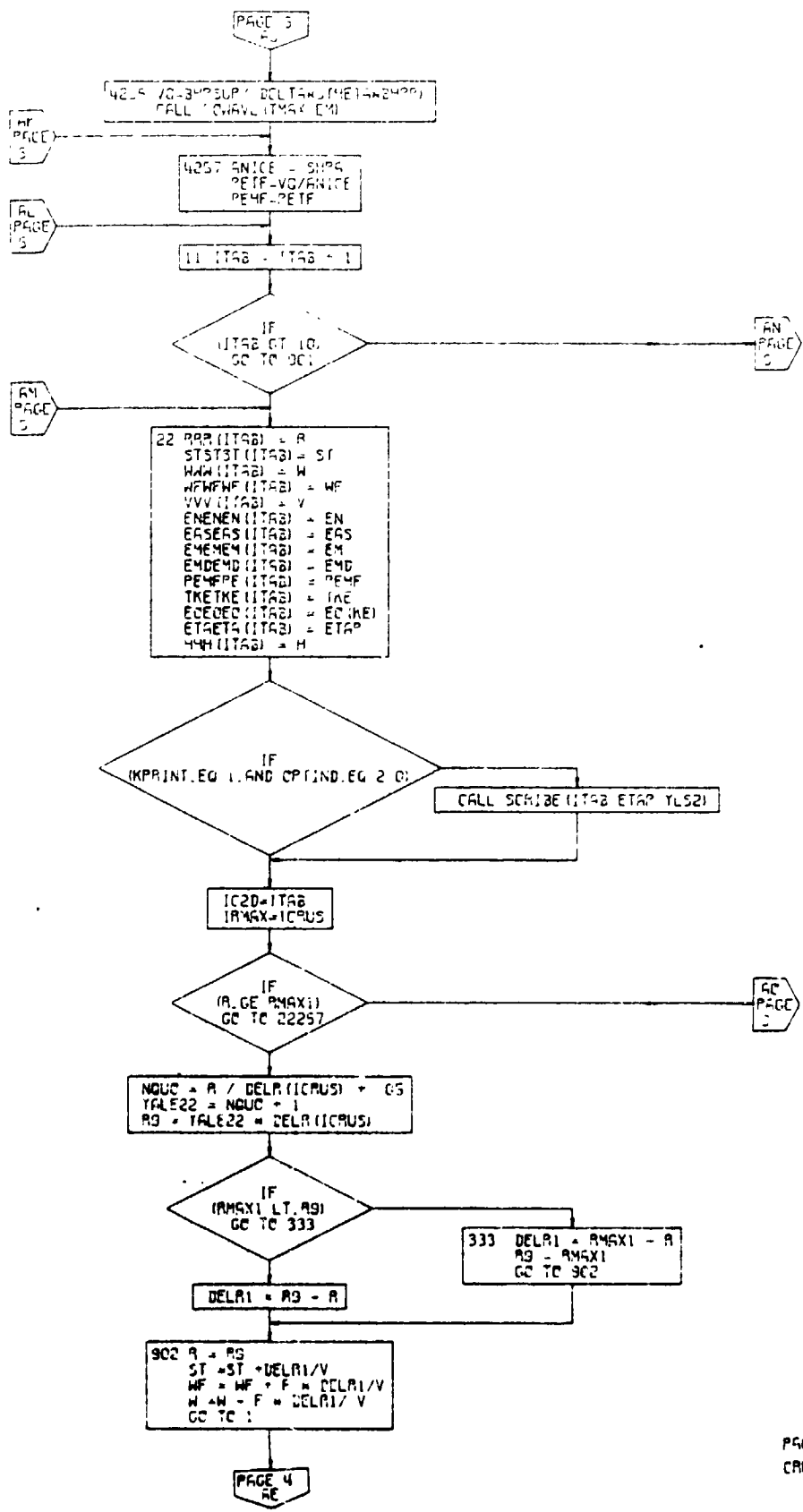
Figure 50C.

CRUS2 Calculations Subroutine, Flow Chart (Part 4 of 8)



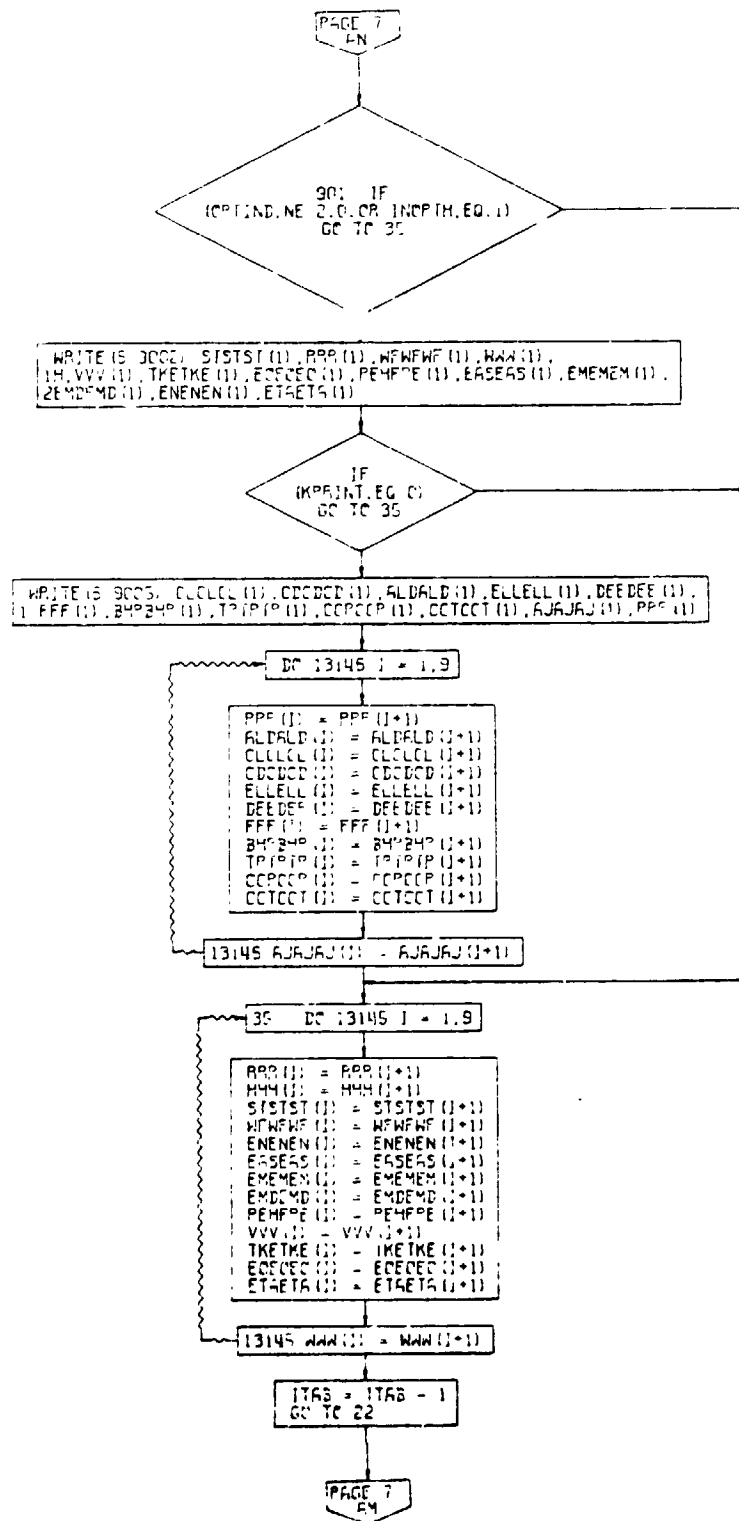
PAGE 5  
CRUS2

Figure 50C. CRUS2 Calculations Subroutine, Flow Chart (Part 5 of 8)



PAGE 7  
CRUS2

Figure 50C. CRUS2 Calculations Subroutine, Flow Chart (Part 6 of 8)



PAGE 3  
CRUS2

Figure 50C CRUS2 Calculations Subroutine, Flow Chart (Part 7 of 8)



C EMPTY1 STANDS FOR THE NEXT 5 IND (SET IN PERFORM LOOP)  
C IF EMPTY1 \* 5 (DESCENT) WE DO NOT PRINT TABLE UNTIL DESCENT 3T.

22257 IF  
(ICPTIND.NE 2) .OR. (EMPTY1.EQ 5)

RETURN

IF  
(INCPH.EQ 1)

RETURN

DO 13147 I = 1, I22

WRITE (6, 9002) STSTST (I), RRR (I), WFWFW (I), WAW (I), H, VVV (I),  
1 TKETRE (I), ECEDEC (I), PEPPE (I), EASEAS (I), EMEHEM (I), EMDEMD (I),  
2 ENENEN (I), ETAETA (I)

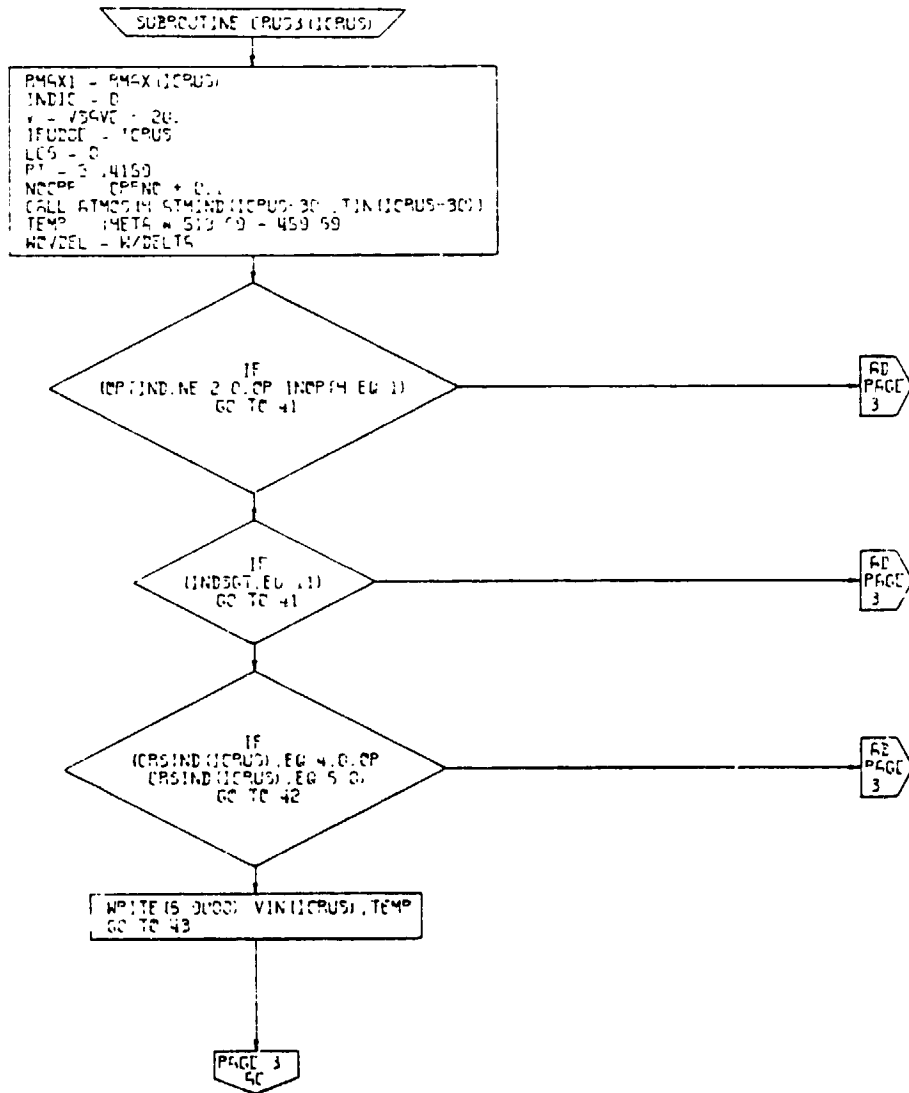
IF  
(KFR.INT.EQ 1)

WRITE (5, 9005) CLCCL (I), CCCC (I), ALDALD (I),  
ELLELL (I), DEEDEC (I), PPF (I), BHPBHP (I), TPTPT (I), CCPCCP (I),  
CCTCCT (I), RAJAJJ (I), PPP (I)

13147 CONTINUE

RETURN

Figure 50C, CRUS2 Calculations Subroutine, Flow Chart (Part 8 of 8)



PAGE 2  
CRUS3

Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 1 of 13)

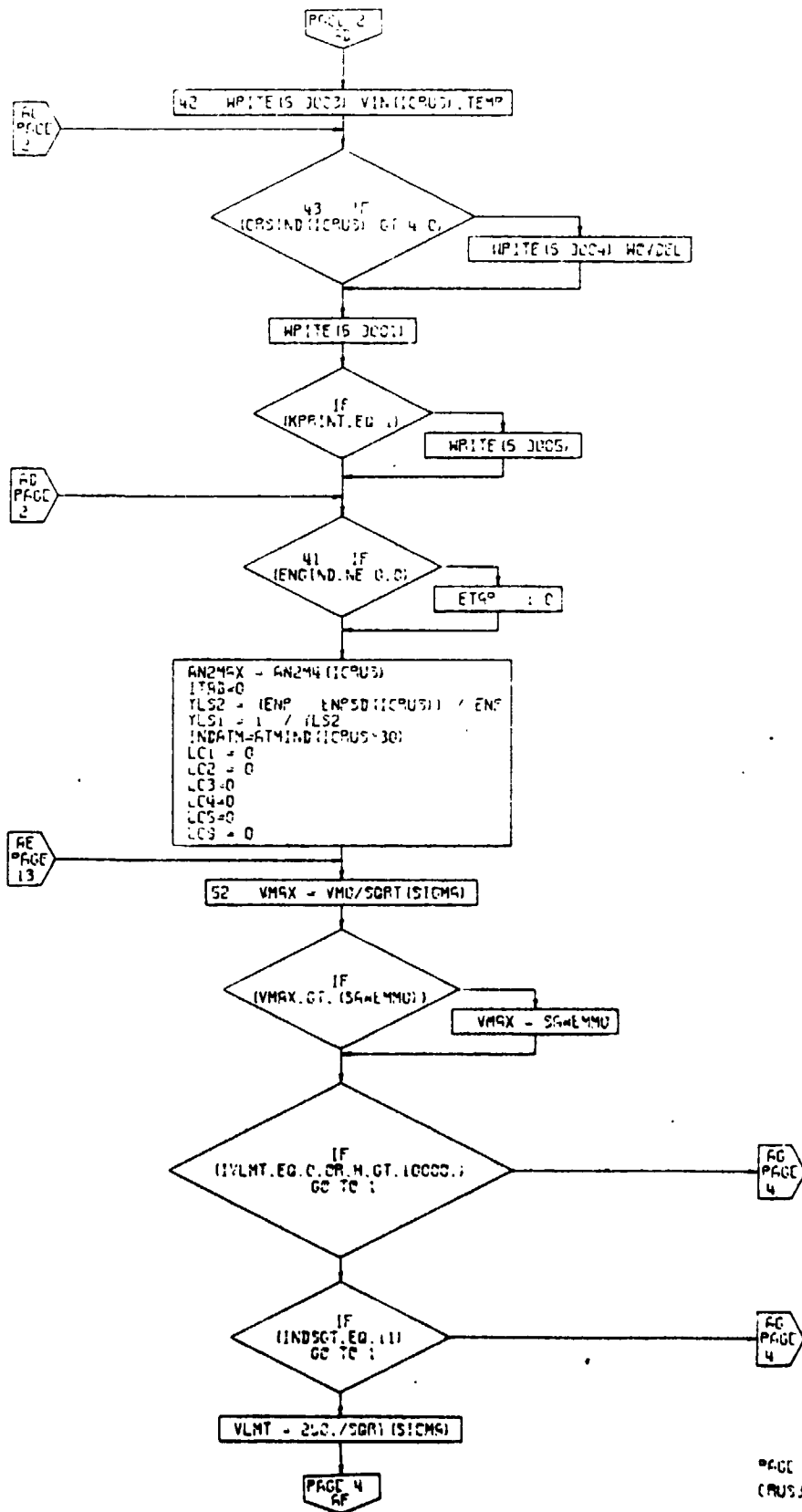


Figure 50D,

CRUS3 Calculations Subroutine, Flow Chart (Part 2 of 13)

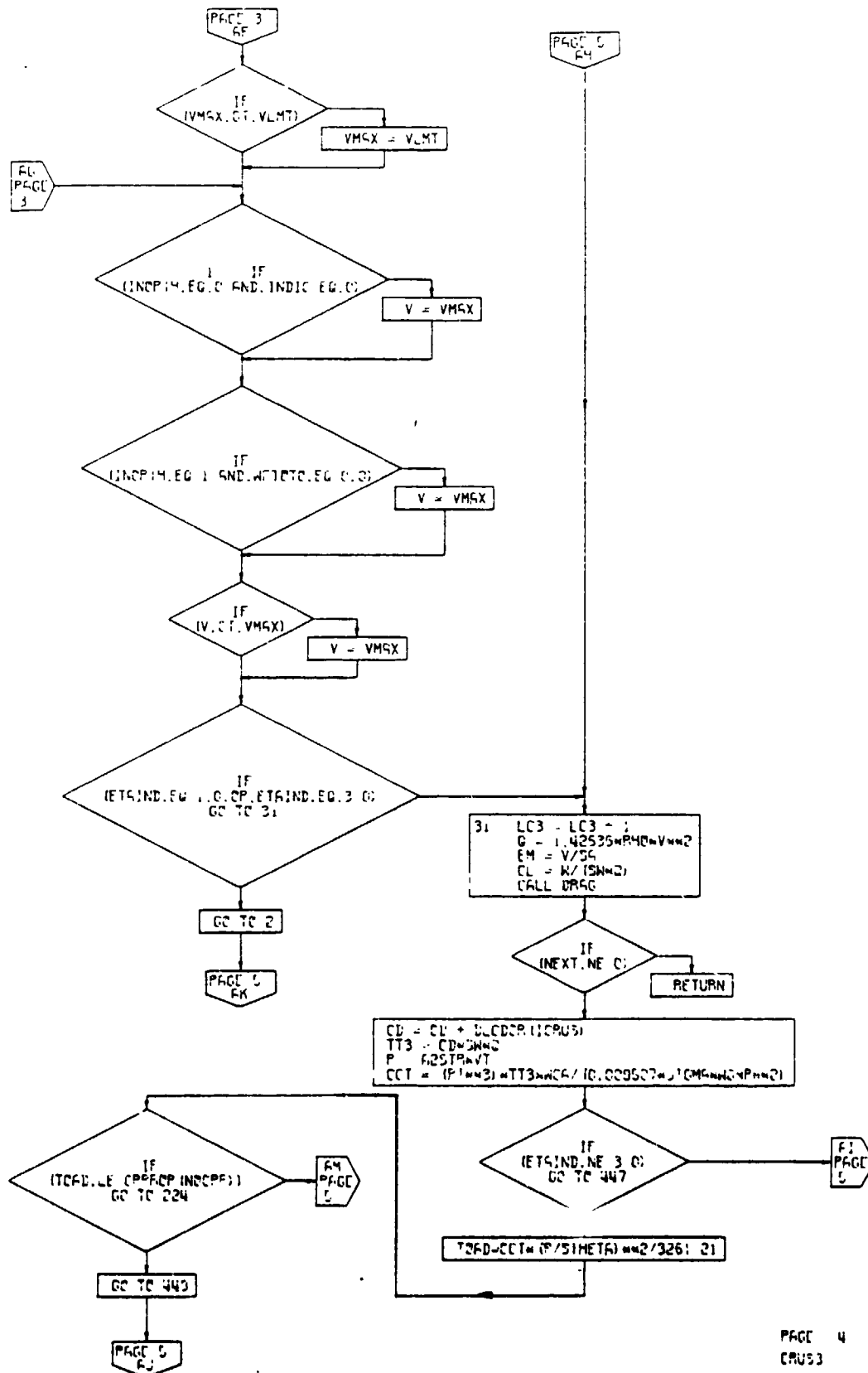


Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 3 of 13)

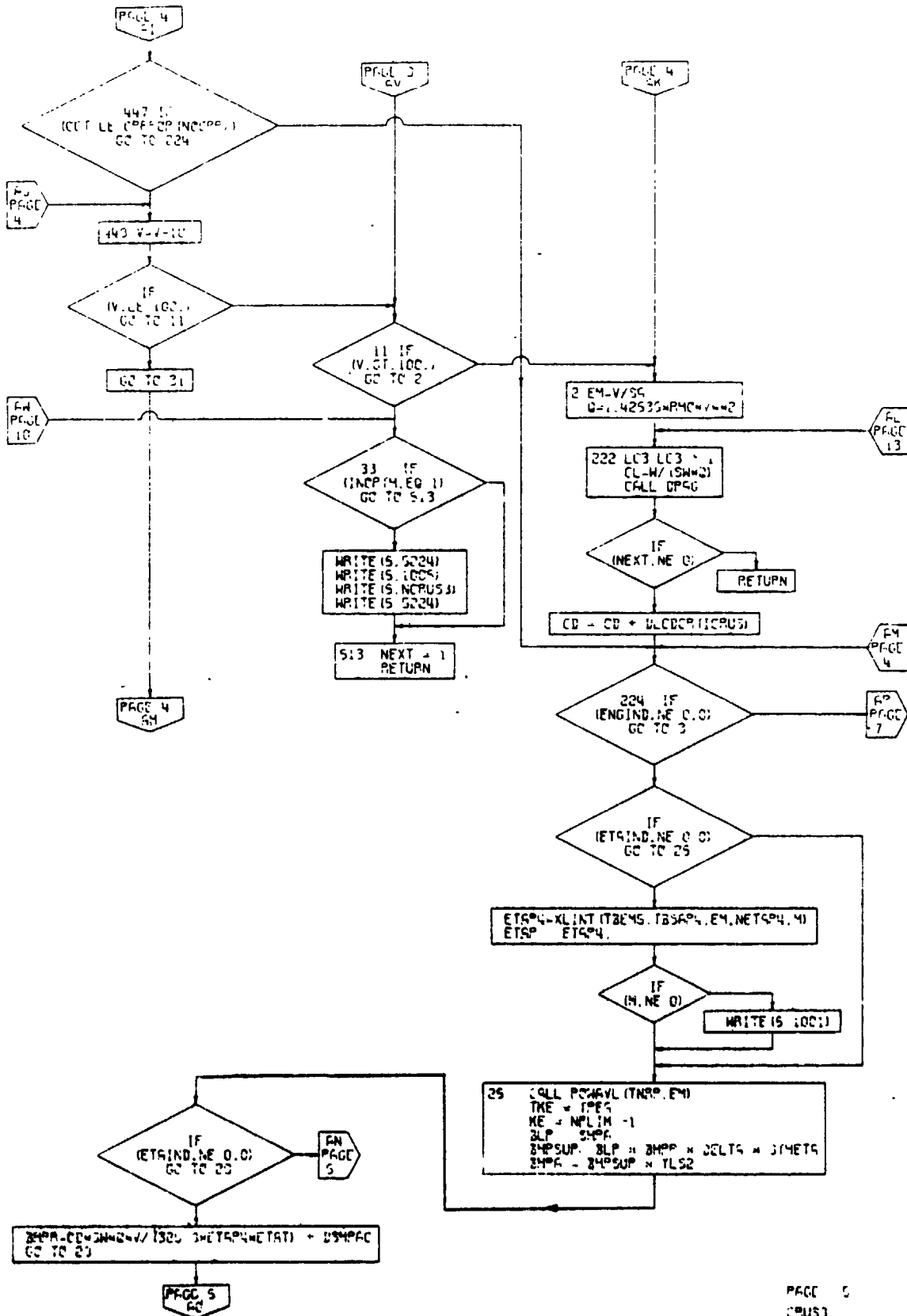


Figure 50D.

CRUS3 Calculations Subroutine, Flow Chart (Part 5 of 13)

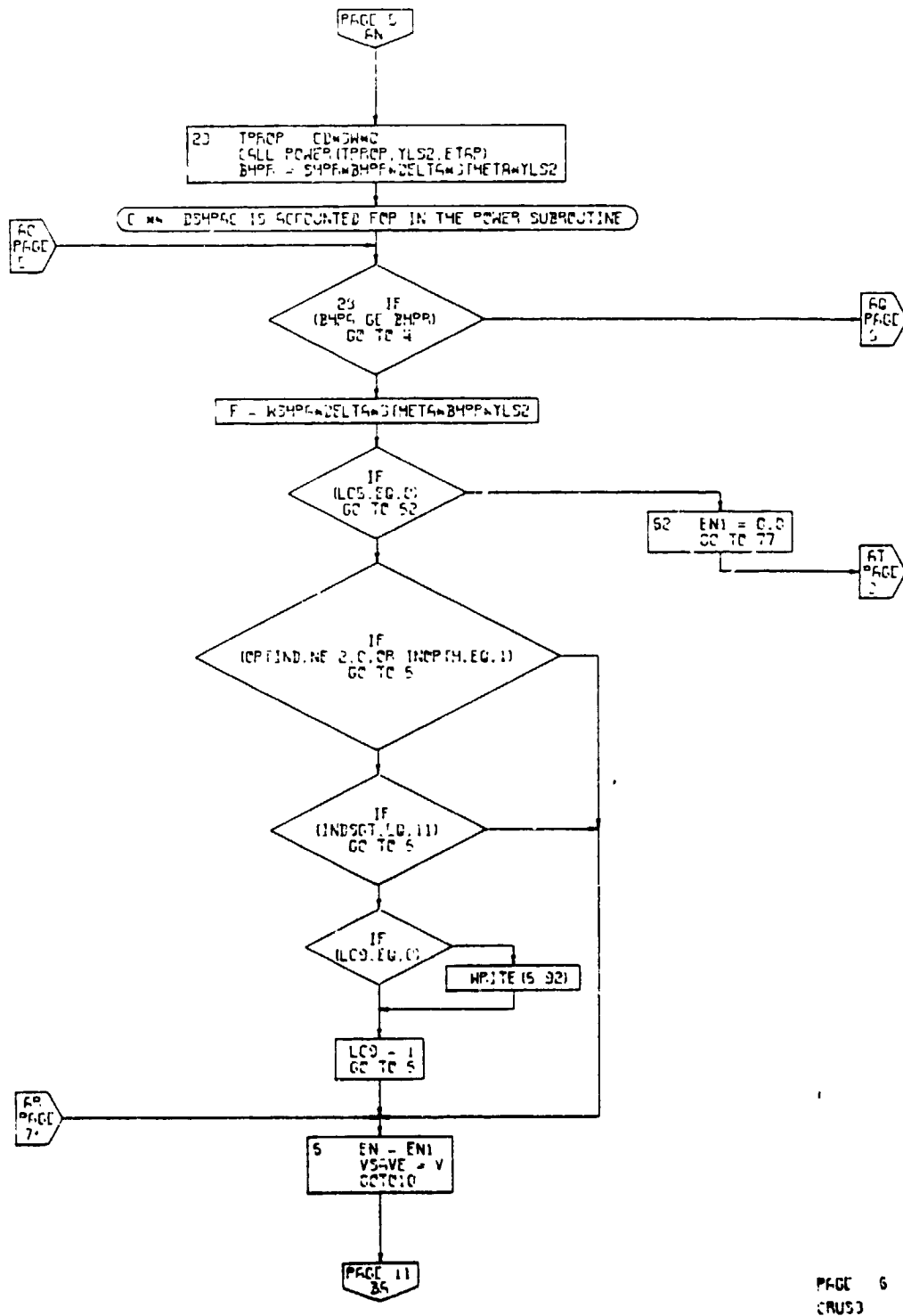


Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 4 of 13)

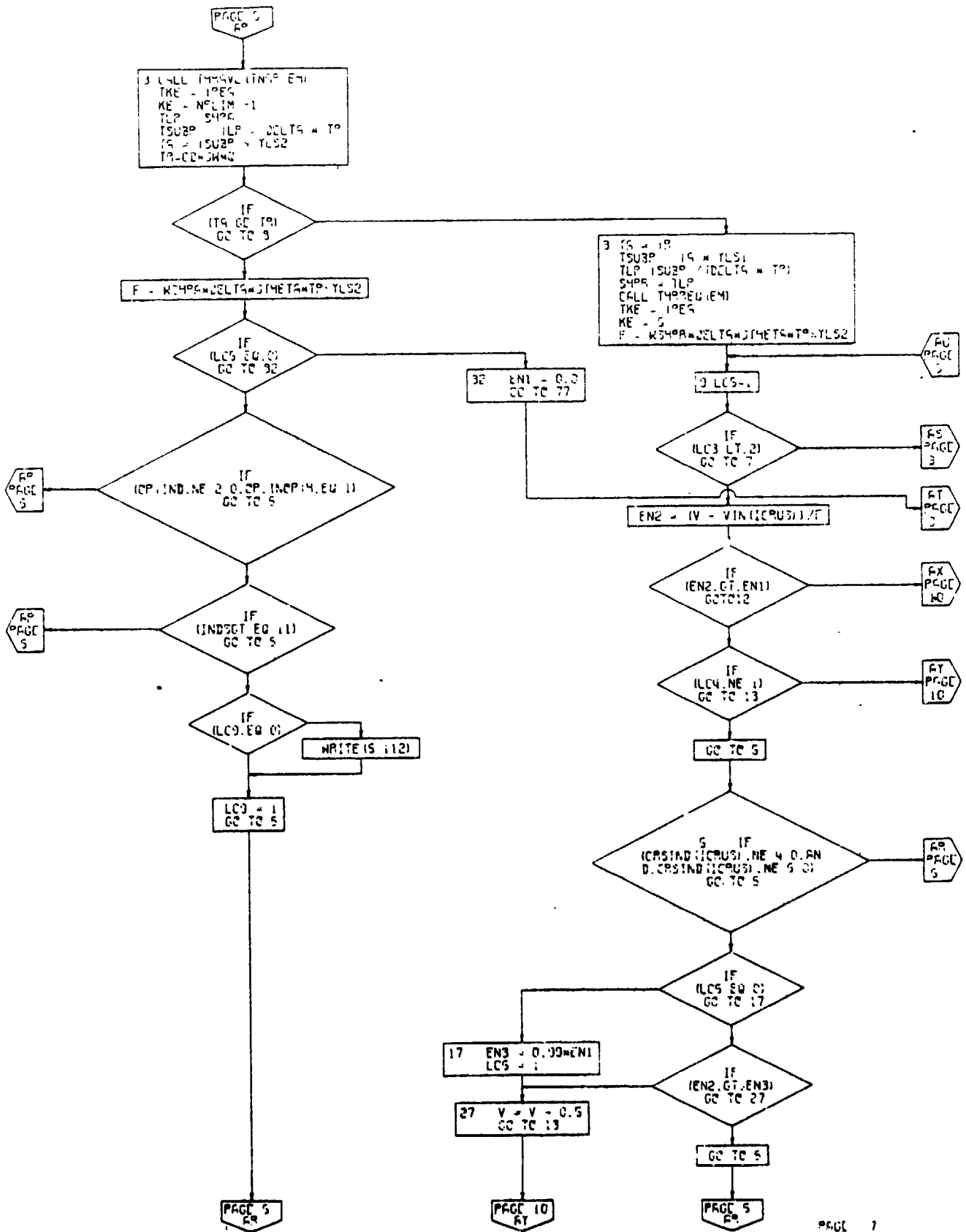
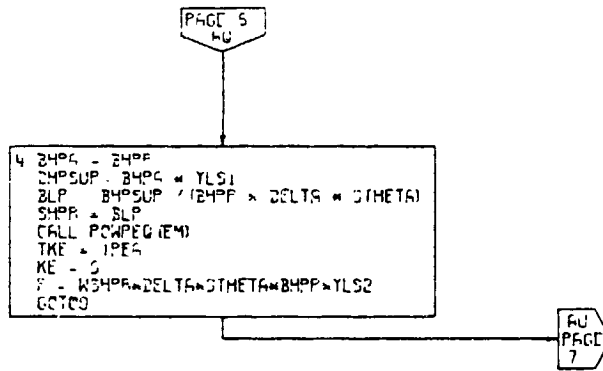
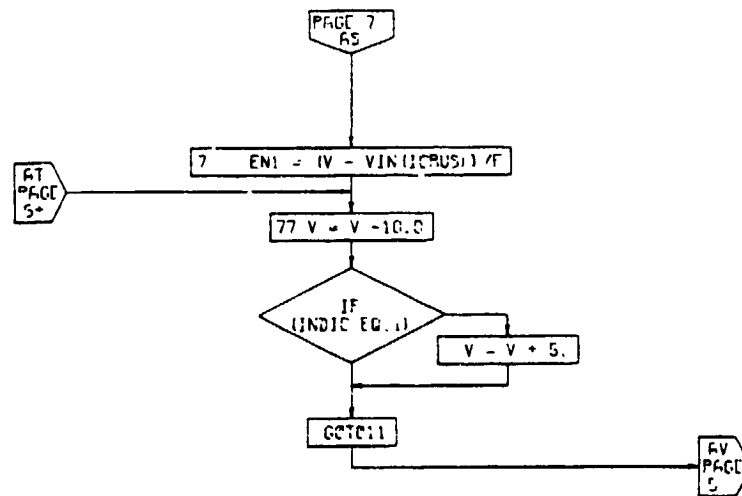


Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 6 of 13) 4-257



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CRUS3



PAGE 5  
CRUS3

Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 7 of 13)



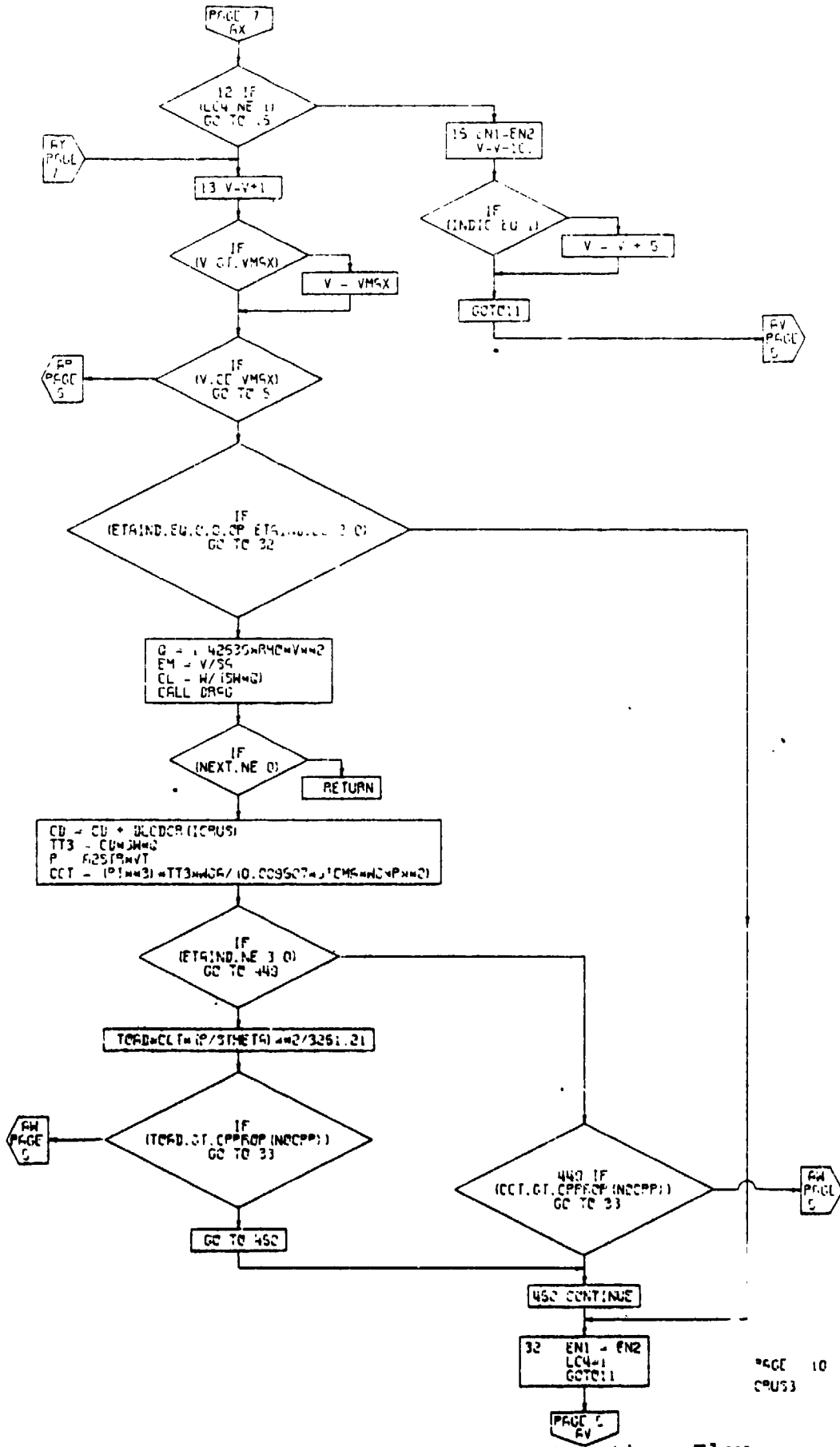
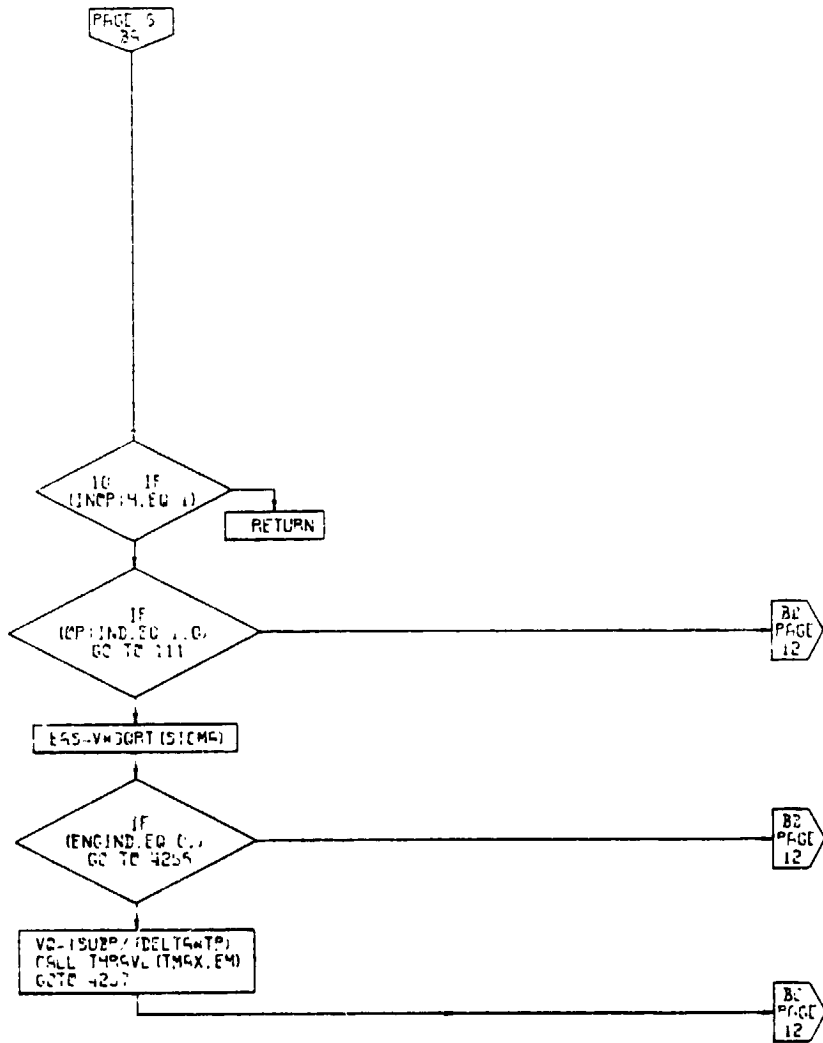


Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 8 of 13)  
4-259

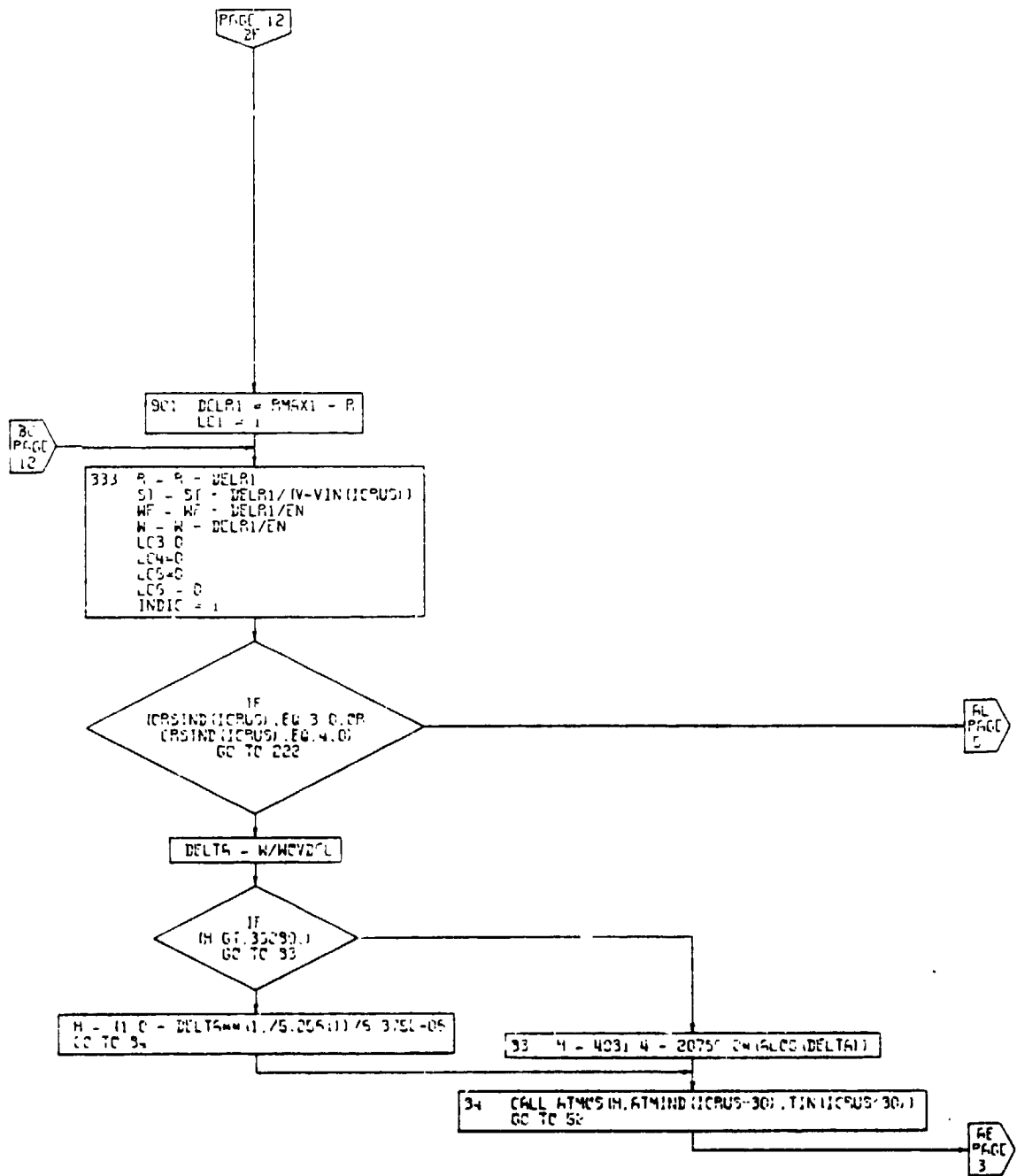


PAGE 11  
CRUS3

Figure 50D.

CRUS3 Calculations Subroutine, Flow Chart (Part 9 of 13)

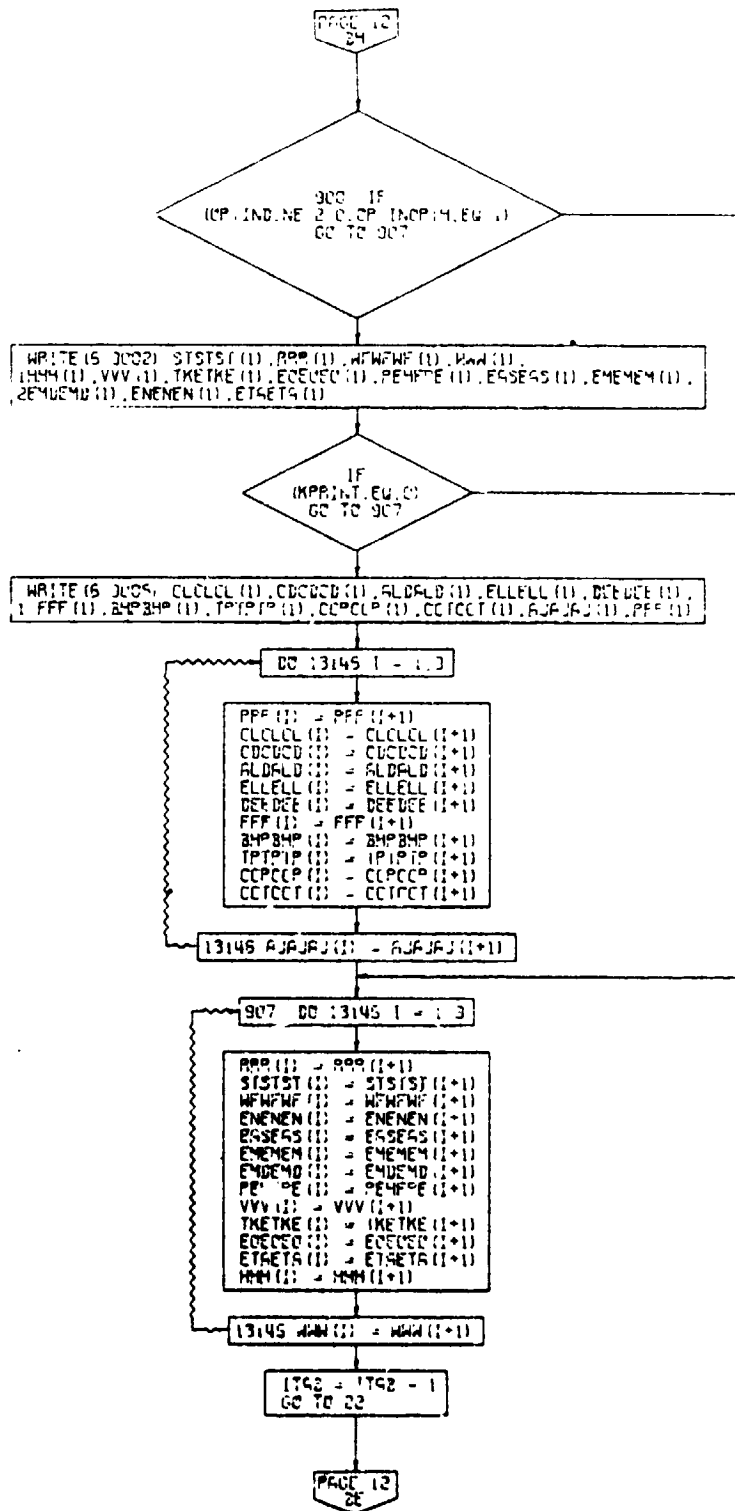




PAGE 13  
CRUS3

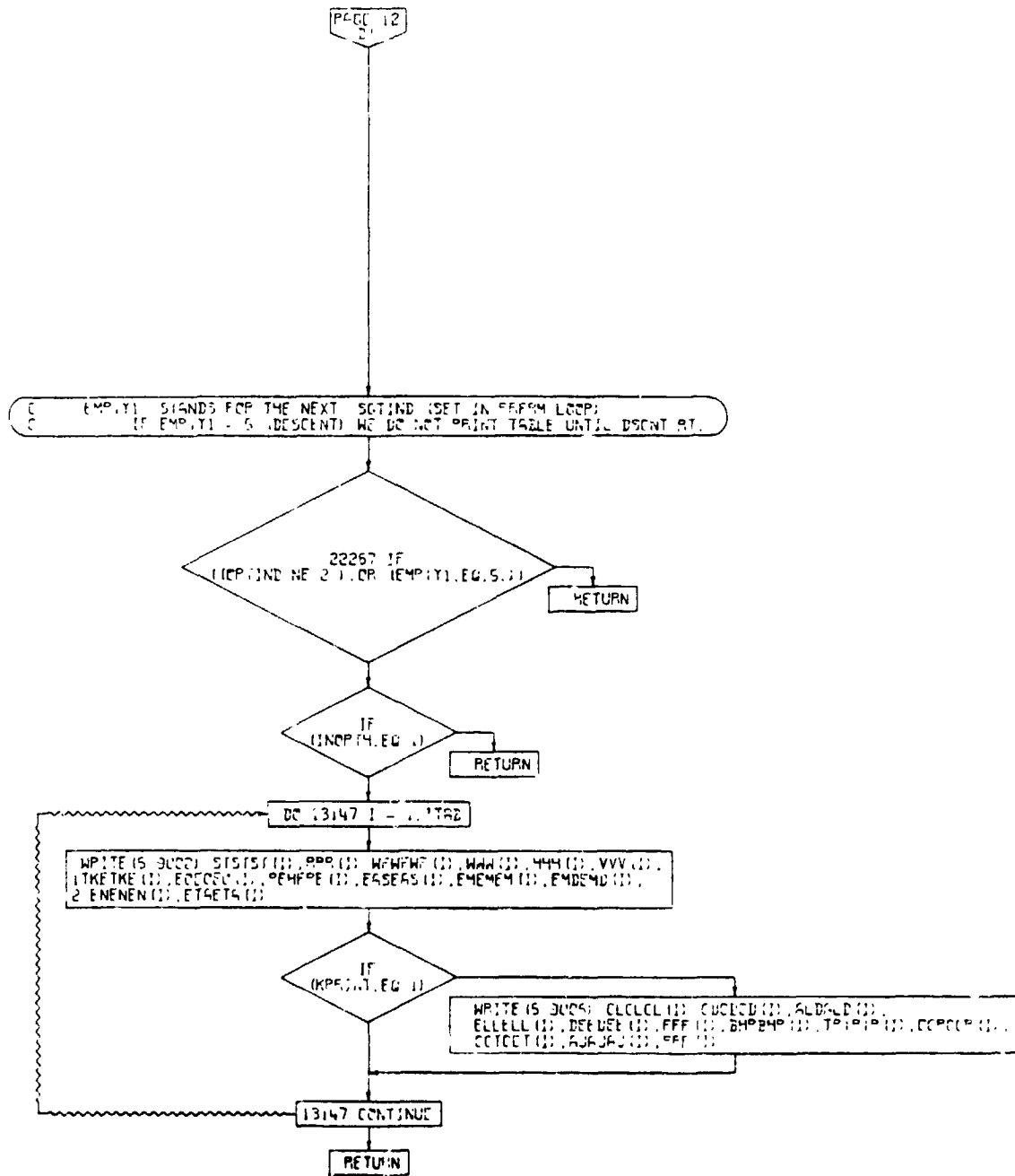
Figure 50D.

CRUS3 Calculations Subroutine, Flow Chart (Part 11 of 13)



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CRUS3

Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 12 of 13)



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 CRUS3

Figure 50D. CRUS3 Calculations Subroutine, Flow Chart (Part 13 of 13)

#### 4.10.5 Descent Calculations Subroutine

Eight different options for descent performance calculation are available. The options fall into four different categories: maximum speed, idle power, constant EAS, and constant Mach number. In addition, each type of descent may be calculated with or without specification of range at the end of descent. The options, set by the input indicator DESIND, are:

<u>Value of DESIND</u>	<u>Type of Descent</u>	<u>Terminal Range Specified?</u>
1	Maximum Speed	Yes
2	Maximum Speed	No
3	Idle Power	Yes
4	Idle Power	No
5	Constant EAS	Yes
6	Constant EAS	No
7	Constant Mach Number	Yes
8	Constant Mach Number	No

All descents are limited by an input value of maximum negative body attitude angle. For the four categories of descent, the following methods are used to modulate power and/or airspeed:

Maximum speed The aircraft will always descend at maximum permissible airspeed (VMO or MMO). This condition corresponds to maximum rate of sink. The power setting will be flight idle unless the body attitude angle falls below the prescribed minimum, in which case the power will be increased (up to normal power level) to the value required to satisfy the cabin angle restriction.

Idle power The aircraft will always use flight idle power setting. The descent will occur at maximum speed unless the cabin angle limit is violated, in which case the airspeed for descent will be decreased.

Constant EAS and Constant Mach number The aircraft will always fly at the specified equivalent airspeed or Mach number. If terminal range is not specified, the engine setting will be flight idle unless this causes the body angle to become too steep, in which case the power will be set to the required level. If terminal range is specified, the aircraft will fly a straight-line descent path to the required terminal point and will modulate power accordingly. If either body angle becomes too steep or power

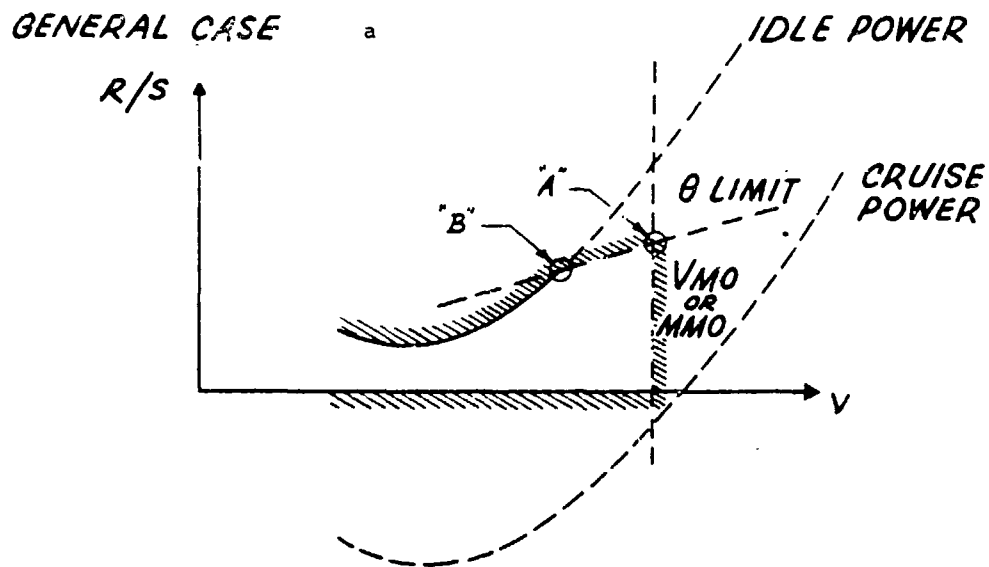
required is greater than normal power, the aircraft will fly at the power setting required to satisfy the corresponding limit. The terminal range will not be satisfied and the program, upon reaching the final altitude, will set the range to the required value with the note: "SPIRAL DESCENT PATH REQUIRED". If body angle becomes too steep and the required power setting is greater than normal power, the program will terminate with the note: "DESCENT CONDITION IMPOSSIBLE: DESIRED FLIGHT PATH IS TOO SHALLOW".

Figure 4-51, in which the rate of sink is plotted against airspeed, illustrates the difference between the maximum speed and the flight idle options. The aircraft is able to make a steady-state descent anywhere within the boundaries shown on this figure. The critical boundaries are:

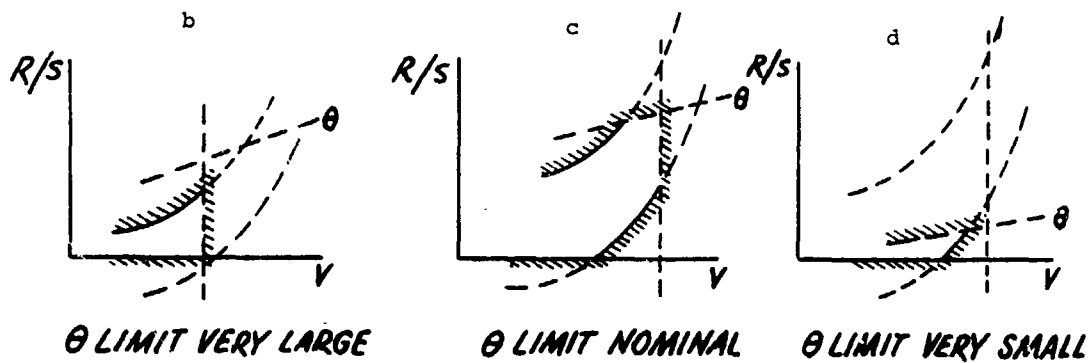
- a. The idle power boundary, defined by the minimum power (flight idle setting) of the aircraft.
- b. The fuselage attitude angle boundary, defined by the most negative permissible body attitude angle ( $\theta_F$ ).
- c. The maximum speed boundary, defined by the maximum operating airspeed ( $V_{MO}$ ) or the maximum operating Mach number ( $M_{MO}$ ).

In the general case (Figure 4-51a), a descent at maximum rate of sink (DESIND = 1,2) will occur at point "A" at a power setting somewhat above flight idle. This option will give the fastest descent. A descent at flight idle power setting (DESIND = 3,4) will occur at point "B" at an airspeed somewhat below  $V_{MO}$ ,  $M_{MO}$ . This option will give the descent at minimum power and thus at minimum fuel flow rate. This descent will approximate (although not be exactly equal to) a minimum fuel consumption descent. Possible variations on the general case are shown in Figures 4-51b through 4-51d. In Figure 4-51b, the attitude angle restriction is relatively large and the options are the same. That is, the aircraft is capable of descending at an airspeed corresponding to  $V_{MO}$ ,  $M_{MO}$  and at a flight idle power setting without exceeding the fuselage angle limit. In Figures 4-51c and 4-51d, the airspeed limit has been set higher than the aircraft cruise speed (that is, even at normal power the aircraft will descend). In Figure 4-51d, this airspeed limit has been coupled with an exceedingly severe restriction on  $\theta_F$  so that, even at cruise power, the aircraft descends with an excessive fuselage angle.





**POSSIBLE VARIATIONS:**



← { AIRCRAFT INCAPABLE OF CRUISING @  $V_{MO/MMO}$  } →

Figure 4-51. Descent Boundaries.

In the event of this most unlikely circumstance, the program will print out an error message and the case will terminate. For other than this condition (Figure 4-5ld, the program will calculate the true airspeed, rate of sink, fuel consumption, and required power during the descent.

A distinction is made between the first two types of descent (maximum speed, flight idle) and the last two (constant EAS, Mach number) in regard to the range at which the descent starts if terminal range is specified. This distinction should be clearly understood.

- a. If DESIND = 5 or 7, the descent will start at the current value for range and, as previously described, the airplane will fly a straight-line path to the desired terminal point. This may necessitate a "spiral" descent path. The descent may follow any other segment (climb, cruise, etc.) or may start the mission.
- b. If DESIND = 1 or 3, no spiral descent path is permitted. The program will calculate the value for range at the beginning of the descent which is required to satisfy the terminal condition on range and altitude. In order to do this, the program "backs up" on the previous segment. If these options (1 and 3) are used, the descent must be preceded by a cruise segment. The input value for maximum range for the preceding cruise segment is a dummy value and the cruise will actually terminate, in order to begin descent, at an earlier point. It is recommended, however, that when descent options 1 or 3 are to be used, the maximum range during the preceding cruise be input as the same value as the terminal range at the end of the following descent.

Any of the descent options for which the terminal range is not specified may be used at any point in the program, following any other segment or at the beginning of the mission. The descent will start at the current value of range.

An increment in airplane drag coefficient may be input in order to simulate the effects of drag brakes.

Input to the subroutine consists of the limiting body angle, the final altitude, the step size (increment in altitude), the increment in drag coefficient, the setting for DESIND and, if required, the following

data: terminal range, required Mach number, and required EAS.

Figure 4-52 is a flow chart for this subroutine.

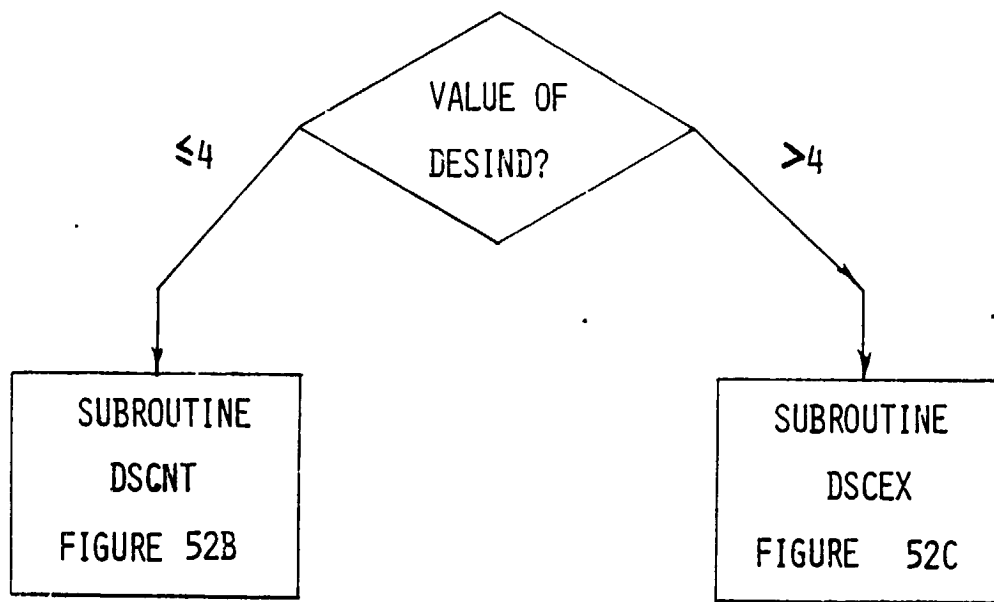
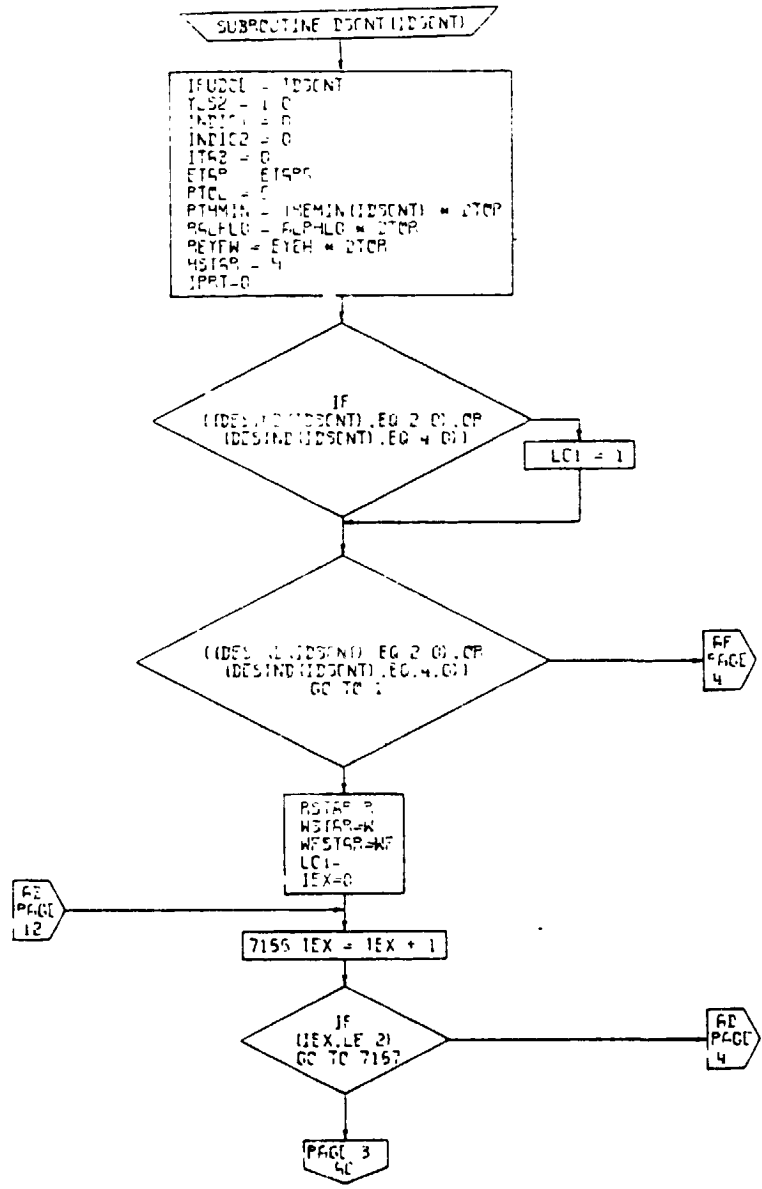
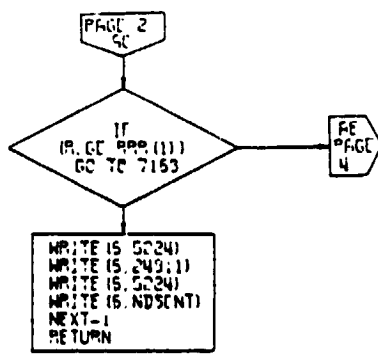


Figure 4-52a. Descent Calculations Subroutine, Program Flow

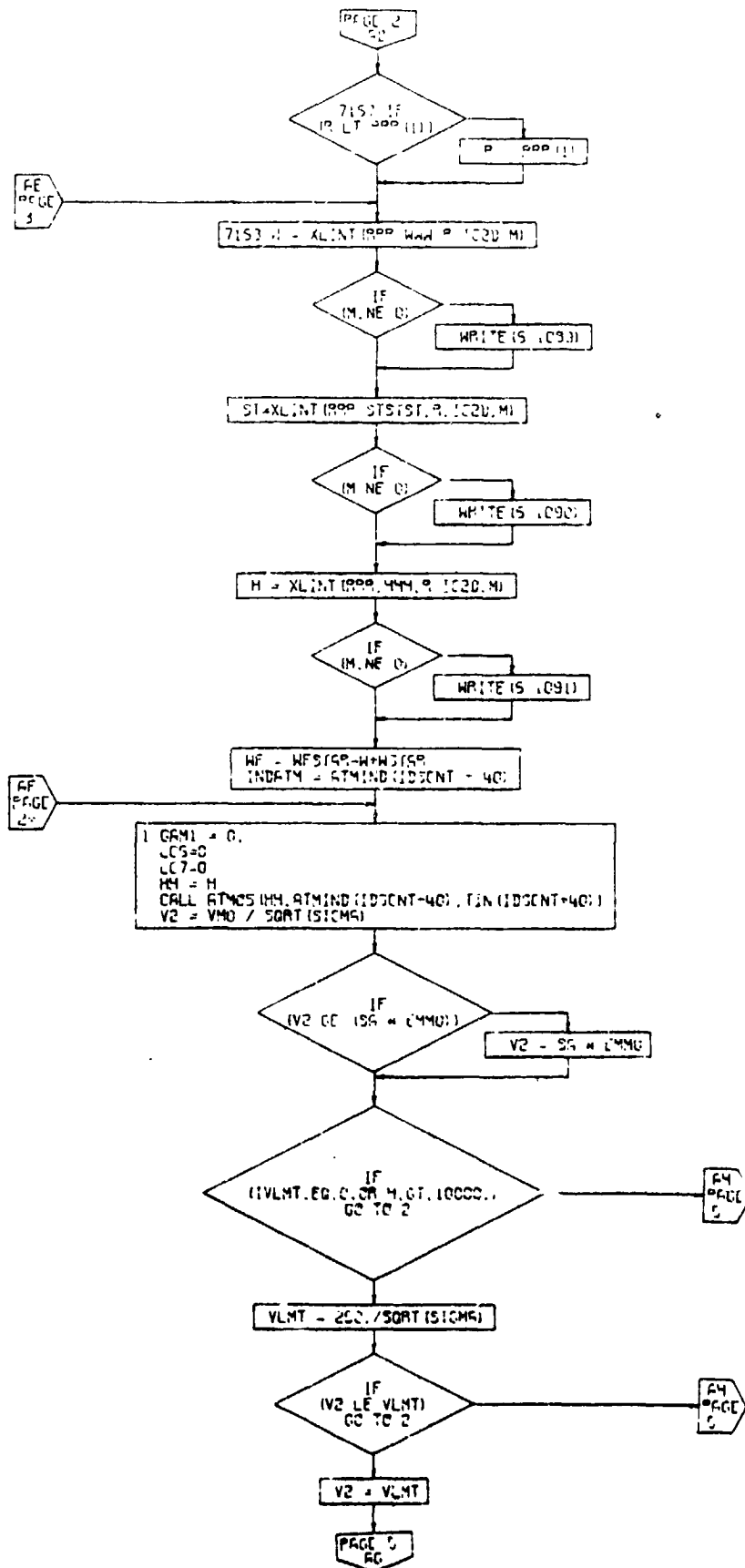


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DSCNT



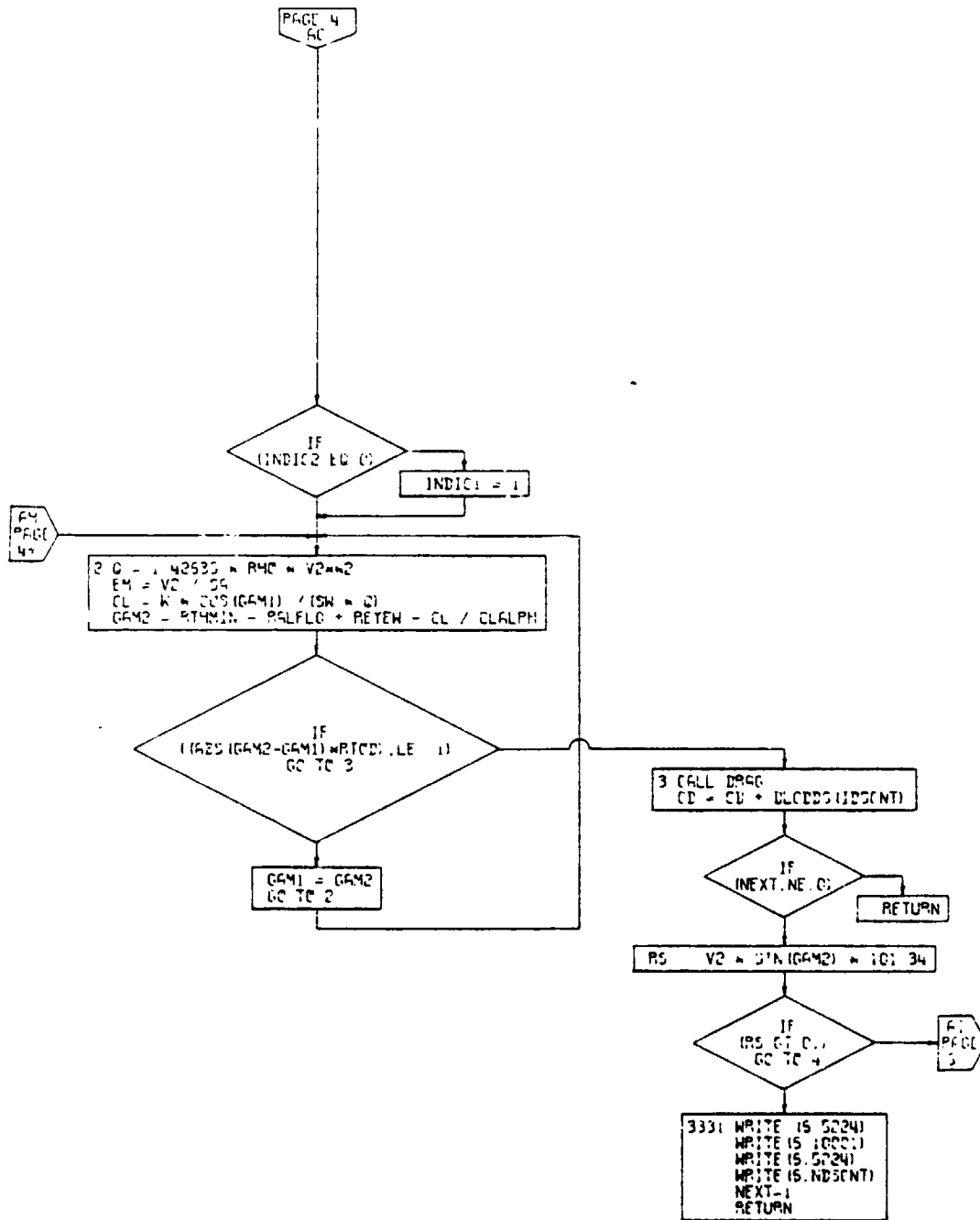
PAGE 3  
DSCNT

Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 1 of 14)



PAGE 4  
DESCNT

Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 2 of 14)



PAGE 2  
DSCNT

Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 3 of 14)

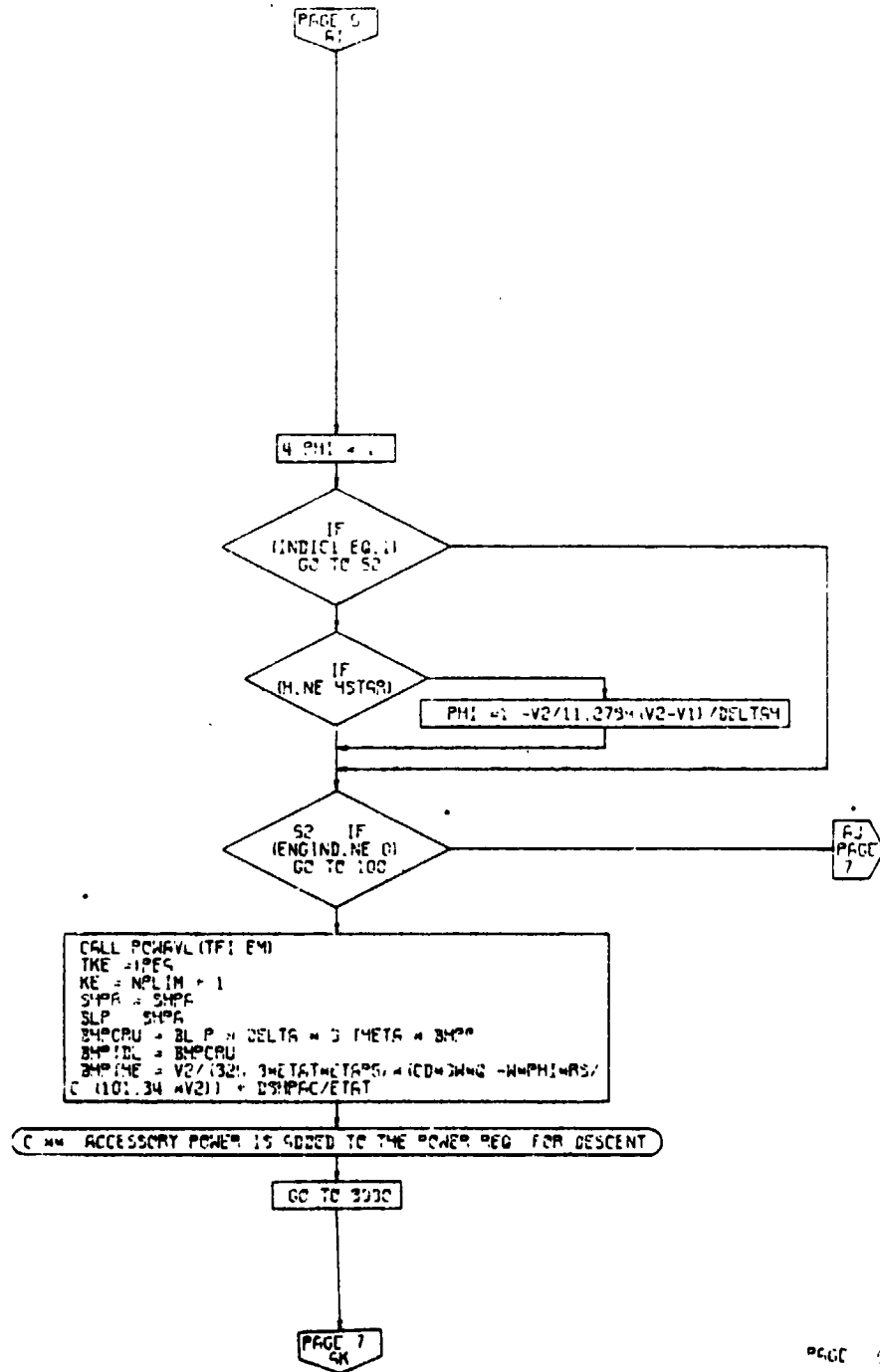
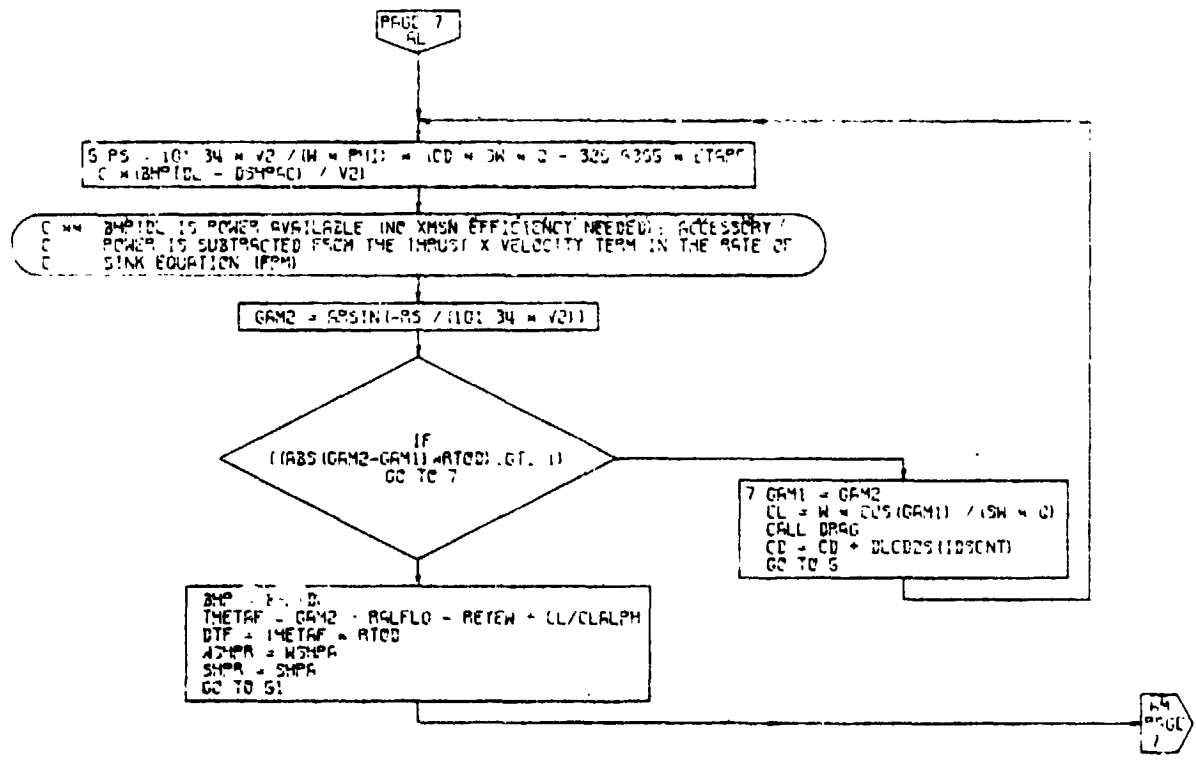


Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 4 of 14)

3 2 1

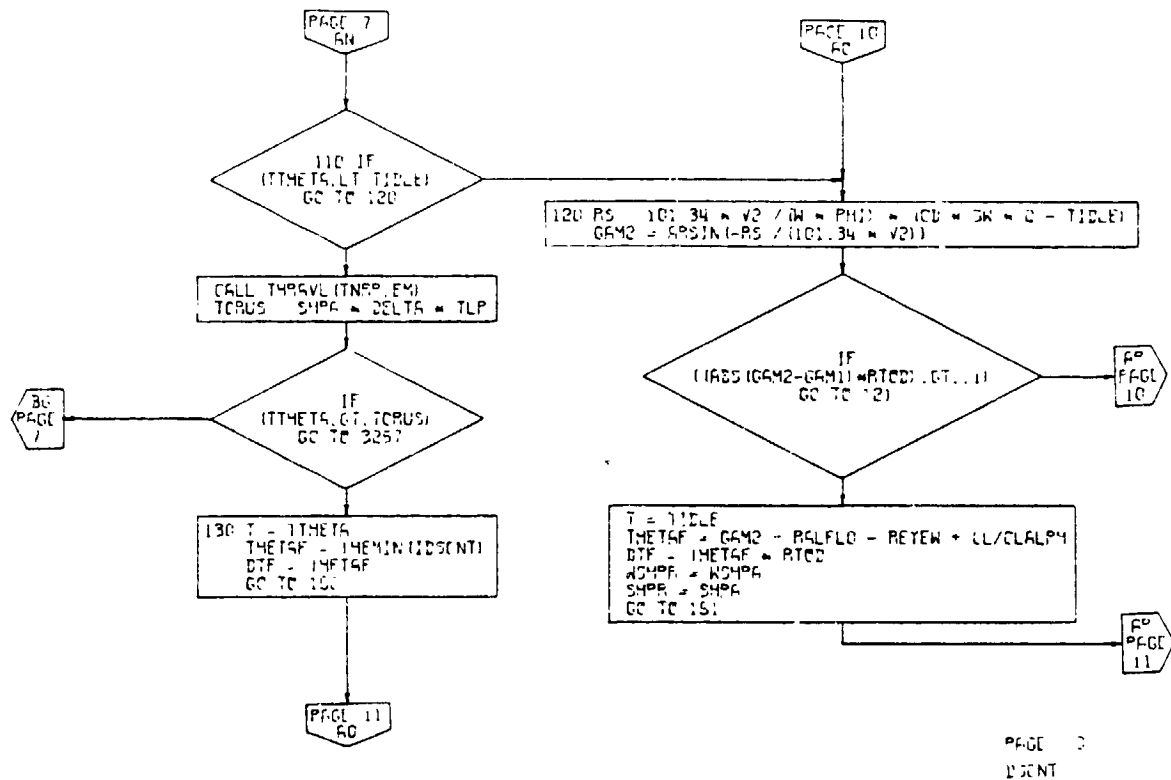




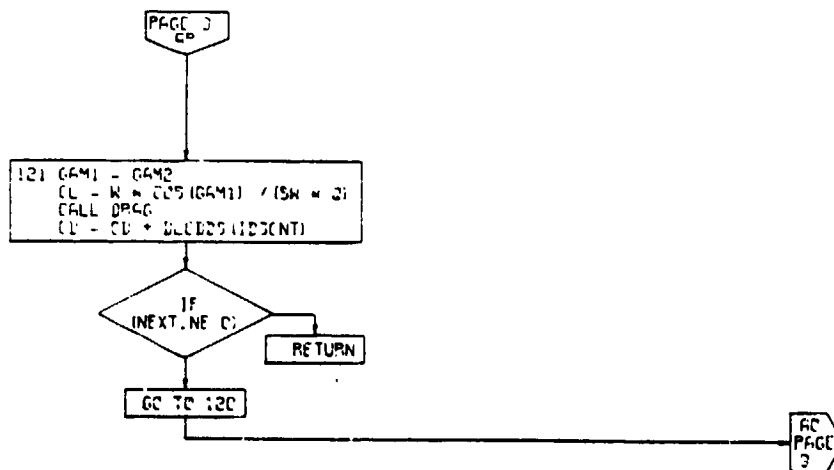


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 DSCNT

Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 6 of 14)



PAGE 3  
DCONT



PAGE 10

Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 7 of 14)

