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Warminster, PA 18974

Attention: Code 6051

Subject: Contract N62269-79-C-0217 -  
Improved Helicopter Sizing and  
Performance Computer Program  
(HESCOMP); HESCOMP Users Manual.

Enclosure: (1) HESCOMP Software (1 copy)  
(2) HESCOMP Users Manual (5 copies)

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1. In accordance with Data Sequence Items A002 and A003 of the Contract Data Requirements List, submitted as Enclosure (1) is the HESCOMP Software which includes one (1) IBM Magnetic Tape and one (1) set of sample cases in the form of IBM punched card inputs and line printer output and submitted as Enclosure (2) is the HESCOMP Users Manual.

2. Upon completion of the one-day oral review to be conducted at NADC on 6 December 1979, all direct activity required under the subject contract will


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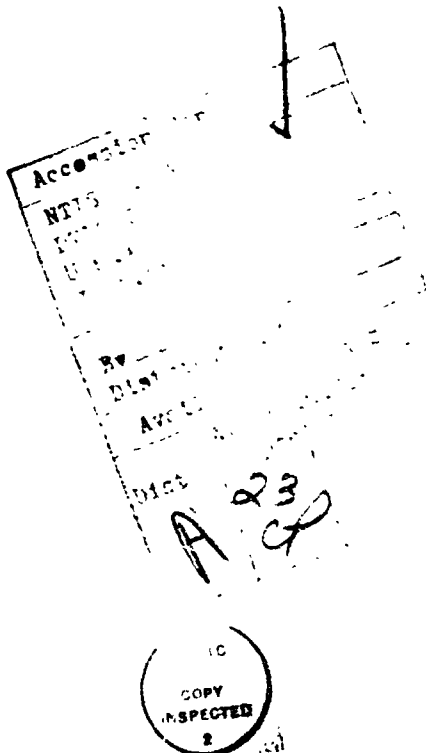
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The program has two primary independent applications, a third which is a combination of the first two, and a fourth option used for obtaining aircraft weight only. It may be used for the sizing of helicopters for which the type of aircraft and the mission profile are specified. Alternatively, it 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 a helicopter for a given mission and then calculate the off-design point performance for other missions. IT

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.

The program contains size trends equations which reflect the variation of helicopter 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, a library of rotor cycle data, and a variety of optional procedures for calculating rotor and propeller (propeller only) performance.

The program can be used to study any single, tandem, or coaxial pure, wing compound, or auxiliary propulsion helicopter.



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# **USER'S MANUAL FOR HESCOMP THE HELICOPTER SIZING AND PERFORMANCE COMPUTER PROGRAM**

Developed under  
Contract No. NAS2-6107 (Study of the Methodology for Evaluation  
of an Interurban and Intraurban V/STOL  
Transportation System)

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## FOREWORD

HESCOMP, the Helicopter Sizing and Performance Computer Program, provides helicopter designers with the same capability for sizing and performance calculations that VASCOMP II provides for fixed-wing aircraft designers.

Since in time the program will change to reflect new thinking and grow to include more sophisticated methods of simulating advanced helicopters, this User's Manual is loose-leaf bound to facilitate updating of the program.

Inquiries regarding the program should be directed to the authors.



# CONTENTS

	<u>Page</u>
FOREWORD . . . . .	i
LIST OF ILLUSTRATIONS . . . . .	ii
LIST OF TABLES . . . . .	xi
1.0 INTRODUCTION . . . . .	1-1
1.1 Background . . . . .	1-1
1.2 Application . . . . .	1-2
2.0 SPECIFICATION OF HELICOPTER CHARACTERISTICS . . . . .	2-1
2.1 Helicopter Geometry . . . . .	2-1
2.2 Propulsion System . . . . .	2-2
2.3 Helicopter Weight Summary . . . . .	2-10
2.4 Aerodynamic Characteristics . . . . .	2-10
2.5 Rotor Characteristics . . . . .	2-10
3.0 PROGRAM OPERATION . . . . .	3-1
3.1 General . . . . .	3-1
3.1.1 The Option Indicator . . . . .	3-1
3.1.2 Description of Mission Profile . . . . .	3-2
3.1.3 Special Flight Path Control Option . . . . .	3-5
3.1.4 Propeller Efficiency . . . . .	3-6
3.1.5 Rotor Power Required Calculation . . . . .	3-6
3.2 Program Options . . . . .	3-7
3.2.1 Propulsion Indicators . . . . .	3-7
3.2.2 Aerodynamics Indicators . . . . .	3-10
3.2.3 Size Trends Indicators . . . . .	3-10
3.2.4 Mission Performance Indicators . . . . .	3-13
3.2.5 Flight Path Control Indicators . . . . .	3-15
3.2.6 Atmosphere Indicator . . . . .	3-15
3.2.7 Optional Print Indicator . . . . .	3-15
3.3 Program Flow . . . . .	3-16
3.4 Subroutine Cross Reference . . . . .	3-21
4.0 DETAILED PROGRAM DESCRIPTION . . . . .	4-1
4.1 Main Control Loop . . . . .	4-1
4.2 Atmosphere Subroutine . . . . .	4-15
4.3 Drag Calculations Subroutine . . . . .	4-17

	<u>Page</u>
4.4 Engine Library and Engine Cycle Subroutines . . . . .	4-19
4.5 Rotor Performance Subroutine . . . . .	4-49
4.6 Rotor Limits Subroutine . . . . .	4-85
4.7 Propeller Performance Calculations . . . . .	4-96
4.8 Size Trends Subroutine . . . . .	4-114
4.9 Aerodynamics Calculations Subroutine . . . . .	4-138
4.10 Engine Sizing Subroutine . . . . .	4-157
4.11 Weight Trends Subroutine . . . . .	4-174
4.11.1 Weight Trend Data . . . . .	4-174
4.11.2 Aircraft Balance . . . . .	4-216
4.12 Performance Calculations Subprogram . . . . .	4-225
4.12.1 Taxi Calculations Subroutine . . . . .	4-232
4.12.2 Takeoff, Hover, and Landing Calculations Subroutine . . . . .	4-235
4.12.3 Climb Calculations Subroutine . . . . .	4-240
4.12.4 Cruise Calculations Subroutine . . . . .	4-257
4.12.5 Descent Calculations Subroutine . . . . .	4-290
4.12.6 Loiter Calculations Subroutine . . . . .	4-307
4.12.7 Change of Weight Subroutine . . . . .	4-320
4.12.8 Transfer Altitude . . . . .	4-323
4.12.9 General Performance Calculations Subroutine . . . . .	4-325
4.12.10 Function BIV Subroutine . . . . .	4-335
4.12.11 Function PARA Subroutine . . . . .	4-338
4.12.12 Function TABLE Subroutine . . . . .	4-340
4.12.13 Function TRIV Subroutine . . . . .	4-343
4.12.14 Function XLINT Subroutine . . . . .	4-349
4.12.15 Function XLKUP Subroutine . . . . .	4-351
4.12.16 Function KIBIV Subroutine . . . . .	4-354
5.0 PROGRAM INPUT . . . . .	5-1
5.1 General . . . . .	5-1
5.1.1 General Information . . . . .	5-1
5.1.2 Aircraft Description Information . . . . .	5-2
5.1.2.1 Dimensional Information . . . . .	5-2
5.1.2.2 Propulsion Information . . . . .	5-2
5.1.2.3 Aerodynamics Information . . . . .	5-2
5.1.2.4 Weights Information . . . . .	5-2
5.1.2.5 Rotor Limits Information . . . . .	5-3
5.1.2.6 Non-Standard Atmosphere Information . . . . .	5-3

	<u>Page</u>
5.1.3	Mission Profile Information . . . . . 5-3
5.1.4	Rotor Tip Speed Schedule . . . . . 5-4
5.1.5	Auxiliary Propulsion Schedule Input . . . . . 5-4
5.1.6	Engine Cycle Information . . . . . 5-4
5.1.7	Rotor Performance Data . . . . . 5-5
5.1.8	Propeller Performance Data . . . . . 5-5
5.1.9	Supplementary Information . . . . . 5-6
5.2	Specimen Input Sheet . . . . . 5-7
5.3	Program Input . . . . . 5-50
5.3.1	Program Variables . . . . . 5-50
5.3.2	Program Indicators . . . . . 5-79
5.3.3	Fortran Variables . . . . . 5-89
6.0	PROGRAM OUTPUT . . . . . 6-1
6.1	Description of Printout . . . . . 6-1
6.1.1	General Printout . . . . . 6-1
6.1.2	Input Data . . . . . 6-2
6.1.3	Sizing Data . . . . . 6-2
6.1.4	Mission Performance Data . . . . . 6-11
6.2	List of Diagnostic Error Printouts . . . . . 6-19
6.2.1	Errors Affecting Main Control Loop . . . . . 6-19
6.2.2	Errors Related to Tabulated Inputs . . . . . 6-22
6.2.3	Errors Occuring in Performance Calculation . . . . . 6-25
7.0	PROGRAM USAGE . . . . . 7-1
7.1	Comments on Program Usage . . . . . 7-1
7.1.1	Rules . . . . . 7-1
7.1.2	Suggestions . . . . . 7-2
7.2	Discussion of Program Tolerances . . . . . 7-3
7.3	Sample Cases . . . . . 7-5
7.3.1	Single-Rotor Compound Helicopter (Auxiliary Independent Engines) . . . . . 7-7
7.3.2	Tandem-Rotor Winged Helicopter . . . . . 7-67
7.3.3	Coaxial-Rotor Helicopter with Auxiliary Propulsion . . . . . 7-116

	<u>Page</u>
7.3.4 Coaxial-Rotor Helicopter with Auxiliary Propulsion . . . . .	7-192
7.3.5 Single-Rotor Winged Helicopter .	7-259
References . . . . .	R-1

## ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
2-1	Typical Helicopter Geometry - Single Rotor Helicopter . . . . .	2-3
2-2	Typical Helicopter Geometry - Tandem Rotor Helicopter . . . . .	2-5
3-1	Sketch of Program Geometry . . . . .	3-16
4-1	Main Control Loop (MAIN) Flow Chart . . . . .	4-2
4-2	Atmosphere Subroutine, Flow Chart . . . . .	4-16
4-3	Drag Calculations (DRAG) Subroutine, Flow Chart . . . . .	4-18
4-4	Typical Reynolds Number Correction Factor for a Turboshaft Engine Cycle . . . . .	4-25
4-5	POWAVL Subroutine, Flow Chart . . . . .	4-27
4-6	POWREQ Subroutine, Flow Chart . . . . .	4-32
4-7	POWAVI Subroutine, Flow Chart . . . . .	4-33
4-8	POWRQI Subroutine, Flow Chart . . . . .	4-40
4-9	THRAVL Subroutine, Flow Chart . . . . .	4-42
4-10	THRREQ Subroutine, Flow Chart . . . . .	4-45
4-11	ENG 1 Subroutine, Flow Chart . . . . .	4-46
4-12	ENG 1 I Subroutine, Flow Chart . . . . .	4-47
4-13	Comparison of "Short Form Aero" Rotor Performance and Flight Test Data . . . . .	4-51
4-14	"Short Form Aero" Rotor Performance Equations Summary . . . . .	4-53
4-15	Non-Uniform Downwash as Stored in Block Data . . . . .	4-54
4-16	Download Sensitivity to Ground Proximity . . . . .	4-57
4-17	Thrust Augmentation in Ground Effect . . . . .	4-58

<u>Figure</u>		<u>Page</u>
4-18	HESCOMP Interpolation of Rotor L/C <sub>E</sub> vs. X/L . . . . .	4-60
4-19	ROTPOW Subroutine, Flow Chart . . . . .	4-62
4-20	Summary of Typical Rotor Limits . . . . .	4-87
4-21	ROTLIM Subroutine, Flow Chart . . . . .	4-89
4-22	Comparison of "Short Method" and Detailed Calculations for Propeller Hover and Cruise Efficiency . . . . .	4-101
4-23	THRUST Subroutine, Flow Chart . . . . .	4-103
4-24	POWER Subroutine, Flow Chart . . . . .	4-107
4-25	POWERI Subroutine, Flow Chart . . . . .	4-110
4-26	Tail Rotor Diameter Sizing Trend . . . . .	4-116
4-27	Tail Rotor/Vertical Tail Fin Interference Data . . . . .	4-118
4-28	Horizontal Tail Sizing . . . . .	4-122
4-29	Size Trends (SIZTR) Subroutine, Flow Chart . . . . .	4-126
4-30	Parasite Drag Buildup Options . . . . .	4-139
4-31	Typical Hub and Shank Drag Coefficients . . . . .	4-142
4-32	Rotor Hub/Shank Geometry Used in Program for Hub Drag Calculations . . . . .	4-144
4-33	Typical Parasite Drag Trends . . . . .	4-147
4-34	Aerodynamics Calculations (AERO) Subroutine, Flow Chart . . . . .	4-153
4-35	Engine Sizing Subroutine, Flow Chart . . . . .	4-161
4-36	Weight Trends Subroutine . . . . .	4-175
4-37	Weight Trends Subroutine, Flow Chart . . . . .	4-177
4-38	Rotor Blade Weight Trend . . . . .	4-190
4-39	Rotor Hub and Hinge Weight Trend . . . . .	4-191
4-40	Rotor Group Weight Trend . . . . .	4-193

<u>Figure</u>	<u>Page</u>
4-41 Body Group Weight Trend . . . . .	4-196
4-42 Drive System Weight Trend-Primary . . . . .	4-204
4-43 Drive System Weight Trend-Auxiliary . . . . .	4-206
4-44 Cockpit Controls Weight Trend . . . . .	4-208
4-45 Rotor Controls Weight Trend . . . . .	4-209
4-46 Rotor System and Hydraulics Weight Trend . .	4-210
4-47 Auxiliary Rotor Controls Weight Trend . . .	4-212
4-48 Performance Calculations Subprogram Flow Chart . . . . .	4-226
4-49 Taxi Calculations Subroutine, Flow Chart . .	4-233
4-50 Takeoff, Hover, and Landing Subroutine, Flow Chart . . . . .	4-236
4-51 Climb Calculations Subroutine, Flow Chart .	4-242
4-52 Cruise Calculations Subroutine, Flow Chart . . . . .	4-259
4-53 Descent Boundaries . . . . .	4-291
4-54 DESPOW Subroutine, Flow Chart . . . . .	4-294
4-55 Descent Calculations Subroutine, Flow Chart . . . . .	4-297
4-56 Loiter Calculations Subroutine, Flow Chart . . . . .	4-308
4-57 Change of Fuel Weight Subroutine, Flow Chart . . . . .	4-321
4-58 Change of Payload Weight Subroutine, Flow Chart . . . . .	4-322
4-59 Transfer Altitude Subroutine, Flow Chart . .	4-324
4-60 General Performance Subroutine, Flow Chart . . . . .	4-326
4-61 BIV Function, Flow Chart . . . . .	4-336

---

<u>Figure</u>		<u>Page</u>
4-62	PARA Function, Flow Chart . . . . .	4-339
4-63	TABLE Function, Flow Chart . . . . .	4-341
4-64	TRIV Function, Flow Chart . . . . .	4-344
4-65	XLINT Function, Flow Chart . . . . .	4-350
4-66	XLKUP Function, Flow Chart . . . . .	4-352
4-67	XIBIV Function, Flow Chart . . . . .	4-355
7-1	Design MSN - Sample Case No. 1 . . . . .	7-7
7-2	Design MSN - Sample Case No. 2 . . . . .	7-67
7-3	Design MSN - Sample Case No. 3 . . . . .	7-116
7-4	Design MSN - Sample Case No. 4 . . . . .	7-192
7-5	Design MSN - Sample Case No. 5 . . . . .	7-259



## TABLES

<u>Table</u>		<u>Page</u>
1-1	Helicopter Configurations Which may be Studied Using HESCOMP . . . . .	1-4
2-1	Typical Geometric Characteristics - Single Rotor Helicopters . . . . .	2-7
2-2	Typical Geometric Characteristics - Tandem Rotor Helicopters . . . . .	2-8
2-3	List of Engine Cycles . . . . .	2-9
2-4	List of Rotor Cycles . . . . .	2-11
3-1	Summary of Subroutines . . . . .	3-17
4-1	Engine Cycle Data Format . . . . .	4-20
4-2	HESCOMP Engine Library . . . . .	4-21
4-3	Coefficients for Propeller Equivalent Polars . . . . .	4-113
4-4	Production Helicopter Horizontal Tail Parameters . . . . .	4-122
4-5	Hub and Shank Drag Coefficients Correction Summary . . . . .	4-145
4-6	Drag Breakdown for Hypothetical Single Rotor Compound Helicopter $R_e/Ft = 1.56 \times 10^6$ ( $V = 189$ Kt) . . . . .	4-149
4-7	Summary of Aerodynamics Input for Compound Helicopter of Table 4-6 . . . . .	4-150
4-8	Drag Breakdown for Hypothetical Tandem Rotor Winged Helicopter $R_e/Ft = 1.49 \times 10^6$ ( $V = 181$ Kt) . . . . .	4-151
4-9	Summary of Aerodynamics Input for Helicopter of Table 4-8 . . . . .	4-152
4-10	Weight Summary Form . . . . .	4-176
4-11	Helicopter Weight Information . . . . .	4-185
4-12	Landing Gear Weights . . . . .	4-198
4-13	Engine Installation Weights . . . . .	4-202

<u>Table</u>		<u>Page</u>
4-14	Fixed Equipment and Fixed Useful Load Weights . . . . .	4-213
4-15	Multiplicative Factors . . . . .	4-215
7-1	Program Tolerances . . . . .	7-4

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

HESCOMP is a helicopter sizing and performance computer program very similar in format and operation to VASCOMP II, the V/STOL Aircraft Sizing and Performance Computer Program, described in Reference 1. This similarity is dictated by the requirement to obtain compatibility in both usage and results when using HESCOMP and VASCOMP II in helicopter-V/STOL aircraft comparative design studies. The program's purpose is to rapidly provide helicopter sizing 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. It 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. The program should maintain generality and flexibility - A program of this type must be comprehensive and flexible in order to permit an accurate simulation of many types of helicopter configurations. It must be capable of approximating the design process involved in layout and sizing of a wide variety of helicopters 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 primarily consists of a series of single point values specifying, for example, main rotor disc loading, solidity, twist, aspect ratio, taper ratio, etc. of the wing, tail, and rotor pylons (where applicable), 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. The program should 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, it 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 helicopter and its operation.
5. The program should be compatible with VASCOMP II - In order to insure program compatibility, care has been exercised in planning the input/output format. The input sheets are similar (and in a few cases - identical) to those of VASCOMP II. The output format is the same except for the additions of those output quantities peculiar to helicopter performance. Further, this User's Manual is identical in format to the VASCOMP II User's Manual. In addition, HESCOMP utilizes (unchanged) the engine cycle library, propeller tables, and propeller short form performance method developed for VASCOMP II.

## 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. It may be used for the sizing of helicopters for which the type of aircraft and the mission profile are specified. Alternatively, it 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 a helicopter 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 helicopter 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, a library of rotor cycle data, and a variety of optional procedures for calculating rotor and propeller (cruise only) performance.

The program can be used to study any single, tandem, or coaxial pure, winged, compound, or auxiliary propulsion helicopter (see Table 1-1).