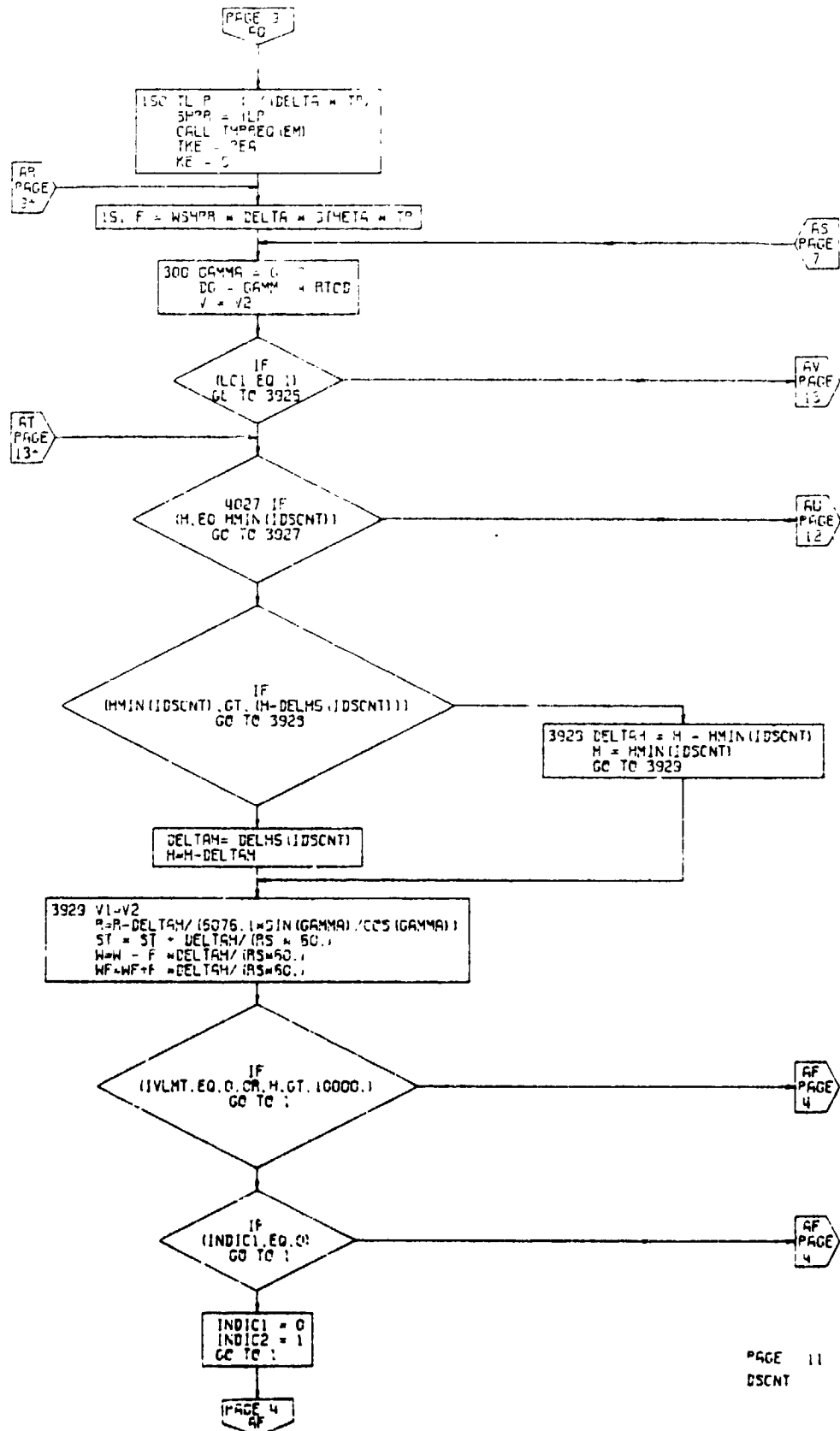
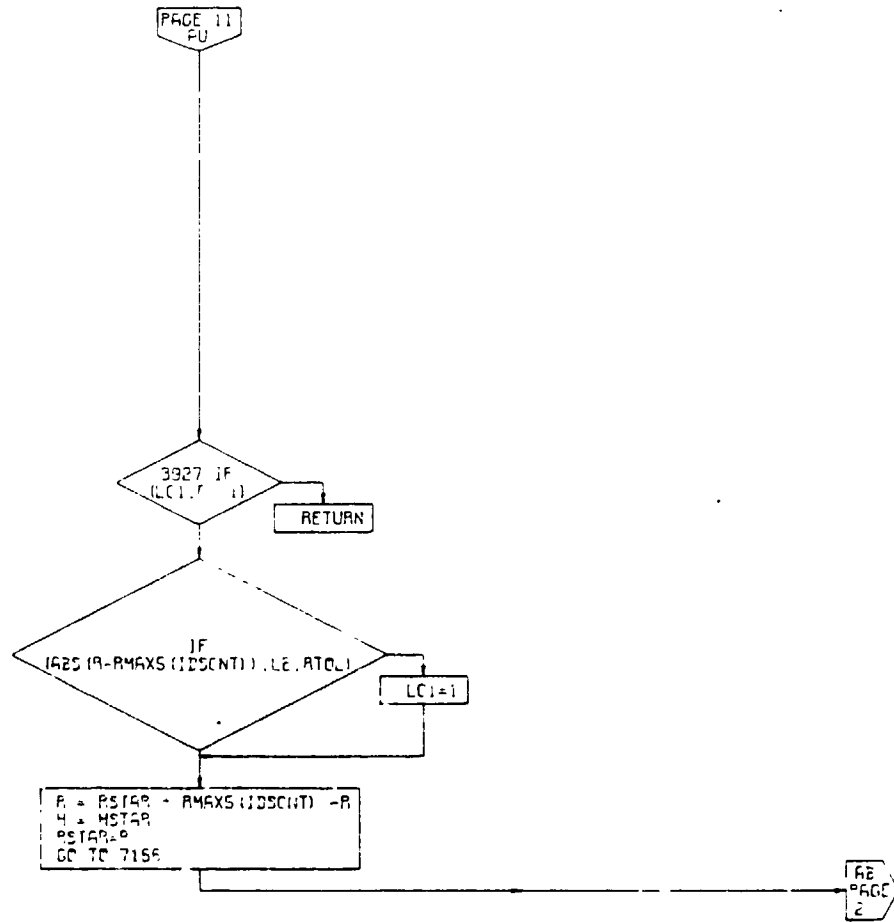


Figure 52B . Descent Calculations Subroutine,  
Flow Chart (Part 8 of 14)



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DESCNT

Figure 52B. Descent Calculations Subroutine,  
Flow Chart (Part 9 of 14)

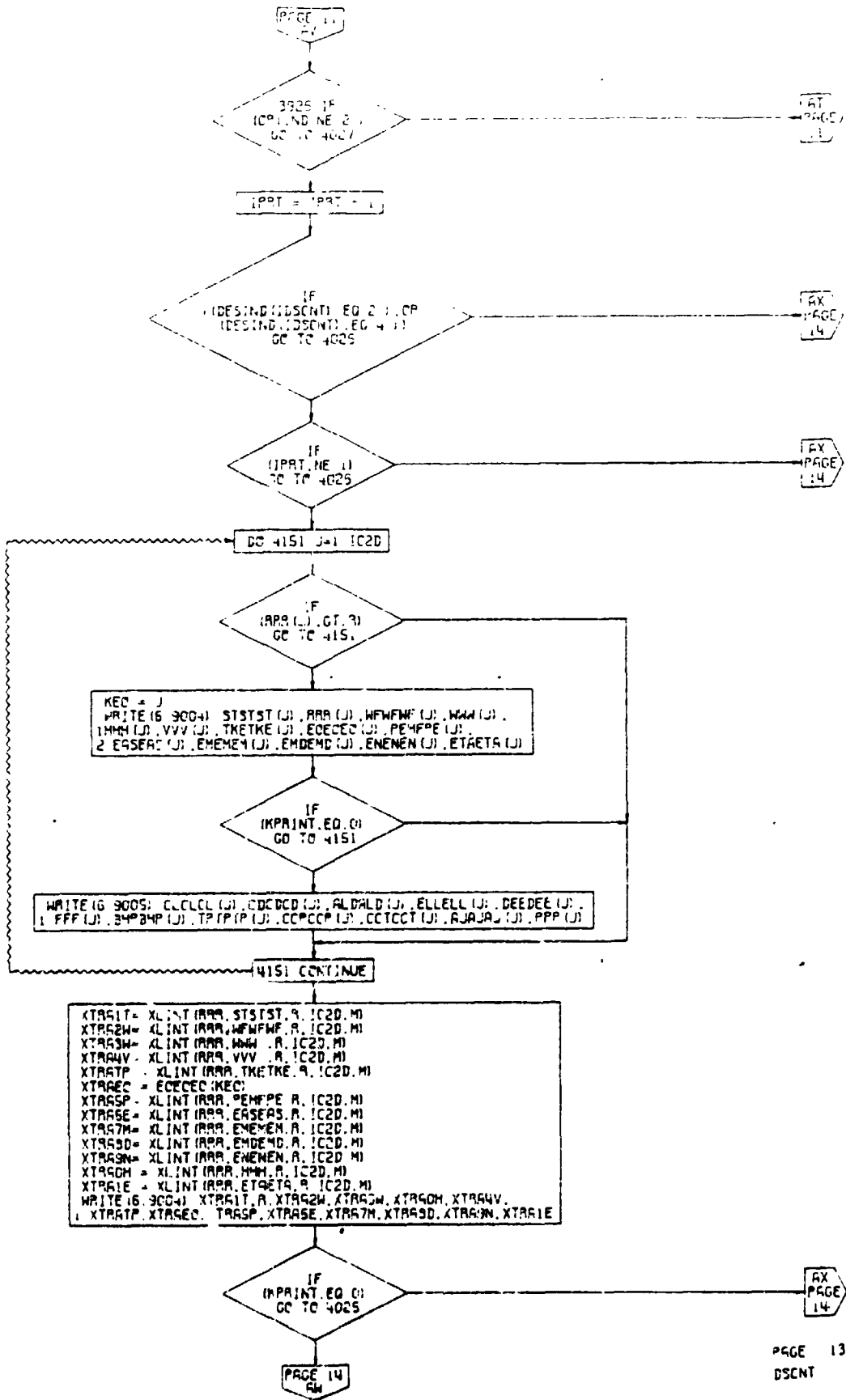
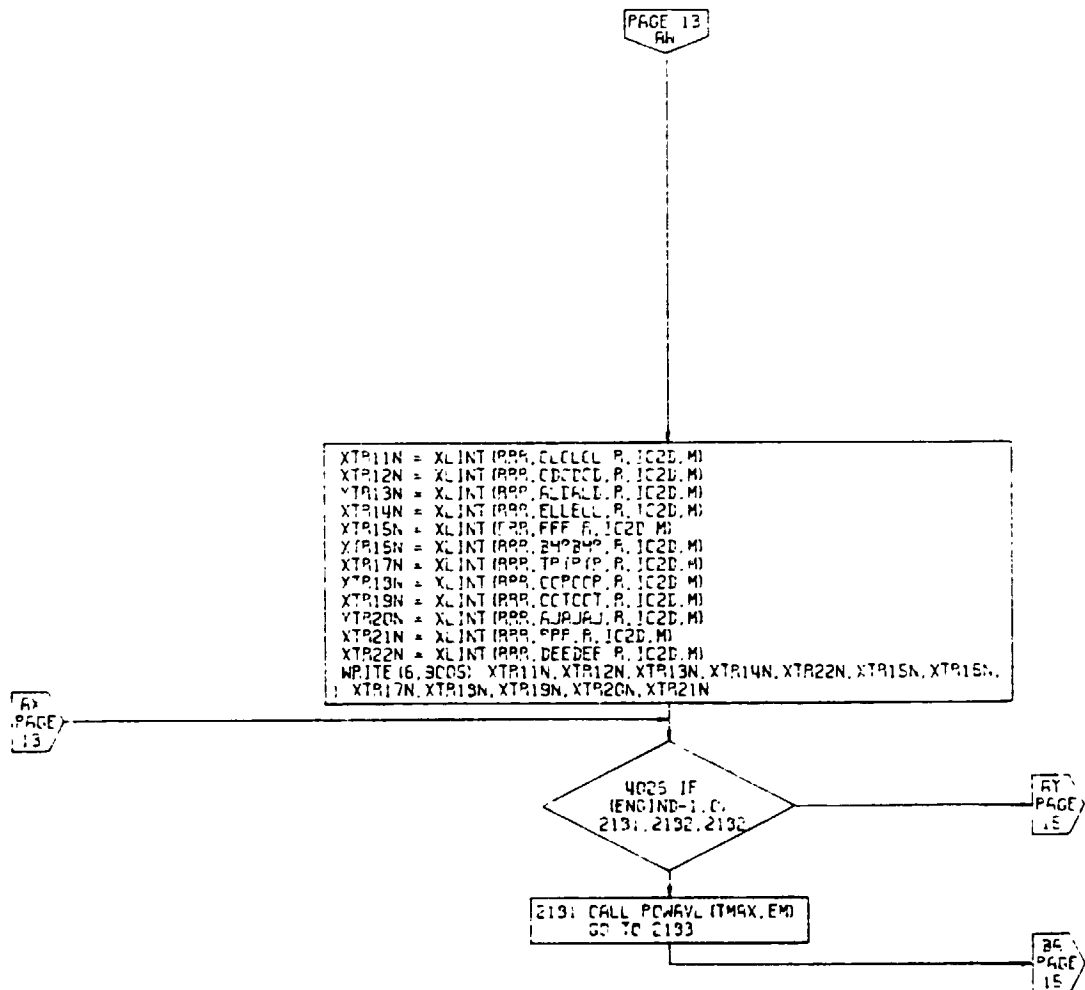


Figure 52B. Descent Calculations Subroutine, Flow Chart (Part 10 of 14)



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DSCNT

Figure 52B. Descent Calculations Subroutine,  
FlowChart (Part 11 of 14)

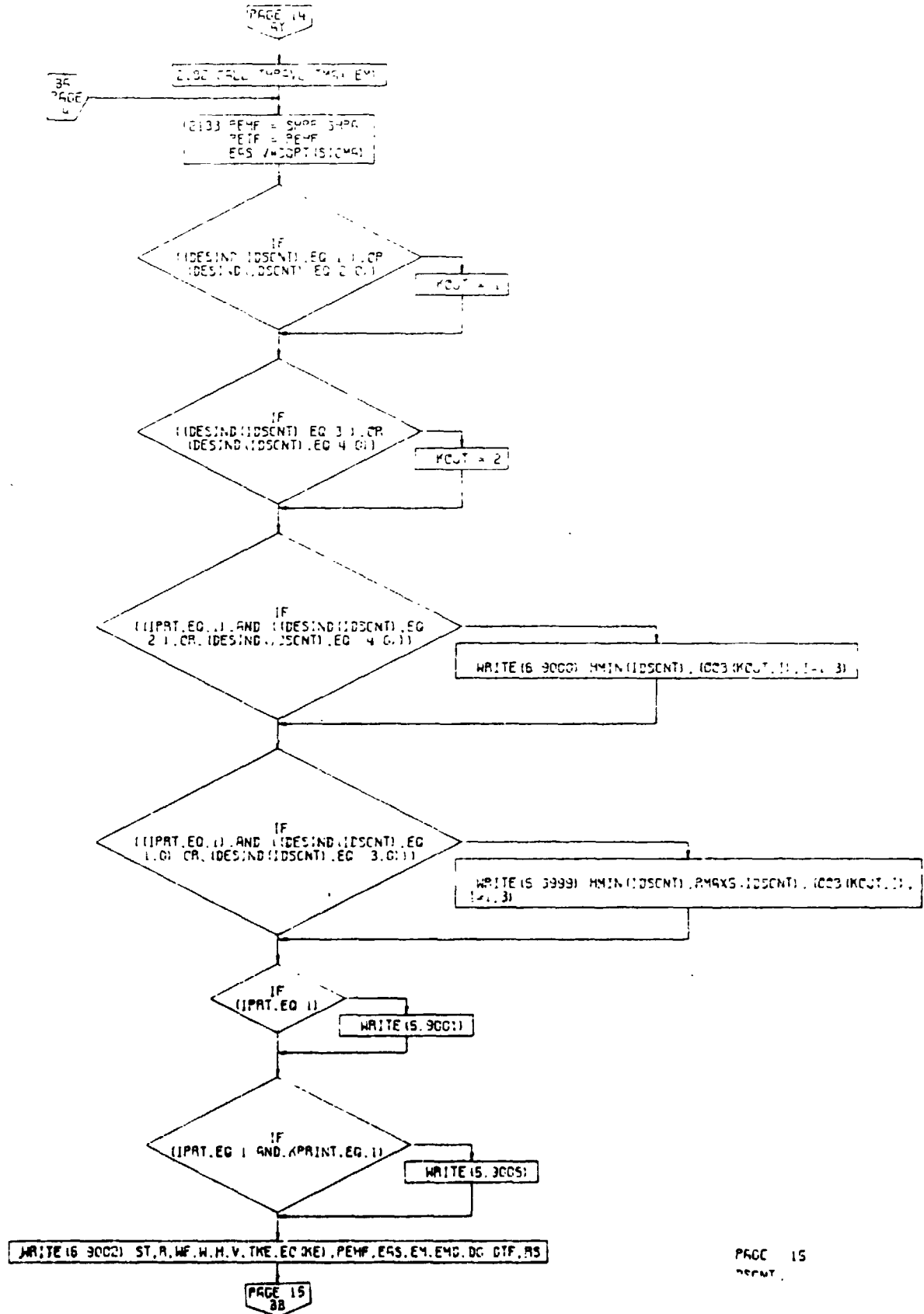
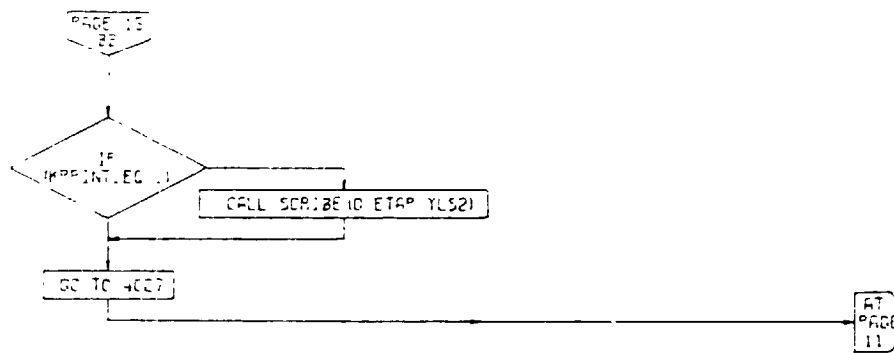


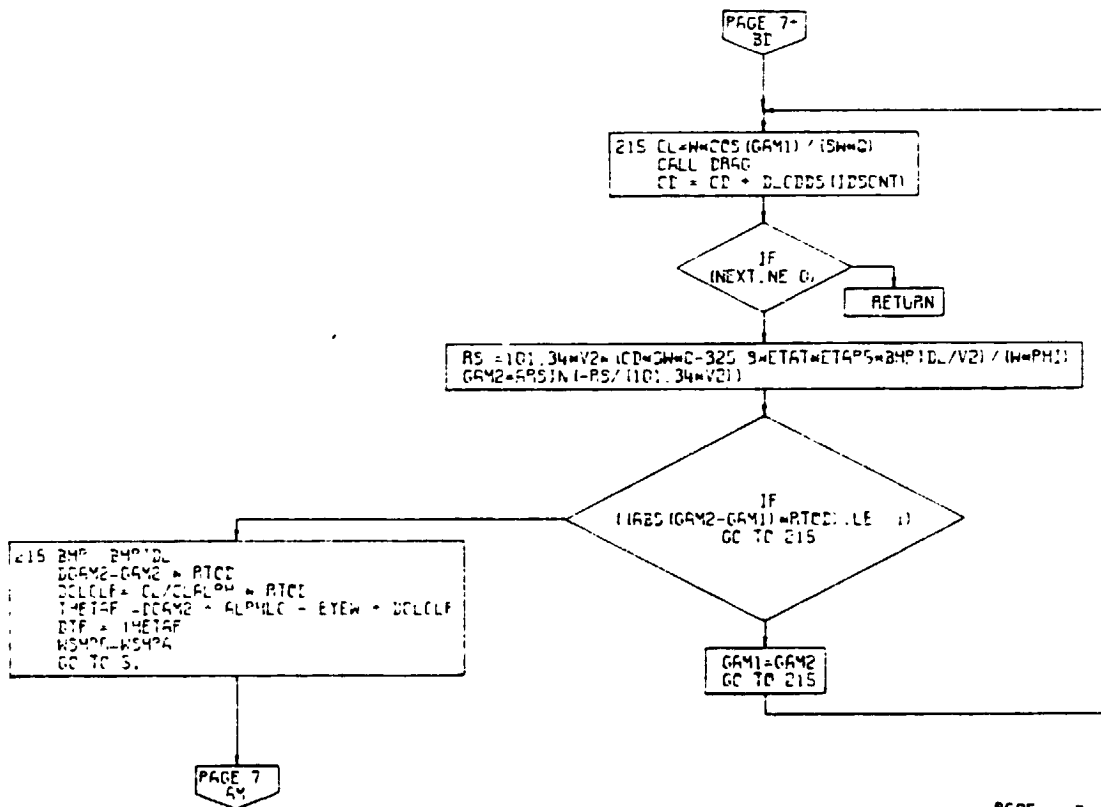
Figure 52B .

Descent Calculations Subroutine,  
Flow Chart (Part 12 of 14)

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DSCNT

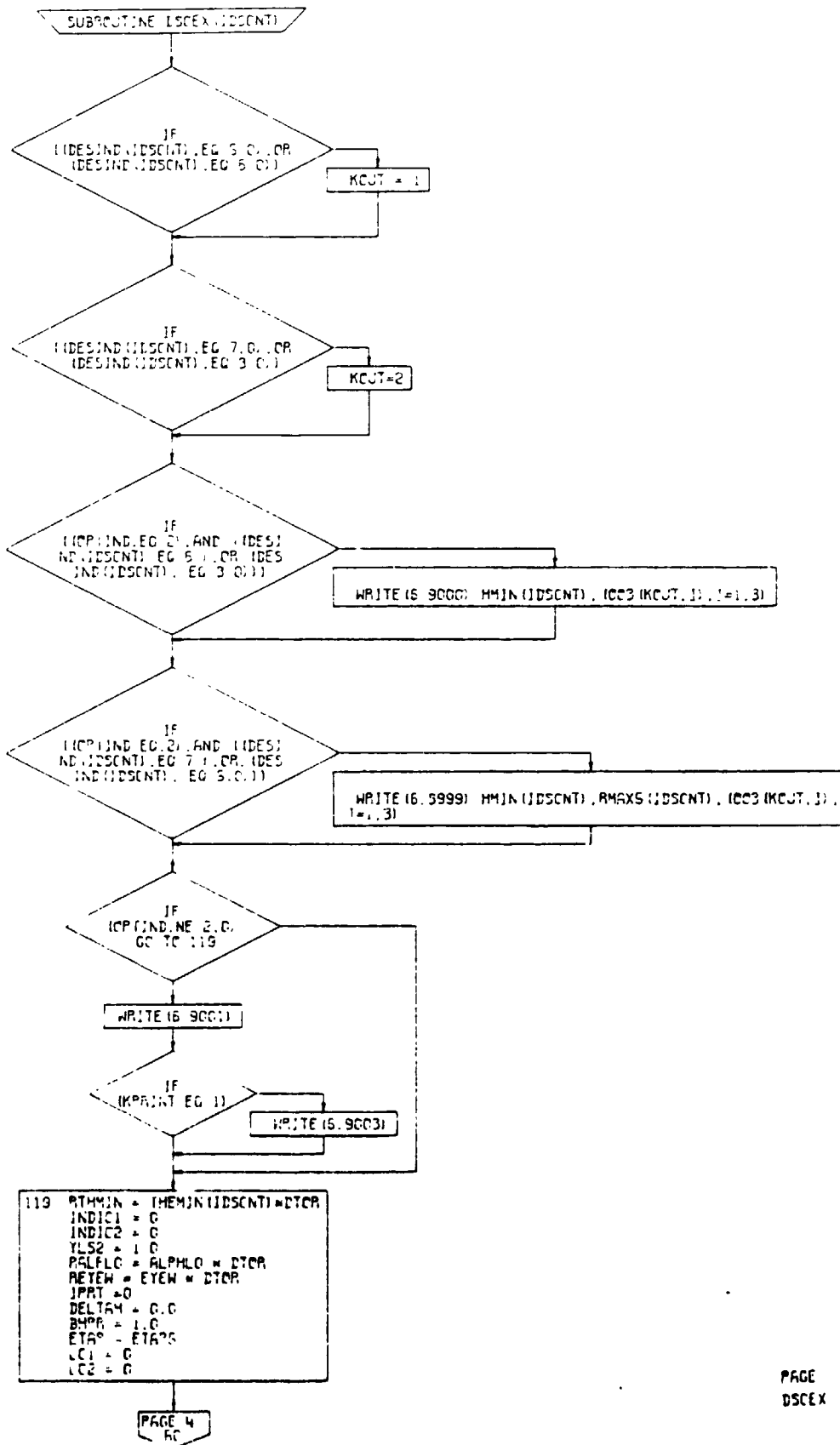


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DSCNT

Figure 52B . Descent Calculations Subroutine,  
Flow Chart (Part 13 of 14)



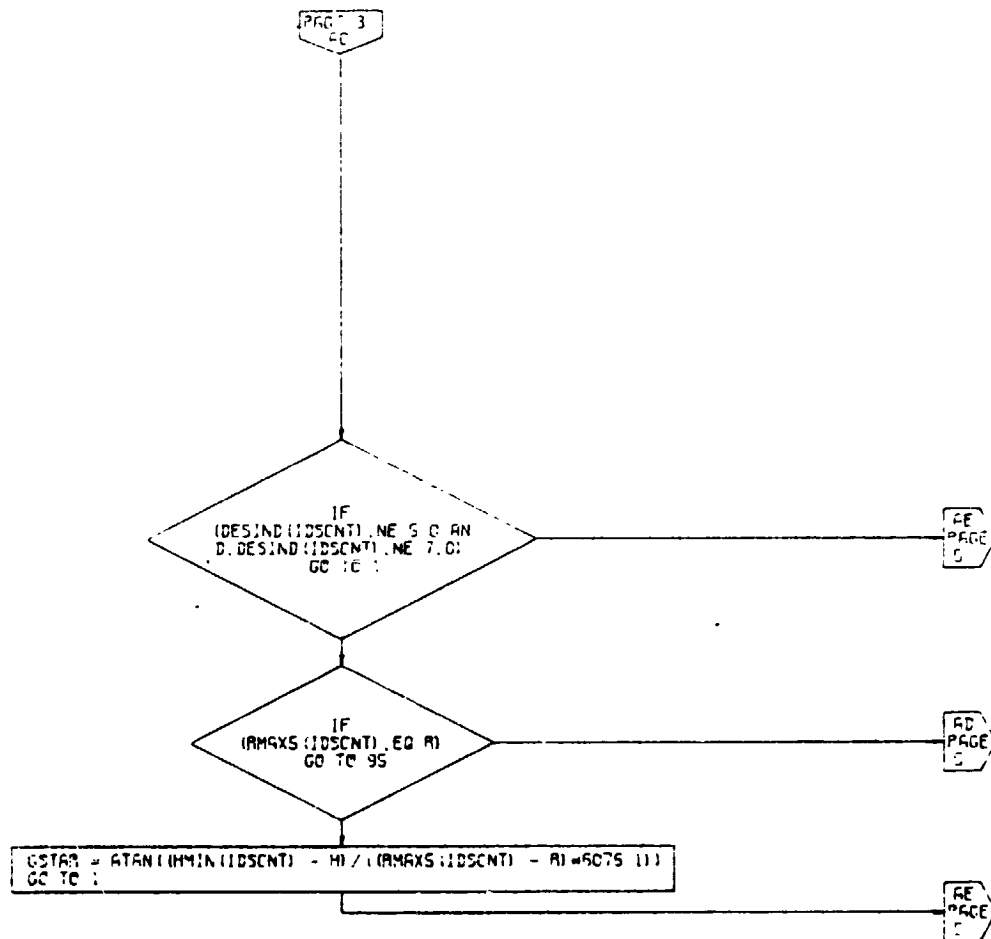




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DSCEX

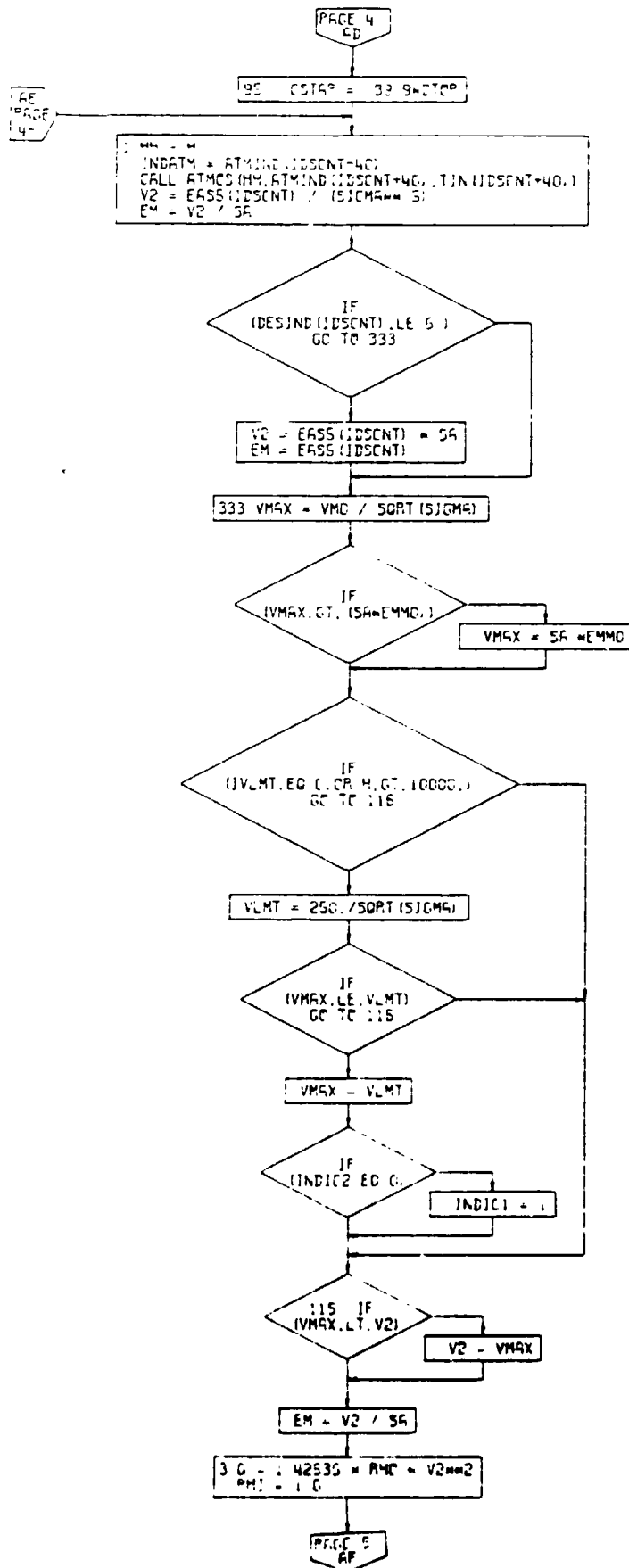
Figure 52C

DSEX Calculations Subroutine,  
Flow Chart (Part 1 of 9)



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DSEX

Figure 52C. DSEX Calculation Subroutine,  
Flow Chart (Part 2 of 9)



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DSCEX

Figure 52C .

DSCEX Calculations Subroutine,  
Flow Chart (Part 3 of 9)

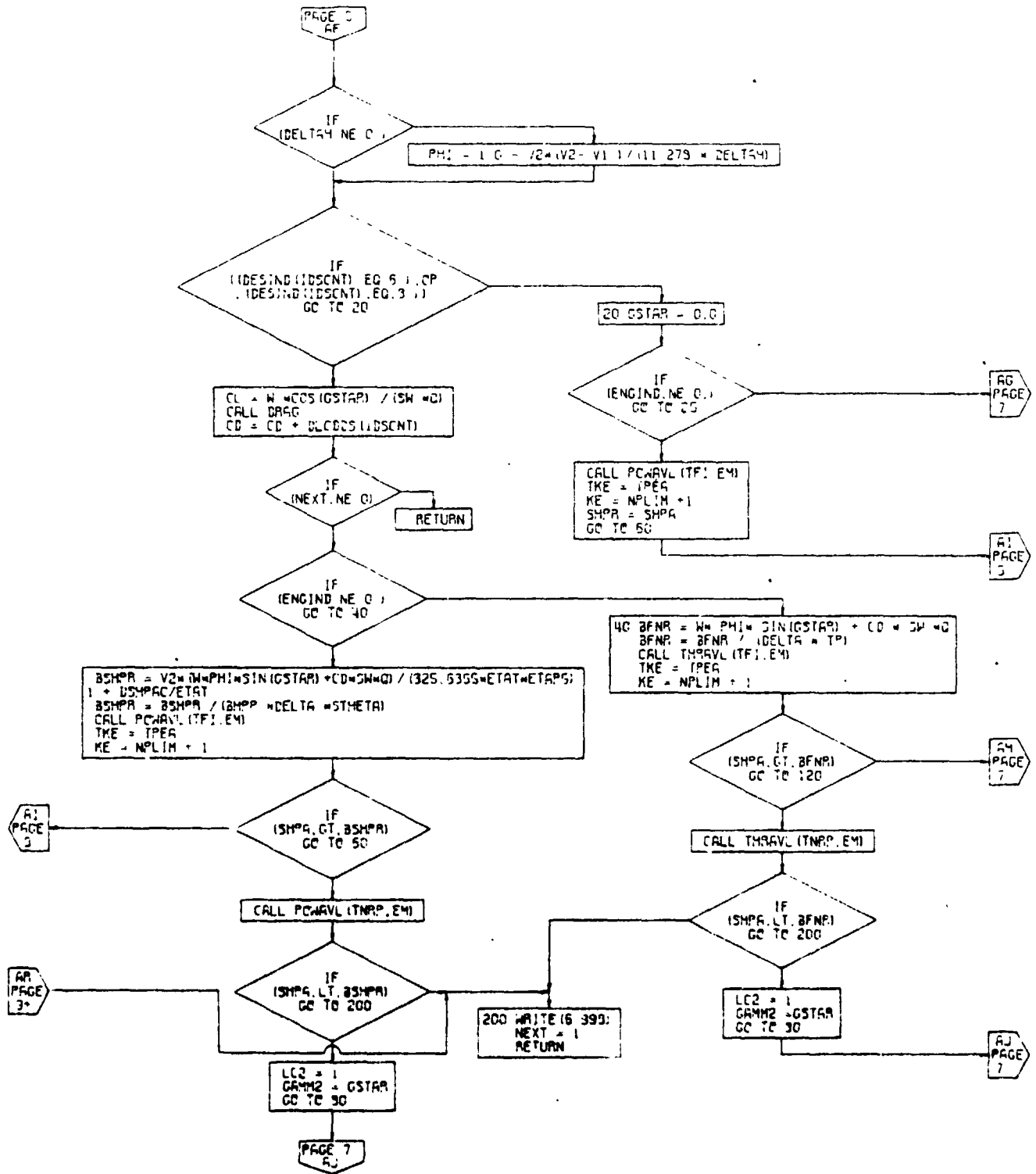
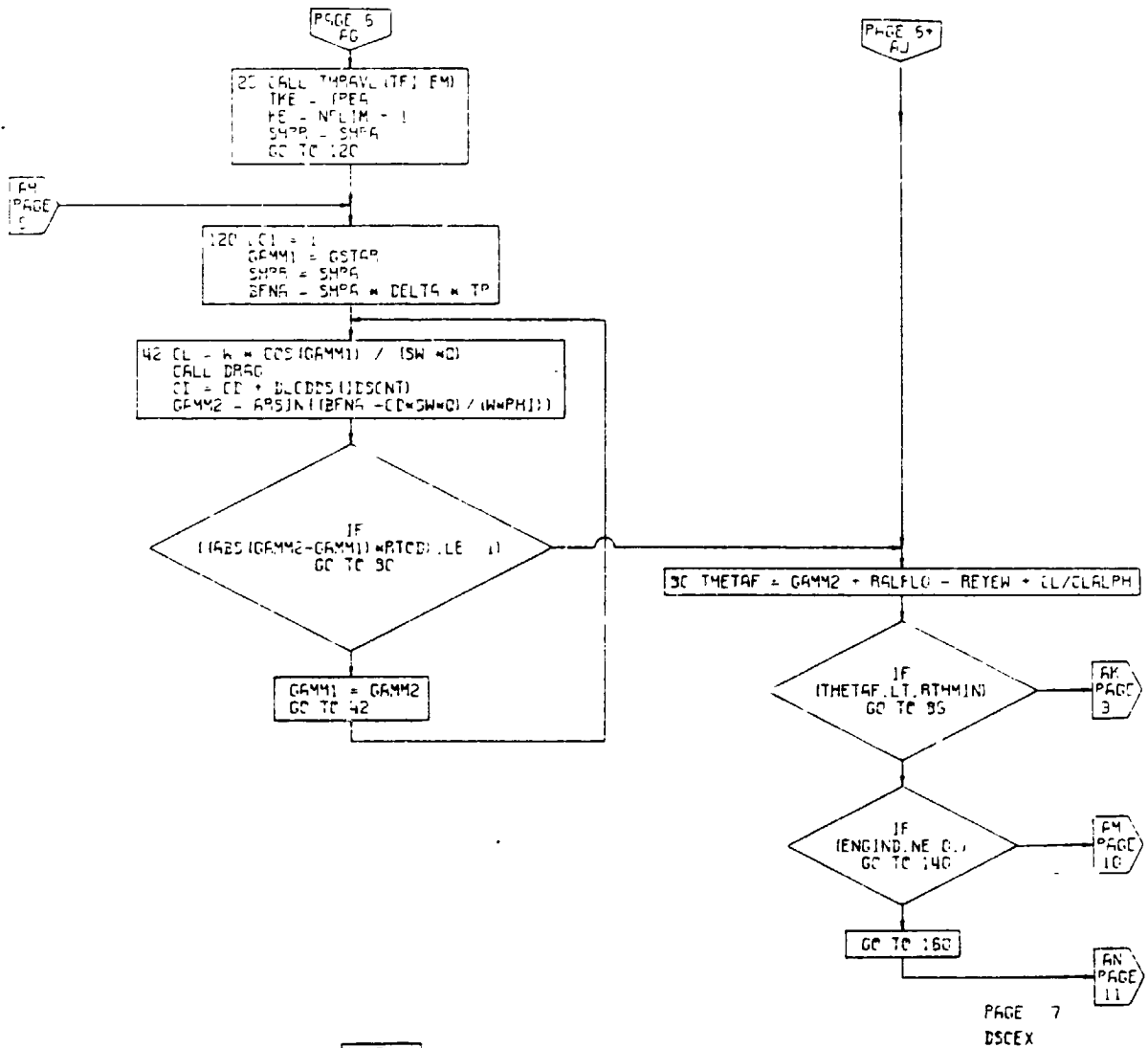
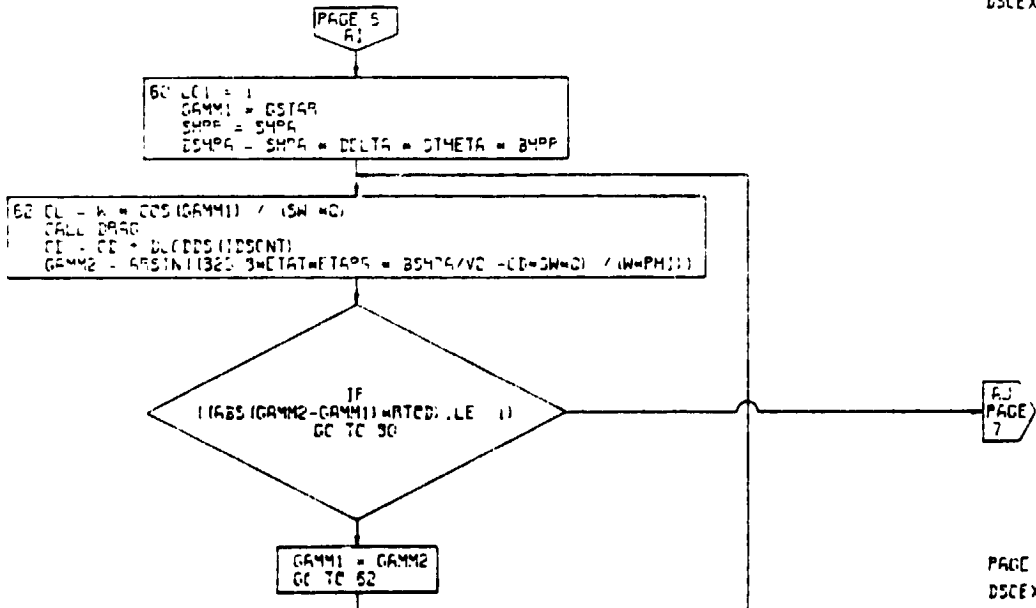


Figure 52C. DSCEX Calculations Subroutine, Flow Chart (Part 4 of 9)

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DSCEX

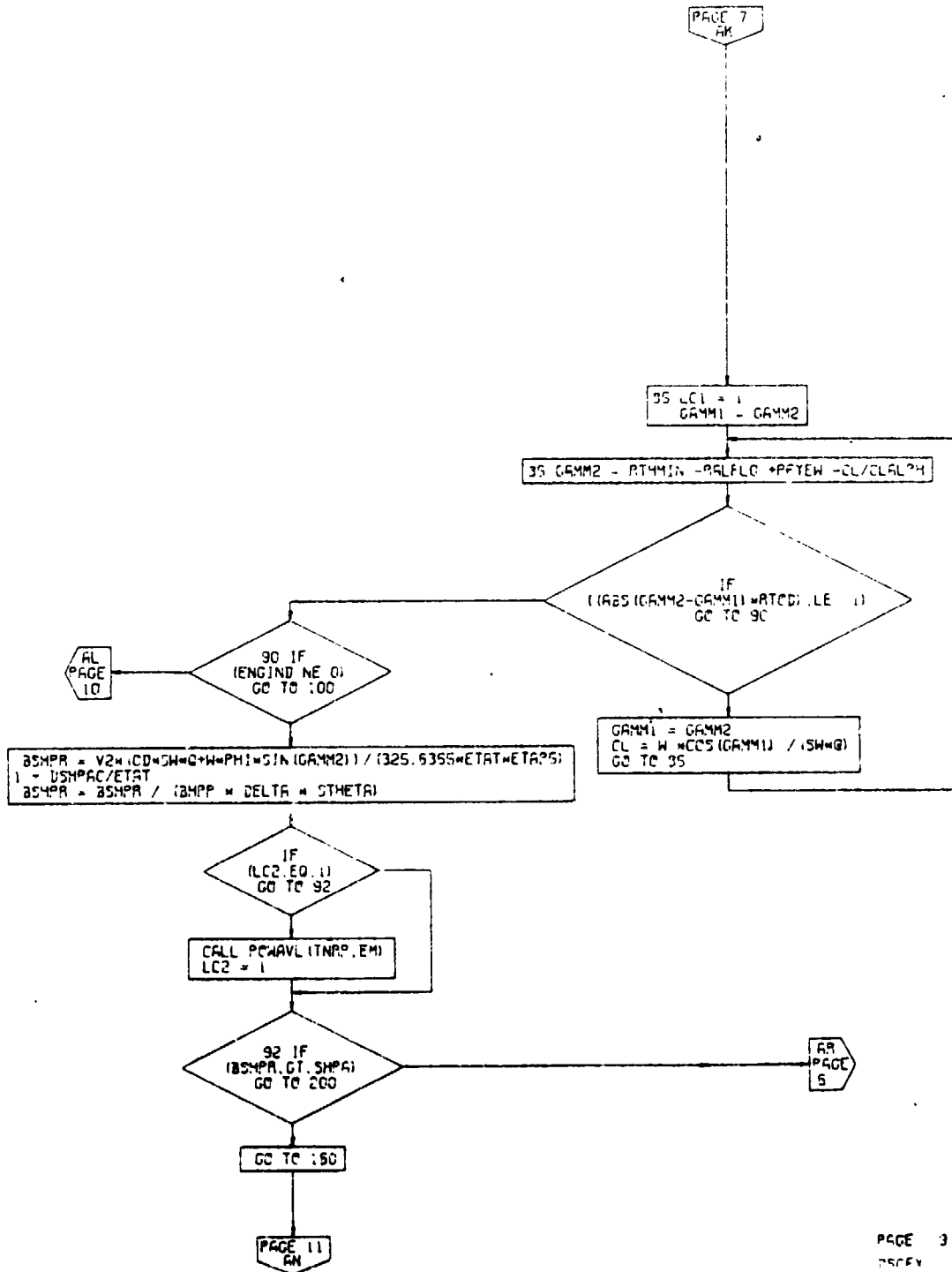


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DSCFX



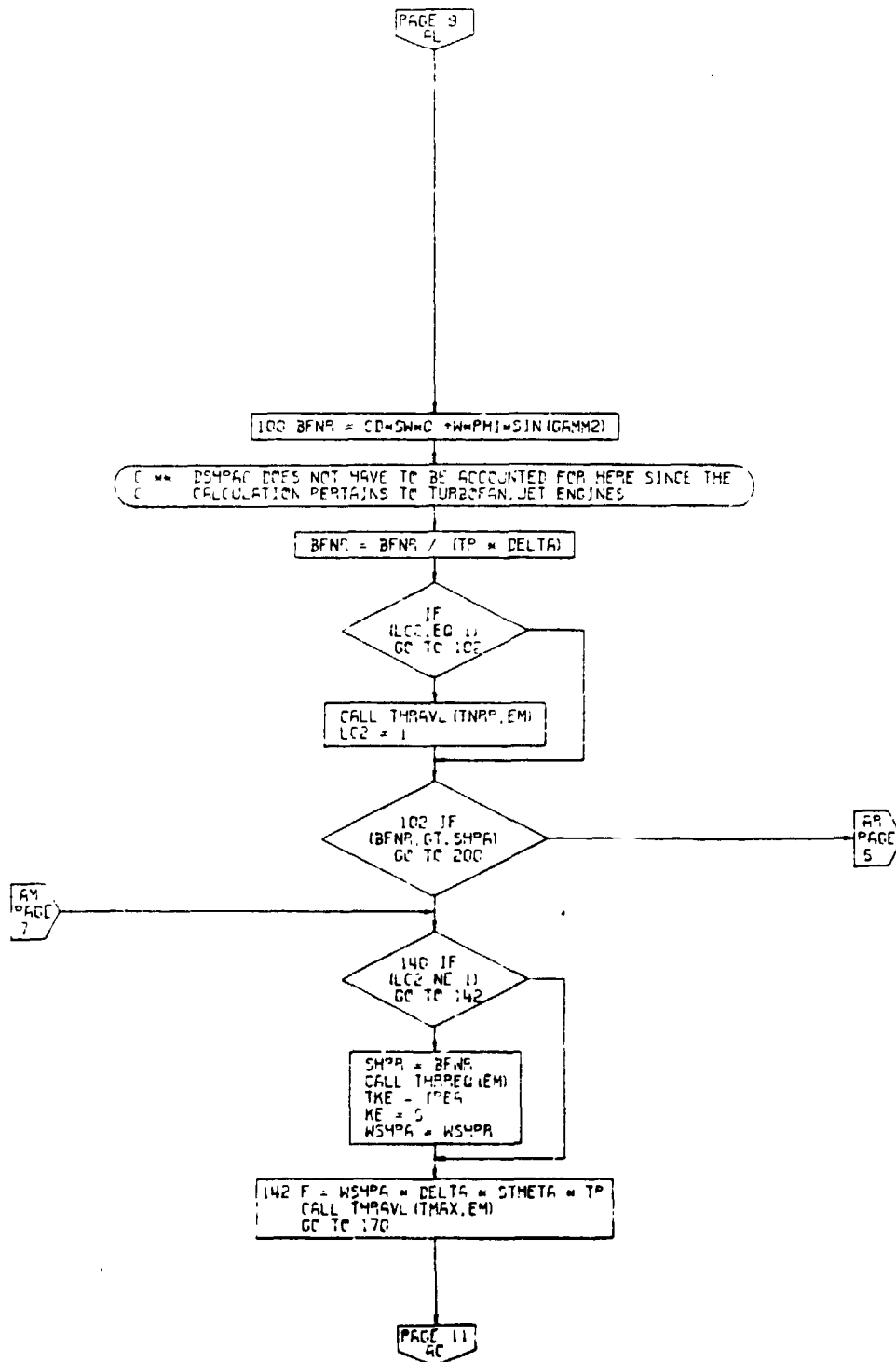
PAGE 5  
DSCFX

Figure 52C. DSCFX Calculations Subroutine, Flow Chart. (Part 5 of 9)



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DSCEX

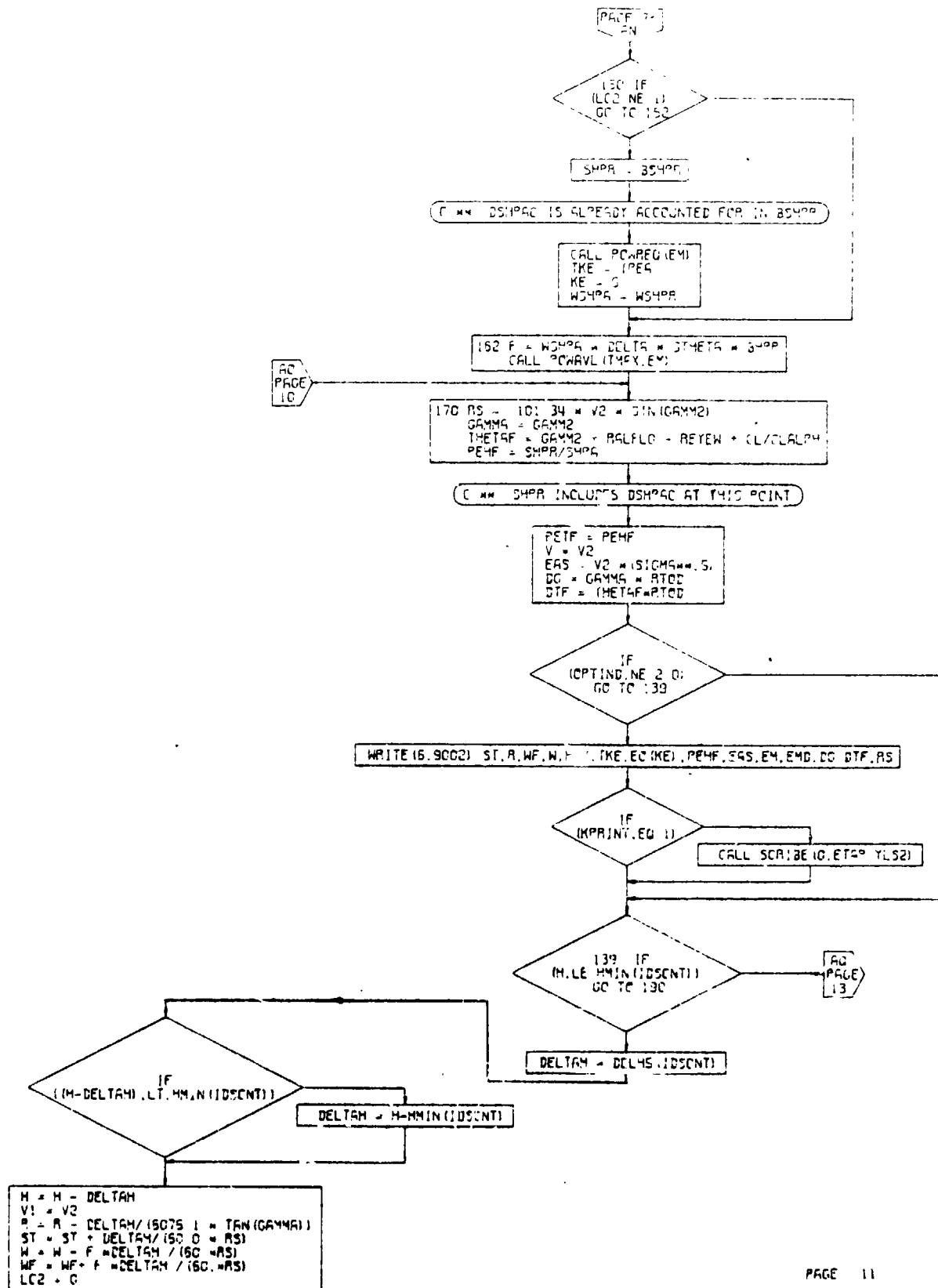
Figure 52C, DSCEX Calculations Subroutine, Flow Chart (Part 6 of 9)



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DSCEX

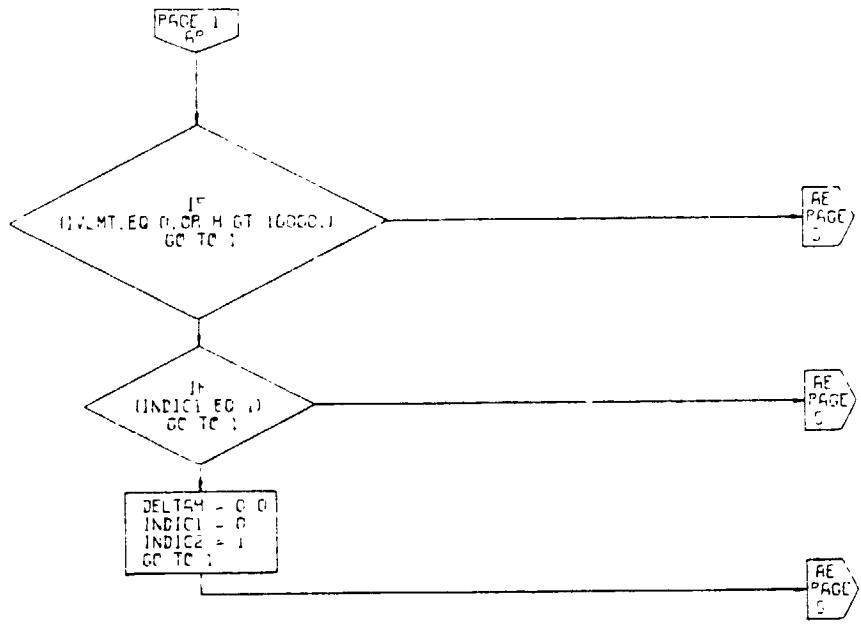
Figure 52C. DSCEX Calculations Subroutine,  
Flow Chart (Part 7 of 9)



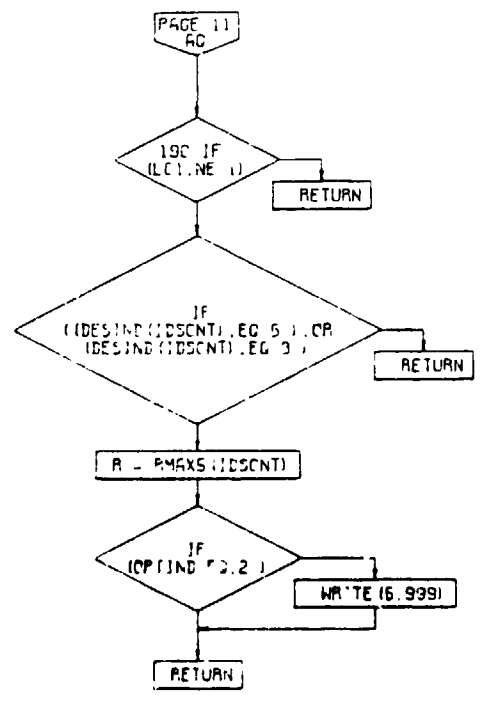


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DSCEX

Figure 52C. DSCEX Calculations Subroutine, Flow Chart (Part 8 of 9)



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DSEX



PAGE 13  
DSEX

Figure 52C .

DSEX Calculations Subroutine,  
Flow Chart (Part 9 of 9)

#### 4.10.6 Loiter Calculations Subroutine

The sixth performance segment represents a calculation of aircraft loiter performance. In this subroutine, the aircraft will fly at the airspeed for best endurance. This subroutine calculates the power required and the airspeed to maximize the endurance of the aircraft. It also determines the fuel required to loiter for a specified period of time.

If the limiting speed option ( $V_{LIMIND}=1$ ) is used, the program will monitor the loiter speed at altitudes of 10,000 feet or less to ensure that the speed is less than 250 knots equivalent airspeed.

It is possible to use a loiter segment in the mission profile to account for a reserve fuel requirement (in which case the aircraft weight at the end of loiter is set back to the weight at the beginning of loiter) or as a part of the basic mission (in which case the weight is not reset). In either case, the fuel used during loiter is included in the total fuel required to size the aircraft. A loiter indicator, LTRIND, specifies to the program which option is being used. If LTRIND is input as zero, the loiter fuel will be included as part of the reserve fuel. If LTRIND is input as unity, the loiter fuel will be included as part of the mission fuel.

An engine shutdown during loiter may be simulated by an input for N<sub>PSD</sub>. One or more engines may be shut down. An increment in drag coefficient ( $\Delta C_D$  LOITER) may be input to represent drag changes due to external stores or flaps.

Input to this subroutine consists of the value of LTRIND, the time for loiter, step size (incremental time), the incremental drag coefficient, the number of engines shut down, and the atmospheric conditions. A flow chart of this subroutine is shown in Figure 4-53.

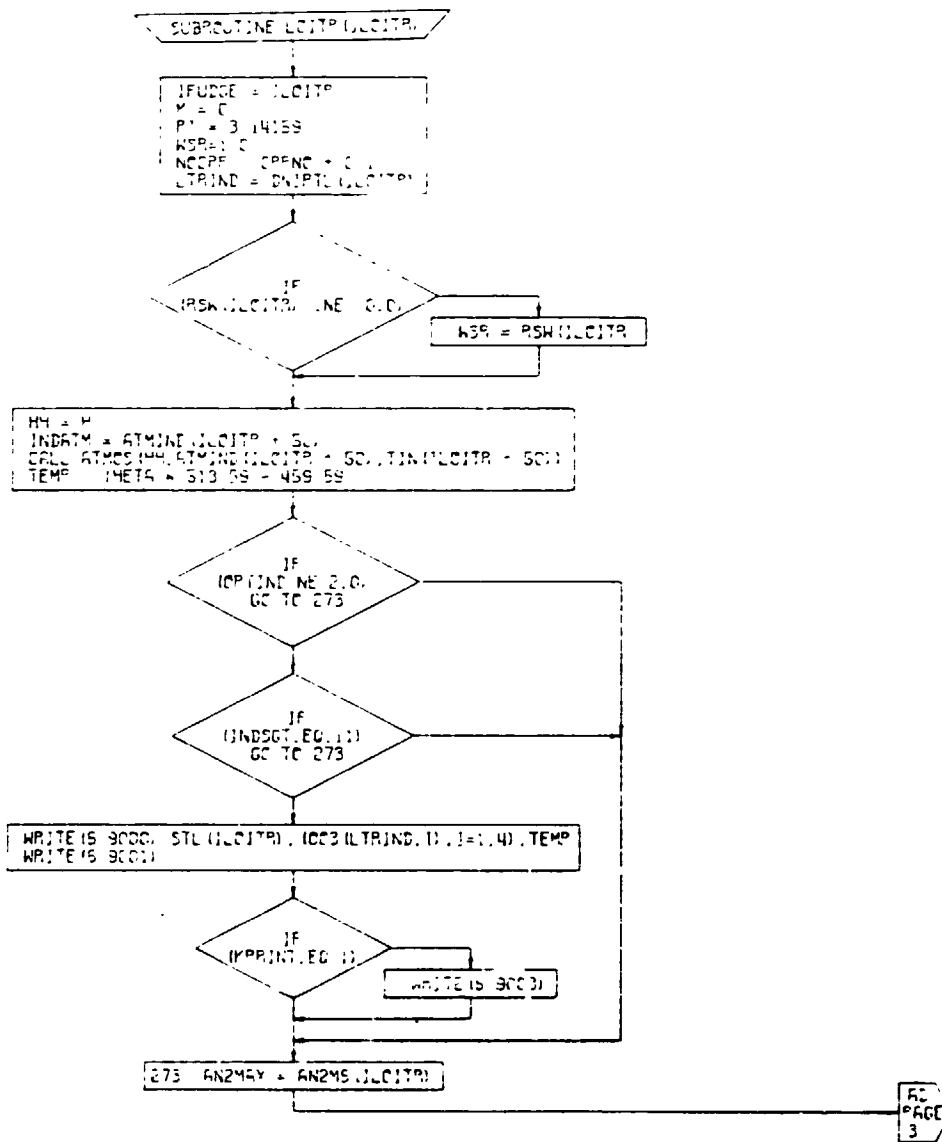


Figure 4-53. LOITER Calculations Subroutine,  
Flow Chart (Part 1 of 11)

PAGE 2  
LCITR

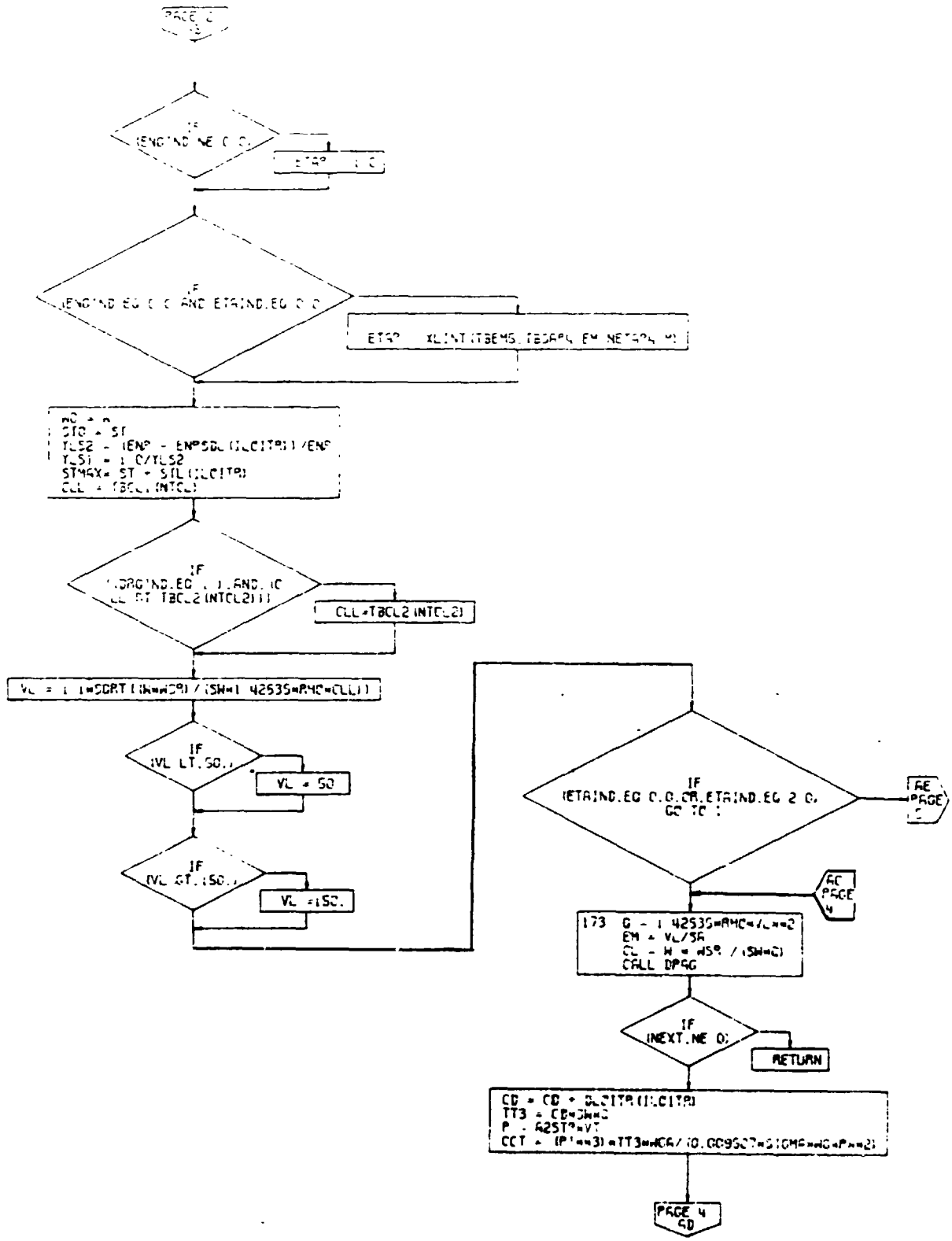
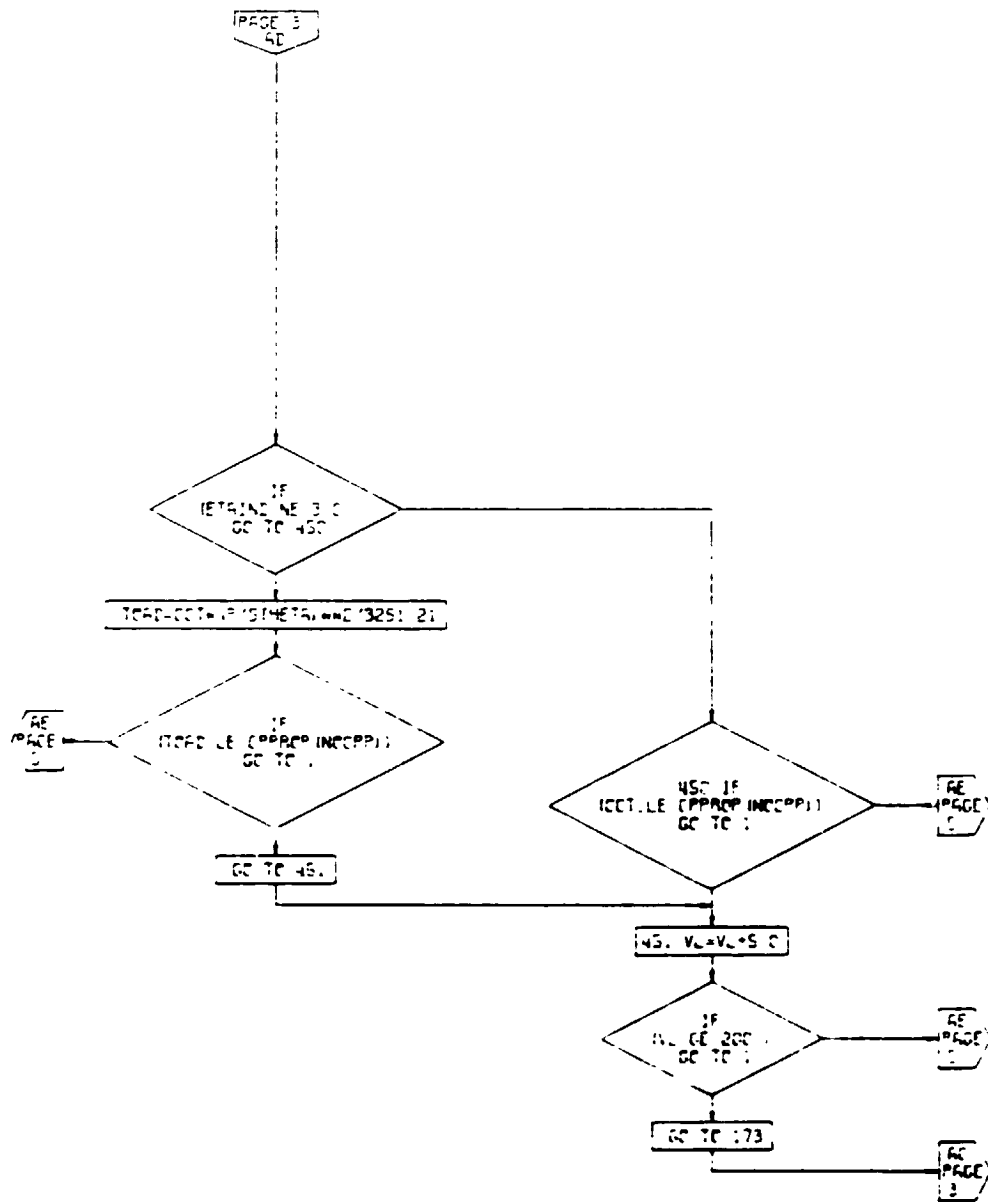


Figure 4-53. LOITER Calculations Subroutine, Flow Chart (Part 2 of 11)

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 LOITER



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LOITER

Figure 4-53. LOITER Calculations Subroutine,  
Flow Chart (Part 3 of 11)

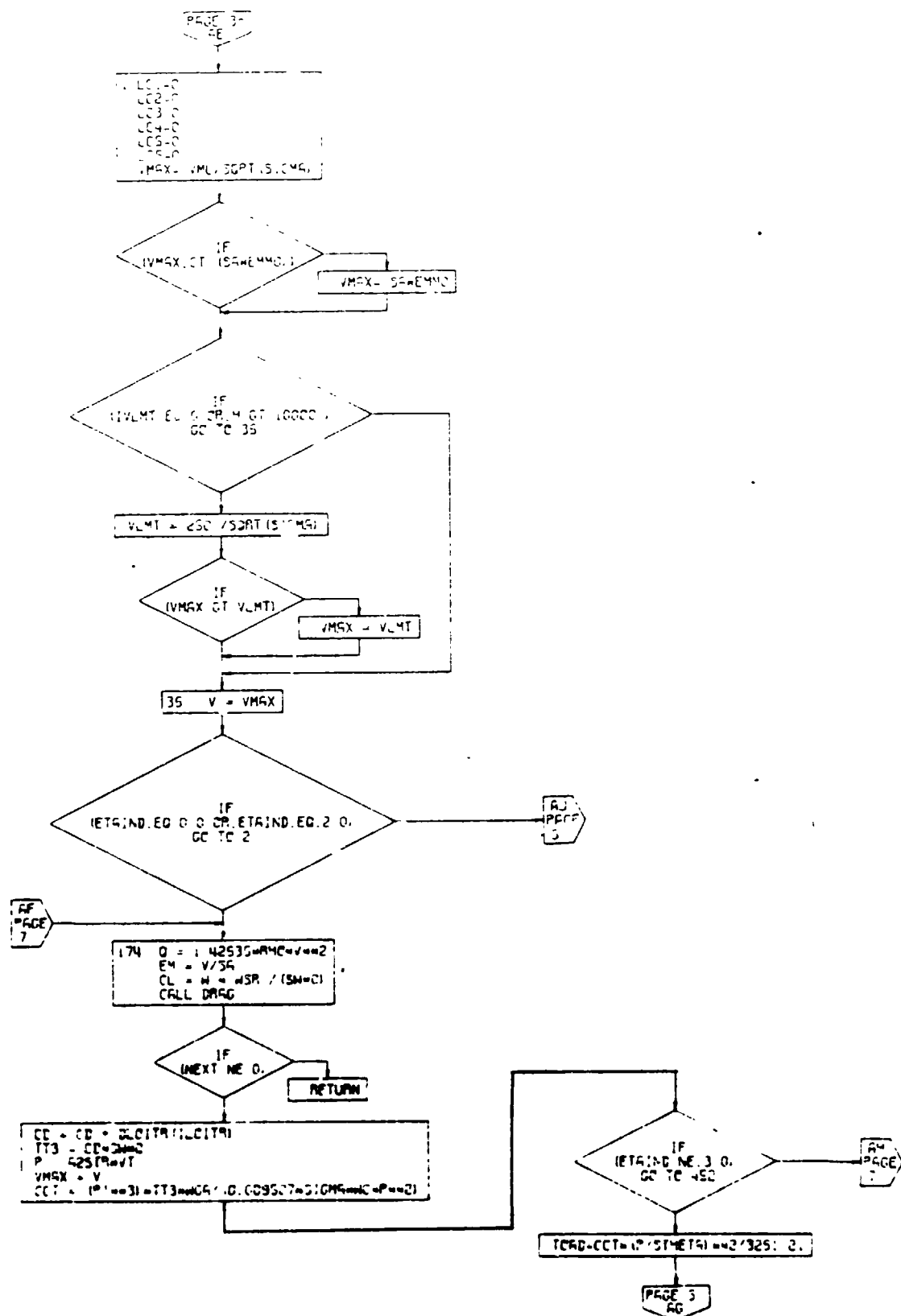
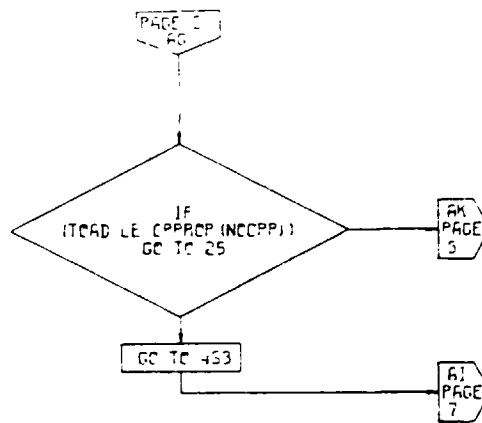
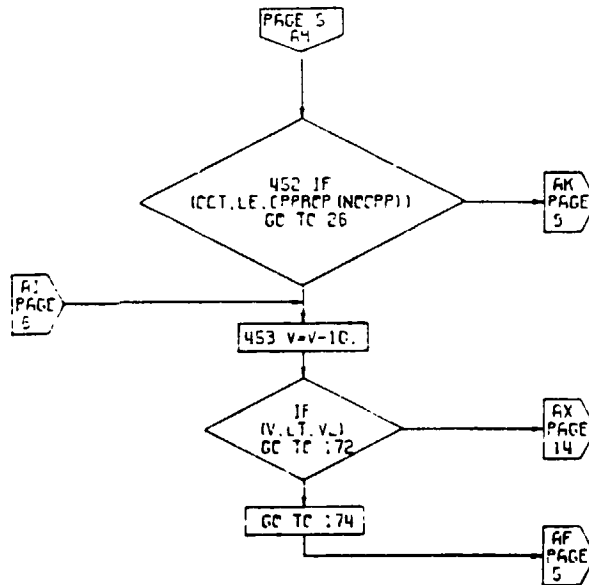


Figure 4-53. LOITER Calculations Subroutine, Flow Chart (Part 4 of 11)



PAGE 5  
LC:TR



PAGE 7  
LC:TR

Figure 4-53. LOITER Calculations Subroutine, Flow Chart (Part 5 of 11)



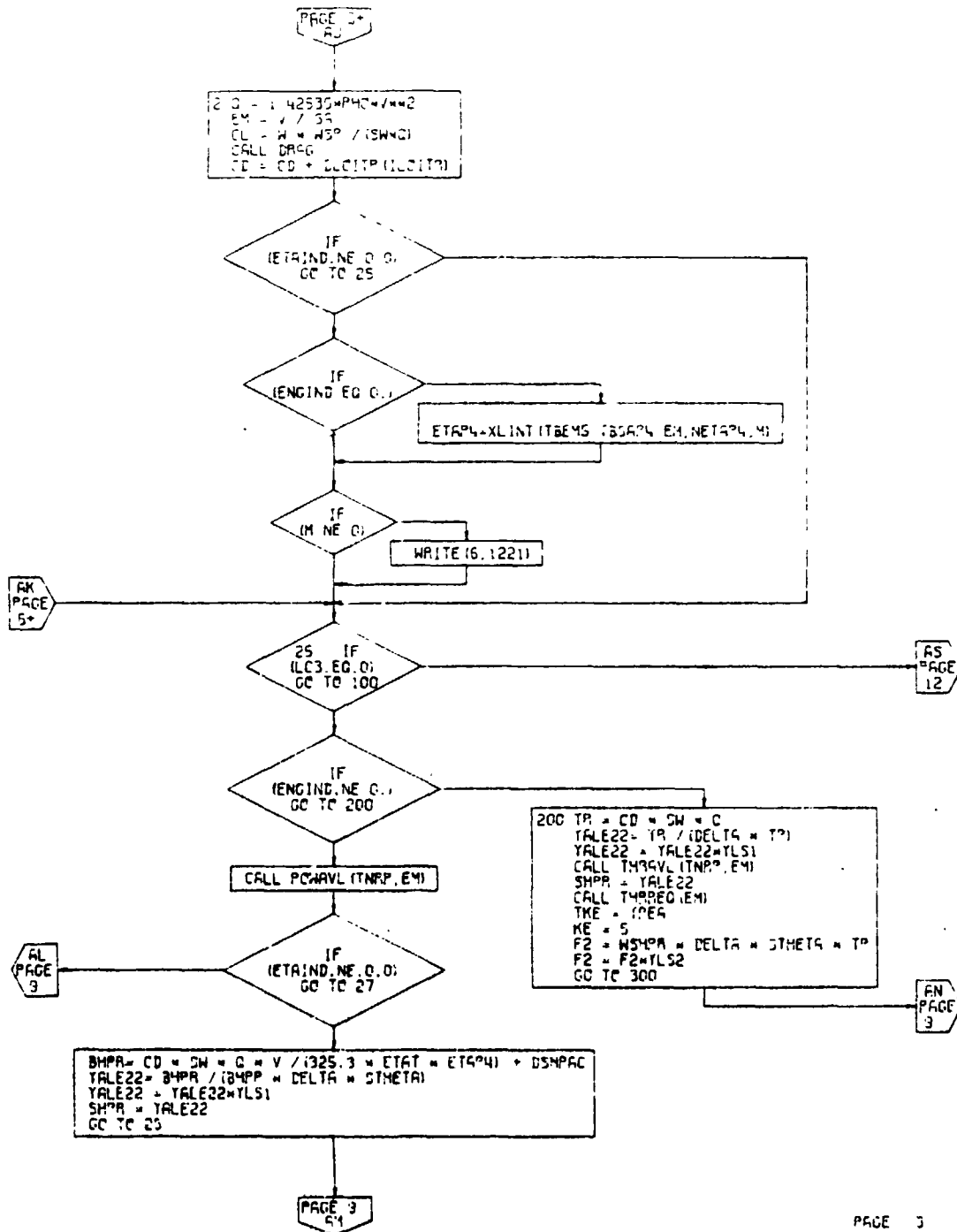


Figure 4-53. LOITER Calculations Subroutine, Flow Chart (Part 6 of 11)



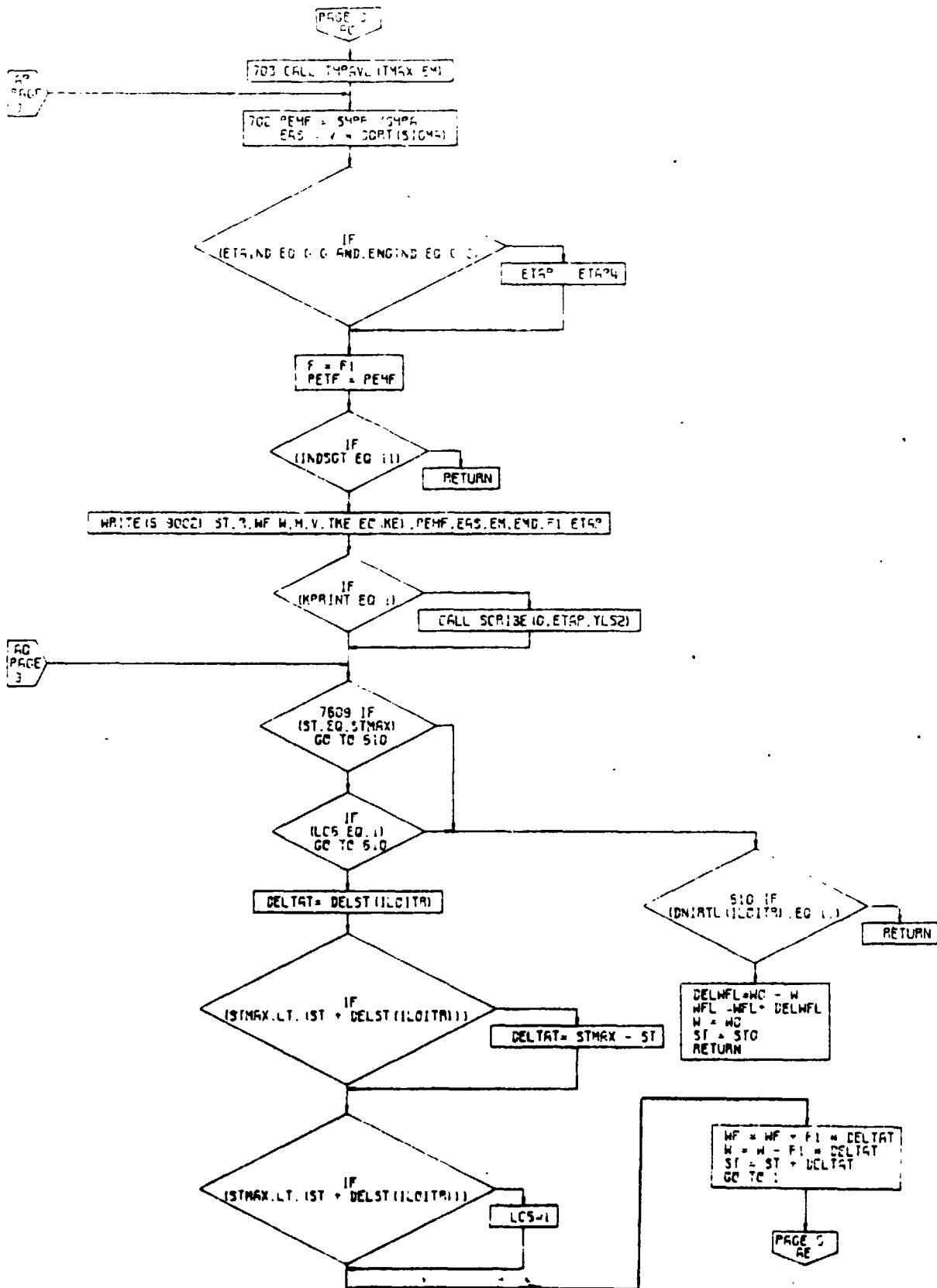
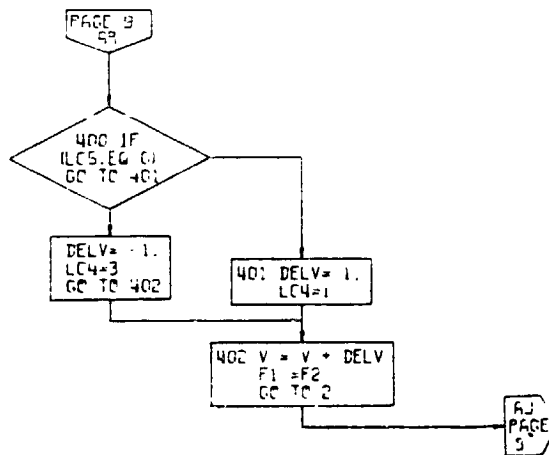
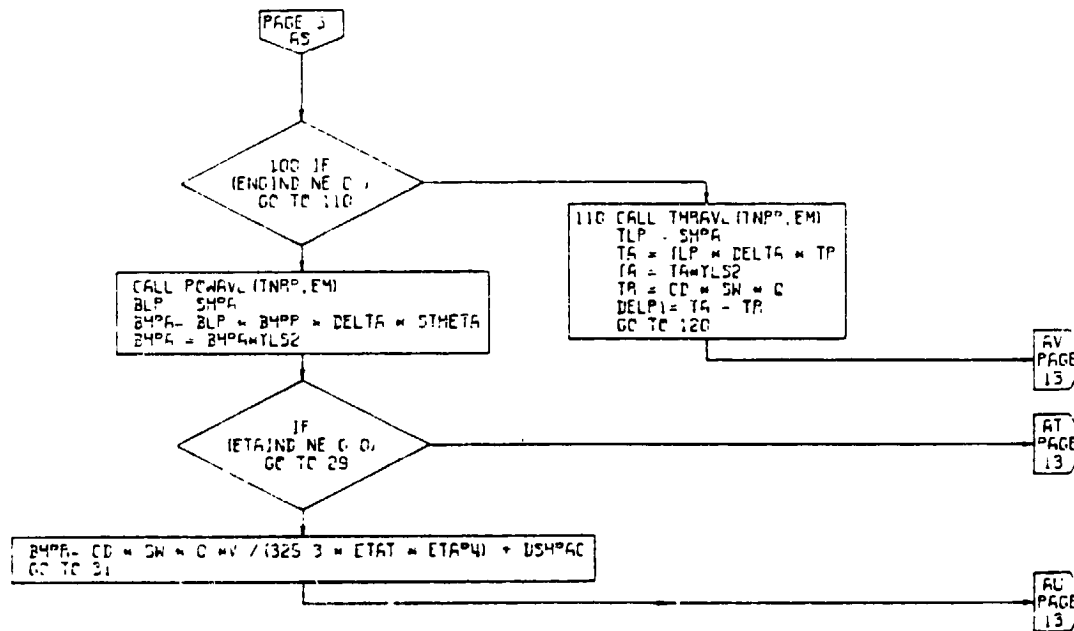


Figure 4-53. LOITER Calculations Subroutine, Flow Chart (Part 8 of 11)

PAGE 10  
LOITER

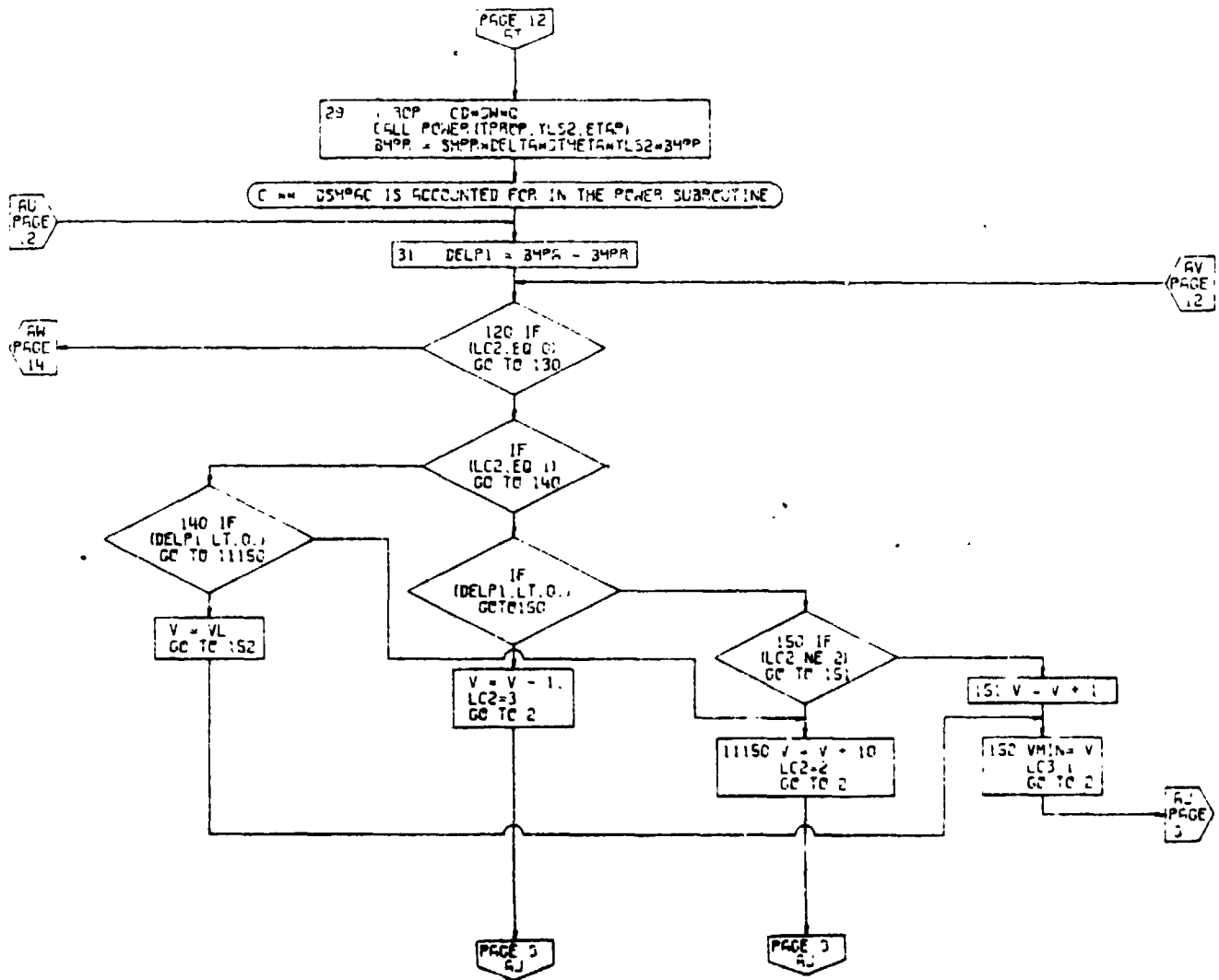


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LC17A



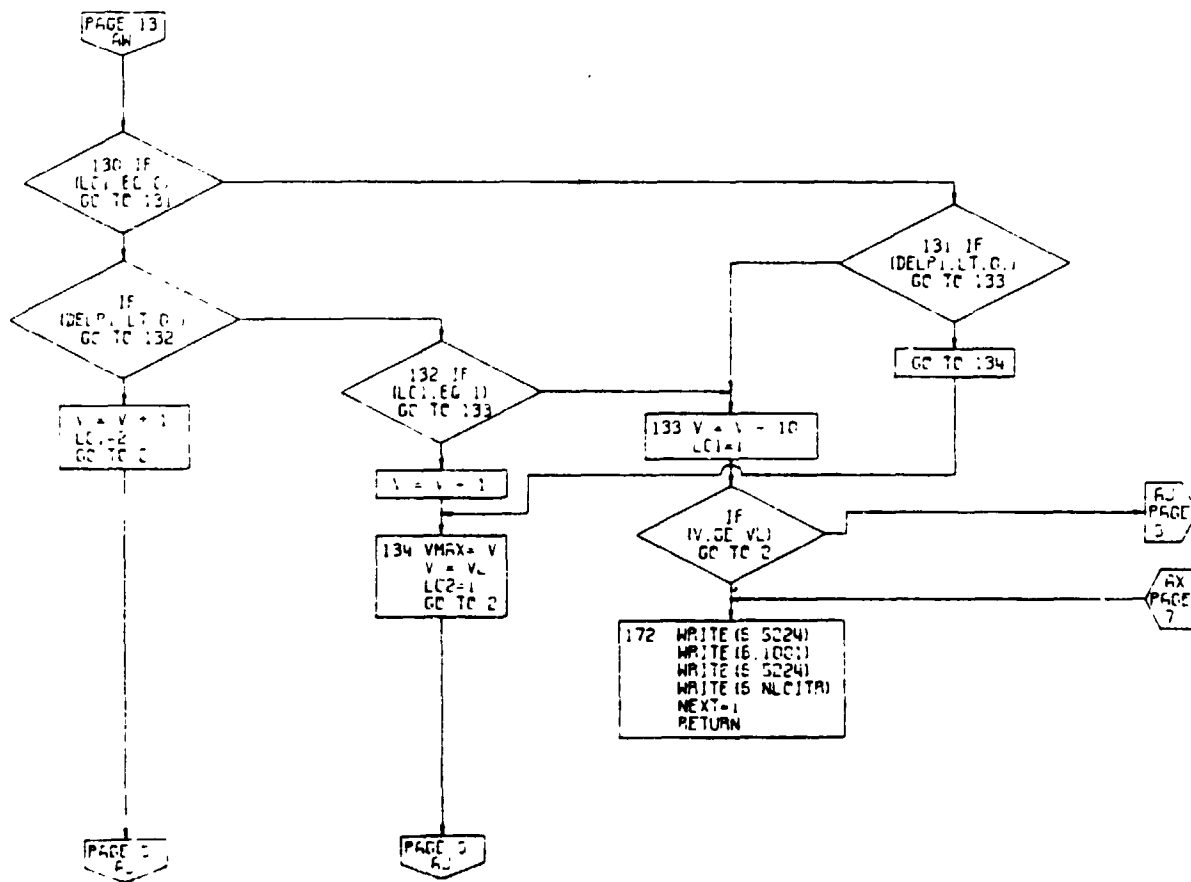
PAGE 12  
LC17A

Figure 4-53. LOITER Calculations Subroutine, Flow Chart (Part 9 of 11)



PAGE 13  
LC17\*

Figure 4-53. LOITER Calculations Subroutine,  
Flow Chart (Part 10 of 11)



PAGE 14  
LC1TR

Figure 4-53. LOITER Calculations Subroutine,  
Flow Chart (Part 11 of 11)

#### 4.10.7 Change of Weight Subroutines

The seventh and eighth performance segments represent an incremental change in weight of fuel or payload. These options would be used to simulate refueling, unloading or loading of passengers, or a fuel drop. The input to the subroutines consists of the increment in weight and a corresponding increment in time. The fuel or payload weight which is added is not allowed to increase the aircraft weight to a value greater than the gross weight unless a performance case is being run and WGTIND = 1. Inputting a large value for the increment in weight will bring the aircraft weight up to gross weight if WGTIND = 0 or a sizing case is being run. Figures 4-54 and 4-55 are flow charts of these subroutines.

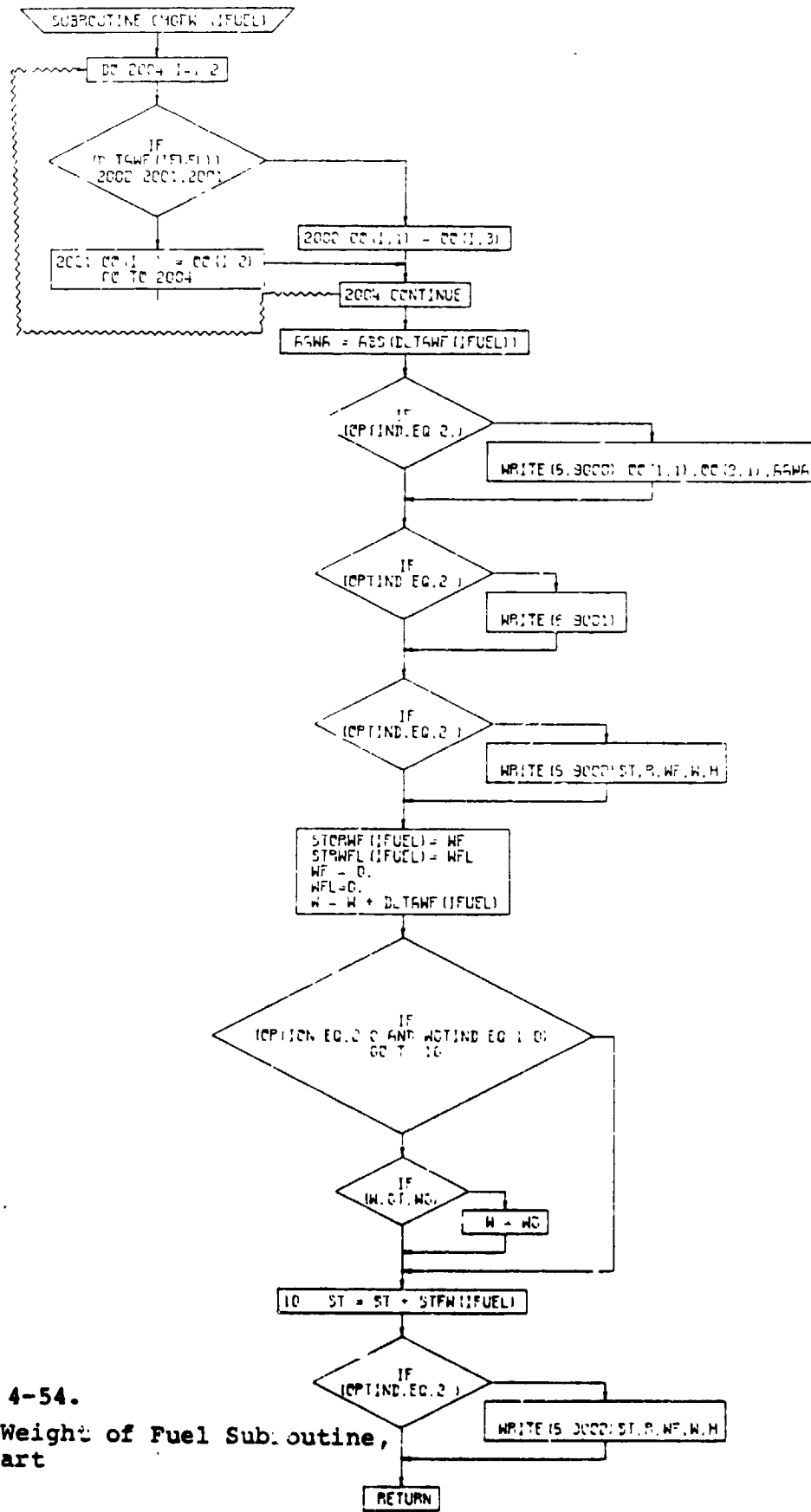


Figure 4-54.  
Change Weight of Fuel Subroutine,  
Flow Chart



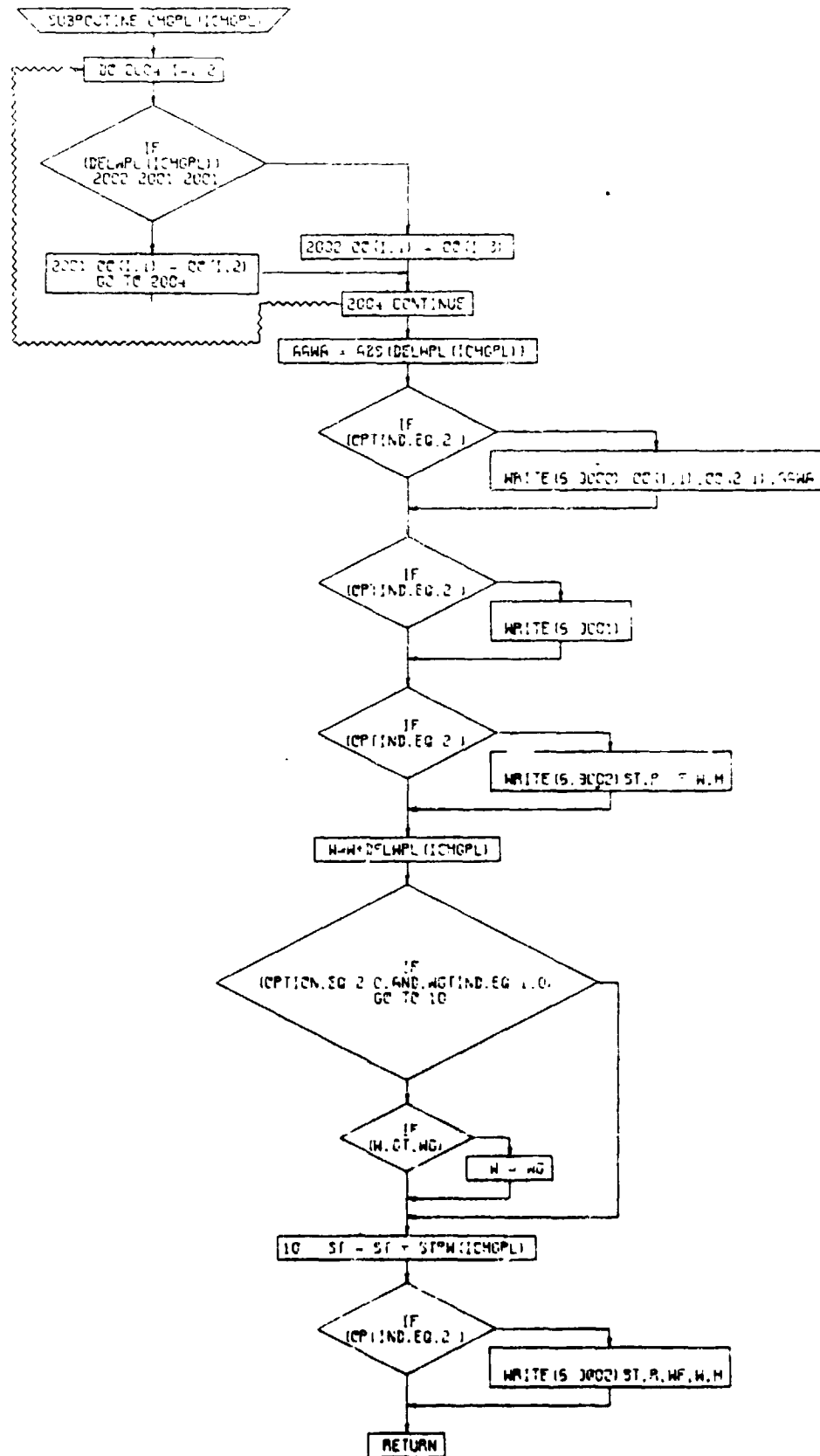


Figure 4-55. Change of Payload Weight Subroutine, Flow Chart

#### 4.10.8 Transfer Altitude

There are many different applications for which a discontinuous change in altitude may be desirable:

- a. The flight profile may require takeoff at hot day, high altitude conditions followed by climb from sea level to specified altitude for standard day conditions.
- b. It may be required that no credit be taken for range, fuel, or distance during descent (for example, Reference 5).
- c. It may be required to study cruise speed at specified power at a series of different altitudes. This can be accomplished by a series of very short cruise segments interspersed with altitude transfers.

For these and other reasons, the program includes a transfer altitude segment, specified by SGTIND = 9. The only required input is the altitude to which the airplane is to be transferred.

Transfer altitude may also be used during an optimum altitude search when it is followed by a cruise. In that case, the altitude which is input represents the maximum altitude permitted for the subsequent cruise.

Figure 4-56 is a flow chart of this subroutine.



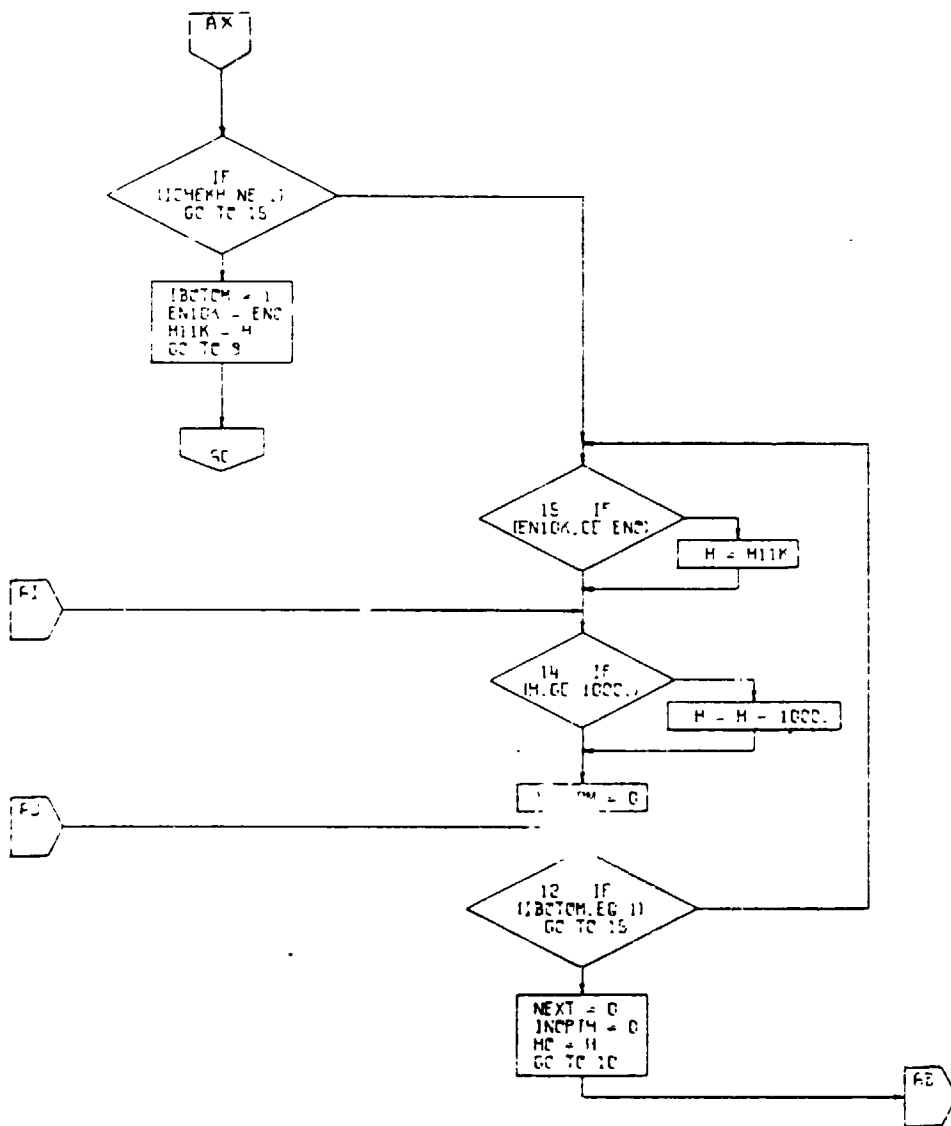


Figure 4-56. Transfer Altitude Subroutine, Flow Chart (Part 2 of 3)

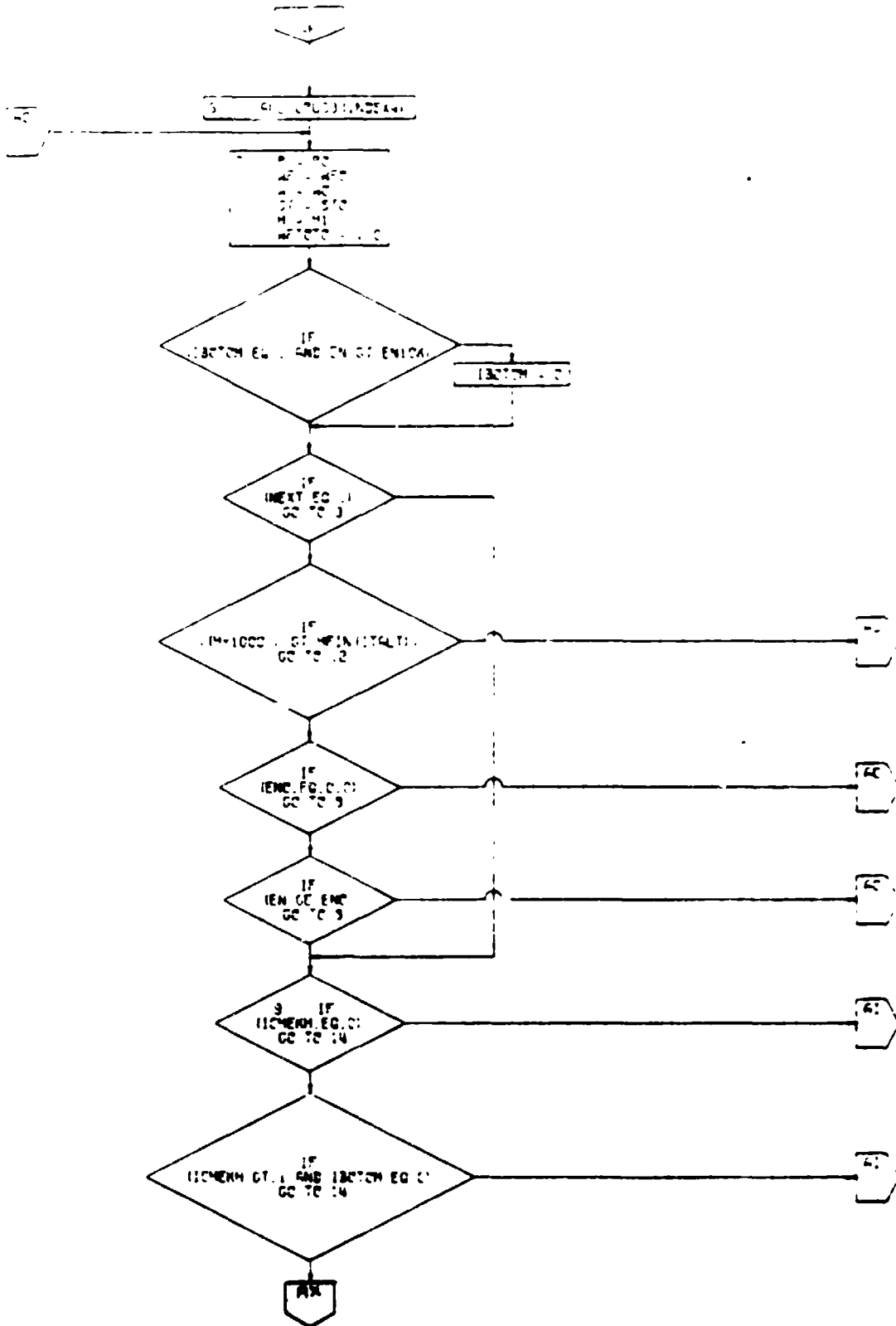


Figure 4-56. Transfer Altitude Subroutine,  
Flow Chart (Part 3 of 3)

#### 4.10.9 General Performance

SGTIND = 11 represents the calculation of aircraft general performance. The general performance calculation is used on gross weight or a change in gross weight as determined by the input indicator GWIND. If

GWIND = 1. - User inputs the incremental change in gross weight into LOC(2211)

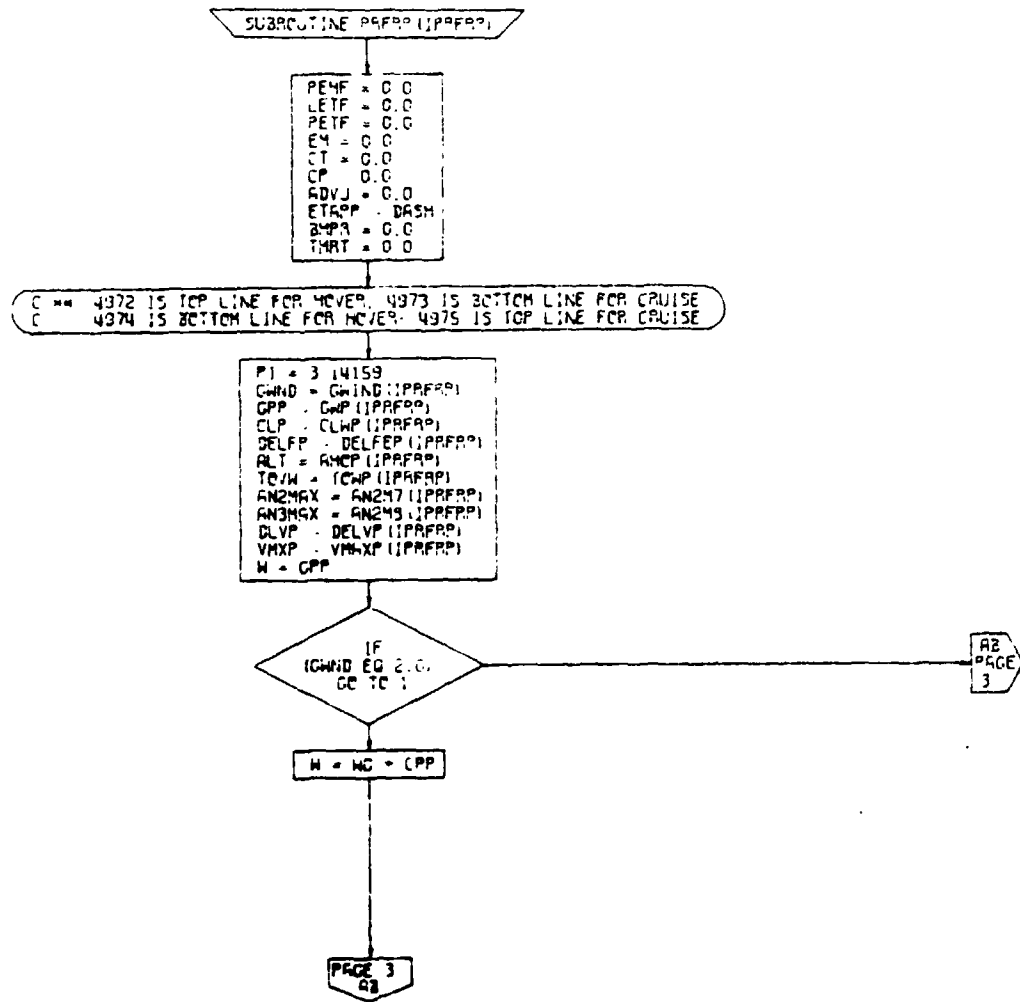
GWIND = 2. - User inputs gross weight into LOC(2211).

The Fortran code of the general performance subroutine has been assembled primarily from existing VASCOMP II coding. The program section for hover utilizes the coding from subroutine TOHL, with a built-in TOLIND value (LOC(0601)) equal to 1.0. In general performance the user inputs required thrust to weight, LOC(2271). The airplane will use maximum power from lift engines before augmenting with primary engines, or will use only primary engines if no lift engines are specified, LOC(0013) = 0.

The cruise section of general performance is similar to the CRUS2 subroutine with CRSIND, LOC(0801) = 2. In general performance each iterative calculation is done at the present constant TAS.

The aircraft performance is calculated and printed out starting with the hover condition,  $V=0$ . The second performance set of values corresponds to the velocity,  $V_H$ , at the highest lift coefficient,  $C_{LMAX}$ , input in locations 0317 - 0324. The third performance set is printed out at the velocity  $V_H$  rounded up to the next highest tens value. This rounded velocity is referred to as  $V_R$ . Aircraft performance is then calculated and printed out in velocity increments specified in LOC(2291). Performance printed out after  $V_R$  utilizes the wing lift coefficient  $C_L$  input LOC(2231). In addition to the above inputs, the program user specified the altitude, temperature, power turbine speed ratio, thrust to weight, and incremental change in drag coefficient.

The general performance mission is usually input after an end of mission segment indicator, SGTIND = 0. A flow chart of the subroutine is shown in Figure 4-57.



PAGE 2  
PAFRP

Figure 4-57. General Performance Subroutine, Flow Chart (Part 1 of 13)

PAGE 2  
GE

```
Q25TR = Q2MAX*QAN24X  
P = Q25TR*VT  
LC = 0  
V = 0.0  
VM = 0.0  
VP = 0.0  
EAS = 0.0  
EN = 0.0  
CALL ATMC5 (ALT, ATCP (IPRFP), TJNGP (IPRFP))  
FTJNGP = 3.0 59*THETA - 459.69  
EM = V/SA  
DELRTM = DEL (R*STHETA)  
WDEL = W/DELTA  
WRITE (5,100), W, WDEL, ALT, DELRTM, FTJNGP, DELTA, THETA  
WRITE (5,4971)
```

IF (ETAIND.EG 0.0)  
ETA<sup>0</sup> = ETAP2

IF (DN:TFL.EG 1.0)  
GC TC 19

IF (JNDENG.NE 0)  
GC TC 14

\*\*\* IF ENGINE = 2 PROGRAM SETS ETAIND = 0; ETAP2 IS INPUT

14 CALL THRVL (TMAX,0.0)  
ILP = SHPA  
TKE = TPEA  
KE = NPLJM + 1  
TSUBP = ILP\*DELTA\*TP

CALL PCWAVL (TMAX,0.0)  
BLP = SHPA  
TKE = TPEA  
BHP<sub>SUP</sub> = BLP\*BHPF\*DELTA\*STHETA  
KE = NPLJM + 1

IF (ENGINE.EG 1.0)  
GC TC 9

BHP<sub>SUP</sub> = TSUBP/BETA  
GC TC 13

13 IF (ETAIND.NE 0.0)  
GC TC 23

BHP<sub>PS</sub> = (TOWP (IPRFP) \* 1.5 \* W \* GRT (MGA))  
1 / (350 \* ETAT \* ETAP2 \* 52840) \* B54PAC  
BHP<sub>R</sub> = BHP<sub>PS</sub>

IF (BHP<sub>SUP</sub> GE BHP<sub>PS</sub>)  
GC TC 11

\*\*\* BHP<sub>SUP</sub> = POWER AVAILABLE AND BHP<sub>PS</sub> = POWER REQUIRED

GC TC 22

PAGE 4  
GE

PAGE 3  
PRFP

Figure 4-57. General Performance Subroutine, Flow Chart (Part 2 of 13)



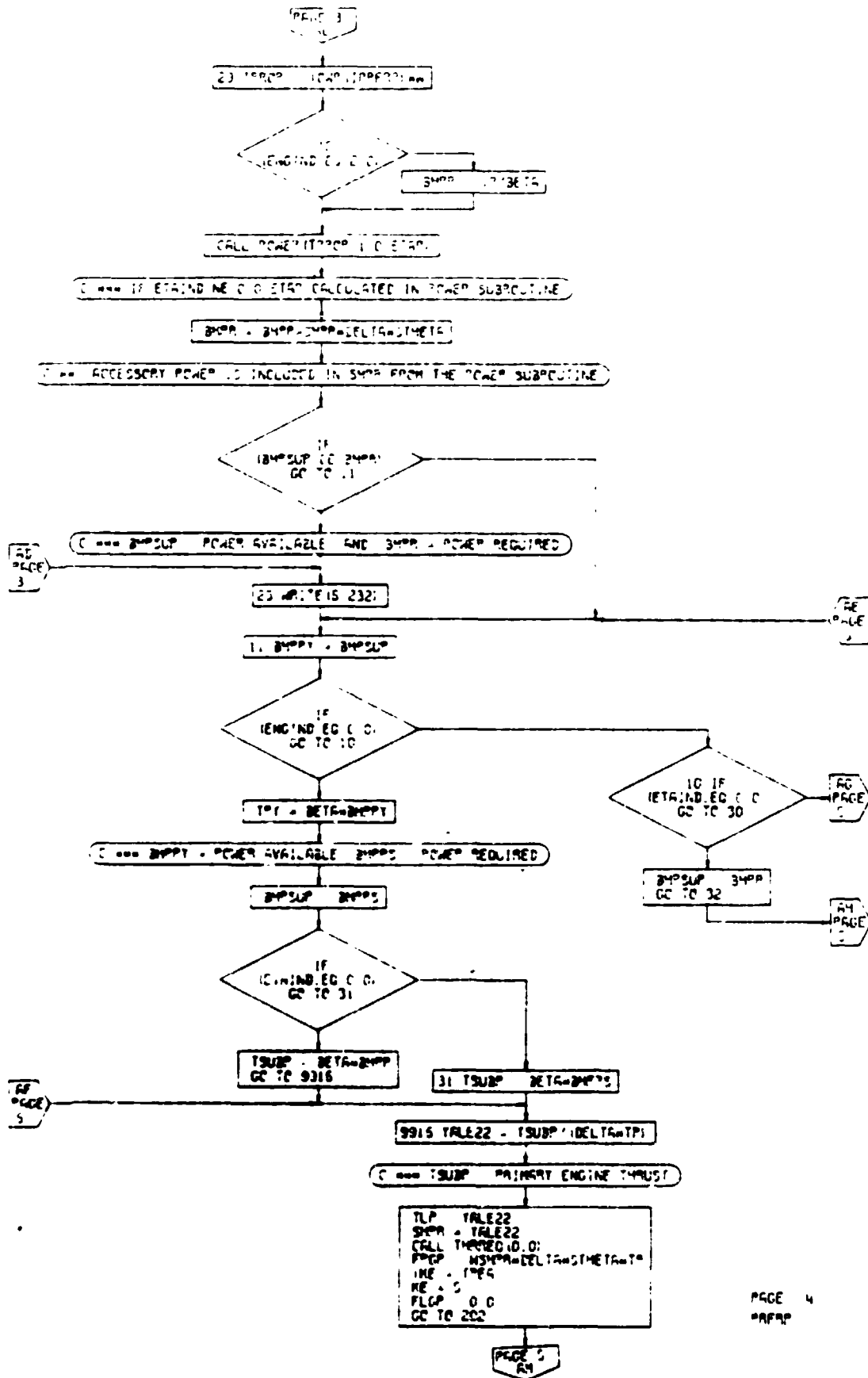


Figure 4-57. General Performance Subroutine, Flow Chart (Part 3 of 13)

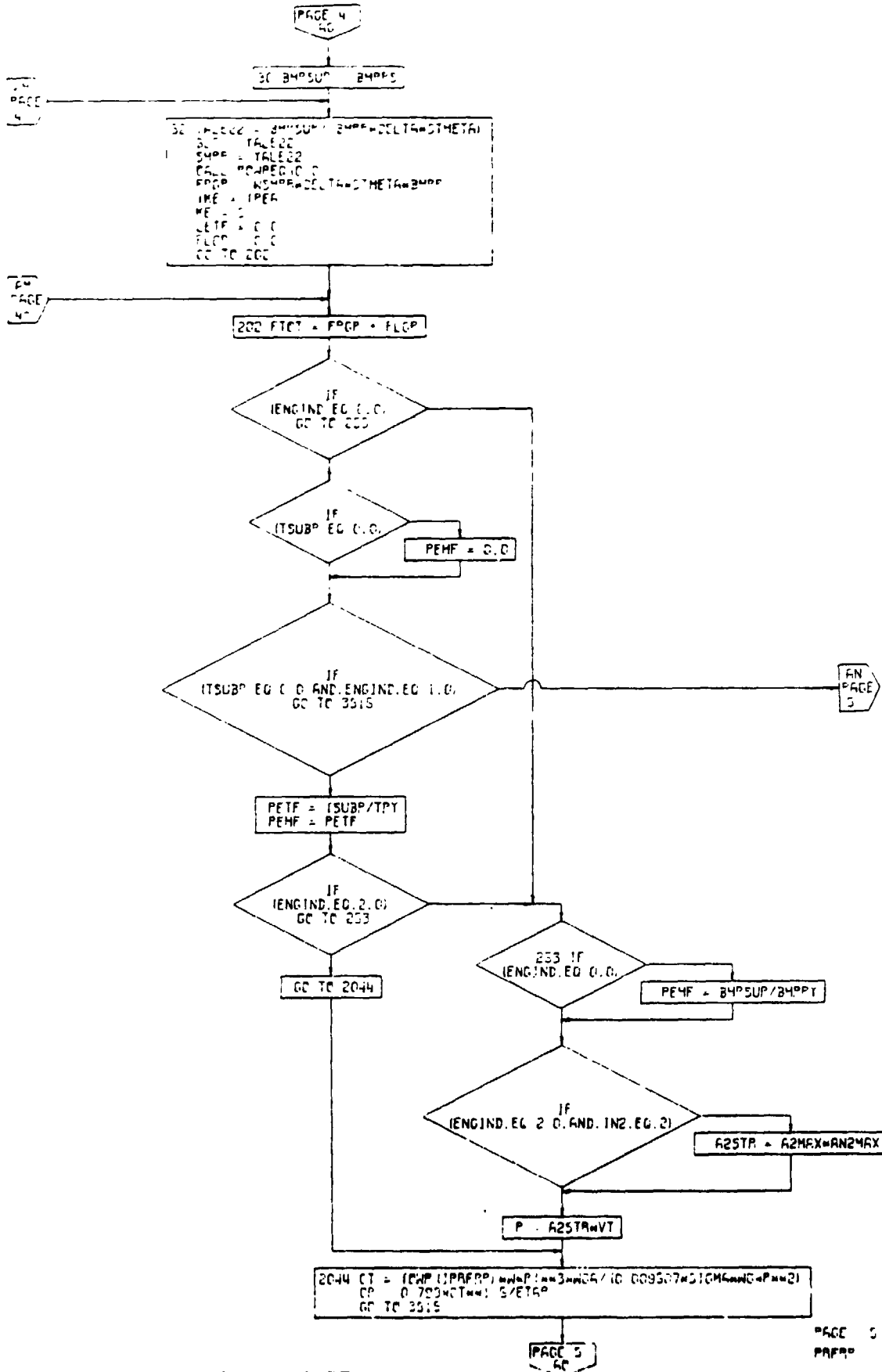
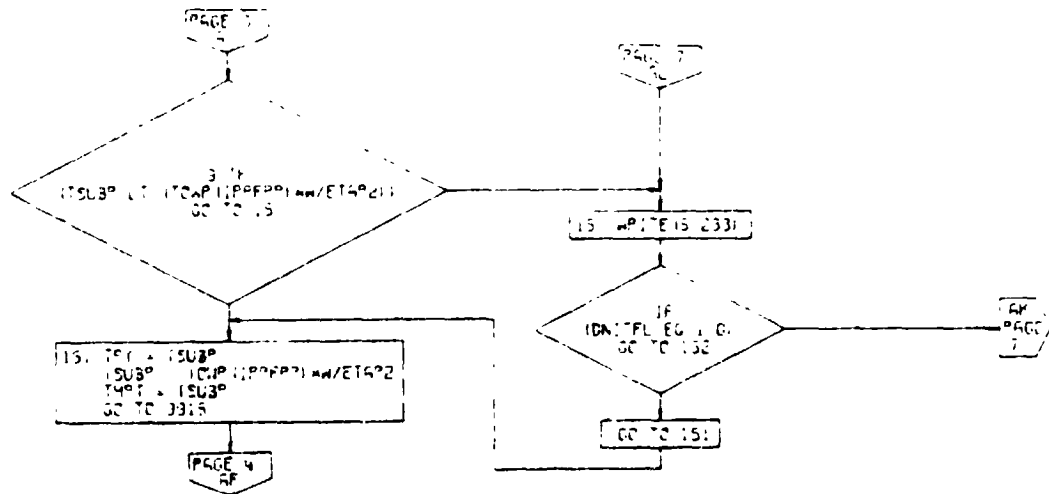
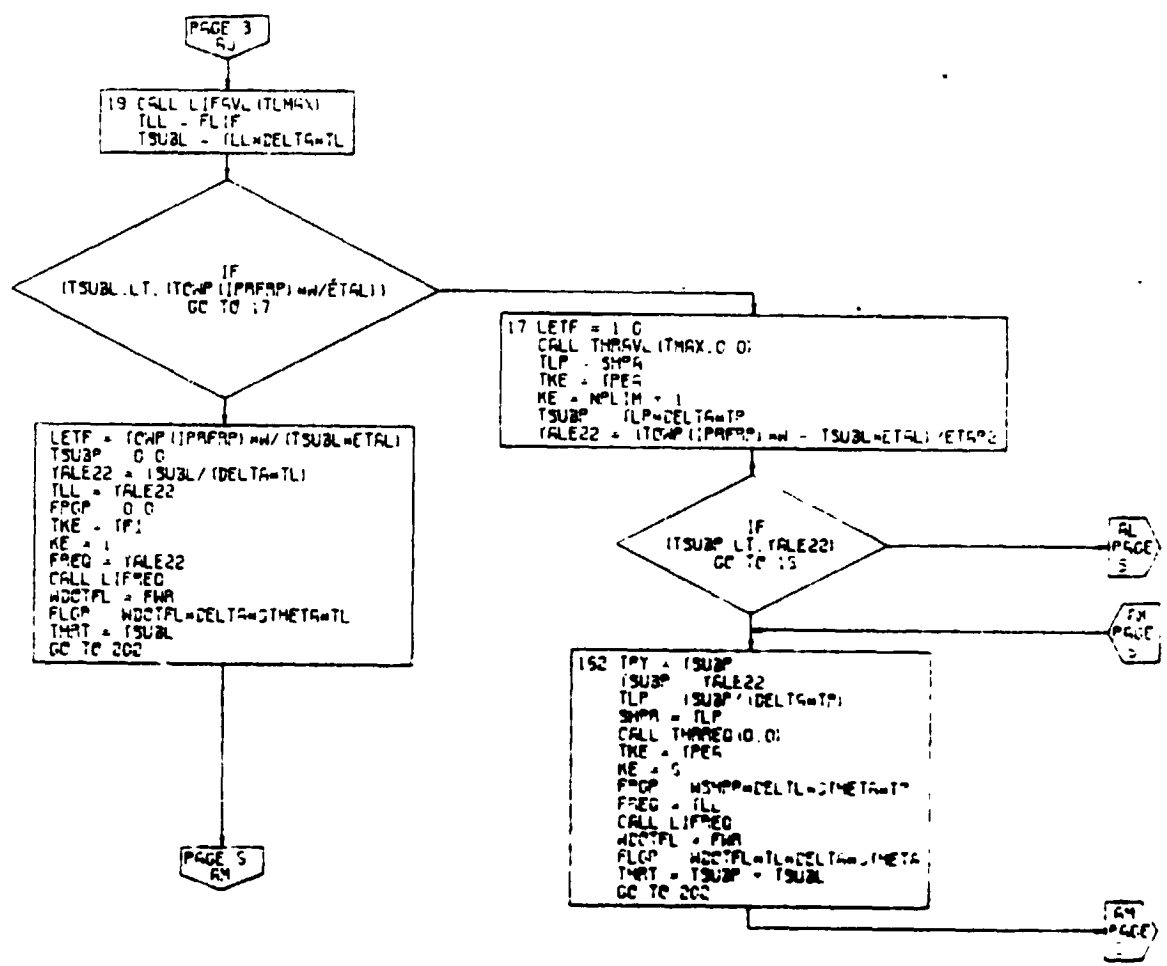


Figure 4-57. General Performance Subroutine, Flow Chart (Part 4 of 13)



PAGE 5  
PFRP



PAGE 7  
PFRP

Figure 4-57. General Performance Subroutine, Flow Chart (Part 5 of 13)

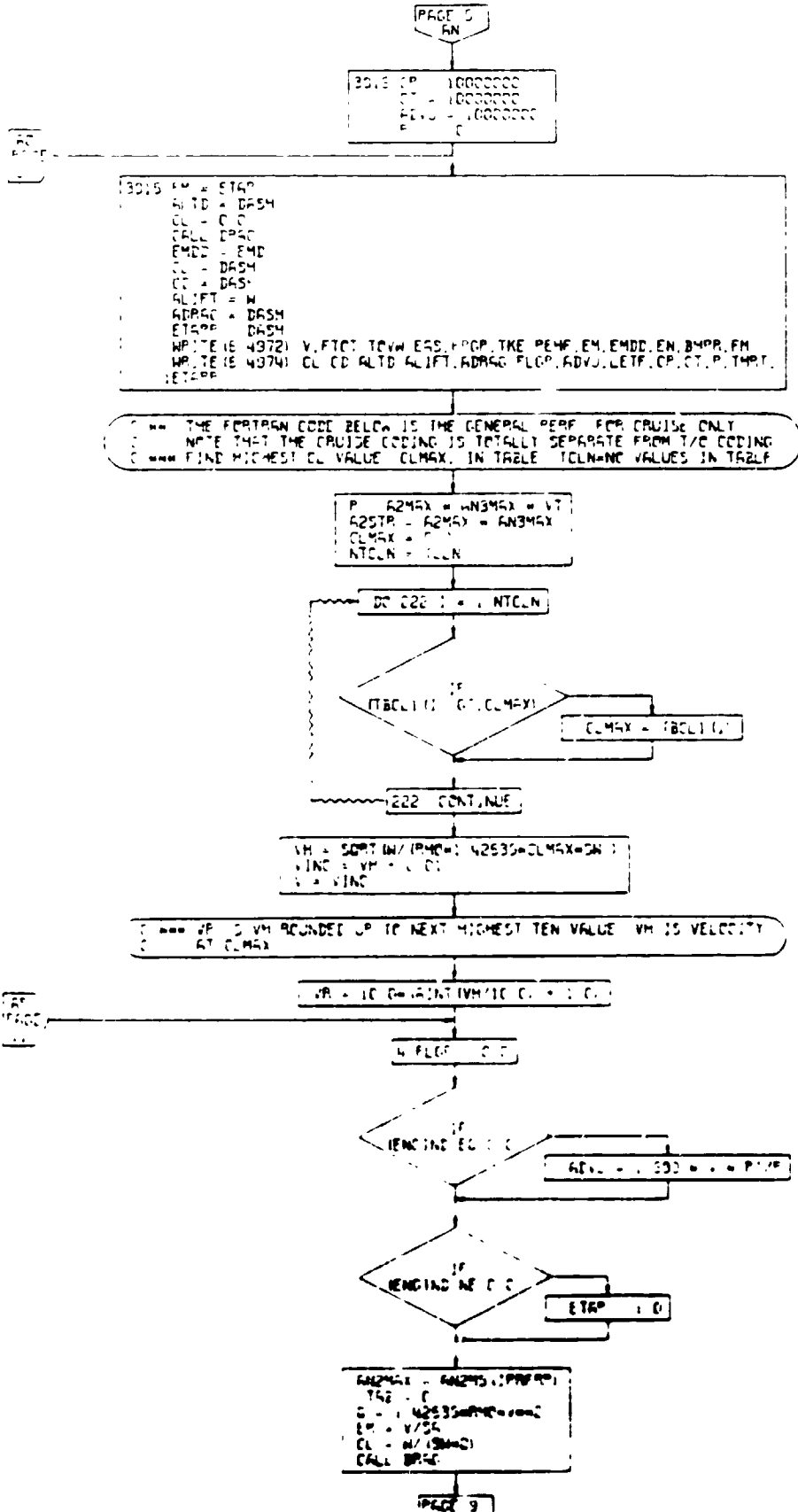


Figure 4-57. General Performance Subroutine, Flow Chart (Part 6 of 13)

4-318

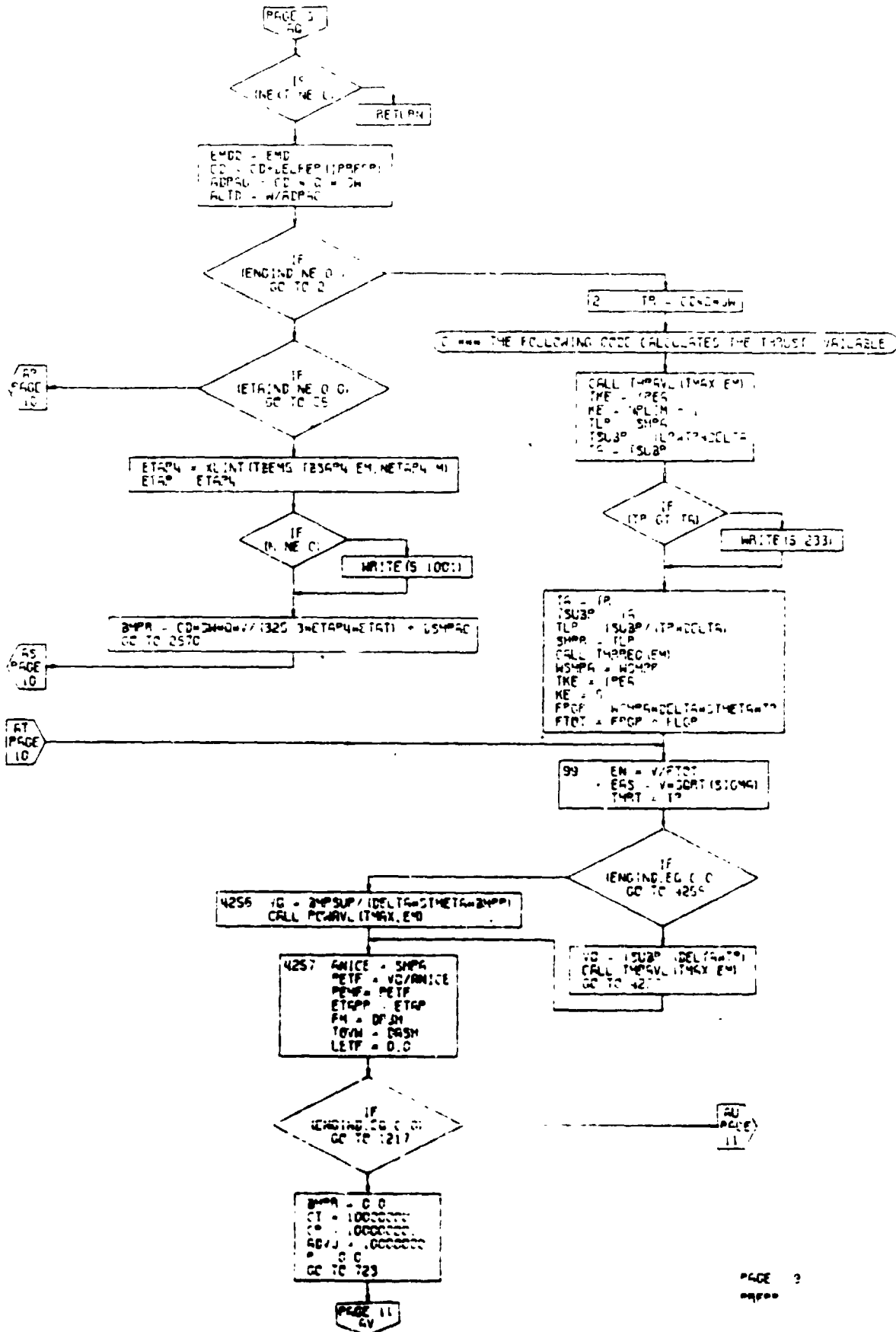


Figure 4-57. General Performance Subroutine, Flow Chart (Part 7 of 13)

```
CE TPRP CDWKG  
YLS2 = 1.0  
CALL POWER(TPRP,YLS2,ETAP)  
BMPA = SHPPWBPWDELTA*STHETA
```

C \*\* ACCESSORY POWER IS INCLUDED IN THE POWER SUBROUTINE  
C \*\*\* BELOW IS CODE YIELDING AVAILABLE POWER. THIS OPTION COMPARES POWER  
C REQUIRED TO POWER AVAILABLE FOR PERH AND FUTURE MODIFICATIONS

PS  
PAGE

```
2570 CALL FCWAVL(TMAX,EM)  
TKE = IPEA  
KE = NPLIM-1  
BLP = SHPP  
B4PSUP = BLP*DELTA*STHETA*BMPA  
B4PA = B4PSUP
```

IF  
(B4PA GT B4PA)

WRITE(S 232)

```
B4PA = B4PA  
B4PSUP = B4PA  
BLP = B4PSUP / (BMPA*DELTA*STHETA)  
SHPP = BLP  
CALL PCWREG(EM)  
WSHPP = WSHPP  
TKE = IPEA  
KE = 0  
FPCP = WSHPP*DELTA*STHETA*BMPA  
FTOT = FPCP + ILOP  
GC TO 93
```

AT  
PAGE  
3

Figure 4-57. General Performance Subroutine,  
Flow Chart (Part 8 of 13)

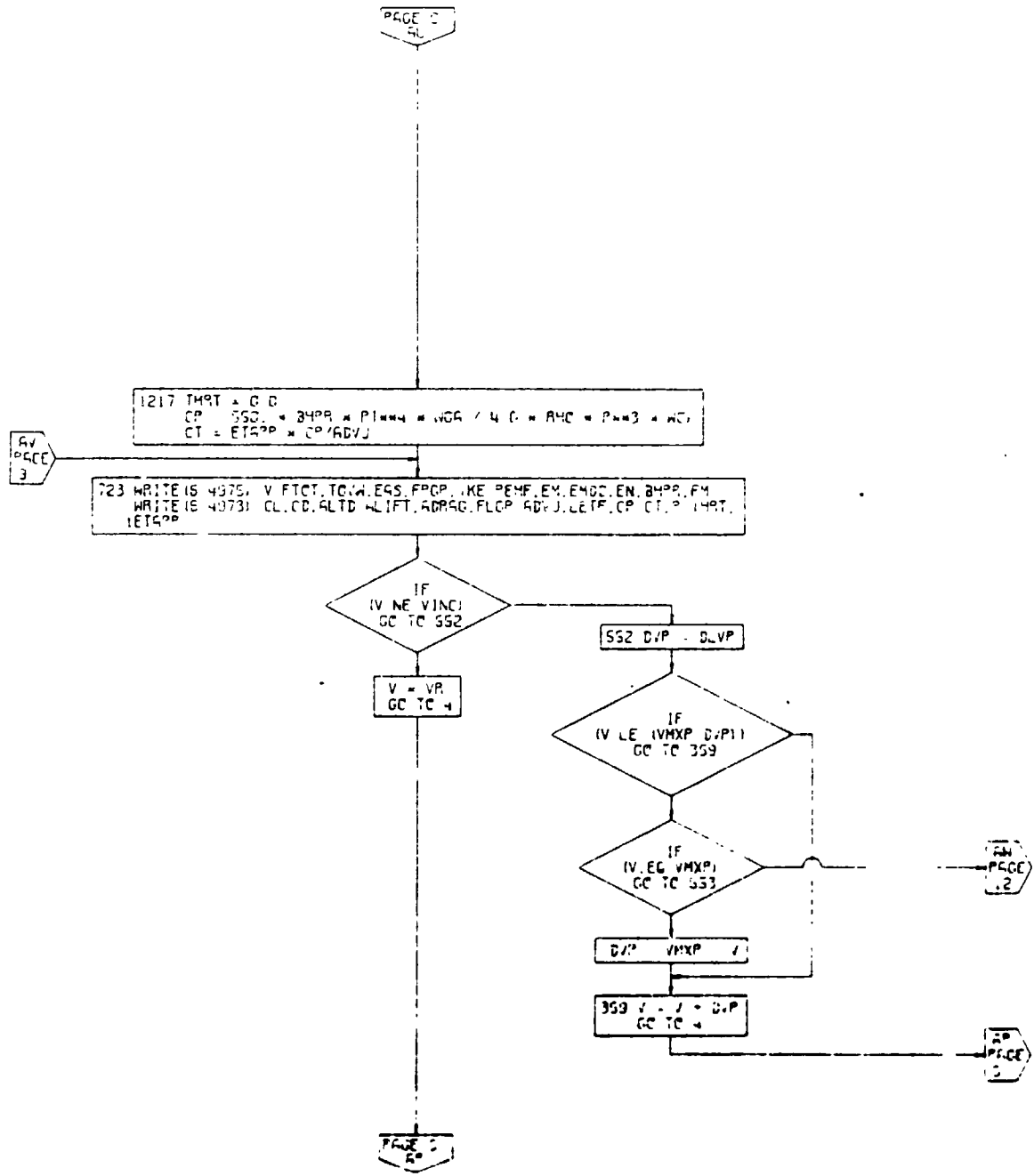


Figure 4-57. General Performance Subroutine, Flow Chart (Part 9 of 13)

553 CONTINUE

C \*\*\* END OF POWER SPEED CALC BEGIN SPEED (TEMP) AND TORQUE LIMIT CALC

```

LOS = 0
LOS = 0
INDSGT = 11
ICRUS = IPREFP
VIN(ICRUS) = 0.0
ATMIND(ICRUS - 30) = ATGP(IPREFP)
DELF(ICRUS) = 2.0
TIM(ICRUS - 30) = TINGP(IPREFP)
PMAX(ICRUS) = 2.0
ENPSD(ICRUS) = 0.0
AN2M4(ICRUS) = AN2M3(IPREFP)
DLCICR(ICRUS) = DELFEP(IPREFP)
LCITR = IPREFP
DNIRTL(LCITR) = 1.0
RELSI(LCITR) = 0.0
ATMIND(LCITR - 30) = ATGP(IPREFP)
STL(LCITR) = 0.0
TIM(LCITR - 30) = TINGP(IPREFP)
ENPSD(LCITR) = 0.0
AN2M5(LCITR) = AN2M3(IPREFP)
DLCITR(LCITR) = DELFEP(IPREFP)
PSH(LCITR) = 1.0
POWER(ICRUS) = 2.0
CALL CRUS(ICRUS)

```

IF (INPLIM.EG 4) → VGLIM = V

IF (INPLIM.EG 4) → LOS = .

C \*\* INPLIM IS AN ENGINE OPERATING CODE WHICH IS PASSED FROM POWER

IF (INEXT.EG 1) → LC1 = 1

IF (INPLIM.NE 4) GO TO 100

C \*\* NOTE - TORQUE LIMIT CONDITION EXISTS EITHER WHEN OPERATING NO. IS GREATER THAN 3 OR SIZE NUMBER OF WHEN ENGINE CODE LIMITED

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 426 = 4251\*

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PAGE 11

Figure 4-57. General Performance Subroutine. Flow Chart (Part 10 of 13)



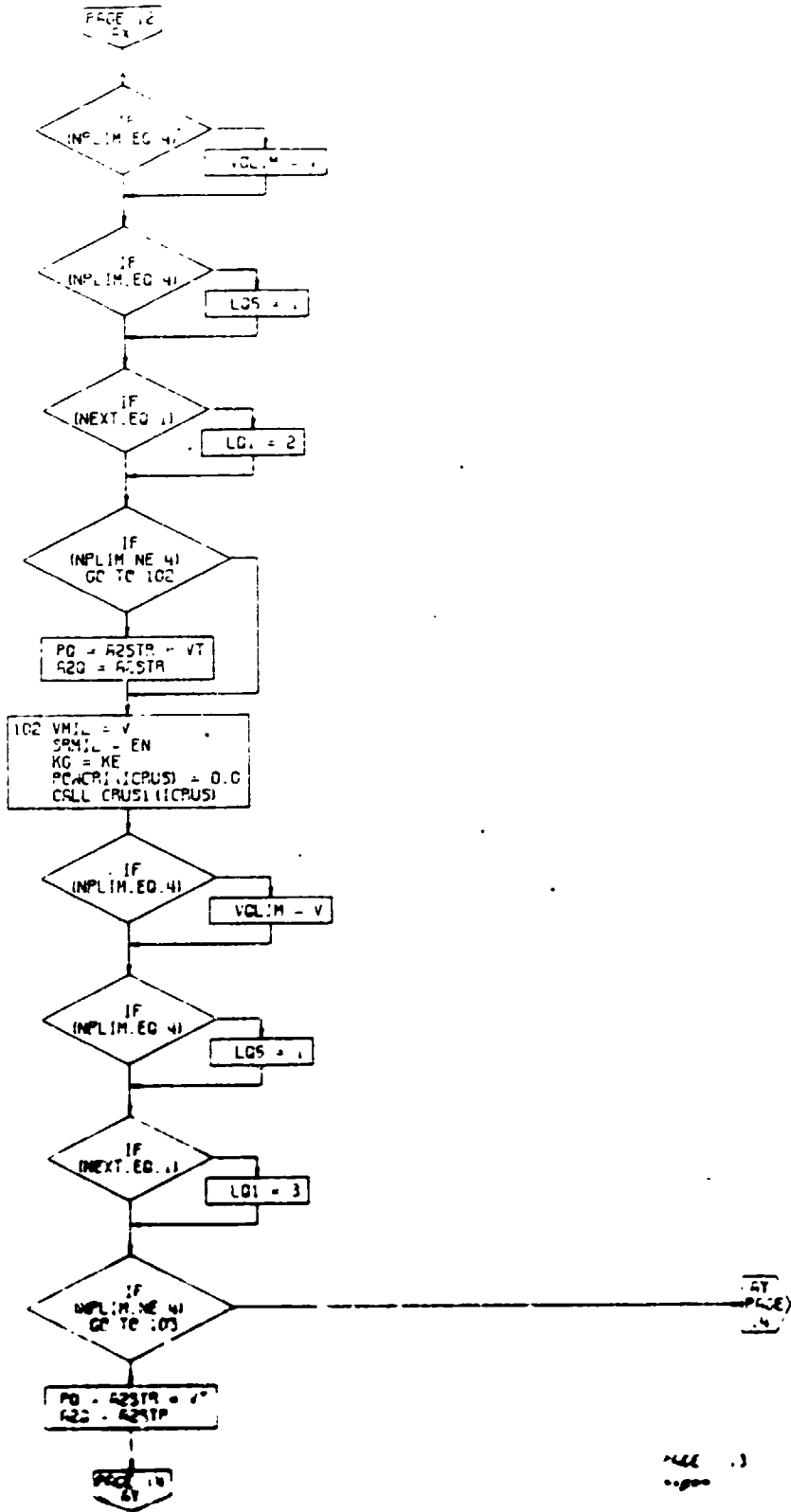


Figure 4-57. General Performance Subroutine,  
Flow Chart (Part 11 of 13)

```

ICE VMXCP V
SMAX = EN
M = KE
(CSIND(JCRUS) = 3 0
CALL (CRUS3(JCRUS)
VBE = V
SDEP = EN
M = KE
(CSIND(JCRUS) = 4 0
CALL (CRUS3(JCRUS)
V992P = V
S992P = EN
M = KE
CALL (COTR1(LC1TR)
VBE = V
FFBE = F1
M = KE

```

IF  
(CIND, C1, C, C)  
GC TO 24

```

WRITE (5, LOG7)
GC TO 2305

```

24 IF  
(LOG5 NE 1)  
GC TO 45

```

P = PG
A2STR = A2C
RPM = 50 * P / (P1ND)
24PG = 0MAX * 34PF * AN2TC * AN3MAX * A2MAX/ANXMAX

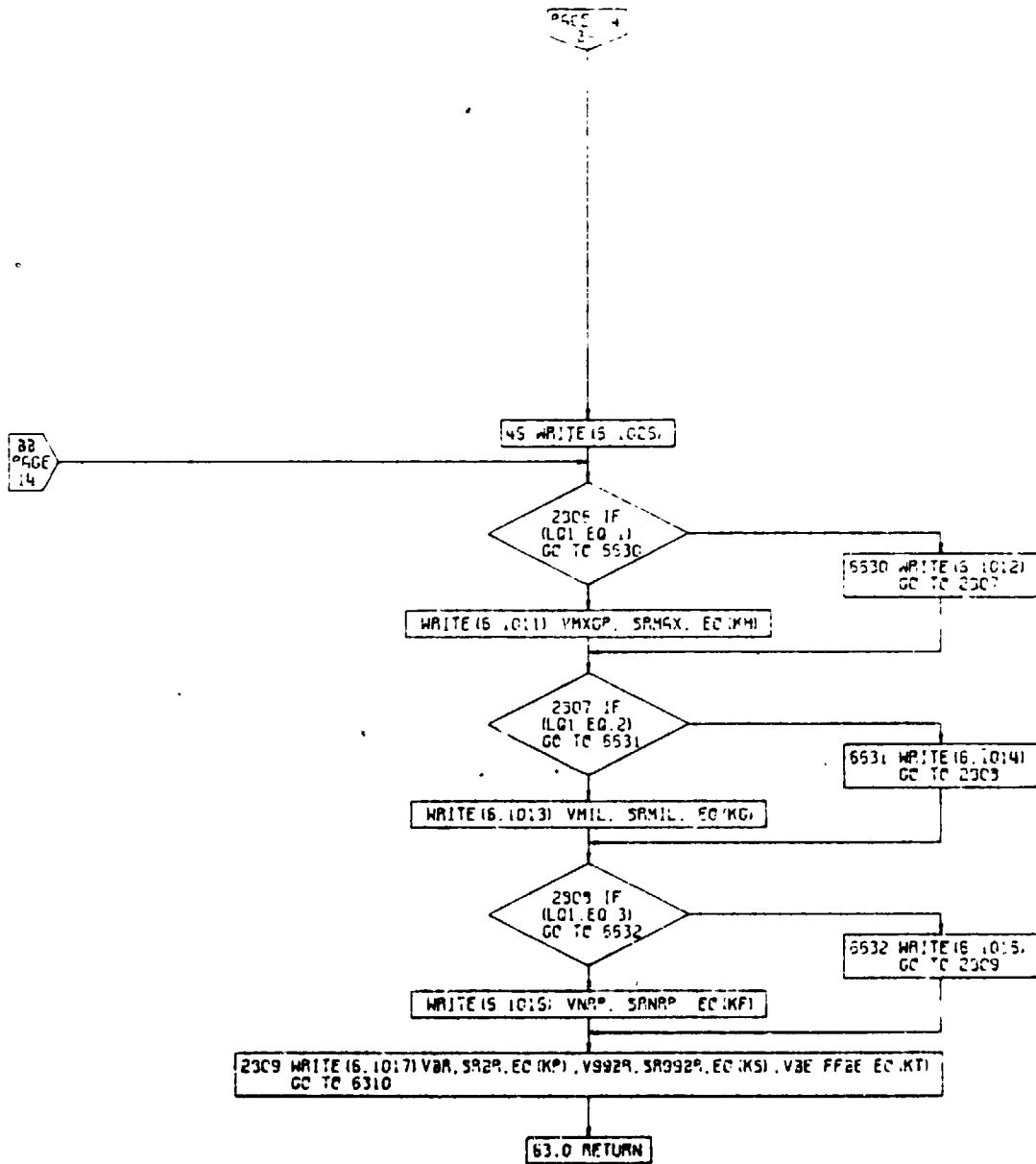
```

```

XCLM = 275 * BHPG * D/P
WRITE (5, LOG5, VCLIM, P, RPM, 24PG, XCLM)
GC TO 2305

```

Figure 4-57. General Performance Subroutine, Flow Chart (Part 12 of 13)



PAGE 15  
PAGE

Figure 4-57. General Performance Subroutine,  
Flow Chart (Part 13 of 13)

4.10.10 Function BIV

Function BIV is a two-dimensional Bivarian table look-up used to interpret values such as referred thrust or horsepower, referred fuel flow, and referred  $N_1$  and  $N_{11}$ . The BIV function performs a linear interpolation between two points on the ordinate and two points on the abscissa. A flow chart of the subroutine is shown in Figure 4-58.

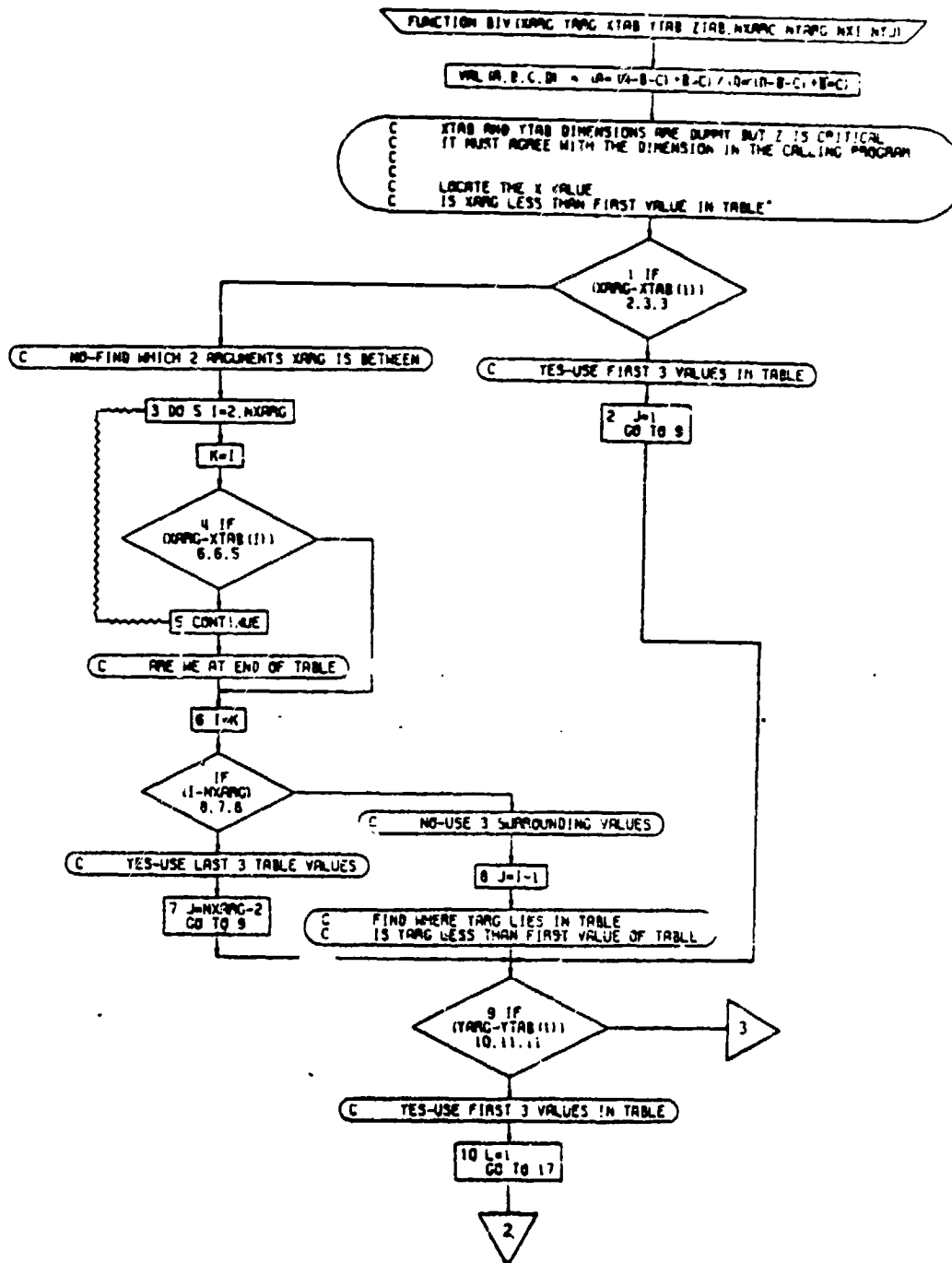


Figure 4-58. BIV Function, Flow Chart (Part 1 of 2)

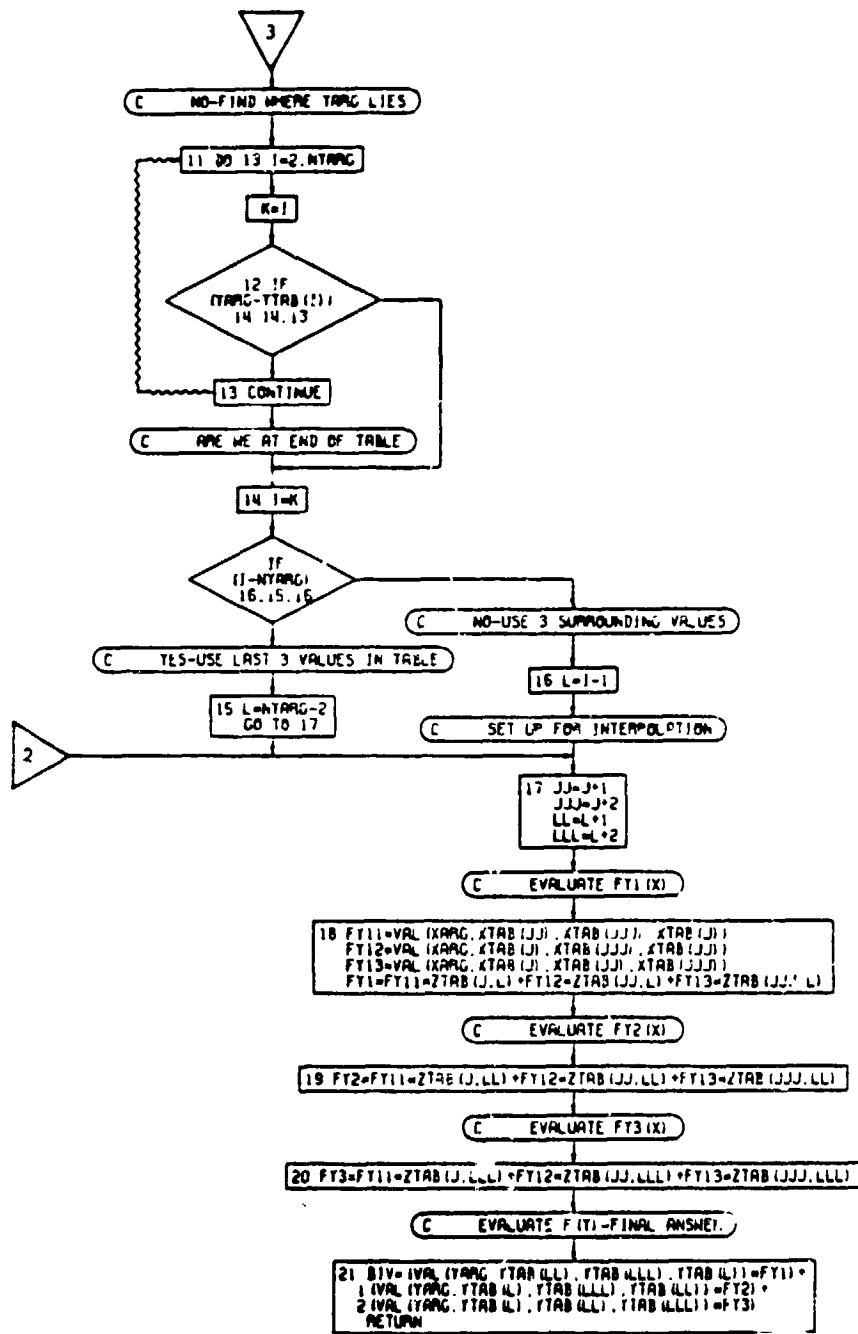


Figure 4-58. BIV Function, Flow Chart (Part 2 of 2)

#### 4.10.11 Function PARA

PARA is a two-dimensional parabolic interpolation function used periodically throughout VASCOMP. A flow chart of the subroutine is shown in Figure 4-59.

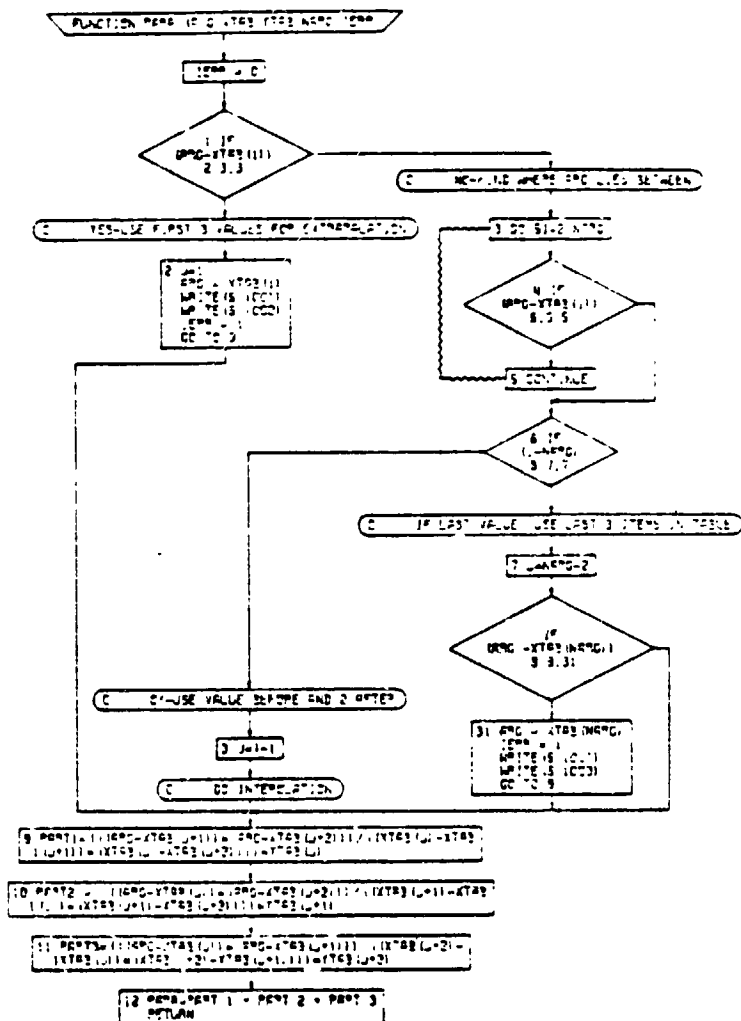


Figure 4-59. PARA Function, Flow Chart



4.10.12 Function Table

TABLE is a fourth-order Lagrangian interpolation function shown flowcharted in Figure 4-60.

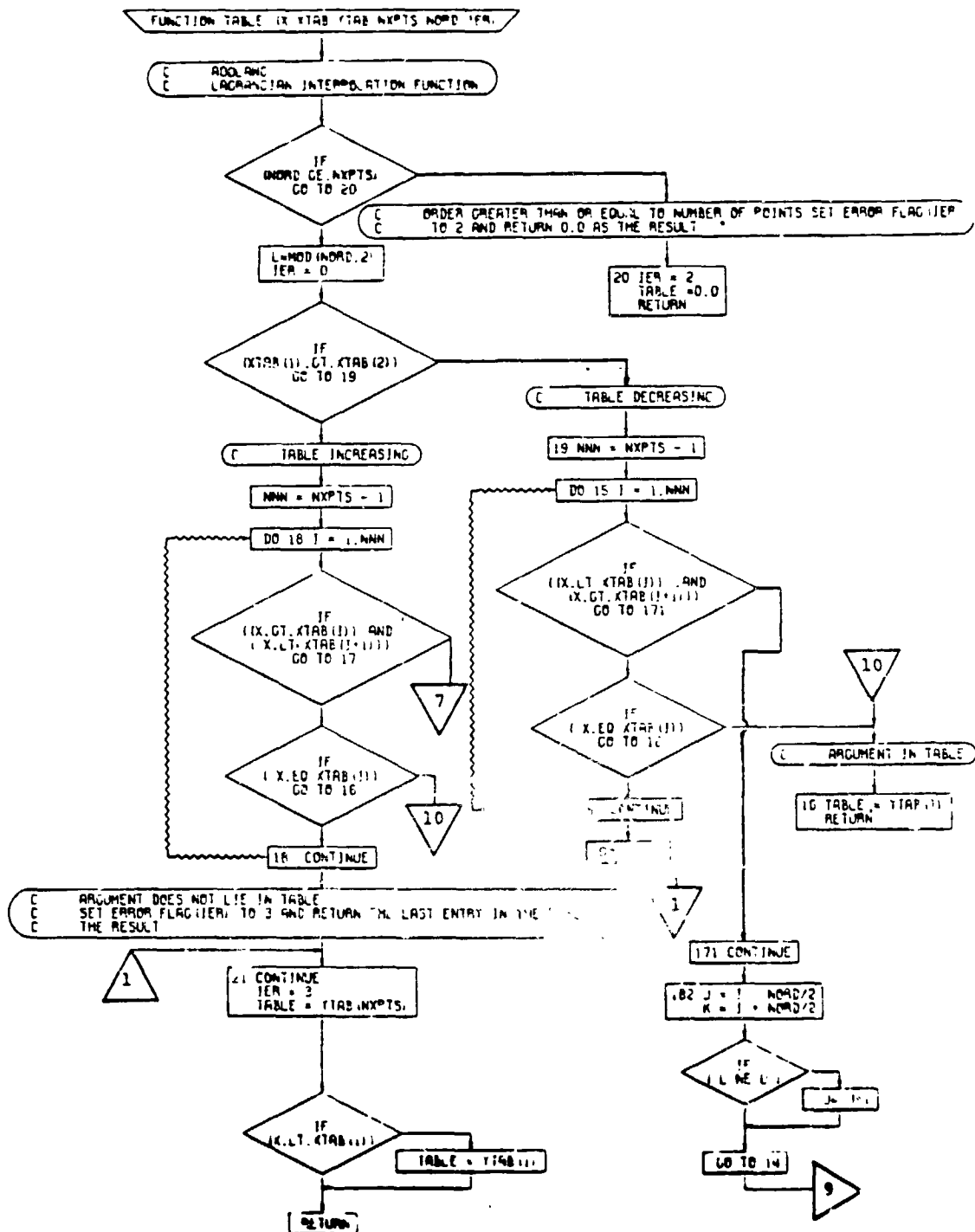


Figure 4-60. TABLE Function, Flow Chart (Part of 2)



#### 4.10.13 Function XLINT

XLINT performs a two-dimensional linear interpolation between two points. This subroutine is used extensively in subroutines ROTLIM and ROTPOW, and shown in flowchart form in Figure 4-61.

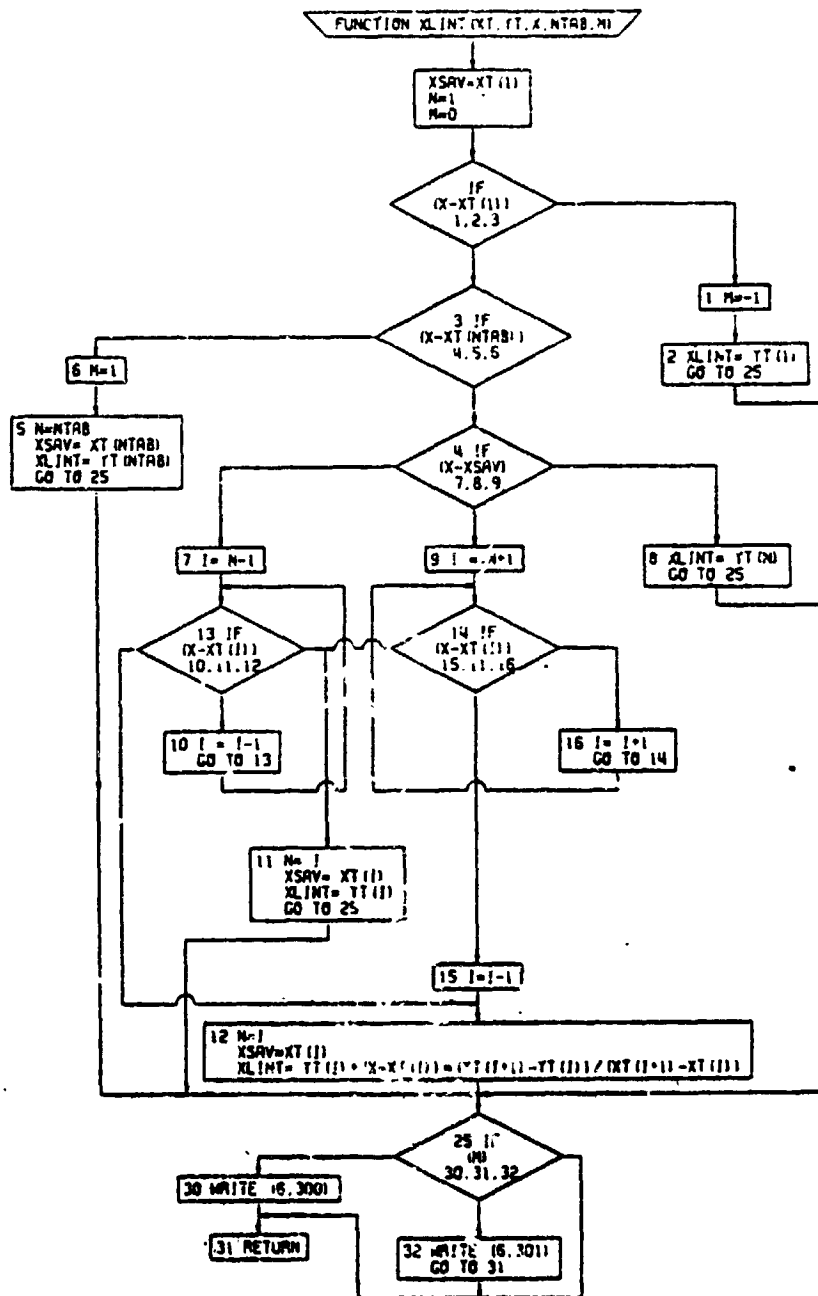


Figure 4-61. XLINT Function, Flow Chart

4.10.14 Function XLKUP

XLKUP is a double table parabolic look-up function. A flowchart of the subroutine is shown in Figure 4-62.