TABLE 1-1. HELICOPTER CONFIGURATIONS WHICH MAY BE STUDIED USING HESCOMP.							
Helicopter Type (Both Single & Tandem Rotor)	Additional Lift/Propulsion System Components Which Must be Added to "Pure" Conf.	Wing	Propeller for Auxiliary Propulsion	Auxiliary Independent Engines	Type of Auxiliary Independent Engines		
					T/Shaft	T/Fan	T/Jet
Pure Helicopter							
Winged Helicopter		X					
Compound Helicopter							
(1) Coupled (prim. engines drive auxiliary propulsion system)		X	X				
(2) Auxiliary independent propulsion system							
(a) T/Shaft engine		X	X	X	X		
(b) T/Fan engine		X	X	X		X	
(c) T/Jet engine		X	X	X			X
Auxiliary Propulsion Helicopter							
(1) Coupled (prim. engines drive auxiliary propulsion system)			X				
(2) Auxiliary independent propulsion system							
(a) T/Shaft engine			X	X	X		
(b) T/Fan engine			X	X		X	
(c) T/Jet engine			X	X			X
Coaxial Rotor Helicopter							
(1) Coupled (prim. engines drive auxiliary propulsion system)			X				
(2) Auxiliary independent propulsion system							
(a) T/Shaft engine			X	X	X		
(b) T/Fan engine			X	X		X	
(c) T/Jet engine			X	X			X

## 2.0 SPECIFICATION OF HELICOPTER 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 mostly through use of nondimensional geometric information.

### 2.1 HELICOPTER 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 aircraft. Adding a nose and tail section of reasonable fineness ratio onto the cabin section would complete the fuselage geometry if this were an airplane (as sized by VASCOMP II). In a helicopter, however, additional geometric characteristics must be determined before the external fuselage dimensions are completely defined.

For example, in the case of the single rotor helicopter, the total fuselage length (in addition to the nose, tail, and constant diameter sections) includes the tail boom, the length of which, in turn, is established by the tail rotor diameter and the need to maintain a reasonable gap between the main and tail rotor discs. Additionally, the tail boom length itself is affected by the relative position of the main rotor on the fuselage. Vertical tail geometry is determined both by dimensional constraints and the need to fulfill directional stability requirements (e.g., sufficient vertical tail area to counteract main rotor torque in the event of tail rotor loss). So, although the basic cabin internal dimensions are fixed, the external overall dimensions can vary widely, depending on how conflicting requirements are resolved.

In the case of the tandem rotor helicopter, not even the internal cabin dimensions are necessarily constant. For example, the need to require a certain level of external configuration compactness (by specifying a high overlap/diameter ratio) can result in overall fuselage dimensions which directly conflict with internal volume requirements.

Wing geometry may be dictated by maneuver "g" requirements, a specified wing loading or aspect ratio, or even propeller tip/fuselage clearance (in the case of a compound helicopter with wing-mounted propellers).

Primary and auxiliary independent engine nacelle size is set



by the type of engine and its size (which, in turn, is dictated by power requirements)

Figures 2-1 and 2-2 of hybrid single and tandem rotor helicopter configurations illustrate the type of information concerning the helicopter geometry which may be required of the user. Tables 2-1 and 2-2 illustrate typical values of selected geometric characteristics for various aircraft. A complete list of input geometric variables is included in Section 5.3.1.

## 2.2 PROPULSION SYSTEM

This program permits the use of either a single, primary propulsion system or a combination of a primary system and an auxiliary independent propulsion system. For the primary system, turboshaft cycles are always used. For the auxiliary independent system, either turboshaft, turboprop, or turbojet cycles may be used. The program includes the applicable cycles (shown in Table 2-3) from the standard library of eighty-one different generalized engine cycles developed for the VASCOMP II program. 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 turboshaft 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 helicopters employing multiple propulsion systems, the primary system may be sized to provide power to the main rotor(s) for producing lift and part of the total propulsive thrust required; and the auxiliary independent system will be sized to provide the remaining propulsive thrust or power.

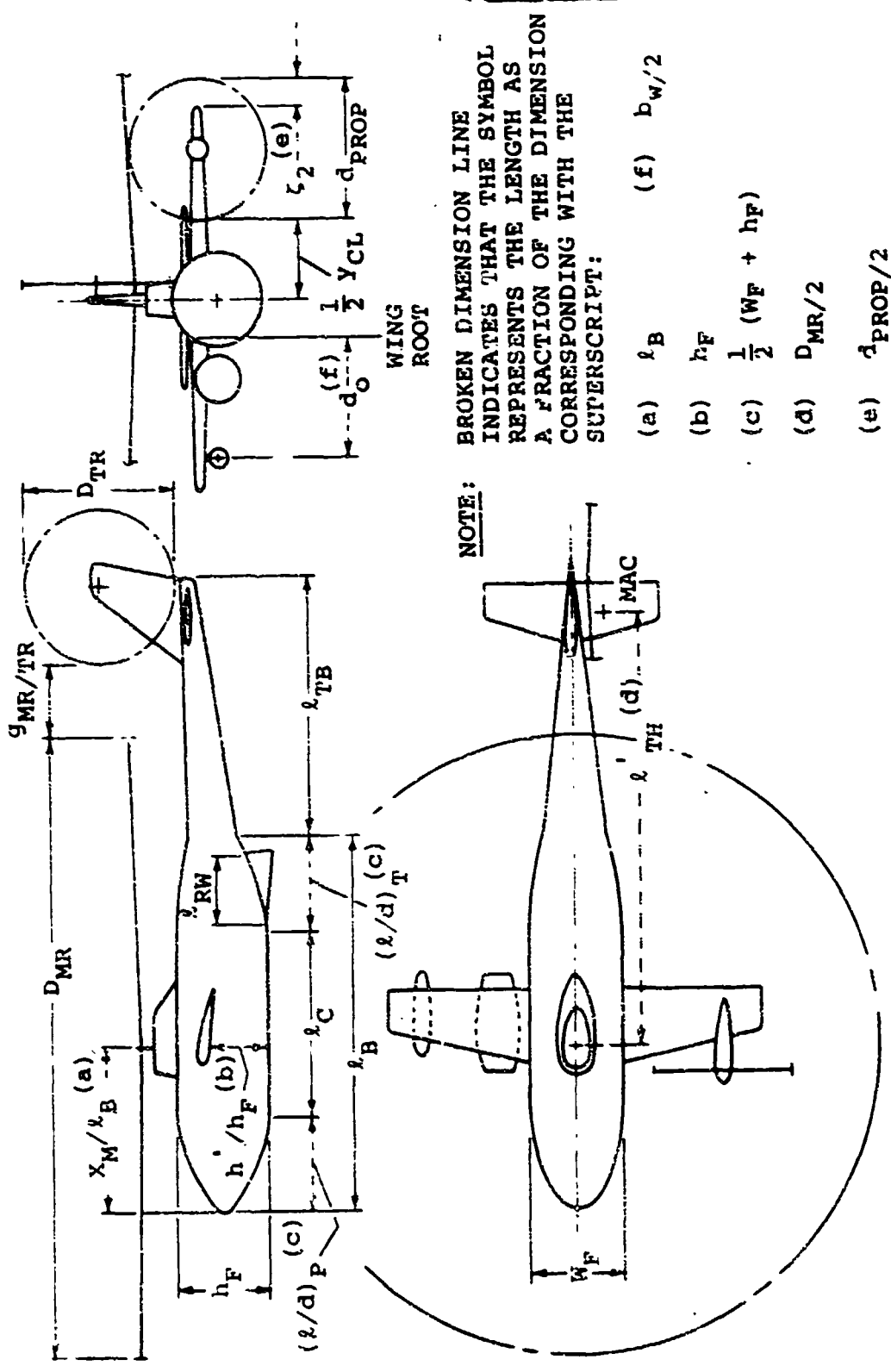
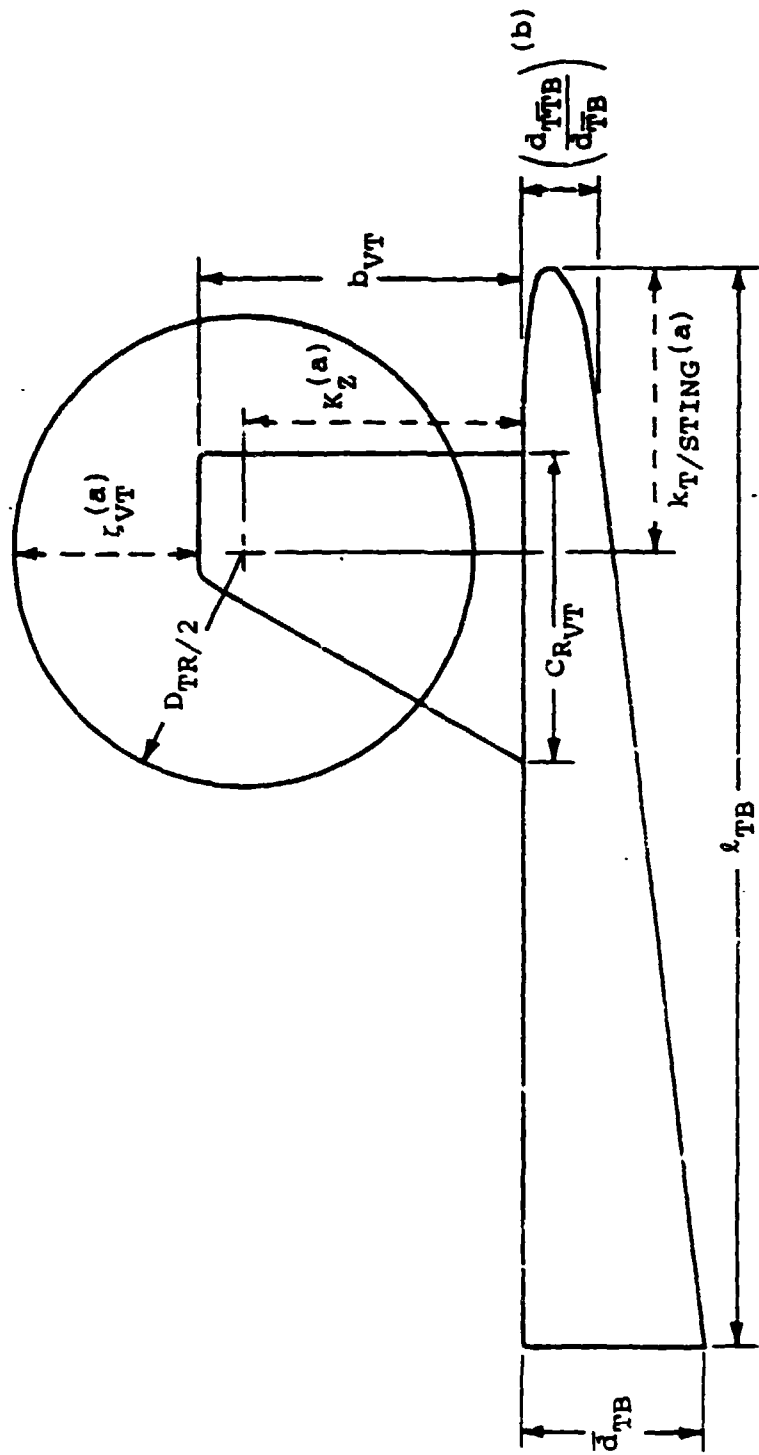


Figure 2-1. Typical Helicopter Geometry ~ Single Rotor Helicopter (Part 1 of 2).