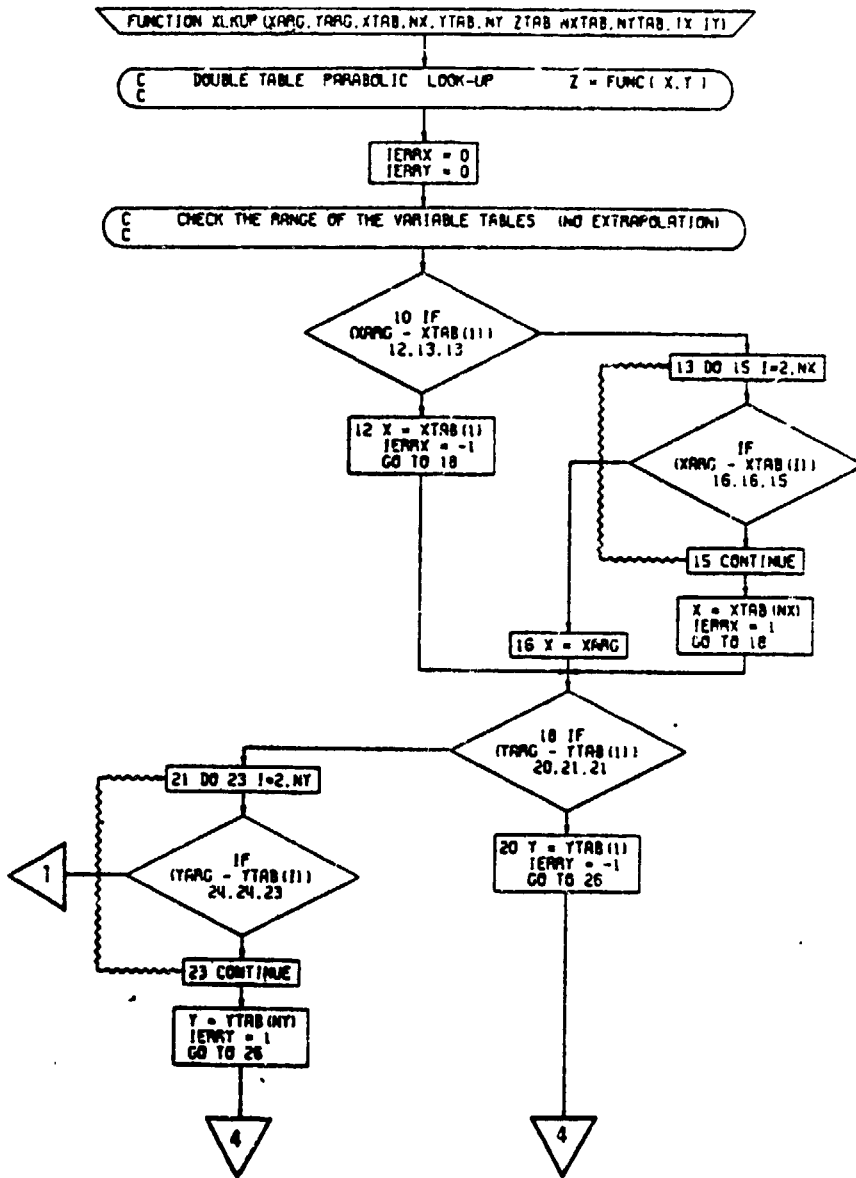


Figure 4-62. XLKUP Function, Flow Chart (Part 1 of 2)





4.10.15 Function XIBIV

XIBIV is an inverse double table parabolic look-up. A schematic of the flowchart is shown in Figure 4-63.

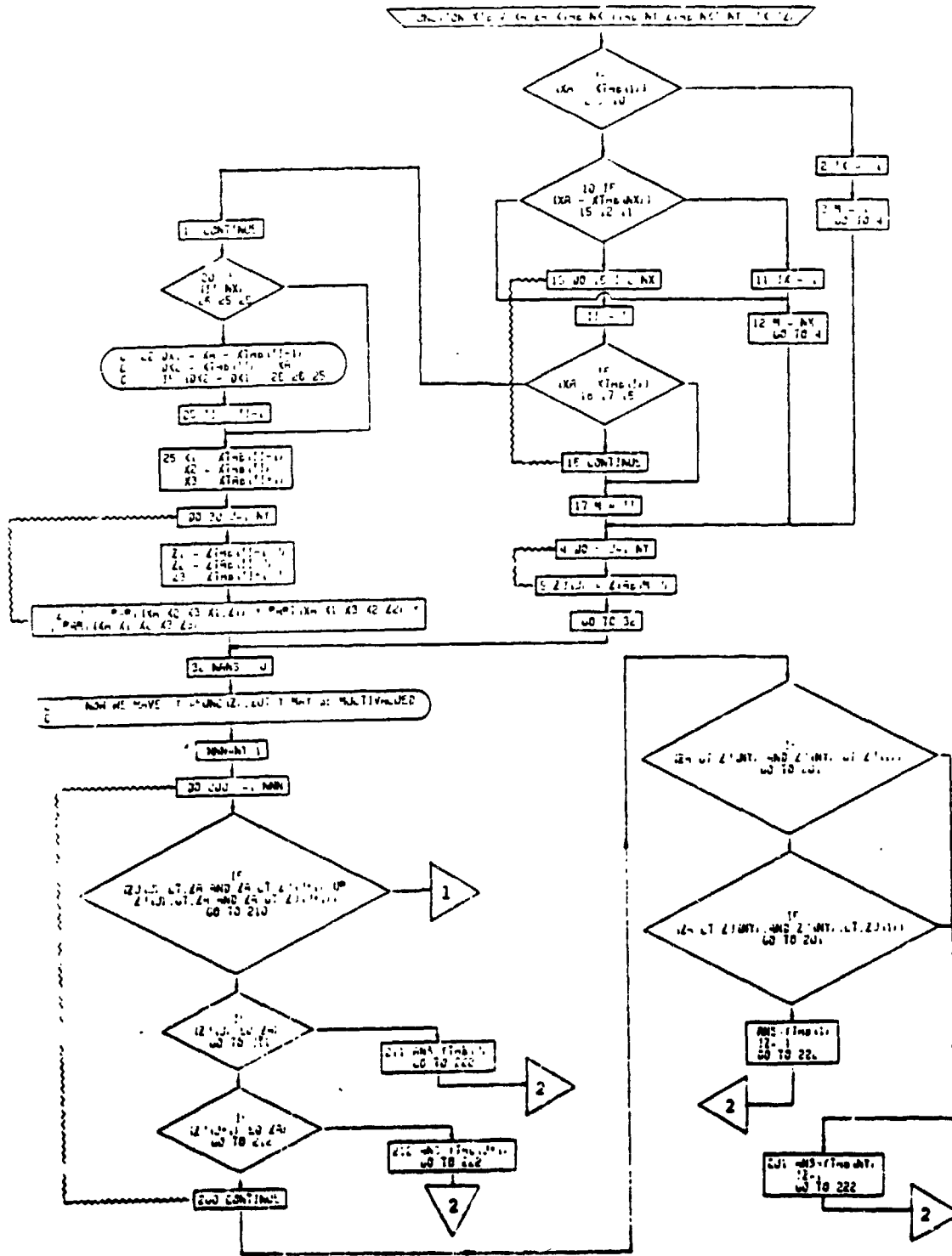


Figure 4-63. XIEIV Function, Flow Chart (Part 1 of 3)





## 5.0 PROGRAM INPUT

### 5.1 GENERAL

Input to the program is made by means of a standard set of input sheets. Although there are large quantities of possible input, necessitated by the requirement to keep the program flexible and general, the input sheets have been configured to give maximum visibility and reduce the tediousness of inputting the data. This has been accomplished through several means:

- a. All input of a similar nature has been grouped together. Thus, all dimensional information is on the same input sheet, regardless of whether it is used in the size trends subroutine or elsewhere.
- b. The input sheets have been color-coded to distinguish between the data required in the sizing option (OPTIND = 1) and the much smaller amount of data required for performance calculations (OPTIND = 2 or 3).
- c. Footnotes on the input sheets call attention to input which is not required due to selection of one of the optional paths of computation.
- d. For parametric studies where only one or two variables are being changed from case to case, a special supplementary input sheet may be used, thus reducing the quantity of paper work.

Altogether there are twenty-four different input sheets which can be loosely grouped into six categories: general information, aircraft descriptive information, mission profile information, engine cycle information, propeller data, and supplementary information. A specimen copy of each input sheet is included in this report on pages 5-5 to 5-51. Descriptions of input variables and indicators are given in sections 5.3.1 and 5.3.2. The use of the various input sheets is discussed below in 5.1.1 and 5.1.2.

#### 5.1.1 General Information

Input all primary program indicators (except those for specific mission segments, such as CRSIND), mission

initial conditions, reserve fuel factors, and maneuver load factor.

### 5.1.2 Aircraft Description Information

- 5.1.2.1 Dimensional Information - Input characteristic geometric information for aircraft being studied.
- 5.1.2.2 Propulsion Information - Input data for propulsive efficiencies, numbers of engines, engine clusters, propellers, etc., and critical engine sizing conditions. There are four different input sheets for propulsion information - divided into one sheet for propeller data when using turboshaft engines and one sheet for each of the engine types which may be selected: turboshaft (ENGIND = 0), turbojet or turbofan (ENGIND = 1), and convertible (ENGIND = 2). Thus, the user need select only the input sheet(s) corresponding to the type of engine which he is using.
- 5.1.2.3 Aerodynamics Information - Input aircraft drag characteristics and wing section lift characteristics.
- 5.1.2.4 Weight Information - Input the factors and constants for weight trends calculations.

### 5.1.3 Mission Profile Information

There are 8 input sheets for mission profile information. They are:

- a. Taxi Information
- b. Takeoff, Hover, and Landing Information
- c. Climb Information
- d. Cruise Information
- e. Descent Information
- f. Loiter Information
- g. Change of Weight and Transfer Altitude Information (incorporating change of fuel weight, change of payload weight, and transfer altitude)
- h. General Performance

Each input variable on the mission profile sheets is represented by an array of ten input locations. The data for these locations is filled in sequentially by rows as the particular mission segment is used. For example, the first time that taxi is used in a particular case, the required input information is filled in on the first row of the input sheet. Data for the second taxi of a case is filled in on the second row, and so on. Thus, up to ten of any particular segment may be used in a case.

#### 5.1.4 Engine Cycle Information

The engine cycle sheets may be used to input engine cycle data when one of the standard engine cycles is not used. The five engine cycle sheets are divided into standard performance information and nonstandard performance information. The standard performance data, of which there are three sheets (two for primary engines and one for lift engines), represent the performance of idealized engine cycles. These data are unlimited except for the effect of engine ratings, which are dictated by values of turbine temperature. The nonstandard performance represents limiting values of fuel flow, torque, rpm and other nonstandard effects.

#### 5.1.5 Propeller Performance Data

The propeller performance sheets may be used to input a data for a specific propeller when using  $\eta_{IND} = 1$ , or a specific fan using  $\eta_{IND} = 3$ . The data is input as a table of  $C_p$  as a function of  $C_m$  and  $J$ .

#### 5.1.6 Supplementary Information

The supplementary input sheet may be used for the second and subsequent cases of a parametric study. For example, if the user wishes to change both the wing loading (location 0106 - see dimensional information sheet) and the disc loading (location 0225 - see propulsion information sheet), these locations and their new values may be filled in on the supplementary input sheet.

Two typical problems, from input to output, are discussed in Section 7.3.





VASCOMP II - STOL AIRCRAFT SIZING AND PERFORMANCE COMPUTER PROGRAM

INPUT INFORMATION

WING PLANFORM

WING PLANFORM	
WING AREA	0104
WING SPAN	0105
WING CHORD	0106
WING TIP CHORD	0107
WING ROOT CHORD	0108

HDF

WING TIP	0109
WING ROOT	0110
WING CHORD	0111
WING TIP CHORD	0112
WING ROOT CHORD	0113

PROP

PROP DIAMETER	0114
PROP PITCH	0115
PROP RPM	0116
PROP EFFICIENCY	0117
PROP WEIGHT	0118
PROP TORQUE	0119

GENERAL

SWAY SW	0120
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BODY

WING AREA	0121
WING SPAN	0122
WING CHORD	0123
WING TIP CHORD	0124
WING ROOT CHORD	0125
WING AREA	0126

VERT. TAIL

VERT. TAIL AREA	0127
VERT. TAIL SPAN	0128
VERT. TAIL CHORD	0129
VERT. TAIL TIP CHORD	0130
VERT. TAIL ROOT CHORD	0131
VERT. TAIL AREA	0132

MAIN GEAR

MAIN GEAR	0133
-----------	------

PRIM. ENG.

PRIM. ENG.	0134
------------	------

LIFT ENG.

LIFT ENG.	0135
LIFT ENG.	0136

PRIM. ENGINE NACELLE

PRIM. ENGINE NACELLE	0137
PRIM. ENGINE NACELLE	0138
PRIM. ENGINE NACELLE	0139
PRIM. ENGINE NACELLE	0140
PRIM. ENGINE NACELLE	0141

NOTE: INPUT NOT NECESSARY WHEN:

- a. WDMIND = 1,2
- b. WDMIND = 0
- c. DRGIND = 1 & OPTIND = 2
- d. FDMIND = 0,2
- e. FDMIND = 1,2
- f. LFTYND = 0
- g. ENGINDD = 1
- h. WDMIND = 0,2
- i. WDMIND = 1
- j. HTIND = 2
- k. HTIND = 1
- l. VTIND = 2
- m. VTIND = 1
- n. FDMIND = 0
- o. FDMIND = 2

PASSENGER DATA REQUIRED FOR FUSELAGE SIZING (FDMIND = 2)

VARIABLE	LOC.	VALUE
GALLEY INDICATOR	51	
GALLEY AREA	2	

SEE PROG. CALL GALLEY SIZE  
FOR INPUT GALLEY AREA  
(SEE NOTE (1))

VARIABLE	LOC.	VALUE
LAVATORY INDICATOR	0159	
NO. OF LAVS	0160	

SEE PROG. CALL NO. OF LAVS  
FOR INPUT NO. OF LAVS  
(SEE NOTE (1))

1<sup>ST</sup> CLASS SERVICE

VARIABLE	LOC.	VALUE
NO. OF PASSENGERS	0153	
SEATS ABREAST	0154	
NO. OF AISLES	0155	
UNIT SEAT WIDTH (IN.)	0156	27"
SEAT PITCH (IN.)	0157	38"
aisle width (in.)	0158	20"

TYPICAL VALUES  
(SEE NOTE (1))

TOURIST SERVICE

VARIABLE	LOC.	VALUE
NO. OF PASSENGERS	0161	
SEATS ABREAST	0162	
NO. OF AISLES	0163	
UNIT SEAT WIDTH (IN.)	0164	20"
SEAT PITCH (IN.)	0165	34"
aisle width (in.)	0166	16"

TYPICAL VALUES  
(SEE NOTE (1))

- NOTES:
- GALLEY AREA IS NOT REQUIRED WHEN GALLEY INDICATOR = 0.
  - NUMBER OF LAVATORIES IS NOT REQUIRED WHEN LAVATORY INDICATOR = 0.  
LAVATORY AREA IS CALCULATED @ 16 FT.<sup>2</sup> PER LAVATORY.
  - TYPICAL VALUES ARE SHOWN FOR GUIDANCE ONLY.

AIRCRAFT PROPULSION INFORMATION REQUIRED WHEN ENGINE = 0 (TURBOSHAFT ENGINES)

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

PRIMARY ENGINE CYCLE NO.	0201
--------------------------	------

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	SHP*	HP	0202	

$N_p$	0204
-------	------

PRIMARY ENGINE DATA

	$\eta_T$		0206
h	XMSNIND		0257
h	SHP <sub>XM</sub> /SHP*		0258
	$\Delta$ SHP <sub>ACE</sub>	HP	0259

TRANSMISSION AND ACC DATA

	$N_R$		0223
	$V_{TIP}$	FPS	0224
b	$W_{G/A}$	PSF	0225
c	DIA.	FT.	0226

FAN OR PROPELLER DATA

\*  $N_{II} = N_{II}$   
ALWAYS REQ'D. IF OPTIND = 2 OR 3 †

NOTE: INPUT NOT NECESSARY WHEN

- a. FIXIND = 1
- b. OPTIND = 1 AND PDMIND = 1 OR 3
- c. PDMIND = 2 OR 4
- d. N2IND = 0,1
- † INPUT FAN LOADING IF  $\tau_{pIND} = 3$
- † INPUT DIA =  $(D_r^2 - D_r^2)^{1/2}$  IF  $\tau_{pIND} = 3$

TAKEOFF CONDITIONS FOR ENGINE AND TRANSMISSION SIZING (\*\*\*)

NOTE	VARIABLE	UNIT	LOC.	VALUE
	$h_{TO}$	FT	0207	
	$h$		0208	
	$T_{inTO}$	F	0209	
d	$\left( \frac{N_{II}}{N_{II MAX}} \right)_{TO}$		0210	
e	$N_{PO}$		0211	
e	$N_{LO}$		0212	
	SHP <sub>E</sub> SHP*		026J	
	$V_{R/C}$	F/ MIN	0261	
	KRC		0262	

CRUISE CONDITIONS FOR ENGINE AND TRANSMISSION SIZING (††)

	POWIND		0213
f	$h_c$	FT	0214
f	VC	KTS	0215
f	$\Delta T_{inc}$	F	0216
g	$\left( \frac{N_{II}}{N_{II MAX}} \right)_C$		0217

NOTE:

- \* FOR STANDARD ATMOSPHERE, INPUT  $T_{in} = 0$
- \*\* POWIND: 0 = MAX. POWER  
1 = MIL POWER  
2 = NORMAL POWER
- \*\*\* THESE LOCATIONS MUST BE INPUT IN FIXIND (LOC 0010) = 0

†† THESE LOCATIONS MUST BE INPUT IF XMSNIND = 1

**PROPELLER DATA REQUIRED WHEN ENGINE = 0 (TURBOSHAFT ENGINES)**

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

P4: CRUISE AND LOITER

**VALUES OF EFFICIENCY**

NOTE	VARIABLE	UNIT	LOC.	VALUE
	$\eta_{p2}$		0232	
	$\eta_{p3}$		0233	
	$\eta_{p5}$		0234	

LOG.	VALUE	LOC.	VALUE
0235		0245	
0236		0247	
0237		0243	
0238		0249	
0239		0250	
0240		0251	
0241		0252	
0242		0253	
0243		0254	
0244		0255	

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	$C_T$		0227	
b	ACT. FACTOR PER BLADE		0228	
b	NO. OF BLADES		0229	

OPTIND 0200

- 0 = INPUT  $\eta_{p5}$ 'S
- 1 = INPUT PROP. TABLE
- 2 = PRG. CALC. PROP. PERF.
- 3 = INPUT FAN TABLE

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	$C_{T/D}$		0227	
b	ACT. FACTOR PER BLADE		0228	
b	NO. OF BLADES		0229	

PROP. TABLE NO. (FAN TABLE NO.)	LOC.
$\eta_{p5}$	0234
	0256

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	$C_{T/D}$		0227	
c	ACT. FACTOR PER BLADE		0228	

NO. OF BLADES	LOC.
$C_L$	0229
$\eta_{p5}$	0230
	0234

NOTE: ALSO INPUT PROP FAN TABLE (LOCS. 1700 - 2142)

ALWAYS REQ'D. IF OPTIND = 2 OR 3

NOTE: INPUT NOT NECESSARY WHEN

- a. PMIND = 1 OR 2
- b. PMIND = 3 OR 4



AIRCRAFT PROPULSION INFORMATION REQUIRED WHEN ENGINE = 1 (TURBOJET OR TURBOFAN ENGINES)

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHAD-D BLOCKS

PRIMARY ENGINE CYCLE NO.	0201
--------------------------	------

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	F <sub>N</sub>	LBS	0203	
	N <sub>p</sub>		0204	

PRIMARY ENGINE DATA

LIFT ENGINE CYCLE NO. (NOTE C)	0218
--------------------------------	------

	F <sub>NL</sub>	LBS	LOC.	VALUE
b			0219	
c	N <sub>L</sub>		0220	
c	N <sub>C</sub>		0221	

LIFT ENGINE DATA

VALUES OF EFFICIENCY

	$\eta_L$	LOC.	VALUE
c		0231	
	$\eta_{P2}$	0232	

TAKEOFF, HOVER, LAND

NOTE: INPUT NOT NECESSARY WHEN

- a. FIXIND = 1
- b. FIXIND = 1 OR LFTIND = 0
- c. LIFTIND = 0
- d. N2IND = 0, 1 OR FIXIND = 0
- e. FIXIND = 0
- f. FIXIND = 0 OR ESZIND = 0
- g. N2IND = 0, 1 OR FIXIND = 0 OR ESZIND = 0

TAKEOFF CONDITIONS FOR ENGINE SIZING

INDEX	VARIABLE	LOC.	VALUE
		0207	
		0208	
		0209	
d	(N <sub>L</sub> )	0210	
e	(N <sub>C</sub> )	0211	
e	(N <sub>C</sub> )	0212	

CRUISE CONDITIONS FOR ENGINE SIZING

INDEX	VARIABLE	LOC.	VALUE
		0213	
f	(N <sub>L</sub> )	0214	
f	(N <sub>L</sub> )	0215	
f	(N <sub>L</sub> )	0216	
g	(N <sub>L</sub> )	0217	

NOTE

- \* FOR STANDARD ATMOSPHERE, NFLT = 1
- \*\* POWIND = 0 = MAX POWER  
1 = MIL POWER  
2 = NORMAL POWER

DUCTED FAN DATA

	FIXIND	LOC.	VALUE
		0200	
		0256	

MUST BE INPUT AS 3, ALSO INPUT FAN TABLE (LOCS. 1700 - 2142) K<sub>R,P</sub> (LOC 0457) MUST BE INPUT AS 0

**AIRCRAFT PROPULSION INFORMATION REQUIRED WHEN ENGINE = 2 (CONVERTIBLE ENGINES)**

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

PRIMARY ENGINE CYCLE NO.	0201
--------------------------	------

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	$F_N$	LBS	0203	
	$N_p$		0204	
	$\beta$	LBS/HP	0205	

**PRIMARY ENGINE DATA**

	$\eta_T$		0206	
J	XMSNIND		0257	
J	SHP <sub>XM</sub> /SHP <sup>*</sup>		0258	
J	$\Delta$ SHP <sub>ACC</sub>	HP	0259	

**TRANSMISSION AND ACC DATA**

	NR		0223	
	V <sub>TIP</sub>	FPS	0224	
b	W <sub>G/A</sub>	PSF	0225	
c	DIA.	FT.	0226	
d	$C_T/\sigma$		0227	
e	ACT. FACTOR PER BLADE		0228	
e	NO. OF BLADES		0229	

**PROPELLER DATA**

FOR ROTOR SIZING  
ALWAYS REQUIRED IF OPTIND = 2,3

**VALUE OF EFFICIENCY**

$\eta_{p2}$	0232
-------------	------

**TAKEOFF, HOVER, LAND**

NOTE	VARIABLE	UNIT	LOC.	VALUE
	$h_{TO}$	FT.	0207	
	$r$		0208	
	$T_{inTO}$	F	0209	
f	$\left( \frac{N_{II}}{N_{II,MAX}} \right)_{TO}$		0210	
g	$N_{PO}$		0211	
g	$N_{LO}$		0212	
	SHP <sub>E</sub> /SHP <sup>*</sup>		0260	
	$V_{R/C}$	FT/MIN	0261	
	$K_{AC}$		0262	

**TAKEOFF CONDITIONS FOR ENGINE AND TRANSMISSION SIZING (†)**

h	POWIND		0213	
h	$h_c$	FT.	0214	
h	VC	KTS	0215	
h	$T_{inC}$	F	0216	
i	$\left( \frac{N_{II}}{N_{II,MAX}} \right)_C$		0217	

**CRUISE CONDITIONS FOR ENGINE SIZING**

NOTE:  
\* FOR STANDARD ATMOSPHERE, INPUT  $T_{in} = 0$   
\*\* POWIND: 0 = MAX. POWER  
1 = MIL POWER  
2 = NORMAL POWER

† THESE LOCATIONS MUST BE INPUT IF FIXIND (LOC 0010) = 0

NOTES: INPUT NOT NECESSARY WHEN:

- a. FIXIND = 1
- b. PDMIND = 1 OR 3
- c. PDMIND = 2 OR 4
- d. PDMIND = 1 OR 2
- e. PDMIND = 3 OR 4
- f. N2IND = 0, 1 OR FIXIND = 0
- g. FIXIND = 0
- h. FIXIND = 0 OR ESZIND = 0
- i. H2IND = 0, 1 OR FIXIND = 0 OR ESZIND = 0
- j. ENGINE = 1

AIRCRAFT AERODYNAMICS INFORMATION

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BOXES.

VARIABLE	LOC	VALUE
$C_{L_{max}}$	0301	
$C_{L_{min}}$	0302	
$C_{D_{min}}$	0303	
a $C_{D_{min}}$	0304	
$\Delta C_D$	0305	
b e	0306	
$t_{eFT2}$	0307	

VARIABLE	LOC	VALUE
$C_{L_{max}}$	0311	
KW	0312	
$C_{L_{min}}$	0313	
$C_{L_{min}}$	0314	
$C_{L_{min}}$	0315	
$C_{L_{min}}$	0316	

VARIABLE	LOC	VALUE
$C_{L_{max}}$	0321	
$\alpha_{LO}$	0322	
$C_{L_{max}}$	0323	
$C_{L_{max}}$	0324	

WING PROFILE DRAG AS FUNCTION OF  $C_L$

NO. OF PAIRS IN TABLE	LOC	VALUE
	0308	

$C_L$	LOC	VALUE
CL (1)	0317	
CL (2)	0318	
CL (3)	0319	
CL (4)	0320	
CL (5)	0321	
CL (6)	0322	
CL (7)	0323	
CL (8)	0324	

$C_L$	LOC	VALUE
$C_{LW}$ (1)	0325	
$C_{LW}$ (2)	0326	
$C_{LW}$ (3)	0327	
$C_{LW}$ (4)	0328	
$C_{LW}$ (5)	0329	
$C_{LW}$ (6)	0330	
$C_{LW}$ (7)	0331	
$C_{LW}$ (8)	0332	

COMPRESSIBILITY DRAG AS A FUNCTION OF M AND  $C_L$  (Note d)

NUMBER OF M	LOC	VALUE
	0309	
NUMBER OF $C_L$	LOC	VALUE
	0310	

VALUES OF M		
M <sub>1</sub>	0325	
M <sub>2</sub>	0326	
M <sub>3</sub>	0327	
M <sub>4</sub>	0328	
M <sub>5</sub>	0329	

VALUES OF $C_L$		
CL (1)	0343	
CL (2)	0344	
CL (3)	0345	
CL (4)	0346	
CL (5)	0347	
CL (6)	0348	
CL (7)	0349	

VALUES OF  $\Delta C_D$

	M <sub>1</sub> =		M <sub>2</sub> =		M <sub>3</sub> =		M <sub>4</sub> =		M <sub>5</sub> =	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
CL1 =	0350		0357		0364		0371		0378	
CL2 =	0351		0358		0365		0372		0379	
CL3 =	0352		0359		0366		0373		0380	
CL4 =	0353		0360		0367		0374		0381	
CL5 =	0354		0361		0368		0375		0382	
CL6 =	0355		0362		0369		0376		0383	
CL7 =	0356		0363		0370		0377		0384	

NOTE: INPUT NOT NECESSARY WHEN: a. LFTIND = 0 c. DRGIND = 1

CASE NO.	CASE NO.
----------	----------

WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE ITEMS WITH A VALUE IN THE FOLLOWING TABLES

**AIRCRAFT WEIGHT INFORMATION**

VARIABLE	LOC	VALUE
† OWE	0400	
W <sub>FE</sub> LBS	0401	
W <sub>FULL</sub> LBS	0402	
†† W <sub>PL</sub> LBS	0403	

VARIABLE	LOC	VALUE
W <sub>FE</sub>	0401	
W <sub>FULL</sub>	0402	
W <sub>PL</sub>	0403	

VARIABLE	LOC	VALUE
P <sub>FE</sub> S.I.	0450	
W <sub>FE</sub> LB	0451	
Y <sub>FE</sub>	0452	

**GROUP WEIGHT INFORMATION**

**PROPULSION**

FLIGHT CONTROLS

k <sub>CC</sub>	0404	
k <sub>FW</sub>	0405	
k <sub>H</sub>	0406	
k <sub>SAS</sub>	0407	
k <sub>TM</sub>	0408	
k <sub>UC</sub>	0409	

GROUP WEIGHT INFORMATION

k <sub>U</sub>	0420	
k <sub>LFS</sub>	0421	
k <sub>L</sub>	0422	
k <sub>MG</sub>	0423	
k <sub>TL</sub>	0424	
k <sub>WC</sub>	0425	
k <sub>WW</sub>	0426	
k <sub>Y</sub>	0427	
k <sub>Z</sub>	0428	
k <sub>PES</sub>	0429	
k <sub>MT</sub>	0430	
k <sub>NAC</sub>	0431	
ℓ <sub>MT</sub>	0432	

k <sub>DS</sub>	0453	
k <sub>FS</sub>	0454	
k <sub>LEI</sub>	0455	
k <sub>PEI</sub>	0456	
†† k <sub>RRP</sub>	0457	
k <sub>VT</sub>	0458	

† OWE IS NOT NECESSARY WHEN OPTIND = 1,2  
 †† W<sub>PL</sub> IS NOT NECESSARY WHEN OPTIND = 2

\* NOT NECESSARY WHEN LFTIND = 0  
 \*\* NOT NECESSARY WHEN ENGINE = 1  
 †† INPUT AS 0 IF P<sub>IND</sub> (LOC 0200) = 3  
 TO USE k<sub>MT</sub>, k<sub>NAC</sub>, & ℓ<sub>MT</sub> INPUT k<sub>PES</sub> = 0  
 IF k<sub>PES</sub> IS INPUT AS NON-ZERO, k<sub>MT</sub>, k<sub>NAC</sub>,  
 AND ℓ<sub>MT</sub> ARE NOT REQUIRED.

MULTIPLICATIVE FACTORS  
 NOMINALLY = 1.0

K <sub>15</sub>	0410	
K <sub>16</sub>	0411	
K <sub>17</sub>	0412	
K <sub>18</sub>	0413	
K <sub>19</sub>	0414	
K <sub>20</sub>	0415	

K <sub>8</sub>	0413	
K <sub>9</sub>	0414	
K <sub>10</sub>	0415	
K <sub>11</sub>	0416	
K <sub>12</sub>	0417	
K <sub>13</sub>	0418	
K <sub>14</sub>	0419	

K <sub>2</sub>	0459	
K <sub>3</sub>	0460	
K <sub>4</sub>	0461	
K <sub>5</sub>	0462	
K <sub>6</sub>	0463	
K <sub>7</sub>	0464	
K <sub>21</sub>	0465	

**ATMOSPHERE TEMPERATURE**

NO. OF PAIRS	0416	
--------------	------	--

NOTE: THIS TABLE IS NOT NECESSARY IF ATMIND IS NEVER SET TO 2

h <sub>1</sub> FT	0440	
h <sub>2</sub> FT	0441	
h <sub>3</sub> FT	0442	
h <sub>4</sub> FT	0443	
h <sub>5</sub> FT	0444	
h <sub>6</sub> FT	0445	
h <sub>7</sub> FT	0446	
h <sub>8</sub> FT	0447	
h <sub>9</sub> FT	0448	
h <sub>10</sub> FT	0449	

θ <sub>1</sub>	0466	
θ <sub>2</sub>	0467	
θ <sub>3</sub>	0468	
θ <sub>4</sub>	0469	
θ <sub>5</sub>	0470	
θ <sub>6</sub>	0471	
θ <sub>7</sub>	0472	
θ <sub>8</sub>	0473	
θ <sub>9</sub>	0474	
θ <sub>10</sub>	0475	



PAGE NO.

**TAXI INFORMATION**

SGT INE :

**ATMIND**

	LOC	VALUE
1 <sup>ST</sup>	0501	
2 <sup>ND</sup>	0502	
3 <sup>RD</sup>	0503	
4 <sup>TH</sup>	0504	
5 <sup>TH</sup>	0505	
6 <sup>TH</sup>	0506	
7 <sup>TH</sup>	0507	
8 <sup>TH</sup>	0508	
9 <sup>TH</sup>	0509	
10 <sup>TH</sup>	0510	

	LOC	VALUE
	0521	
	0522	
	0523	
	0524	
	0525	
	0526	
	0527	
	0528	
	0529	
	0530	

N<sub>22</sub> N<sub>22</sub> MAX  
(NOTE 1)

	LOC	VALUE
	0541	
	0542	
	0543	
	0544	
	0545	
	0546	
	0547	
	0548	
	0549	
	0550	

- 0 STD. ATMOSPHERE
- 1 STD. + T<sub>in</sub>
- 2 ARBITRARY (h)

**t<sub>1</sub> (HR)**

	LOC	VALUE
1 <sup>ST</sup>	0511	
2 <sup>ND</sup>	0512	
3 <sup>RD</sup>	0513	
4 <sup>TH</sup>	0514	
5 <sup>TH</sup>	0515	
6 <sup>TH</sup>	0516	
7 <sup>TH</sup>	0517	
8 <sup>TH</sup>	0518	
9 <sup>TH</sup>	0519	
10 <sup>TH</sup>	0520	

**k<sub>1L</sub>**

	LOC	VALUE
	0531	
	0532	
	0533	
	0534	
	0535	
	0536	
	0537	
	0538	
	0539	
	0540	

**NOTE:** a. INPUT NOT NECESSARY WHEN ATMIND = 0, 2  
 b. INPUT NOT NECESSARY WHEN N2IND = 0, 1

**NOTE:** WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

**TAKE OFF, HOVER AND LANDING INFORMATION**

**TOLIND**  
(NOTE a)

LOC.	VALUE
0601	
0602	
0603	
0604	
0605	
0606	
0607	
0608	
0609	
0610	

**ATMIND**

LOC.	VALUE
0611	
0612	
0613	
0614	
0615	
0616	
0617	
0618	
0619	
0620	

**SGTIND 2**

LOC.	VALUE
0631	
0632	
0633	
0634	
0635	
0636	
0637	
0638	
0639	
0640	

**VE**

LOC.	VALUE
0677	
0678	
0679	
0680	

0 = STANDARD ATMOSPHERE  
1 = STD. 1.5 T<sub>H</sub>  
2 = ARBITRARY (h)

1 = INPUT REQ'D BY AIRPLANE WILL USE MAX. POWER FROM LIFT ENGINES BEFORE AUGMENTING WITH PRIMARY ENGINES OR - WILL USE ONLY PRIMARY ENGINES IF LFTIND = 0.

2 = INPUT REQ'D BY AIRPLANE WILL TAKE EQUAL FRACTION OF POWER FROM LIFT AND PRIMARY ENGINES.

3 = INPUT REQ'D FRACTION OF MAX. POWER (PETF/PEHF AND LETF)

**PETF OR PEHF**  
(NOTE c)

LOC.	VALUE
0621	
0622	
0623	
0624	
0625	
0626	
0627	
0628	
0629	
0630	

**LETF**  
(NOTE c)

LOC.	VALUE
0641	
0642	
0643	
0644	
0645	
0646	
0647	
0648	
0649	
0650	

**t<sub>H</sub> HR**

LOC.	VALUE
0661	
0662	
0663	
0664	
0665	
0666	
0667	
0668	
0669	
0670	

**t<sub>H</sub> HR**

LOC.	VALUE
0681	
0682	
0683	
0684	
0685	
0686	
0687	
0688	
0689	
0690	

**VE (FT/MIN)**

LOC.	VALUE
2321	
2322	
2323	
2324	
2325	
2326	
2327	
2328	
2329	
2330	

**NOTES:**  
a. DO NOT INPUT TOLIND = 2 IF LFTIND = 0.  
b. INPUT NOT NECESSARY WHEN ATMIND = 0.  
c. INPUT NOT NECESSARY WHEN SGTIND = 2.  
d. INPUT NOT NECESSARY WHEN VE = 0.  
e. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
f. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
g. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
h. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
i. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
j. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
k. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
l. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
m. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
n. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
o. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
p. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
q. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
r. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
s. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
t. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
u. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
v. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
w. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
x. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
y. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.  
z. INPUT NOT NECESSARY WHEN T<sub>H</sub> = 0.

CLIMB INFORMATION  
SGTIND = 3

NOTE: WHEN OPTIND = 2 CONSIDER ONLY  
THOSE ITEMS IN THE SHADED BLOCKS

CLMIND

LOC.	VALUE
0701	
0702	
0703	
0704	
0705	
0706	
0707	
0708	
0709	
0710	

ATMIND

LOC.	VALUE
0711	
0712	
0713	
0714	
0715	
0716	
0717	
0718	
0719	
0720	

$\Delta T_{in} (^{\circ}F)$   
(NOTE a)

LOC.	VALUE
0731	
0732	
0733	
0734	
0735	
0736	
0737	
0738	
0739	
0740	

POWIND

LOC.	VALUE
0751	
0752	
0753	
0754	
0755	
0756	
0757	
0758	
0759	
0760	

$N_{II} N_{II MAX}$   
(NOTE b)

LOC.	VALUE
0771	
0772	
0773	
0774	
0775	
0776	
0777	
0778	
0779	
0780	

$n$  CLIMB (E-M CALCS)

LOC.	VALUE
0791	
0792	
0793	
0794	
0795	
0796	
0797	
0798	
0799	
0800	

1 = MAX R/C  
2 = CONSTANT EAS  
3 = CONSTANT MACH  
4 = CONSTANT TAS

0 = STANDARD ATMOSPHERE  
1 = STD.  $\Delta T_{in}$   
2 = ARBITRARY  $\rho(h)$

0 = MAX POWER  
1 = MIL POWER  
2 = NORMAL POWER

(NOMINAL  $n = 0$ )

MACH REASORT TAB(S)  
(NOTE c)

LOC.	VALUE
0701	
0702	
0703	
0704	
0705	
0706	
0707	
0708	
0709	
0710	

$\Delta h$  (FT)

LOC.	VALUE
0721	
0722	
0723	
0724	
0725	
0726	
0727	
0728	
0729	
0730	

$h_{MAX}$  (FT)

LOC.	VALUE
0741	
0742	
0743	
0744	
0745	
0746	
0747	
0748	
0749	
0750	

$\gamma_{MAX}$  (DEG)

LOC.	VALUE
0761	
0762	
0763	
0764	
0765	
0766	
0767	
0768	
0769	
0770	

$C_D$  CLIMB

LOC.	VALUE
0781	
0782	
0783	
0784	
0785	
0786	
0787	
0788	
0789	
0790	

NOTES

1. INPUT NOT NECESSARY WHEN AT MINE = 02  
2. INPUT NOT NECESSARY WHEN POWIND = 0  
3. INPUT NOT NECESSARY WHEN CLIMB = 0

**NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS**

**CRSIND**

LOC.	VALUE
0801	
0802	
0803	
0804	
0805	
0806	
0807	
0808	
0809	
0810	

10 98% TD POWER  
20 98% TD TAS  
30 BEST HNDP  
40 98% BEST HNDP  
50 BEST HNDP, CONST. W/S  
60 98% BEST HNDP, CONST. W/S

**Vin or HEADWIND**  
(NOTE d)

LOC.	VALUE
0811	
0812	
0813	
0814	
0815	
0816	
0817	
0818	
0819	
0820	

**ATMIND**

LOC.	VALUE
0821	
0822	
0823	
0824	
0825	
0826	
0827	
0828	
0829	
0830	

01 STANDARD ATMOSPHERE  
10 STD. TIP  
20 ARBITRARY TIP

**CR (NM)**

LOC.	VALUE
0831	
0832	
0833	
0834	
0835	
0836	
0837	
0838	
0839	
0840	

**CRUISE INFORMATION**  
SGTIND = 4

(TIME F)  
(NOTE 3)

LOC.	VALUE
0841	
0842	
0843	
0844	
0845	
0846	
0847	
0848	
0849	
0850	

POWIND  
(NOTE 1)

LOC.	VALUE
0861	
0862	
0863	
0864	
0865	
0866	
0867	
0868	
0869	
0870	

MAX. WIND  
1. MAX. WIND  
2. WIND RANGE

**N**

LOC.	VALUE
0871	
0872	
0873	
0874	
0875	
0876	
0877	
0878	
0879	
0880	

NIZ NIZ MAX  
(NOTE 1)

LOC.	VALUE
0881	
0882	
0883	
0884	
0885	
0886	
0887	
0888	
0889	
0890	

**NOTES: INPUT NOT NECESSARY WHEN:**

a. ATMIND = 0,2

b. CRSIND = 3

c. N2IND = 0,1

d. INPUT V WHEN CRSIND = 1  
INPUT HEADWIND WHEN CRSIND = 2 OR 3

**BOEING VERTOL COMPANY VASCOMP II V STOL AIRCRAFT SIZE 10 PERFORMANCE COMPUTER PROGRAM B-93**  
 A DIVISION OF THE BOEING COMPANY

**NOTE: WHEN OPT2ND = 2 CONSIDER  
 THOSE ITEMS IN THE SHADED BLOCKS**

**DESCENT INFORMATION  
 SGTIND = 5**

**DESIND**

	LOC.	VALUE
1ST	0901	
2ND	0902	
3RD	0903	
4TH	0904	
5TH	0905	
6TH	0906	
7TH	0907	
8TH	0908	
9TH	0909	
10TH	0910	

**ATMIND**

	LOC.	VALUE
	0921	
	0922	
	0923	
	0924	
	0925	
	0926	
	0927	
	0928	
	0929	
	0930	

**T<sub>10</sub> (F)**  
 (NOTE a)

	LOC.	VALUE
	0941	
	0942	
	0943	
	0944	
	0945	
	0946	
	0947	
	0948	
	0949	
	0950	

**R<sub>MAX</sub> (NM)**  
 (NOTE b)

	LOC.	VALUE
	0961	
	0962	
	0963	
	0964	
	0965	
	0966	
	0967	
	0968	
	0969	
	0970	

**N<sub>1</sub> NZI MAX**  
 (NOTE c)

	LOC.	VALUE
	0981	
	0982	
	0983	
	0984	
	0985	
	0986	
	0987	
	0988	
	0989	
	0990	

0 = STANDARD ATMOSPHERE  
 1 = STD.  $\gamma$   $\Delta$  TIR  
 2 = ARBITRARY  $\theta$  (h)

1.3 = VALUE  
 0.4 = SCALE POWER  
 0.0 = CONSTANT BAR  
 7.5 = CONSTANT MACH  
 1.2, 0.2 = TERMINAL RANGE SPECIFIED  
 2.4, 0.2 = TERMINAL RANGE NOT SPECIFIED  
**MACH ON EAS (KTS)**  
 (NOTE d)

**$\theta$  MIN (DEG)**

	LOC.	VALUE
	0931	
	0932	
	0933	
	0934	
	0935	
	0936	
	0937	
	0938	
	0939	
	0940	

**h (FT)**

	LOC.	VALUE
	0951	
	0952	
	0953	
	0954	
	0955	
	0956	
	0957	
	0958	
	0959	
	0960	

**h<sub>MIN</sub> (FT)**

	LOC.	VALUE
	0971	
	0972	
	0973	
	0974	
	0975	
	0976	
	0977	
	0978	
	0979	
	0980	

**C<sub>D</sub> DESC.**

	LOC.	VALUE
	0991	
	0992	
	0993	
	0994	
	0995	
	0996	
	0997	
	0998	
	0999	
	1000	

**NOTES: INPUT NOT NECESSARY WHEN:**  
 a. ATMIND = 0.2      c. N2IND = 0.1  
 b. DESIND = 2,4,6,8      d. DESIND = 1,2,3,4

**BOEING VERTOL COMPANY VASCOMP II V STOL AIRCRAFT SIZING AND PERFORMANCE COMPUTER PROGRAM B-93**  
 A DIVISION OF THE BOEING COMPANY

**LOITER INFORMATION**

**NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS**

SGTIND 6

LTRIND

ATMIND

T<sub>TR</sub> (F)  
(NOTE 4)

NII NIT MAX  
(NOTE 5)

LOC.	VALUE
1001	
1002	
1003	
1004	
1005	
1006	
1007	
1008	
1009	
1010	

1 = FUEL REQUIRED FOR MISSION  
 2 = RESERVE FUEL CALCULATION

LOC.	VALUE
1021	
1022	
1023	
1024	
1025	
1026	
1027	
1028	
1029	
1030	

0 = STANDARD ATMOSPHERE  
 1 = SEA LEVEL  
 2 = ARBITRARY (h)

LOC.	VALUE
1041	
1042	
1043	
1044	
1045	
1046	
1047	
1048	
1049	
1050	

t<sub>L</sub> (HR)

LOC.	VALUE
1011	
1012	
1013	
1014	
1015	
1016	
1017	
1018	
1019	
1020	

t (HR)

LOC.	VALUE
1031	
1032	
1033	
1034	
1035	
1036	
1037	
1038	
1039	
1040	

N<sub>TR</sub> (F)

LOC.	VALUE
1051	
1052	
1053	
1054	
1055	
1056	
1057	
1058	
1059	
1060	

C<sub>TR</sub>

LOC.	VALUE
1061	
1062	
1063	
1064	
1065	
1066	
1067	
1068	
1069	
1070	

N<sub>S</sub> (F)

LOC.	VALUE
1081	
1082	
1083	
1084	
1085	
1086	
1087	
1088	
1089	
1090	

SHEET NO	CASE NO
09	

CHANGE IN FUEL WEIGHT

SGTIND = 7

	LOC.	VALUE
1ST	1101	
2ND	1102	
3RD	1103	
4TH	1104	
5TH	1105	
6TH	1106	
7TH	1107	
8TH	1108	
9TH	1109	
10TH	1110	

	LOC.	VALUE
	1121	
	1122	
	1123	
	1124	
	1125	
	1126	
	1127	
	1128	
	1129	
	1130	

CHANGE IN PAYLOAD WEIGHT

SGTIND = 8

	LOC.	VALUE
	1131	
	1132	
	1133	
	1134	
	1135	
	1136	
	1137	
	1138	
	1139	
	1140	

	LOC.	VALUE
	1141	
	1142	
	1143	
	1144	
	1145	
	1146	
	1147	
	1148	
	1149	
	1150	

TRANSFER ALTITUDE; SGTIND = 9

h<sub>OPT</sub> (FT.) (h<sub>OPT</sub> IND = 0)  
OR h<sub>MAX</sub> (FT.) (h<sub>OPT</sub> IND = 1)

	LOC.	VALUE
1ST	1111	
2ND	1112	
3RD	1113	
4TH	1114	
5TH	1115	
6TH	1116	
7TH	1117	
8TH	1118	
9TH	1119	
10TH	1120	

CHANGE FUEL OR CHANGE PAYLOAD

SGTIND = 7  
OR SGTIND = 8

LOC	VALUE
1151	

0 = W + ΔW ≤ W<sub>G</sub>  
1 = NO WEIGHT RESTRICTION

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

GENERAL PERFORMANCE INFORMATION (GOTIND) (1)

**GWIND**

LOC	VALUE
2201	
2202	
2203	
2204	
2205	
2206	
2207	
2208	
2209	
2210	

1 = ΔGW INPUT  
2 = GW INPUT

**ATMIND**

LOC	VALUE
2221	
2222	
2223	
2224	
2225	
2226	
2227	
2228	
2229	
2230	

0 = STANDARD ATMOSPHERE  
1 = STD + T<sub>IN</sub>  
2 = ARBITRARY ρ(h)

**T<sub>IN</sub> F**  
Note a)

LOC	VALUE
2241	
2242	
2243	
2244	
2245	
2246	
2247	
2248	
2249	
2250	

**WIND**

LOC	VALUE
2271	
2272	
2273	
2274	
2275	
2276	
2277	
2278	
2279	
2280	

**PERFORM**  
OPTIND

LOC	VALUE
2291	
2292	
2293	
2294	
2295	
2296	
2297	
2298	
2299	
2300	

**PERFORM**  
OPTIND

LOC	VALUE
2311	
2312	
2313	
2314	
2315	
2316	
2317	
2318	
2319	
2320	

51 20

WHEN OPTIND = 2 OR 3 CONSULT PROGRAM HOSE LENGTH VALUES

**GW OR ΔGW(LB)**  
(Note b)

LOC	VALUE
2211	
2212	
2213	
2214	
2215	
2216	
2217	
2218	
2219	
2220	

**C<sub>L</sub> WING**

LOC	VALUE
2231	
2232	
2233	
2234	
2235	
2236	
2237	
2238	
2239	
2240	

**C<sub>D</sub> CR(FT<sup>2</sup>)**

LOC	VALUE
2251	
2252	
2253	
2254	
2255	
2256	
2257	
2258	
2259	
2260	

**T W**

LOC	VALUE
2271	
2272	
2273	
2274	
2275	
2276	
2277	
2278	
2279	
2280	

**PERFORM**

LOC	VALUE
2291	
2292	
2293	
2294	
2295	
2296	
2297	
2298	
2299	
2300	

**PERFORM**

LOC	VALUE
2311	
2312	
2313	
2314	
2315	
2316	
2317	
2318	
2319	
2320	

NOTES: a. INPUT NOT NECESSARY WHEN ATMIND = 0, 2  
b. INPUT GW WHEN GWIND = 1  
INPUT GW WHEN GWIND = 2



BOEING VERTOL COMPANY **VASCOMP II** V STOL AIRCRAFT SIZING AND PERFORMANCE COMPUTER PROGRAM B-93

ENGINE CYCLE DATA; NON-STANDARD PERFORMANCE

SHEET NO	CASE NO

PRIMARY ENGINE DATA

VARIABLE	LOC	VALUE
WDTIND	1201	
N1IND	1202	
N1θIND	1203	
N2IND	1204	
QIND	1205	

VARIABLE	LOC	VALUE
$W_{MAX}/W^*$	1220	
$N_{I MAX}/N_I^*$	1221	
$(N_I/\rho_0 N_I^*)_{MAX}$	1222	
$N_{II MAX}/N_{II}^*$	1223	
$Q_{MAX}/Q^*$	1224	

INPUT IF WDTIND = 1  
 INPUT IF N1IND = 1  
 INPUT IF N1θIND = 1  
 INPUT IF N2IND = 1,2  
 INPUT IF QIND = 1

WDTIND: { 0 = NO FUEL FLOW CUTOFF  
 1 = FUEL FLOW CUTOFF  
 N1IND: { 0 = NO N1 CUTOFF  
 1 = N1 CUTOFF

N2IND: { 0 = NO N2 CUTOFF; OPTIMUM N2 VARIATION  
 1 = N2 CUTOFF; OPTIMUM N2 VARIATION  
 2 = N2 CUTOFF; NON-OPTIMUM N2 VARIATION

QIND: { 0 = NO TORQUE CUTOFF  
 1 = TORQUE CUTOFF  
 N1θIND: { 0 = NO REFERRED N1 CUTOFF  
 1 = REFERRED N1 CUTOFF

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

VARIABLE	LOC	VALUE
RNOIND	1206	

0 = NO REYNOLDS NO. CORRECTIONS  
 1 = REYNOLDS NO. CORRECTIONS

REYNOLDS NO. CORRECTION FACTOR

VALUES OF  $\frac{N_I}{N_I^*} \frac{D}{V_1}$

LOC	VALUE
1207	
1208	
1209	
1210	
1211	
1212	
1213	
1214	
1215	
1216	

VALUES OF  $K_{PR}$

LOC	VALUE
1225	
1226	
1227	
1228	
1229	
1230	
1231	
1232	
1233	
1234	

OUTPUT SH AFT SPEED CORRECTION

VALUES OF  $\frac{N_{II}}{N_{II(OPT)}}$

LOC	VALUE
1238	
1239	
1240	
1241	
1242	
1243	
1244	
1245	
1246	
1247	

VALUES OF  $K_{PN}$

LOC	VALUE
1248	
1249	
1250	
1251	
1252	
1253	
1254	
1255	
1256	
1257	

INPUT THIS TABLE IF RNOIND = 1

INPUT THIS TABLE IF N2IND = 2 AND NON-STANDARD CORRECTION IS DESIRED

LIFT ENGINE DATA

VARIABLE	LOC	VALUE
LWDIND	1217	
LN1IND	1218	
LN2IND	1219	

VARIABLE	LOC	VALUE
$(W_{MAX}/W^*)_L$	1235	
$(N_{I MAX}/N_I)_L$	1236	
$(N_{II MAX}/N_{II})_L$	1237	

INPUT IF LWDIND = 1  
 INPUT IF LN1IND = 1  
 INPUT IF LN2IND = 1

LWDIND: { 0 = NO FUEL FLOW CUTOFF  
 1 = FUEL FLOW CUTOFF

LN1IND: { 0 = NO N1 CUTOFF  
 2 = N1 CUTOFF

LN2IND: { 0 = NO N2 CUTOFF  
 1 = N2 CUTOFF

PRIMARY ENGINE CYCLE INFORMATION (Sheet 1)

THESE TABLES NOT REQUIRED WHEN STANDARD CYCLE IS SELECTED.

VARIABLE	LOC	VALUE
CYCLE NO.	1301	
$k_3$	1302	
$k_4$	1303	

VARIABLE	LOC	VALUE
$\xi_4$	1304	
$T_{GI}$ (°R)	1305	
$T_{FI}$ (°R)	1306	

VARIABLE	LOC	VALUE
$T_{NP}$ R	1307	
$T_{ML}$ R	1308	
$T_{MAX}$ R	1309	

NOTE a.

NO. OF T/θ	LOC	VALUE
1	1311	
2	1312	
3	1313	
4	1314	
5	1315	
6	1316	
7	1317	
8	1318	

NO. OF M	LOC	VALUE
M1	1320	
M2	1321	
M3	1322	
M4	1323	
M5	1324	
M6	1325	

ALL TABLES MUST BE AT LEAST 3 x 3 IN SIZE

VALUES OF REFERRED THRUST OR HORSEPOWER

(T/θ) <sub>1</sub>	(T/θ) <sub>2</sub>	(T/θ) <sub>3</sub>	(T/θ) <sub>4</sub>	(T/θ) <sub>5</sub>	(T/θ) <sub>6</sub>	(T/θ) <sub>7</sub>	(T/θ) <sub>8</sub>
LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M1	1326	1332	1338	1344	1350	1356	1362
M2	1327	1333	1339	1345	1351	1357	1363
M3	1328	1334	1340	1346	1352	1358	1364
M4	1329	1335	1341	1347	1353	1359	1365
M5	1330	1336	1342	1348	1354	1360	1366
M6	1331	1337	1343	1349	1355	1361	1367

NOTE: WHEN OPTIND = 2 CONSIDER THOSE ITEMS IN THE SHADED BLOCKS

NO. OF T/θ	LOC	VALUE
1	1375	
2	1376	
3	1377	
4	1378	
5	1379	
6	1380	
7	1381	
8	1382	

NO. OF M	LOC	VALUE
M1	1384	
M2	1385	
M3	1386	
M4	1387	
M5	1388	
M6	1389	

VALUES OF REFERRED FUEL FLOW

(T/θ) <sub>1</sub>	(T/θ) <sub>2</sub>	(T/θ) <sub>3</sub>	(T/θ) <sub>4</sub>	(T/θ) <sub>5</sub>	(T/θ) <sub>6</sub>	(T/θ) <sub>7</sub>	(T/θ) <sub>8</sub>
LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M1	1390	1396	1402	1408	1414	1420	1426
M2	1391	1397	1403	1409	1415	1421	1427
M3	1392	1398	1404	1410	1416	1422	1428
M4	1393	1399	1405	1411	1417	1423	1429
M5	1394	1400	1406	1412	1418	1424	1430
M6	1395	1401	1407	1413	1419	1425	1431

NOTE a.  $k_4$  IN LBS, IF ENGINE... IF ENGINE...  
b. IF ENGINE 0, 1, 4... IF ENGINE... IF ENGINE...

PRIMARY ENGINE CYCLE INFORMATION (Sheet 2)

LOC	VALUE
1439	
1440	
1441	
1442	
1443	
1444	
1445	
1446	

LOC	VALUE
1447	
1448	
1449	
1450	
1451	
1452	
1453	

VALUES OF REFERRED N<sub>I</sub> (N<sub>I</sub> √ N<sub>I</sub>)

	(T <sup>2</sup> ) <sub>1</sub> =		(T <sup>2</sup> ) <sub>2</sub> =		(T <sup>2</sup> ) <sub>3</sub> =		(T <sup>2</sup> ) <sub>4</sub> =		(T <sup>2</sup> ) <sub>5</sub> =		(T <sup>2</sup> ) <sub>6</sub> =	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M <sub>1</sub>	1454		1460		1466		1472		1479		1484	
M <sub>2</sub>	1455		1461		1467		1473		1479		1484	
M <sub>3</sub>	1456		1462		1468		1474		1480		1485	
M <sub>4</sub>	1457		1463		1469		1475		1481		1487	
M <sub>5</sub>	1458		1464		1470		1476		1482		1488	
M <sub>6</sub>	1459		1465		1471		1477		1483		1489	

NOTE: WHEN OPTIND = 2 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

LOC	VALUE
1502	
1503	
1504	
1505	
1506	
1507	
1508	
1509	
1510	

LOC	VALUE
1511	
1512	
1513	
1514	
1515	
1516	
1517	

VALUES OF REFERRED N<sub>II</sub> (N<sub>II</sub> √ N<sub>II</sub>)

	(T <sup>2</sup> ) <sub>1</sub> =		(T <sup>2</sup> ) <sub>2</sub> =		(T <sup>2</sup> ) <sub>3</sub> =		(T <sup>2</sup> ) <sub>4</sub> =		(T <sup>2</sup> ) <sub>5</sub> =		(T <sup>2</sup> ) <sub>6</sub> =	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M <sub>1</sub>	1518		1524		1530		1536		1542		1548	
M <sub>2</sub>	1519		1525		1531		1537		1543		1549	
M <sub>3</sub>	1520		1526		1532		1538		1544		1550	
M <sub>4</sub>	1521		1527		1533		1539		1545		1551	
M <sub>5</sub>	1522		1528		1534		1540		1546		1552	
M <sub>6</sub>	1523		1529		1535		1541		1547		1553	

**VASCOMP II V STOL AIRCRAFT SIZING AND PERFORMANCE COMPUTER PROGRAM B-93**

**LIFT ENGINE CYCLE INFORMATION** (NOT REQUIRED WHEN STANDARD CYCLE) (IS SELECTED OR WHEN LFTIND = 0)

NOTE: WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

VAR	LOC	VALUE
CYCLE IND.	1601	
$k_1$	1602	
$k_2$	1603	

VAR	LOC	VALUE
$S_1$	1604	
$S_2$	1605	
$S_3$	1606	

NOTE a.

VAR	LOC	VALUE
$T_{GI}$	1607	
$T_{MAX}$	1608	

NOTE a.  $k_1$  IN LBS.,  $k_2$  IN LB LBTHRUST.

NOTE 1.  $S_1$  IN FT.,  $S_2$  IN FT.,  $S_3$  IN FT. LBTHRUST.

REFERRED THRUST AS A FUNCTION OF T

VARIABLE	LOC	VALUE
$(T/\theta)_1$	1609	
$(T/\theta)_2$	1610	
$(T/\theta)_3$	1611	
$(T/\theta)_4$	1612	
$(T/\theta)_5$	1613	
$(T/\theta)_6$	1614	
$(T/\theta)_7$	1615	
$(T/\theta)_8$	1616	

VARIABLE	LOC	VALUE
$(F_N / \delta F_{NL})_1$	1617	
$(F_N / \delta F_{NL})_2$	1618	
$(F_N / \delta F_{NL})_3$	1619	
$(F_N / \delta F_{NL})_4$	1620	
$(F_N / \delta F_{NL})_5$	1621	
$(F_N / \delta F_{NL})_6$	1622	
$(F_N / \delta F_{NL})_7$	1623	
$(F_N / \delta F_{NL})_8$	1624	

REFERRED  $N_I$  AS A FUNCTION OF T

VARIABLE	LOC	VALUE
$(T/\theta)_1$	1641	
$(T/\theta)_2$	1642	
$(T/\theta)_3$	1643	
$(T/\theta)_4$	1644	
$(T/\theta)_5$	1645	
$(T/\theta)_6$	1646	
$(T/\theta)_7$	1647	
$(T/\theta)_8$	1648	

VARIABLE	LOC	VALUE
$(N_I N_{IL})_1$	1649	
$(N_I N_{IL})_2$	1650	
$(N_I N_{IL})_3$	1651	
$(N_I N_{IL})_4$	1652	
$(N_I N_{IL})_5$	1653	
$(N_I N_{IL})_6$	1654	
$(N_I N_{IL})_7$	1655	
$(N_I N_{IL})_8$	1656	

REFERRED FUEL FLOW AS A FUNCTION OF T

VARIABLE	LOC	VALUE
$(T/\theta)_1$	1625	
$(T/\theta)_2$	1626	
$(T/\theta)_3$	1627	
$(T/\theta)_4$	1628	
$(T/\theta)_5$	1629	
$(T/\theta)_6$	1630	
$(T/\theta)_7$	1631	
$(T/\theta)_8$	1632	

VARIABLE	LOC	VALUE
$(W_f / \delta W_{fNL})_1$	1633	
$(W_f / \delta W_{fNL})_2$	1634	
$(W_f / \delta W_{fNL})_3$	1635	
$(W_f / \delta W_{fNL})_4$	1636	
$(W_f / \delta W_{fNL})_5$	1637	
$(W_f / \delta W_{fNL})_6$	1638	
$(W_f / \delta W_{fNL})_7$	1639	
$(W_f / \delta W_{fNL})_8$	1640	

REFERRED  $N_{II}$  AS A FUNCTION OF T

VARIABLE	LOC	VALUE
$(T/\theta)_1$	1657	
$(T/\theta)_2$	1658	
$(T/\theta)_3$	1659	
$(T/\theta)_4$	1660	
$(T/\theta)_5$	1661	
$(T/\theta)_6$	1662	
$(T/\theta)_7$	1663	
$(T/\theta)_8$	1664	

VARIABLE	LOC	VALUE
$(N_{II} N_{IIL})_1$	1665	
$(N_{II} N_{IIL})_2$	1666	
$(N_{II} N_{IIL})_3$	1667	
$(N_{II} N_{IIL})_4$	1668	
$(N_{II} N_{IIL})_5$	1669	
$(N_{II} N_{IIL})_6$	1670	
$(N_{II} N_{IIL})_7$	1671	
$(N_{II} N_{IIL})_8$	1672	

HOVER PERFORMANCE MAP

TABLE NO. \_\_\_\_\_

	LOC	VALUE
NO. OF $C_T/\sigma$ 'S	2351	

	LOC	VALUE
NO. OF MTIP'S	2362	

VALUES OF  $C_T/\sigma$

	LOC	VALUE
$(C_T/\sigma)_1$	2352	
$(C_T/\sigma)_2$	2353	
$(C_T/\sigma)_3$	2354	
$(C_T/\sigma)_4$	2355	
$(C_T/\sigma)_5$	2356	
$(C_T/\sigma)_6$	2357	
$(C_T/\sigma)_7$	2358	
$(C_T/\sigma)_8$	2359	
$(C_T/\sigma)_9$	2360	
$(C_T/\sigma)_{10}$	2361	

VALUES OF MTIP

	LOC	VALUE
MT <sub>1</sub>	2363	
MT <sub>2</sub>	2364	
MT <sub>3</sub>	2365	
MT <sub>4</sub>	2366	
MT <sub>5</sub>	2367	
MT <sub>6</sub>	2368	

$C_T/\sigma = \text{THRUST} \cdot \eta^2 / V_{TIP}^2$

INPUT VALUES OF FIGURE OF MERIT  
FOR COMBINATIONS OF  
 $C_T/\sigma$  AND MTIP

	MTIP <sub>1</sub> =		MTIP <sub>2</sub> =		MTIP <sub>3</sub> =		MTIP <sub>4</sub> =		MTIP <sub>5</sub> =		MTIP <sub>6</sub> =	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
$(C_T/\sigma)_1 =$	2369		2379		2389		2399		2409		2419	
$(C_T/\sigma)_2 =$	2370		2380		2390		2400		2410		2420	
$(C_T/\sigma)_3 =$	2371		2381		2391		2401		2411		2421	
$(C_T/\sigma)_4 =$	2372		2382		2392		2402		2412		2422	
$(C_T/\sigma)_5 =$	2373		2383		2393		2403		2413		2423	
$(C_T/\sigma)_6 =$	2374		2384		2394		2404		2414		2424	
$(C_T/\sigma)_7 =$	2375		2385		2395		2405		2515		2425	
$(C_T/\sigma)_8 =$	2376		2386		2396		2406		2516		2426	
$(C_T/\sigma)_9 =$	2377		2387		2397		2407		2517		2427	
$(C_T/\sigma)_{10} =$	2378		2388		2398		2408		2518		2428	

- NOTES: a. WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS  
b.  $C_T$  IS IN PROPELLER ROTATION  
c. INPUT AT LEAST 3 VALUES OF  $C_T/\sigma$  AND MTIP

ASST. NO.

PROPELLER FAN PERFORMANCE DATA (Sheet 1 of 3)

THIS SHEET IS REPRODUCED FROM THE ORIGINAL DATA SHEET.

NOTE: ALL VALUES ARE IN PERCENT UNLESS OTHERWISE SPECIFIED. VALUES OF  $C_p$  OR  $C_{T, P}$  ARE IN PERCENT.

PROP/FAN TABLE NO. 1700

NOTE: SHADING INDICATES UNDESIRABLE OPERATING POINTS. UNDESIRABLE OPERATING POINTS ARE INDICATED BY HATCHED BLOCKS.

NO. OF ADVANCE RATIO PER MACH NUMBER 1700

NO. OF PROP THRUST COEFFICIENTS ( $C_T$ ) OR REFERRED THRUST ( $F_N$ ) AREA 1722

TABLE NO. OR MACH NO.

TABLE NO. OR  $F_N$  REF.

TABLE NO. OR MACH NO.	VALUE
J <sub>1</sub> or M <sub>1</sub>	1702
J <sub>2</sub> or M <sub>2</sub>	1703
J <sub>3</sub> or M <sub>3</sub>	1704
J <sub>4</sub> or M <sub>4</sub>	1705
J <sub>5</sub> or M <sub>5</sub>	1706
J <sub>6</sub> or M <sub>6</sub>	1707
J <sub>7</sub> or M <sub>7</sub>	1708
J <sub>8</sub> or M <sub>8</sub>	1709
J <sub>9</sub> or M <sub>9</sub>	1710
J <sub>10</sub> or M <sub>10</sub>	1711
J <sub>11</sub> or M <sub>11</sub>	1712
J <sub>12</sub> or M <sub>12</sub>	1713
J <sub>13</sub> or M <sub>13</sub>	1714
J <sub>14</sub> or M <sub>14</sub>	1715
J <sub>15</sub> or M <sub>15</sub>	1716
J <sub>16</sub> or M <sub>16</sub>	1717
J <sub>17</sub> or M <sub>17</sub>	1718
J <sub>18</sub> or M <sub>18</sub>	1719
J <sub>19</sub> or M <sub>19</sub>	1720
J <sub>20</sub> or M <sub>20</sub>	1721

TABLE NO. OR $F_N$ REF.	VALUE
G <sub>1</sub> or FN <sub>1</sub>	1723
G <sub>2</sub> or FN <sub>2</sub>	1724
G <sub>3</sub> or FN <sub>3</sub>	1725
G <sub>4</sub> or FN <sub>4</sub>	1726
G <sub>5</sub> or FN <sub>5</sub>	1727
G <sub>6</sub> or FN <sub>6</sub>	1728
G <sub>7</sub> or FN <sub>7</sub>	1729
G <sub>8</sub> or FN <sub>8</sub>	1730
G <sub>9</sub> or FN <sub>9</sub>	1731
G <sub>10</sub> or FN <sub>10</sub>	1732
G <sub>11</sub> or FN <sub>11</sub>	1733
G <sub>12</sub> or FN <sub>12</sub>	1734
G <sub>13</sub> or FN <sub>13</sub>	1735
G <sub>14</sub> or FN <sub>14</sub>	1736
G <sub>15</sub> or FN <sub>15</sub>	1737
G <sub>16</sub> or FN <sub>16</sub>	1738
G <sub>17</sub> or FN <sub>17</sub>	1739
G <sub>18</sub> or FN <sub>18</sub>	1740
G <sub>19</sub> or FN <sub>19</sub>	1741
G <sub>20</sub> or FN <sub>20</sub>	1742

NOTE: A<sub>2</sub> IS THE ANNULUS AREA OF THE FAN

BOEING VERTOL COMPANY VASCOMP II V STOL AIRCRAFT SIZING AND PERFORMANCE COMPUTER PROGRAM B-93  
A DIVISION OF THE BOEING COMPANY

PROPELLER/FAN PERFORMANCE DATA (Sheet 2 of 3)

THIS SHEET IS REQUIRED WHEN  $\tau_{p,IND} = 1$  OR 3

NOTE: WHEN OPTIND = 2 CONSIDER THOSE ITEMS IN THE SHADED BLOCKS

INPUT VALUES OF PROP OR FAN POWER COEFFICIENT FOR COMBINATIONS OF J OR M AND CT OR FN REF

PROPELLER OR FAN THRUST COEFFICIENT

ADVANCE RATIO OR MACH NO.	CT <sub>1</sub> /FN <sub>1</sub>		CT <sub>2</sub> /FN <sub>2</sub>		CT <sub>3</sub> /FN <sub>3</sub>		CT <sub>4</sub> /FN <sub>4</sub>		CT <sub>5</sub> /FN <sub>5</sub>		CT <sub>6</sub> /FN <sub>6</sub>		CT <sub>7</sub> /FN <sub>7</sub>		CT <sub>8</sub> /FN <sub>8</sub>		CT <sub>9</sub> /FN <sub>9</sub>	
	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE
J <sub>1</sub> /M <sub>1</sub> =	1743	1763	1783	1803	1823	1843	1863	1883	1903	1923								
J <sub>2</sub> /M <sub>2</sub> =	1744	1764	1784	1804	1824	1844	1864	1884	1904	1924								
J <sub>3</sub> /M <sub>3</sub> =	1745	1765	1785	1805	1825	1845	1865	1885	1905	1925								
J <sub>4</sub> /M <sub>4</sub> =	1746	1766	1786	1806	1826	1846	1866	1886	1906	1926								
J <sub>5</sub> /M <sub>5</sub> =	1747	1767	1787	1807	1827	1847	1867	1887	1907	1927								
J <sub>6</sub> /M <sub>6</sub> =	1748	1768	1788	1808	1828	1848	1868	1888	1908	1928								
J <sub>7</sub> /M <sub>7</sub> =	1749	1769	1789	1809	1829	1849	1869	1889	1909	1929								
J <sub>8</sub> /M <sub>8</sub> =	1750	1770	1790	1810	1830	1850	1870	1890	1910	1930								
J <sub>9</sub> /M <sub>9</sub> =	1751	1771	1791	1811	1831	1851	1871	1891	1911	1931								
J <sub>10</sub> /M <sub>10</sub> =	1752	1772	1792	1812	1832	1852	1872	1892	1912	1932								
J <sub>11</sub> /M <sub>11</sub> =	1753	1773	1793	1813	1833	1853	1873	1893	1913	1933								
J <sub>12</sub> /M <sub>12</sub> =	1754	1774	1794	1814	1834	1854	1874	1894	1914	1934								
J <sub>13</sub> /M <sub>13</sub> =	1755	1775	1795	1815	1835	1855	1875	1895	1915	1935								
J <sub>14</sub> /M <sub>14</sub> =	1756	1776	1796	1816	1836	1856	1876	1896	1916	1936								
J <sub>15</sub> /M <sub>15</sub> =	1757	1777	1797	1817	1837	1857	1877	1897	1917	1937								
J <sub>16</sub> /M <sub>16</sub> =	1758	1778	1798	1818	1838	1858	1878	1898	1918	1938								
J <sub>17</sub> /M <sub>17</sub> =	1759	1779	1799	1819	1839	1859	1879	1899	1919	1939								
J <sub>18</sub> /M <sub>18</sub> =	1760	1780	1800	1820	1840	1860	1880	1900	1920	1940								
J <sub>19</sub> /M <sub>19</sub> =	1761	1781	1801	1821	1841	1861	1881	1901	1921	1941								
J <sub>20</sub> /M <sub>20</sub> =	1762	1782	1802	1822	1842	1862	1882	1902	1922	1942								

NOTE: 1. IF MORE THAN 10 VALUES OF C<sub>T</sub> OR F<sub>N</sub> ARE REQUIRED, USE SHEET 3 FOR CONTINUATION OF TABLE.

PROPELLER/FAN PERFORMANCE DATA (Sheet 3 of 3)

THIS SHEET IS REQUIRED WHEN  $T_p IND = 1$  OR  $3$

INPUT VALUES OF PROP OR FAN POWER COEFFICIENT FOR COMBINATION OF J OR M AND C OF ENGINE

PROPELLER OR FAN THRUST COEFFICIENT

ADVANCE RATIO OR MACH NO.	C <sub>T11</sub> /M <sub>11</sub> <sup>2</sup>		C <sub>T12</sub> /M <sub>12</sub> <sup>2</sup>		C <sub>T13</sub> /M <sub>13</sub> <sup>2</sup>		C <sub>T14</sub> /M <sub>14</sub> <sup>2</sup>		C <sub>T15</sub> /M <sub>15</sub> <sup>2</sup>		C <sub>T16</sub> /M <sub>16</sub> <sup>2</sup>		C <sub>T17</sub> /M <sub>17</sub> <sup>2</sup>		C <sub>T18</sub> /M <sub>18</sub> <sup>2</sup>		C <sub>T19</sub> /M <sub>19</sub> <sup>2</sup>		C <sub>T20</sub> /M <sub>20</sub> <sup>2</sup>		
	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE	LOC. VALUE
J <sub>1</sub> /M <sub>1</sub> =	1943	1963	1983	2003	2023	2043	2063	2083	2103	2123											
J <sub>2</sub> /M <sub>2</sub> =	1944	1964	1984	2004	2024	2044	2064	2084	2104	2124											
J <sub>3</sub> /M <sub>3</sub> =	1945	1965	1985	2005	2025	2045	2065	2085	2105	2125											
J <sub>4</sub> /M <sub>4</sub> =	1946	1966	1986	2006	2026	2046	2066	2086	2106	2126											
J <sub>5</sub> /M <sub>5</sub> =	1947	1967	1987	2007	2027	2047	2067	2087	2107	2127											
J <sub>6</sub> /M <sub>6</sub> =	1948	1968	1988	2008	2028	2048	2068	2088	2108	2128											
J <sub>7</sub> /M <sub>7</sub> =	1949	1969	1989	2009	2029	2049	2069	2089	2109	2129											
J <sub>8</sub> /M <sub>8</sub> =	1950	1970	1990	2010	2030	2050	2070	2090	2110	2130											
J <sub>9</sub> /M <sub>9</sub> =	1951	1971	1991	2011	2031	2051	2071	2091	2111	2131											
J <sub>10</sub> /M <sub>10</sub> =	1952	1972	1992	2012	2032	2052	2072	2092	2112	2132											
J <sub>11</sub> /M <sub>11</sub> =	1953	1973	1993	2013	2033	2053	2073	2093	2113	2133											
J <sub>12</sub> /M <sub>12</sub> =	1954	1974	1994	2014	2034	2054	2074	2094	2114	2134											
J <sub>13</sub> /M <sub>13</sub> =	1955	1975	1995	2015	2035	2055	2075	2095	2115	2135											
J <sub>14</sub> /M <sub>14</sub> =	1956	1976	1996	2016	2036	2056	2076	2096	2116	2136											
J <sub>15</sub> /M <sub>15</sub> =	1957	1977	1997	2017	2037	2057	2077	2097	2117	2137											
J <sub>16</sub> /M <sub>16</sub> =	1958	1978	1998	2018	2038	2058	2078	2098	2118	2138											
J <sub>17</sub> /M <sub>17</sub> =	1959	1979	1999	2019	2039	2059	2079	2099	2119	2139											
J <sub>18</sub> /M <sub>18</sub> =	1960	1980	2000	2020	2040	2060	2080	2100	2120	2140											
J <sub>19</sub> /M <sub>19</sub> =	1961	1981	2001	2021	2041	2061	2081	2101	2121	2141											
J <sub>20</sub> /M <sub>20</sub> =	1962	1982	2002	2022	2042	2062	2082	2102	2122	2142											





### 5.3.1 PROGRAM VARIABLES

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
AF	0228	AF	Activity factor (per blade) of propeller
AR	0101	DAM2	Wing aspect ratio
AR <sub>HT</sub>	0109	ARHT	Horizontal tail aspect ratio
Aisle Width (IN)	0158	WAISL1	Width of the aisles in first class
Aisle Width (IN)	0166	WAISLT	Width of the aisle in tourist class
AR <sub>VT</sub>	0129	ARVT	Vertical tail aspect ratio
a <sub>H</sub>	0110	SAE	Height of horizontal tail above top of local fuselage (fraction of vertical tail span)
$\bar{c}/D$	0103	DAM3	Mean wing chord to propeller diameter ratio
C <sub>DFTi</sub>	0302	CDFTI	Profile drag coefficient of lift engine nacelles at R <sub>e</sub> = 10 <sup>7</sup> (based on total wetted area of nacelle clusters)
C <sub>DLNi</sub>	0304	CDLNI	Profile drag coefficient of horizontal tail at R <sub>e</sub> = 10 <sup>7</sup> (based on horizontal tail planform area)
C <sub>DNI</sub>	0303	CDNI	Profile drag coefficient of primary engine nacelles at R <sub>e</sub> = 10 <sup>7</sup> (based on wetted area of all nacelles)
C <sub>DVTi</sub>	0301	CDVTI	Profile drag coefficient of vertical tail at R <sub>e</sub> = 10 <sup>7</sup> (based on vertical tail planform area)
C <sub>DWi</sub>	0335-0342	TBCDWI	Profile drag coefficient of wing at R <sub>e</sub> = 10 <sup>7</sup> (based on wing planform area)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$\Delta C_D$	0305	DELCD	Profile drag increment (based on wing planform area)
$\Delta C_{DCLIMB}$	0781-0790	DCLIMB	Profile drag increase during climb.
$\Delta C_{DCR}$	0891-0900	DLCDRC	Profile drag increase during cruise due to engines being shut down (based on wing planform area)
$\Delta C_{DDESC}$	0991-1000	CLCDDS	Profile drag increase during descent. Used to simulate drag brakes.
$\Delta C_{DDM}$	0350-0384	TBCDM	Increase in airplane drag due to Mach number (compressibility effects). Input table as a function of Mach number and lift coefficient (based on wing planform area)
$\Delta C_{DLOITER}$	1071-1080	DLOITR	Increase in planform drag during loiter
$C_{Li}$	0230	CLEYE	Propeller integrated design lift coefficient
$C_{L\alpha}$	0331	CSALF	Two-dimensional lift coefficient slope (Rad. <sup>-1</sup> )
$C_i$	0317-0324	TBCL1	Values of lift coefficients
$C_L$	0343-0349	TBCL2	Values of lift coefficients
$C_p$	1723-1742	CPPROP	Propeller power coefficient (550 HP/ $\rho\eta D^5$ )
$C_T$	1743-2142	CTPROP	Propeller thrust coefficient (Thrust/ $\rho\eta^2 D^4$ )
$C_T/\sigma$	0227	CTSIG	Ratio of thrust coefficient to propeller solidity (helicopter $C_T = \text{thrust}/\rho AV_{TIP}^2$ )
DIA	0226	DI	Propeller diameter (ft.)

<u>VAR</u> <u>ABLE</u>	<u>LOCATION</u>	<u>FORTTRAN</u> <u>NAME</u>	<u>DESCRIPTION</u>
EAS	0911-0920	EASS	Equivalent airspeed required during descent
EAS	0701-0710	EMACH	Equivalent airspeed required during climb
e	0306	DAM10	Span loading efficiency factor (Oswald's efficiency factor)
$\Delta f_e$	0307	DELFE	Increment in equivalent flat plate area parasite drag of fuselage (sq ft)
$F_N^*$	0203	DAM6	Primary engine maximum static thrust at sea level, standard conditions (total thrust for all engines)
Galley Area (ft <sup>2</sup> )	0152	AGLLEY	Total area of the galley(s)
$F_{NL}^*$	0219	DAM9	Lift engine maximum static thrust at sea level, standard conditions (total thrust for all engines)
Headwind	0811-0820	VIN	Headwind during cruise (knots)
$h_o$	0015	H00	Initial altitude at start of mission
$h_c$	0214	HC	Cruise altitude for sizing engines (feet)
$h_{final}$ ( $h_{opt}^{IND=0}$ )	1111-1120	HFIN(FT)	Final altitude for transfer altitude segment (SGTIND=9)
or $h_{max}(h_{opt}^{IND=1})$			
$h_{max}$	0741-0750	HMAX	Maximum altitude during climb (feet) or during transfer altitude (feet)
$h_{min}$	0971-0980	HMIN	Minimum altitude during descent (feet)
$h_1$	0440-0449	TBH	Input altitude for non-standard atmosphere map.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$K_{18}$	0413	CK18	Fixed wing controls multiplicative weight factor
$K_{19}$	0414	CK19	SAS multiplicative weight factor
$K_{20}$	0415	CK20	Tilt mechanism multiplicative weight factor
$K_{21}$	0465	CK21	Fuel system multiplicative weight factor
$K_f$	0314	CKF	Fuselage multiplicative drag factor
$K_{if}$	0026	CKFF	Fuel flow multiplicative drag factor
$K_{ht}$	0316	CKHT	Horizontal tail multiplicative drag factor
$K_{ln}$	0311	CKLN	Lift nacelle multiplicative drag factor
$K_n$	0313	CKN	Primary nacelle multiplicative drag factor
$K_{pn}$	1248-1257	PNZ	Ratio of power available at specified $N_{II}$ to power available at optimum $N_{II}$
$K_{pr}$	1225-1234	RNE	Correction factor for engine power to account for Reynolds' number effects
$K_{rc}$	0262	CKRC	Multiplicative constant to be used to calculate takeoff vertical climb power, nominally 2.0 for turboshaft aircraft and lower for high disc loaded aircraft and fans
$K_{vt}$	0315	CKVT	Vertical tail multiplicative drag factor
$K_w$	0312	CKW	Wing multiplicative drag factor

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
LETF	0641-0650	FLET2	Lift engine thrust fraction. Required when TOLIND = 3
K <sub>2</sub>	0459	CK2	Propeller group multiplica- tive weight factor
K <sub>3</sub>	0460	CK3	Drive system multiplicative weight factor
K <sub>4</sub>	0461	CK4	Lift engine multiplicative weight factor
K <sub>5</sub>	0462	CK5	Primary engine multiplica- tive weight factor
K <sub>6</sub>	0463	CK6	Lift engine installation multiplicative weight factor
K <sub>7</sub>	0464	CK7	Primary engine installation multiplicative weight fac- tor
K <sub>8</sub>	0433	CK8	Wing weight multiplicative weight factor
K <sub>9</sub>	0434	CK9	Horizontal tail weight mul- tiplicative weight factor
K <sub>10</sub>	0435	CK10	Vertical tail weight multi- plicative weight factor
K <sub>11</sub>	0436	CK11	Fuselage weight multipli- cative weight factor
K <sub>12</sub>	0437	CK12	Landing gear weight multi- plicative weight factor
K <sub>13</sub>	0438	CK13	Lift engine section multi- plicative weight factor
K <sub>14</sub>	0439	CK14	Primary engine section mul- tiplicative weight factor
K <sub>15</sub>	0410	CK15	Cockpit controls multipli- cative weight factor

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
K <sub>16</sub>	0411	CK16	Upper controls multiplicative weight factor
K <sub>17</sub>	0412	CK17	Hydraulics multiplicative weight factor
K <sub>B</sub>	0420	SKP	Body group weight adjustment factor
K <sub>DS</sub>	0453	SKDS	Drive system weight adjustment factor
K <sub>FS</sub>	0454	SKFS	Fuel system weight adjustment factor
K <sub>lei</sub>	0455	SKLEI	Lift engine installation weight factor
K <sub>les</sub>	0421	SKLES	Lift engine section weight factor
K <sub>lg</sub>	0422	SKLG	Weight of alighting gear as a percentage of gross weight
K <sub>mg</sub>	0423	SKMG	Ratio of main alighting gear weight to gross weight
K <sub>mt</sub>	0430	SKMT	Engine nacelle type factor
K <sub>nac</sub>	0431	SKNAC	Engine nacelle adjustment factor
K <sub>pei</sub>	0456	SKPEI	Primary engine installation weight factor
K <sub>pes</sub>	0429	SKPES	Primary engine section weight factor
K <sub>r/p</sub>	0457	SKRP	Rotor or propeller weight adjustment factor for type of system
K <sub>sas</sub>	0407	SKSAS	Factor for stability augmented system and mixing units
K <sub>tl</sub>	0424	SKTL	Tail load adjustment factor
K <sub>tm</sub>	0408	SKTM	Multiplicative constant for tilting mechanism.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
$K_{uc}$	0409	SKUC	Multiplicative constant for upper control mechanics
$K_{vt}$	0458	SKVT	Adjustment factor for variations in drive system weight due to nonuniformities in hover and XMSN tipspeeds or maximum and XMSN powers
$K_{wf}$	0425	SKWF	Wing bending relief moment adjustment factor
$K_{ww}$	0426	SKWW	Wing type weight adjustment factor
$K_y$	0427	SKY	Pitch radius of gyration, feet
$K_z$	0428	SKZ	Yaw radius of gyration, feet
$\Delta h$	0721-0730	DELH3	Step size for climb (feet)
$\Delta h$	0951-0960	DELH5	Step size for descent (feet)
$h_F$	0121	HF	Height of fuselage (feet)
$h_{TO}$	0207	HES	Takeoff altitude for sizing engines
$i_w$	0103	EYEW	Wing incidence angle with respect to fuselage (degrees)
$k_1$	1602	SK1	{ Lift engines weight factors
$k_2$	1603	SK2	
$k_3$	1302	SK3	{ Primary engine weight factors
$k_4$	1303	SK4	
$K_{FL}$	0531-0540	SKFL	Lift engine taxi segment factor (0 = lift engines off during taxi 1 = lift engines operating)
$K_1$	0C24	CK1	Fuel required multiplicative reserve factor





<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
$K_{CC}$	0404	SKCC	Cockpit controls constant
$K_{DS}$	0453	SKDS	Drive system weights constant
$K_{FS}$	0454	SKFS	Fuel system weights constant
$K_{FW}$	0405	SKFW	Fixed-wing controls constant
$K_H$	0406	SKH	System and hydraulics constant
$K_{LEI}$	0455	SKLEI	Lift engine installation factor
$l_{CONSTANT\ DIA}$	0125	ELC	Constant diameter section (cabin) length (feet)
$l_F$	0122	DAM5	Fuselage length (feet)
$l_{MT}$	0432	SKLMT	Distance between engine center of gravity and closest struc- tural attachment point between nacelle and wing, ratioed to length of nacelle
$l_{RW}$	0126	ELRW	Length of ramp well (feet)
$l_{TN}$	0111	ELTH	Horizontal tail moment arm (feet)
$l_{TV}$	0130	ELTV	Vertical tail moment arm (feet)
$(l/d)_{nose}$	0123	ELPD	Fineness ratio airplane nose section
$(l/d)_{tail}$	0124	ELTD	Fineness ratio airplane tail section
Mach	0701-0710	EAS5	Mach number required during climb
Mach	0911-0920	EMACH	Mach number required during descent
$M_{LF}$	0023	ENLF	Maneuver load factor (g's)
$M_{WO}$	0020	EMMO	Maximum operating mach number

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$N_C$	0221	ENC	Number of clusters of lift engines
$N_L$	0220	ENL	Number of lift engines
$N_{LO}$	0212	ENLO	Number of lift engines inoperative (for engine sizing)
$N_p$	0204	ENP	Number of primary engines
$N_{PO}$	0211	ENPO	Number of primary engines inoperative (for engine sizing)
$N_{PSD_{CR}}$	0871-0880	ENPSD	Number of primary engines shut down during cruise
$N_{PSD_{LOITER}}$	1051-1060	ENPSDL	Number of primary engines shut down during loiter
$N_R$	0223	ENR	Number of rotors or propellers
$(N_{I_{MAX}}/N_I^*)_L$	1236	AILMAX	Gas generator RPM limit - ratio of max gas generator RPM to RPM at maximum static power, sea level, standard for lift engines
$(N_{I_{MAX}}/N_I^*)_L$	1221	AIMAX	Gas generator RPM limit - ratio of max gas generator RPM to RPM at maximum static power, sea level, standard for primary engines
$(N_I/\sqrt{\theta}/N_I^*)_{MAX}$	1222	A3MAX	Gas generator referred RPM limit ( $\theta$ = temperature ratio @ compression face), this input simulates a restriction on compression speed

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$N_{II}/N_{II_{OPT}}$	1238-1247	A2NO	<p>Ratio of operating power turbine speed to optimum power turbine speed (input when N2IND = 2). <math>N_{II}/N_{II_{OPT}}</math> is set = 1.0, and <math>N_{II}/N_{II_{MAX}}</math> is determined from</p> $\frac{N_{II}}{N_{II_{OPT}}} = \frac{\frac{N_{II}}{N_{II_{MAX}}} \frac{N_{II_{MAX}}}{N_{II}^*}}{\frac{N_{II_{OPT}}}{N_{II}^* \sqrt{\theta}}} \frac{1}{\sqrt{\theta}}$ <p>If <math>N_{II}/N_{II_{MAX}}</math> is much greater than 1.0, then set <math>N_{II}/N_{II_{MAX}} = 1</math> and calculate <math>N_{II}/N_{II_{OPT}}</math>.</p>
$(N_I/N_I^*) \frac{D}{V_1}$	1207-1216	PRN	Reynold's number correction for gas generator shaft speed (RPM)
$(N_I/N_{I_L} \sqrt{\theta})_1$	1649-1656	FONE	Values of referred gas generator shaft speed limit ratio, input as a function of referred temperature for lift engines
$(N_{II}/N_{II_L} \sqrt{\theta})_1$	1665-1672	FTWO	Values of referred power turbine speed limit ratio, input as a function of referred temperature for lift engines

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$(N_{II}/N_{II\text{MAX}})$	0217 C	AN2CR	Ratio of operating power turbine speed to maximum power turbine speed (input when sizing primary engines for cruise)

If in cruise the rotor is slowed to a known velocity,

$$\frac{N_{II}}{N_{II\text{MAX}} \text{ CR}}$$

can be determined from

$$\frac{N_{II}}{N_{II\text{MAX}} \text{ CR}} = \frac{V_{\text{OPERATING}}}{\frac{N_{II\text{MAX}}}{N_{II}^*} V_{T\text{REF}}}$$

where  $V_T$  is input in LOC (0181), and

$\frac{N_{II\text{MAX}}}{N_{II}^*}$  is in LOC (1223).

$N_{II}/N_{II\text{MAX}} \text{ TAXI}$	0591-0550	AN2M1	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segment 1, TAXI).
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This value can be altered to obtain the desired operating tip velocity through the correlation

$$V_{T\text{OPERATING}} = \frac{N_{II}}{N_{II\text{MAX}}} \frac{N_{II\text{MAX}}}{N_{II}^*} V_{T\text{REF}}$$

where  $\frac{N_{II\text{MAX}}}{N_{II}^*}$  is input in LOC (1223)

and  $V_T$  is input in LOC (0181).

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$\frac{N_{II}}{N_{II}^{MAX}}$ TAKEOFF	0671-0680	AN2M2	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segment 2, TAKEOFF, HOVER, LAND)
$\frac{N_{II}}{N_{II}^{MAX}}$ CLIMB	0771-0780	AN2M3	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segment 3, CLIMB)
$\frac{N_{II}}{N_{II}^{MAX}}$ CRUISE	0881-0890	AN2M4	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segment 4, CRUISE)
$\frac{N_{II}}{N_{II}^{MAX}}$ DESC	0981-0990	AN2M5	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segment 5, DESCENT)
$\frac{N_{II}}{N_{II}^{MAX}}$ LOITER	1061-1070	AN2M6	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segment 6, LOITER)
$\frac{N_{II}}{N_{II}^{MAX}}$ TO	0201	AN2TO	Ratio of operating power turbine speed to maximum power turbine speed (input when sizing primary engines for takeoff).

This value is set to obtain the desired operating tip velocity at takeoff from the equation.

$$\frac{N_{II}}{N_{II}^{MAX TO}} = \frac{V_{T OPERATING}}{\frac{N_{II}^{MAX}}{N_{II}} V_{T REF}}$$

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$N_{II\_MAX} / N_{II}^*$	1223	A2MAX	Power turbine speed limit ratio of maximum power turbine speed to power turbine speed at maximum static power, sea level, standard for the primary engines.
$N_{II\_MAX} / N_{II}^* L$	1237	AL2MAX	Power turbine speed limit ratio of maximum power turbine speed to power turbine speed at maximum static power, sea level, standard.
Number of Advance Ratios (J)	1701	XPXNO	Number of advance ratio values in locations 1702-1721
Atmosphere Temp. No. of Pairs	0416	THN	Number of temperature pairs in locations 0440-0449 & 0466-0475
No. of Aisles	0155	AN1SL1	Number of aisles in the first class section
No. of Aisles	0163	AN1SLT	Number of aisles in the tourist class section
No. of Blades	0229	BLDN	Number of blades on prop/rotor
No. of Lavs.	0160	ANLAVS	Number of lavatories onboard
No. of CL.	0310	TCLZN	Number of CL values in locations 0343-0349
No. of M	1319	UMS	Number of mach number values in locations 1320-1325
No. of M	1383	UMW	Number of mach number values in locations 1384-1389
No. of M	1447	UMN1	Number of mach number values in locations 1448-1453
No. of M	1551	UMN2	Number of mach number values in locations 1512-1517

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
No. of M	0309	TENN	Number of mach numbers
No. of Pairs in Table	0308	TLLN	Number of pairs in $C_L \sim C_{Di}$ table
No. Pairs $\eta_{p4}$ Table	0245	ETAP4N	Number of $\eta_{p4}$ pairs in locations 0235-0255
No. of Passengers	0153	ANPX1	Number of passengers in the first class section of the aircraft
No. of Passengers	0161	ANPXT	Number of passengers in the tourist class section of the aircraft
No. of Prop Thrust Coef- ficients ( $C_T$ )	1722	CPPNO	Number of prop thrust coef- ficients in locations 1723- 1742
No. of T/θ	1310	UNTS	Number of refered tempera- tures in locations 1311-1318
No. of T/θ	1374	UNTW	Number of refered tempera- tures in locations 1375-1382
No. of T/θ	1433	UNT1	Number of refered tempera- tures in locations 1439-1446
No. of T/θ	1502	UNT2	Number of refered tempera- tures in locations 1503-1510
$n_T$	0651-0660	ENT	Thrust-to-weight ratio during takeoff (Takeoff, Hover, and Landing Calculations Subrou- tine)
n	0208	SENE	Thrust-to-weight ratio for engine sizing
$\Delta n_{CLIMB}$	0791-0800	ENCLIMB	Incremental normal load fac- tor for energy-maneuverability calculations
OWE	0400	ONE1	Operating Weight Empty (pounds)
PETF or PETH	0621-0630	PFET2	Primary engine power (or thrust) fraction. Required when TOLIND = 3.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$\Delta P_{PSI}$	0450	DELP	Limit differential cabin pressure (PSI)
$Q_{MAX}/Q^*$	1224	QMAX	Ratio of maximum torque limit to torque developed at sea level static standard day conditions. See engine and transmission sizing for the options available.
$R_0$	0016	ROO	Initial range at start of mission (nautical miles)
$R_{MAX\ CRUISE}$	0851-0860	RMAX	Range at end of cruise (nautical miles)
$R_{MAX\ DESC.}$	0961-0970	RMAX5	Range at end of descent (nautical miles)
$\Delta R$	0831-0840	DELR	Step size for cruise (nautical miles)
$R_e/l_z$	0330	RECI	Mean Reynold's number per foot for mission
r	0116	SR	Propeller blade attachment distance from hub center line (fraction of propeller radius)
$S_F$	0127	DAM6	Fuselage wetted area ( $FT^2$ )
$S_{HT}$	0115	AAW11	Area of horizontal tail. Used when HTIND = 2.
$S_{VT}$	0134	AAW12	Area of vertical tail. Used when VTIND = 2.
Seats Abreast	0162	ANABT	Seats abreast in tourist
Seats Abreast	0154	ANAB1	Seats abreast in first class
Seat Pitch	0157	PSEAT1	Seat pitch in first class
Seat Pitch	0165	PSEATT	Seat pitch in tourist



<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
SHP*	0202	DAM7	Primary engine maximum static horsepower at sea level standard conditions (total power for all engines)
SHP <sub>E</sub> /SHP*	0260	SHPTO	Fraction of power input for sizing engines; nominally input as 1.0
SHP <sub>XM</sub> /SHP*	0258	XMSMRT	Fraction of power for transmission sizing
$\Delta S_{WET}/S_W$	0120	DLSWSW	Incremental wetted area of airplane ratioed to wing planform area
SW <sub>F</sub>	0025	DELWF	Reserve fuel factor
t <sub>0</sub>	0017	STOO	Initial time at start of mission hours
(t/c)HT	0112	TLCT	Horizontal tail mean thickness/chord ratio
(t/c)R	0104	TCR	Wing root thickness to chord ratio
(t/c)T	0105	TCT	Wing tip thickness chord ratio
(t/c)VT	0131	TCVT	Vertical tail mean thickness chord ratio
T <sub>FI</sub> (°R)	1306	TFI	Turbine inlet temperature at flight idle power setting primary engines
T <sub>GI</sub> (°R)	1305	TGI	Turbine inlet temperature at ground idle power setting primary engines
T <sub>GI</sub>	1607	TLGI	Lift engine turbine inlet temperature at ground idle
t <sub>F</sub>	0681-0690	STF	Incremental time for houer (HR)
$\Delta t_F$	0661-0670	DELTF	Step size for houer (Hours)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
$t_{FW}$	1121-1130	STFW	Incremental time for change of fuel weight
$\Delta T_{in\_TAXI}$ ( $^{\circ}F$ )	0521-0530	TIN1	Increment in ambient temperature for engine sizing at TAXI conditions ( $^{\circ}R$ )
$\Delta T_{in\_T/O}$ ( $^{\circ}F$ )	0631-0640	TIN2	Increment in ambient temperature for engine sizing at takeoff conditions ( $^{\circ}R$ )
$\Delta T_{in\_CLIMB}$ ( $^{\circ}F$ )	0731-0740	TIN3	Increment in ambient temperature for engine sizing at CLIMB conditions ( $^{\circ}R$ )
$\Delta T_{in\_CRUISE}$ ( $^{\circ}F$ )	0631-0640	TIN4	Increment in ambient temperature for engine sizing at CRUISE conditions ( $^{\circ}R$ )
$\Delta T_{in\_DESCENT}$ ( $^{\circ}F$ )	0941-0950	TIN5	Increment in ambient temperature for engine sizing at DESCENT conditions ( $^{\circ}R$ )
$\Delta T_{in\_LOITER}$ ( $^{\circ}F$ )	0041-1050	TIN6	Increment in ambient temperature for engine sizing at LOITER conditions ( $^{\circ}R$ )
$\Delta T_{in\_TO}$ ( $^{\circ}F$ )	0209	TINY	Increment in ambient temperature for engine sizing at takeoff conditions ( $^{\circ}R$ )
$\Delta T_{in\_C}$ ( $^{\circ}F$ )	0216	ATMIY	Increment in ambient temperature for engine sizing at cruise conditions ( $^{\circ}R$ )
$t_L$ (HR)	1031-1040		Incremental time for loiter (HRS)
$\Delta t_L$	1011-1020	DELST	Step size for loiter (HRS)
$T_{MAX}$	1608	TLMAX	Turbine inlet temperature (maximum power setting), or input on engine cycle sheets for lift engines
$T_{MAX}$ ( $^{\circ}R$ )	1309	TMAX	Turbine inlet temperature (maximum power setting), or input on engine cycle sheets

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
$T_{MIL}$ ( $^{\circ}R$ )	1308	TMIL	Turbine inlet temperature (military power setting), or input on engine cycle sheets
$T_{NP}$ ( $^{\circ}R$ )	1307	TNRP	Turbine inlet temperature (normal power setting), or input on engine cycle sheets
$t_{pw}$ (HR)	1141-1150	STPW	Incremental time for change of payload weight (HRS)
$t_T$ (HR)	0511-0520	DELTT	Incremental time for taxi (hours)
T/0 (Primary Engine Cycle No.)	1311-1318	TSHP	Referred turbine temperature ( $^{\circ}R$ )
T/0 (Primary Engine Cycle No.)	1375-1382	TWD	Referred turbine temperature ( $^{\circ}R$ )
T/0 (Primary Engine Cycle No.)	1439-1446	TN1	Referred turbine temperature ( $^{\circ}R$ )
T/0 (Primary Engine Cycle No.)	1503-1510	TN2	Referred turbine temperature ( $^{\circ}R$ )
Unit Seat Width	0156	WSEAT1	Input width of the seats in first class
Unit Seat Width	0164	WSEATT	Input width of the seats in tourist class
Values of $\eta_{p4}$	0246-0255	TB8AP4	Values of ETAPU in locations 0246-0255
Values of $K_{PR}$	1225-1234	RNE	Table of $K_{PR}$ values
Values of M	0235-0244	TBEM5	Table of mach numbers for M- $\eta_{p4}$ pairs for turboshaft engines

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
Values of M	1320-1325	AMSHP	Values of mach number for the referred thrust table
Values of M	1384-1389	AMWD	Values of mach number for the referred fuel flow table
Values of M	1448-1453	AM1	Values of mach number for the referred gas generator RPM limit
Values of M	1512-1517	AM2	Values of mach number for the referred power turbine RPM limit table
Values of $N_I$	1454-1501	AONE	Values of referred power generator RPM speed limit
Values of $N_{II}$	1518-1565	ATWO	Values of referred power turbine RPM speed limit
Values of Referred Thrust ( $F_N/SF_{NL}^*$ ) <sub>1</sub>	1609-1616	TF	Referred fuel flow as a function of (T/θ) for lift engines
Values of Referred Fuel Flow	1625-1632	TFW	function of (T/θ)
Values of Referred $N_I$	1641-1648	TF1	Referred $N_I$ as a function of (T/θ) for lift engines
Values of Referred $N_{II}$	1657-1664	TF2	Referred $N_{II}$ as a function of (T/θ) for lift engines
Values of Referred Thrust or Horsepower	1326-1373	SHPAV	Table of power available referred to T/θ
Values of Fuel Flow	1390-1437	WDOT	Values of fuel flow as a function of (T/θ)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTTRAN NAME</u>	<u>DESCRIPTION</u>
Values of M	0325-0329	TBEM	Table of mach numbers used in generating compressibility effect
$V_{R/C}$	2321-2330	VRCTO	Vertical rate of climb in FT/MIN for takeoff, hover, and landing segment
$V_{R/CTAKEOFF}$	0261	VRCRC	Vertical rate of climb in FT/MIN for engine sizing for takeoff
$V_{TIP}$	0224	VT	Propeller tip speed (fps) Note: for $ENGINE = 0$ this is the tip speed corresponding to $N_{II} = N_{II}^*$
$\bar{V}_v$	0132	VBARV	Vertical tail volume coefficient
$W_c$	0451	WC	Weight of concentrated load
$W_{FE}$	0401	WFE	Weight of fixed equipment
$W_{FUL}$	0402	WFUL	Weight fixed useful load
$W_{go}$	0014	WGOO	Initial gross weight at start of mission (pounds)
$W_{g/A}$	0225	WGA	DISC loading (psf)
$W_{PL}$	0403	WPL	Weight of payload (pounds)
$W_{g/S}$	0106	DAM4	Wing loading (psf)
$\Delta W_{FC}$	0417	DELWFZ	Flight controls group incremental weight (pounds)
$\Delta W_F$	1101-1110	DLTAWF	Increment in fuel weight during change of fuel weight subroutine (pounds)
$\Delta W_P$	0418	DELWP	Propulsion group incremen-

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
Values of J	1702-1721	XPJ	Table of prop advance ratio
$V_C$	0215	VC	True airspeed for engine sizing at cruise conditions
$V_{DIVE}$	0022	VDIV	Dive speed (knot gas)
$V_{IN}$	0811-0820	VIN	True airspeed for cruise during cruise segment with CRSIND = 2 (knots)
$V_{MO}$	0021	VMO	Maximum operative equivalent airspeed (knots)
$\bar{V}_H$	0113	VBARH	Horizontal tail volume coefficient
$\Delta W_{PL}$	1131-1140	DELWPL	Increment in payload weight during change of payload weight subroutine (pounds)
$\Delta W_{ST}$	0419	DELWST	Structures group incremental weight (LBS)
$W_F$	0128	SWF	Width of fuselage
$W_{MAX}^*$	1220	WMAX	Referred fuel flow cutoff for primary engines

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$W_{MAX}^*/W_L^*$	1235	WLMAX	Referred fuel flow cutoff for lift engines
$\dot{W}_F/\delta\sqrt{\theta}F_{NL}^*$	1633-1640	FWDOT	Referred fuel flow rate for lift engines (lbs/hr/lb $F_{NL}^*$ )
$W_F/\delta\sqrt{\theta}F_N^*$ $W_F/\delta\sqrt{\theta}SHP^*$	1390-1437	WDOT	Referred fuel flow rate for primary engines (lbs/hr/lb $F_N^*$ or lbs/hr/SHP*)
(W/S Wing & Flap/(W/S) Wing)	1081-1090	RSW	Wing area increase due to flap extension
$Y_C$	0452	YC	Position of concentrated load outboard from aircraft $\bar{g}$ (fraction of wing semi span)
$Y_u$	0117	YCL	Clearance from inboard propeller tip to inboard propeller tip across fuselage (feet)
$Y_l$	0137	YL	Mean position of lift engines outboard from aircraft $\bar{g}$ (fraction of wing semi span)
$Y_{mg}$	0135	YMG	Position of main landing gear outboard from side of body (fraction of wing semi-span)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$Y_p$	0136	YP	Mean position of primary engines outboard from airplane $\bar{c}$ (fraction of wing semi span)
$Z_1$	0139	AZETA1	Primary engine nacelle dimensional factors
$Z_2$	0140	AZETA2	
$Z_3$	0141	AZETA3	
$\alpha_{LO}$	0332	ALPHL	Angle of attack where zero lift occurs
$\beta$	0205	BETA	Conversion ratio for convertible engines (lbs/hp)
$\epsilon$	0138	EPSLON	Life engine cluster gap factor (see Section 2.1)
$\zeta$	0118	ZETA1	Propeller over propeller overlap fraction of radius



<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$\zeta$	0119	ZETA2	Propeller over wingtip overlap (fraction of radius)
$\eta_L$	0231	ETAC	Lift engine efficiency for Takeoff, Hover, and Landing Calculations Subroutine
$\eta_{P2}$	0232	ETAP2	Primary engine propulsive efficiency for SGTIND = 2
$\eta_{P3}$	0233	ETAP3	Primary engine propulsive efficiency for SGTIND = 3
$\eta_{P5}$	0234	ETAP5	Primary engine propulsive efficiency for SGTIND = 5
$\eta_T$	0206	ETAT	Transmission efficiency
$\theta$	0466-0475	TBTHE	Ambient temperature ratio, tabular function of altitude
$\theta_{max}$ (DEG)	0761-0770	THEMAX	Maximum body attitude angle, climb (degrees)
$\theta_{min}$ (DEG)	0931-0940	THEMIN	Minimum body attitude angle, descent (degrees)
$\Lambda_{C/4}$	0104	DLMC4	Sweep angle of wing quarter chord (degree)
$\lambda$	0108	SLM	Taper ratio of wing
$\lambda_H$	0114	SLMH	Taper ratio of horizontal tail
$\lambda_V$	0133	SLMV	Taper ratio of vertical tail
$\xi_1$	1604	XI1	
$\xi_2$	1605	XI2	Lift engine dimensional factors
$\xi_3$	1606	XI3	
$\xi_4$	1304	XI4	Primary engine dimensional factor

### 5.3.2 Program Indicators

#### Option Indicators

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
OPTIND	0001	OPTIND	1 = size aircraft 2 = calculate performance (specify initial gross weight) 3 = calculate performance (specify operating weight empty)
OPTIONAL PRINT	0002	TNIRPK	0 = Standard print 1 = Detailed print

#### Propulsion Indicators

ENGIND	0011	ENGIND	0 = turboshaft (power producing) engine 1 = turbofan or turbojet (thrust producing) engine 2 = convertible engine
LFTIND	0013	DNITFL	0 = no lift propulsion engine selected 1 = lift propulsion engine selected
FIXIND	0010	FIXIND	0 = "fixed" size engines. User inputs maximum power or thrust. 1 = "rubberized" engines. Program will calculate maximum power or thrust.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
The following five indicators are for primary engines:			
WDTIND	1201	WGTIND	0 = no fuel flow limit 1 = fuel flow limit
QIND	1205	QIND	0 = no torque limit 1 = torque limit
N1IND	1202	AN1IND	0 = no $N_I$ limit 1 = $N_I$ limit
N1θIND	1203	AN3IND	0 = no $N_I/\sqrt{\theta_1}$ limit 1 = $N_I/\sqrt{\theta_1}$ limit
N2IND	1204	AN2IND	0 = no $N_{II}$ limit. Engine operating at optimum $N_{II}$ 1 = $N_{II}$ limit. Engine operating at optimum $N_{II}$ 2 = $N_{II}$ limit. Engine operating at known value of $N_{II}$ (in general, non-optimum)

The following four indicators are for lift engines:

LWDIND	1217	VWDIND	0 = no fuel flow limit 1 = fuel flow limit
LNIND	1218	VN1IND	0 = no $N_I$ limit 1 = $N_I$ limit
LN2IND	1219	VN2IND	0 = no $N_{II}$ limit 1 = $N_{II}$ limit
RNOIND	1205	RNOIND	0 = no Reynolds' number corrections for Primary Engines

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
POWIND	0751-0760	POWCLI	1 = Reynolds' number corrections
POWIND	0861-0870 or 0213	POWCRI POWESI	0 = maximum engine rating  1 = military engine rating  2 = normal engine rating

(The indicator listed below is applicable  
only if LFTIND = 0 and FIXIND = 1)

ESZIND	0012	ESZIND	0 = program will size engines for takeoff only  1 = program will size engines for more critical choice of takeoff or cruise
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Aerodynamics Indicators

DRGIND	0003	DRGIND	0 = program calculates compressibility drag coefficient  1 = user inputs table of compressibility drag coefficient as a function of Mach number and lift coefficient
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<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
OSWIND	0004	OSWIND	0 = user inputs Oswald's efficiency (e)  1 = program calculates Oswald's efficiency
<u>Size Trends Indicators</u>			
FDMIND	0006	FDMIND	0 = user inputs fuselage length and wetted area  1 = user inputs constant diameter (cabin) length, nose and tail fineness ratios. Program calculates total length and wetted area.  2 = user inputs (l/d) NOSE, (l/d) TAIL, and passenger data. Program calculates fuselage dimensions required to accommodate passengers.
WDMIND	0007	WDMIND	0 = user inputs wing loading and aspect ratio  1 = user inputs chord to diameter ratio and disc loading. Program calculates wing loading and aspect ratio.  2 = user inputs wing loading and disc loading. Program calculates chord to diameter ratio and aspect ratio.
HTIND	0008	HTIND	1 = input horizontal tail volume coefficient and moment arm. Program calculates tail area.  2 = input tail area

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
VTIND	0009	VTIND	1 = input vertical tail volume coefficient and moment arm. Program calculates tail area.  2 = input tail area
PDMIND	0005	PDMIND	1 = input prop diameter and activity factor per blade  2 = input prop disc loading and activity factor per blade  3 = input prop diameter and thrust coefficient to solidity ratio  4 = input prop disc loading and thrust coefficient to solidity ratio
XSMNIND	0218	XMSND	0 = aircraft transmission sized at a specified fraction (LOC 0258) of installed power  1 = aircraft transmission sized at a specified fraction (LOC 0258) of power required to hover or cruise power required, whichever is most critical.
GALLERY INDICATOR	0151	DN11GN	0 = program calculates galley area by trend equation  1 = user inputs galley area
LAVATORY	0159	DNIVAL	0 = program calculates number of lavatories by trend equation  1 = user inputs number of lavatories

Flight Path Control Indicators

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
$A_{opt} IND$	0018	HOPTIND	0 = cruise segments performed at specified altitude 1 = cruise segments preceded by climb or transfer altitude are performed at optimum altitude, constrained by an input maximum altitude
VLMIND	0019	VLMIND	0 = no constraint or equivalent airspeed 1 = equivalent airspeed constrained to be less than or equal to 250 knots at altitudes of 10,000 feet or less

Mission Performance Indicators

SGTIND	0027-0076	SGTIND	0 = end of mission 1 = taxi 2 = takeoff, hover and landing 3 = climb 4 = cruise 5 = descent 6 = loiter 7 = change of fuel weight 8 = change of payload weight 9 = transfer altitude 10 = X-Y Plotter output 11 = general performance 100 = end of case
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<u>TABLE</u>	<u>NO.</u>	<u>NAME</u>	<u>DEFINITION</u>
CLIND	0601-0610	CLIND	<ul style="list-style-type: none"> <li>1 = input required thrust-weight ratio. Airplane will use maximum power from lift engines before augmenting with primary engines--or-- will use only primary engines if LIFTIND = 0.</li> <li>2 = input required thrust-weight ratio. Airplane will use equal percentages of power from lift and primary engines.</li> <li>3 = input required fraction of maximum power</li> </ul>
CLMIND	0691-0700	CLMIND	<ul style="list-style-type: none"> <li>1 = maximum rate of climb</li> <li>2 = climb at constant EAS</li> <li>3 = climb at constant mach number</li> <li>4 = climb at constant true airspeed</li> </ul>
CRSIND	0801-0810	CRSIND	<ul style="list-style-type: none"> <li>1 = cruise at cruise power</li> <li>2 = cruise at constant true airspeed</li> <li>3 = cruise at speed for best specific range</li> <li>4 = cruise at speed for 99% of best specific range</li> <li>5 = cruise-climb (constant W/d) at speed for best specific range</li> <li>6 = cruise-climb (constant W/d) at speed for 99% of best specific range</li> </ul>



<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
DESCIND	0901-0910	DESCIND	1 = descend at maximum speed, terminal range specified
			2 = descend at maximum speed, terminal range not specified
			3 = descend at idle power, terminal range specified
			4 = descend at idle power, terminal range not specified
			5 = descend at constant EAS, terminal range specified
			6 = descend at constant EAS, terminal range not specified
			7 = descend at constant Mach number, terminal range specified
			8 = descend at constant Mach number terminal range not specified
LTRIND	1001-1010	DNI.MTL	0 = loiter mission used for reserve fuel calculation (gross weight reset following loiter)
			1 = loiter mission used as part of basic mission profile (gross weight not reset)
WGTIND	1151	WGTIND	0 = restriction on maximum airplane weight. Weight cannot exceed gross weight.
			1 = no restriction on air- plane weight (will only apply when running performance)

Atmosphere Indicator

<u>VARIABLE</u>	<u>LOCATION</u>	<u>FORTRAN NAME</u>	<u>DESCRIPTION</u>
ATMIND	0501-0510	ATMIN1	0 = standard atmosphere
	0611-0620	ATMIN2	1 = non-standard atmosphere. User inputs single point value for increment in ambient temperature above standard day value.
	0711-0720	ATMIN3	
	0821-0830	ATMIN4	
	0921-0930	ATMIN5	2 = non-standard atmosphere. User inputs table of temperature ratio as a function of altitude.
	1021-1030	ATMIN6	
	2221-2230	ATMIN7	

5.3.3 FORTTRAN VARIABLES

<u>FORTTRAN VARIABLE</u>	<u>PROGRAM VARIABLE</u>	<u>INPUT LOCATION</u>
A1LMAX	$(N_{I_{MAX}}/N^*_{I})L$	1236
A1MAX	$N_{I_{MAX}}/N^*_{I}$	1221
A2MAX	$N_{II_{MAX}}/N^*_{II}$	1223
A2NO	$N_{II}/N_{II}$ OPT	1238 - 1247
A3MAX	$(N_{I\sqrt{\theta_1}}/N^*_{I})MAX$	1222
AAW11	$S_{HT}$	0115
AAW12	$S_{VT}$	0134
AF	ACTIVITY FACTOR PER BLADE	0228
AGLEY	GALLEY AREA (FT <sup>2</sup> )	0152
AL2MAX	$(N_{II_{MAX}}/N^*_{II})L$	1237
ALPHL	$\alpha_{LO}$ (DEG)	0332
AM1	VALUES OF M	1448 - 1453
AM2	VALUES OF M	1512 - 1517
AMSHP	VALUES OF M	1320 - 1325
AMWD	VALUES OF M	1384 - 1389
AN1IND	N1IND	1202
AN2CR	$(N_{II}/N_{II_{MAX}})^C$	0217
AN2IND	N2IND	1204
AN2M1	$N_{II}/N_{II_{MAX}}$ - TAXI	0541 - 0550
AN2M2	$N_{II}/N_{II_{MAX}}$ - TAKEOFF	0671 - 0680
AN2M3	$N_{II}/N_{II_{MAX}}$ - CLIMB	0771 - 0780
AN2M4	$N_{II}/N_{II_{MAX}}$ - CRUISE	0881 - 0890
AN2M5	$N_{II}/N_{II_{MAX}}$ - DESCENT	0981 - 0990
AN2M6	$N_{II}/N_{II_{MAX}}$ - LOITER	1061 - 1070

<u>FORTTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
AN2M	$N_{II}/N_{II_{MAX}}$ - T/O GEN. PERF.	2281
AN2MS	$N_{II}/N_{II_{MAX}}$ - CR. GEN. PERF.	2311
AN2TO	$(N_{II}/N_{II_{MAX}})TO$	0210
AN3IND	N10IND	1203
ANAB1	SEATS ABREAST	0154
ANABT	SEATS ABREAST	0162
ANISL1	NO. OF AISLES	0155
ANISLT	NO. OF AISLES	0163
ANLAVS	NO. OF LAVATORIES	0160
ANPX1	NO. OF PASSENGERS	0153
ANPXT	NO. OF PASSENGERS	0161
AONE	VALUES OF REFERRED $N_I$	1454 - 1501
ARHT	$AR_{HT}$	0109
ARVT	$AR_{VT}$	0129
ATMIN1	ATMIND	0501 - 0510
ATMIN2	ATMIND	0611 - 0620
ATMIN3	ATMIND	0711 - 0720
ATMIN4	ATMIND	0821 - 0830
ATMIN5	ATMIND	0921 - 0930
ATMIN6	ATMIND	1021 - 1030
ATMIY	$\Delta Tin_c$	0216
ATWO	VALUES OF REFERRED $N_{II}$	1518 - 1565
AXETA1	$\eta_1$	0139
AZETA2	$\eta_2$	0140
AZETA3	$\eta_3$	0141

<u>FORTTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
BETA	$\beta$	0205
BLDN	NO. OF BLADES	0229
CDHTI	$C_{DHTi}$	0302
CDLNI	$C_{DLNi}$	0304
CDNI	$C_{DNI}$	0303
CDVTI	$C_{DVTi}$	0301
CK1	$K_1$	0024
CK10	$K_{10}$	0435
CK11	$K_{11}$	0436
CK12	$K_{12}$	0437
CK13	$K_{13}$	0438
CK14	$K_{14}$	0439
CK15	$K_{15}$	0410
CK16	$K_{16}$	0411
CK17	$K_{17}$	0412
CK18	$K_{18}$	0413
CK19	$K_{19}$	0414
CK2	$K_2$	0459
CK20	$K_{20}$	0415
CK21	$K_{21}$	0465
CK3	$K_3$	0460
CK4	$K_4$	0461
CK5	$K_5$	0462
CK6	$K_6$	0463
CK7	$K_7$	0464

<u>FORTRAN VARIABLE</u>	<u>PROGRAM VARIABLE</u>	<u>INPUT LOCATION</u>
CK8	$K_8$	0433
CK9	$K_9$	0434
CKF	$K_F$	0314
CKFF	$K_{FF}$	0026
CKHT	$K_{HT}$	0316
CKLN	$K_{LN}$	0311
CKN	$K_N$	0313
CKRC	$K_{R/C}$	0262
CKVT	$K_{VT}$	0315
CKW	$K_W$	0312
CLEYE	$C_{L_i}$	0230
CLMIND	CLMIND	0691 - 0700
CPPNO	NO. OF PROP TRUST CO- EFFICIENTS ( $C_T$ )	1722
CPPROP	VALUES OF $C_T$	1723 - 1742
CRSIND	CRSIND	0801 - 0810
CSALF	$C_{L\alpha}$ ( $\text{RAD}^{-1}$ )	0331
CTPROP	VALUES OF PROPELLER POWER COEFFICIENT	1743 - 2142
CTSIG	$C_T/\sigma$	0227
CYCLFL	CYCLE NO.	1601
CYCLFP	LIFT ENGINE CYCLE NO.	0218
CYCPRL	CYCLE NO.	1301
CYCPRP	PRIMARY ENGINE CYCLE NO.	0201
CYPROP	PROPELLER TABLE NO.	0256

<u>FORTRAN</u> <u>VARIABLE</u>	<u>PROGR</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
D1	DIA	0226
DAM10	e	0306
DAM2	AR	0101
DAM3	C/D	0102
DAM4	W /S	0106
DAM5	IF	0122
DAM6	$\epsilon_F$	0127
DAM7	$SHP^*_P$	0202
DAM8	$F^*_N$	0207
DAM9	$F^*_{NL}$	0219
DCLIMB	$\Delta CD$ CLIMB	0781 - 0790
DELCD	$\Delta CD$	0305
DELFE	$\Delta fe$ (FT <sup>2</sup> )	0307
DELH3	$\Delta h$ (FT)	0721 - 0730
DELH5	$\Delta h$ (FT)	0951 - 0960
DELP	$\Delta P$ (P.S.I.)	0450
DELR	$\Delta R$ (NM)	0831 - 0840
DELST	$\Delta t_L$ (HR)	1011 - 1020
DELTH	$\Delta t_H$ (HR)	0661 - 0670
DELTT	$\Delta t_T$ (HR)	0511 - 0520
DELWF	$\Delta W_f$	0025
DELWFZ	$\Delta W_{FC}$ (LBS)	0417
DELWP	$\Delta W_p$ (LBS)	0418
DELWPL	$\Delta W_{PL}$ (LBS)	1131 - 1140
DELWST	$\Delta W_{ST}$ (LBS)	0419

<u>FORTRAN VARIABLE</u>	<u>PROGRAM VARIABLE</u>	<u>INPUT LOCATION</u>
DESIND	DESIND	0901 - 0910
DLCLCR	$\Delta C_D$ CR	0891 - 0900
DLCDDS	$\Delta C_D$ DESC.	0991 - 1000
DLMCH	$\Delta c/4$	0107
DLOITR	$\Delta C_D$ LOITER	1071 - 1080
PLSWSW	$\Delta S_{WET}/S_W$	0120
DLTAWF	$\Delta W_F$ (LBS)	1101 - 1110
DNILGN	GALLEY INDICATOR	0151
DNIRTL	LTRIND	1001 - 1010
DNITFL	LFTIND	0013
DNIVAL	LAVATORY INDICATOR	0159
DRGIND	DRGIND	0003
DSHPAC	$\Delta SHP_{acc}$	0259
EAS5	MACH CR EAS (KTS)	0911 - 0920
ELC	$L_{CONST. DIA.}$	0125
ELPD	$(L/d)$ NOSE	0123
ELRW	$l_{RW}$	0126
ELTD	$(L/d)_{TAIL}$	0124
ELTH	$l_{TH}$	0111
ELTV	$l_{TV}$	0130
EMACH	MACH OR EAS (KTS)	0701 - 0710
EMLF	$M_{LF}$	0023
EMMO	$M_{MO}$	0020
ENC	$N_c$	0221
ENCLIMB	$\Delta_n$ CLIMB (E-M CALCS)	0791 - 0800
EYEW	$i_w$	0103



<u>FORTRAN VARIABLE</u>	<u>PROGRAM VARIABLE</u>	<u>INPUT LOCATION</u>
ENGIND	ENGIND	0011
ENL	$N_L$	0220
ENLC	$N_{LO}$	0212
ENP	P	0204
ENP0	$N_{P0}$	0211
ENPSD	$N_{PSDCR}$	0871 - 0880
ENR	$N_R$	0223
ENPSDL	$N_{PSDLOITER}$	1051 - 1060
ENT	$n_T$	0651 - 0660
EPSLON	$\epsilon$	0138
ESZIND	ESZIND	0012
ETAIND	$\eta_P$ IND	0200
ETAL	$\eta_L$	0231
ETAP2	$\eta_{P2}$	0232
ETAP3	$\eta_{P3}$	0233
ETAP4N	NO. OF PAIRS IN $\eta_{P4}$ TABLE	0245
ETAP5	$\eta_{P5}$	0234
FAVL	$(F_N/F_{NL}^*)_1$	1617 - 1624
FDMIND	FDMIND	0006
FIXIND	FIXIND	0010
FLET2	LETF	0641 - 0650
FONE	$(N_I/N_{IL}^* \sqrt{\theta})_1$	1649 - 1656
FTWO	$(N_{II}/N_{II}^* \sqrt{\theta})_1$ L	1665 - 1672
FWDOT	$(W_F/\delta \sqrt{\theta F_{NL}^*})_1$	1633 - 1640

<u>FORTRAN VARIABLE</u>	<u>PROGRAM VARIABLE</u>	<u>INPUT LOCATION</u>
HC	$h_c$	0214
HES	$h_{TO}$	0207
HF	$h_F$	0121
HFIN	$h_{FINAL}$ (FT)( $h_{OPT}$ IND=0) OR $h_{MAX}$ (FT)( $h_{OPT}$ IND=1)	1111 - 1120
HMAX	$h_{MAX}$ (FT)	0741 - 0750
HMIN	$h_{MIN}$ (FT)	0971 - 0980
H00	$h_0$	0015
HOPTIN	$h_{OPT}$ IND	0018
HTIND	HTIND	0008
OPTIND	OPTIND	0001
OSWIND	OSWIND	0004
OWE1	OWE	0400
PDMIND	PDMIND	0005
PFET2	PETF OR PEHF	0621 - 0630
PN2	$K_{PN}$	1248 - 1257
POWCLI	POWIND	0751 - 0760
POWCRI	POWIND	0861 - 0870
POWESI	POWIND	0213
PRN	$(N_1/N_1^*) (D/v_1)$	1207 - 1216
PROPCY	PROP. TABLE NO.	1700
PSEAT1	SEAT PITCH (IN)	0157
PSEATT	SEAT PITCH (IN)	0165

<u>FORTTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
QIND	QIND	1205
QMAX	$Q_{MAX}/Q^*$	1224
RELI	$R_e/l_i$	0330
RMAX	$R_{MAX}$ (NM)	0851 - 0860
RMAX5	$R_{MAX}$ (NM)	0961 - 0970
RNE	VALUES OF $K_{PR}$	1225 - 1234
RNOIND	RNOIND	1206
ROO	$R_C$	0016
RSW	$(W/S)_{WING+FLAP}/(W/S)_{WING}$	1081 - 1090
SAH	$a_H$	0110
SENE	$n$	0208
SGTIND	SGTIND	0027 - 0076
SHPAV	VALUES OF REFERRED THRUST OR HORSEPOWER	
SHPTO	$SHP_E/SHP^*$	0260
SK1	$k_1$	1602
SK2	$k_2$	1603
SK3	$k_3$	1302
SK4	$k_4$	1303
SKCC	$k_{CC}$	0404
SKDS	$k_{DS}$	0453
SKFL	$k_{FL}$	0531 - 0540
SKFS	$k_{FS}$	0454
SKFW	$k_{FW}$	0405
SKH	$k_H$	0406
SKLEI	$k_{LEI}$	0455

<u>FORTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
SKLES	$k_{LES}$	0421
SKLG	$k_{LG}$	0422
SKLMT	$l_{MT}$	0432
SKMG	$k_{MG}$	0423
SKMT	$k_{MT}$	0430
SKNAC	$k_{NAC}$	0431
SKP	$k_B$	0420
SKPEI	$k_{PEI}$	0456
SKPES	$k_{PES}$	0429
SKRP	$k_{R/P}$	0457
SKSAS	$k_{SAS}$	0407
SKTL	$k_{TL}$	0424
SKTM	$k_{TM}$	0408
SKUC	$k_{UC}$	0409
SKVT	$k_{VT}$	0458
SKWF	$k_{WF}$	0425
SKWW	$k_{WW}$	0426
SKY	$k_Y$	0427
SKZ	$k_Z$	0428
SLM	$\lambda$	0108
SLMH	$\lambda_H$	0114
SLMV	$\lambda_V$	0133
SR	$r$	0116
ST00	$t_0$	0017
STFW	$t_{FW}(\text{HR})$	1121 - 1130

<u>FORTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
STH	$t_H$ (HR)	0681 - 0690
STL	$t_L$ (PR)	1031 - 1040
STPW	$t_{PW}$ (HR)	1141 - 1150
SWF	F	0128
TB8AP4	VALUES OF $\eta_{P4}$	0246 - 0255
TBCDM	VALUES OF $C_{DM}$	0350 - 0384
TBCDWI	VALUES OF $C_{DWI}$	0335 - 0342
TBCL1	VALUES OF $C_L$	0317 - 0324
TBCL2	VALUES OF $C_L$	0343 - 0349
TBEM	VALUES OF M	0325 - 0329
TBEM5	VALUES OF M	0235 - 0244
TBH	$h_1$ (FT)	0440 - 0449
THN	ATMOSPHERE TEMP NO. OF PAIRS	0416
TBTHE	$\theta_1$	0466 - 0475
TCLIN	NUMBER OF $C_L$	0310
TCLN	NO. OF PAIRS IN TABLE	0308
TCR	$(t/c)_R$	0104
TCT	$(t/c)_T$	0105
TCVT	$(t/c)_{VT}$	0131
TFNN	NUMBER OF M	0309
TF	REFERRED THRUST AS A FUNCTION OF $(T/\theta)$	1609 - 1616
TF1	REFERRED $N_1$ AS A FUNCTION OF $(T/\theta)$	1641 - 1648
TF2	REFERRED $N_{II}$ AS A FUNCTION OF $(T/\theta)$	1657 - 1664

TERMINAL VARIABLE	DESCRIPTION	VALUES
TFI	$T_{FI}$	1300
TFW	REFERRED FUEL FLOW AS A FUNCTION OF (T/θ)	0.15 - 0.02
TGI	$T_{GI}$ (°P)	1305
THEMAX	$\theta_{MAX}$ (DEG)	0761 - 0770
THEMIN	$\theta_{MIN}$ (DEG)	0931 - 0940
TIN1	$T_{in}$ (°F) (TAXI)	0521 - 0530
TIN2	$\Delta T_{in}$ (°F) (TO, HOVER AND LANDING)	0631 - 0640
TIN3	$\Delta T_{in}$ (°F) (CLIMB)	0731 - 0740
TIN4	$\Delta T_{in}$ (°F) (CRUISE)	0841 - 0850
TIN5	$\Delta T_{in}$ (°F) (DESCENT)	0941 - 0950
TIN6	$\Delta T_{in}$ (°F) (LOITER)	1041 - 1050
TIN7	$\Delta T_{in}$ (°F) (GENERAL PERF.)	2241 - 2250
TINY	$\Delta T_{in}$ (°F) (10)	0209
TLCT	( $\tau/c$ ) <sub>HT</sub>	0112
TLGI	$T_{GI}$	1607
TLMAX	$T_{MAX}$	1608
TMAX	$T_{MAX}$ (°R)	1309
TMIL	$T_{MIL}$ (°R)	1308
TN1	T/θ (PRIMARY ENGINE CYCLE NO.)	1439 - 1446
TN2	T/θ (PRIMARY ENGINE CYCLE NO.)	1509 - 1510
TN1RPK	OPTIONAL PRINT	0002
TNRP	$T_{NR}$ (°R)	1307
TOLIND	TOLIND	0601 - 0610

<u>FORTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
TSHP	T/O PRIMARY ENGINE CYCLE	1311 - 1318
TWD	T/O PRIMARY ENGINE CYCLE	1375 - 1382
UMS	NO. OF M	1319
UMW	NO. OF M	1387
UNM1	NO. OF M	1447
UNM2	NO. OF M	1511
UNT1	NO. OF T/O	1438
UN12	NO. OF T/O	1502
UNFS	NO. OF T/O	1310
UNTW	NO. OF T/O	1374
VBARH	$V_H$	0113
VBARV	$V_V$	0132
VC	VC	0215
VDIV	$V_{DIVE}$	0022
VIN	VIN OR HEADWIND	0811 - 0820
VLMIND	$V_{LIM IND}$	0019
V10	$V_{MC}$	0021
VN1IND	LN1IND	1218
VN2IND	LN2IND	1219
VRCRC	$V_{R/C}$	0261
VRCTO	$V_{R/C}$ - TAKEOFF	2321 - 2330
VT	$V_{TIP}$	0224
VTIND	VTIND	0009
VWDIND	LWDIND	1217
WAISL1	AI5LE WIDTH (IN.)	0158
WAISLT	AI5LE WIDTH (IN.)	0166

<u>FORTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>IN. T. LOCATION</u>
WC	$w_c$ (LBS)	0451
WDMIND	WDMIND	0007
WDOT	VALUES OF REFERRED FUEL FLOW	1390 - 1437
WDTIND	WDTIND	1201
WFE	$w_{FE}$ (LBS)	0401
WFUL	$w_{FUL}$ (LBS)	0402
WGA	$w_{G/A}$	0225
WG00	$w_{G_0}$	0014
WGTIND	WGTIND	1151
WLMAX	$(\frac{w_{MAX}^*}{w^*})_L$	1235
WMAX	$(\frac{w_{MAX}^*}{w^*})$	1220
WPL	$w_{PL}$ (LBS)	0403
WSEAT1	UNIT SEAT WIDTH (IN)	0156
WSEAT2	UNIT SEAT WIDTH (IN)	0164
XCPS	(X/C)	0333
XCTCM	$(X/C)_{max t/c}$	0334
XI1	$\xi_1$	1604
XI2	$\xi_2$	1605
XI3	$\xi_3$	1606
XI4	$\xi_4$	1304
XMSMRT	$SHP_{xm}/SHP^*$	0258
XMSND	XMSNDIND	0257
XPJ	VALUES OF J	1702 - 1721
XPXNO	NO. OF ADVANCE RATIOS (J)	1701



<u>FORTRAN</u> <u>VARIABLE</u>	<u>PROGRAM</u> <u>VARIABLE</u>	<u>INPUT LOCATION</u>
YC	$Y_C$	0452
YCL	$Y_{cl}$	0117
YL	$Y_1$	0137
YMG	$Y_{MG}$	0135
YP	$Y_P$	0136
ZETA1	$\eta_1$	0118
ZETA2	$\eta_2$	0119

## 6.0 PROGRAM OUTPUT

A reproduction of the program output for two sample cases is included in Section 7.8. The following discussion describes the program printout in general and lists the diagnostic error printouts which are possible.

### 6.1 DESCRIPTION OF PRINTOUT

The printout for VASCOMP II consists of four types of information:

- a. General
- b. Input Data
- c. Sizing Data (program output)
- d. Mission Performance Data (for the "sized" airplane)

The general information (item a) is printed out at the beginning of each new case. Each of the other groupings (input, sizing data, and performance data) starts on a new page. For cases with OPTIND = 2 or 3 (performance only), the sizing data is not printed out. The printout is described in detail below.

#### 6.1.1 General Printout

##### 6.1.1.1 Fixed Heading:

V A S C O M P I I

V/STOL AIRCRAFT SIZING AND PERFORMANCE COMPUTER PROGRAM

##### 6.1.1.2 Arbitrary Heading

An arbitrary heading may be input by the user on a title card (see Section 5.2, input sheet for general information).

#### 6.1.2 Input Data

All program input data is printed out as it appears on the data cards. Seven columns are printed. These correspond to the first location on the card, the number of variables on the card (from 1 to 5), and the values of these variables. With this information and a copy of the input sheets it is possible to determine the input value for any variable.

### 6.1.2 Sizing Data

This group is printed out only if OPTIND = 1. The data is represented by a symbol, followed by a written description, followed by the value with the unit. For example:

WG/A                    DISC LOADING                    45.0 LB/SQFT

The data is printed out in groups, each group having a heading. The specific variables which are printed out will depend upon certain options chosen. Notations are made in the following list to show where this occurs.

#### 6.1.3.1 Dimensional Data

Fuselage:

$l_F$ ,  $w_F$ ,  $S_F$

Wing:

$AR_w$ ,  $S_w$ ,  $b_w$ ,  $c_w$ ,  $\Lambda_{C/4}$ ,  $\lambda$ ,  $(t/c)_R$ ,  $(t/c)_T$ ,  
 $W_G/S$ ,  $\overline{C/D}$  (print  $\overline{C/D}$  only if WDMIND = 1, 2 or  
ENGIND = 0, 2)

Horizontal Tail:

$AR_{HT}$ ,  $S_{HT}$ ,  $b_{HT}$ ,  $c_{HT}$ ,  $(t/c)_{HT}$ ,  $l_{TH}$   
(print  $l_{TH}$  only if HTIND = 1)

Vertical Tail:

$AR_{VT}$ ,  $S_{VT}$ ,  $b_{VT}$ ,  $c_{VT}$ ,  $(t/c)_{VT}$ ,  $l_{TV}$   
(print  $l_{TV}$  only if VTIND = 1)

Primary Engine Nacelle:

$l_N$ ,  $\bar{d}_N$ ,  $S_N$

Lift Engine Nacelle:

- i.) If LFTIND = 1 print:  $l_{LN}$ ,  $\bar{d}_{LN}$ ,  $S_{LN}$
- ii.) If LFTIND = 0 print: NO LIFT PROPULSION  
SELECTED

Propeller:

- i.) If ENGIND = 0 or 2 print: D,  
 $\sigma_{R/P}, W_G/A, C_T/\sigma, N_R$ , No. Blades
- ii.) If ENGIND = 1 print: NO PROPELLER ON THIS AIRCRAFT

Passenger Sizing Data:

If FDMIND = 2, print the following data:

	<u>TOURIST</u>	<u>FIRST CLASS</u>	
NO. OF PASS.	XX.	YY.	
NO. ABREAST	XX.	YY.	
NO. OF AISLES	XX.	YY.	
UNIT SEAT WIDTH	XX. IN.	YY. IN.	
SEAT PITCH	XX. IN.	YY. IN.	
AISLE WIDTH	XX. IN.	YY. IN.	
NUMBER OF LAVATORIES		ZZ.ZZ	
GALLEY AREA		ZZ.Z	SQ. FT.
CLOSET AREA		ZZ.Z	SQ. FT.
CABIN DIAMETER		ZZ.Z	IN. ***
BODY DIAMETER		ZZ.Z	IN. ***
NOSE SECTION LENGTH		ZZ.Z	FT.
TAIL SECTION LENGTH		ZZ.Z	FT.
CONST. DIA. LENGTH		ZZ.Z	FT.
TOTAL FUSELAGE LENGTH		ZZ.Z	FT.

\*\*\* Adjacent to CABIN DIAMETER and BODY DIAMETER will be printed the words:

TOURIST CLASS CRITICAL  
or  
FIRST CLASS CRITICAL

This will designate which class of service determined the body diameter.

6.1.3.2. Weights Data

First print  $G_{LF}$ , then print:

PROPULSION GROUP

$K_2 W_{R/P}, K_3 W_{DS}, K_4 W_{EL}, K_5 W_{EP}, K_6 W_{LEI}$

$K_7 W_{PEI}, K_{21} W_{FS}, \Delta W_p, W_p$

STRUCTURES GROUP

$K_8^{W_W}$ ,  $K_9^{W_{HT}}$ ,  $K_{10}^{W_{VT}}$ ,  $K_{11}^{W_B}$ ,  $K_{12}^{W_{LG}}$

$K_{13}^{W_{LES}}$ ,  $K_{14}^{W_{PES}}$ ,  $\Delta W_{ST}$ ,  $W_{ST}$

FLIGHT CONTROL GROUP

$K_{15}^{W_{CC}}$ ,  $K_{16}^{W_{UC}}$ ,  $K_{17}^{W_H}$ ,  $K_{18}^{W_{FW}}$ ,  $K_{19}^{W_{SAS}}$

$K_{20}^{W_{TM}}$ ,  $\Delta W_{FC}$ ,  $W_{FC}$

WEIGHT EMPTY

$W_E$

FIXED USEFUL LOAD

$W_{FUL}$

OPERATING WEIGHT EMPTY

$W_{OE}$

PAYLOAD

$W_{PL}$

FUEL

$(W_f)_A$ ,  $W_{FW}$

GROSS WEIGHT

$W_G$

6.1.3.3 Propulsion Data

The type of propulsion data to be printed is dependent upon the type of engines selected and certain input indicators.

6.1.3.3.1 Primary Engine Data

Print the following:

PRIMARY PROPULSION CYCLE NO. \_\_\_\_\_

XXXXX ENGINE

(XXXXX will be either TURBOFAN TURBOJET, OR  
TURBOSHAFT)

XXK ENGINES (XXX will be the number of  
primary engines,  $N_p$ )

F\*N = (If ENGIN = 1 or 2)

SHP\* = (If ENGIN = 0 or 2)

After this data has been printed out, one of the  
following four statements should be printed:

1. ENGINE SIZED FOR TAKEOFF AT T/W = \_\_\_\_\_,  
PERCENT, \* POWER SETTING  
VERTICAL RATE OF CLIMB = \_\_\_\_\_ FT/MIN,  
H = FT., TEMPERATURE = \_\_\_\_\_ °F  
AND \_\_\_\_\_ ENGINES INOPERATIVE

\*MAXIMUM, MILITARY, OR NORMAL

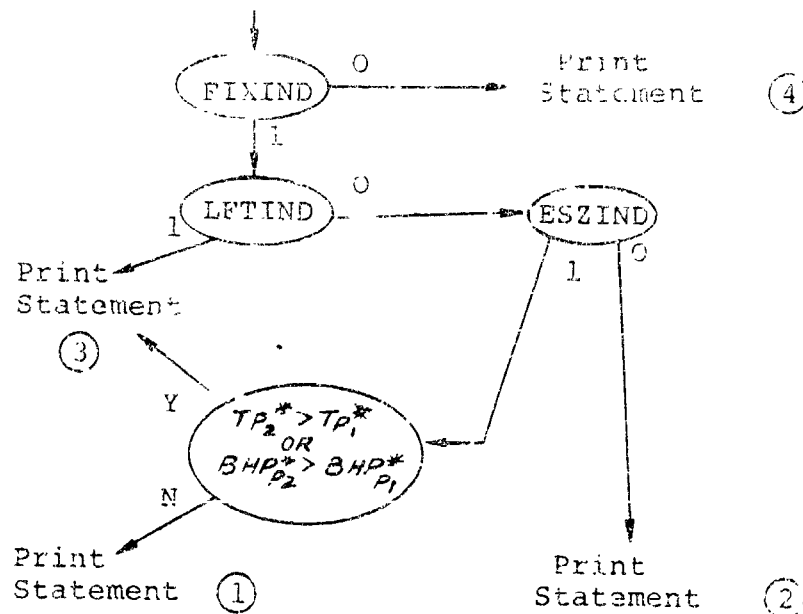
2. Print the same as 1, then print:

NO CRUISE CONDITION SPECIFIED

3. ENGINE SIZED FOR CRUISE AT VC =  
KNOTS, HC = \_\_\_\_\_ FT., TEMPERATURE =  
\_\_\_\_\_ °F.

4. ENGINE SIZE WAS FIXED BY INPUT

The statement which will be printed  
out depends upon the following logic:



#### 6.1.3.3.2 Lift Engine Data

If LFTIND = 0 print the following:

NO LIFT ENGINE CYCLE SELECTED

Otherwise (if LFTIND = 1) print the following:

LIFT ENGINE CYCLE NO. \_\_\_\_\_

XXXXX ENGINE

(XXXXX will be either LIFT FAN OR LIFT TURBOFAN)

XXX ENGINES IN YYY CLUSTERS (XXX will be the number of lift engines, Y and YYY will be the number of clusters, N<sub>C</sub>)

F\*NL =

After this data has been printed out one of the following three statements should be printed:

1. ENGINE SIZED FOR TAKEOFF WITH T/W = \_\_\_\_\_,  
PERCENT POWER  
AUGMENTED BY PRIMARY PROPULSION OF \_\_\_\_\_ %.  
CRITICAL SIZING CONDITION IS \_\_\_\_\_ PRIMARY  
ENGINES INOPERATIVE.
2. ENGINE SIZED FOR TAKEOFF WITH T/W = \_\_\_\_\_,  
PERCENT POWER  
AUGMENTED BY PRIMARY PROPULSION OF \_\_\_\_\_ %.  
CRITICAL SIZING CONDITION IS \_\_\_\_\_ LIFT  
ENGINES INOPERATIVE.

3. ENGINE SIZE WAS FIXED BY INPUT.

#### 6.1.3.4 Aerodynamics Data

The following data is printed:

$f_e$ ,  $S_{WET}$ ,  $\bar{C}_f$

If OPTIND = 1, this is followed by:

DRAG BREAKDOWN:

WING FE =

FUSELAG<sup>F</sup> FE =

VERTICAL TAIL FE =

HORIZONTAL TAIL FE =

PRIM. ENGINE NACELLE FE =

LIFT ENGINE NACELLE FE =

If DRGIND = 0, the following data is then printed:

$a_1$ ,  $a_2$ ,  $a_3$ ,  $a_4$

This is followed by:

$a_5$ ,  $a_6$ ,  $a_7$

Then print the following:

OSWALD'S FACTOR =

THREE DIMENSIONAL LIFT COEFFICIENT SLOPE =

#### 6.1.4 Mission Performance Data

Two types of output are possible. If the OPTIONAL PRINT INDICATOR is input as 0 a standard printout will occur. If the indicator is input as 1 a detailed printout will occur. This will include all data printed in the standard printout plus additional information.

##### 6.1.4.1 Standard Printout

The mission performance data is printed out by segment in chronological sequence. Up to fifteen columns of data are printed out depending upon the segment. For all segments, the following information is printed:



t: time in hours  
R: range in nautical miles  
 $W_F$ : weight of fuel used in pounds  
W: airplane weight in pounds  
h: altitude in feet  
TAS: the true airspeed in knots  
T: the engine turbine temperature

ENGINE CODE: a code letter which designates the condition governing the engine performance:

P = power (or thrust) required

T = turbine temperature  
(engine rating)

W = fuel flow limit

N1 = gas generator shaft rpm limit

C = compressor ( $N_1/\sqrt{\theta_1}$ ) limit

N2 = output shaft rpm limit

Q = torque limit

PETF or PEHF: the primary engine thrust fraction or horsepower fraction. This is the ratio of thrust or power being used at any altitude, Mach number condition to the maximum thrust, or power available at that condition.

In addition, the following data is printed out in different segments:

T/W: The thrust-weight ratio. (Printed out in takeoff, hover and landing.)

LETF: The lift engine thrust fraction. (Printed out in taxi and takeoff, hover and landing.)

EAS: The equivalent airspeed in knots. (Printed out in climb, cruise, descent, and loiter.)

- MACH: The Mach number. (Printed out in climb, cruise, descent, and loiter.)
  - MACH DIV: The Mach number for drag divergence. (Printed out in climb, cruise, and descent.)
  - GAMMA: The flight path angle in degrees. (Printed out in climb and descent.)
  - THETA F: The fuselage attitude angle in degrees. (Printed out in climb and descent.)
  - R/C: Rate of climb in feet per minute. (Printed out in climb.)
  - NMPP: The specific range in nautical miles per pound. (Printed out in cruise.)
  - R/S: Rate of sink in feet per minute. (Printed out in descent.)
  - FUEL RATE: Time rate of fuel consumption in pounds per hour. (Printed out in loiter.)
  - ETAP PROP: Propeller efficiency. (Printed out in takeoff/hover/landing, cruise, and descent.)
  - CT: Propeller thrust coefficient
  - CP: Propeller power coefficient
  - VTIP: Prop tip speed (feet/sec)
- } Printed out in takeoff, hover, and landing

**6.1.4.3 Detailed Printout**

In addition to the data printed above, the following data will be printed in climb, cruise, descent, and loiter segments if the OPTION<sup>2</sup> RINT indicator = 1:

- CL: Lift coefficient
- CD: Drag coefficient
- L/D: Lift to drag ratio
- LIFT: Total lift in pounds
- DRAG: Total drag in pounds
- FUEL FLOW: Pounds per hour of fuel consumption

BR: Brake horsepower  
 IPR: Horsepower of engine  
 CP: Propeller power coefficient  
 CT: Propeller thrust coefficient  
 C: Propeller advance ratio  
 VTIP: Tip speed of the propeller in feet per second  
 ETAP: Propeller efficiency

#### 6.1.4.3 Headings

At the beginning of each segment, a printout will identify the segment data which follows. The following messages can be printed:

- a. TAXI FOR \_\_\_ HRS. AT GROUND IDLE ENGINE RATING
- b. TAKEOFF, HOVER, OR LAND AT T/W = \_\_\_ FOR \_\_\_ HRS.  
 or: TAKEOFF, HOVER, OR LAND AT PETF = \_\_\_\_\_,  
 LETF = \_\_\_\_\_ FOR \_\_\_ HRS.
- c. CLIMB TO \_\_\_ FT. WITH MAX R/C AT \_\_\_ ENGINE RATING  
 CLIMB TO \_\_\_ FT. WITH CONSTANT EAS AT \_\_\_ ENGINE RATING  
 CLIMB TO \_\_\_ FT. WITH CONST. MACH NO. AT \_\_\_ ENGINE RATING  
 CLIMB TO \_\_\_ FT, WITH CONSTANT TAS AT \_\_\_ ENGINE RATING  
 CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAX. R/C AT \_\_\_ ENGINE RATING, MAXIMUM ALT. \_\_\_ FT.  
 CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH CONSTANT EAS AT \_\_\_ ENGINE RATING, MAXIMUM ALT. \_\_\_ FT.  
 CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH CONST. MACH NO. AT \_\_\_ ENGINE RATING, MAXIMUM ALT. \_\_\_ FT.  
 CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH CONSTANT TAS AT \_\_\_ ENGINE RATING, MAXIMUM ALT. \_\_\_ FT.
- d. CRUISE AT \_\_\_ ENGINE RATING  
 CRUISE AT \_\_\_ KNOTS TAS LIMITED BY \_\_\_ ENGINE R

CRUISE AT BEST RANGE SPEED WITH HEADWIND OF \_\_\_ KNOTS

CRUISE AT SPEED FOR 99 PERCENT BEST RANGE WITH  
HEADWIND 0 \_\_\_ KNOTS

CRUISE AT BEST RANGE SPEED WITH HEADWIND OF \_\_\_  
KNOTS, CONSTANT W/DELTA = \_\_\_

- e. DESCEND TO H= \_\_\_ FT AT MAX SPEED  
DESCEND TO H= \_\_\_ FT, R= \_\_\_ NM AT MAX SPEED  
DESCEND TO H= \_\_\_ FT AT FLIGHT IDLE ENGINE RATING  
DESCEND TO H= \_\_\_ FT, R= \_\_\_ NM AT FLIGHT IDLE ENGINE  
RATING  
DESCEND TO H= \_\_\_ FT AT CONSTANT EAS  
DESCEND TO H= \_\_\_ FT, R= \_\_\_ NM AT CONSTANT EAS  
DESCEND TO H= \_\_\_ FT AT CONSTANT MACH NO.  
DESCEND TO H= \_\_\_ FT, R= \_\_\_ NM AT CONSTANT MACH NO.
- f. LOITER FOR \_\_\_ HRS.  
LOITER FOR \_\_\_ HRS. FOR RESERVE FUEL
- g. CHANGE FUEL, ADD \_\_\_ LB  
CHANGE FUEL, REMOVE \_\_\_ LB
- h. CHANGE PAYLOAD, ADD \_\_\_ LB  
CHANGE PAYLOAD, REMOVE \_\_\_ LB
- i. TRANSFER ALTITUDE TO \_\_\_ FT

After the complete mission history has been printed,  
the following fuel summary will be printed:

MISSION FUEL REQUIRED =

RESERVE FUEL REQUIRED =

TOTAL FUEL REQUIRED =

### 6.1.5 General Performance

At the top of each general performance segment, the following data will be printed out:

GROSS WEIGHT = _____	LB	W/DELTA = _____	LB
ALTITUDE = _____	FT	DELTRTH = _____	
TEMPERATURE = _____	DEG., F.	DELTA = _____	
		THETA = _____	

where W = aircraft weight  
 DELTA =  $\delta$  = pressure ratio  
 THETA =  $\theta$  = temperature ratio  
 DELTRTH =  $\delta\sqrt{\theta}$

In addition to the above data, general performance mission data will also be printed out and consists of:

TAS: True Airspeed  
 CL: Wing Lift Coefficient  
 TOTAL FUEL FLOW: Primary and Lift Engine Fuel Flow  
 CD: Aircraft Drag Coefficient  
 L/D: Lift to Drag Ratio  
 THRUST TO WEIGHT: Total Thrust to Aircraft Weight  
 LIFT: Lift Produced by Wings and/or Engines  
 EAS: Estimated Airspeed  
 DRAG: Total Aircraft Drag  
 FUEL FLOW PRIM. ENG: PRIMARY FUEL FLOW IN LBS/HR  
 FUEL FLOW LIFT ENG: LIFT ENGINE FUEL FLOW IN LBS/HR  
 TURB. TEMP. (R): ENGINE TURBINE TEMPERATURE IN DEGREES R

$$J: \text{ADVANCE RATIO} = \frac{5.30615 (\text{AIRCRAFT VELOCITY-KTS})}{V_{\text{TIP OPERATING}}}$$

PETF OR PEHF: PRIMARY ENGINE THRUST OR HORSEPOWER FRACTION  
 LETF: LIFT ENGINE THRUST FRACTION  
 MACH: AIRCRAFT MACH NUMBER

$$CP: \text{POWER COEFFICIENT} = \frac{550 (\text{HORSEPOWER}) \pi^3}{(V_{\text{TIP OPER}})^3 (\text{DIAMETER})^2}$$

MACH DIV: MACH DIVERGENCE NUMBER

$$CT: \text{THRUST COEFFICIENT} = \frac{(\text{THRUST}) \pi^2}{(V_{\text{TIP OPER}})^2 (\text{DIAMETER})}$$

$$\text{OR CT} = \frac{\text{CP (PROP EFFICIENCY)}}{\text{ADVANCE RATIO}}$$

SPEC. RANGE (NMPP): SPECIFIC RANGE =  $\frac{\text{VELOCITY}}{\text{FUEL FLOW}}$  IN  
NAUTICAL MILES PER POUND

VTIP: PROPELLER OPERATING TIP SPEED IN FEET PER  
SECOND

BHP: ENGINE BRAKE HORSEPOWER

$$[\text{BHP}]_{\text{T/O}} = \frac{\text{THRUST}^{3/2} \text{ GW } \sqrt{\text{DISC LOADING}}}{550 \sqrt{2\rho} \eta_T \eta_P} + \Delta\text{SHP}_{\text{ACCESSORY}}$$

$$[\text{BHP}]_{\text{CR}} = \frac{\text{CD (WING AREA)} (1/2 \rho V^2) V}{550 \eta_T \eta_P} + \Delta\text{SHP}_{\text{ACCESSORY}}$$

NET THRUST: NET PRIMARY AND LIFT ENGINE THRUST

$$\text{FM: FIGURE OF MERIT} = \frac{0.798(\text{CT}^{1.5})}{\text{CP}}$$

ETAP PROP: PROPELLER EFFICIENCY IN CRUISE FLIGHT

Main transmission torque limit messages will be printed out after the performance calculation for  $V_{\text{MAX}}$ . One of the following messages will be printed depending on the options chosen by the user:

- MAIN TRANSMISSION TORQUE LIMIT NOT APPLIED
- MAIN TRANSMISSION TORQUE LIMIT NOT EXCEEDED AT THESE FLIGHT CONDITIONS
- MAIN TRANSMISSION TORQUE LIMIT (ALL ENGINES OPERATING) OCCURS AT

V	=	_____	KTAS
MAIN ROTOR VIIP	=	_____	FT/SEC
MAIN ROTOR RPM	=	_____	
POWER	=	_____	SHP
TORQUE	=	_____	FT-LB

A summary of the aircraft's velocity as a function of power, and corresponding specific range and engine code is printed out after the transmission torque limit message. The following is an example:

**V (MAX PWR)	=	_____	KTAS	SPEC. RANGE =	_____	NM/LB	*
**V (MIL PWR)	=	_____	KTAS	SPEC. RANGE =	_____	NM/LB	*
**V (NRP)	=	_____	KTAS	SPEC. RANGE =	_____	NM/LB	*
V (BEST RANGE)	=	_____	KTAS	SPEC. RANGE =	_____	NM/LB	*
V (99 PERCENT BR)	=	_____	KTAS	SPEC. RANGE =	_____	NM/LB	*
V (BEST ENDURANCE)	=	_____	KTAS	FUEL FLOW =	_____	LB/HR	*

\*SIGNIFIES ENGINE OPERATING CODE

\*\*In the event that cruise is not possible at any one of these power conditions the following message will be printed:

INSUFFICIENT POWER AVAILABLE FOR CRUISE AT \_\_\_\_\_  
ENGINE RATING

Where MAXIMUM, MILITARY, or NORMAL ENGINE RATING will be printed.

## 6.2 LIST OF DIAGNOSTIC ERROR PRINTOUTS

### 6.2.1 Errors Affecting Main Control Loop

- 6.2.1.1 \*\*\* ERROR THE USER REQUESTED PRIMARY ENGINE CYCLE NO. XXX BUT THE INPUT DECK WAS SET UP TO USE NO. YYY

The operator used an engine cycle whose identification number differed from that requested by the user (LOC. 0201).

REMEDY: Use correct engine cycle.

- 6.2.1.2 \*\*\* ERROR THE USER REQUESTED LIFT ENGINE CYCLE NO. XXX BUT THE INPUT DECK WAS SET UP TO USE NO. YYY

The operator used an engine cycle whose identification number differed from that requested by the user (LOC. 0218).

REMEDY: Use correct engine cycle.

- 6.2.1.3 \*\*\* ERROR THE USER REQUESTED PROP TABLE NO. XXX BUT THE INPUT DECK WAS SET UP TO USE NO. YYY

The operator used a propeller table whose identification number differed from that requested by the user (LOC. 0256).

REMEDY: Use correct propeller table.

- 6.2.1.4 ERROR \*\*\* THE FIRST SEGMENT INDICATOR OF A MISSION CANNOT BE 0., 100., or 5. (DESIND = 1, 3) SEE USERS MANUAL

- a. Segment indicators 0., 100., represent the end of a mission calculation and the end of a particular case respectively. Either of these indicators at the beginning of a set would be meaningless.
- b. Descent options 1 and 3 must be preceded by a cruise segment.

REMEDY: Rewrite segment indicator list (Starts at LOC. 0027)



6.2.1.5 ERROR \*\*\* DESCENT 1 or 3 MUST BE PRECEDED BY A CRUISE

See 6.2.1.4 (b)

REMEDY: Redefine the mission with a different sequence of segment indicators.

6.2.1.6 \*\*\* ERROR FUEL AVAILABLE AND FUEL REQUIRED DO NOT CONVERGE AT A POSITIVE GROSS WEIGHT

This indicates that the performance requirements are too stringent or that the weight is excessive. This may be due to pessimistic weight input constants or drag characteristics, or it may be that the mission required cannot be flown by any airplane sized by VASCOMP. It may require some novel design considerations.

6.2.1.7 \*\*\* ERROR WFR WEIGHT OF FUEL REQUIRED IS LESS THAN OR EQUAL TO ZERO.

This message can occur only if negative values of reserve fuel factors are input (LOC. 0024, 5, 6)

REMEDY: Correct reserve fuel factors.

6.2.1.8 \*\*\*\*\* THIS AIRCRAFT HAS NOT CONVERGED AFTER 25 ATTEMPTS. THE WEIGHT OF FUEL AVAILABLE (WFA) = XXX THE WEIGHT OF FUEL REQUIRED (WFR) = YYY (WFA) MUST BE WITHIN ZZZ OF (WFR) FOR THE AIRCRAFT TO CONVERGE. THIS TOLERANCE IS SET IN THE MAIN PROGRAM UNDER THE NAME TOL.

If this message occurs it is probable that the mission required cannot be flown by an aircraft of the type specified by the input data. A possible cause may be unrealistic input values of the reserve fuel factors or weights constants.

6.2.1.9 \*\*\* ERROR - NO TITLE CARD AFTER SEVEN CARD, COLUMNS 1 THRU 6 ON TITLE CARD MUST BE BLANK OR THERE WAS A 6 IN COLUMN 5 OF AN INPUT CARD

This message is printed if the input card deck is improperly set up. No output is generated.

REMEDY: Examine input deck for errors indicated in message and correct them.

6.2.1.10 ERROR, THE NUMBER OF ITERATIONS IN THE SIZTR ROUTINE EXCEEDED 25, CASE TERMINATED.

This message will be printed if the SIZE TRENDS subroutine is unable to determine the engine size to satisfy the takeoff conditions specified in LOC. 0207 through 0212. This is due to the non-linear scaling of the engine that results when Reynolds Number effects are included.

REMEDY: Correct the table of Reynolds Number correction factor on the Non-standard Engine Cycle Data Input Sheet (LOC. 1206 through 1257) or select a new engine cycle.

6.2.1.11 ERROR, THE NUMBER OF ITERATIONS IN THE ENGINE SIZING ROUTINE EXCEEDED 25, CASE TERMINATED

This message will be printed if the ENGINE SIZING subroutine is unable to determine the engine size to satisfy the engine sizing conditions (takeoff and/or cruise) as specified in LOC. 0207 through 0217. This may be due to an error in the Reynolds Number correction factor table (LOC. 1206 through 1234).

REMEDY: Correct the Reynolds Number correction factor table or select a new engine cycle.

6.2.1.12 (a) J OR M DOES NOT CONVERGE IN 25 ITERATIONS - SUBROUTINE POWER  
(b) CT OR  $F_N$  DOES NOT CONVERGE IN 25 ITERATIONS - SUBROUTINE POWER

These messages are printed if a match cannot be found between propeller/fan thrust and available power. Message (a) is printed in forward flight calculations and (b) is printed in static (Take-off, hover or landing) calculations.

REMEDY: Increase engine power, reduce drag or modify propeller related inputs.

6.2.1.13 GAMMA FAILED TO CONVERGE IN 20 ITERATIONS - SUBROUTINE THRUST

This message will be printed if the propeller thrust calculation routine cannot converge on a thrust and efficiency that will match the required thrust. Such an error is unlikely and would occur only in cases involving extreme thrust requirements.

REMFYD: Review input data that specifies propeller requirements.

6.2.1.14 \*\*\*ERROR\*\*\* TORQUE LIMIT OPTION USED NOT APPLICABLE TO CONVERTIBLE ENGINES. PROGRAM APPLIED XMSN LIMIT AS SPECIFIED FRACTION OF INSTALLED TAKEOFF POWER.

This message is printed if  $ENGIND = 2.0$  and  $XMSNIND = 1.0$ . Convertible engines can only be torque limited in the hover condition.

REMEDY: Change XMSIND (LOC 0257) TO EQUAL 0.

6.2.1.15 \*\*\*WARNING\*\*\* CONVERTIBLE ENGINE SIZED FOR CRUISE. XMSN TORQUE LIMIT OPTION INPUT IGNORED.

This message is printed if the convertible engine was sized for the cruise installed power which was more critical than the hover condition.

REMEDY: Program applies correction by bypassing torque limit option.

6.2.2 Errors Related to Tabulated Inputs

6.2.2.1 Two Dimensional Tables

\*\*\*ERROR\*\*\* THE FOLLOWING VALUES MAY NOT BE ACCURATE. THE INDEPENDENT VARIABLE WAS OUT OF RANGE OF THE TABLE. THESE VALUES WERE CALCULATED USING THE YYYYY VALUE GIVEN IN THE TABLE. THIS ERROR IS IN THE XXXXX TABLE.

This message occurs whenever the computer is required to look up a value in a table of input quantities at a calculated value of the independent variable which lies outside the range of the input values of the independent variable.

If the calculated independent variable is below the lowest value of the input table, the computer uses the first value in the table and YYYYY in the message reads FIRST. If it lies above the highest value, the last value in the table is used and YYYYY becomes LAST.

XXXXX in the last line of this message identifies the table in which the error occurs. The tables in which this could occur are shown below. The third column indicates the part of the message which is shown above as XXXXX.

<u>INDEPENDENT</u> <u>VARIABLE</u>	<u>DEPENDENT</u> <u>VARIABLE</u>	<u>XXXXX</u>
M	$\eta_{p4}$	M, ETAP4
$C_L$	$C_{Dwi}$	CL, CDWI
h	$\theta$	H-THETA
$(F_N/\delta F_N^*)_L$	T/ $\theta$	LIFT ENGINE POWER
$(\dot{W}/\delta \sqrt{\theta} F_N^*)_L$	T/ $\theta$	LIFT ENGINE FUEL FLOW
$N_I/\sqrt{\theta} N_I^*$	T/ $\theta$	LIFT ENGINE NSUB1
$N_{II}/\sqrt{\theta} N_{II}^*$	T/ $\theta$	LIFT ENGINE NSUB2
$N_{II}/N_{IIOPT}$	$K_{PN}$	NSUB2 CORRECTION FACTOR
$(N_I/N_I^*)(D/v_1)$	$K_{PR}$	REYNOLDS NUMBER
Q/Q*	T/ $\theta$	TORQUE LIMIT LOOK UP
$(SHP/\delta \sqrt{\theta} SHP^*)_{REQ}$	T/ $\theta$	POWER REQUIRED LOOK UP
$C_L$	$\gamma$	PROPELLER EQUIVALENT LIFT DRAG POLAR†
$C_{Ti}$	$C_p$	CTI - CP

† Strictly speaking, this table is not an input. The table is calculated in the main control loop using BLOCK DATA and the input value of INTEGRATED LIFT COEFFICIENT (LOC. 0230). The error message indicates that the value of  $C_L$  used was above the maximum value in the table. This will occur only if an unusual combination of high power coefficient and low propeller activity factor exists. In such a case the user should change the propeller input parameters to obtain a propeller that more closely matches the performance requirements.

### 6.2.2.2 Three Dimensional Tables

\*\*\*ERROR\*\*\* THE FOLLOWING VALUES MAY NOT BE ACCURATE. THE AAA INDEPENDENT VARIABLE IS OUT OF RANGE OF THE TABLE. THE PROGRAM USED THE BBB VALUE IN TABLE TO CALCULATE. THIS ERROR IS IN THE XXXX PART OF THE YYYYY TABLE.

This message is printed whenever one of the calculated independent variables lies outside the range of the independent variables defining the table input by the user.

The XXXX and YYYYY parts of the message respectively name the independent variable and the table in which the error occurred. AAA stands for FIRST or SECOND, BBB stands for FIRST or LAST.

The tables in which this error could arise are shown below. The items in parentheses show the variables as they appear in the error message.

<u>DEPENDENT VARIABLE</u>	<u>INDEPENDENT VARIABLES (XXXX)</u>	<u>NAME OF TABLE (YYYYY)</u>
$\Delta C_{DM}$	$C_L (CL), M$	COMPRESSIBILITY DRAG
$F_N / \delta F_N^*$	$T/\theta (T), M$	REFERRED THRUST
$SHP / \delta \sqrt{\theta} SHP^*$	$T/\theta (T), M$	REFERRED POWER
$\dot{W} / \delta \sqrt{\theta} SHP^*$ or $\dot{W} / \delta \sqrt{\theta} F_N^*$	$T/\theta (T), M$	REFERRED FUEL FLOW
$N_I / \sqrt{\theta} N_I^*$	$T/\theta (T), M$	REFERRED NSUB1
$N_{II} / \sqrt{\theta} N_{II}^*$	$T/\theta (T), M$	REFERRED NSUB2
$C_\eta$	$C_p (CP), M$	PROPELLER POWER COEFFICIENT

REMEDY: Rewrite the input table so that the independent variable that was previously out of range will fall into the range of the new table.