NOTES: 1.  $K_z = b_{VT} = \frac{D_{TR}}{2} [K_z + (1 - \zeta_{VT})]$  2. BROKEN DIMENSION LINE INDICATES THAT THE SYMBOL REPRESENTS THE LENGTH AS A FRACTION OF THE DIMENSION CORRESPONDING WITH THE SUPERSCRIPT:

$\lambda_{VT} = \frac{C_{T_{VT}}}{C_{R_{VT}}}$  WHEN CNFIND = 1.0  
 $AR_{VT} = \frac{b_{VT}^2}{S_{VT}}$  VTFIND = 1.0  
 TRDIND = 0.0

(a)  $\frac{D_{TR}}{2}$  (b)  $d_{TB}^T/B$

Figure 2-1. Typical Helicopter Geometry ~ Single Rotor Helicopter (Tail Boom/Tail Fin/Tail Rotor Geometry) (Part 2 of 2).

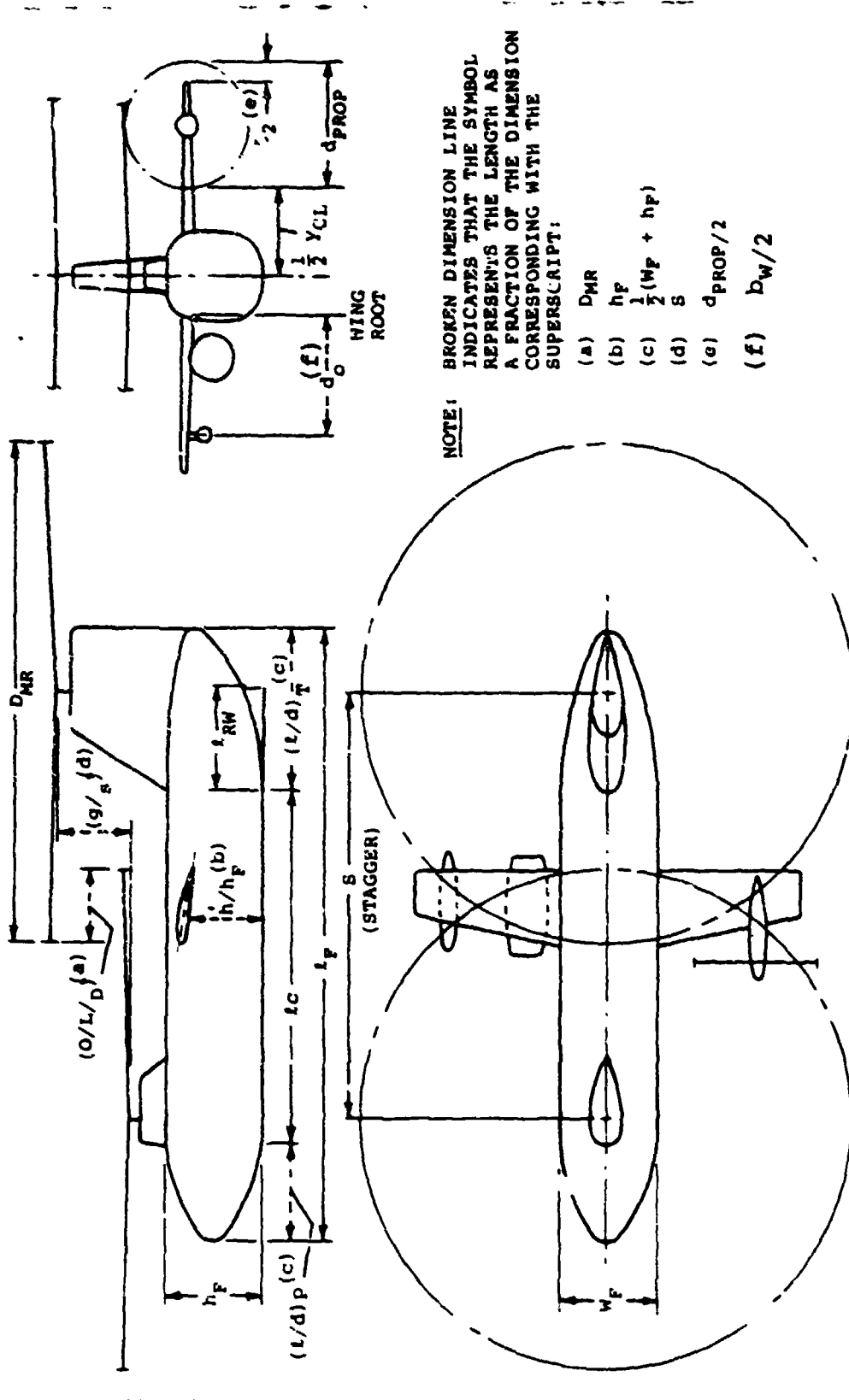
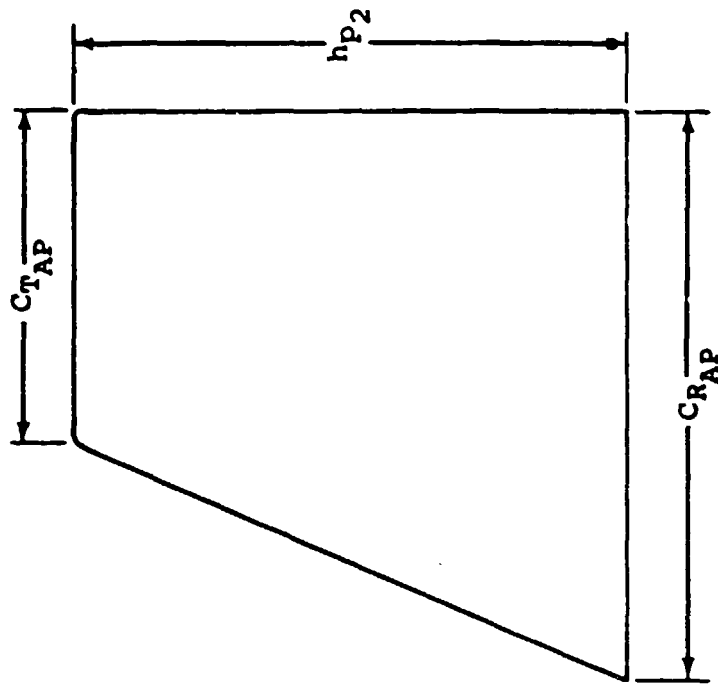


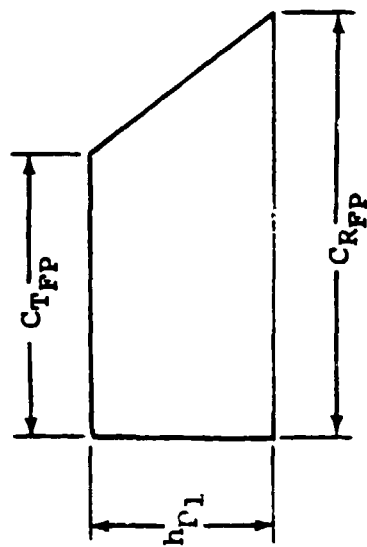
Figure 2-2. Typical Helicopter Geometry ~ Tandem Rotor Helicopter (Part 1 of 2).



AFT ROTOR PYLON

$$\lambda_{AP} = C_{TAP}/C_{RAP}$$

$$AR_{AP} = \frac{2h_{P2}}{C_{RAP}(1 + \lambda_{AP})}$$



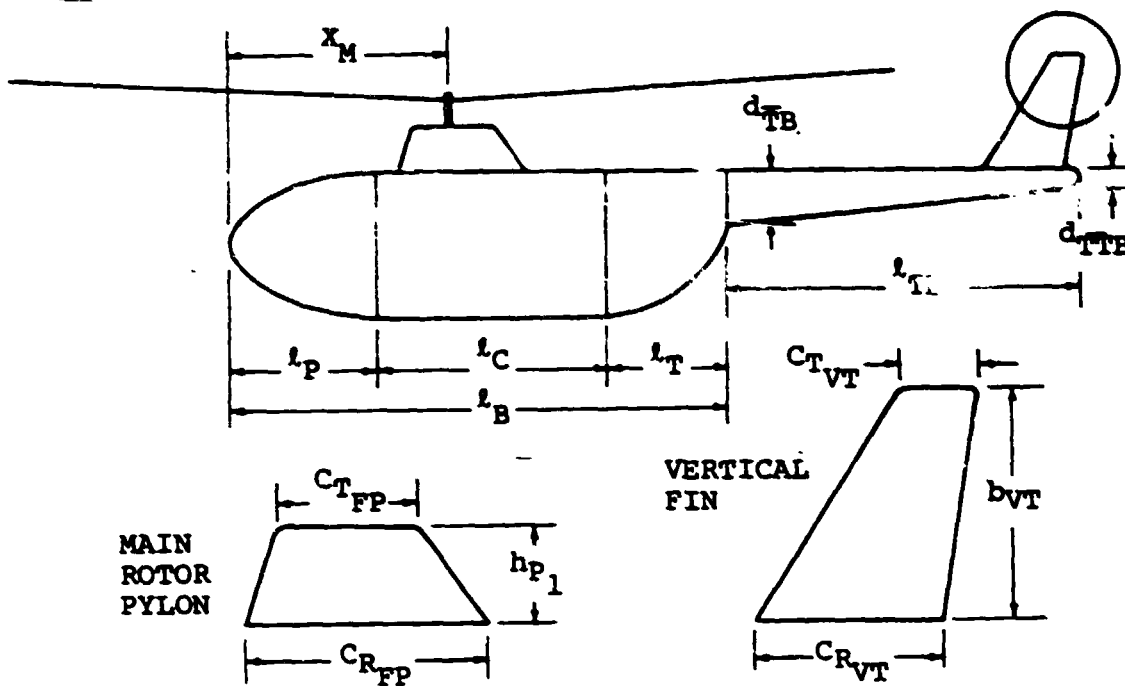
FORWARD OR MAIN ROTOR PYLON

$$\lambda_{FP} = C_{TFP}/C_{RFP}$$

$$AR_{FP} = \frac{2h_{P1}}{C_{RFP}(1 + \lambda_{FP})}$$

Figure 2-2. Typical Helicopter Geometry - Tandem Rotor Helicopter (Rotor Pylon Geometry) (Part 2 of 2).

TABLE 2-1. TYPICAL GEOMETRIC CHARACTERISTICS - SINGLE ROTOR HELICOPTERS



$$\lambda_{FP} = \frac{C_{TFP}}{C_{RFP}}$$

$$AR_{FP} = \frac{h_{p1}^2}{S_{FP}} = \frac{2h_{p1}^2}{(C_{RFP} + C_{TFP})}$$

$$S_{FP} = \text{Planform area} \quad d_F = \frac{W_F + h_F}{2}$$

$$\lambda_{VT} = \frac{C_{TVVT}}{C_{RVT}}$$

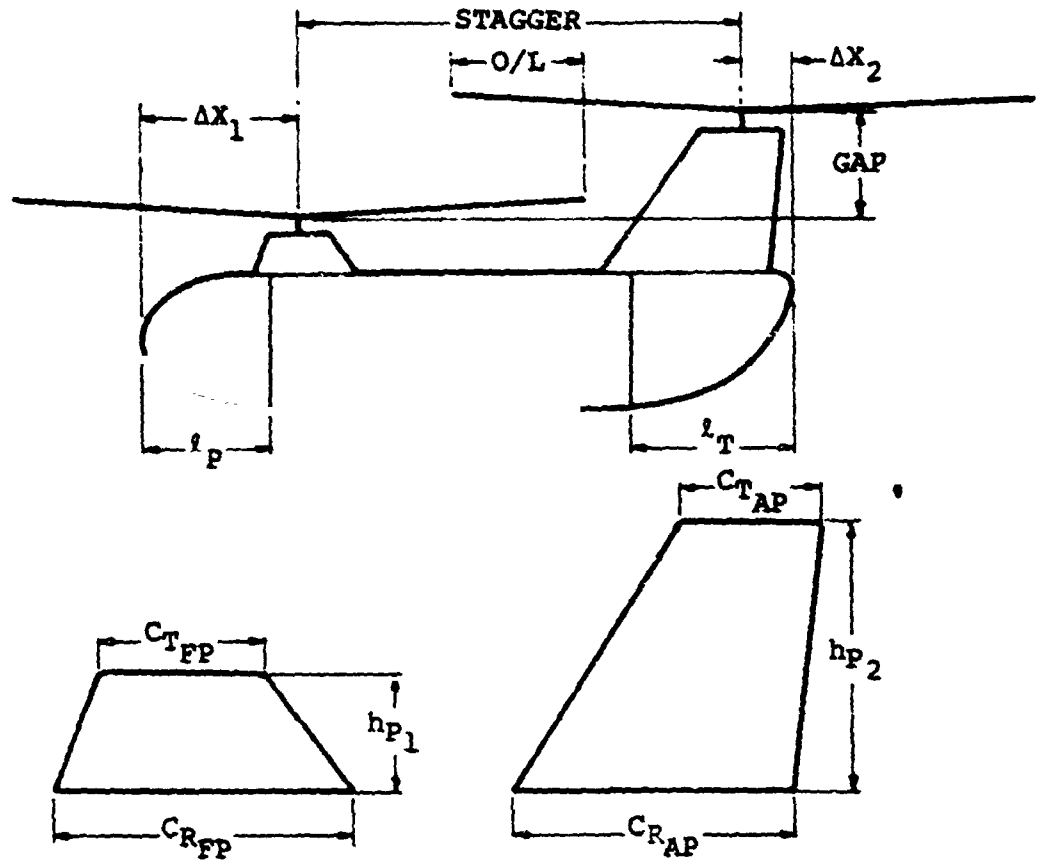
$$AR_V = \frac{b_{VT}^2}{S_{VT}}$$

$$S_{VT} = \text{Planform area}$$

DATA

TYPE	AIRCRAFT	$l_P/d_F$	$l_T/d_F$	$X_M/l_B$	$l_{TB}/d_{TB}$	$d_{TL}/d_{TB}$	$\lambda_{FP}$	$AR_{FP}$	$\lambda_{VT}$	$AR_V$
"PURE" LIGHT HELICOPTERS	BOE BO-105	1.02	.75	.57	7.00	.69	.41	.30	.33	1.37
	BELL OH-58A	1.12	.71	.55	8.50	.35	.53	.15	.64	4.37
"PURE" LT. TRANSPORT HEL.	BELL UH-1B	.84	.77	.71	5.55	.32	.88	.12	.23	1.98
"PURE" MEDIUM TRANSPORT HELICOPTERS	SIK H-34A	.52	.67	.44	2.42	.42	.44	.22	.64	.96
	SIK CH-3C	.78	1.13	.44	4.45	.64	.83	.25	.75	1.72
	SIK CH-53A	.76	1.47	.42	4.38	.94	.74	.21	.62	2.14
	SIK H-37A	.60	-	.56	2.30	.47	.45	.23	.63	3.36
WINGED HELICOPTERS	BELL AH-1G	2.47	.44	.65	4.91	.42	.70	.27	.48	1.53
	SIK S-67	2.22	1.98	.62	4.17	.47	.83	.27	.48	1.90
COMPOUND HELICOPTERS	LOCKR XH-51A	1.29	.98	.48	5.92	.26	.89	.33	.60	.73
	LOCKR AH-56A	1.40	1.36	.62	4.43	.52	.77	.12	.46	1.29

TABLE 2-2. TYPICAL GEOMETRIC CHARACTERISTICS  
TANDEM ROTOR HELICOPTERS



$$\lambda_{FP} = \frac{C_{TFP}}{C_{RFP}}$$

$$\lambda_{AP} = \frac{C_{TAP}}{C_{RAP}}$$

$$AR_{FP} = \frac{h_{P1}^2}{S_{FP}}$$

$$AR_{AP} = \frac{h_{P2}^2}{S_{AP}}$$

S<sub>FP</sub> = planform area

$$d_F = \frac{W_F + h_F}{2}$$

S<sub>AP</sub> = planform area

TYPE	AIRCRAFT	$l_p/d_F$	$l_t/d_F$	$O/L/D$	GAP/STAG	$\Delta X_1/l_p$	$\Delta X_2/l_t$	$\lambda_{FP}$	AR <sub>FP</sub>	$\lambda_{AP}$	AR <sub>AP</sub>
"PURE" LIGHT TRANSPORT HELICOPTER	B-V HUP-1	.73	1.03	.37	.08	1.00	1.00	.38	.35	.57	.78
	B-V H-21	.64	2.19	.04	.00	.89	.02	.35	.45	.23	.43
"PURE" MEDIUM - HEAVY TRANSPORT HELICOPTERS	B-V CH-46A	.71	1.53	.33	.14	1.16	.51	.63	.34	.69	.61
	B-V CH-47C	.69	1.29	.34	.12	.85	.59	1.00	1.10	.81	.53
	B-V YH-16A	.84	1.81	.37	.16	.48	.84	.34	.25	.58	.84
	B-V MCO 147	.85	1.57	.23	.15	.73	.55	.98	.41	.84	.66

TABLE 2-3. LIST OF ENGINE CYCLES

	1970	Intermediate	Advanced
<u>Primary Propulsion</u>			
<b>Turboshaft</b>			
Engine press. ratio	13, 16	13, 16, 19	13, 16, 19, 22
Turb. inlet temp.	2600°R	2900°R	3200°R
<u>Auxiliary Independent Propulsion</u>			
<b>Turboshaft</b>			
Engine press. ratio	13, 16	13, 16, 19	13, 16, 19, 22
Turb. inlet temp.	2600°R	2900°F	3200°R
<b>Turbojet</b>			
Engine press. ratio	13, 16	13, 16, 19	13, 16, 19, 22
Turb. inlet temp.	2600°F	2900°	3200°R
<b>Turbofan</b>			
Engine press. ratio	5, 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



### 2.3 HELICOPTER WEIGHT SUMMARY

A detailed helicopter weight summary is provided by the program through use of statistical weight trend equations. A description of, and justification for, these equations is given in Section 4.11. Three major categories of weights are calculated: the propulsion group, the structures group, and the flight controls group.