6.2.2.3 MACH NUMBER OUT OF RANGE FOR DRAG CALCULATIONS SET  
DRGIND = 1

This message indicates that the current value of M is outside the range of Mach Number in which a calculation of  $\Delta C_{DM}$  can be performed by the program.

REMEDY: Set DRGIND = 1. (LOC. 0003), input a table of  $\Delta C_{DM}$  versus  $C_L$ , M in the Aerodynamics Information Input Sheet.

6.2.3 Errors Occurring In Performance Calculations

- 6.2.3.1 a. CAUTION \*\* PEHF IS GREATER THAN 1.  
b. CAUTION \*\* PETF IS GREATER THAN 1.

These messages indicate a condition for which greater than 100 percent of maximum power or thrust was required during takeoff, hover, or landing.

REMEDY: Increase engine power available or decrease required thrust-weight for hover.

6.2.3.2 CAUTION, STATIC THRUST NOT INCLUDED IN PROP DECK,  
LOWEST ADVANCE RATIO USED

This message is printed during execution of the TAKEOFF, HOVER or LANDING SUBROUTINE if the propeller input table does not include static performance data (J=0). The table should include static performance data if accurate answers are required for hover performance.

REMEDY: Rewrite the propeller table to include static performance data.

6.2.3.3 TAKEOFF AND LANDING OPTION NO. 2 IS NOT PERMITTED IF  
ENGIND = 0, 2 OR LFTIND = 0

TOLIND (LOC. 0601 through 0610) = 2. requires that equal amounts of power are drawn from primary and lift-engines. If ENGIND (LOC. 0011) = 0. or 2., or if LFTIND (LOC. 0013) = 0., no lift engines are specified so execution of the program calculation is terminated.

REMEDY: Specify Lift Engine Cycle and LFTIND if required or change TOLIND array to eliminate 2.'s in LOC. 0601 through 0610.

6.2.3.4 ERROR \* INSUFFICIENT POWER AVAILABLE FOR CLIMB

The message is printed if the engine thrust or power input by the user is insufficient to allow the aircraft to climb.

REMEDY: (a) Increase the engine power or thrust, whichever is appropriate, or (b) inspect the inputs which determine  $C_D$  and adjust them if they appear to give a grossly overrated value of  $C_D$ .

6.2.3.5 ERROR \* INSUFFICIENT POWER AVAILABLE FOR CRUISE AT V GREATER THAN 150 KTS

This message will be printed if the thrust or power available at the required altitude is less than the minimum thrust or power required for steady level flight, that is, if the aircraft is above its absolute ceiling.

REMEDY: If OPTIND = 1, check to find if one of the cruise segments of the mission makes a demand inconsistent with the engine sizing criteria (LOC. 0213 through 0217). If OPTIND = 2 or if FIXIND = 0, it may be that engine power or thrust is unreasonably low or the drag excessive. Check the inputs in LOC. 0202 or 0203 and those on AIRCRAFT AERODYNAMICS INFORMATION input sheet.

6.2.3.6 ERROR \*\*\*\*\* INSUFFICIENT POWER AVAILABLE FOR CRUISE AT DESIRED SPEED

This message will be printed during cruise if CRSIND = 2 (cruise at specified true airspeed) and insufficient power is available to maintain steady level flight at the desired speed. The remaining cruise calculations will be at constant power setting.

REMEDY: Increase engine power, decrease drag level, or decrease required cruise speed.

6.2.3.7 CAUTION SPEED LIMITED BY POWER/THRUST AVAILABLE AT SPECIFIED POWER SETTING

This message will be printed when power or thrust available is insufficient to allow the aircraft to cruise at speed for 99% best range as specified by selecting CRSIND = 4. or 6. (LOC. 0801 through 0810)

6.2.3.8 ERROR INSUFFICIENT POWER AVAILABLE FOR CRUISE AT V  
GREATER THAN 100 KTS

This message will be printed during cruise if  
CRSIND = 3, 4, 5 or 6 and insufficient thrust or  
power is available to maintain steady level flight  
at speeds greater than 100 knots TAS.

REMEDY: Increase engine power or reduce drag level.

6.2.3.9 DESCENT CONDITION IMPOSSIBLE R/S IS LESS THAN OR EQUAL  
TO 0.

The reason for this printout is that the flight  
path angle necessary to maintain the required body  
inclination has become positive.

REMEDY: Make the quantity  $(\theta_{min} - \alpha_{LO} + i_w)$  more  
negative (See LOC. 0931 through 0940, 0332,  
and 0103).

6.2.3.10 DESCENT CONDITION IMPOSSIBLE DESIRED FLIGHT PATH IS  
TOO SHALLOW

This message will be printed out during descent at  
constant EAS or constant Mach number (DESIND = 5,  
6, 7, 8). There are two possible sources for this  
error message:

- a. The terminal range with DESIND = 5,7 is at  
such a great distance from the initial condition  
of descent that an extremely shallow flight path  
is required. This source of error is unlikely  
since it implies that insufficient power is  
available for cruise.
- b. The required flight path angle is extremely  
shallow due to the restriction on minimum body  
attitude angle. Insufficient power is avail-  
able to maintain flight at the required flight  
path angle.

REMEDY: Check  $\theta_{min}$  (LOC. 0931 through 0940),  $R_{max}$   
(LOC. 0961 through 0970), and power available.

6.2.3.11 \*\*ERROR\*\* THE RANGE NECESSARY TO DESCEND IS GREATER  
THAN THE RANGE OF THE TABLE CALCULATED IN CRUISE. THIS  
MAY BE DUE TO A DELTA R IN CRUISE WHICH IS TOO SMALL.



The computer saves the last ten points of the cruise from  $R_{max}$  backward so that an iteration can be carried out to find the correct point to start the descent when  $DESIND = 1,3$ . This error message is printed if the stored values do not cover a sufficient range back from  $R_{max}$ . Either  $\Delta R$  is too small or the angle of descent is very small.

REMEDY: Check  $\Delta R$  (LOC. 0831 through 0840),  $\theta_{min}$  (LOC. 0931 through 0940),  $\alpha_{LO}$  (LOC. 0332) and  $i_w$  (LOC. 0103).

#### 6.2.3.12 INSUFFICIENT POWER FOR STEADY LEVEL FLIGHT

This message appears during the loiter segment calculations.

REMEDY: Check power available and drag level.

#### 6.2.3.13 THIS ERROR IS IN THE XXXX PART OF THE FIGURE OF MERIT TABLE.

XXXX IS EITHER CT/SIGMA OR MACH NO.

This error message refers to the table look-up of figure of merit, FM, found in table locations 2351 to 2432. FM is a function of CT/SIGMA and MACH NUMBER.

REMEDY: Check to make sure that the number of table inputs for CT/SIGMA and MACH NO. matches the No. of Values in table input locations 2351 and 2362, respectively.

#### 6.2.3.14 THE NUMBER OF ITERATIONS FOR TRANSMISSION SIZING FOR FIXED SIZE ENGINES EXCEEDED 25, SUBROUTINE MAIN, CASE TERMINATED

This error message is printed out only if  $FIXIND = 0.0$  and  $XMSNIND = 1.0$ . This is due to the inability of the program to converge at a specified cruise power required, which depends on the  $\eta_{PTND}$  chosen.

REMEDY: Possible choices are to reduce the power

requirements, change  $n_{PIND}$  to 0.0, or set  
XMSNIND = 0.0.

- 6.2.3.15 \*\*\*ERROR\*\*\* TORQUE LIMIT OPTION USED NOT APPLICABLE TO  
CONVERTIBLE ENGINES. PROGRAM APPLIED XMSN LIMIT AS  
SPECIFIED FRACTION OF INSTALLED TAKEOFF POWER

This message appears during engine sizing and is  
generated when  $ENGIND = 2.0$ , and  $XMSNIND = 1.0$ .

REMEDY: Set  $XMSNIND = 0.0$ .

- 6.2.3.16 \*\*\*WARNING\*\*\* CONVERTIBLE ENGINE SIZED FOR CRUISE. XMSN  
TORQUE LIMIT OPTION IGNORED

This message is printed during engine sizing if  $ENGIND$   
 $= 2.0$ ,  $XMSNIND = 0.0$ , and  $ESZIND = 1.0$  where the engine  
is sized for cruise.

REMEDY: If it is desired to size transmission at  
specified power, the user should minimize  
cruise requirements.

## 7.0 PROGRAM USAGE

### 7.1 COMMENTS ON PROGRAM USAGE

Following are a list of rules and suggestions for using the program:

#### 7.1.1 Rules

- 7.1.1.1 Do not use descent options 1 or 3 unless preceded by a cruise.
- 7.1.1.2 Do not input a turboshaft engine cycle (cycles 1-9) if LFTIND = 1.
- 7.1.1.3 Do not input WDMIND = 1 or 2 if ENGIND = 1.
- 7.1.1.4 If OPTIND = 2, the airplane profile drag coefficient should be divided into two terms. The wing profile drag coefficient is input to the table of  $C_{D_{wi}}$  versus  $C_L$ , and all other component contributions are input by means of the term  $\Delta C_D$  (LOC. 0305). The terms  $C_{D_{VTi}}$ ,  $C_{D_{HTi}}$ ,  $C_{D_{Ni}}$ ,  $C_{D_{LNi}}$ , and  $\Delta f_e$  and the factors  $K_{LN}$ ,  $K_N$ ,  $K_F$ ,  $K_{VT}$ , and  $K_{HT}$ , are not used in OPTIND = 2. If the option indicator is 1, all terms and factors may be used. However, if it is desired to minimize input, the technique described above may also be used when OPTIND = 1. The major disadvantage is a slight reduction in accuracy since the term  $\Delta C_D$  is not modified by the Reynolds' number functions and therefore would not reflect aircraft growth.
- 7.1.1.5 If cruise is followed by descent with DESIND = 1 or 3, the cruise step size (LOC. 0831 - 0840) should not be less than 10 to 15 nautical miles. This is necessitated by the fact that a table of cruise conditions is compiled during cruise to use in the determination of the starting point for descent. This table consists of 10 points. The cruise step size therefore must be sufficiently large to ensure that the total of nine steps in range is greater than the range required for the following descent. A cruise step size which is too small will lead to termination of the case with the printout:
- 7.1.1.6 If  $\eta_p$  IND = 1.0, the first value of advance ratio J should correspond to at most the forward flight stall speed, and should never equal zero.

\*\*\* ERROR \*\*\* THE RANGE NECESSARY TO DESCEND IS GREATER THAN THE RANGE OF THE TABLE CALCULATED IN CRUISE. THIS MAY BE DUE TO A DELTA R IN CRUISE WHICH IS TOO SMALL.

- 7.1.1.7 At present do not use SGTIND = 7 with OPTIND = 1 unless a sufficiently large  $\Delta W_f$  is input to completely refuel the aircraft. This rule will be eliminated by future modifications to the program. For the present, missions employing change of fuel can be analyzed by running separate cases, a new case each time the fuel is changed. The aircraft can be separately sized for each case and compared manually.
- 7.1.1.8 The value for payload which is input (LOC. 0403) should be the payload at initial takeoff.
- 7.1.1.9 To calculate a conventional climb path, input  $\Delta n_{CLIMB}$  into LOC. 0791 - 0800. The airplane lift to weight ratio will be correctly calculated by the program as  $L/W = \cos \gamma$ . To calculate energy-maneuverability data, input  $\Delta n_{CLIMB} \neq 0$ . The airplane lift to weight ratio will be calculated as  $L/W = 1 + \Delta n_{CLIMB}$ . In order to calculate energy maneuverability at  $L/W = 1$ , input  $\Delta n_{CLIMB}$  as a small non-zero number (for example 0.001).
- 7.1.1.10 Do not use transmission sizing option XMSNIND = 1.0 when employing convertible engines (LOC 0011 = 2.0), as convertible engines do not use a transmission for cruise flight.
- 7.1.2 Suggestions
- 7.1.2.1 If nonstandard atmosphere is required only for constant altitude segments, such as loiter, cruise, and takeoff, the table of temperature ratio versus altitude need not be filled in. The nonstandard atmosphere may be obtained by use of ATMIND = 1.
- 7.1.2.2 If it is desired to run OPTIND = 2 for an aircraft which has previously been sized in a separate case, the drag will be represented correctly if the output values of  $a_5$  and  $a_6$  from the sizing case are input for the OPTIND = 2 case to  $\Delta C_D$  (LOC. 0305) and  $K_W$  (LOC. 0312) respectively, and if the  $C_{DWi}$  table is filled in identically to the sizing case.
- 7.1.2.3 To represent engines which are buried in the fuselage, input  $K_N$  (LOC. 0313) or  $K_{LN}$  (LOC. 0311) or both as zero. The component drag will then be zero and calculation of engine dimensions will be bypassed.

- 7.1.2.4 The order in which segments 7 and 8 are used is important due to the fact that the program will not permit the aircraft weight, during a change of weight segment, to exceed gross weight. As an example, to simulate adding 200 pounds of payload, followed by refueling back to gross weight limits, the eighth performance segment (change of payload weight) should be entered first with an input of  $\Delta W_{PL}$  (LOC. 1131 through 1140) of 200. Then, the change of fuel weight segment can be entered with a large number input for the  $\Delta W_f$  quantity.
- 7.1.2.5 The weights factors K2 through K21 (LOC. 0410, 0415, 0422-0439, 0459-0465) have a nominal value of 1.0 assigned to them by the program. These factors need not be input unless a nonunity value is desired. Similarly, the incremental group weights,  $\Delta W_{FC}$  (LOC. 0417),  $\Delta W_p$  (LOC. 0418), and  $\Delta W_{ST}$  (LOC. 0419), are nominally zero and need not be input unless a nonzero value is desired. The reserve fuel factors K1 (LOC. 0024) and  $\delta W_f$  (LOC. 0025) are nominally unity and zero respectively. The fuel flow multiplier  $K_{FF}$  (LOC. 0026) is nominally 1.0.
- 7.1.2.6 A cruise may be run with a headwind for cruise options 3 through 6 by input of the headwind in knots in locations 0811 through 0820. For cruise option 2 (specified constant true airspeed), the user can simulate cruise with a headwind by inputting an "equivalent" value for  $R_{max}$  (loc. 0851 - 0860), obtained by adjusting the true ground range desired by the ratio  $\text{airspeed} \div \text{ground speed}$ . The program output values for range must then be readjusted by the inverse of this ratio to obtain the correct ground range.
- 7.1.2.7 When a vertical rate of climb at takeoff is warranted for either engine sizing or performance calculations it is suggested that the constant  $K_{R/C}$ /LOC (0262), be input as follows:

If ENGIND = 0	$K_{R/C} = 1.5 - 2.0$
If ENGIND = 1	$K_{R/C}$ NOT APPLICABLE
If ENGIND = 2	$K_{R/C} = 1.0 - 1.4$

7.1.2.8 Consider an aircraft configured with turbofan/jet primary engines, and lift engines. If takeoff with a specified vertical rate of climb is warranted solely from the lift engines, it is suggested the user inputs a T/W that would correspond to the additional thrust above hover necessary to achieve the specified vertical rate of climb.

## 7.2 DISCUSSION OF PROGRAM TOLERANCES

The tolerances tabulated below represent the accuracy required of iterated values calculated at certain points in the program. Whenever the values of the quantities named in the table below become less than the value quoted, the iterating calculation is terminated.

TABLE 7-1  
PROGRAM TOLERANCES

SYMBOL	VALUE	VARIABLE BEING CALCULATED	SITUATION IN PROGRAM	FUNCTION OF TOLERANCE
TOL	.01	$W_G$ , Gross Weight	Main Control Loop	When the quantity <del>W_G</del> TOL the fuel required and available are considered to be sufficiently close and the sizing calculation is terminated.
$\Delta\gamma$	.1°	$\gamma$ , Flight Path Angle	Climb & Descent Sub-routines	Determines flight path angle to within .1°
$\Delta BHP$	10.HP	$BHP_R$ Power Required	Cruise	The cruise speed is set when $BHP_R$ is within 10 HP of $BHP_A$
$\Delta T$	10.LB	$T_R$ Thrust Required	Subroutine	The cruise speed is set when $T_R$ is within 10 lb. of $T_A$
$\Delta B$	.01	$\frac{B_1 - B_2}{B_2}$	CRSIND = 1	$\frac{B_1 - B_2}{B_2}$ is used to adjust $\Delta V$ to expedite computation. If $\frac{B_1 - B_2}{B_2}$ becomes less than $\Delta B$ , $BHP_R$ always exceeds $BHP_A$
$\Delta T_1$	.01	$\frac{T_1 - T_2}{T_2}$		$\frac{T_1 - T_2}{T_2}$ is used to adjust $\Delta V$ to expedite computation. If $\frac{T_1 - T_2}{T_2}$ becomes less than $\Delta T_1$ , $T_R$ always exceeds $T_A$
$R_{TOL}$	5.n.m. R, Range		Descent Sub-routine	If the range at the end of descent is within $R_{TOL}$ n.m. of $R_{max}$ the calculation terminates.

### 7.3 SAMPLE CASES

To illustrate the use of the program, three sample cases have been run and the output included here.

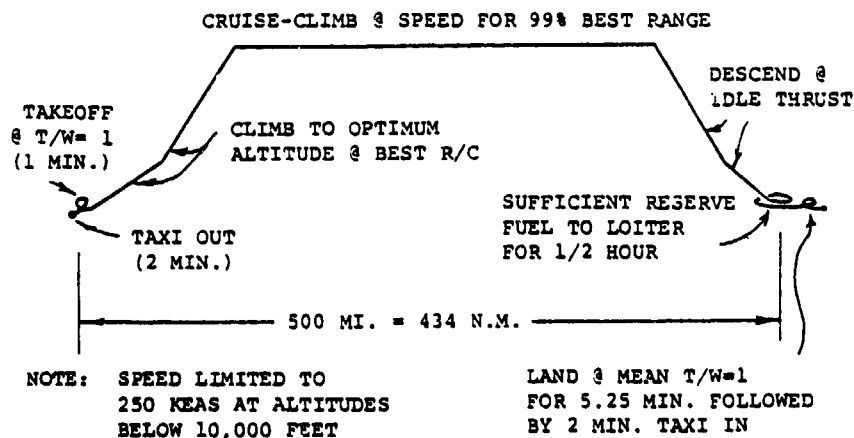
The first case is for a 60-passenger commercial lift fan VTOL aircraft similar to that shown in NASA CR-743. This case illustrates the use of dual propulsion (lift and primary), the sizing of a fuselage for specified passenger requirements and the automatic observance of speed restrictions at altitudes below 10,000 feet. The engines are sized to meet specified takeoff and cruise requirements. Runs 2 and 3 illustrate the use of standard printout and weights data, respectively.

The second case is for a military high-performance COIN turboprop. It illustrates the use of the automatic propeller performance subroutine, the study of a mission which is partly at optimum altitude and partly at specified altitude, and the determination of energy-maneuverability performance. The engine size is fixed for this case, but the transmission is sized for specified fraction of installed power in Run 1, and for a specified fraction of either hover or cruise power required (chooses the most critical condition).

The third case calculates sizing and performance data for a tilt-rotor aircraft. It illustrates the use of the general performance subroutine, figure of merit hover map, and engine sizing for; specified power fraction, vertical rate of climb, and accessory horse power.

#### 7.3.1 Lift Fan VTOL Aircraft

All inputs are discussed for this case. A complete copy of the program printout is shown following the description of the input. The design mission profile is shown below:



VASCOMP II - DESCRIPTION OF SAMPLE CASE 1

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
Run 1			
<u>General Information Sheet</u>			
OPTIND	0001	1.0	Sizing run
TNIRPK	0002	1.0	Print indicator-optional print
DRGIND	0003	0.0	Program calculates compressibility drag
OSWIND	0004	1.0	Program calculates induced drag factor
FDMIND	0006	2.0	Size fuselage for passenger requirements
WDMIND	0007	0.0	Wing not dependent on propeller size
HTIND	0008	1.0	} Input tail volume coefficients
VTIND	0009	1.0	
FIXIND	0010	1.0	Program sizes engines
ENGIND	0011	1.0	Turbo fan primary engines
WG <sub>o</sub>	0014	70000.	1st guess at design gross weight
h <sub>o</sub>	0015	0.	Start altitude Normally 0. except for
R <sub>o</sub>	0016	0.	Starting range partial mission
t <sub>o</sub>	0017	0.	Starting time analysis
HOPTIN	0018	1.0	Cruise desired at optimum altitude
VLMIND	0019	1.0	Airspeed limited to 250 knots EAS at altitude of 10,000 ft or less
M <sub>mo</sub>	0020	0.83	Maximum operating mach number
V <sub>mo</sub>	0021	400	Maximum operating EAS knots
V <sub>DIVE</sub>	0022	450	Design dive speed



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$M_{LF}$	0023	2.5	Maneuver load factor
$K_1$	0024	1.0	Factor on mission fuel burned to give reserve fuel, i.e. 1.1 would give 10% reserve
$SW_F$	0025	0.	Fixed fuel increment for reserves or other use
$K_{FF}$	0026	1.0	Use nominal engine fuel
SGTIND	0027	1.	TAXI
	0028	2.	TAKEOFF
	0029	3.	CLIMB
	0030	4.	CRUISE
	0031	5.	DESCEND
	0032	60.	LOITER (Reserve fuel in this case)
	0033	2.	APPROACH AND LAND
	0034	1.	TAXI
	0035	100.	END OF CASE

Aircraft Dimensional Sheet

AR	0101	3.2	Wing aspect ratio
$i_w$	0103	2.0	Wing incidence angle to fuselage horizontal datum (degrees)
$(L/C)_R$	0104	.145	Root thickness-chord ratio
$(L/C)_T$	0105	.1	Tip thickness-chord ratio
$W_G/S$	0106	75.	Wing loading at design gross weight
$\Lambda c/4$	0107	35.	Quarter chord mean sweep angle, degrees
$\lambda$	0108	.23	Taper ratio (tip chord/root chord)
$AR_{HT}$	0109	3.3	Horizontal tail aspect ratio
$a_H$	0110	0.	Vertical position of horizontal tail on vertical tail, spans above vertical tail root chord. Value is 0. on or below root chord, 1.0 for "T" tail

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$l_{TH}$	0111	36.	Horizontal tail arm, FT
$(t/c)_{HT}$	0112	.1	Horizontal tail mean thickness/ chord ratio
$\bar{V}_H$	0113	.6	Horizontal tail volume coefficient
$\lambda_H$	0114	.45	Horizontal tail taper ratio
$\Delta S_{WET}/S_W$	0120	0.	Increment in wetted area for landing gear or other protrusions
$(l/d)_{nose}$	0123	1.85	Fineness ratio of nose
$(l/d)_{tail}$	0124	2.5	Fineness ratio of tail
$l_{RW}$	0126	0.	Length of ramp well or other strengthened fuselage portion (e.g., rear engine attachments). Used to compute fuselage weight penalty.
$AR_{VT}$	0129	1.5	Vertical tail aspect ratio
$l_{TV}$	0130	32.5	Vertical tail arm
$(t/c)_{VT}$	0131	.1	Vertical tail thickness/chord ratio
$\bar{V}_V$	0132	.1	Vertical tail volume ratio
$\lambda_V$	0133	.45	Vertical tail taper ratio
$Y_{mg}$	0135	0.0	Spanwise distance of landing gear from mean spanwise distance of cruise engine from wing root in semispans. Used in wing relief term.
$Y_P$	0136	.48	
$Y_L$	0137	0.	Mean spanwise distance of lift propulsion system from wing root in semispans. Taken as 0. here since fans are inboard on the wing and gas generator, etc. are in the fuselage.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\epsilon$	0138	-2.	Length of lift engine nacelle over and above engine diameters (see figure 2-1). This would not be used if $K_{LW}$ (LOC. 0311) were 0 because the lift nacelle dimension calculation would be bypassed (see figure 4-12). However, we wanted the fan diameter to be printed out in the lift engine nacelle mean diameter location. Therefore $\epsilon$ was set to -2. to give the wetted area of the nonexistent lift nacelles

$$S_W = 2 \bar{d}_{LN} (N_L + \alpha N_C) l_{LM}$$

as zero, and therefore give 0 nacelle drag, but allow

$$d = \frac{(T_L^*)^{\frac{1}{2}}}{N_L}$$

to be printed out.  $\xi_1$  has been chosen in the engine library, information to make  $\bar{d}_{LN}$  equal to the fan diameter.

$Z_1$	0139	.0334	
$Z_2$	0140	0.	} Primary engine sizing constants
$Z_3$	0141	.1105	

Passenger Data Required For Fuselage Sizing

Gallery Indicator	0151	0.	The program will use a trend equation to determine gally size
No. of Passengers	0153	60.	
Seats Abreast	0154	5.	
No. of Aisles	0155	1.	Data required for determining fuselage size this aircraft has a single class service.
Unit Seat Width	0156	22.	The data was input as first information, and the tourist data was zeroed out.
Seat Pitch	0157	36.	
Aisle Width	0158	18.	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
Lavatory Indicator	0159	0.	The program will use a trend equation to determine the number of lavatories
No. of Passengers	0161	0.	
Seats Abreast	0162	0.	
No. of Aisles	0163	0.	Tourist class inputs zeroed, because aircraft is single service, and necessary information was input as first class information
Unit Seat Width	0164	0.	
Seat Pitch	0165	0.	
Aisle Width	0166	0.	

Aircraft Propulsion Information Required When Using Turbo Fan/Jet Engines - Primary Engine

Cycle No.	0201	22.	Cruise engine selection
$N_p$	0204	4.	Number of cruise engines
$h_{TO}$	0207	0.	Takeoff pressure altitude for engine sizing
$n$	0208	1.04	Takeoff thrust/weight ratio 1.0 is required in this case but .04 has been added to allow for control and trim
$\Delta T_{INTO}$	0209	27.	Takeoff ambient temperature = 86°F (27.° above standard)
$N_{po}$	0211	0.	Number of cruise engines inoperative in hover. In this case we know the lift engine out condition is critical.
$N_{LO}$	0212	0.7	Number of lift engines inoperative. Actually 1.0 in this case but reduced to .7 because of 1.1 emergency rating or equivalent of 3.3 engines operating
POWIND	0213	2.0	Engine sizing will be done at normal power

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$h_C$	0214	30000.	Cruise engine sizing altitude, feet
$V_C$	0215	466.	Cruise engine sizing speed, knots TAS
$Tin_C$	0216	0	Zero indicates standard atmosphere nonstandard increment in temperature would be entered in °F.
Lift Engine Cycle No.	0218	55.	Lift fan and gas generator Selected
$N_L$	0220	4.	Number of lift fans
$N_L$	0221	2.	Number of lift fan clusters chosen to give zero lift nacelle wetted area (see explanation for location 0138)
$\eta_L$	0231	1.1	Lift engine hover efficiency normally used for turning nozzle or similar losses. Here it is used to account for the fact that one gas generator inoperative out of four does not depreciate thrust by .75 but B $(0.75)^{2/3} (0.75)^{2/3} / .75 = 1$ all four fans are operating due to cross ducting.
$\eta_{P2}$	0232	.96	Cruise engine hover efficiency. 4 percent loss assumed for turning nozzles
$SHP_E/SHP^*$	0260	1.0	Engine sized at 100% power
$V_{R/C}$	0261	0.0	Engine sized at 0 ft/min vertical rate of climb

Aircraft Aerodynamics Information Sheet

$C_{DUTi}$	0301	.005	Profile drag coefficient of vertical tail at $R_e = 10^7$
$C_{DHTi}$	0302	.005	Profile drag coefficient of horizontal tail at $R_e = 10^7$
$C_{DNI}$	0303	.0025	Profile drag coefficient of primary engine nacelle at $R_e = 10^7$

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$C_{DLNi}$	0304	0.0	Profile drag coefficient lift engine nacelles at $R_e = 10^7$
$\Delta C_D$	0305	.001	Profile drag increment
$\Delta f_e \text{ FT}^2$	0307	0.0	Increment in equivalent flat plat area parasite drag of fuselage ( $\text{ft}^2$ )
No. of Pairs in Table	0308	8.0	Number of $C_L$ - $C_{Dwi}$ Pairs in locations 317-330 and 335-342
$K_{LN}$	0311	1.0	Lift nacelle multiplicative drag factor
$K_W$	0312	1.2	Wing multiplicative drag factor
$K_N$	0313	2.5	Primary nacelle multiplicative drag factor
$K_F$	0314	1.3	Fuselage multiplicative drag factor
$K_{VT}$	0315	1.5	Vertical tail multiplicative drag factor
$K_{HT}$	0316	1.5	Horizontal tail multiplicative drag factor
$C_{L1}$	0317	0.0	
$C_{L2}$	0318	0.2	
$C_{L3}$	0319	0.4	Table of lift coefficients used in the development of wing profile drag.
$C_{L4}$	0320	0.6	
$C_{L5}$	0321	0.8	
$C_{L6}$	0322	1.0	
$C_{L7}$	0323	1.2	
$C_{L8}$	0324	1.4	
$(R_e/l)_i$	0330	$2.0 \times 10^6$	Mean Reynolds number per foot for mission
$C_{l\alpha} \text{ RAD}^{-1}$	0331	6.28	Two dimensional wing lift coefficient slope

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\alpha_{LO}$ DEG.	0332	-3.0	Angle of attack where the lift equals zero
$(X/c)_{ps}$	0333	0.3	Position of peak suction location on wing
$(X/c)_{max_{c/c}}$	0334	0.35	Position of maximum thickness on wing
$C_{Dwi}(1)$	0335	.0066	
$C_{Dwi}(2)$	0336	.0063	
$C_{Dwi}(3)$	0337	.0065	
$C_{Dwi}(4)$	0338	.0072	Table of wing induced drag coefficients.
$C_{Dwi}(5)$	0339	.0088	
$C_{Dwi}(6)$	0340	.010	
$C_{Dwi}(7)$	0341	.0128	
$C_{Dwi}(8)$	0342	.0156	

Aircraft Weight Information Sheet

$W_{FE}$ LBS	0401	11040.	Weight of fixed equipment, in LBS.
$W_{FUL}$ LBS	0402	1450.	Weight of fixed useful load in LBS.
$W_{PL}$ LBS	0403	13200.	Weight of payload in LBS.
$K_{CC}$	0404	26.0	Cockpit controls weight factor
$K_{FW}$	0405	.015	Fixed wing controls weight factor
$K_H$	0406	40.0	Constant for flight control hydraulics
$K_{SAS}$	0407	175.0	Stability augmentation system (SAS) weight factor, usually in range of 20-100 LBS
$K_{TM}$	0408	0.0	Tilt mechanism weight factor
$K_{UC}$	0409	0.0	Upper control weight factor

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta W_{FC}$ LBS	0417	500.0	Flight controls increment of 500 lb. for VTOL phasing and mixing
$\Delta W_P$	0418	0.0	Incremental propulsion group weight
$\Delta W_{ST}$	0419	0.0	Structures group incremental weight, in LBS
$K_{LES}$	0421	0.0	Lift engine section added to fuselage weight
$K_{LG}$	0422	.043	Landing gear weight factor, percentage of gross weight
$K_{MG}$	0423	.8	Main landing gear weight factor
$K_{TL}$	0424	1.0	Tail load factor
$K_{WF}$	0425	.314	Wing binding relief moment
$K_{WW}$	0426	291.0	Detailed wing weight factor, adjusts the constant 220 in $W_w = 220a (k)^{.582}$ depending on the complexity of the control surfaces
$K_Y$	0427	.190	Pitch radius of gyration, feet
$K_Z$	0428	.280	Yaw radius of gyration, feet
$K_{PES}$	0429	.342	Primary engine section factor
$\Delta P_{PSI}$	0450	7.5	Cabin pressure differential limit (psi)
$W_c$ lbs	0451	0.0	Weight of concentrated load
$Y_c$	0452	0.0	Position of concentrated load outboard from $C_L$ in wing semispans
$K_{FS}$	0454	.07	Fuel system weights factor
$K_{LEI}$	0455	.250	Lift engine installation, used to account for reaction control system
$K_{PEI}$	0456	.400	Primary engine weight factor



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
<u>Taxi Information Sheet</u>			
ATMIN1	0501	0.0	Taxi out standard day
ATMIN2	0502	0.0	Taxi in standard day
$t_T$ (HR) 1st	0511	.0333	Taxi out 2 minutes
$t_T$ (HR) 2nd	0512	.0333	Taxi in 2 minutes
$K_{FL}$	0531	1.0	Taxi out lift system running
$K_{FL}$	0532	0.	Taxi in lift system inoperative
<u>Takeoff, Hover and Landing Information Sheet</u>			
TOLIND	0601	2.0	Takeoff and land sharing equal fraction of thrust from primary and lift engines
	0602	2.0	
ATMIND	0611	0.	Takeoff standard day
ATMIND	0612	0.	Landing standard day
$n_T$	0651	1.	Takeoff mean T/W = 1.
$n_T$	0651	1.	Landing T/W would normally be a mean value of .43. It has been increased to 1.0 to account for the go-around required in the reserves.
$\Delta t_H$	0661	.0167	Takeoff compute in 1 minute increments
$\Delta t_H$	0662	.0167	Landing compute in 1 minute increments
$t_H$	0681	.0167	Takeoff in 1 minute
$t_H$	0682	.0875	Landing in 5.25 minutes
$V_{R/C}$	2321	0.0	No vertical rate of climb specified
	2322	0.0	
<u>Climb Information Sheet</u>			
CLMIND	0691	1.0	Climb at speed for max. R/C
ATMIND	0711	0.0	Climb standard day
$\Delta h$	0721	1000.0	Compute in 1000. foot increments

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$h_{MAX}^{FT}$	0741	50000.	The airplane will climb to altitude for minimum fuel consumed during climb and cruise so long as the altitude is below 50,000 ft.
POWIND	0751	1.0	Climb at mil power
$\theta_{MAX}$	0761	12.0	Maximum cabin angle, degrees
$\Delta C_{D_{CLIMB}}$	0781	0.0	No drag increment required
$\Delta n_{CLIMB}$	0791	0.0	Nominally zero

Cruise Information Sheet

CRSIND	0801	6.000	Cruise climb (constant W/ $\delta$ at speed for 99% of best range)
HEADWIND	0811	0.0	Headwind for airplane is zero in this case, input is read as headwind when CRSIND is equal to 3 thru 6.
ATMIND	0821	0.0	Cruise @ standard day
$\Delta R$	0831	25.0	Increment for calculations
$R_{MAX}$	0851	434.	Range at end of cruise calculations. Cruise is followed by a descent. The descent terminates at $R = 434$ n.m.
POWIND	0861	2.0	Cruise limited by normal power
$N_{PSD_{CR}}$	0871	0.0	No cruise engines inoperative during cruise
$\Delta C_{DCR}$	0891	0.0	No drag increment (for shutdown engine)

Descent Information Sheet

DESIND	0901	3.0	Descent at idle power
ATMIND	0921	0.0	Descent standard day
$\theta_{MIN}$	0931	-6.0	Cabin angle not to exceed six degree, nose down

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta h$	0951	1000.	Compute in 1000. FT increments
$R_{MAX}$	0961	434.	Terminate descent at R = 434 nmi.
$h_{MIN}$	0971	0.0	Altitude at completion of descent
$\Delta C_{DDESC_{CR}}$	0991	0.0	No drag increment used

Loiter Information Sheet

LTRIND	1001	2.0	Loiter indicator, fuel is for reserves and will not be printed out in the mission data
$\Delta t_L$	1011	0.10	Compute loiter in 6 MIN (.1HR) increments
ATMIND	1021	0.0	Loiter standard day
$t_L$	1031	.5	Loiter for 1/2 hour
$N_{PSD_{LOITER}}$	1051	0.0	Number of engines inoperative
$\Delta C_{D_{LOITER}}$	1071	0.0	No drag increment used (for shutdown engines)

Primary Engine Data

WDTIND	1201	1.0	Engine is flat rated by fuel flow restriction
$\dot{w}_{MAX}/\dot{w}$	1220	.8	Maximum fuel flow is 80% of fuel flow at maximum static thrust, sea level standard

Primary Engine Cycle Information Sheet Number 1

Cycle No.	1301	22.	Primary engine cycle number
$K_3$	1302	.122	Primary engine weights multiplicative factor
$K_4$	1303	95.	Primary engine weights additional factors
$T_{GI} (^{\circ}R)$	1305	1417	Turbine inlet temperature, ground idle power setting

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
T <sub>FI</sub> (°R)	1306	1776	Turbine inlet temperature, flight idle power setting
T <sub>NP</sub> (°R)	1307	2340	Turbine inlet temperature. normal power setting. When this power setting is desired the input temperature is referred for the given altitude. The referred temperature, T/θ is used in the table lookup for referred fuel flow, Gas generator RPM limit, and power turbine limit.
T <sub>MIL</sub> (°R)	1308	2444	Turbine inlet temperature, military power setting when this setting is desired the temperature is referred for the given altitude. The referred temperature, T/θ, is used in the beforementioned table look-ups.
T <sub>MAX</sub> (°R)	1309	2600.00	Turbine inlet temperature, maximum power setting when this power setting when this power setting is specified the input temperature is referred for the given altitude. The referred temperature, T/θ, is used in the beforementioned table lookup.
No. of T/θ	1310	4.0	Number of referred temperatures in locations 1311-1318
Values of T/θ	1311 1312 1313 1314	1339.0 2080. 2600. 3458	Values of referred temperatures for the referred thrust or horsepower tables
No. of M.	1319	6.0	Number of mach numbers in locations 1320-1325
Values of M.	1320 1321 1322 1323 1324 1325	0.0 .2 .4 .6 .8 1.0	Values of mach number for the referred thrust or horsepower tables

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>	
Referred, Thrust or Horsepower	1326	0.0	Values of referred thrust or horsepower corresponding to T/θ location 1311 and mach number found in locations 1320 - 1325	
	1327	-.04		
	1328	-.09		
	1329	-.185		
	1330	-.33		
	1331	-.49		
	1332	.55		
	1333	.445		
	1334	.375		
	1335	.315		
	1336	.240		
	1337	.150		
	1338	.980		Values of referred thrust or horsepower corresponding to T/θ location 1313 and mach number found in locations 1320 - 1325
	1339	.860		
1340	.750			
1341	.700			
1342	.650			
1343	.595			
	1344	1.70	Values of referred thrust or horsepower corresponding to T/θ location 1314 and mach number found in locations 1320 - 1325	
	1345	1.58		
	1346	1.46		
	1347	1.375		
	1348	1.265		
	1349	1.330		
No. of T/θ	1374	4.0	Number of referred temperatures in location 1375 - 1382	
Values of T/θ	1375	1339.	Values of referred temperatures for the referred fuel flow table	
	1376	2080.		
	1377	2600.		
	1378	3458.		
No. of M.	1383	6.	Number of mach numbers in locations 1384 - 1389	
Values of M	1384	0.	Values of mach number for the referred fuel flow table	
	1385	.2		
	1386	.4		
	1387	.6		
	1388	.8		
	1389	1.0		

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
	1390	.013	
	1391	.013	Values of referred fuel flow correspond to the T/θ location 1375 and mach numbers in locations 1384 - 1389
	1392	-.017	
	1393	-.079	
	1394	-.205	
	1395	-.390	
	1396	.26	
	1397	.265	Values of referred fuel flow correspond to the T/θ location 1376 and mach numbers in locations 1384 - 1389
	1398	.210	
	1399	.270	
	1400	.222	
	1401	.170	
	1402	.530	
	1403	.540	Values of referred fuel flow correspond to the T/θ location 1377 and mach numbers in locations 1384 - 1389
	1404	.550	
	1405	.571	
	1406	.572	
	1407	.589	
	1408	1.040	
	1409	1.072	Values of referred fuel flow correspond to the T/θ location 1378 and mach numbers in locations 1384 - 1389
	1410	1.105	
	1411	1.170	
	1412	1.211	
	1413	1.345	

Primary Engine Cycle Information Sheet Number 2

No. of T/θ	1438	8.0	
	1439	1300.	
	1440	1560.	
	1441	1820.	Values of referred temperatures for the referred gas generator RPM
	1442	2080.	
	1443	2340.	
	1444	2600.	
	1445	3120.	
1446	3640.		
No. of M.	1447	6.0	Number of mach numbers in locations 1448 - 1453
Value of M.	1448	0.0	
	1449	0.2	
	1450	0.4	Values of mach number for the referred gas generator RPM
	1451	0.6	
	1452	0.8	
	1453	1.0	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
Referred Gas Generator RPM	1454	.679	Values of referred gas generator RPM limit corresponding to T/θ location 1439 and mach number locations 1448 - 1453
	1455	.678	
	1456	.677	
	1457	.676	
	1458	.675	
	1459	.673	
	1460	.740	
	1461	.7385	
	1462	.737	
	1463	.735	
	1464	.732	
	1465	.730	
	1466	.804	
	1467	.802	
	1468	.799	
1469	.797		
1470	.794		
1471	.789		
1472	.868	Values of referred gas generator RPM limit corresponding to T/θ location 1442 and mach number locations 1448 - 1453	
1473	.865		
1474	.8625		
1475	.860		
1476	.855		
1477	.849		
1478	.934	Values of referred gas generator RPM limit corresponding to T/θ location 1443 and mach number locations 1448 - 1453	
1479	.931		
1480	.928		
1481	.925		
1482	.918		
1483	.910		
1484	1.0	Values of referred gas generator RPM limit corresponding to T/θ location 1444 and mach number locations 1448 - 1453	
1485	.997		
1486	.9945		
1487	.992		
1488	.983		
1489	.974		
1490	1.145	Values of referred gas generator RPM limit corresponding to T/θ location 1445 and mach number locations 1448 - 1453	
1491	1.140		
1492	1.136		
1493	1.131		
1494	1.119		
1495	1.107		

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
	1496	1.292	
	1497	1.286	Values of referred gas generator RPM limit corresponding to T/θ location 1445 and mach number locations 1448 - 1453
	1498	1.281	
	1499	1.276	
	1500	1.263	
	1501	1.250	
No. of T/θ	1502	8.0	
Values of T/θ	1503	1300.	Values of referred temperature for the referred power turbine speed limit ratio
	1504	1560.	
	1505	1820.	
	1506	2080.	
	1507	2340.	
	1508	2500.	
	1509	3120.	
1510	3510.		
No. of M	1511	6.	Number of mach numbers in locations 1512 - 1517
Values of M	1512	0.0	Values of mach number for the referred power turbine speed limit ratio
	1513	0.2	
	1514	0.4	
	1515	0.6	
	1516	0.8	
	1517	1.0	
Referred Power Turbine Limit Table	1518	.12	Values of referred power turbine speed limit corresponding to T/θ location 1503 and mach number locations 1512 - 1517
	1519	.17	
	1520	.22	
	1521	.272	
	1522	.352	
	1523	.412	
	1524	.382	
	1525	.419	
	1526	.455	
	1527	.499	
	1528	.549	
	1529	.599	
	1530	.601	
	1531	.626	
	1532	.650	
1533	.680		
1534	.712		
1535	.754		



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
	1536	.774	
	1537	.788	Values of referred power turbine speed limit corresponding to T/θ location 1506 and mach number locations 1512 - 1517
	1538	.801	
	1539	.820	
	1540	.847	
	1541	.880	
	1542	.900	
	1543	.912	Values of referred power turbine speed limit corresponding to T/θ location 1507 and mach number locations 1512 - 1517
	1544	.924	
	1545	.940	
	1546	.960	
	1547	.988	
	1548	1.00	
	1549	1.01	Values of referred power turbine speed limit corresponding to T/θ location 1508 and mach number locations 1512 - 1517
	1550	1.02	
	1551	1.032	
	1552	1.049	
	1553	1.073	
	1554	1.16	
	1555	1.166	Values of referred power turbine speed limit corresponding to T/θ location 1509 and mach number locations 1512 - 1517
	1556	1.172	
	1557	1.180	
	1558	1.190	
	1559	1.204	
	1560	1.261	
	1561	1.264	Values of referred power turbine speed limit corresponding to T/θ location 1510 and mach number locations 1512 - 1517
	1562	1.266	
	1563	1.275	
	1564	1.280	
	1565	1.284	

Lift Engine Cycle

Cycle No.	1601	55.	Lift engine cycle number
$K_1$	1602	.157	Lift engine weights multiplicative factors
$K_2$	1603	-610.	Lift engine weights additional factors
$\xi_1$	1604	.0512	} Lift engine dimensional factors
$\xi_2$	1605	0.0	
$\xi_3$	1606	.0855	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
T <sub>GI</sub>	1607	1331.	Turbine inlet temperature at ground idle power setting, °R
T <sub>MAX</sub>	1608	2600.	Turbine inlet temperature at max. power setting
Values of T/θ	1609	1300.	Values of referred temperature for the referred thrust tables
	1610	1560.	
	1611	1820.	
	1612	2080.	
	1613	2340.	
	1614	2600.	
	1615	3120.	
Referred Thrust Table	1616	3458.	Values of referred thrust corresponding to T/θ locations 1609 - 1616
	1617	0.0	
	1618	.180	
	1619	.372	
	1620	.575	
	1621	.782	
	1622	1.00	
Values of T/θ	1623	1.433	Values of referred temperature for the referred fuel flow table
	1624	1.710	
	1625	1300.	
	1626	1560.	
	1627	1820.	
	1628	2080.	
	1629	2340.	
Table of Referred Fuel Flow	1630	2600.	Values of referred fuel flow corresponding to T/θ locations 1625 - 1632
	1631	3120.	
	1632	3458.	
	1633	.0379	
	1634	.0682	
	1635	.127	
	1636	.199	
Values of T/θ	1637	.235	Values of referred temperature for referred gas generator RPM table
	1638	.379	
	1639	.5837	
	1640	.7201	
	1641	1200.	
	1642	1440.	
	1643	1680.	
1644	1920.		
1645	2160.		
1646	2400.		
1647	2880.		
1648	3360.		

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
Referred Gas	1649	.679	
Generator	1650	.740	
RPM Table	1651	.804	Values of referred gas generator RPM corresponding to T/θ Loca- tions 1641 - 1649
	1652	.868	
	1653	.934	
	1654	1.000	
	1655	1.145	
	1656	1.292	
Values of T/θ	1657	1200.	Values of referred temperature for referred power turbine speed unit
	1658	1440.	
	1659	1680.	
	1660	1920.	
	1661	2160.	
	1662	2400.	
	1663	2880.	
	1664	3240.	
Referred Power	1665	.1200	Values of referred power turbine limit corresponding to T/θ loca- tions 1657 - 1664
Turbine Limit	1666	.382	
Table	1667	.001	
	1668	.774	
	1669	.90	
	1670	1.0	
	1671	1.16	
	1672	1.261	
Run 2			
KPRINT	0002	0.0	Standard printout
Run 3			
OPTIND	0001	0.0	Weights data only
End of Data			

V A S C O M P II  
 V/STOL AIRCRAFT STING & PERFORMANCE COMPUTER PROGRAM B-93

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUMBER GIVEN ON INPUT SHEET  
 NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. =5)  
 VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL1 VALUE CORRESPONDING TO LOC.+0001  
 VAL2 VALUE CORRESPONDING TO LOC.+0002  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
1501	3	22.000	12200	95.000	2444.0	2600.0
1505	5	1417.0	1776.0	2340.0	2600.0	3458.0
1510	5	4.0000	1339.0	2080.0	40000	60000
1519	5	6.0000	0	20000	0	0
1524	5	.80000	1.0000	0	-.40000E-01	-.90000E-01
1529	5	-1.8500	-33000	-49000	.55000	.44500
1534	5	.37500	31500	24000	.15000	.98000
1539	5	.86000	76000	70000	.65000	.59500
1544	5	1.7000	1.5800	1.4600	1.3750	1.0650
1549	1	1.3300	1339.0	2080.0	2600.0	3458.0
1574	5	4.0000	0	20000	40000	60000
1583	5	6.0000	1.0000	.13000E-01	.13000E-01	-.17000E-01
1588	5	.80000	-20500	-.39000	.26000	.26500
1593	5	-.79000E-01	-27000	.2200	.17000	.53000
1598	5	.27000	27000	.57100	.57200	.58900
1403	5	.54000	55000	1.1050	1.1700	1.2110
1408	5	1.0400	1.0720	1.1050	1.1700	1.2110
1413	1	1.3450	1300.0	1560.0	1820.0	208.0
1438	5	8.0000	2690.0	3120.0	3640.0	6.0000
1443	5	2340.0	20000	40000	.60000	.80000
1448	5	0	.67900	.67800	.67700	.67600
1453	5	1.0000	.67300	.74000	.73850	.73700
1458	5	.67500	.73200	.73000	.80400	.80300
1463	5	.73500	.79700	.79400	.78900	.78800
1468	5	.79900	.86250	.86000	.85500	.85400
1473	5	.86500	.93100	.92800	.92500	.92400
1478	5	.93400	1.0000	.99700	.99450	.99200
1483	5	.91000	.97400	1.1450	1.1400	1.1360
1488	5	.82300	1.1190	1.1070	1.2920	1.2860
1493	5	1.1310	1.2760	1.2630	1.2500	1.2400
1498	4	1.2810	1300.0	1560.0	1820.0	2080.0
1502	5	8.0000	2600.0	3120.0	3510.0	6.0000
1507	5	2340.0	20000	40000	.60000	.80000
1512	5	0	.12000	.17000	.22000	.27200
1517	5	1.0000	.41200	.38200	.41900	.45500
1522	5	.35200	.54900	.59900	.60100	.62600
1527	5	.49900	.68000	.71200	.75400	.77400
1532	5	65000	.80100	.82000	.84700	.88000
1537	5	.78800	.91200	.92400	.94000	.96000
1542	5	.90000	1.0000	1.0100	1.0200	1.0320
1547	5	98800	1.0730	1.1600	1.1660	1.1720
1552	5	1.0490	1.0730	1.1600	1.1660	1.1720

1557	5	1.1800	1.1900	1.2040	1.2610	1.2640
1562	4	1.2660	1.2750	1.2800	1.2840	
1601	5	55.000	.15700	-610.00	.51200E-01	.0
1606	5	.85500E-02	1331.0	2600.0	1300.0	1560.0
1611	5	1820.0	2080.0	2340.0	2600.0	3120.0
1616	5	.0	.0	.18000	.37200	.57500
1621	5	78200	1.0000	1.4330	1.7100	1300.0
1626	5	1560.0	1820.0	2080.0	2340.0	2600.0
1631	5	3120.0	3458.0	.37900E-01	.68200E-01	.12700
1636	5	.19900	.28500	.37900	.58370	.72010
1641	5	1200.0	1440.0	1680.0	1920.0	2160.0
1646	5	2400.0	2330.0	3360.0	.67900	.74000
1651	5	.80400	.86800	.93400	1.0000	1.1450
1656	5	1.2920	1200.0	1440.0	1680.0	1920.0
1661	5	2160.0	2400.0	2880.0	3240.0	.12000
1666	5	.38200	.60100	.77400	.90000	1.0000
1671	4	1.1600	1.2610	.0	1.0000	
6	5	1.0000	1.0000	1.0000	1.0000	1.0000
11	1	2.0000	.0			
13	1	1.0000				
14	4	1.0000	.0	.0	.0	
18	2	1.0000	1.0000	450.00		
20	3	.83000	400.00			
23	1	2.5000				
24	3	1.0000	.0	1.0000	4.0000	5.0000
27	5	1.0000	2.0000	3.0000	100.00	
32	4	6.0000	2.0000	1.0000		
101	1	3.2000	.14500	.10000	75.000	35.000
103	5	2.0000	.0	36.000	.10000	.60000
108	1	.23000				
109	5	3.3000				
114	1	.45000				
120	1	.0				
123	2	1.8500	2.5000			
126	1	.0				
129	5	1.5000	32.500	.10000	.10000	.45000
135	1	.0				
136	1	.48000				
137	2	.0	-2.0000	.11050		
139	3	.33400E-01	.0			
151	1	.0	5.0000	1.0000	22.000	36.000
153	5	60.000				
158	1	18.000				
159	1	.0	.0	.0	.0	.0
161	5	.0				
166	1	.0				
201	1	22.000				
204	1	4.0000				
207	3	.0				
211	2	.0	1.0400	27.000		
213	4	55.000	.70000			
218	1	4.0000	30000.	466.00	.0	
220	2	4.0000	2.0000			
231	5	1.1000	.96000			
301	2	.50000E-02	.50000E-02	.25000E-02	.0	.10000E-02
307	5	.0	8.0000			
311	5	1.0000	1.2000	2.5000	1.3000	1.5000
316	5	1.5000	.0	.20000	.40000	.60000
321	4	.80000	1.0000	1.2000	1.4000	

330	1	20000E+07	-3.0000	.65000E-02	.72000E-02	.88000E+02
331	2	6.2800	.35000	.15600E-01		
333	2	.0000	.63000E-02	.13200		
335	3	.66000E-02	.12900E-01	40.000	175.00	
340	3	1.0000E-01	1450.0	.0		
401	3	11040	15000E-01	.0		
404	5	26.000	.0	.43000E-01	.80000	1.9000
409	1	.0	.0	.19000	.28000	.34200
417	3	500.00	291.70	.0		
420	5	125.00	.0	.0		
425	5	.31400	.25000	.40000		
450	3	7.5000	.0			
454	3	.70000E-01	.0			
501	2	.0	.33300E-01			
511	2	.33300E-01	.0			
531	2	1.0000	.0			
601	2	2.0000	2.0000			
611	2	.0	.0			
651	2	1.0000	1.0000			
661	2	.16700E-01	.15700E-01			
681	2	.16700E-01	.87500E-01			
691	1	1.0000	.0			
711	1	.0	.0			
721	1	1000.0	1000.0			
741	1	50000.	50000.			
751	1	1.0000	1.0000			
761	1	12.0000	12.0000			
781	1	.0	.0			
791	1	.0	6.0000			
801	1	.0	.0			
811	1	.0	.0			
821	1	.0	.0			
831	1	25.000	25.000			
851	1	434.00	434.00			
861	1	2.0000	2.0000			
871	1	.0	.0			
891	1	.0	.0			
901	1	3.0000	3.0000			
921	1	.0	.0			
931	1	-6.0000	-6.0000			
951	1	1000.0	1000.0			
961	1	434.00	434.00			
971	1	.0	.0			
991	1	.0	.0			
1001	1	2.0000	2.0000			
1011	1	.10000	.10000			
1021	1	.0	.0			
1031	1	.50000	.50000			
1051	1	.0	.0			
1071	1	.0	.0			
1201	1	1.0000	1.0000			
1220	1	.80000	.80000			
260	1	1.0000	1.0000			
2321	2	.0	.0			
WG = 0.70000E+05						
WG = 0.70000E+05						
WG = 0.754672E+05						
WFA = 0.0						
WFA = 0.682529E+04						
WFA = 0.962225E+04						
WFR = 0.0						
WFR = 0.106524E+05						
WFR = 0.113911E+05						

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
 V A S C O M P II

SIZE DATA THIS RUN CONVERGED IN 3 ITERATIONS

GROSS WEIGHT = 80166. LB

FUSELAGE	LENGTH	83.2	FT
LF	WIDTH	11.4	FT
SF	WETTED AREA	2496.	SQFT
WING	ASPECT RATIO	3.20	
AR	AREA	1068.9	SQFT
SW	SPAN	58.5	FT
B	GEOM. MEAN CHORD	18.3	FT
CBARW	QUARTER CHORD SWEEP	35.0	DEG
LAMBDA C/4	TAPER RATIO	0.230	
LAMBDA	ROOT THICKNESS	0.145	
(T/C)R	TIP THICKNESS	0.100	
(T/C)T	WING LOADING	75.0	LB/SQFT
WG/SW			
HOR. TAIL	ASPECT RATIO	3.30	
ARHT	AREA	325.6	SQFT
SHT	SPAN	32.8	FT
BHT	MEAN CHORD	9.9	FT
CBARHT	THICKNESS / CHORD	0.100	
(T/C)HT	MOMENT ARM	36.0	FT
LTH			
VERT. TAIL	ASPECT RATIO	1.50	
ARVT	AREA	192.3	SQFT
SVT	SPAN	17.0	FT
BVT	MEAN CHORD	11.3	FT
CBARVT	THICKNESS / CHORD	0.100	
(T/C)VT	MOMENT ARM	32.5	FT
LTV			
PRIMARY ENG. MACELLE	LENGTH	9.4	FT
LN	MEAN DIAMETER	2.8	FT
DBARN	WETTED AREA	337.2	SQFT
SN			
LIFT ENG. MACELLE	LENGTH	0.0	FT
LN	DEPTH	1.2	FT
LLN	MEAN DIAMETER	7.	FT
DBARLN	WETTED AREA	0.	SQFT
SLN			
PROPELLER			

NO PROPELLER ON THIS AIRCRAFT

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
 V A S C O M P II

P A S S E N G E R S I Z I N G D A T A

NO. OF PASS.	0.	FIRST CLASS	60.
NO. ABREAST	0.		5.
NO. OF AISLES	0.		1.
UNIT SEAT WIDTH	0. IN.		22. IN.
SEAT PITCH	0. IN.		36. IN.
AIISLE WIDTH	0. IN.		18. IN.

NUMBER OF LAVATORIES	2.00	
GALLEY AREA	39.0 SQ. FT.	
CLOSET AREA	6.3 SQ. FT.	
CABIN DIAMETER	129.1 IN.	*** FIRST CLASS CRITICAL
BODY DIAMETER	137.4 IN.	*** FIRST CLASS CRITICAL

NOSE SECTION LENGTH	21.2 FT.
TAIL SECTION LENGTH	28.6 FT.
CONST. DIA. LENGTH	33.4 FT.
TOTAL FUSELAGE LENGTH	83.2 FT.



V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

P R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE NO. 22.000  
TURBOFAN ENGINE

4. ENGINES  
TWP MAX. STANDARD S.L. STATIC THRUST 29160. LB

ENGINE SIZED FOR CRUISE AT VC = 466. KNOTS,  
HC = 30000. FT. TEMPERATURE = -47.98 DEG F.

LIFT ENGINE CYCLE NO. 55.000  
LIFT FAN ENGINE  
4. ENGINES IN 2. CLUSTERS  
T\*XL MAX. STANDARD S.L. STATIC THRUST 75327. LB

ENGINE SIZED FOR TAKEOFF WITH T/W = 1.04.,  
100.0 PERCENT POWER,  
AUGMENTED BY PRIMARY PROPULSION OF 80.PERC CENT

CRITICAL SIZING CONDITION IS 0.700 LIFT ENGINES INOPERATIVE

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM V A S C O M P II B-93

W E I G H T S D A T A		IN LBS	
GLF	GUST LOAD	FACTOR	
<b>STRUCTURES GROUP</b>			
K8 WM	WING		5948.
K9 WHT	HOR. TAIL		1183.
K10 WVT	VERT. TAIL		715.
K11 WB	FUSELAGE		9832.
K12 WLG	LANDING GEAR		3467.
K13 WLES	LIFT ENGINE SECTION	0.	
K14 WPES	PRIMARY ENGINE SECTION	1347.	
DELTA WST	STRUCTURE WEIGHT INCREMENT	0.	
WST	TOTAL STRUCTURE WEIGHT	22471.	
<b>PROPULSION GROUP</b>			
K2 WR/P	ROTOR OR PROP	0.	
K3 WDS	DRIVE SYSTEM	0.	
K4 WEL	LIFT ENGINES	9386.	
K5 WEP	PRIMARY ENGINES	3937.	
K6 WLEI	LIFT ENGINE INSTALLATION	2347.	
K7 WPEI	PRIMARY ENGINE INSTALLATION	1575.	
K21 WFS	FUEL SYSTEM	832.	
DELTA WP	PROPULSION GROUP WEIGHT INCREMENT	C.	
WP	TOTAL PROPULSION GROUP WEIGHT	18078.	
<b>FLIGHT CONTROLS GROUP</b>			
K15 MCC	COCKPIT CONTROLS	157.	
K16 WUC	UPPER CONTROLS	0.	
K17 WH	HYDRAULICS	0.	
K18 WFW	FIXED WING CONTROLS	1202.	
K19 WSAS	SAS	175.	
K20 WTM	TILT MECHANISM	0.	
DELTA WFC	CONTROL WEIGHT INCREMENT	500.	
WFC	TOTAL CONTROL WEIGHT	2034.	
WFE	WEIGHT OF FIXED EQUIPMENT	11040.	
WE	WEIGHT EMPTY	53623.	
WFUL	FIXED USEFUL LOAD	1450.	
OWE	OPERATING WEIGHT EMPTY	55073.	
WPL	PAYLOAD	13200.	
(WF)A	FUEL	11893.	(WF)W
WG	GROSS WEIGHT	80166.	10973.

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

A E R O D Y N A M I C S D A T A		
FE	TOTAL EFFECTIVE FLATPLATE AREA	19.489
SWET	TOTAL WEIATED AREA	5693.
CBARF	MEAN SKIN FRICTION COEFF.	0.003424
D R A G B R E A K D O W N	IN SQFT	
FEM	WING FE	6.923
FEF	FUSELAGE FE	6.131
FEVT	VERT. TAIL FE	1.268
FEN	HOR. TAIL FE	2.191
FELM	PRIMARY ENG. NACELLE FE	1.906
DELTA FE	LIFT ENG. NACELLE FE	0.0
	INCREMENTAL FE	1.069
A E R O D Y N A M I C C O E F F .		
A1		0.83950
A2		-0.13007
A3		0.02221
A4		0.09636
A5		0.01176
A6		0.98140
A7		0.11831
CL ALPHA		3.72296
E	3-D LIFT SLOPE	0.84075
	OSWALD FACTOR	
		PER RADIAN

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM R-93  
 MISSION PERFORMANCE DATA

TAXI FOR 0.033 HRS. AT GROUND IDLE ENGINE RATING TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF
0.0	0.0	0.0	80166.	0.	0.0	1417.0	T	0.067	0.021
0.033	0.0	130.8	80035.	0.	0.0	1417.0	T	0.067	0.021

TAYEOFF, HOVER, OR LAND AT T/W = 1.000 FOR 0.017 HRS. TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTIP (FFS)
0.033	0.0	130.8	80035.	0.	0.0	2165.2	P	0.757	0.757	1.000	0.960			
0.050	0.0	623.3	79543.	0.	0.0	2160.5	P	0.752	0.752	1.000	0.960			

CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAXIMUM R/C AT MILITARY. ENGINE RATING, MAXIMUM ALT. 50000. FT.

TIME (HRS)	CL	CD	RANGE (N.M.)	FUEL USED (LBS)	L/D	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	FUEL FLOW (LBS/HR)	BHP	THRUST (LBS)	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/C (FFM)
0.050	0.0	0.0324	0.0	623.3	0.0	79543.	0.	250.0	2377.5	0.	1.000	250.0	0.378	0.794	7.3	7.7	3232.
0.348	0.0324	0.0324	0.0	10.737	0.	78892.	7348.	12364.	12364.	0.	17496.	*****	*****	*****	0.0	1.000	
0.055	1.28	0.0324	0.0	687.0	0.	79479.	1000.	253.7	2391.9	0.	1.000	250.0	0.385	0.794	6.7	7.1	3019.
0.348	0.0324	0.0324	0.0	10.749	0.	78929.	7343.	12364.	12364.	0.	17451.	*****	*****	*****	0.0	1.000	
0.061	2.67	0.0324	0.0	755.3	0.	79411.	2000.	257.5	2407.0	0.	1.000	250.0	0.392	0.794	6.7	7.1	3045.
0.348	0.0324	0.0324	0.0	10.749	0.	78868.	7338.	12364.	12364.	0.	17404.	*****	*****	*****	0.0	1.000	
0.066	4.07	0.0324	0.0	823.0	0.	79343.	3000.	261.3	2422.7	0.	1.000	250.0	0.399	0.794	6.7	7.0	3071.
0.348	0.0324	0.0324	0.0	10.748	0.	78807.	7332.	12364.	12364.	0.	17357.	*****	*****	*****	0.0	1.000	
0.072	5.48	0.0324	0.0	890.1	0.	79276.	4000.	265.3	2438.2	0.	1.000	250.0	0.407	0.794	6.6	7.0	3096.
0.348	0.0324	0.0324	0.0	10.747	0.	78748.	7327.	12364.	12364.	0.	17303.	*****	*****	*****	0.0	1.000	
0.077	6.90	0.0323	0.0	956.6	0.	79209.	5000.	269.3	2444.0	0.	0.988	250.0	0.414	0.794	6.4	6.8	3057.
0.348	0.0323	0.0323	0.0	10.747	0.	78711.	7324.	12217.	12217.	0.	17050.	*****	*****	*****	0.0	1.000	
0.082	8.36	0.0323	0.0	1023.3	0.	79142.	6000.	273.4	2444.0	0.	0.970	250.0	0.422	0.794	6.2	6.5	2980.
0.347	0.0323	0.0323	0.0	10.746	0.	78663.	7322.	11987.	11987.	0.	16686.	*****	*****	*****	0.0	1.000	
0.088	9.88	0.0323	0.0	1090.3	0.	79075.	7000.	277.7	2444.0	0.	0.952	250.0	0.430	0.794	5.9	6.3	2903.
0.347	0.0323	0.0323	0.0	10.745	0.	78653.	7320.	11757.	11757.	0.	16325.	*****	*****	*****	0.0	1.000	
0.094	11.47	0.0323	0.0	1157.8	0.	79008.	8000.	282.0	2444.0	0.	0.934	250.0	0.438	0.794	5.7	6.0	2824.

0.347	0.0323	10.744	78621.	7318.	11529.	0.	15967.	*****	*****	*****	0.0	1.000
0.100	13.13	1225.8	78940.	9000.	286.4	2444.0	0.917	250.0	0.447	0.794	5.4	5.8
0.347	0.0323	10.743	78586.	7315.	11301.	0.	15613.	*****	*****	*****	0.0	1.000
0.106	14.86	1294.5	78871.	10000.	290.9	2444.0	0.899	250.0	0.456	0.794	5.2	5.5
0.347	0.0323	10.742	78549.	7312.	11075.	0.	15261.	*****	*****	*****	0.0	1.000
0.112	16.68	1363.9	73802.	11000.	322.1	2444.0	0.888	272.4	0.506	0.802	5.2	4.7
0.292	0.0231	10.383	78480.	7559.	10944.	0.	14667.	*****	*****	*****	0.0	1.000
0.118	18.49	1425.8	78760.	12000.	324.9	2444.0	0.870	270.5	0.513	0.801	4.6	4.1
0.296	0.0284	10.426	78487.	7528.	10711.	0.	14348.	*****	*****	*****	0.0	1.000
0.124	20.54	1493.6	78672.	13000.	327.9	2444.0	0.855	268.6	0.519	0.801	4.4	4.0
0.300	0.0287	10.462	78441.	7498.	10480.	0.	14033.	*****	*****	*****	0.0	1.000
0.131	22.69	1562.2	78603.	14000.	330.8	2444.0	0.856	266.7	0.526	0.800	4.2	3.9
0.304	0.0290	10.496	78393.	7469.	10251.	0.	13719.	*****	*****	*****	0.0	1.000
0.137	24.93	1631.9	78534.	15000.	333.8	2444.0	0.857	264.8	0.533	0.799	4.0	3.7
0.308	0.0293	10.529	78342.	7441.	10025.	0.	13409.	*****	*****	*****	0.0	1.000
0.144	27.28	1702.7	78463.	16000.	336.9	2444.0	0.858	262.9	0.540	0.799	3.8	3.6
0.313	0.0296	10.560	78289.	7414.	9801.	0.	13102.	*****	*****	*****	0.0	1.000
0.152	29.76	1774.7	78391.	17000.	340.0	2444.0	0.859	261.0	0.547	0.798	3.6	3.5
0.317	0.0299	10.590	78234.	7388.	9579.	0.	12797.	*****	*****	*****	0.0	1.000
0.159	32.36	1848.1	78317.	18000.	343.1	2444.0	0.860	259.0	0.554	0.798	3.4	3.4
0.321	0.0303	10.618	78177.	7363.	9360.	0.	12496.	*****	*****	*****	0.0	1.000
0.167	35.11	1923.1	78242.	19000.	346.3	2444.0	0.861	257.1	0.561	0.797	3.2	3.3
0.326	0.0306	10.644	78117.	7339.	9143.	0.	12197.	*****	*****	*****	0.0	1.000
0.176	38.01	1999.9	78165.	20000.	349.6	2444.0	0.862	255.2	0.569	0.796	3.1	3.1
0.331	0.0310	10.669	78054.	7316.	8929.	0.	11902.	*****	*****	*****	0.0	1.000
0.185	41.09	2078.7	78087.	21000.	352.8	2444.0	0.863	253.2	0.576	0.796	2.9	3.0
0.336	0.0314	10.692	77988.	7294.	8718.	0.	11610.	*****	*****	*****	0.0	1.000
0.194	44.37	2159.7	78006.	22000.	356.2	2444.0	0.864	251.2	0.584	0.795	2.7	2.9
0.341	0.0318	10.712	77919.	7274.	8509.	0.	11321.	*****	*****	*****	0.0	1.000
0.204	47.87	2243.4	77922.	23000.	359.3	2444.0	0.865	249.1	0.592	0.794	2.5	2.9
0.346	0.0323	10.733	77846.	7253.	8302.	0.	11036.	*****	*****	*****	0.0	1.000
0.214	51.59	2325.4	77836.	24000.	361.1	2444.0	0.866	246.0	0.597	0.793	2.5	2.9
0.355	0.0330	10.757	77764.	7229.	8095.	0.	10762.	*****	*****	*****	0.0	1.000
0.225	55.43	2415.4	77750.	25000.	362.0	2444.0	0.867	242.3	0.601	0.792	2.4	3.0
0.365	0.0339	10.779	77684.	7207.	7886.	0.	10495.	*****	*****	*****	0.0	1.000
0.236	59.43	2502.6	77663.	26000.	362.6	2444.0	0.869	238.5	0.605	0.791	2.2	3.0
0.377	0.0349	10.794	77605.	7190.	7677.	0.	10230.	*****	*****	*****	0.0	1.000
0.248	63.71	2593.3	77572.	27000.	365.8	2444.0	0.871	236.3	0.613	0.790	1.9	2.7
0.383	0.0355	10.798	77531.	7180.	7471.	0.	9948.	*****	*****	*****	0.0	1.000
0.262	68.80	2697.2	77468.	28000.	369.1	2444.0	0.872	234.2	0.621	0.789	1.7	2.7

0.390	0.0361	10.798	77435.	7171.	7270.	0.	9668.	*****	*****	0.0	1.000
0.277	74.46	2803.6	77356.	29000.	373.3	2444.0	T	0.874	232.6	0.631	0.788
0.395	0.0365	10.797	77332.	7163.	7072.	0.	9385.	*****	*****	0.0	1.000
0.294	80.98	2932.1	77233.	30000.	378.5	2444.0	T	0.876	231.5	0.642	0.788
0.398	0.0368	10.795	77215.	7153.	6879.	0.	9099.	*****	*****	0.0	1.000
0.315	88.64	3071.2	77094.	31000.	383.7	2444.0	T	0.878	230.4	0.654	0.787
0.401	0.0371	10.792	77081.	7143.	6690.	0.	8816.	*****	*****	0.0	1.000
0.338	97.58	3227.1	76938.	32000.	388.9	2444.0	T	0.880	229.2	0.666	0.787
0.404	0.0375	10.786	76929.	7133.	6506.	0.	8539.	*****	*****	0.0	1.000

TEMPERATURE = -55.1 DEG.F

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS  
 CRUISE-CLIMB AT CONSTANT W/Delta = 283989.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT (FT)	IAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PENF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP	THRUST (LBS)	CP	CT	J	VIIP (FPS)		
*** CAUTION - SPEED LIMITED BY THRUST AVAILABLE AT SPECIFIED POWER SETTING													
0.378	97.58	3227.1	76938.	32000.	465.5	2340.0	T	0.802	274.4	0.797	0.803	.07760	1.000
0.282	0.0274	10.282	76938.	7483.	5997.	0.	7480.	*****	*****	*****	*****	0.0	
0.343	100.00	3258.2	76907.	32009.	465.5	2340.0	T	0.802	274.3	0.797	0.803	.07763	1.000
0.282	0.0274	10.282	76907.	7480.	5996.	0.	7478.	*****	*****	*****	*****	0.0	
0.397	125.00	3580.3	76585.	32099.	466.5	2340.0	T	0.802	274.4	0.799	0.803	.07794	1.000
0.281	0.0273	10.266	76585.	7460.	5984.	0.	7458.	*****	*****	*****	*****	0.0	
0.450	150.00	3901.0	76264.	32190.	467.5	2340.0	T	0.802	274.6	0.801	0.803	.07825	1.000
0.279	0.0272	10.249	76264.	7441.	5972.	0.	7437.	*****	*****	*****	*****	0.0	
0.504	175.00	4220.5	75944.	32280.	468.5	2340.0	T	0.802	274.7	0.803	0.803	.07856	1.000
0.278	0.0271	10.233	75944.	7422.	5961.	0.	7417.	*****	*****	*****	*****	0.0	
0.557	200.00	4538.7	75626.	32371.	469.5	2340.0	T	0.802	274.8	0.805	0.804	.07887	1.000
0.276	0.0270	10.216	75626.	7402.	5949.	0.	7396.	*****	*****	*****	*****	0.0	
0.610	225.00	4855.7	75309.	32461.	470.0	2340.0	T	0.802	274.6	0.806	0.804	.07918	1.000
0.276	0.0270	10.207	75309.	7378.	5936.	0.	7377.	*****	*****	*****	*****	0.0	
0.664	250.00	5171.5	74993.	32551.	471.0	2340.0	T	0.802	274.7	0.808	0.804	.07949	1.000
0.274	0.0269	10.190	74993.	7360.	5924.	0.	7357.	*****	*****	*****	*****	0.0	
0.717	275.00	5486.0	74679.	32641.	472.0	2340.0	T	0.803	274.9	0.810	0.804	.07979	1.000
0.273	0.0268	10.172	74679.	7342.	5913.	0.	7337.	*****	*****	*****	*****	0.0	
0.770	300.00	5799.3	74365.	32732.	472.5	2340.0	T	0.803	274.7	0.811	0.804	.08010	1.000
0.272	0.0268	10.161	74365.	7318.	5900.	0.	7318.	*****	*****	*****	*****	0.0	
0.775	302.45	5829.8	74335.	32741.	472.6	2340.0	T	0.803	274.7	0.811	0.804	.08013	1.000
0.272	0.0268	10.160	74335.	7317.	5899.	0.	7316.	*****	*****	*****	*****	0.0	

DESCEND 1-4 = 0. FT. ,R = 434.00 N.MI. AT FLIGHT IDLE

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	IAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/S (FPM)
CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP		THRUST (LBS)	CP	CT	J	VTIP (FPS)	ETAP	
0.775	302.45	5829.7	74335.	32741.	275.5	1776.0	T	0.377	160.1	0.473	0.738	-13.8	-6.9	6666.
0.777	0.0917	8.477	72193.	8516.	2592.	0.		3870.	*****	*****	*****	0.0	0.0	
0.777	303.12	5836.2	74328.	31741.	302.6	1776.0	T	0.368	179.2	0.517	0.758	-10.8	-6.2	5768.
0.627	0.0656	9.564	72998.	7633.	2664.	0.		3832.	*****	*****	*****	0.0	0.0	
0.780	303.98	5843.9	74321.	30741.	327.7	1776.0	T	0.359	197.7	0.558	0.772	-9.5	-6.6	5499.
0.517	0.0502	10.306	73285.	7111.	271.1	0.		3792.	*****	*****	*****	0.0	0.0	
0.783	304.96	5852.1	74312.	29741.	350.9	1776.0	T	0.349	215.6	0.594	0.783	-8.6	-6.9	5316.
0.436	0.0407	10.700	73468.	6866.	2765.	0.		3748.	*****	*****	*****	0.0	0.0	
0.786	306.04	5860.8	74304.	28741.	371.0	1776.0	T	0.342	232.2	0.626	0.790	-7.1	-6.3	4663.
0.377	0.0350	10.794	73728.	6831.	2779.	0.		3711.	*****	*****	*****	0.0	0.0	
0.790	307.36	5870.7	74294.	27741.	389.1	1776.0	T	0.334	248.0	0.654	0.796	-6.7	-6.6	4592.
0.331	0.0310	10.667	73786.	6917.	2785.	0.		3668.	*****	*****	*****	0.0	0.0	
0.794	308.76	5880.8	74284.	26741.	404.2	1776.0	T	0.324	262.3	0.676	0.801	-5.8	-6.3	4160.
0.296	0.0284	10.426	73899.	7088.	2789.	0.		3624.	*****	*****	*****	0.0	0.0	
0.798	310.38	5892.0	74272.	25741.	416.3	1776.0	T	0.314	275.0	0.693	0.804	-5.2	-6.0	3810.
0.270	0.0266	10.136	73965.	7297.	2794.	0.		3582.	*****	*****	*****	0.0	0.0	
0.802	312.19	5904.2	74260.	24741.	426.3	1776.0	T	0.304	286.7	0.707	0.807	-5.0	-6.2	3753.
0.248	0.0253	9.823	73979.	7532.	2797.	0.		3538.	*****	*****	*****	0.0	0.0	
0.806	314.08	5916.6	74248.	23741.	434.4	1776.0	T	0.293	297.3	0.718	0.809	-4.8	-6.2	3683.
0.231	0.0243	9.513	73987.	7778.	2799.	0.		3496.	*****	*****	*****	0.0	0.0	
0.811	316.04	5929.3	74235.	22741.	439.5	1776.0	T	0.284	306.1	0.723	0.811	-4.4	-6.0	3392.
0.218	0.0236	9.246	74013.	8004.	2806.	0.		3464.	*****	*****	*****	0.0	0.0	
0.816	318.19	5943.1	74221.	21741.	443.5	1776.0	T	0.275	314.3	0.727	0.813	-4.4	-6.2	3458.
0.207	0.0230	8.989	74001.	8233.	2813.	0.		3432.	*****	*****	*****	0.0	0.0	
0.821	320.33	5956.6	74208.	20741.	445.5	1776.0	T	0.266	321.2	0.727	0.814	-4.2	-6.2	3329.
0.198	0.0226	8.769	74013.	8440.	2825.	0.		3410.	*****	*****	*****	0.0	0.0	
0.826	322.55	5970.8	74193.	19741.	445.6	1776.0	T	0.259	326.7	0.724	0.815	-4.0	-6.1	3178.
0.191	0.0223	8.588	74011.	8619.	2845.	0.		3405.	*****	*****	*****	0.0	0.0	
0.831	324.88	5985.7	74179.	18741.	444.6	1776.0	T	0.253	331.5	0.720	0.815	-4.0	-6.1	3146.
0.186	0.0220	8.428	73997.	8779.	2868.	0.		3401.	*****	*****	*****	0.0	0.0	
0.836	327.23	6000.9	74163.	17741.	442.6	1776.0	T	0.246	335.6	0.714	0.816	-4.0	-6.2	3096.
0.181	0.0219	8.295	73986.	8920.	2896.	0.		3404.	*****	*****	*****	0.0	0.0	
0.842	329.61	6016.5	74148.	16741.	439.6	1776.0	T	0.241	338.9	0.706	0.816	-3.9	-6.2	3026.
0.178	0.0217	8.187	73976.	9036.	2929.	0.		3413.	*****	*****	*****	0.0	0.0	
0.847	332.03	6032.6	74131.	15741.	435.4	1776.0	T	0.236	341.2	0.697	0.817	-3.8	-6.1	2908.
0.175	0.0216	8.112	73972.	9119.	2971.	0.		3433.	*****	*****	*****	0.0	0.0	

0.853	334.52	6049.6	74114.	14741.	430.1	1776.0	T	0.232	342.6	0.686	0.817	-3.7	-6.0	2794.
0.174	0.0216	8.066	73962.	9170.	3022.	0.		3463.	*****	*****	*****	0.0	0.0	
0.859	337.08	6067.6	74096.	13741.	425.0	1775.0	T	0.228	344.1	0.675	0.817	-3.7	-6.1	2793.
0.172	0.0215	8.017	73945.	9224.	3073.	0.		3490.	*****	*****	*****	0.0	0.0	
0.865	339.61	6085.9	74078.	12741.	420.2	1776.0	T	0.229	345.7	0.665	0.817	-3.8	-6.1	2804.
0.171	0.0214	7.966	73925.	9280.	3124.	0.		3513.	*****	*****	*****	0.0	0.0	
0.871	342.11	6104.5	74059.	11741.	414.5	1776.0	T	0.230	346.5	0.653	0.817	-3.7	-6.1	2702.
0.170	0.0214	7.939	73906.	9309.	3154.	0.		3546.	*****	*****	*****	0.0	0.0	
0.877	344.66	6124.1	74040.	10741.	408.9	1776.0	T	0.231	347.3	0.642	0.818	-3.7	-6.1	2687.
0.169	0.0214	7.910	73884.	9340.	3245.	0.		3577.	*****	*****	*****	0.0	0.0	
0.883	347.19	6144.3	74020.	9741.	289.7	1776.0	T	0.287	250.0	0.453	0.797	-0.4	-0.4	204.
0.327	0.0307	10.645	74018.	6953.	3756.	0.		4869.	*****	*****	*****	0.0	0.0	
0.965	370.94	6451.9	73712.	8741.	285.2	1776.0	T	0.289	250.0	0.445	0.797	-1.4	-1.4	707.
0.325	0.0306	10.637	73690.	6927.	3790.	0.		4919.	*****	*****	*****	0.0	0.0	
0.988	377.66	6541.2	73623.	7741.	280.9	1776.0	T	0.290	250.0	0.436	0.797	-1.4	-1.4	681.
0.325	0.0306	10.635	73602.	6921.	3820.	0.		4966.	*****	*****	*****	0.0	0.0	
1.013	384.54	6634.7	73529.	6741.	276.6	1776.0	T	0.292	250.0	0.428	0.797	-1.3	-1.3	656.
0.325	0.0305	10.633	73510.	6913.	3847.	0.		5010.	*****	*****	*****	0.0	0.0	
1.038	391.56	6732.3	73431.	5741.	272.4	1776.0	T	0.293	250.0	0.420	0.797	-1.3	1.3	633.
0.324	0.0305	10.630	73413.	6906.	3871.	0.		5050.	*****	*****	*****	0.0	0.0	
1.065	398.73	6834.2	73330.	4741.	268.3	1776.0	T	0.295	250.0	0.412	0.797	-1.3	-1.3	612.
0.324	0.0305	10.628	73312.	6898.	3892.	0.		5086.	*****	*****	*****	0.0	0.0	
1.092	406.04	6940.2	73224.	3741.	264.3	1776.0	T	0.296	250.0	0.405	0.797	-1.3	-1.3	592.
0.323	0.0304	0.625	73206.	6890.	3909.	0.		5118.	*****	*****	*****	0.0	0.0	
1.120	413.48	7050.2	73114.	2741.	260.3	1776.0	T	0.296	250.0	0.397	0.798	-1.2	-1.3	573.
0.323	0.0304	10.622	73097.	6881.	3930.	0.		5149.	*****	*****	*****	0.0	0.0	
1.149	421.05	7164.4	72999.	1741.	256.5	1776.0	T	0.298	250.0	0.390	0.798	-1.2	-1.3	554.
0.322	0.0303	10.619	72983.	6873.	3962.	0.		5182.	*****	*****	*****	0.0	0.0	
1.179	428.78	7283.8	72880.	741.	252.7	1776.0	T	0.298	250.0	0.383	0.798	-1.2	-1.2	535.
0.322	0.0303	10.616	72865.	6863.	3993.	0.		5212.	*****	*****	*****	0.0	0.0	
1.202	434.61	7375.8	72788.	0.	250.0	1776.0	T	0.299	250.0	0.378	0.798	-1.2	-1.2	523.
0.321	0.0303	10.614	72773.	6856.	4015.	0.		5230.	*****	*****	*****	0.0	0.0	

TEMPERATURE = 59.0 DEG.F

LOITER FOR 0.500 HRS. FOR RESERVE FUEL

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	URB. TEMP. (R)	ENG. CODE	PETF OR PETF	EAS	MACH	MACH DIV	FUEL RATE (LB-HR)	ETAP PROP
CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP	THRUST (LBS)	CP	CT	J	VIIP (FPS)	ETAP	ETAP
1.202	434.61	7375.8	72788.	0.	208.8	1833.1	P	208.8	0.315	0.780	4743.	1.000	
0.461	0.0435	10.601	72788.	6866.	4743.	0.	6866.	*****	*****	*****	*****	0.0	1.000



TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PET OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTIP (FPS)
1.302	434.61	7850.1	72314.	0.	208.8	1830.3	P	0.371	208.8	0.315	0.780	4711.	1.000	
0.458	0.0431	10.614	72314.	6813.	4711.	0.		6813.	*****	*****	*****	0.0	1.000	
1.402	434.61	8321.2	71842.	0.	207.8	1827.5	P	0.369	207.8	0.314	0.780	4679.	1.000	
0.459	0.0433	10.608	71842.	6773.	4679.	0.		6773.	*****	*****	*****	0.0	1.000	
1.502	434.61	8789.1	71375.	0.	206.8	1824.7	P	0.366	206.8	0.312	0.780	4648.	1.000	
0.461	0.0435	10.602	71375.	6732.	4648.	0.		6732.	*****	*****	*****	0.0	1.000	
1.602	434.61	9252.9	70910.	0.	205.8	1821.9	P	0.364	205.8	0.311	0.779	4617.	1.000	
0.462	0.0436	10.595	70910.	6693.	4617.	0.		6693.	*****	*****	*****	0.0	1.000	
1.702	434.61	9715.6	70448.	0.	205.8	1819.1	P	0.361	205.8	0.311	0.780	4586.	1.000	
0.459	0.0433	10.608	70448.	6641.	4586.	0.		6641.	*****	*****	*****	0.0	1.000	
1.702	434.61	9715.6	70448.	0.	205.8	1819.1	P	0.361	205.8	0.311	0.780	4586.	1.000	
0.459	0.0433	10.608	70448.	6641.	4586.	0.		6641.	*****	*****	*****	0.0	1.000	

TAKEOFF, HOVER, OK LAND AT T/W = 1.000 FOR 0.087 HRS.  
 VERTICAL RATE OF CLIMB = 0.0 FT/MIN TEMPERATURE = 59.0 DEG.F

TAXI FOR 0.033 HRS. AT GROUND IDLE ENGINE RATING TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PET OR PEHF	LETF
1.290	434.61	11981.6	70522.	0.	0.0	1417.0	T	0.067	0.0
1.323	434.61	12012.1	70491.	0.	0.0	1417.0	T	0.067	0.0

MISSION FUEL REQUIRED = 9672.14  
 RESERVE FUEL REQUIRED = 2339.94  
 TOTAL FUEL REQUIRED = 12012.08

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END OF SUCCESSFUL CASE

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V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUMBER GIVEN ON INPUT SHEET  
 NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. =5)  
 VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL1 VALUE CORRESPONDING TO LOC.+0001  
 VAL2 VALUE CORRESPONDING TO LOC.+0002  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
2	1	0				
WG		0.700000E+05	WFA = 0.118927E+05	WFR = 0.126121E+05		
WG		0.700000E+05	WFA = 0.682529E+04	WFR = 0.106524E+05		
WG		0.7546672E+05	WFA = 0.962225E+04	WFR = 0.113911E+05		



V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

P A S S E N G E R S I Z I N G D A T A

NO. OF PASS.	0.	FIRST CLASS	60.
NO. ABREAST	0.		5.
NO. OF AISLES	0.		1.
UNIT SEAT WIDTH	0. IN.		22. IN.
SEAT PITCH	0. IN.		36. IN.
AISLE WIDTH	0. IN.		18. IN.