### 2.4 AERODYNAMIC CHARACTERISTICS

The aerodynamic data which are calculated by the program are the helicopter drag and (in the case of winged or compound helicopters) the lift curve slope of the wing (used for calculations of the gust load factor). Drag data may be input to the program in a variety of forms including a single point value of flat plate area, drag trends, or by a detailed drag summary. Scaling effects on drag based upon Reynolds number corrections are included. Wing spanwise loading efficiency (Oswald's factor) may be either input to the program or may be program calculated.

### 2.5 ROTOR CHARACTERISTICS

Rotor performance may be calculated either by the short form aerodynamic performance method or by using input rotor maps. The short form method employs input rotor "cycles". Corrections for the specific rotor and helicopter configuration geometry, (e.g., blade twist, number, cut-out, rotor overlap, etc.) being analyzed are made by the program. Included with the program is a brief library of currently available "cycles" (Table 2-4 lists their pertinent characteristics).

Two types of rotor maps, differing in the type and format of the input data required, may be used. These are designated as Type I and Type II rotor maps and their differences are noted in Section 3.1.5. The Type I rotor map may be used in two ways. In the first case, isolated rotor data derived for a specific rotor configuration is input and, as in the short form method, blade and configuration geometry corrections are applied by the program. In the second approach, a rotor map generated from total configuration rotor power data (e.g. in the case of a single rotor helicopter, this would be the sum of main and tail rotor power) is input. No corrections are applied. Thus, the particular blade and helicopter configuration geometry inherent in the data from which the map is generated is reflected unchanged in the calculated rotor performance. The Type II rotor map may be used, however, only as outlined in the first approach noted above.

TABLE 2-4. LIST OF ROTOR CYCLES

Rotor Cycle No.	Rotor Blade Planform Char.	Rotor Blade Airfoil Section Description	Rotor Blade Spanwise Airfoil Distr. Represented in Rotor Cycle	Helicopters Employing This Rotor Blade Type
1	Constant Chord	"Conventional" symmetrical NACA airfoil section	NACA 0012 from C.L. ROT to blade tip	CH-47A UH-1B SH-3A
2	Constant Chord	Cambered blade section developed by modification of NACA 230 (5 digit) series airfoil section	BV 23010-1.58 from C.L. ROT to blade tip	CH-47C MOD. 347 BO-105C
3	Constant Chord	High speed (transonic) airfoil section (s) developed from NACA 6 - series airfoil sections and optimized for maximum lift and low pitching moments.	BV VR-7 from C.L. ROT to $r/R = 0.85$ BV VR-8 at blade tip ( $r/R = 1.00$ )	HLH (XCH-62)

## 3.0 PROGRAM OPERATION

### 3.1 GENERAL

#### 3.1.1 The Option Indicator

As previously described, the program has two major options, a third which is a combination of these two, and a fourth option used for obtaining aircraft weight only. 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).

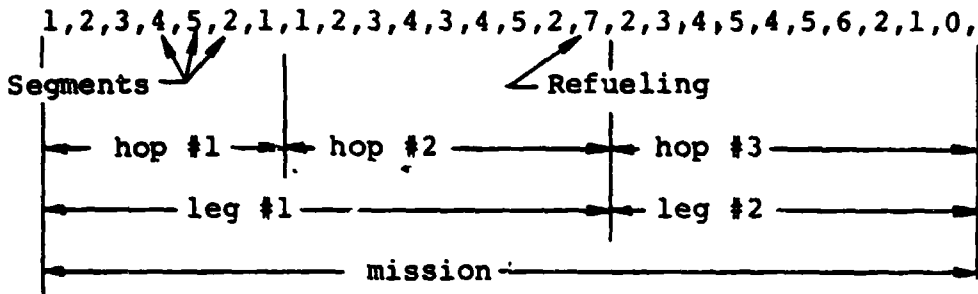
### 3.1.2 Description of Mission Profile

The performance calculation subprogram in HESCOMP, 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:

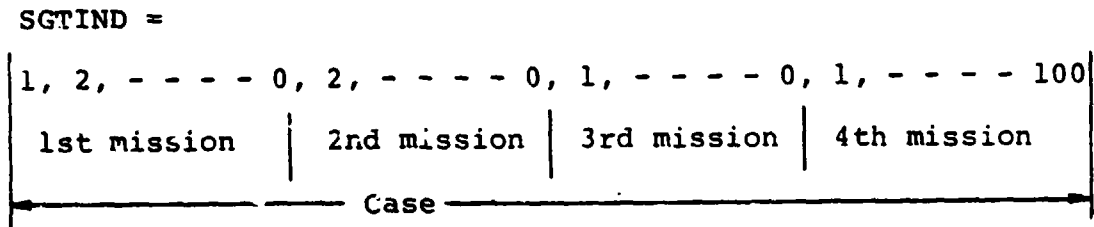
1. Segment - A segment of a mission profile is a unique portion of the mission such as a cruise or a climb. A segment starts with a set of initial conditions of one or more of the variables of state (altitude, range, weight, etc.) and ends when a terminal condition (or conditions) has been satisfied.
2. 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.
3. 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.
4. 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.
5. 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 nine 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:

SGTIND =



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 SGTIND = 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 segments 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, etc. to 29,500 feet. As the step size is decreased, the program accuracy improves, but the computing time lengthens.

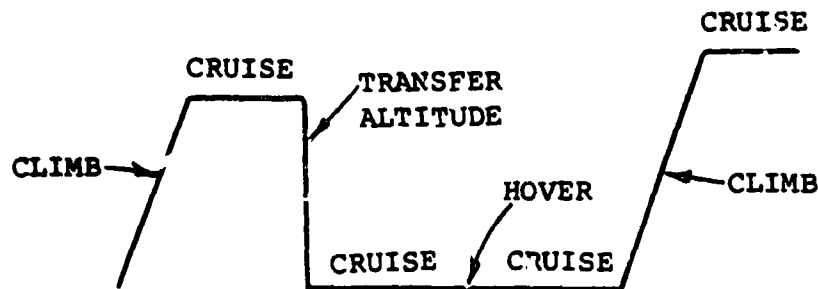
Atmospheric conditions may vary from segment to segment. For example, the first segment, a climb, may be for a standard atmosphere; the second segment, a cruise, may use a constant increment in temperature above standard; and the third segment,

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. Segments 1 through 6 (taxi through loiter) may be used to simulate an additional requirement for reserve fuel. The reserve fuel calculated in this manner is used as part of the total fuel required to size the aircraft. However, the aircraft weight is not reduced by the amount of the reserve fuel. This option is specified by inserting a value of  $10 \times \text{SGTIND}$  for the particular mission segment indicator where reserve fuel is to be calculated. For example, if it is desired to calculate reserve fuel at a specified cruise condition,  $\text{SGTIND} = 40$ ; i.e.,  $(\text{SGTIND} = 4) \times 10$  is input.

### 3.1.3 Special Flight Path Control Option

hOPTIND - 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  $h_{\text{MAX}}$  input for the preceding climb or the  $h_{\text{FINAL}}$  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 below in which the low altitude segments represent sea level dashes. For this mission, the user specified  $h_{\text{FINAL}} = 0$  for the transfer altitude segment.



### 3.1.4 Propeller Efficiency

Propeller efficiency can be calculated in three different ways for compound and auxiliary propulsion helicopters. The option chosen is specified by means of a propulsive efficiency indicator,  $\eta_{\text{IND}}$ . 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 4.7.

### 3.1.5 Rotor Power Required Calculation

The method most likely to be used, and certainly the most convenient, from the point of view of inputs, is the short form aerodynamic performance method. Rotor blade performance data is input in the form of "cycles", with corrections for the specific rotor and helicopter configuration under study being applied by the program.

Two types of rotor maps may be input. These differ in the type and format of the input data required. The Type I rotor map requires  $C_{P_H}/\sigma$  as a function of  $C_T/\sigma$  and  $M_{\text{TIP}}$  (hover performance) and  $C_p/\sigma$  as a function of  $u$ ,  $C_T'/\sigma$ , and  $C_X/\sigma$  (cruise performance). The Type II rotor map requires F.M. as a function of  $C_T/\sigma$  and  $M_{\text{TIP}}$  (hover performance) and rotor  $L/D_R$  as a function of  $u$ ,  $C_T'/\sigma$ , and  $X/L$  (cruise performance). The Type I rotor map data may be input in two ways. The first utilizes isolated rotor data derived for a specified rotor configuration, but corrected by the program for the specific rotor and helicopter configurations under study. The second uses total configuration rotor data (i.e., in the case of a single rotor helicopter, this would include both main and tail rotor power) and applies no corrections to the data. The Type II rotor map option always uses isolated rotor data derived for a specified rotor configuration, but corrected by the program for the specific rotor and helicopter configuration under study.

The short form aerodynamic performance method, and the Type I (1st version) and Type II rotor map options are suitable for use both in sizing and performance only calculations, since corrections for variations in rotor and helicopter configurations are applied. The Type I (2nd version) rotor map option, however, must be restricted to use only in non-sizing applications. Possible areas of use could be, for example, the case where (a) it is inconvenient for the magnitude of the particular application to generate the data required for creating a rotor cycle or generalized rotor map, or (b) in calculating the mission performance of existing helicopters (e.g. the HH-43B, WG-13, UH-2, etc.) utilizing rotor maps derived from Flight Handbooks, etc.



## 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: 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

AIPIND - Indicator which differentiates between compounds with and without auxiliary independent engines. AIPIND = 1 denotes a compound helicopter having a single set of engines connected both to the main rotor and auxiliary propulsion systems. AIPIND = 2 indicates a compound helicopter with independent engines for auxiliary propulsion.

ENGIND - Two different classes of cruise engines are included in the program. They are "horsepower producing" engines and "thrust producing" engines. The horsepower producing engines which are included in the standard engine library are turbo-shaft engine cycles. The thrust producing engines in the engine library are either turbojet or turbofan engines. If ENGIND = 0, a power producing cycle is selected. If ENGIND = 1, a thrust producing cycle is selected.

ESCIND - 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, ESCIND. If ESCIND = 1, the program will size the engines for takeoff conditions only. If ESCIND = 2, 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.

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 = 0, the engines are fixed in size. If FIXIND = 1, the engine sizing subroutine is used to calculate the size of the "rubberized" engines.

FIXINDI - FIXINDI serves the same function for the auxiliary independent engines that FIXIND does for the primary engines.

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.

WDTIND, QIND, N1IND, N1θIND, 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<sub>II</sub> for each flight segment, and the program will calculate the effect on engine performance.

WDTINDI, QINDI, N1INDI, N1θINDI, N2INDI - These indicators specify to the program that the auxiliary independent engine performance is restricted by a maximum level of fuel flow, torque, gas generator 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. N2INDI has a third possible value which the user may input for turboshaft engines, N2INDI = 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<sub>II</sub> for each flight segment, and the program will calculate the effect on engine performance.

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.

RNOINDI - This indicator serves the same purpose for the auxiliary independent engines as RNOINDI serves for the primary engines.

ROTIND - Controls the selection of the rotor performance computation method. In addition to the short form aerodynamic performance method, rotor performance may be calculated with the two alternate forms of rotor map. The Type I rotor map (input locations 2700-3410) requires  $C_{pq}/\sigma$  as a function of  $C_T/\sigma$  and  $M_{TIP}$  (hover performance) and  $C_q/\sigma$  as a function of  $u$ ,  $C_T/\sigma$ , and  $C_x/\sigma$  (cruise performance). The Type II rotor map (input locations 3420-4130) requires  $F_{L/D}$  as a function of  $C_T/\sigma$  and  $M_{TIP}$  (hover performance) and rotor  $L/DE$  as a function of  $u$ ,  $C_T/\sigma$ , and  $X/L$  (cruise performance). If ROTIND = 1, rotor performance is calculated by the short form aerodynamic performance method (requiring the input of a rotor "cycle"). If ROTIND = 2, a Type I rotor map is input with corrections being applied by the program for the specific rotor and helicopter configuration geometry being studied. If ROTIND = 3, a Type I rotor map is input, with no corrections being applied. If ROTIND = 4, a Type II rotor map is input with corrections being applied by the program for the specific rotor and helicopter configuration geometry being studied. The program accepts the  $V_{TIP}$  schedule and the TAUX/T schedule. However, TAUX/T = 2,000 cannot be used with this option. If ROTIND = 5, a Type II rotor map is input similar to ROTIND = 4. The program accepts the  $V_{TIP}$  schedule and all modes of the TAUX/T schedule. In this option, the rotor is operated at maximum  $L/DE$  with TAUX/T as output. If ROTIND = 6, a Type II rotor map is input similar to ROTIND = 4 or 5. The program accepts the  $V_{TIP}$  schedule and all modes of the TAUX/T schedule. In this option, the rotor is operated at maximum configuration  $L/DE$  with TAUX/T as output.

$\eta_p$ IND - This indicator permits the user to select one of three different methods for predicting propeller performance for compound and auxiliary propulsion helicopters. If  $\eta_p$ IND = 0, the user can specify a set of point value efficiencies for

each climb and descent and a table of efficiency versus Mach number for cruise and loiter. An input of  $\eta_p\text{IND} = 1$  will permit the user to load in a propeller performance map to be used during climb, cruise, and loiter while an input of  $\eta_p\text{IND} = 2$  will permit use of an automatic subroutine within the program for calculating prop performance. 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 4.7.

### 3.2.2 Aerodynamics Indicators

DRGIND - The method of determining the total parasite drag of the helicopter is specified to the program by means of the indicator DRGIND. If DRGIND = 1, configuration parasite drag is built up in component fashion, with Reynolds number scaling. If DRGIND = 2, the parasite drag is calculated from a parasite drag trend derived from the inputs (GW/Fe) and  $K_{PED}$ .

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 = 1 will cause the program to use the approximate equation to calculate the value for efficiency.

### 3.2.3 Size Trends Indicators

APHIND - The aft rotor pylon height of a tandem rotor helicopter is specified by use of this indicator. If APHIND = 1, aft pylon height is input directly in feet. If APHIND = 2, the tandem rotor gap/stagger (g/s) ratio is input and aft pylon height is sized accordingly.

AUXIND - Four versions of both the single and tandem rotor helicopter may be specified through this indicator. They are: a pure helicopter (AUXIND = 1), a winged helicopter only (AUXIND = 2), an auxiliary propulsion helicopter, only (AUXIND = 3), and a compound (wings and auxiliary propulsion) helicopter (AUXIND = 4).

$b_w\text{IND}$  - For a configuration having wings, this option determines the manner in which wing span is calculated during the sizing process. If  $b_w\text{IND} = 1$ , wing span/rotor diameter ratio ( $b_w/D$ ) is input. If  $b_w\text{IND} = 2$ , wing aspect ratio (AR) is input. If  $b_w\text{IND} = 3$  (used when dealing with wing-mounted

propellers) wing span is determined from propeller tip/fuselage clearance considerations.

CNFIND - This indicator specifies the helicopter configuration to be analyzed. These are: the single rotor helicopter (CNFIND = 1) and the tandem rotor helicopter (CNFIND = 2).

FDMIND - Determines the manner in which a tandem rotor helicopter fuselage is sized. If FDMIND = 1, tandem rotor overlap ((O/L)/D) and forward and aft rotor positions ( $\Delta X_1/l_p$ ,  $\Delta X_2/l_T$ ) are specified. If FDMIND = 2, overlap and cabin length ( $l_c$ ) are input. If FDMIND = 3, cabin length and forward and aft rotor positions are input.

HTIND - Permits the user to input fixed-size horizontal tail surfaces to the program or, optionally, to have the program calculate the tail surface size based upon an input tail "volume" coefficient. If HTIND = 0, the program will assume no horizontal tail exists. If HTIND = 1, the tail area may be input directly. If HTIND = 2, the program will calculate the size based upon a tail "volume" coefficient.

MRPIND - Specifies the placement of the main rotor of a single rotor helicopter on its fuselage. If MRPIND = 0, the user inputs directly the main rotor position (aft of the nose) as a fraction of body length ( $X_M/l_B$ ). If MRPIND = 1, the program does a simple mass balance calculation and determines the rotor position relative to the aircraft cg. If MRPIND = 2, the same procedure is carried out as with MRPIND = 1 with the exception that the program assumes the auxiliary drive system, propeller, and auxiliary independent engines (if any) to be located on the wing.

RDMIND - Specifies manner in which main rotor is sized. If RDMIND = 1, main rotor diameter and solidity are input directly. If RDMIND = 2, disc loading and solidity are input, diameter is calculated. If RDMIND = 3, diameter and  $C_T/\sigma$  are input, solidity is calculated. If RDMIND = 4, disc loading and  $C_T/\sigma$  are input and both diameter and solidity are calculated.

SWIND - Specifies options available for wing sizing. These are: wing area input directly (SWIND = 1), wing area sized based on an input wing loading (SWIND = 2), and wing area sized by rotor/wing maneuver requirements (SWIND = 3).

TRDIND - Determines manner in which tail rotor diameter is sized. If TRDIND = 0, the helicopter is sized without a tail rotor (Note: this indicator is only used in conjunction with CNFIND = 1.0). If TRDIND = 1, tail rotor diameter is calculated from a trend of DMR/DTR contained in the program. If

TRDIND = 2, tail rotor diameter is input directly. If TRDIND = 3, a value of net tail rotor disc loading,  $(T/A)_{NET}$ , is input and tail rotor diameter is determined through an iterative procedure.

TRSIND - Tail rotor solidity sizing indicator. If TRSIND = 1, tail rotor solidity is input directly. If TRSIND = 2,  $C_T/\sigma$  is input and tail rotor solidity is sized based on either hover-antitorque or hovering turn requirements.

VTFIND - Vertical tail area sizing indicator. If VTFIND = 1, vertical tail size is based on input values of aspect ratio ( $AR_{VT}$ ) and tail fin/tail rotor overlap ( $h_{VT}$ ). If VTFIND = 2, tail fin/tail rotor overlap and directional stability requirements, (sufficient tail area to counteract main rotor torque in cruise flight, if tail rotor is lost), dictate vertical tail area. If VTFIND = 3, the same requirements must be met as with VTFIND = 2, with the exceptions that  $AR_{VT}$  is specified and tail fin overlap is calculated along with vertical tail area.

XMSNIND - Indicator that controls drive system transmission sizing. When XMSNIND = 0.0 or 1.0 and ESCIND (LOC 0022) = 2.0, the transmission can be rated at cruise RPM input LOC (0238). If XMSNIND = 0, main, tail and auxiliary drive system ratings are specified as a fraction of primary engine installed power (in the case of a compound helicopter with auxiliary independent drive system rating is specified as a fraction of the auxiliary independent engine installed power).

XMSNIND - Indicator that controls drive system transmission sizing. If XMSNIND = 0, main, tail and auxiliary drive system ratings are specified as a fraction of primary engine installed power (in the case of a compound helicopter with auxiliary independent propulsion, the auxiliary independent drive system rating is specified as a fraction of the auxiliary independent engine installed power).

If XMSNIND = 1, the drive system ratings calculated are equal to the product of the applicable multiplicative factors ( $SHP_{MRX}/SHP_{MR}$ ,  $SHP_{TRX}/SHP_{TRP}$ ,  $SHP_{AUX}/SHP_{AUX}$ ) and the component (main, tail, and auxiliary) power obtained from the proportional split (based on power required) of the total sea level standard maximum (installed) engine power.

If XMSNIND = 2, main, tail, and auxiliary drive system ratings are specified at a fraction of the power required to hover or cruise at design conditions (more critical of the two conditions is selected).

If XMSNIND = 3, the same applies as in the case where XMSNIND = 2, except the most critical of the two design conditions is

compared to the drive system rating required at an alternate payload/gross weight hover at the design point conditions. The most critical of these three conditions is selected.