TOURIST	2.00
NUMBER OF LAVATORIES	39.0 SQ. FT.
GALLEY AREA	6.3 SQ. FT.
CLOSET AREA	129.1 IN.
CABIN DIAMETER	137.4 IN.
BODY DIAMETER	*** FIRST CLASS CRITICAL
	*** FIRST CLASS CRITICAL

NOSE SECTION LENGTH	21.2 FT.
TAIL SECTION LENGTH	28.6 FT.
CONST. DIA. LENGTH	33.4 FT.
TOTAL FUSELAGE LENGTH	83.2 FT.

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM

B-93

WEIGHTS DATA IN LBS

GLF	GUST LOAD	FACTOR	
		2.654	
STRUCTURES GROUP			
K8 WM	WING		5948.
K9 WHT	HOR. TAIL		1183.
K10 WVT	VERT. TAIL		715.
K11 WB	FUSELAGE		9832.
K12 WLG	LANDING GEAR		3447.
K13 WLES	LIFT ENGINE SECTION		0.
K14 WPES	PRIMARY ENGINE SECTION		1347.
DELTA WST	STRUCTURE WEIGHT INCREMENT		0.
WST	TOTAL STRUCTURE WEIGHT		22471.
PROPULSION GROUP			
K2 MR/P	ROTOR OR PROP		0.
K3 MDS	DRIVE SYSTEM		0.
K4 WEL	LIFT ENGINES		9386.
K5 WEP	PRIMARY ENGINES		3937.
K6 WLEI	LIFT ENGINE INSTALLATION		2347.
K7 UPEI	PRIMARY ENGINE INSTALLATION		1575.
K21 WFS	FUEL SYSTEM		832.
DELTA WP	PROPULSION GROUP WEIGHT INCREMENT		0.
WP	TOTAL PROPULSION GROUP WEIGHT		18078.
FLIGHT CONTROLS GROUP			
K15 MCC	COCKPIT CONTROLS		157.
K16 MUC	UPPER CONTROLS		0.
K17 MH	HYDRAULICS		0.
K18 MFW	FIXED WING CONTROLS		1202.
K19 WSAS	SAS		175.
K20 WTM	TILT MECHANISM		0.
DELTA WFC	CONTROL WEIGHT INCREMENT		500.
WFC	TOTAL CONTROL WEIGHT		2034.
WFE	WEIGHT OF FIXED EQUIPMENT		11040.
WE	WEIGHT EMPTY		53623.
WFU'	FIXED USEFUL LOAD		1450.
OWE	OPERATING WEIGHT EMPTY		55073.
WPL	PAYLOAD		13200.
(WF)A	FUEL		11893.
WG	GROSS WEIGHT		80166.

10973.

(WF)W

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
V A S C O M P II

P R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE NO. 22.000  
TURBOFAN ENGINE

4. ENGINES			
TXP	MAX. STANDARD S.L. STATIC THRUST	29160.	LB
	ENGINE SIZED FOR CRUISE AT VC = 466. KNOTS, HC = 30000. FT, TEMPERATURE = -47.98 DEG F.		

LIFT ENGINE CYCLE NO. 55.000			
LIFT FAN ENGINE			
4. ENGINES IN 2. CLUSTERS			
TXL	MAX. STANDARD S.L. STATIC THRUST	75327.	LB

ENGINE SIZED FOR TAKEOFF WITH T/W = 1.04.,  
100.0 PERCENT POWER, PROPULSION OF 80.PER CENT  
AUGMENTED BY PRIMARY

CRITICAL SIZING CONDITION IS 0.700 LIFT ENGINES INOPERATIVE

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

II

A E R O D Y N A M I C S D A T A

FE	TOTAL EFFECTIVE FLATPLATE AREA	19.489	SQFT
SWET	TOTAL WETTED AREA	5693.	SQFT
CBARF	MEAN SKIN FRICTION COEFF.	0.003424	

D R A G B R E A K D O W N

FEW	WING FE	6.923
FEF	FUSELAGE FE	6.131
FEVT	VERT. TAIL FE	1.268
FEN	HOR. TAIL FE	2.191
FEIN	PRIMARY ENG. NACELLE FE	1.906
DELTA FE	LIFT ENG. NACELLE FE	0.0
	INCREMENTAL FE	1.069

A E R O D Y N A M I C C O E F F .

A1	0.83950
A2	-0.13007
A3	0.92221
A4	0.09636
A5	0.61176
A6	0.98110
A7	0.11831
CL ALPHA	3.72296
E	0.84075

3-D LIFT SLOPE PER RADIAN  
OSWALD FACTOR

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

TAXI FOR 0.033 HRS. AT GROUND IDLE ENGINE RATING TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETP OR PEHF	LETF
0.0	0.0	0.0	80166.	0.	0.0	1417.0	T	0.067	0.021
0.033	0.0	130.8	80035.	0.	0.0	1417.0	T	0.067	0.021

TAKEOFF, HOVER, OR LAND AT T/W = 1.000 FOR 0.017 HRS. TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETP OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTIF (FPS)
0.033	0.0	130.8	80035.	0.	0.0	2165.2	P	0.757	0.757	1.000	0.960			
0.050	0.0	623.3	79543.	0.	0.0	2160.5	P	0.752	0.752	1.000	0.960			

CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAXIMUM R/C AT MILITARY ENGINE RATING, MAXIMUM ALT. 50000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETP OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THEIA - F (DEG)	R/C (FPM)
0.050	0.0	623.3	79543.	0.	250.0	2377.5	W	1.000	250.0	0.378	0.794	7.3	7.7	3232.
0.055	1.28	687.0	79479.	1000.	253.7	2391.9	W	1.000	250.0	0.385	0.794	6.7	7.1	3019.
0.061	2.67	755.3	79411.	2000.	257.5	2407.0	W	1.000	250.0	0.392	0.794	6.7	7.1	3045.
0.066	4.07	823.0	79343.	3000.	261.3	2422.7	W	1.000	250.0	0.399	0.794	6.7	7.0	3071.
0.072	5.48	890.1	79276.	4000.	265.3	2438.2	W	1.000	250.0	0.407	0.794	6.6	7.0	3090.
0.077	6.90	956.6	79209.	5000.	269.3	2444.0	T	0.988	250.0	0.414	0.794	6.4	6.8	3057.
0.082	8.36	1023.3	79142.	6000.	273.4	2444.0	T	0.970	250.0	0.422	0.794	6.2	6.5	2980.
0.088	9.88	1090.8	79075.	7000.	277.7	2444.0	T	0.952	250.0	0.430	0.794	5.9	6.3	2903.
0.094	11.47	1157.8	79008.	8000.	282.0	2444.0	T	0.934	250.0	0.438	0.794	5.7	6.0	2824.
0.100	13.13	1225.8	78940.	9000.	286.4	2444.0	T	0.917	250.0	0.447	0.794	5.4	5.8	2743.
0.106	14.86	1294.5	78871.	10000.	290.9	2444.0	T	0.899	250.0	0.456	0.794	5.2	5.5	2661.
0.112	16.68	1363.9	78802.	11000.	322.1	2444.0	T	0.888	272.4	0.506	0.802	5.2	4.7	2644.
0.118	18.49	1425.8	78740.	12000.	324.9	2444.0	T	0.870	270.5	0.513	0.801	4.6	4.1	2634.
0.124	20.54	1493.6	78672.	13000.	327.9	2444.0	T	0.855	268.6	0.519	0.801	4.6	4.0	2544.
0.131	22.69	1562.2	78603.	14000.	330.8	2444.0	T	0.856	266.7	0.526	0.800	4.2	3.9	2452.
0.137	24.93	1631.9	78534.	15000.	333.8	2444.0	T	0.856	264.8	0.533	0.799	4.0	3.7	2361.
0.144	27.28	1702.7	78463.	16000.	336.9	2444.0	T	0.858	262.9	0.540	0.799	3.8	3.6	2267.
0.152	29.76	1774.7	78391.	17000.	340.0	2444.0	T	0.859	261.0	0.547	0.798	3.6	3.5	2175.
0.159	32.36	1848.1	78317.	18000.	343.1	2444.0	T	0.860	259.0	0.554	0.798	3.4	3.4	2080.
0.167	35.11	1923.1	78242.	19000.	346.3	2444.0	T	0.861	257.1	0.561	0.797	3.2	3.3	1985.
0.176	38.01	1999.9	78165.	20000.	349.6	2444.0	T	0.862	255.2	0.569	0.796	3.1	3.1	1889.
0.185	41.09	2078.7	78087.	21000.	352.8	2444.0	T	0.864	253.2	0.576	0.796	2.9	3.0	1793.
0.194	44.37	2159.7	78006.	22000.	356.2	2444.0	T	0.864	251.2	0.584	0.795	2.7	2.9	1695.
0.204	47.87	2243.4	77922.	23000.	359.3	2444.0	T	0.865	249.1	0.592	0.794	2.5	2.9	1609.
0.214	51.59	2329.4	77836.	24000.	361.1	2444.0	T	0.866	246.0	0.597	0.793	2.5	2.9	1570.
0.225	55.43	2415.4	77750.	25000.	362.0	2444.0	T	0.867	242.3	0.601	0.792	2.4	3.0	1507.
0.236	59.43	2502.6	77663.	26000.	362.6	2444.0	T	0.869	238.5	0.605	0.791	2.2	3.0	1411.
0.243	63.71	2593.3	77572.	27000.	365.8	2444.0	T	0.871	236.3	0.613	0.790	1.9	3.0	1198.



0.262	68.80	2697.2	77468.	28000.	369.1	2444.0	T	0.872	234.2	0.621	0.789	1.7	1088.
0.277	74.46	2808.6	77356.	29000.	373.3	2444.0	T	0.874	232.6	0.631	0.788	2.5	954.
0.294	80.98	2932.1	77233.	30000.	378.5	2444.0	T	0.876	231.5	0.642	0.788	2.4	824.
0.315	88.64	3071.2	77094.	31000.	383.7	2444.0	T	0.878	230.4	0.654	0.787	2.2	716.
0.338	97.58	3227.1	76938.	32000.	388.9	2444.0	T	0.880	229.2	0.666	0.787	2.1	611.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS  
 CRUISE-CLIMB AT CONSTANT W/Delta = 283989. TEMPERATURE = -55.1 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PEIF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	EIAP PROP
0.338	97.58	3227.1	76938.	32000.	465.5	2340.0	T	0.802	274.4	0.797	0.803	.07760	1.000
0.343	100.00	3258.2	76907.	32009.	465.5	2340.0	T	0.802	274.3	0.797	0.803	.07763	1.000
0.397	125.00	3580.3	76585.	32099.	466.5	2340.0	T	0.802	274.4	0.799	0.803	.07794	1.000
0.450	150.00	3901.0	76264.	32190.	467.5	2340.0	T	0.802	274.6	0.801	0.803	.07825	1.000
0.504	175.00	4220.5	75944.	32280.	468.5	2340.0	T	0.802	274.7	0.803	0.803	.07856	1.000
0.557	200.00	4538.7	75626.	32371.	469.5	2340.0	T	0.802	274.8	0.805	0.804	.07887	1.000
0.610	225.00	4855.7	75309.	32461.	470.0	2340.0	T	0.802	274.6	0.806	0.804	.07918	1.000
0.664	250.00	5171.5	74993.	32551.	471.0	2340.0	T	0.802	274.7	0.808	0.804	.07949	1.000
0.717	275.00	5486.0	74679.	32641.	472.0	2340.0	T	0.803	274.9	0.810	0.804	.07979	1.000
0.770	300.00	5799.3	74365.	32732.	472.5	2340.0	T	0.803	274.7	0.811	0.804	.08010	1.000
0.775	302.45	5829.8	74335.	32741.	472.6	2340.0	T	0.803	274.7	0.811	0.804	.08013	1.000

DESCEND TO H = 0. FT., R = 434.00 N.M.I. AT FLIGHT IDLE

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PEIF OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/S (RPM)
0.775	302.45	5829.7	74335.	32741.	472.5	1776.0	T	0.377	160.1	0.473	0.738	-13.8	-6.9	6666.
0.777	303.12	5836.2	74328.	31741.	302.6	1775.9	T	0.368	179.2	0.517	0.758	-10.8	-6.2	5768.
0.780	303.98	5843.9	74321.	30741.	327.7	1776.0	T	0.359	197.7	0.558	0.772	-9.5	-6.6	5499.
0.783	304.96	5852.1	74312.	29741.	350.9	1776.0	T	0.349	215.6	0.594	0.783	-8.6	-6.9	5316.
0.786	306.04	5860.8	74304.	28741.	371.0	1776.0	T	0.342	232.2	0.626	0.790	-7.1	-6.3	4663.
0.790	307.36	5870.7	74294.	27741.	389.1	1776.0	T	0.334	248.0	0.654	0.796	-6.7	-6.6	4592.
0.794	308.76	5880.8	74284.	26741.	404.2	1776.0	T	0.324	262.3	0.676	0.801	-5.8	-6.3	4160.
0.798	310.38	5892.0	74274.	25741.	416.3	1776.0	T	0.314	275.0	0.693	0.804	-5.2	-6.0	3810.
0.802	312.19	5904.2	74260.	24741.	426.3	1776.0	T	0.304	286.7	0.707	0.807	-5.0	-6.2	3753.
0.806	314.08	5916.6	74248.	23741.	434.4	1776.0	T	0.293	297.3	0.718	0.809	-4.8	-6.0	3683.
0.816	318.19	5943.1	74221.	21741.	443.5	1776.0	T	0.275	314.3	0.727	0.813	-4.4	-6.2	3458.
0.821	320.33	5956.6	74208.	20741.	445.6	1776.0	T	0.266	321.2	0.724	0.815	-4.0	-6.1	3378.
0.826	322.55	5970.8	74193.	19741.	445.6	1776.0	T	0.259	326.7	0.720	0.815	-4.0	-6.1	3146.
0.831	324.88	5985.7	74179.	18741.	444.6	1776.0	T	0.253	331.5	0.720	0.815	-4.0	-6.1	3146.
0.836	327.23	6000.9	74163.	17741.	442.6	1776.0	T	0.246	335.6	0.714	0.816	-4.0	-6.2	3096.
0.842	329.61	6016.5	74148.	16741.	439.6	1776.0	T	0.241	338.9	0.706	0.816	-3.9	-6.2	3026.
0.847	332.03	6032.6	74131.	15741.	435.4	1776.0	T	0.236	341.2	0.697	0.817	-3.8	-6.1	2908.
0.853	334.52	6049.6	74114.	14741.	430.1	1776.0	T	0.232	342.6	0.686	0.817	-3.7	-6.0	2794.
0.859	337.08	6067.6	74096.	13741.	425.0	1776.0	T	0.228	344.1	0.675	0.817	-3.7	-6.1	2790.
0.865	339.61	6085.9	74078.	12741.	420.2	1776.0	T	0.229	345.7	0.665	0.817	-3.8	-6.1	2504.
0.871	342.11	6104.5	74059.	11741.	414.5	1776.0	T	0.230	345.5	0.653	0.817	-3.7	-6.1	2702.
0.877	344.66	6124.1	74040.	10741.	408.9	1776.0	T	0.231	347.3	0.642	0.813	-3.7	-6.1	2687.
0.883	347.19	6144.3	74020.	9741.	289.7	1776.0	T	0.287	250.0	0.453	0.797	-0.4	-0.4	204.
0.965	370.94	6451.9	73712.	8741.	285.2	1776.0	T	0.289	250.0	0.445	0.797	-1.4	-1.4	707.
0.988	377.66	6541.2	73623.	7741.	280.9	1776.0	T	0.290	250.0	0.436	0.797	-1.4	-1.4	681.
1.013	384.54	6634.7	73529.	6741.	276.6	1776.0	T	0.292	250.0	0.428	0.797	-1.3	-1.3	656.
1.038	391.56	6732.3	73431.	5741.	272.4	1775.0	T	0.293	250.0	0.420	0.797	-1.3	-1.3	633.
1.065	398.73	6834.2	73330.	4741.	268.3	1776.0	T	0.295	250.0	0.412	0.797	-1.3	-1.3	612.
1.092	406.04	6940.2	73224.	3741.	264.3	1776.0	T	0.296	250.0	0.405	0.797	-1.3	-1.3	592.

1.120	413.48	7050.2	73114.	2741.	260.3	1776.0	T	0.296	250.0	0.397	0.798	-1.2	-1.3	573.
1.149	421.05	7164.4	72999.	1741.	256.5	1776.0	T	0.298	250.0	0.390	0.798	-1.2	-1.3	554.
1.179	428.78	7283.8	72880.	741.	252.7	1776.0	T	0.298	250.0	0.383	0.798	-1.2	-1.2	535.
1.202	434.61	7375.8	72788.	0.	250.0	1776.0	T	0.299	250.0	0.378	0.798	-1.2	-1.2	523.

LOITER FOR 0.500 HRS. FOR RESERVE FUEL

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	FUEL RATE (LB-HR)	ETAP PROP
1.202	434.61	7375.8	72788.	0.	208.8	1833.1	P	0.374	208.8	0.315	0.780	4743.	1.000
1.302	434.61	7850.1	72314.	0.	208.8	1830.3	P	0.371	208.8	0.315	0.780	4711.	1.000
1.402	434.61	8321.2	71842.	0.	207.8	1827.5	P	0.369	207.8	0.314	0.780	4679.	1.000
1.502	434.61	8789.1	71375.	0.	206.8	1824.7	P	0.366	206.8	0.312	0.780	4648.	1.000
1.602	434.61	9253.9	70910.	0.	205.8	1821.9	P	0.364	205.8	0.311	0.779	4617.	1.000
1.702	434.61	9715.6	70448.	0.	205.8	1819.1	P	0.361	205.8	0.311	0.780	4586.	1.000
1.702	434.61	9715.6	70448.	0.	205.8	1819.1	P	0.361	205.8	0.311	0.780	4586.	1.000

TAKEOFF, HOVER, OR LAND AT T/W = 1.000 FOR 0.087 HRS.

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	FRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTIP (FPS)
1.202	434.61	9715.6	72788.	0.	0.0	2095.1	P	0.689	0.689	1.000	0.960			
1.213	434.61	10128.6	72375.	0.	0.0	2091.1	P	0.685	0.685	1.000	0.960			
1.224	434.61	10538.8	71965.	0.	0.0	2087.1	P	0.681	0.681	1.000	0.960			
1.235	434.61	10946.2	71557.	0.	0.0	2083.2	P	0.677	0.677	1.000	0.960			
1.246	434.61	11350.8	71153.	0.	0.0	2079.2	P	0.673	0.673	1.000	0.960			
1.281	434.61	11752.7	70751.	0.	0.0	2075.3	P	0.669	0.669	1.000	0.960			
1.290	434.61	11981.6	70522.	0.	0.0	2073.1	P	0.667	0.667	1.000	0.960			

7-48

TAXI FOR 0.033 HRS. AT GROUND IDLE ENGINE RATING

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF
1.290	434.61	11981.6	70522.	0.	0.0	1417.0	T	0.067	0.0
1.323	434.61	12012.1	70491.	0.	0.0	1417.0	T	0.067	0.0

MISSION FUEL REQUIRED = 9672.14  
 RESERVE FUEL REQUIRED = 2339.94  
 TOTAL FUEL REQUIRED = 12012.08

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END OF SUCCESSFUL CASE

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V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUMBER GIVEN ON INPUT SHEET  
NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. =5)  
VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
VAL1 VALUE CORRESPONDING TO LOC.+0001  
VAL2 VALUE CORRESPONDING TO LOC.+0002  
ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
1	1	0				

WG = 0.700000E+05 MFA = 0.118927E+05 WFR = 0.120121E+05

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

SIZE DATA THIS RUN CONVERGED IN 0 ITERATIONS

GROSS WEIGHT = 70000. LB

FUSELAGE	LENGTH	83.2	FT
LF	WIDTH	11.4	FT
WF	WETTED AREA	2496.	SQFT
SF			
WING	ASPECT RATIO	3.20	
AR	AREA	933.3	SQFT
SW	SPAN	54.7	FT
B	GEOM. MEAN CHORD	17.1	FT
CBARW	QUARTER CHORD SWEEP	35.0	DEG
LAMBDA C/4	TAPER RATIO	0.230	
LAMBDA	ROOT THICKNESS	0.145	
(T/C)R	TIP THICKNESS	0.100	
(T/C)T	WING LOADING	75.0	LB/SQFT
WG/SW			
HOR. TAIL	ASPECT RATIO	3.30	
ARHT	AREA	265.7	SQFT
SHT	SPAN	29.6	FT
BHT	MEAN CHORD	9.0	FT
CBARHT	THICKNESS / CHORD	0.100	
(T/C)HT	MOMENT ARM	36.0	FT
LTH			
VERT. TAIL	ASPECT RATIO	1.50	
ARVT	AREA	156.9	SQFT
SVT	SPAN	15.3	FT
BVT	MEAN CHORD	10.2	FT
CBARVT	THICKNESS / CHORD	0.100	
(T/C)VT	MOMENT ARM	32.5	FT
LTV			
PRIMARY ENG. NACELLE	LENGTH	8.9	FT
LN	MEAN DIAMETER	2.7	FT
DBARN	WETTED AREA	297.7	SQFT
SN			
LIFT ENG. NACELLE	LENGTH	0.0	FT
LNG	DEPTH	1.1	FT
LLN	MEAN DIAMETER	7.	FT
DBARLN	WETTED AREA	0.	SQFT
SLN			
PROPELLER			

NO PROPELLER ON THIS AIRCRAFT

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

P A S S E N G E R S I Z I N G D A T A

NO. OF PASS.	0.	FIRST CLASS
NO. ABREAST	0.	60.
NO. OF AISLES	0.	5.
UNIT SEAT WIDTH	0. IN.	1.
SEAT PITCH	0. IN.	22. IN.
AISLE WIDTH	0. IN.	36. IN.
		18. IN.

NUMBER OF LAVATORIES	2.00
GALLEY AREA	39.0 SQ. FT.
CLOSET AREA	6.3 SQ. FT.
CABIN DIAMETER	129.1 IN.
BODY DIAMETER	137.4 IN.

\*\*\* FIRST CLASS CRITICAL  
\*\*\* FIRST CLASS CRITICAL

NOSE SECTION LENGTH	21.2 FT.
TAIL SECTION LENGTH	28.6 FT.
CONST. DIA. LENGTH	33.4 FT.
TOTAL FUSELAGE LENGTH	83.2 FT.



V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

P R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE NO. 22.000  
TURBOFAN ENGINE

4. ENGINES  
TMP MAX. STANDARD S.L. STATIC THRUST 26194. LB

ENGINE SIZED FOR CRUISE AT VC = 466. KNOTS,  
HC = 3000. FT, TEMPERATURE = -47.98 DEG F.

LIFT ENGINE CYCLE NO. 55.000  
LIFT FAN ENGINE  
4. ENGINES IN 2. CLUSTERS  
MAX. STANDARD S.L. STATIC THRUST 65080. LB

ENGINE SIZED FOR TAKEOFF WITH T/W = 1.04.,  
100.0 PERCENT POWER,  
AUGMENTED BY PRIMARY PROPULSION OF 80.PERC CENT

CRITICAL SIZING CONDITION IS 0.700 LIFT ENGINES INOPERATIVE

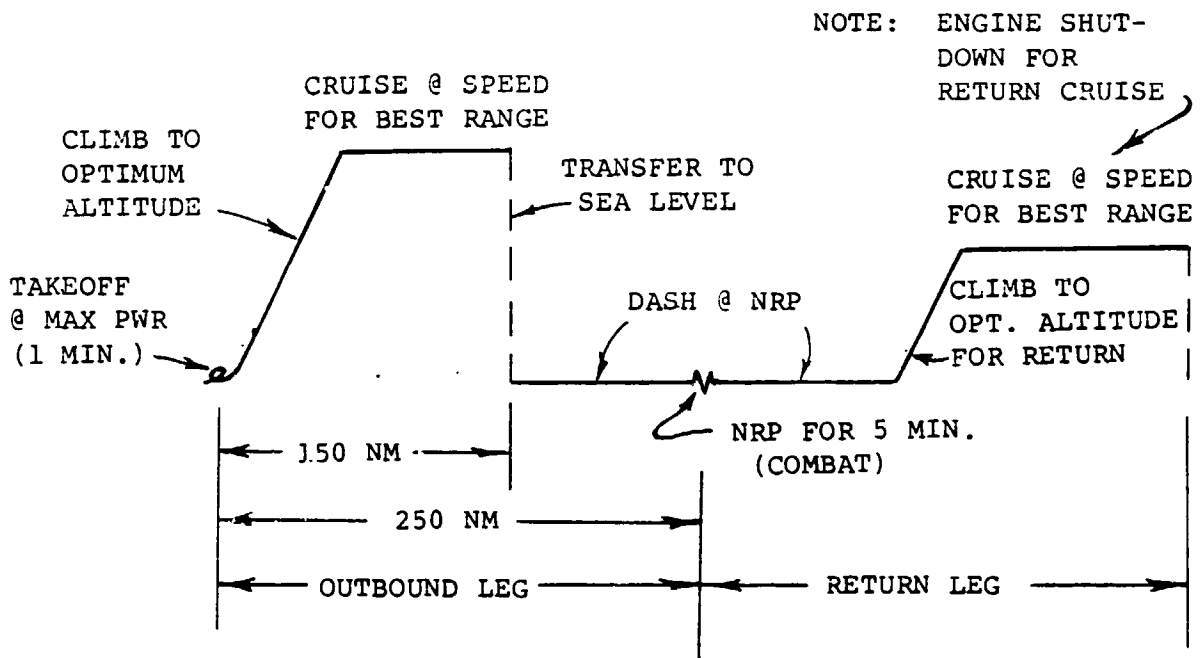
V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

A E R O D Y N A M I C S D A T A			
FE	TOTAL EFFECTIVE FLATPLATE AREA	17.739	SQFT
SWET	TOTAL WETTED AREA	5214.	SQFT
CBARF	MEAN SKIN FRICTION COEFF.	0.003712	
D R A G B R E A K D O W N			
FEM	WING FE	6.107	
FFF	FUSELAGE FE	6.131	
FEVT	VERT. TAIL FE	1.051	
FEHT	HOR. TAIL FE	1.815	
FEN	PRIMARY ENG. NACELLE FE	1.700	
FELN	LIFT ENG. NACELLE FE	0.0	
DELTA FE	INCREMENTAL FE	0.933	
A E R O D Y N A M I C C O E F F .			
A1		0.84039	
A2		-0.13007	
A3		0.02205	
A4		0.09594	
A5		0.01246	
A6		0.99140	
A7		0.11831	
CL ALPHA		3.72296	
E		0.84075	PER RADIAN
	3-D LIFT SLOPE		
	OSWALD FACTOR		



7.3.2 High-Performance COIN Turboprop

Only those inputs which are of prime interest are discussed below. A copy of the output follows the input. The design mission profile is illustrated below. The case was set up so that following the sizing the program would calculate the specific excess power ( $P_s$ ) of the airplane at a given altitude and airspeed.



VASCOMP II - DESCRIPTION OF SAMPLE CASE 2

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
<u>General Information Sheet</u>			
OPTIND	0001	1.0	Sizing run
TNIRPK	0002	1.0	Print indicator-optional print
DRGIND	0003	0.0	Program calculates compressibility drag
OSWIND	0004	1.0	Program calculates induced drag factor
FDMIND	0006	0.0	Size fuselage for passenger requirements
WDMIND	0007	2.0	Wing not dependent on propeller size
HTIND	0008	2.0	} Input tail volume coefficients
VTIND	0009	2.0	
FIXIND	0010	0.0	Program sizes engines
ENGIND	0011	0.0	Turboshaft primary engines
LFTIND	0013	0.0	No lift engines specified
WG <sub>o</sub>	0014	20000.	1st guess at design gross weight
h <sub>o</sub>	0015	0.	Start altitude
R <sub>o</sub>	0016	0.	Starting range
t <sub>o</sub>	0017	0.	Starting time
HOPTUN	0018	1.0	Cruise desired at optimum altitude
VLMIND	0019	0.0	Airspeed limited to 250 knots EAS at altitude of 10,000 ft or less
M <sub>mo</sub>	0020	0.667	Maximum operating mach number
V <sub>mo</sub>	0021	400.	Maximum operating EAS knots
V <sub>DIVE</sub>	0022	450.	Design dive speed

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$M_{LF}$	0023	7.33	Maneuver load factor
$K_1$	0024	1.0	Factor on mission fuel burned to give reserve fuel, i.e. 1.1 would give 10% reserve
$SW_F$	0025	0.	Fixed fuel increment for reserves or other use
$K_{FF}$	0026	1.05	Use nominal engine fuel
SGTIND	0027	2.	TAKEOFF
	0028	3.	CLIMB
	0029	4.	CRUISE
	0030	9.	TRANSFER ALTITUDE
	0031	4.	CRUISE
	0032	2.	TAKEOFF
	0033	4.	CRUISE
	0034	3.	CLIMB
	0035	4.	CRUISE
	0036	0.	END OF MISSION
	0037	9.	TRANSFER ALTITUDE
	0038	3.	CLIMB
0039	100.	END OF CASE	

SEQUENCE  
OR  
DESIGN  
MISSION

#### Aircraft Dimensional Sheet

$l_w$	0103	2.0	Wing incidence angle to fuselage horizontal datum (degrees)
$(L/C)_R$	0104	.17	Root thickness-chord ratio
$(L/C)_T$	0105	.13	Tip thickness-chord ratio
$W_G/S$	0106	50.	Wing loading at design gross weight
$\Lambda_{c/4}$	0107	0.	Quarter chord mean sweep angle, degrees
$\lambda$	0108	.5	Taper ratio (tip chord/root chord)
$AR_{HT}$	0109	4.65	Horizontal tail aspect ratio
$a_H$	0110	0.405	Vertical position of horizontal tail on vertical tail, spans above vertical tail root chord. Value is 0. on or below root chord, 1.0 for "T" tail

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$l_{TH}$	0111	23.	Horizontal tail arm, FT
$(t/c)_{HT}$	0112	.12	Horizontal tail mean thickness/ chord ratio
$\lambda_H$	0114	.4	Horizontal tail taper ratio
$S_{HT}$	0115	128.	Area of horizontal tail
$r$	0116	.075	Prop blade attachment distance from centerline of hob (fraction of prop radius)
$Y_{CL}$	0117	8.3	Clearance from inboard prop tip to inboard prop tip across fuse- lage (feet)
$\zeta_1$	0118	1.0	Prop over prop overlap (fraction of radius)
$\zeta_2$	0119	-2.0	Prop over wing tip overlap (frac- tion of radius)
$\Delta S_{WET}/S_W$	0120	.	Increment in wetted area for landing gear or other protusions
$l_f$	0122	46.	Fuselage length (feet)
$l_{RW}$	0126	0.	Length of ramp well or other strengthened fuselage portion (e.g., rear engine attachments). Used to compute fuselage weight penalty.
$S_F$	0127	530.	Fuselage wetted area (square feet)
$w_F$	0128	4.3	Width of fuselage (feet)
$AR_{VT}$	0129	1.8	Vertical tail aspect ratio
$l_{TV}$	0130	22.	Vertical tail arm
$(t/c)_{VT}$	0131	.12	Vertical tail thickness/chord ratio
$\lambda_V$	0133	.3	Vertical tail taper ratio
$S_{VT}$	0134	90.	Area of vertical tail

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
$Y_{mg}$	0135	.29	Spanwise distance of landing gear from mean spanwise distance of cruise engine from wing root in semispans. Used in wing relief term.
$Y_p$	0136	.29	

Aircraft Propulsion Information Required When Using Turboshaft Engines - Primary Engine

$\eta_{p1ND}$	0200	2.0	Program calculates prop performance
Cycle No.	0201	4.	Cruise engine selection
$SHP_p^*$	0202	10000.	Maximum static sea level horsepower
$N_p$	0204	2.	Number of cruise engines
$\eta_T$	0206	.98	Transmission efficiency
$h_{TO}$	0207	0.	Takeoff pressure altitude for engine sizing
$N_R$	0223	2.	Number of rotors
$V_{TIP}$	0224	1013.5	Prop tip speed
DIA	0226	11.5	Prop diameter
AF	0228	125.	Activity factor per blade
BLDN	0229	4.0	Number of blades
$C_{L_i}$	0230	.46	Induced lift coefficient of wing
XMSNIND	0257	0.0	Size transmission at specified fraction of installed power
$SHP_{XM}/SHP^*$	0258	0.9	Size transmission at 90% installed power
$\Delta SHP_{ACC}$	0259	0.0	No accessory horsepower added
$SHP_E/SHP^*$	0260	1.0	Engines sized at 100% power
$V_{R/C}$	0261	0.0	No vertical rate of climb specified for engine sizing

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$K_{R/C}$	0262	2.0	Constant used to calculate additional horsepower necessary to climb at the specified vertical rate of climb. This value is based on momentum theory, and is used in the following equation:
$\Delta SHP_{R/C} = \frac{(\text{Gross Weight}) V_{R/C}}{33000. \times K_{R/C}}$			

Aircraft Aerodynamics Information Sheet

$\Delta C_D$	0305	.01	Profile drag increment
$\Delta f_e \text{ FT}^2$	0307	7.0	Increment in equivalent flat plat area parasite drag of fuselage ( $\text{ft}^2$ )
No. of Pairs in Table	0308	2.0	Number of $C_L$ - $C_{Dwi}$ Pairs in locations 317-330 and 335-342
$K_W$	0312	1.0	Wing multiplicative drag factor
$C_{L1}$	0317	0.0	Wing lift coefficient
$C_{L2}$	0318	0.4	
$(Re/l)_i$	0330	$.215 \times 10^6$	Mean Reynolds number per foot for mission
$C_{l\alpha} \text{ RAD}^{-1}$	0331	6.28	Two dimensional wing lift coefficient slope
$\alpha_{LO} \text{ DEG.}$	0332	-1.0	Angle of attack where the lift equals zero
$(X/c)_{ps}$	0333	0.35	Position of peak suction location on wing
$(X/c)_{\max c/c}$	0334	.4	Position of maximum thickness on wing
$C_{Dwi} (1)$	0335	0.	Wing induced drag coefficient
$C_{Dwi} (2)$	0336	0.	

Aircraft Weight Information Sheet

$W_{FE} \text{ LBS}$	0401	4000.	Weight of fixed equipment, in LBS.
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<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$W_{FUL}$ LBS	0402	550.	Weight of fixed useful load in LBS.
$W_{PL}$ LBS	0403	5000.	Weight of payload in LBS.
$K_{CC}$	0404	0.	Cockpit controls weight factor
$K_{FW}$	0405	.024	Fixed wing controls weight factor
$K_H$	0406	0.	Constant for flight control hydraulics
$K_{SAS}$	0407	0.	Stability augmentation system (SAS) weight factor, usually in range of 20-100 LBS
$K_{TM}$	0408	0.0	Tilt mechanism weight factor
$K_{UC}$	0409	.2	Upper control weight factor
$\Delta W_P$	0418	75.	Incremental propulsion group weight
$\Delta W_{ST}$	0419	350.	Structures group incremental weight, in LBS
$K_{LG}$	0422	.05	Landing gear weight factor, percentage of gross weight
$K_{MG}$	0423	.8	Main landing gear weight factor
$K_{TL}$	0424	1.0	Tail load factor
$K_{WW}$	0426	205.	Detailed wing weight factor, adjusts the constant 220 in $W_W = 220a (k)^{.582}$ depending on the complexity of the control surfaces
$K_Y$	0427	.16	Pitch radius of gyration, feet
$K_Z$	0428	.24	Yaw radius of gyration, feet
$K_{PES}$	0429	.55	Primary engine section factor
$K_8$	0433	.9	Wing weight multiplicative factor

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$K_{DS}$	0453	300.	Drive system weights constant
$K_{FS}$	0454	.33	Fuel system weights factor
$K_{PEI}$	0456	.3	Primary engine weight factor
<u>Takeoff, Hover and Landing Information Sheet</u>			
TOLIND	0601	3.	Takeoff and land sharing equal fraction of thrust from primary and lift engines
	0602	3.	
ATMIND	0611	0.	Takeoff standard day
ATMIND	0612	0.	Landing standard day
PEHF	0621	1.0	Takeoff engine fractional power = 1.0
PEHF	0622	.714	Engine fractonal power = .714
$\Delta t_H$	0661	.0167	Takeoff compute in 1 minute increments
$\Delta t_H$	0662	.0167	Landing compute in 1 minute increments
$N_{II}/N_{IIMAX}$	0671	1.0	Power turbine speed ratio - takeoff
$N_{II}/N_{IIMAX}$	0672	1.0	Power turbine speed ratio - land
$t_H$	0681	.0167	Takeoff in 1 minute
$t_H$	0682	.0833	Landing in 5.0 minutes
$V_{R/C}$	2321	0.0	} No vertical rate of climb specified
	2322	0.0	

Climb Information Sheet

CLMIND	0691	1.0	Climb at speed for max. R/C
	0692	1.0	Climb at speed for max. R/C
	0693	4.0	Climb at constant TAS
TAS	0703	300.	Climb at constant TAS = 300 knots



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
ATMIND	0711	0.	Standard atmosphere
	0712	0.	
	0713	0.	
$\Delta h$	0721	1000.	Print climb data in specified intervals
	0722	1000.	
	0723	20.	
$h_{MAX}^{FT}$	0741	50000.	The airplane will climb to altitude for minimum fuel consumed during climb and cruise so long as the altitude is below 50,000 ft.
	0742	50000.	
	0743	1020.	
POWIND	0751	1.0	} Climb at mil power Climb at maximum power
	0752	1.0	
	0753	0.0	
$\theta_{MAX}$	0761	40.	} Maximum cabin angle, degrees
	0762	40.	
	0763	40.	
$N_{II}/N_{IIMAX}$	0771	1.0	} Power turbine speed ratio
	0772	1.0	
	0773	1.0	
$\Delta n_{CLIMB}$	0791	0.0	} Incremental normal load factor
	0792	0.0	
	0793	2.0	

Cruise Information Sheet:

CRSIND	0801	3.0	} Cruise indicator
	0802	1.0	
	0803	1.0	
	0809	3.0	
ATMIND	0821	0.0	} Cruise @ standard day
	0822	0.0	
	0823	0.0	
	0824	0.0	
$\Delta R$	0831	20.0	} Increment for calculations
	0832	20.0	
	0833	20.0	
	0834	20.0	
$R_{MAX}$	0851	150.	Range at end of cruise calculations.
	0852	250.	
	0853	350.	
	0854	500.	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
POWIND	0862	2.0	} Cruise limited by normal power
	0863	2.0	
$N_{PSD_{CR}}$	0871	0.0	Number of cruise engines inoperative during cruise
	0872	0.0	
	0873	0.0	
	0874	1.0	
$N_{II}/N_{IIMAX}$	0881	0.7	} Power turbine operating ratio
	0882	1.0	
	0883	0.7	
	0884	1.0	

Transfer Altitude Sheet

$h_{final}$	1111	0.0	Transfer aircraft to specified altitude
	1112	1000.0	

Primary Engine Data Information

WDTIND	1201	1.0	Fuel flow cutoff
N1IND	1202	0.0	No gas generator cutoff
N10IND	1203	0.0	No referred gas generator cutoff
N2IND	1204	2.0	Non-optimum power turbine variation
QIND	1205	0.0	No torque cutoff
RNOIND	1206	0.0	No Reynolds No. correction
$w_{MAX}/w^*$	1220	.906	Fuel flow cutoff at 90.6% of maximum sea level fuel flow
$N_{IIMAX}/N_{II}^*$	1223	.888	Power turbine cutoff at 88.8% of maximum sea level turbine power

Run 2

$\eta_{PIND}$	0200	0.0	Input efficiency values
XMSNIND	0257	1.0	Transmission sized for either hover or cruise power required (the most critical condition is chosen)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
$SHP_{XM}/SHP^*$	0258	0.9	Transmission sized at 90% of chosen power required
$\eta_{P2}$	0232	.93	Input hover efficiency
$\eta_{P3}$	0233	.93	Input climb efficiency
$\eta_{P5}$	0234	.93	Input descent efficiency
No. of Pairs in $\eta_P$ Table	0245	2.0	Number of Mach number vs. Cruise efficiency pairs
Values of M	0235 0247	0.0 0.85	} Values of Cruise Efficiencies

The following inputs for transmission sizing are necessary to determine the power required for takeoff:

$h_{TO}$	0207	0.0	Takeoff altitude
n	0208	.631	Takeoff T/W
$\Delta T_{in_{TO}}$	0209	0.0	Standard atmosphere for takeoff
$N_{II}/N_{IIMAX_{TO}}$	0210	1.0	Power turbine referred operating speed for takeoff

The following inputs for transmission sizing are necessary to determine the power required for cruise:

$h_C$	0214	0.0	Cruise altitude
$V_C$	0215	225.0	Cruise velocity in knots
$\Delta T_{in_{CR}}$	0216	0.0	Standard atmosphere for cruise
$N_{II}/N_{IIMAX_{CR}}$	0217	1.0	Power turbine referred operating speed for takeoff

End of Data

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THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUMBER GIVEN ON INPUT SHEET  
NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. =5)  
VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
VAL1 VALUE CORRESPONDING TO LOC. +0001  
VAL2 VALUE CORRESPONDING TO LOC. +0002  
ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
1301	3	4.0000	.76200E-01	107.00	2726.0	2900.0
1305	5	1975.0	1948.0	2610.0	2600.0	3200.0
1310	5	5.0000	1650.0			
1315	1	3510.0				
1319	5	6.0000	.0	20000	.40000	.60000
1324	5	80000	1.0000	-.35500	-.33500	-.25000
1329	5	-.19000	-.12500	.0	.80000E-01	.11000
1334	5	16000	.24500	.34000	.46000	.70500
1339	5	73500	.80500	.94000	1.0850	1.3250
1344	5	1.2600	1.3050	1.4250	1.6300	1.9000
1349	5	2.3000	1.7200	1.7850	1.9800	2.3100
1354	2	7.9150	3.4950			
1374	5	5.0000	1650.0	2000.0	2600.0	3200.0
1379	1	3910.0				
1383	5	6.0000	.0	.20000	.40000	.60000
1388	5	.80000	1.0070	-.25000E-01	-.15000E-01	.50000E-02
1393	5	.29000E-01	.55000E-01	.85000E-01	.11000	.12000
1398	5	.13900	.16000	.17900	.20500	.32100
1403	5	.33000	.35000	.38000	.42000	.46100
1408	5	.52000	.52500	.56100	.62900	.70500
1413	5	.79000	.74500	.75000	.85000	.97000
1418	2	1.1040	1.2480			
1438	5	6.0000	1300.0	1480.0	2000.0	2600.0
1443	2	3120.0	3510.0			
1447	5	6.0000	.0	.70000	.40000	.60000
1452	5	.80000	1.0000	.0000	.51900	.51800
1457	5	51700	.51600	.53000	.59600	.59400
1462	5	.59300	.58800	.58500	.58100	.80100
1467	5	.79700	.79500	.78800	.77800	.76500
1472	5	1.0000	.99500	.99100	.98200	.96500
1477	5	.94490	1.1500	1.1460	1.1410	1.1280
1482	5	1.1070	1.0840	1.2550	1.2500	1.2450
1487	5	1.2300	1.2050	1.1800		
1502	5	5.0000	1450.0	2000.0	2600.0	3200.0
1507	1	3910.0				
1511	5	6.0000	.0	.20000	.40000	.60000
1516	5	.80000	1.0000	.18000	.22500	.30000
1521	5	.40000	.51000	.61500	.57500	.60280
1526	5	.50000	.73000	.83700	.93400	.89000
1531	5	.91000	.94200	1.0110	1.0980	1.1870
1536	5	1.0840	1.0990	1.1290	1.1860	1.2600
1541	5	1.3460	1.2160	1.2340	1.2520	1.2950



821	4	.0	.0	.0	.0
831	4	20.000	20.000	20.000	20.000
851	4	150.00	250.00	350.00	500.00
862	2	2.0000	2.0000		
871	4	.0	.0	.0	1.0000
881	4	.70000	1.0000	1.0000	.70000
1111	2	.0			
1201	5	1.0000			2.0000
1206	1	.0			
1220	1	.90600			
1223	1	.88800			

821	4	.0	.0	.0	.0
831	4	20.000	20.000	20.000	20.000
851	4	150.00	250.00	350.00	500.00
862	2	2.0000	2.0000		
871	4	.0	.0	.0	1.0000
881	4	.70000	1.0000	1.0000	.70000
1111	2	.0			
1201	5	1.0000			2.0000
1206	1	.0			
1220	1	.90600			
1223	1	.88800			

821	4	.0	.0	.0	.0
831	4	20.000	20.000	20.000	20.000
851	4	150.00	250.00	350.00	500.00
862	2	2.0000	2.0000		
871	4	.0	.0	.0	1.0000
881	4	.70000	1.0000	1.0000	.70000
1111	2	.0			
1201	5	1.0000			2.0000
1206	1	.0			
1220	1	.90600			
1223	1	.88800			

821	4	.0	.0	.0	.0
831	4	20.000	20.000	20.000	20.000
851	4	150.00	250.00	350.00	500.00
862	2	2.0000	2.0000		
871	4	.0	.0	.0	1.0000
881	4	.70000	1.0000	1.0000	.70000
1111	2	.0			
1201	5	1.0000			2.0000
1206	1	.0			
1220	1	.90600			
1223	1	.88800			

WFA = 0.268000E+05    WFR = 0.0  
 MG = 0.206000E+05    WFA = -1.09915E+03    WFR = 0.343686E+04  
 MG = 0.250663E+05    WFA = 0.275970E+04    WFR = 0.374829E+04

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SIZE DATA THIS RUN CONVERGED IN 3 ITERATIONS

GROSS WEIGHT = 27025. LB

FUSELAGE	LENGTH	46.0	FT
LF	WIDTH	4.3	FT
WF	WETTED AREA	530.	SQFT
SF			
WING	ASPECT RATIO	5.46	
AR	AREA	540.5	SQFT
SW	SPAN	54.3	FT
B	GEOM MEAN CHORD	10.0	FT
CBARW	QUARTER CHORD SWEEP	0.0	DEG
LAMBDA C/4	TAPER RATIO	0.500	
LAMBDA	ROOT THICKNESS	0.170	
(T/C)R	TIP THICKNESS	0.130	
(T/C)T	WING LOADING	50.0	LB/SQFT
WG/SW	MEAN CHORD / PROP. DIA.	0.866	
C BAR / D			
HOR. TAIL	ASPECT RATIO	4.65	
ARHT	AREA	128.0	SQFT
SHT	SPAN	24.4	FT
BHT	MEAN CHORD	5.2	FT
CBARHT	THICKNESS / CHORD	0.120	
(T/C)HT			
VERT. TAIL	ASPECT RATIO	1.80	
ARVT	AREA	90.0	SQFT
SVT	SPAN	12.7	FT
BVT	MEAN CHORD	7.1	FT
CBARVT	THICKNESS / CHORD	0.120	
(T/C)VT			
PRIMARY ENG. NA'ELLE	LENGTH	0.0	FT
LN	MEAN DIAMETER	0.0	FT
DBARN	WETTED AREA	0.0	SQRT
SN			
LIFT ENG. MACELLE	NO LIFT PROPULSION SELECTED		
PROPPELLER	DIAMETER	11.5	FT
D	SOLIDITY	0.204	
SIGMA R/P	DISC LOADING	130.1	LB/SQFT
MG/A	THRUST COEFF. / SOLIDITY	0.0	
CI/SIGMA	NO. OF PROPELLERS	2.000	
NR	NO. OF BLADES/PROP	4.000	
NU			





V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

V A S C O M P II

PROPELLSION DATA  
PRIMARY PROPELLSION CYCLE NO. 4.000  
TURBOSHAFT ENGINE

2. ENGINES  
BHP/P MAX. STANDARD S.L. STATIC H.P. 10000. H.P.

ENGINE SIZE HAS FIXED BY INPUT

NO LIFT ENGINE CYCLE SELECTED

XMSN SIZED AT 90. PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.L. STATIC H.P.), 100.0 PERCENT HOVER RPM

V A S C O M P II  
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A E R O D Y N A M I C S D A T A		
FE	TOTAL EFFECTIVE FLATPLATE AREA	12.417
SWET	TOTAL WETTED AREA	1991.
CBARF	MEAN SKIN FRICTION COEFF.	0.006237
D R A G B R E A K D O W N		
FEW	WING FE	0.0
FEF	FUSELAGE FE	7.013
FEVT	VERT. TAIL FE	0.0
FEHT	HOR. TAIL FE	0.0
FEN	PRIMARY ENG. NACELLE FE	0.0
FELN	LIFT ENG. NACELLE FE	0.0
DELTA FE	INCREMENTAL FE	5.405
A E R O D Y N A M I C C O E F F .		
A1		0.71001
A2		-0.09923
A3		0.06623
A4		0.11567
A5		0.02297
A6		1.29876
A7		0.07318
CL ALPHA	3-D LIFT SLOPE	4.97113
E	OSWALD FACTOR	0.79736

PER RADIAN

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

TAKEOFF, HOVER, OR LAND AT PETF = 1.000  
VERTICAL RATE OF CLIMB = 0.0 FT/MIN

LETF = 0.0 FOR 0.017 HRS.  
TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTIP (FPS)
0.0	0.0	0.0	27025.	0.	0.0	2758.9	W	1.000	0.0	0.613	0.451	8834.	0	3210
0.017	6.0	65.5	26959.	0.	0.0	2758.9	W	1.000	0.0	0.614	0.451	8834.	0	3210

CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAXIMUM R/C AT MILITARY ENGINE RATING, MAXIMUM ALT. 50000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/C (FPM)
0.019	0.50	75.7	26949.	1000.	208.5	2726.0	T	0.977	205.4	0.316	0.677	17.2	18.1	6261.
0.333	0.0310	10.725	25738.	2400.	3908.	8823.	T	10626.	0.3314	0.2121	1.229	900.0	0.787	
0.622	1.03	86.1	26939.	2000.	210.2	2726.0	T	0.951	204.1	0.320	0.677	16.7	17.6	6106.
0.338	0.0313	10.805	25808.	2389.	3820.	8672.	T	10363.	0.3354	0.2131	1.239	900.0	0.787	
0.025	1.58	96.5	26528.	3000.	212.0	2726.0	T	0.927	202.8	0.324	0.676	16.1	17.1	5958.
0.343	0.0315	10.880	25873.	2378.	3733.	8518.	T	10100.	0.3395	0.2139	1.250	900.0	0.788	
0.027	2.15	106.9	26918.	4000.	213.7	2726.0	T	0.897	201.4	0.328	0.675	15.6	16.6	5826.
0.349	0.0318	10.956	25926.	2366.	3647.	8362.	T	9842.	0.3434	0.2148	1.260	900.0	0.788	
0.030	2.74	117.4	26907.	5000.	218.0	2726.0	T	0.878	202.4	0.335	0.676	14.2	15.2	5421.
0.368	0.0317	10.959	26085.	2380.	3567.	8219.	T	9526.	0.3478	0.2143	1.285	900.0	0.792	
0.033	3.39	128.3	26896.	6000.	221.2	2726.0	T	0.863	202.3	0.341	0.676	13.9	14.9	5186.
0.368	0.0318	10.959	26109.	2382.	3486.	8067.	T	9252.	0.3520	0.2145	1.304	900.0	0.795	
0.036	4.05	139.1	26886.	7000.	222.1	2726.0	T	0.866	199.9	0.344	0.675	14.1	15.2	5491.
0.356	0.0322	11.042	26073.	2361.	3402.	7901.	T	9029.	0.3554	0.2159	1.309	900.0	0.795	
0.039	4.71	149.4	26875.	8000.	223.3	2726.0	T	0.868	198.0	0.347	0.674	13.6	14.8	5305.
0.364	0.0326	11.146	26126.	2344.	3319.	7736.	T	8798.	0.3589	0.2170	1.316	900.0	0.796	
0.043	5.39	159.9	26865.	9000.	224.2	2726.0	T	0.871	195.7	0.350	0.673	13.2	14.5	5197.
0.373	0.0331	11.252	26152.	2324.	3238.	7569.	T	8576.	0.3622	0.2182	1.322	900.0	0.796	
0.046	6.09	170.3	26855.	10000.	225.1	2726.0	T	0.874	193.4	0.352	0.672	12.8	14.2	5042.
0.382	0.0336	11.356	26190.	2306.	3158.	7401.	T	8353.	0.3655	0.2192	1.327	900.0	0.796	

0.049	6.82	180.7	26844.	11000.	226.0	2726.0	T	0.876	191.2	0.355	0.671	12.3	13.9	4805.
0.392	0.0342	11.455	26224.	2289.	3079.	7233.		8137.	0.3686	0.2203	1.332	900.0	0.796	
0.053	7.57	191.2	26834.	12000.	226.9	2726.0	T	0.878	188.9	0.358	0.670	11.9	13.5	4743.
0.401	0.0347	11.550	26257.	2273.	3002.	7065.		7911.	0.3717	0.2212	1.338	900.0	0.796	
0.056	8.35	201.7	26823.	13000.	227.9	2726.0	T	0.881	186.7	0.361	0.669	11.5	13.2	4593.
0.412	0.0354	11.640	26287.	2258.	2925.	6898.		7693.	0.3747	0.2221	1.343	900.0	0.796	
0.060	9.16	212.3	26812.	14000.	228.8	2726.0	T	0.883	184.4	0.364	0.668	11.0	12.9	4662.
0.422	0.0360	11.725	26316.	2244.	2850.	6730.		7476.	0.3776	0.2229	1.349	900.0	0.796	
0.063	10.00	223.0	26802.	15000.	229.7	2726.0	T	0.885	182.2	0.367	0.667	10.6	12.6	4285.
0.433	0.0367	11.804	26344.	2232.	2777.	6564.		7260.	0.3804	0.2236	1.354	900.0	0.796	
0.067	10.88	233.8	26791.	16000.	230.7	2726.0	T	0.887	180.0	0.370	0.666	10.2	12.3	4130.
0.444	0.0374	11.876	26370.	2220.	2704.	6398.		7046.	0.3832	0.2243	1.360	900.0	0.796	
0.071	11.80	244.8	26780.	17000.	231.7	2726.0	T	0.890	177.8	0.373	0.665	9.7	12.0	3972.
0.455	0.0381	11.941	26394.	2210.	2633.	6234.		6834.	0.3858	0.2248	1.366	900.0	0.796	
0.076	12.76	255.8	26769.	18000.	232.6	2726.0	T	0.892	175.6	0.376	0.664	9.3	11.7	3819.
0.467	0.0389	12.000	26416.	2201.	2564.	6070.		6625.	0.3884	0.2253	1.372	900.0	0.796	
0.080	13.76	267.0	26758.	19000.	233.4	2726.0	T	0.894	173.3	0.378	0.662	9.0	11.5	3682.
0.481	0.0399	12.054	26432.	2193.	2495.	5907.		6421.	0.3908	0.2258	1.376	900.0	0.796	
0.084	14.80	278.3	26747.	20000.	234.2	2726.0	T	0.896	170.9	0.381	0.661	8.5	11.2	3521.
0.494	0.0408	12.101	26450.	2186.	2427.	5745.		6219.	0.3932	0.2262	1.381	900.0	0.796	
0.089	15.90	289.8	26735.	21000.	235.0	2726.0	T	0.897	168.6	0.384	0.660	8.1	11.0	3363.
0.508	0.0418	12.138	26467.	2180.	2361.	5585.		6020.	0.3955	0.2266	1.385	900.0	0.796	
0.094	17.05	301.5	26723.	22000.	235.8	2726.0	T	0.899	166.4	0.387	0.658	7.7	10.7	3203.
0.522	0.0429	12.167	26482.	2177.	2296.	5427.		5823.	0.3977	0.2268	1.391	900.0	0.793	
0.099	18.27	313.4	26711.	23000.	236.7	2726.0	T	0.901	164.1	0.390	0.657	7.3	10.5	3046.
0.537	0.0440	12.186	26495.	2174.	2233.	5270.		5628.	0.3999	0.2270	1.396	900.0	0.792	
0.105	19.56	325.6	26699.	24000.	237.7	2726.0	T	0.903	161.9	0.393	0.655	6.9	10.2	2885.
0.552	0.0452	12.195	26507.	2174.	2170.	5116.		5435.	0.4019	0.2270	1.401	900.0	0.791	
0.111	20.92	338.2	26687.	25000.	238.8	2726.0	T	0.905	159.8	0.396	0.654	6.5	10.0	2721.
0.566	0.0464	12.196	26517.	2174.	2110.	4965.		5244.	0.4040	0.2268	1.408	900.0	0.790	

CRUISE AT BEST RANGE SPEED WITH HEADWIND OF 0.0 KNOTS TEMPERATURE = -30.1 DEG.F

TIME (HRS.)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETP OR PETP	EAS	MACH	MACH DIV	SPFC. RANGE (HR/100)	FIAP PROP
0.111	20.92	338.2	26687.	25000.	238.8	2033.6	P	0.455	176.5	0.438	0.664	2.4509	0.855
0.468	6.0390	11.997	26687.	2224.	1076.	2150.		2225.	0.5101	0.1964	2.221	630.0	
0.183	40.60	416.0	26609.	25000.	263.6	2032.1	P	0.453	176.5	0.438	0.664	2.4562	0.855
0.466	0.0389	11.991	26609.	2219.	1073.	2144.		2220.	0.5088	0.1960	2.221	630.0	

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (HRPP)	FTAP PROP
0.259	60.00	497.5	26527.	25000.	262.6	2028.2	P	0.450	175.8	0.436	0.664	24617	0.855
0.468	0.0390	12.001	26527.	2210.	1067.	2128.		2211.	0.5048	0.1952	2.212	630.0	
0.335	80.00	578.7	26446.	25000.	262.6	2026.7	P	0.449	175.8	0.436	0.664	24673	0.855
0.467	0.0389	11.994	26446.	2205.	1064.	2122.		2206.	0.5034	0.1947	2.212	630.0	
0.411	100.00	659.8	26365.	25000.	262.6	2025.1	P	0.448	175.8	0.436	0.664	24729	0.856
0.465	0.0388	11.987	26365.	2199.	1062.	2116.		2200.	0.5020	0.1942	2.212	630.0	
0.487	120.00	740.6	26284.	25000.	262.6	2023.5	P	0.446	175.8	0.436	0.664	24784	0.856
0.464	0.0387	11.981	26284.	2194.	1060.	2110.		2195.	0.5007	0.1937	2.212	630.0	
0.563	140.00	821.3	26203.	25000.	262.6	2022.0	P	0.445	175.8	0.436	0.664	24839	0.856
0.463	0.0386	11.974	26203.	2188.	1057.	2105.		2189.	0.4993	0.1932	2.212	630.0	
0.601	150.00	861.6	26163.	25000.	262.6	2021.2	P	0.445	175.8	0.436	0.664	24867	0.856
0.462	0.0386	11.970	26163.	2186.	1056.	2102.		2187.	0.4986	0.1930	2.212	630.0	

TRANSFER ALTITUDE TO 0. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0.601	150.00	861.6	26163.	25000.
0.601	150.00	861.6	26163.	0.

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (HRPP)	FTAP PROP
0.628	160.00	965.7	26059.	6371.	383.3	2610.0	T	0.995	383.3	0.579	0.700	09602	0.876
0.097	0.0237	4.090	26059.	6371.	3992.	92.8.		6356.	0.3373	0.1232	2.260	900.0	
0.680	180.00	1174.0	25851.	6370.	383.4	2610.0	T	0.995	383.4	0.579	0.700	09603	0.876
0.096	0.0236	4.058	25851.	6370.	3993.	9249.		6355.	0.3373	0.1232	2.260	900.0	
0.732	200.00	1382.3	25642.	6369.	383.5	2610.0	T	0.995	383.5	0.580	0.701	09604	0.825
0.095	0.0236	4.026	25642.	6369.	3993.	9249.		6354.	0.3373	0.1232	2.261	900.0	
0.784	220.00	1590.6	25434.	6368.	383.5	2610.0	T	0.995	383.5	0.580	0.701	09605	0.825
0.094	0.0236	3.994	25434.	6368.	3993.	9250.		6353.	0.3373	0.1231	2.261	900.0	
0.836	240.00	1798.8	25226.	6367.	383.6	2610.0	T	0.995	383.6	0.580	0.701	09606	0.825
0.094	0.0236	3.962	25226.	6367.	3993.	9251.		6352.	0.3374	0.1231	2.262	900.0	
0.862	250.00	1902.9	25122.	6366.	383.6	2610.0	T	0.995	383.6	0.580	0.701	09607	0.825
0.093	0.0236	3.946	25122.	6366.	3993.	9251.		6352.	0.3374	0.1231	2.262	900.0	

TAKEOFF, HOVER, OR LAND AT PETF = 0.714 LEIF = 0.0 FOR 0.083 HRS.  
 VERTICAL RATE OF CLIMB = 0.0 FT/MIN TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETP OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VITE (FPS)
0.862	250.00	1902.9	25122.	0.	0.0	2522.0	W	0.714	0.0	0.613	0.566	6307.	0.2985	900.
0.879	250.00	1954.4	25070.	0.	0.0	2522.0	W	0.714	0.0	0.614	0.566	6307.	0.2935	900.
0.895	250.00	2005.9	25019.	0.	0.0	2522.0	W	0.714	0.0	0.615	0.566	6307.	0.2985	900.
0.912	250.00	2057.4	24967.	0.	0.0	2522.0	W	0.714	0.0	0.617	0.566	6307.	0.2985	900.
0.929	250.00	2108.9	24916.	0.	0.0	2522.0	W	0.714	0.0	0.618	0.566	6307.	0.2985	900.
0.946	250.00	2160.3	24865.	0.	0.0	2522.0	W	0.714	0.0	0.619	0.566	6307.	0.2985	900.

TEMPERATURE = 59.0 DEG.F

CRUISE AT NORMAL ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PEIF OR PEHF	EAS	MACH	MACH DIV	SPFC RANGE (HHP)	EIAP PROP
0.946	250.00	2160.3	24865.	0.	383.7	2610.0	T	0.995	383.7	0.580	0.701	0.9608	0.825
0.992	0.0236	3.906	24865.	6365.	3993.	9252.		6350.	0.3374	0.1231	2.262	900.0	
0.972	260.00	2264.3	24760.	0.	383.7	2610.0	T	0.995	383.7	0.580	0.701	0.9608	0.825
0.992	0.0236	3.890	24760.	6365.	3993.	9252.		6350.	0.3374	0.1231	2.262	900.0	
1.024	280.00	2472.5	24552.	0.	383.8	2610.0	T	0.995	383.8	0.580	0.701	0.9609	0.825
0.991	0.0236	3.858	24552.	6364.	3994.	9252.		6349.	0.3374	0.1231	2.262	900.0	
1.076	300.00	2680.6	24344.	0.	383.8	2610.0	T	0.995	383.8	0.580	0.701	0.9611	0.825
0.990	0.0236	3.826	24344.	6363.	3994.	9253.		6348.	0.3374	0.1230	2.263	900.0	
1.125	320.00	2888.7	24136.	0.	383.9	2610.0	T	0.995	383.9	0.580	0.701	0.9612	0.825
0.989	0.0236	3.794	24136.	6362.	3994.	9253.		6347.	0.3375	0.1230	2.263	900.0	
1.180	340.00	3096.8	23928.	0.	383.9	2610.0	T	0.995	383.9	0.580	0.701	0.9613	0.825
0.939	0.0235	3.762	23928.	6361.	3994.	9254.		6346.	0.3375	0.1230	2.264	900.0	
1.206	350.00	3200.8	23824.	0.	384.0	2610.0	T	0.995	384.0	0.580	0.701	0.9613	0.825
0.928	0.0235	3.746	23824.	6360.	3994.	9254.		6345.	0.3375	0.1230	2.264	900.0	

CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAXIMUM R/C AT MILITARY ENGINE RATING, MAXIMUM ALT. 50000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	DRAG (LBS)	FUEL FLOW (LBS/HR)	FUEL FLOW BHP	THRUST (LBS)	CP	EAS	MACH	MACH DIV	SPFC RANGE (HHP)	EIAP PROP
1.266	350.00	3200.8	23824.	0.	205.4	2726.0	T	1.003	205.4	0.310	0.682	21.6	21.7	7587.			
0.287	0.0290	9.894	22184.	2242.	3995.	8964.		10928.	0.3269	0.2118	1.711	900.0	0.725				
1.208	350.42	3209.6	23815.	1000.	206.7	2726.0	T	0.976	203.7	0.313	0.681	20.3	20.7	7762			
0.294	0.0293	10.045	22338.	2224.	3905.	8813.		10675.	0.3310	0.2131	1.719	900.0	0.785				
1.211	350.87	3213.6	23806.	2000.	208.1	2726.0	T	0.950	202.0	0.317	0.680	19.7	20.1	7093			
0.300	0.2295	10.159	22417.	2207.	3817.	8659.		10421.	0.3350	0.2142	1.727	900.0	0.785				
1.213	351.33	3227.5	23797.	3000.	209.7	2726.0	T	0.926	200.6	0.320	0.680	18.9	19.5	6897			
0.305	0.0297	10.261	22509.	2194.	3729.	8505.		10159.	0.3389	0.2152	1.737	900.0	0.785				

1.215	351.81	3236.5	23788.	4000.	211.4	2726.0	T	0.896	199.3	0.324	0.679	18.3	6739
0.310	0.0300	10.355	22581.	2181.	3643.	8349.		9899.	0.3428	0.2160	1.247	900.0	18.9 0.786
1.218	352.30	3245.6	23779.	5000.	213.6	2726.0	T	0.876	198.2	0.328	0.679	17.6	6576
0.315	0.0302	10.436	22672.	2172.	3559.	8193.		9631.	0.3468	0.2166	1.259	900.0	18.0 0.787
1.220	352.82	3254.6	23770.	6000.	219.5	2726.0	T	0.863	200.7	0.339	0.680	15.5	5955.
0.310	0.0299	10.383	22909.	2206.	3483.	8058.		9287.	0.3516	0.2154	1.294	900.0	16.0 0.795
1.223	35	3264.4	23760.	7000.	220.4	2726.0	T	0.866	198.4	0.341	0.679	16.6	6366
0.316	0.0300	10.438	22775.	2182.	3399.	7892.		9064.	0.3550	0.2167	1.299	900.0	17.0 0.795
1.226	353.97	3273.3	23751.	8000.	221.2	2726.0	T	0.868	196.1	0.344	0.678	16.1	6709
0.324	0.0306	10.575	22822.	2158.	3316.	7725.		8841.	0.3584	0.2180	1.304	900.0	16.8 0.795
1.229	354.54	3282.2	23743.	9000.	222.0	2726.0	T	0.871	193.7	0.346	0.677	15.6	6044
0.332	0.0310	10.709	22868.	2135.	3234.	7557.		8619.	0.3617	0.2192	1.309	900.0	16.4 0.795
1.231	355.13	3291.1	23734.	10000.	222.8	2726.0	T	0.873	191.4	0.349	0.676	15.1	6887
0.341	0.0315	10.840	22914.	2114.	3154.	7389.		8397.	0.3649	0.207	1.313	900.0	16.0 0.795
1.234	355.74	3300.1	23725.	11000.	223.3	2726.0	T	0.876	188.9	0.351	0.675	14.7	5767
0.351	0.0320	10.975	22947.	2091.	3075.	7219.		8181.	0.3679	0.2216	1.317	900.0	15.8 0.795
1.237	356.37	3309.0	23716.	12000.	224.2	2726.0	T	0.878	186.7	0.354	0.674	14.1	5544
0.360	0.0325	11.097	22999.	2072.	2997.	7051.		7961.	0.3710	0.2226	1.322	900.0	15.3 0.795
1.240	357.02	3318.0	23707.	13000.	225.1	2726.0	T	0.881	184.4	0.356	0.673	13.6	5180
0.370	0.0330	11.215	23038.	2054.	2921.	6883.		7742.	0.3739	0.2235	1.327	900.0	14.0 0.795
1.243	357.70	3327.0	23698.	14000.	226.1	2726.0	T	0.883	182.3	0.359	0.672	13.1	5117
0.379	0.0335	11.324	23080.	2038.	2846.	6717.		7522.	0.3768	0.2247	1.333	900.0	14.0 0.795
1.246	358.41	3336.2	23689.	15000.	227.0	2726.0	T	0.885	180.0	0.362	0.671	12.7	5041
0.389	0.0340	11.430	23113.	2022.	2772.	6550.		7306.	0.3796	0.2251	1.338	900.0	14.1 0.795
1.250	359.14	3345.3	23679.	16000.	227.8	2726.0	T	0.887	177.8	0.365	0.670	12.2	4874
0.400	0.0346	11.533	23146.	2007.	2700.	6384.		7093.	0.3823	0.2258	1.343	900.0	13.3 0.795
1.253	359.90	3354.6	23670.	17000.	228.6	2726.0	T	0.890	175.5	0.368	0.669	11.7	4709
0.411	0.0353	11.632	23176.	1992.	2628.	6219.		6882.	0.3849	0.2264	1.348	900.0	11.7 0.795

CRUISE AT BEST RANGE SPEED WITH HEADWIND OF 0.0 KNOTS TEMPERATURE = -1.6 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPLC. PANG. (N.M.P)	LTAP PROP
CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP	THRUST (LBS)	CP	CT	J	VIIIP (F%)		
1.253	359.90	3354.6	23670.	17000.	213.8	2203.2	P	0.522	164.1	0.344	0.662	271.5	0.810
0.480	0.0398	12.049	23670.	1964.	788.	1532.		1967.	0.2765	0.1321	1.800	630.0	
1.347	380.00	3428.7	23596.	17000.	213.8	2201.5	P	0.521	164.1	0.344	0.663	271.87	0.810
0.478	0.0397	12.043	23596.	1959.	786.	1528.		1962.	0.2757	0.1317	1.800	630.0	
1.441	400.00	3502.2	23522.	17000.	213.8	2199.7	P	0.519	164.1	0.344	0.663	272.48	0.860
0.477	0.0396	12.037	23522.	1954.	785.	1524.		1957.	0.2750	0.1314	1.800	630.0	

1.534	420.00	3575.6	23449.	17000.	212.8	2194.8	P	0.515	163.3	0.342	0.662	27509	0.860
0.450	0.0398	12.049	23449.	1946.	779.	1511.		1949.	0.2726	0.1308	1.792	630.0	
1.628	440.00	3648.9	23376.	17000.	212.8	2193.0	P	0.514	163.3	0.342	0.663	27510	0.860
0.478	0.0397	12.043	23376.	1941.	777.	1507.		1944.	0.2719	0.1305	1.792	630.0	
1.722	460.00	3721.9	23303.	17000.	212.8	2191.3	P	0.512	163.3	0.342	0.663	27499	0.860
0.477	0.0396	12.037	23303.	1936.	776.	1503.		1939.	0.2712	0.1302	1.792	630.0	
1.816	480.00	3794.9	23230.	17000.	212.8	2189.6	P	0.511	163.3	0.342	0.663	27493	0.860
0.475	0.0395	12.031	23230.	1931.	774.	1499.		1934.	0.2704	0.1298	1.792	630.0	
1.910	500.00	3867.6	23157.	17000.	212.8	2187.9	P	0.510	163.3	0.342	0.663	27555	0.860
0.474	0.0394	12.025	23157.	1926.	772.	1495.		1928.	0.2697	0.1295	1.792	630.0	
1.910	500.00	3867.6	23157.	17000.	212.8	2187.9	P	0.510	163.3	0.342	0.663	27555	0.860
0.474	0.0394	12.025	23157.	1926.	772.	1495.		1928.	0.2697	0.1295	1.792	630.0	

MISSION FUEL REQUIRED = 3867.60  
 RESERVE FUEL REQUIRED = 0.0  
 TOTAL FUEL REQUIRED = 3867.60



V A S C O M P II  
STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

TRANSFER ALTITUDE TO 1000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0 0	0 0	0 0	27025.	0.
0 0	0 0	0 0	27025.	1000.

CLIMB TO 1020 FT. WITH CONSTANT TAS AT MAXIMUM ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETP OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA (DEG)	R/C (FPM)
0 0	0 0	0 0	27025.	1000.	300.0	2691.9	W	1.000	295.6	0.455	0.660	3.5	2 4	1852
0 162	0 0417	4 036	26975.	6683.	3993.	9199.		8329.	0.3455	0.1663	1.769	900.0	0 851	
0 000	0 05	0 7	27024.	1020.	300.0	2692.4	W	1.000	295.5	0.455	0.660	3.5	2 4	1854
0 169	0 0418	4 037	26974.	6682.	3993.	9200.		8330.	0.3457	0.1664	1.769	900 0	0 851	

MISSION FUEL REQUIRED = 0.72  
RESERVE FUEL REQUIRED = 0.0  
TOTAL FUEL REQUIRED = 0.72

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END OF SUCCESSFUL CASE

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V/SYOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

V A S C O M P II

5 1 2 F L A T A THIS RUN CONVERGED IN 3 ITERATIONS

GROSS WEIGHT = 26221. LB

FUJELAGE  
 LF 46.0 FT  
 WF 4.3 FT  
 SI 530. SQFT

MISC  
 AR 5.62 SQFT  
 SW 524.4 FT  
 B 54.3 FT  
 CBARM 9.7 DEG  
 LAMBDA C/4 0.0  
 LAMBDA 0.500  
 (T/C)R 0.170  
 (T/C)T 0.130  
 WG/SW 50.0 LB/SQFT  
 C BAR / D 0.840

HOR. TAIL  
 AKHT 4.65 SQFT  
 SHT 128.0 FT  
 DHT 24.4 FT  
 CBARHT 5.2 FT  
 (T/C)HT 0.120

WEST. TAIL  
 ARVT 1.80 SQFT  
 SVT 90.0 FT  
 BVT 12.7 FT  
 CBARVT 7.1 FT  
 (T/C)VT 0.120

PRIMARY ENG. MACELLE  
 LN 0.0 FT  
 DBARN 0.0 FT  
 CH 0.0 SQFT

LIFT ENG. MACELLE  
 NO LIFT PROPULSION SELECTED

PROPELLER  
 D 11.5 FT  
 SIGMA R/P 0.204 LB/SQFT  
 WG/A 126.2  
 CT/SIGMA 0.160  
 NR 2.000  
 NO. OF BLADES 4.000

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

## WEIGHTS DATA IN LBS

GLF	GUST LOAD	FACTOR	4 1R6
<b>STRUCTURES GROUP</b>			
K8 WWT	WING		3192.
K9 WWT	HOR. TAIL		349.
K10 WWT	VERT. TAIL		251.
K11 WWT	FUSELAGE		1938.
K12 WLG	LANDING GEAR		1311.
K13 WLES	LIFT ENGINE SECTION		0.
K14 WPCS	PRIMARY ENGINE SECTION		537.
DELTA WST	STRUCTURE WEIGHT INCREMENT		350.
WST	TOTAL STRUCTURE WEIGHT		7927.
<b>PROPULSION GROUP</b>			
K2 UR/P	ROTOR OR FROP		742.
K3 WDS	DRIVE SYSTEM		689.
K4 WEL	LIFT ENGINES		0.
K5 WEP	PRIMARY ENGINES		976.
K6 WLEI	LIFT ENGINE INSTALLATION		0.
K7 WFEI	PRIMARY ENGINE INSTALLATION		293.
K21 WFS	FUEL SYSTEM		1273.
DELTA WP	PROPULSION GROUP WEIGHT INCREMENT		75.
WP	TOTAL PROPULSION GROUP WEIGHT		4099.
<b>FLIGHT CONTROLS GROUP</b>			
K15 WCC	COCKPIT CONTROLS		0.
K16 MUC	UPPER CONTROLS		158.
K17 RH	HYDRAULICS		0.
K18 WFW	FIXED WING CONTROLS		629.
K19 WSAS	SAS		0.
K20 WTM	TILT MECHANISM		0.
DELTA WFC	CONTROL WEIGHT INCREMENT		0.
WFC	TOTAL CONTROL WEIGHT		788.
WFE	WEIGHT OF FIXED EQUIPMENT		4000.
WE	WEIGHT EMPTY		16814.
WFUL	FIXED USEFUL LOAD		50.
OWE	OPERATING WEIGHT EMPTY		17364
WPL	PA LOAD		5000.
(WF)A	FUEL		3858.
WG	GROSS WEIGHT		26221.
			(LFW) 0.

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
V A S C O M P II

PROPELLSION DATA  
PRIMARY PROPULSION CYCLE NO. 4.000  
TURBOSHAFTE ENGINE

2. ENGINES  
BHP\*P MAX. STANDAKD S.L. STATIC H.P. 10000. H.P.  
ENGINE SIZE WAS FIXED BY INPUT

NO LIFT ENGINE CYCLE SELECTED  
XMSN SIZED AT 90. PERCENT OF ROTOR HOVER POWER REQUIRED  
AT H= 0. FT, TEMP= 59.00 DEG.F., 100.0 PERCENT HOVER RPM

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

V A S C O M P II

A E R O D Y N A M I C S D A T A  
 FE TOTAL EFFECTIVE FLATPLATE AREA 12.257 SQFT  
 SWET TOTAL WETTED AREA 1961. SQFT  
 CBARF MEAN SKIN FRICTION COEFF. 0.006252

D R A G B R E A K D O W N I N S Q F T  
 FEW WING FE 0.0  
 FEF FUSELAGE FE 7.013  
 FEVT VERT. TAIL FE 0.0  
 FEHT HOR. TAIL FE 0.0  
 FEN PRIMARY ENG. NACELLE FE 0.0  
 FELN LIFT ENG. NACELLE FE 0.0  
 DELTA FE INCREMENTAL FE 5.244

A E R O D Y N A M I C C O E F F .  
 A1 0.70996  
 A2 -0.09922  
 A3 0.06625  
 A4 0.11567  
 A5 0.02337  
 A6 1.30578  
 A7 0.07127  
 CL ALPHA 5.03255 PER RADIAN  
 E OSWALD FACTOR 0.79440

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

TAKEOFF, HOVER, OR LAND AT PETF = 1.000 LETF = 0.0 FOR 0.017 HRS.  
VERTICAL RATE OF CLIMB = 0.0 FT/MIN TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VIIP (FPS)
0.0	0.0	0.0	26221.	0.	0.0	2758.9	W	1.000	0.0	1.023	0.930	8821.	0.5197	900.
0.017	0.0	65.5	26156.	0.	0.0	2758.9	W	1.000	0.0	1.025	0.930	8821.	0.5197	900.

CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAXIMUM P/C AT MILITARY ENGINE RATING, MAXIMUM ALT. 50000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/C (FPM)
0.017	0.0	65.5	26156.	0.	148.2	2726.0	T	0.974	148.2	0.224	0.657	36.9	40.0	9018.
0.536	0.0439	12.204	20916.	1714.	3915.	8686.		17394.	0.3168	0.3371	0.874	900.0	0.930	
0.019	0.22	72.8	26148.	1000.	147.6	2726.0	T	0.948	145.4	0.224	0.654	36.6	40.0	8929.
0.558	0.0459	12.159	20979.	1725.	3825.	8528.		17148.	0.3203	0.3423	0.870	900.0	0.930	
0.020	0.44	79.9	26141.	2000.	146.4	2726.0	T	0.922	142.1	0.223	0.651	36.3	40.0	8788.
0.586	0.0484	12.125	21061.	1737.	3735.	8367.		16961.	0.3236	0.3487	0.863	900.0	0.930	
0.022	0.66	87.0	26134.	3000.	145.0	2726.0	T	0.894	138.7	0.221	0.648	36.0	40.0	8629.
0.618	0.0513	12.066	21154.	1753.	3645.	8202.		16788.	0.3269	0.3556	0.855	900.0	0.930	
0.024	0.89	94.0	26127.	4000.	143.4	2726.0	T	0.872	135.1	0.220	0.644	35.5	40.0	8448.
0.655	0.0547	11.978	21259.	1775.	3557.	8035.		16629.	0.3299	0.3629	0.845	900.0	0.930	
0.026	1.12	101.1	26120.	5000.	141.8	2726.0	T	0.859	131.6	0.218	0.640	35.1	40.0	8263.
0.694	0.0585	11.851	21370.	1803.	3469.	7867.		16465.	0.3329	0.3704	0.836	900.0	0.930	
0.028	1.36	108.1	26113.	6000.	140.0	2726.0	T	0.862	128.0	0.216	0.636	34.6	40.0	8056.
0.738	0.0631	11.690	21496.	1839.	3383.	7697.		16316.	0.3358	0.3783	0.825	900.0	0.930	
0.030	1.59	115.1	26106.	7000.	138.2	2726.0	T	0.865	124.4	0.214	0.631	34.1	40.0	7842.
0.786	0.0684	11.489	21630.	1883.	3297.	7526.		16161.	0.3385	0.3864	0.815	900.0	0.930	
0.032	1.84	122.1	26099.	8000.	136.4	2726.0	T	0.868	120.9	0.212	0.626	33.5	40.0	7622.
0.837	0.0744	11.250	21773.	1935.	3213.	7354.		16001.	0.3412	0.3946	0.804	900.0	0.930	
0.035	2.09	129.1	26092.	9000.	134.8	2726.0	T	0.871	117.7	0.210	0.621	32.9	40.0	7412.
0.890	0.0810	10.994	21917.	1994.	3130.	7183.		15814.	0.3438	0.4023	0.795	900.0	0.930	
0.037	2.34	136.1	26085.	10000.	133.0	2726.0	T	0.873	114.3	0.208	0.615	32.2	40.0	7177.
0.951	0.0889	10.691	22079.	2065.	3048.	7011.		15645.	0.3462	0.4106	0.784	900.0	0.930	

0.039	2.60	143.2	26078.	11000.	131.4	2726.0	T	0.876	131.2	0.207	0.609	31.5	40.0	6951.
1.013	0.0977	16.365	22243.	2146.	2967.	6840.	T	15449.	0.3486	0.4185	0.775	900.0	0.930	
0.042	2.87	150.3	26071.	12000.	129.8	2726.0	T	0.879	108.1	0.205	0.602	30.7	40.0	6717.
1.080	0.1078	10.018	22416.	2237.	2888.	6669.	T	15248.	0.3509	0.4264	0.765	900.0	0.930	
0.044	3.15	157.5	26064.	13000.	148.4	2726.0	T	0.881	121.6	0.235	0.621	19.8	27.6	5094.
0.933	0.0810	11.515	24523.	2130.	2824.	6560.	T	13119.	0.3564	0.3788	0.875	900.0	0.930	
0.047	3.61	166.7	26054.	14000.	155.7	2726.0	T	0.883	125.5	0.247	0.625	20.7	27.6	5565.
0.870	0.0758	11.488	24380.	2122.	2754.	6418.	T	12235.	0.3601	0.3648	0.918	900.0	0.930	
0.050	4.04	175.0	26046.	15000.	161.7	2726.0	T	0.886	128.3	0.258	0.628	19.4	25.9	5438.
0.840	0.0725	11.579	24570.	2122.	2685.	6273.	T	11513.	0.3636	0.3546	0.953	900.0	0.930	
0.053	4.51	183.2	26038.	16000.	167.0	2726.0	T	0.888	130.3	0.267	0.629	18.2	24.5	5283.
0.819	0.0704	11.640	24737.	2125.	2617.	6126.	T	10868.	0.3669	0.3466	0.984	900.0	0.930	
0.057	5.01	191.5	26030.	17000.	171.9	2726.0	T	0.890	131.9	0.276	0.631	17.0	23.2	5103.
0.804	0.0688	11.689	24887.	2129.	2550.	5979.	T	10324.	0.3701	0.3396	1.013	900.0	0.930	
0.060	5.55	199.8	26021.	18000.	176.5	2726.0	T	0.892	133.3	0.285	0.632	16.0	22.0	4916.
0.792	0.0676	11.727	25019.	2134.	2484.	5832.	T	9805.	0.3732	0.3335	1.041	900.0	0.930	
0.063	6.12	208.2	26013.	19000.	181.0	2726.0	T	0.894	134.4	0.293	0.633	14.9	20.8	4726.
0.783	0.0666	11.757	25135.	2138.	2419.	5686.	T	9322.	0.3762	0.3279	1.067	900.0	0.930	
0.067	6.74	216.7	26004.	20000.	185.4	2726.0	T	0.896	135.3	0.302	0.633	14.0	19.8	4535.
0.775	0.0658	11.780	25236.	2142.	2355.	5540.	T	8870.	0.3792	0.3227	1.093	900.0	0.930	
0.070	7.40	225.4	25996.	21000.	189.7	2726.0	T	0.898	136.1	0.310	0.634	13.1	18.8	4343.
0.769	0.0652	11.799	25324.	2146.	2293.	5396.	T	8444.	0.3821	0.3178	1.118	900.0	0.930	
0.074	8.11	234.2	25987.	22000.	193.9	2726.0	T	0.900	136.8	0.318	0.634	12.2	17.9	4151.
0.763	0.0646	11.815	25401.	2150.	2233.	5253.	T	8040.	0.3850	0.3132	1.143	900.0	0.930	
0.078	8.87	243.2	25978.	23000.	198.1	2726.0	T	0.902	137.4	0.326	0.635	11.4	17.0	3962.
0.759	0.0642	11.826	25467.	2153.	2174.	5112.	T	7658.	0.3878	0.3088	1.168	900.0	0.930	
0.082	9.69	252.3	25969.	24000.	202.4	2726.0	T	0.904	137.9	0.335	0.635	10.6	16.2	3768.
0.755	0.0638	11.838	25527.	2156.	2116.	4972.	T	7292.	0.3907	0.3045	1.193	900.0	0.930	
0.087	10.57	261.7	25960.	25000.	205.8	2726.0	T	0.905	137.8	0.342	0.635	10.0	15.7	3634.
0.758	0.0641	11.817	25562.	2163.	2058.	4832.	T	968.	0.3932	0.3014	1.213	900.0	0.930	
0.091	11.50	271.1	25950.	26000.	210.5	2726.0	T	0.907	138.4	0.351	0.635	9.1	14.7	3371.
0.752	0.0635	11.840	25624.	2164.	2004.	4697.	T	6624.	0.3961	0.2968	1.241	900.0	0.930	
0.096	12.53	281.0	25940.	27000.	215.3	2726.0	T	0.909	139.1	0.360	0.636	8.4	13.9	3184.
0.746	0.0629	11.861	25662.	2164.	1951.	4565.	T	6295.	0.3990	0.2924	1.269	900.0	0.930	
0.102	13.65	291.2	25930.	28000.	219.6	2726.0	T	0.910	139.3	0.369	0.636	7.8	13.3	3031.
0.745	0.0628	11.863	25688.	2165.	1899.	4434.	T	5994.	0.4017	0.2886	1.294	900.0	0.930	
0.107	14.34	301.7	25920.	29000.	223.9	2726.0	T	0.912	139.5	0.378	0.636	7.2	12.7	2851.
0.743	0.0626	11.866	25714.	2167.	1848.	4305.	T	5706.	0.4045	0.2849	1.320	900.0	0.930	
0.113	16.14	312.5	25909.	30000.	228.3	2726.0	T	0.913	139.7	0.387	0.636	6.6	12.1	2674.
0.742	0.0625	11.869	25735.	2168.	1799.	4178.	T	5430.	0.4072	0.2813	1.346	900.0	0.930	







CLIMB TO OPT. ALT. FOR NEXT CRUISE WITH MAXIMUM R/C AT MILITARY ENGINE RATING, MAXIMUM ALT. 50000. FT.															
TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	FUEL FLOW (LBS/HR)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/C (FPM)
CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP	(R)		THRUST (LBS)	CP	CT	J	VTIP (FPS)	ETAP	
1.198	350.00	3183.4	23038.	0.	162.6	2726.0	T	0.981	162.6	0.246	0.672	38.6	40.0	10289.	
0.383	0.0338	11.312	17995.	1591.	3932.	8745.		15962.	0.3189	0.3094	0.959	900.0	0.930		
1.200	350.21	3189.7	23031.	1000.	162.0	2726.0	T	0.954	159.6	0.246	0.670	38.5	40.0	10212.	
0.398	0.0348	11.422	18034.	1579.	3841.	8587.		15731.	0.3225	0.3140	0.955	900.0	0.930		
1.201	350.41	3196.0	23025.	2000.	160.8	2726.0	T	0.928	156.1	0.245	0.668	38.2	40.0	10087.	
0.417	0.0361	11.564	18083.	1564.	3750.	8424.		15548.	0.3258	0.3196	0.948	900.0	0.930		
1.203	350.62	3202.2	23019.	3000.	159.2	2726.0	T	0.903	152.3	0.243	0.666	38.0	40.0	9929.	
0.440	0.0376	11.712	18143.	1549.	3660.	8257.		15393.	0.3290	0.3260	0.939	900.0	0.930		
1.205	350.83	3208.3	23013.	4000.	157.4	2726.0	T	0.875	148.3	0.241	0.663	37.7	40.0	9753.	
0.465	0.0393	11.845	18210.	1537.	3570.	8088.		15250.	0.3321	0.3328	0.928	900.0	0.930		
1.206	351.05	3214.4	23007.	5000.	155.6	2726.0	T	0.859	144.4	0.239	0.660	37.4	40.0	9573.	
0.493	0.0413	11.941	18281.	1531.	3482.	7917.		15101.	0.3351	0.3397	0.917	900.0	0.930		
1.208	351.26	3220.5	23001.	6000.	153.6	2726.0	T	0.862	140.4	0.237	0.657	37.0	40.0	9376.	
0.524	0.0436	12.009	18360.	1529.	3395.	7745.		14965.	0.3379	0.3470	0.906	900.0	0.930		
1.210	351.48	3226.5	22995.	7000.	151.4	2726.0	T	0.865	136.3	0.235	0.654	36.6	40.0	9157.	
0.558	0.0464	12.045	18451.	1532.	3309.	7571.		14842.	0.3406	0.3549	0.893	900.0	0.930		
1.212	351.70	3232.5	22989.	8000.	149.2	2726.0	T	0.868	132.3	0.232	0.650	36.2	40.0	8932.	
0.596	0.0496	12.032	18548.	1542.	3224.	7397.		14714.	0.3432	0.3628	0.880	900.0	0.930		
1.214	351.92	3238.6	22983.	9000.	147.0	2726.0	T	0.871	128.3	0.229	0.646	35.7	40.0	8702.	
0.637	0.0532	11.967	18653.	1559.	3140.	7223.		14582.	0.3457	0.3709	0.867	900.0	0.930		
1.215	352.15	3244.6	22977.	10000.	144.8	2726.0	T	0.873	124.4	0.227	0.641	35.2	40.0	8466.	
0.682	0.0575	11.851	18766.	1583.	3057.	7048.		14447.	0.3481	0.3792	0.854	900.0	0.930		
1.217	352.39	3250.6	22971.	11000.	142.6	2726.0	T	0.876	120.6	0.224	0.636	34.7	40.0	824.	
0.730	0.0625	11.685	18888.	1616.	2975.	6874		14307.	0.3504	0.3875	0.841	900.0	0.930		
1.219	352.62	3256.6	22964.	12000.	140.4	2726.0	T	0.879	116.9	0.222	0.631	34.1	40.0	797.	
0.783	0.0683	11.469	19019.	1658.	2895.	6701.		14164.	0.3525	0.3961	0.828	900.0	0.930		
1.222	352.87	3262.7	22958.	13000.	138.4	2726.0	T	0.881	113.4	0.219	0.626	33.5	40.0	7733.	
0.838	0.0747	11.207	19154.	1709.	2816.	6528.		13999.	0.3546	0.4042	0.816	900.0	0.930		
1.224	353.12	3268.7	22952.	14000.	136.2	2726.0	T	0.884	109.8	0.217	0.620	32.7	40.0	7466.	
0.900	0.0824	10.924	19305.	1767.	2738.	6356.		13850.	0.3566	0.4130	0.803	900.0	0.930		
1.226	353.37	3274.9	22946.	15000.	134.2	2726.0	T	0.886	106.5	0.214	0.613	32.0	40.0	7207.	
0.966	0.0912	10.590	19459.	1838.	2662.	6185.		13679.	0.3585	0.4214	0.791	900.0	0.930		
1.228	353.63	3281.0	22940.	16000.	132.2	2726.0	T	0.888	103.2	0.212	0.606	31.2	40.0	6938.	
1.037	0.1014	10.227	19624.	1919.	2586.	6016.		13506.	0.3603	0.4299	0.779	900.0	0.930		

TIME (HRS)	CL	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
1.231		353.91	3287.2	22934.	17000.	149.7	2726.0	T	0.890	114.9	0.241	0.622	20.4	27.8
0.916		0.0789	11.608	21494.	1852.	2528.	5904.		11706.	0.3654	0.3851	0.883	900.0	0.930
1.234		354.35	3295.2	22926.	18000.	157.6	2726.0	T	0.892	119.0	0.254	0.627	20.7	27.4
0.852		0.0734	11.610	21443.	1847.	2463.	5767.		10858.	0.3690	0.3693	0.929	900.0	0.930
1.237		354.78	3302.5	22919.	19000.	163.9	2726.0	T	0.895	121.7	0.266	0.629	19.5	25.8
0.821		0.0702	11.684	21609.	1849.	2400.	5626.		10186.	0.3723	0.3582	0.966	900.0	0.930
1.240		355.25	3309.7	22911.	20000.	169.5	2726.0	T	0.897	123.7	0.276	0.631	18.2	24.3
0.800		0.0681	11.741	21766.	1854.	2337.	5484.		9604.	0.3754	0.3494	0.999	900.0	0.930
1.243		355.75	3316.9	22904.	21000.	174.6	2726.0	T	0.899	125.3	0.285	0.633	17.0	22.9
0.785		0.0666	11.784	21905.	1859.	2275.	5342.		9081.	0.3783	0.3418	1.029	900.0	0.930
1.246		356.29	3324.3	22897.	22000.	179.5	2726.0	T	0.900	126.6	0.294	0.634	15.9	21.7
0.773		0.0654	11.817	22026.	1864.	2215.	5201.		8602.	0.3812	0.3351	1.058	900.0	0.930

TEMPERATURE = -19.5 DEG.F

CRUISE AT BEST RANGE SPEED WITH HEADWIND OF 0.0 KNOTS

TIME (HRS)	CL	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
1.246		356.29	3324.3	22897.	22000.	224.6	2350.7	P	0.680	158.4	0.368	0.659	27355	0.769
0.513		0.0421	12.177	22897.	1880.	821.	1720.		1879.	0.3675	0.1494	1.892	630.0	
1.263		360.00	3337.8	22883.	22000.	224.6	2350.2	P	0.679	158.4	0.368	0.659	27368	0.769
0.513		0.0421	12.177	22883.	1879.	821.	1719.		1878.	0.3673	0.1493	1.892	630.0	
1.352		380.00	3410.9	22810.	22000.	224.6	2347.6	P	0.677	158.4	0.368	0.659	27438	0.769
0.511		0.0420	12.172	22810.	1874.	819.	1714.		1873.	0.3662	0.1489	1.892	630.0	
1.441		400.00	3483.8	22737.	22000.	224.6	2345.0	P	0.675	158.4	0.368	0.659	27508	0.769
0.509		0.0419	12.168	22737.	1869.	817.	1709.		1868.	0.3652	0.1485	1.892	630.0	
1.530		420.00	3556.5	22665.	22000.	224.6	2342.5	P	0.674	158.4	0.368	0.660	27578	0.769
0.508		0.0417	12.163	22665.	1863.	814.	1704.		1862.	0.3642	0.1481	1.892	630.0	
1.619		440.00	3629.0	22592.	22000.	224.6	2340.0	P	0.672	158.4	0.368	0.660	27646	0.769
0.506		0.0416	12.158	22592.	1858.	812.	1700.		1857.	0.3632	0.1476	1.892	630.0	
1.708		460.00	3701.4	22520.	22000.	224.6	2337.5	P	0.670	158.4	0.368	0.660	27715	0.769
0.505		0.0415	12.154	22520.	1853.	810.	1695.		1852.	0.3621	0.1472	1.892	630.0	
1.797		480.00	3773.5	22448.	22000.	224.6	2335.0	P	0.668	158.4	0.368	0.660	27784	0.769
0.503		0.0414	12.149	22448.	1848.	808.	1690.		1847.	0.3611	0.1468	1.892	630.0	
1.886		500.00	3845.5	22376.	22000.	224.6	2332.5	P	0.666	158.4	0.368	0.660	27852	0.769
0.501		0.0413	12.144	22376.	1843.	806.	1685.		1842.	0.3601	0.1464	1.892	630.0	
1.886		500.00	3845.5	22376.	22000.	224.6	2332.5	P	0.666	158.4	0.368	0.660	27852	0.769
0.501		0.0413	12.144	22376.	1843.	806.	1685.		1842.	0.3601	0.1464	1.892	630.0	

MISSION FUEL REQUIRED = 3845.53

RESERVE FUEL REQUIRED = 0.0  
TOTAL FUEL REQUIRED = 3845.53

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

TRANSFER ALTITUDE TO 1000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0.0	0.0	0.0	26221.	0.
0.0	0.0	0.0	26221.	1000.

CLIMB TO 1020. FT. WITH CONSTANT TAS AT MAXIMUM ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR FEHF	EAS	MACH	MACH DIV	GAMMA (DEG)	THETA -F (DEG)	R/C (FPM)
0.0	0.0	0.0	26221.	1000.	300.0	2691.9	W	1.000	295.6	0.455	0.660	5.8	4.7	3050.
0.168	0.0416	4.032	26089.	6470.	3993.	9199.		9100.	0.3455	0.1816	1.769	900.0	0.930	
0.000	0.03	0.4	26221.	1020.	300.0	2692.4	W	1.000	295.5	0.455	0.660	5.8	4.7	3052.
0.168	0.0417	4.033	26088.	6469.	3993.	9200.		9102.	0.3457	0.1818	1.769	900.0	0.930	

MISSION FUEL REQUIRED = 0.44  
RESERVE FUEL REQUIRED = 0.0  
TOTAL FUEL REQUIRED = 0.44

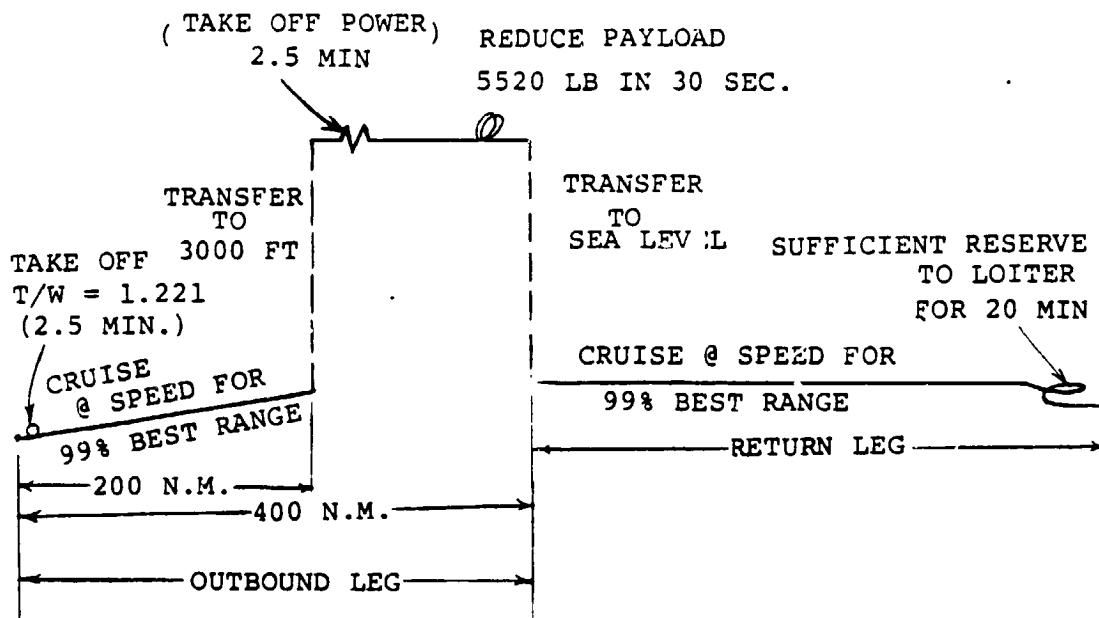
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END OF SUCCESSFUL CASE

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### 7.3.3 Tilt-Rotor Study Aircraft

Only those inputs which are of prime interest are discussed below. This sample case illustrates the use of the General Performance option (SGTIND=11.), and the Figure of Merit map. A copy of the output follows the input.



VASCOMP II - DESCRIPTION OF SAMPLE CASE 3

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
<u>General Information Sheet</u>			
OPTIND	0001	1.0	Sizing run
TNIRPK	0002	1.0	Print indicator-optional print
DRGIND	0003	0.0	Program calculates compressibility drag
OSWIND	0004	1.0	Program calculates induced drag factor
FDMIND	0006	0.0	Size fuselage for passenger requirements
WDMIND	0007	0.0	Wing not dependent on propeller size
HTIND	0008	1.0	} Input tail volume coefficients
VTIND	0009	1.0	
FIXIND	0010	1.0	Program sizes engines
ENGIND	0011	0.0	Turboshaft primary engines
LFTIND	0013	0.0	No lift engines specified
WG <sub>o</sub>	0014	35000.	1st guess at design gross weight
h <sub>o</sub>	0015	0.0	Start altitude
R <sub>o</sub>	0016	0.0	Starting range
t <sub>o</sub>	0017	0.0	Starting time
HOPTIN	0018	0.0	Cruise desired at specified altitude
VLMIND	0019	0.0	Airspeed limited to 250 knots EAS at altitude of 10,000 ft or less
M <sub>mo</sub>	0020	0.681	Maximum operating mach number
V <sub>mo</sub>	0021	450.	Maximum operating EAS knots
V <sub>DIVE</sub>	0022	450.	Design dive speed



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>	
$M_{LF}$	0023	3.0	Maneuver load factor	
$K_1$	0024	1.0	Factor on mission fuel burned to give reserve fuel, i.e. 1.1 would give 10% reserve	
$SW_F$	0025	0.	Fixed fuel increment for reserves or other use	
$K_{FF}$	0026	1.068	Use nominal engine fuel	
SCTIND	0027	2.	TAKEOFF	SEQUENCE OR DESIGN MISSION
	0028	4.	CRUISE	
	0029	9.	TRANSFER ALTITUDE	
	0030	2.	TAKEOFF	
	0031	8.	CHANGE PAYLOAD	
	0032	9.	TRANSFER ALTITUDE	
	0033	4.	CRUISE	
	0034	6	LOITER	
	0035	0.	END OF MISSION	
	0036	4.	CRUISE	
	0037	0.	END OF MISSION	
	0038	9.	TRANSFER ALTITUDE	
	0039	4.	CRUISE	
	0040	0.	END OF MISSION	
0041	11.	GENERAL PERFORMANCE		
0042	100.	END OF CASE		

Aircraft Dimensional Sheet

AR	0101	6.0	Wing aspect ratio
$i_w$	0103	0.0	Wing incidence angle to fuselage horizontal datum (degrees)
$(L/C)_R$	0104	.18	Root thickness-chord ratio
$(L/C)_T$	0105	.18	Tip thickness-chord ratio
$W_G/S$	0106	100.	Wing loading at design gross weight
$\Lambda_{C/4}$	0107	0.	Quarter chord mean sweep angle, degrees
$\lambda$	0108	1.0	Taper ratio (tip chord/root chord)
$AR_{HT}$	0109	4.0	Horizontal tail aspect ratio

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$a_H$	0110	.15	Vertical position of horizontal tail on vertical tail, spans above vertical tail root chord. Value is 0. on or below root chord, 1.0 for "T" tail
$l_{TH}$	0111	22.67	Horizontal tail arm, FT
(t/c)HT	0112	.15	Horizontal tail mean thickness/chord ratio
$\bar{V}_H$	0113	1.05	Horizontal tail volume coefficient
$\lambda_H$	0114	.4	Horizontal tail taper ratio
$\Gamma$	0116	.1	Prop blade attachment distance from centerline of hob (fraction of prop radius)
$Y_{CL}$	0117	9.1666	Clearance from inboard prop tip to inboard prop tip across fuselage (feet)
$\xi_1$	0118	0.	Prop over prop overlap (fraction of radius)
$\xi_2$	0119	1.0	Prop over wing tip overlap (fraction of radius)
$\Delta S_{WET}/S_W$	0120	0.	Increment in wetted area for landing gear or other protusions
$l_f$	0122	46.5	Fuselage length (feet)
$l_{RW}$	0126	15.	Length of ramp well or other strengthened fuselage portion (e.g., rear engine attachments). Used to compute fuselage weight penalty.
$S_F$	0127	999.4	Fuselage wetted area (square feet)
$b$	0128	7.1666	Width of fuselage (feet)
$AR_{VT}$	0129	1.153	Vertical tail aspect ratio
$l_{TV}$	0130	20.	Vertical tail arm
(t/c)VT	0131	.15	Vertical tail thickness/chord ratio

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\bar{V}_V$	0132	.128	Vertical tail volume coefficient
$\lambda_V$	0133	.325	Vertical tail taper ratio
$Y_{mg}$	0135	0.	Spanwise distance of landing gear from mean spanwise distance of cruise engine from wing root in semispans. Used in wing relief term.
$Y_p$	0136	.904	
$Z_1$	0139	0.0	} Primary engine nacelle constants
$Z_2$	0140	0.0	

Aircraft Propulsion Information Required When Using Turboshaft Engines - Primary Engine

$\eta_{pIND}$	0200	0.0	Program calculates prop performance
Cycle No.	0201	1.82	Cruise engine selection
$SHP_P^*$	0202	10000.	Maximum static sea level horsepower
$N_p$	0204	4	Number of cruise engines
$\eta_T$	0206	.97	Transmission efficiency
$h_{TO}$	0207	0.	Takeoff pressure altitude for engine sizing
$n$	0208	1.1955	Thrust to weight for engine sizing - takeoff condition
$\Delta T_{in_{TO}}$	0209	30.8	Increase in temperature above standard for engine sizing
$N_{II}/N_{II_{MAX}}$	0210	.943	Power turbine operating speed for engine sizing
$N_{PO}$	0211	0.0	Number of primary engines shut down during engine sizing
$N_{LO}$	0212	0.0	Number of lift engines shut down during engine sizing
$N_R$	0223	2.	Number of rotors

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
$V_{TIP}$	0224	775.18	Prop tip speed
$W_{G/A}$	0225	15.0	Disc loading
DIA	0226	35.0	Prop diameter
AF	0228	95.02	Activity factor per blade
BLDN	0229	3.0	Number of blades
$C_{L_i}$	0230	.46	Induced lift coefficient of wing
$\eta_{P2}$	0232	.736	Takeoff, hover, land efficiency
$\eta_{P3}$	0233	.837	Climb efficiency
$\eta_{P4}$	0234	.700	Descent efficiency
No. Pairs $\eta_{P4}$ Table	0245	9.0	Number of pairs in $\eta_{P4}$ efficiency table
M	0235	0.0	} Values of mach number
	1236	0.1	
	1237	0.2	
	0238	0.3	
	0239	0.4	
	0240	0.5	
	0241	0.6	
	0242	0.7	
	0243	0.8	
$\eta_{P4}$	0246	0.672	} Values of $\eta_{P4}$
	0247	0.700	
	0248	0.718	
	0249	0.738	
	0250	0.750	
	0251	0.760	
	0252	0.765	
	0253	0.758	
	0254	0.751	
XMSNIND	0257	1.0	Transmission sized at either hover or cruise power required (the most critical is chosen)
$SHP_{XM}/SHP^*$	0258	0.95	Transmission sized at 95% power chosen
$\Delta SHP_{ACC}$	0259	200.0	Accessory horsepower

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$SHP_E/SHP^*$	0260	0.9	Engine sized for 90% power; oversized by factor of $1/.9 = 1.111$
$V_{R/C}$	0261	500.0	Engine sized at 500 ft/min vertical rate of climb
$K_{FC}$	0262	2.0	Vertical climb constant chosen for this tilt rotor aircraft

Aircraft Aerodynamics Information Sheet

$C_{DVTi}$	0301	0.0	Profile drag of vertical tail
$C_{DHTi}$	0302	0.0	Profile drag of horizontal tail
$C_{DNI}$	0303	0.0	Profile drag of primary engine nacelles
$C_{DLNI}$	0304	0.0	Profile drag of life engine nacelles
$\Delta C_D$	0305	.16205	Profile drag increment
$\Delta a_e \text{ FT}^2$	0307	6.4151	Increment in equivalent flat plate area parasite drag of fuselage ( $\text{ft}^2$ )
No. of Pairs in Table	0308	2.0	Number of $C_L-C_{DWi}$ Pairs in locations 317-330 and 335-342
$K_{LN}$	0311	0.0	Lift engine nacelle multiplicative drag factor
$K_W$	0312	1.0	Wing multiplicative drag factor
$K_{LT}$	0316	0.0	Horizontal tail multiplicative drag factor
$C_{L1}$	0317	0.0	Wing lift coefficient
$C_{L2}$	0318	10.	
$(R_e/l)_i$	0330	$.215 \times 10^6$	Mean Reynolds number per foot for mission
$C_{l\alpha} \text{ RAD}^{-1}$	0331	6.28	Two dimensional wing lift coefficient slope

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\alpha_{LO}$ DEG.	0332	-2.8	Angle of attack where the lift equals zero
$(X/c)_{ps}$	0333	0.45	Position of peak suction location on wing
$(X/c)_{max_{c/c}}$	0334	.45	Position of maximum thickness on wing
$C_{DWi}(1)$	0335	0.	Wing induced drag coefficient
$C_{DWi}(2)$	0336	0.	

Aircraft Weight Information Sheet

$W_{FE}$ LBS	0401	5622.	Weight of fixed equipment, in LBS.
$W_{FUL}$ LBS	0402	1550.	Weight of fixed useful load in LBS.
$W_{PL}$ LBS	0403	5630.	Weight of payload in LBS.
$K_{CC}$	0404	26.	Cockpit controls weight factor
$K_{FW}$	0405	.012	Fixed wing controls weight factor
$K_H$	0406	40.	Constant for flight control hydraulics
$K_{SAS}$	0407	75.	Stability augmentation system (SAS) weight factor, usually in range of 20-100 LBS
$K_{TM}$	0408	.015	Tilt mechanism weight factor
$K_{UC}$	0409	.3	Upper control weight factor
$K_{15}$	0410	1.0	Cockpit controls weight factor
$K_{16}$	0411	1.206	Upper controls weight factor
$K_{17}$	0412	1.25	Hydraulics weights factor
$K_{18}$	0413	1.0	Fixed wing controls weight factor
$K_{19}$	0414	1.0	SAS weights factor
$K_{20}$	0415	1.0	Tilt mechanism weights factor

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta W_{FC}$	0417	0.0	Flight controls incremental group weight
$\Delta W_P$	0418	100.	Incremental propulsion group weight
$\Delta W_{ST}$	0419	1300.	Structures group incremental weight, in LBS
$K_B$	0420	170.0	Body weight factor
$K_{LG}$	0422	.04	Landing gear weight factor, percentage of gross weight
$K_{MG}$	0423	.8	Main landing gear weight factor
$K_{TL}$	0424	1.15	Tail load factor
$K_{WW}$	0426	220.	Detailed wing weight factor, adjusts the constant 220 in $W_w = 220a (k)^{.582}$ depending on the complexity of the control surfaces
$K_Y$	0427	.18	Pitch radius of gyration, feet
$K_Z$	0428	.28	Yaw radius of gyration, feet
$K_8$	0433	1.02	Wing weight multiplicative factor
$K_9$	0434	0.85	Horizontal tail weight factor
$K_{10}$	0435	0.85	Vertical tail weight factor
$K_{DS}$	0453	238.6	Drive system weights constant
$K_{FS}$	0454	.15	Fuel system weights factor
$K_{PEI}$	0456	.37	Primary engine weight factor
$K_{R/P}$	0457	12.71	Prop/Rotor weights factor
$K_{VT}$	0458	0.9675	Adjustment for variations in drive system weight
$K_2$	0459	0.92	Prop group weight factor
$K_3$	0460	0.93	Drive system weight factor

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
<u>Takeoff, Hover and Landing Information Sheet</u>			
TOLIND	0601	3.	Takeoff and land sharing equal fraction of thrust from primary and lift engines
	0602	1.	
ATMIND	0611	0.	Takeoff standard day
ATMIND	0612	1.	Landing standard day
PEHF	0621	1.0	Takeoff engine fractional power = 1.0
$\Delta T_{in}$	0632	43.2	Incremental temperature above standard
$n_T$	0652	1.1221	Thrust to weight
$\Delta t_H$	0661	.02083	Takeoff compute in 2 minute increments
$\Delta t_H$	0662	.0167	Landing compute in 1 minute increments
$N_{II}/N_{IIMAX}$	0671	.943	Power turbine speed ratio - takeoff
$N_{II}/N_{IIMAX}$	0672	.943	Power turbine speed ratio - land
$t_H$	0681	.041667	Takeoff in 2.5 minutes
$t_H$	0682	.0333	Landing in 2.0 minutes
$V_{R/C}$	2321	500.0	Takeoff, hover, or land at specified vertical rate of climb
	2322	300.0	

Cruise Information Sheet

CRSIND	0801	4.	} Cruise indicator
	0802	4.	
	0803	1.0	
	0809	4.0	
Headwind	0811	0.0	} Cruise headwind
	0812	0.0	
	0813	0.0	
	0814	0.0	



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE</u> <u>ASSIGNED</u>	<u>REMARKS</u>
ATMIND	0821	0.0	} Cruise @ standard day
	0822	0.0	
	0823	0.0	
	0824	0.0	
$\Delta R$	0831	40.	} Increment for calculations
	0832	40.	
	0833	1.	
	0834	1.	
$R_{MAX}$	0851	200.	Range at end of cruise calculations.
	0852	400.	
	0853	1.0	
	0854	1.0	
POWIND	0861	2.0	} Cruise limited by normal power
	0862	2.0	
	0863	2.0	
	0864	2.0	
$N_{PSD_{CR}}$	0871	0.0	Number of cruise engines inoperative during cruise
	0872	0.0	
	0873	0.0	
	0874	0.0	
$N_{II}/N_{IIMAX}$	0881	.6601	} Power turbine operating ratio
	0882	.6601	
	0883	.6601	
	0884	.6601	
$\Delta C_{D_{CRUISE}}$	0891	0.0	No additional aircraft drag during cruise
	0892	0.0	
	0893	0.0	
	0894	0.0	

Loiter Information Sheet

LTRIND	1001	2.0	Loiter for reserve fuel calculation
$\Delta t_L$	1011	0.111	Calculate performance in 0.111 hours
ATMIND	1021	0.0	Standard atmosphere
$t_L$	1031	0.333	Loiter for .333 hours
$N_{PSD}$	1051	0.0	Loiter with 0 engines inoperative

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$N_{II}/N_{IIMAX}$	1061	0.6601	Power turbine operating speed
$\Delta C_D$	1071	0.0	No additional aircraft drag during loiter

Transfer Altitude Sheet

$h_{final}$	1111	3000.	Transfer aircraft to specified altitude
	1112	0.0	
	1113	20000.	

Change in Payload Weight Sheet

$\Delta W_{PL}$	1131	-5520.	Remove 5520 pounds from aircraft
$t_{PW}$	1141	.00833	Remove weight in 30 seconds

General Performance Information Sheet

GWIND	2201	1.0	Input $\Delta$ gross weight
$\Delta GW$	2211	0.0	Aircraft performed based on gross weight
ATMIND	2221	0.0	Standard atmosphere
$C_{LWING}$	2231	0.8	Wing lift coefficient
$\Delta C_{D_{CRUISE}}$	2251	0.005	Additional drag coefficient added to baseline aircraft
ALT.	2261	1000.	Altitude in feet
T/W	2271	1.122	Thrust to weight ratio
$(N_{II}/N_{IIMAX})_{TO}$	2281	1.0	Power turbine operating speed for takeoff
$\Delta V$	2291	20.0	Performance velocity printout in knots
$V_{MAX}$	2301	225.0	Maximum cruise velocity in knots
$(N_{II}/N_{IIMAX})_{CR}$	2311	1.0	Power turbine operating speed for cruise



V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUMBER GIVEN ON INPUT SHEET  
 NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. =5)  
 VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL1 VALUE CORRESPONDING TO LOC.+0001  
 VAL2 VALUE CORRESPONDING TO LOC.+0002  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
1201	5	.0	.0	.0	2.0000	1.0000
1206	1	.0	1.4100	90.000	.30690E-01	1750.0
1223	2	1.0260	.96000E-01	2645.0	2645.0	8.0000
1301	5	1.8200	2522.0	2150.0	2400.0	2650.0
1306	5	1800.0	1900.0	3550.0	6.0000	.0
1311	5	1750.0	3200.0	.60000	.70000	1.0000
1316	5	2900.0	.40000	.70000E-01	.70000E-01	.70000E-01
1321	5	.20000	.70000E-01	.19000	.19100	.19300
1326	5	.70000E-01	.18900	.39200	.39600	.40200
1331	5	.70000E-01	.20000	.45500	.68800	.70100
1336	5	.41100	.42100	.73600	.84000	1.0050
1341	5	.71000	.72500	1.0970	1.1540	1.3800
1346	5	1.0200	1.0420	1.3230	1.3980	1.4600
1351	5	1.2440	1.2740	1.4800	1.5400	1.6540
1356	5	1.8000	1.4390	1.5900	1.6400	1.7000
1361	5	1.7500	2.2500	2.6300	8.0000	1750.0
1366	5	1.8200	1.9600	2150.0	2650.0	2900.0
1371	5	1900.0	3550.0	6.0000	.0	.20000
1376	5	3200.0	.60000	.70000	1.0000	.12300
1381	5	.40000	.12300	.12300	.12300	.12300
1386	5	.12300	.16200	.16200	.16200	.16200
1391	5	.16200	.16200	.16200	.16200	.16200
1396	5	.16200	.24300	.24400	.24400	.24500
1401	5	.24500	.24600	.35500	.35600	.35800
1406	5	.36000	.36100	.37500	.47000	.47700
1411	5	.48500	.49200	.49700	.53500	.56200
1416	5	.57400	.58300	.59900	.62500	.69500
1421	5	.64300	.66400	.67500	.70300	.72700
1426	5	.84500	.74500	.75500	.77200	.81000
1431	5	.84500	.99000	8.0000	1750.0	1900.0
1436	5	.84000	2400.0	2650.0	2900.0	3200.0
1441	5	2150.0	6.0000	.0	.20000	.40000
1446	5	3550.0	.70000	1.0000	.81000	.81000
1451	5	.60000	.81000	.81000	.81000	.81000
1456	5	.81000	.84500	.84500	.84500	.84500
1461	5	.84500	.89800	.89800	.89800	.89800
1466	5	.89800	.95000	.95000	.95000	.95000
1471	5	.89800	.95000	1.0010	1.0010	1.0010
1476	5	.95000	1.0010	1.0010	1.0480	1.0480
1481	5	1.0010	1.0480	1.0480	1.1020	1.1020
1486	5	1.0480	1.1020	1.1020		
1491	5	1.1020				



406	5	40.000	75.000	.15000E-01	.30000	1.0000
411	5	1.2060	1.2500	1.0000	1.0000	1.0000
417	4	.0	100.00	1300.0	170.00	
421	5	.0	.40000E-01	.80000	1.1500	2.0000
426	3	220.00	.18000	.25000		
433	3	1.0200	.85000	1.0000		
436	4	.85000	.85000			
450	1	5.7000				
451	5	.0	.10000E+06	238.60	.15000	.0
456	5	.37000	12.710	.96750	.92000	.93000
461	5	1.0000	1.0000	1.0000	1.0000	1.0000
601	2	3.0000	1.0000			
611	2	.0	1.0000			
621	1	1.0000				
632	1	43.200				
652	1	1.1221				
661	2	.20833E-01	.16660E-01			
671	2	.94300	.94300			
681	2	.41667E-01	.33300E-01			
2321	2	300.00	.0			
801	4	4.0000	4.0000	1.0000	4.0000	
811	4	.0	.0	.0	.0	
821	4	.0	.0	.0	.0	
831	4	40.000	40.000	1.0000	1.0000	
851	4	200.00	400.00	1.0000	1.0000	
861	4	2.0000	2.0000	2.0000	2.0000	
871	4	.0	.0	.0	.0	
881	4	.66010	.66010	.66010	.66010	
891	4	.0	.0	.0	.0	
2201	1	1.0000	1.0000			
2211	1	.0	.0			
2221	1	.0	.0			
2231	1	.80000				
2251	1	.50000E-02				
2261	1	1000.0				
2271	1	1.1220				
2281	1	1.0000				
2291	1	20.000				
2301	1	225.00				
2311	1	1.0000				
1001	1	2.0000				
1011	1	.11100				
1021	1	.0				
1031	1	.33300				
1051	1	.0				
1061	1	.66010				
1071	1	.0				
1111	3	3000.0				
1131	1	-5520.0				
1141	1	.83300E-02				
1201	1	.0				
1206	5	.0				
1223	2	1.0260	1.4100			
1231	3	1.8200	.11520			
1205	1	1.0000				
1224	1	.90000				

WG = 0.350000E+05	WFR = 0.0
WG = 0.350000E+05	WFR = 0.889836E+04
WG = 0.431346E+05	WFR = 0.112963E+05
WG = 0.565112E+05	WFR = 0.154612E+05

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM

V A S C O M P II

B-93

SIZE DATA THIS RUN CONVERGED IN 4 ITERATIONS

GROSS WEIGHT = 57881. LB

FUSELAGE	LENGTH	46.5	FT
LF	WIDTH	7.2	FT
WF	WETTED AREA	999.	SQFT
SF			
WING	ASPECT RATIO	6.00	
AR	AREA	578.8	SQFT
SW	SPAN	58.9	FT
B	SEOM. MEAN CHORD	9.8	FT
CBARW	QUARTER CHORD SWEEP	0.0	DEG
LAMBDA C/4	TAPER RATIO	1.000	
LAMBDA	ROOT THICKNESS	0.180	
(T/C)R	TIP THICKNESS	0.180	
(T/C)T	WING LOADING	100.0	LB/SQFT
WG/SW	MEAN CHORD / PROP. DIA.	0.281	
C BAR / D			
HOR. TAIL	ASPECT RATIO	4.00	
ARHT	AREA	265.3	SQFT
SHT	SPAN	32.5	FT
BHT	MEAN CHORD	8.1	FT
CBARHT	THICKNESS / CHORD	0.150	
(T/C)HT	MOMENT ARM	22.7	FT
LTH			
VERT. TAIL	ASPECT RATIO	1.15	
AKVT	AREA	218.3	SQFT
SVT	SPAN	15.9	FT
BVT	MEAN CHORD	13.8	FT
CBARVT	THICKNESS / CHORD	0.150	
(T/C)VT	MOMENT ARM	20.0	FT
LTV			
PRIMARY ENG. NACELLE	LENGTH	0.0	FT
LN	MEAN DIAMETER	0.0	FT
DBARN	WETTED AREA	0.0	SQFT
SN			
LIFT ENG. NACELLE	NO LIFT PROPULSION SELECTED		
PROPELLER	DIAMETER	35.0	FT
D	SOLIDITY	0.116	
SIGMA R/P	DISC LOADING	30.1	LB/SQFT
WG/A	THRUST COEFF. / SOLIDITY	0.500	
CT/SIGMA	NO. OF PROPELLERS	2.000	
NR	NO. OF BLADES/PROP	3.000	

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

W E I G H T S D A T A		I N L B S	
GLF	GUST LOAD	FACTOR	
<b>STRUCTURES GROUP</b>			
K8 WHJ	WING		3460.
K9 WHT	HOR. TAIL		639.
K10 WVT	VERT. TAIL		412.
K11 WB	FUSELAGE		3918.
K12 WLG	LANDING GEAR		1968.
K13 WLES	LIFT ENGINE SECTION		0.
K14 WPES	PRIMARY ENGINE SECTION		0.
DELTA WST	STRUCTURE WEIGHT INCREMENT		1300.
WST	TOTAL STRUCTURE WEIGHT		11696.
<b>PROPULSION GROUP</b>			
K2 WR/P	ROTOR OP. PROP		2640.
K3 WDS	DRIVE SYSTEM		4922.
K4 WEL	LIFT ENGINES		0.
K5 WEP	PRIMARY ENGINES		2778.
K6 WLEI	LIFT ENGINE INSTALLATION		0.
K7 WPEI	PRIMARY ENGINE INSTALLATION		1028.
K21 WFS	FUEL SYSTEM		2382.
DELTA WP	PROPULSION GROUP WEIGHT INCREMENT		100.
WP	TOTAL PROPULSION GROUP WEIGHT		13849.
<b>FLIGHT CONTROLS GROUP</b>			
K15 WCC	COCKPIT CONTROLS		137.
K16 WUC	UPPER CONTROLS		1038.
K17 WHP	HYDRAULICS		839.
K18 WFW	FIXED WING CONTROLS		695.
K19 WSAS	SAS		75.
K20 WTM	TILT MECHANISM		868.
DELTA WFC	CONTROL WEIGHT INCREMENT		0.
WFC	TOTAL CONTROL WEIGHT		3652.
WFE	WEIGHT OF FIXED EQUIPMENT		5622.
WE	WEIGHT EMPTY		34820.
WFUL	FIXED USEFUL LOAD		1550.
OME	OPERATING WEIGHT EMPTY		36370.
WPL	PAYLOAD		5630.
(WF)A	FUEL		15881.
WG	GROSS WEIGHT		57881.

15881.

(WF)W



VASCOMP II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

PROPELLSION DATA  
PRIMARY PROPULSION CYCLE NO. 1.820  
TURBOSHAFT ENGINE

4. ENGINES

BHP\*P MAX. STANDARD S.L. STATIC H.P. 21611. H.P.

ENGINE SIZED FOR TAKEOFF AT T/W = 1.20  
90.0 PERCENT, MILITARY POWER SETTING  
VERTICAL RATE OF CLIMB = 500.0 FT/MIN  
H = 0. FT, TEMPERATURE = 89.80 DEG F,  
AND 0.0 ENGINES INOPERATIVE.  
NO CRUISE CONDITION SPECIFIED.

NO LIFT ENGINE CYCLE SELECTED

XMSN SIZED AT 95. PERCENT OF ROTOR HOVER POWER REQUIRED  
AT H = 0. FT, TEMP = 89.80 DEG.F., 100.0 PERCENT HOVER RPM

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 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

A E R O D Y N A M I C S D A T A  
 FE TOTAL EFFECTIVE FLATPLATE AREA 100.210 SQFT  
 SWET TOTAL WETTED AREA 3050. SQFT  
 CBARF MEAN SKIN FRICTION COEFF. 0.032858

D R A G B R E A K D O W N I N S Q F T  
 FEM WING FE 0.0  
 FEV FUSELAGE FE 6.415  
 FEVT VERT. TAIL FE 0.0  
 FEN HOR. TAIL FE 0.0  
 FELN PRIMARY ENG. NACELLE FE 0.0  
 DELTA FE LIFT ENG. NACELLE FE 0.0  
 INCREMENTAL FE 93.795

A E R O D Y N A M I C C O E F F .

A1 0.67820  
 A2 -0.06600  
 A3 0.08608  
 A4 0.13500  
 A5 0.17313  
 A6 1.30180  
 A7 0.06734  
 CL ALPHA 5.20400  
 E OSMALD FACTOR 0.78782

3-D LIFT SLOPE  
 PER RADIAN

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
 MISSION PERFORMANCE DATA

TAKEOFF, HOVER, OR LAND AT PETF = 1.000 LETF = 0.0 FOR 0.042 HRS. TEMPERATURE = 59.0 DEG.F  
 VERTICAL RATE OF CLIMB = 300.0 FT/MIN TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTAP (FPS)
0.0	0.0	0.0	57881.	0.	0.0	2526.6	Q	1.000	0.0	1.363	0.736	19129.	0.2376	750.
0.021	0.0	200.1	57680.	0.	0.0	2526.6	Q	1.000	0.0	1.367	0.736	19129.	0.2376	750.
0.042	0.0	400.2	57480.	0.	0.0	2526.6	Q	1.000	0.0	1.372	0.736	19129.	0.2376	750.
0.042	0.0	400.2	57480.	0.	0.0	2526.6	Q	1.000	0.0	1.372	0.736	19129.	0.2376	750.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
0.042	0.0	400.2	57480.	0.	172.0	2236.6	P	0.801	172.0	0.260	0.613	.02647	0.730
0.990	0.2391	4.140	57480.	13883.	6503.	10551.		14145.	0.2071	0.0870	1.738	525.0	
0.274	40.00	1911.5	55969.	0.	171.0	2225.6	P	0.781	171.0	0.258	0.614	.02678	0.730
0.975	0.2372	4.112	55969.	13611.	6391.	10293.		13873.	0.2021	0.0853	1.728	525.0	
0.508	80.00	3405.3	54475.	0.	170.5	2217.1	P	0.766	170.5	0.258	0.615	.02706	0.730
0.955	0.2345	4.072	54475.	13380.	6505.	10095.		13643.	0.1982	0.0839	1.723	525.0	
0.743	120.00	4883.2	52997.	0.	169.0	2204.4	P	0.743	169.0	0.255	0.616	.02739	0.729
0.946	0.2333	4.052	52997.	13078.	6175.	9793.		13344.	0.1922	0.0821	1.708	525.0	
0.979	160.00	6343.6	51537.	0.	166.5	2187.5	P	0.713	166.5	0.252	0.616	.02775	0.728
0.947	0.2336	4.056	51537.	12706.	6004.	9391.		12976.	0.1844	0.0798	1.683	525.0	
1.220	200.00	7785.2	50095.	0.	164.5	2173.3	P	0.687	164.5	0.249	0.616	.02808	0.728
0.943	0.2331	4.048	50095.	12376.	5862.	9052.		12649.	0.1777	0.0778	1.663	525.0	
1.220	200.00	7785.2	50095.	0.	164.5	2173.3	P	0.687	164.5	0.249	0.616	.02808	0.728
0.943	0.2331	4.048	50095.	12376.	5862.	9052.		12649.	0.1777	0.0778	1.663	525.0	

TRANSFER ALTITUDE TO 3000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
1.220	200.00	7785.2	50095.	0.
1.220	200.00	7785.2	50095.	3000.

TAKEOFF, HOVER, OR LAND AT T/W = 1.122 FOR 0.033.HRS.

TEMPERATURE = 91.5 DEG.F

VERTICAL RATE OF CLIMB = 0.0 FT/MIN

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PEIF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VTIP (FPS)
1.220	200.00	7785.2	50095.	3000.	0.0	2608.6	P	0.951	0.0	1.122	0.736	15376.	0.2008	750.
1.236	200.00	7920.9	49960.	3000.	0.0	2608.6	P	0.951	0.0	1.122	0.736	15376.	0.2003	750.
1.253	200.00	8056.5	49824.	3000.	0.0	2608.6	P	0.951	0.0	1.122	0.736	15376.	0.1997	750.

CHANGE PAYLOAD, REMOVE 5520. LB.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
1.253	200.00	8056.5	49824.	3000.
1.261	200.00	8056.5	44304.	3000.

TRANSFER ALTITUDE TO 0. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
1.261	200.00	8056.5	44304.	3000.
1.261	200.00	8056.5	44304.	0.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	CL	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
1.261		200.00	8056.5	44304.	0.	158.0	2119.8	P	0.599	108.0	0.239	0.19	0.726
0.904		0.2282	3.963	44304.	11180.	5364.	7901.		11464.	0.1551	0.0795	1.597	
1.514		240.00	9413.5	42947.	0.	157.0	2109.0	P	0.584	157.0	0.237	0.620	0.725
0.888		0.2262	3.925	42947.	10942.	5272.	7693.		11229.	0.1510	0.0690	1.587	
1.769		280.00	10755.5	41605.	0.	156.0	2098.3	P	0.568	156.0	0.236	0.621	0.725
0.871		0.2242	3.885	41605.	10709.	5182.	7490.		10997.	0.1470	0.0676	1.577	
2.026		320.00	12083.1	40277.	0.	155.0	2087.8	P	0.553	155.0	0.234	0.622	0.725
0.854		0.2223	3.843	40277.	10480.	5094.	7291.		10770.	0.1431	0.0662	1.567	
2.284		360.00	13396.6	38964.	0.	154.5	2079.9	P	0.542	154.5	0.233	0.623	0.725
0.832		0.2197	3.786	38964.	10292.	5029.	7143.		10583.	0.1402	0.0651	1.562	
2.543		400.00	14697.6	37663.	0.	153.5	2069.7	P	0.528	153.5	0.232	0.624	0.724
0.815		0.2178	3.740	37663.	10071.	4946.	6953.		10364.	0.1365	0.0637	1.551	
2.543		400.00	14697.6	37663.	0.	153.5	2069.7	P	0.528	153.5	0.232	0.624	0.724
0.815		0.2178	3.740	37663.	10071.	4946.	6953.		10364.	0.1365	0.0637	1.551	

LOITER FOR 0.333 HRS. FOC. RESERVE FUEL

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH DIV	FUEL RATE (LBS/HR)	ETAP PROP
2.543	400.00	14697.6	37663.	0.	153.5	2069.7	P	0.528	153.5	0.232	0.624	0.724
0.815	0.2178	3.740	37663.	10071.	4946.	6953.		10364.	0.1365	0.0637	1.551	

CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP	THRUST (LBS)	CP	CT	J	VTIP (FPS)	ETAP
2.543	400.00	14697.6	37663.	0.	83.0	1883.8	0.281	83.0	0.125	0.494	3633.	0.705
2.786	0.6958	4.004	37663.	9406.	3633.	3706.	9938.	0.0728	0.0611	0.839	525.0	0.705
2.654	400.00	15100.9	37260.	0.	83.0	1880.8	0.277	83.0	0.125	0.496	3614.	0.705
2.756	0.6847	4.025	37260.	9256.	3614.	3650.	9788.	0.0717	0.0602	0.839	525.0	0.705
2.765	400.00	15502.1	36858.	0.	82.0	1877.9	0.273	82.0	0.124	0.494	3595.	0.704
2.793	0.6986	3.999	36858.	9218.	3595.	3596.	9756.	0.0706	0.0600	0.829	525.0	0.704
2.876	400.00	15901.2	36459.	0.	82.0	1875.0	0.269	82.0	0.124	0.496	3577.	0.704
2.763	0.6873	4.020	36459.	9068.	3577.	3541.	9606.	0.0695	0.0591	0.829	525.0	0.704
2.876	400.00	15901.2	36459.	0.	82.0	1875.0	0.269	82.0	0.124	0.496	3577.	0.704
2.763	0.6873	4.020	36459.	9068.	3577.	3541.	9606.	0.0695	0.0591	0.829	525.0	0.704

MISSION FUEL REQUIRED = 14697.63  
RESERVE FUEL REQUIRED = 1203.60  
TOTAL FUEL REQUIRED = 15901.23

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 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

CRUISE AT -NORMAL		ENGINE RATING		TEMPERATURE = 59.0 DEG.F									
TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROF
0.0	0.0	0.0	57881.	0.	192.5	2349.7	Q	1.000	192.5	0.291	0.626	.02503	0.736
0.796	0.2158	3.688	57881.	15695.	7693.	13181.		15920.	0.2588	0.0979	1.946	525.0	
0.005	1.00	40.0	57841.	0.	192.5	2349.7	Q	1.000	192.5	0.291	0.626	.02503	0.736
0.795	0.2157	3.686	57841.	15693.	7693.	13181.		15918.	0.2588	0.0979	1.946	525.0	

MISSION FUEL REQUIRED = 39.96  
 RESERVE FUEL REQUIRED = 0.0  
 TOTAL FUEL REQUIRED = 39.96

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

TRANSFER ALTITUDE TO 20000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0.0	0.0	0.0	57881.	0.
0.0	0.0	0.0	57881.	20000.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS

TEMPERATURE = -12.3 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	L/D	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
0.0	0.0	0.0	0.0	57881.	20000.	197.5	2522.0	T	0.941	144.2	0.321	0.585	.03427	0.741
1.419	0.3088	4.596	4.596	57881.	12592.	5774.	10808.		12801.	0.3982	0.1477	1.996	525.0	
0.005	1.00	29.2	29.2	57851.	20000.	197.5	2522.0	T	0.941	144.2	0.321	0.585	.03429	0.741
1.419	0.3086	4.596	4.596	57851.	12587.	5774.	10808.		12801.	0.3982	0.1477	1.996	525.0	
0.005	1.00	29.2	29.2	57851.	20000.	197.5	2522.0	T	0.941	144.2	0.321	0.585	.03429	0.741
1.419	0.3086	4.596	4.596	57851.	12587.	5774.	10808.		12801.	0.3982	0.1477	1.996	525.0	

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MISSION FUEL REQUIRED = 29.18  
 RESERVE FUEL REQUIRED = 0.0  
 TOTAL FUEL REQUIRED = 29.18

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

V A S C O M P II

MISSION PERFORMANCE DATA

GROSS WEIGHT = 57881. LB  
 ALTITUDE = 1000.0 FT  
 TEMPERATURE = 55.434 DEG. F.  
 W/Delta = .60018. LB  
 DELTRTH = 0.961  
 DELTA = 0.964  
 THETA = 0.993

TAS (KTS)	TOTAL FUEL FLOW (LBS/HR)	L/D	THRUST TO WEIGHT (LBS)	EAS (KTS)	FUEL PRIM. ENG (LBS/HR)	TURB. TEMP. (R)	PETF OR PEHF	MACH	MACH DIV	SPEC. RANGE (NMPP)	BHP	FM
CL	CD		LIFT (LBS)	DRAG (LBS)	FUEL FLOW* (LBS/HR)	J	LETF	CP	CT	VTIP (FPS)	NET THRUST	ETAP PROP
0.0	8000.9	---	57881.	0.0	8000.9	2394.7	0.720	0.0	0.678	.0	14342.	0.736
55.1	6508.6	1.447	57881.	54.3	6508.6	2247.6	0.514	0.084	0.018	.008469	10236.	0.695
9.996	6.9100			40010.	0.0	0.368	0.0	0.0614	0.1160	795.3	0.	
60.0	6243.7	1.697	57881.	59.1	6243.7	2220.9	0.476	0.091	0.121	.009610	9484.	0.697
8.437	4.9720			34108.	0.0	0.400	0.0	0.0569	0.0991	795.3	0.	
80.0	5601.7	2.800	57881.	78.8	5601.7	2155.4	0.383	0.121	0.365	.014281	7635.	0.704
4.746	1.6950			20671.	0.0	0.534	0.0	0.0458	0.0603	795.3	0.	
100.0	5381.3	3.800	57881.	98.5	5381.3	2132.0	0.351	0.152	0.478	.018583	6996.	0.709
3.037	0.7994			15233.	0.0	0.667	0.0	0.0419	0.0446	795.3	0.	
120.0	5435.2	4.415	57881.	118.3	5435.2	2137.7	0.360	0.182	0.539	.022078	7164.	0.715
2.109	0.4778			13109.	0.0	0.801	0.0	0.0429	0.0383	795.3	0.	
140.0	5708.7	4.560	57881.	138.0	5708.7	2166.0	0.402	0.212	0.576	.024524	8005.	0.720
1.550	0.3399			12693.	0.0	0.934	0.0	0.0480	0.0370	795.3	0.	
160.0	6200.2	4.347	57881.	157.7	6200.2	2216.2	0.476	0.243	0.600	.025806	9478.	0.727
1.187	0.2729			13314.	0.0	1.067	0.0	0.0568	0.0387	795.3	0.	
180.0	6931.4	3.950	57881.	177.4	6931.4	2288.8	0.582	0.273	0.616	.025969	11572.	0.733
0.937	0.2373			14652.	0.0	1.201	0.0	0.0695	0.0424	795.3	0.	
200.0	7938.1	3.500	57881.	197.1	7938.1	2385.0	0.721	0.303	0.628	.025195	14374.	0.738
0.759	0.2170			16537.	0.0	1.334	0.0	0.0862	0.0477	795.3	0.	
220.0	9300.7	3.067	57881.	216.8	9300.7	2499.4	0.899	0.334	0.637	.023654	17908.	0.742
0.628	0.2047			18875.	0.0	1.468	0.0	0.1073	0.0543	795.3	0.	
225.0	9698.4	---	---	221.7	9698.4	2534.9	0.949	0.341	0.639	.023200	18000.	---



0.600 0.2024 2.965 57881. 19523. 0.0 1.501 0.0 0.1133 0.0561 795.3 U. U./43

MAIN TRANSMISSION TORQUE LIMIT (ALL ENGINES OPERATING) OCCURS AT  
V = 227.7 KTAS  
MAIN ROTOR VIIP = 795.3 FT/SEC  
MAIN ROTOR RPM = 434.0  
POWER = 19956. SHP  
TORQUE = 241501. FT-LB

V(MAX PWR) = 227.7 KTAS SPEC.RANGE = 0.0223 NM/LB Q  
V(MIL PWR) = 227.7 KTAS SPEC.RANGE = 0.0223 NM/LB Q  
V(NRP) = 222.1 KTAS SPEC.RANGE = 0.0228 NM/LB T  
V(BEST RANGE) = 173.0 KTAS SPEC.RANGE = 0.0254 NM/LB P  
V(99 PERCENT BR) = 187.5 KTAS SPEC.RANGE = 0.0252 NM/LB P  
V(BEST ENDURANCE) = 102.7 KTAS FUEL FLOW = 5443. LB/HR P

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END OF SUCCESSFUL CASE

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V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUMBER GIVEN ON INPUT SHEET  
 NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. =5)  
 VAL1 EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL2 EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.+0001  
 VAL3 EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.+0002  
 VAL4 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
200	1	1.0000				
256	1	7403.3				
2351	1	7.0000				
2352	5	.0	.7500E-01	.16670	.30640	.53220
2357	2	.76110	1.3330			
2362	1	3.0000				
2363	3	.50000	.70000	.90000		
2369	5	.0	.10700	.26700	.45810	.68600
2374	2	.75300	.10700	.26700	.45810	.68600
2379	5	.0	.72110			
2384	2	.75300	.10700	.26700	.45810	.68600
2389	5	.0	.72110			
2394	2	.75300	.10700	.26700	.45810	.68600
1700	1	7403.3				
1701	1	11.000				
1702	5	.10000E-01	.50000	1.00000	1.50000	2.00000
1707	5	2.50000	3.00000	3.50000	4.00000	4.50000
1712	1	9.0000				
1722	1	12.000				
1723	5	.14000E-03	.68000E-02	.15000E-01	.27400E-01	.47900E-01
1728	5	.68500E-01	.82100E-01	.95700E-01	1.20000	1.50000
1733	2	.17500	.60000			
1743	5	.39000E-02	.41000E-02	.48000E-02	.65000E-02	.82000E-02
1748	5	.11000E-01	.15500E-01	.21500E-01	.35000E-01	.57000E-01
1753	1	.85000E-01				
1763	5	.42000E-02	.79000E-02	.10700E-01	.15600E-01	.20600E-01
1768	5	.26300E-01	.33700E-01	.45100E-01	.69900E-01	1.05500
1773	1	.15300				
1783	5	.55000E-02	.12000E-01	.18500E-01	.28000E-01	.36800E-01
1788	5	.47000E-01	.59500E-01	.74000E-01	1.01000	1.55500
1793	1	.23300				
1803	5	.79000E-02	.18400E-01	.31400E-01	.46900E-01	.62300E-01
1808	5	.78400E-01	.95800E-01	.11870	.15710	.23350
1813	1	.33900				
1823	5	.12200E-01	.30500E-01	.53500E-01	.79500E-01	1.05300
1828	5	.13200	.16030	.19410	.25400	.35750
1833	1	.52500				
1843	5	.19000E-01	.44200E-01	.76900E-01	1.13500	1.49500
1848	5	.18710	.22630	.27270	.35360	.48950
1853	1	.70450				
1863	5	.24600E-01	.54200E-01	.93200E-01	1.36800	1.79800
1868	5	.22460	.27120	.32690	.42820	.59700

1873	1	.90600	.64900E-01	.11050	.16080	.21070
1883	5	.31500E-01	.31690	.38200	.50570	.72350
1888	5	.26270				
1893	1	1.0980				
1903	5	.46000E-01	.87000E-01	.14480	.20300	.27050
1908	5	.33800	.40450	.48000	.65200	.93300
1913	1	1.3900				
1923	5	.75000E-01	.12800	.19150	.26600	.35000
1928	5	.40000	.53600	.67000	.87700	1.2320
1933	1	1.8200				
1943	5	.11700	.17800	.25600	.34800	.45300
1948	5	.56750	.68900	.85300	1.1130	1.5230
1953	1	2.1000				
1963	5	.16600	.24400	.34250	.46100	.59700
1968	5	.74600	.90000	1.1110	1.4325	1.8940
1973	1	2.4300				
MG = 0.350000E+05		WFA = 0.158807E+05	WFR = 0.291773E+02			
MG = 0.350000E+05		WFA = 0.959688E+03	WFR = 0.873029E+04			
MG = 0.461008E+05		WFA = 0.792232E+04	WFR = 0.109142E+05			
MG = 0.530510E+05		WFA = 0.122040E+05	WFR = 0.123707E+05			

V A S C O M P . I I  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

S I Z E D A T A THIS RUN CONVERGED IN 4 ITERATIONS

GROSS WEIGHT = 53461. LB

FUSELAGE	LENGTH	46.5	FT
LF	WIDTH	7.2	FT
WF	WETTED AREA	999.	SQFT
SF			
WING	ASPECT RATIO	6.00	
AR	AREA	534.6	SQFT
SW	SPAN	56.6	FT
B	GEOM. MEAN CHORD	9.4	FT
CBARW	QUARTER CHORD SWEEP	0.0	DEG
LAMBDA C/4	TAPER RATIO	1.000	
LAMBDA	ROOT THICKNESS	0.180	
(T/C)R	TIP THICKNESS	0.180	
(T/C)T	WING LOADING	100.0	LB/SQFT
WG/SW	MEAN CHORD / PROP. DIA.	0.270	
C BAR / D			
HOR. TAIL	ASPECT RATIO	4.00	
ARHT	AREA	233.7	SQFT
SHT	SPAN	30.6	FT
BHT	MEAN CHORD	7.6	FT
CBARHT	THICKNESS / CHORD	0.150	
(T/C)HT	MOMENT ARM	22.7	FT
LTH			
VERT. TAIL	ASPECT RATIO	1.15	
ARVT	AREA	193.8	SQFT
SVT	SPAN	14.9	FT
BVT	MEAN CHORD	13.0	FT
CBARVT	THICKNESS / CHORD	0.150	
(T/C)VT	MOMENT ARM	20.0	FT
LTV			
PRIMARY ENG. NACELLE	LENGTH	0.0	FT
LN	MEAN DIAMETER	0.0	FT
DBARN	WETTED AREA	0.0	SQFT
SN			
LIFT ENG. NACELLE	NO LIFT PROPULSION SELECTED		
PROPELLER	DIAMETER	35.0	FT
D	SOLIDITY	0.116	
SIGMA R/P	DISC LOADING	27.8	LB/SQFT
WG/A	THRUST COEFF. / SOLIDITY	0.462	
CT/SIGMA	NO. OF PROPELLERS	2.000	
NR	NO. OF BLADES/PROP	3.000	
NO. BLADES			

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

V A S C O M P II

W E I G H T S D A T A I N L B S

2.985

GUST LOAD FACTOR

GLF

STRUCTURES GROUP

K8 MW 3157.  
 K9 WHT 574.  
 K10 WVT 366.  
 K11 WB 3865.  
 K12 WLG 1818.  
 K13 WLES 0.  
 K14 WPES 0.  
 DELTA WST 1300.  
 WST 11080.

PROPULSION GROUP

K2 WR/P 2666.  
 K3 WDS 5038.  
 K4 WEL 0.  
 K5 WEP 2851.  
 K6 WLEI 0.  
 K7 WPEI 1055.  
 K21 WFS 1868.  
 DELTA WP 100.  
 WP 13579.

FLIGHT CONTROLS GROUP

K15 MCC 133.  
 K16 MUC 1049.  
 K17 MH 846.  
 K18 MFW 642.  
 K19 WSAS 75.  
 K20 WTH 802.  
 DELTA WFC 0.  
 WFC 3545.

WFE

WEIGHT OF FIXED EQUIPMENT

5622.

WE

WEIGHT EMPTY

33826.

WFUL

FIXED USEFUL LOAD

1550.

OWE

OPERATING WEIGHT EMPTY

35376.

WPL

PAYLOAD

5630.

(WF)A

FUEL

12454.

WG

GROSS WEIGHT

(WF)W

12454.

53461.

V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
V A S C O M P II

PROPELLSION DATA  
PRIMARY PROPULSION CYCLE NO. 1.820  
TURBOSHIFT ENGINE

4. ENGINES  
BHP\*P MAX. STANDARD S.L. STATIC H.P. 22252. H.P.

ENGINE SIZED FOR TAKEOFF AT T/W = 1.20  
90.0 PERCENT MILITARY POWER SETTING  
VERTICAL RATE OF CLIMB = 500.0 FT/MIN  
H = 0. FT, TEMPERATURE = 89.80 DEG F,  
AND 0.0 ENGINES INOPERATIVE.  
NO CRUISE CONDITION SPECIFIED.

NO LIFT ENGINE CYCLE SELECTED

XMSN SIZED AT 95. PERCENT OF ROTOR HOVER POWER REQUIRED  
AT H= 0. FT, TEMP= 89.80 DEG.F., 100.0 PERCENT HOVER RPM

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

A E R O D Y N A M I C S D A T A			
FE	TOTAL EFFECTIVE FLATPLATE AREA	93.049	SQFT
SMET	TOTAL WETTED AREA	2856.	SQFT
CBARF	MEAN SKIN FRICTION COEFF.	0.032580	
D R A G B R E A K D O W N			
FEN	WING FE	0.0	
FEF	FUSELAGE FE	6.415	
FEVT	VERT. TAIL FE	0.0	
FEHT	HOR. TAIL FE	0.0	
FEN	PRIMARY ENG. NACELLE FE	0.0	
FELN	LIFT ENG. NACELLE FE	0.0	
DELTA FE	INCREMENTAL FE	86.633	
A E R O D Y N A M I C C O E F F .			
A1		0.67820	
A2		-0.06600	
A3		0.08608	
A4		0.13500	
A5		0.1405	
A6		1.31108	
A7		0.06734	
CL ALPHA	3-D LIFT SLOPE	5.20400	PER RADIAN
E	OSWALD FACTOR	0.78782	

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
MISSION PERFORMANCE DATA

TAKEOFF, HOVER, OR LAND AT PETF = 1.000 LETF = 0.0 FOR 0.042 HRS.  
VERTICAL RATE OF CLIMB = 300.0 FT/MIN TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VIIP (FPS)
0.0	0.0	0.0	53461.	0.	0.0	2526.6	Q	1.000	0.0	1.361	0.63	19692.	0.2193	750.
0.021	0.0	206.0	53255.	0.	0.0	2526.6	Q	1.000	0.0	1.367	0.633	19692.	0.2193	750.
0.042	0.0	412.0	53049.	0.	0.0	2526.6	Q	1.000	0.0	1.372	0.633	19692.	0.2193	750.
0.042	0.0	412.1	53049.	0.	0.0	2526.6	Q	1.000	0.0	1.372	0.633	19692.	0.2193	750.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPT)	ETAP PROP
0.042	0.0	412.1	53049.	0.	200.5	2265.1	P	0.549	200.5	0.303	0.630	0.2766	0.898
0.728	0.2147	3.390	53049.	15647.	7001.	11258.		15930.	0.0636	0.0427	1.338	795.3	
0.052	2.00	481.9	52979.	0.	200.5	2264.9	P	0.549	200.5	0.303	0.630	0.2766	0.898
0.727	0.2147	3.387	52979.	15640.	7000.	11253.		15923.	0.0635	0.0427	1.338	795.3	
0.052	2.00	481.9	52979.	0.	200.5	2264.9	P	0.549	200.5	0.303	0.630	0.2866	0.898
0.727	0.2147	3.387	52979.	15640.	7000.	11253.		15923.	0.0635	0.0427	1.338	795.3	

TRANSFER ALTITUDE TO 3000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0.052	2.00	481.9	52979.	0.
0.052	2.00	481.9	52979.	3000.

TAKEOFF, HOVER, OR LAND AT T/W = 1.122 FOR 0.033 HRS.  
VERTICAL RATE OF CLIMB = 0.0 FT/MIN TEMPERATURE = 91.5 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	LETF	THRUST TO WEIGHT	FM	BHP	CT	VIIP (FPS)
0.052	2.00	481.9	52979.	3000.	0.0	2602.5	P	0.941	0.0	1.122	0.633	15663.	0.2124	750.
0.068	2.00	620.6	52840.	3000.	0.0	2600.3	P	0.937	0.0	1.122	0.633	15602.	0.2118	750.
0.085	2.00	758.9	52702.	3000.	0.0	2598.1	P	0.933	0.0	1.122	0.633	15542.	0.2113	750.

CHANGE PAYLOAD, REMOVE 5520. LB.

FUEL PRES.



TIME (HRS)	RANGE (N.M.)	USED (LBS)	WEIGHT (LBS.)	ALT. (FT.)
0.085	2.00	758.9	52702.	3000.
0.093	2.00	758.9	47182.	3000.

TRANSFER ALTITUDE TO 0. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT.)
0.093	2.00	758.9	47182.	3000.
0.093	2.00	758.9	47182.	0.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT.)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETIF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP
0.093	2.00	758.9	47182.	0.	173.0	2088.7	P	0.555	173.0	0.261	0.621	.03297	0.911
0.870	0.2250	3.866	47182.	12205.	5251.	7535.		12538.	0.1479	0.0771	1.748	525.0	
0.313	40.00	1911.3	46030.	0.	172.0	2079.9	P	0.543	172.0	0.260	0.622	.03325	0.911
0.858	0.2237	3.838	46030.	11993.	5176.	7365.		12328.	0.1446	0.0758	1.738	525.0	
0.545	80.00	3114.3	44827.	0.	171.5	2073.2	P	0.533	171.5	0.259	0.623	.03352	0.912
0.841	0.2217	3.793	44827.	11817.	5121.	7238.		12153.	0.1421	0.0747	1.733	525.0	
0.779	120.00	4307.7	43633.	0.	171.0	2066.7	P	0.524	171.0	0.258	0.624	.03378	0.912
0.823	0.2197	3.747	43633.	11643.	5067.	7113.		11980.	0.1396	0.0737	1.728	525.0	
1.013	160.00	5492.0	42449.	0.	170.5	2060.3	P	0.515	170.5	0.258	0.625	.03403	0.912
0.806	0.2178	3.700	42449.	11474.	5014.	6991.		11811.	0.1372	0.0726	1.723	525.0	
1.247	200.00	6667.4	41274.	0.	170.0	2054.0	P	0.506	170.0	0.257	0.626	.03428	0.912
0.788	0.2159	3.650	41274.	11307.	4962.	6872.		11646.	0.1349	0.0716	1.718	525.0	
1.483	240.00	7834.1	40107.	0.	169.0	2045.5	P	0.495	169.0	0.255	0.627	.03456	0.912
0.775	0.2145	3.612	40107.	11102.	4894.	6713.		11443.	0.1318	0.0704	1.708	525.0	
1.719	280.00	8991.5	38949.	0.	168.5	2039.4	P	0.486	168.5	0.255	0.628	.03480	0.912
0.757	0.2126	3.560	38949.	10942.	4845.	6599.		11284.	0.1296	0.0694	1.703	525.0	
1.957	320.00	10140.9	37800.	0.	168.0	2033.5	P	0.478	168.0	0.254	0.629	.03504	0.912
0.739	0.2108	3.505	37800.	10785.	4798.	6489.		11128.	0.1274	0.0684	1.698	525.0	
2.195	360.00	11282.5	36658.	0.	167.5	2027.6	P	0.470	167.5	0.253	0.631	.03527	0.912
0.721	0.2090	3.448	36658.	10630.	4752.	6380.		10974.	0.1253	0.0675	1.693	525.0	
2.434	400.00	12416.6	35524.	0.	167.0	2021.9	P	0.462	167.0	0.252	0.632	.03550	0.912
0.703	0.2073	3.390	35524.	10479.	4708.	6275.		10824.	0.1232	0.0666	1.688	525.0	
2.634	400.00	12416.6	35524.	0.	167.0	2021.9	P	0.462	167.0	0.252	0.632	.03550	0.912
0.703	0.2073	3.390	35524.	10479.	4708.	6275.		10824.	0.1232	0.0666	1.688	525.0	

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LOITER FOR 0.010 HRS.

TEMPERATURE = 59.0 DEG.F

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	FUEL RATE (LB-HR)	ETAP PROP
CL	CD	L/D	LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	BHP		THRUST (LBS)	CP	CT	J	VTIP (FPS)	ETAP
2.434	400.00	12416.6	35524.	0.	87.0	1967.6	P	0.163	87.0	0.131	0.507	4304.	0.760
2.589	0.6306	4.106	35524.	8651.	4304.	3336.		9202.	0.0188	0.0247	0.580	795.3	0.760
2.444	400.00	12459.6	35481.	0.	88.0	1967.3	P	0.163	88.0	0.133	0.511	4303.	0.761
2.528	0.6094	4.148	35481.	8553.	4303.	3331.		9099.	0.0188	0.0244	0.587	795.3	0.761

MISSION FUEL REQUIRED = 12459.62  
 RESERVE FUEL REQUIRED = 0.0  
 TOTAL FUEL REQUIRED = 12459.62

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

CRUISE AT		NORMAL		ENGINE RATING		TEMPERATURE = 59.0 DEG.F									
TIME (HRS)	RANGE (N.M.)	CD	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	TAS (KTS)	TURB. TEMP. (R)	ENG. CODE	PETF OR PEHF	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP	
0.0	0.0	0.0	0.0	53461.	0.	219.1	2348.6	Q	1.000	219.1	0.331	0.638	.02768	0.900	
0.614	0.1995	0.1995	3.080	53461.	7356.	7915.	13572.		17613.	0.2664	0.1083	2.214	525.0		
0.005	1.00	1.00	36.1	53425.	0.	219.1	2348.6	Q	1.000	219.1	0.331	0.638	.02769	0.900	
0.614	0.1994	0.1994	3.078	53425.	17355.	7915.	13572.		17612.	0.2664	0.1083	2.215	525.0		

MISSION FUEL REQUIRED = 36.12  
RESERVE FUEL REQUIRED = 0.0  
TOTAL FUEL REQUIRED = 36.12

V A S C O M P II  
 V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
 MISSION PERFORMANCE DATA

TRANSFER ALTITUDE TO 20000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0.0	0.0	0.0	53461.	0.
0.0	0.0	0.0	53461.	20000.

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS

TIME (HRS)	CL	RANGE (N.M.)	CD	FUEL USED (LBS)	L/D	WEIGHT (LBS.)	PRES. ALT. (FT)	DRAG (LBS)	LIFT (LBS)	TURB. TEMP. (R)	TAS (KTS)	FUEL FLOW (LBS/HR)	BHP	ENG. CODE	PETF OR PEHF	THRUST (LBS)	EAS	MACH	MACH DIV	SPEC. RANGE (NMPP)	ETAP PROP	TEMPERATURE = 12.3 DEG.F
0.0		0.0	0.0	0.0		53461.	20000.	20000.	53461.							0.739	148.5	0.331	0.590	0.4281	0.886	
1.337		0.2944	0.2944	4.541	4.541	53461.	11773.	11773.	53461.	2260.0	203.5	4757.	8757.	P	12048.	12048.	0.3227	0.1390	2.057	525.0		
0.005		1.00	1.00	23.4	23.4	53438.	20000.	20000.	53438.	2259.6	203.5	4755.	8754.	P	0.739	12044.	148.5	0.331	0.590	0.4283	0.886	
1.336		0.2943	0.2943	4.541	4.541	53438.	11759.	11759.	53438.	8754.	4755.	4755.	8754.	P	12044.	12044.	0.3225	0.1390	2.057	525.0		
0.005		1.00	1.00	23.4	23.4	53438.	20000.	20000.	53438.	2259.6	203.5	4755.	8754.	P	0.739	12044.	148.5	0.331	0.590	0.4283	0.886	
1.336		0.2943	0.2943	4.541	4.541	53438.	11769.	11769.	53438.	8754.	4755.	4755.	8754.	P	12044.	12044.	0.3225	0.1390	2.057	525.0		

MISSION FUEL REQUIRED = 23.36  
 RESERVE FUEL REQUIRED = 0.0  
 TOTAL FUEL REQUIRED = 23.36

V A S C O M P II  
V/STOL AIRCRAFT SIZING & PERFORMANCE COMPUTER PROGRAM B-93

MISSION PERFORMANCE DATA

GROSS WEIGHT = 53461. LB  
ALTITUDE = 1000.0 FT  
TEMPERATURE = 55.434 DEG..F.  
W/Delta = 55435. LB  
DELTRTH = 0.961  
DELTA = 0.964  
THETA = 0.993

TAS (KTS)	CL	CD	L/D	THRUST TO WEIGHT	EAS (KTS)	FUEL PRIM. (LBS/HR)	FUEL FLOW PRIM. ENG. (LBS/HR)	TURB. TEMP. (R)	PETW OR PEHF	MACH	MACH DIV	SPEC. RANGE (NMPP)	BHP	FM
				LIFT (LBS)	DRAG (LBS)	FUEL FLOW (LBS/HR)	FUEL FLOW (LBS/HR)	J	LETF	CP	CT	VTIP (FPS)	NET THRUST	ETAP PROP
0.0	---	8250.5	---	1.122 53461.	0.0	8250.5	0.0	2395.8 0.0	0.722 0.0	0.0	0.678 0.1655	0	14805.	0.633
55.1	---	6626.6	1.446	---	54.3	6626.6	0.0	2240.3 0.368	0.504 0.0	0.084 0.0619	0.018 0.1072	.008318	10325.	---
60.0	---	6142.4	1.697	---	59.1	6142.4	0.0	2192.7 0.400	0.436 0.0	0.091 0.0536	0.121 0.0917	.009768	8939.	---
8.437	---	4.9730	---	53461.	31510.	---	---	---	---	---	---	---	---	0.685
80.0	---	5200.1	2.799	---	78.8	5200.1	0.0	2092.9 0.534	0.305 0.0	0.121 0.0374	0.365 0.0561	.015384	6245.	---
4.746	---	1.6959	---	53461.	19103.	---	---	---	---	---	---	---	---	0.800
100.0	---	4938.3	3.795	---	98.5	4938.3	0.0	2060.9 0.667	0.269 0.0	0.152 0.0331	0.478 0.0416	.020250	5515.	---
3.037	---	0.8003	---	53461.	14086.	---	---	---	---	---	---	---	---	0.839
120.0	---	4948.5	4.407	---	118.3	4948.5	0.0	2062.0 0.801	0.271 0.0	0.182 0.0333	0.539 0.0358	.024250	5554.	---
2.109	---	0.4787	---	53461.	12132.	---	---	---	---	---	---	---	---	0.861
140.0	---	5149.2	4.548	---	138.0	5149.2	0.0	2086.3 0.934	0.299 0.0	0.212 0.0368	0.576 0.0346	.027188	6.38.	---
1.550	---	0.3408	---	53461.	11756.	---	---	---	---	---	---	---	---	0.877
160.0	---	5537.5	4.333	---	157.7	5537.5	0.0	2131.5 1.067	0.353 0.0	0.243 0.0435	0.600 0.0361	.028394	7250.	---
1.187	---	0.2739	---	53461.	12339.	---	---	---	---	---	---	---	---	0.887
180.0	---	6075.0	3.935	---	177.4	6075.0	0.0	2185.7 1.201	0.433 0.0	0.273 0.0532	0.616 0.0395	.029629	8874.	---
0.937	---	0.2382	---	53461.	13585.	---	---	---	---	---	---	---	---	0.892
200.0	---	6803.8	3.485	---	197.1	6803.8	0.0	2256.8 1.334	0.537 0.0	0.303 0.0660	0.628 0.0444	.029395	11011.	---
0.759	---	0.2179	---	53461.	15339.	---	---	---	---	---	---	---	---	0.898
220.0	---	7761.0	3.053	---	216.8	7761.0	0.0	2346.7 1.468	0.668 0.0	0.334 0.0821	0.637 0.0506	.028347	13699.	---
0.628	---	0.2056	---	53461.	17512.	---	---	---	---	---	---	---	---	0.904
225.0	---	8040.0	---	---	221.7	8040.0	0.0	2372.2	0.705	0.341	0.639	.027985	14461.	---

0.600 0.2033 2.951 53461. 18114. 0.0 1.501 0.0 0.0867 0.0522 795.3 0. 0.905

MAIN TRANSMISSION TORQUE LIMIT (ALL ENGINES OPERATING) OCCURS AT  
V  
MAIN ROTOR VTIP = 255.9 KTAS  
MAIN ROTUR RPM = 795.3 FT/SEC  
POWER = 434.0  
TORQUE = 20548. SHP  
TORQUE = 248665. FT-LB

V(MAX PWR) = 255.9 KTAS SPEC. RANGE = 0.0244 NM/LB Q  
V(MIL PWR) = 255.9 KTAS SPEC. RANGE = 0.0244 NM/LB Q  
V(NRP) = 250.5 KTAS SPEC. RANGE = 0.0249 NM/LB T  
V(BEST RANGE) = 185.0 KTAS SPEC. RANGE = 0.0289 NM/LB P  
V(99 PERCENT BR) = 201.0 KTAS SPEC. RANGE = 0.0286 NM/LB P  
V(BEST ENDURANCE) = 106.7 KTAS FUEL FLOW = 5009. LB/HK P

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END OF SUCCESSFUL CASE

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