If XMSNIND = 4, the same applies as in the case where XMSNIND = 2, except that the tail rotor drive system rating is selected independently of the main rotor drive system to match a specified fraction of power required to hover or cruise at design conditions (more critical of the two conditions is selected).

If XMSNIND = 5, the same applies as in the case where XMSNIND = 3, except that the tail rotor drive system rating is selected independently of the main rotor drive system (as when XMSNIND = 4), and the most critical of the two design conditions is compared to the tail rotor drive system rating required at an alternate payload/gross weight hover at the design point conditions, the most critical of these three conditions being selected.

#### 3.2.4 Mission Performance Indicators

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).

CRSIND - Six types of cruise missions are included in the program: 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).

DESIND - Twelve different descent paths may be calculated by the program. They are of three major types: descent at constant true airspeed (TAS) (DESIND = 1), descent at constant Mach number (DESCIND = 3). Four variations of each of these major types of descent are specified by RMAXND. It should be noted that there are no idle power or autorotative descent options available. However, depending on the descent flight conditions specified, it is possible to operate on an autorotative descent boundary (see Section 4.12.5) during a descent.

RMAXND - Used in conjunction with DESIND to specify types of descent. If RMAXND = 0, the descent flight path ends at a specified terminal range (cruise segment must be input previous to descent). If RMAXND = 1, the program checks the specified terminal range, and, if the predicted flight path will end beyond the specified terminal range value, a spiral descent path is assumed at that point; if the predicted flight path ends

before reaching the specified terminal range point, the program prints "SHALLOWER DESCENT REQUIRED". If RMAXND = 2, the descent ends at a specified minimum altitude, terminal range requirement not considered. If RMAXND = 3, the fuel used and time required for descent are calculated but no range credit given (i.e., spiral descent path).

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 a 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 nine discrete elements. The mission is terminated by an input value for segment indicator = 0. NOTE: Segments 1 through 6 can be used for reserve fuel calculations (gross weight reset following segment) by inputting 10 times SGTIND, i.e., SGTIND = 10, 20, 30, 40, 50, or 60.

TOLIND - The indicator TOLIND is input with each takeoff, hover, and landing segment and dictates the manner in which power is calculated. If TOLIND = 1, the user inputs required thrust-to-weight ratio and vertical rate of climb (VR/C). If TOLIND = 2, the user inputs required fractions of maximum power and vertical rate of climb (T/W ratio is computed). Both TOLIND = 1 and 2 options are calculated, based on the assumptions of hover-out-of-ground effect. If TOLIND = 3, the option is the same as 1, but the analysis includes hover-in-ground effect factors. If TOLIND = 4, the option is the same as 2, but the analysis includes hover-in-ground effect factors.

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 aircraft weight (by adding fuel or payload) to a value which exceeds the initial gross weight of the aircraft. 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 aircraft at any point of the mission. If WGTIND = 0, 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 = 1 (and if the performance option is being



run), the program will permit the aircraft 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, up to 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.

### 3.2.5 Flight Path Control Indicators

hoptIND - By inputting hoptIND = 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 hoptIND = 0 is input, the program will not do an optimum altitude search for the cruise segments.

### 3.2.6 Atmosphere Indicator

ATMIND - The atmosphere for each individual mission profile segment and for the engine sizing calculations may be either a standard or nonstandard 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 = 0, 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 printout are available for the mission performance data. By setting OPTIONAL PRINT INDICATOR = 0, a standard printout will occur. This consists of time, range, fuel used, aircraft weight, pressure altitude, true airspeed, primary engine turbine temperature, an engine code which specifies the condition which is dictating the primary 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

main rotor power and tip speed, tail rotor power and tip speed, auxiliary propulsion power and propeller tip speed, primary and auxiliary engine fuel flows, etc. The printout available from the program is described in more detail in Section 6.1.4.

### 3.3 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 eighteen minor subroutines, four major subroutines, a major subprogram, and a library of engine cycle data, and rotor "cycle" data. The characteristics of these routines are summarized in Table 3-1.

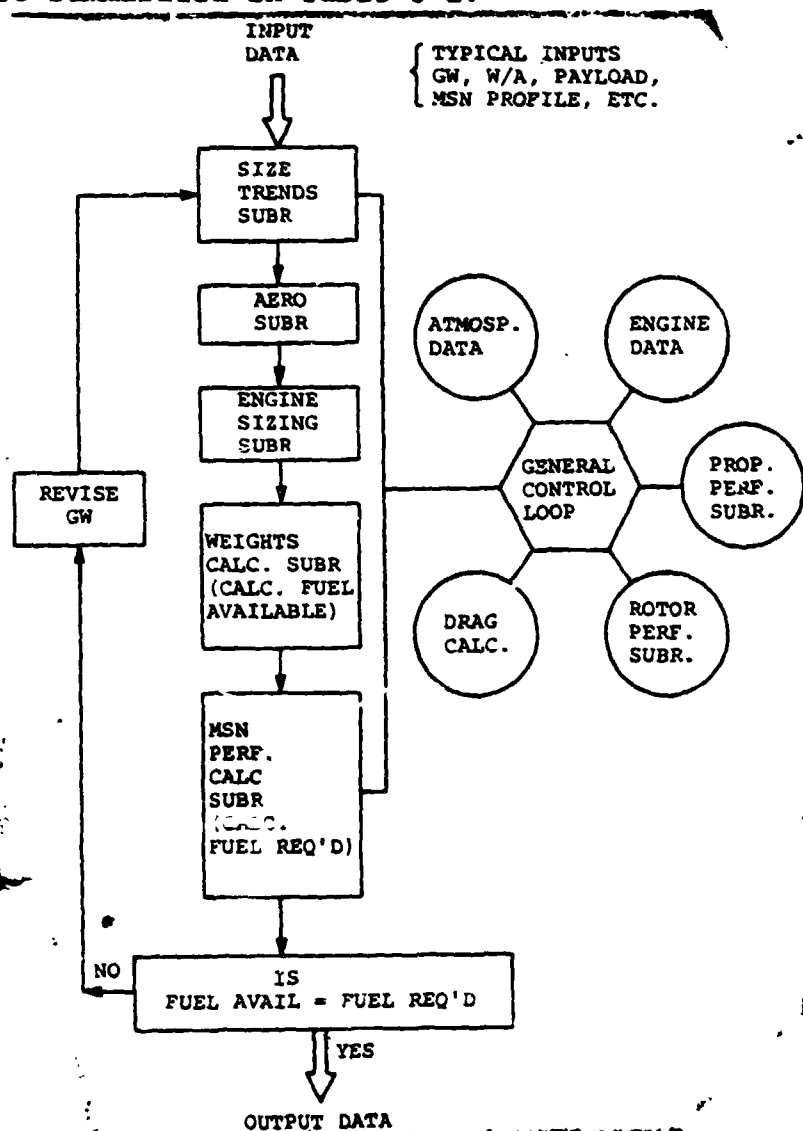


Figure 3-1. Sketch of Program Geometry.

TABLE 3-1. SUMMARY OF SUBROUTINES

ROUTINE	CALLED BY	PURPOSE
Main Control Loop (MAIN)	---	Monitors program operations, checks convergence and calculates gross weight during iterative sizing option (OPTIND = 1)
Minor Subroutines:		
Atmosphere (ATMOS)	Performance subroutines with SGTIND = 1-6, engine sizing and size trends	Calculates atmospheric density, pressure, temperature and speed of sound
DESPOW	Descent subroutine	Calculates power required for descent
Drag Calculations (DRAG)	Performance subroutines with SGTIND = 1-6, and engine sizing	Calculates aircraft propulsive force coefficient ( $C_x$ )
POWAVL	Performance subroutines with SGTIND = 1-6, engine sizing and size trends	Calculates power and fuel flow available for primary turboshaft engines by determining the most critical operating restrictions
POWAVI	Same as POWAVL	Calculates power and fuel flow available for auxiliary independent turboshaft engines by determining the most critical operation restrictions
POWREQ	Same as POWAVL	Calculates fuel flow for primary turboshaft engines when power required is less than power available.

TABLE 3-1. CONTINUED

ROUTINE	CALLED BY	PURPOSE
POWERQI	Same as POWAVI	Calculates fuel flow for auxiliary independent turboshaft when power required is less than power available
ENGL	POWERQ, POWAVL	Calculates power available for primary turboshaft engines at any specified turbine temperature, including effects of Reynold's number and operation at nonoptimum NII
ENGLI	POWERQI, POWAVI	Calculates power available for auxiliary independent turboshaft engines at any specified turbine temperature, including effects of Reynold's number and operation at nonoptimum NII
THR AVL	Same as POWAVL	Calculates thrust and fuel flow available for turbofan and turbojet engines by determining most critical operating restriction
THRREQ	Same as POWAVL	Calculates fuel flow for turbofan and turbojet engines when thrust required is less than thrust available
POWER	Performance Subroutines with SGTIND = 3,4,5,6 & engine sizing and size trends	Calculates propeller power required when thrust and advance ratio are known
POWERI	Same as Power	Calculates propeller power (for auxiliary independent propulsion system) required when thrust and advance ratio are known
PRINT 1 and PRINT 2	Main subroutine	Controls printout of data generated in sizing when OPTIND = 1.0

TABLE 3-1. CONTINUED

ROUTINE	CALLED BY	PURPOSE
ROT LIM	Performance subroutines with SGTIND = 2, 3, 4, 5 & 6	Checks main rotor operating conditions ( $C_t/\sigma$ and $C_x/\sigma$ ) to see if rotor limit has been exceeded.
ROT POW	Performance subroutines with SGTIND = 2, 3, 4, 5, 6 and engine sizing and size trends	Calculates rotor power required (both main and tail rotors)
SCRIBE	Performance subroutines with SGTIND = 4 & 6	Controls printout when detailed print option is desired (OPTIONAL PRINT INDICATOR = 1.0)
THRUST	Same as POWER	Calculates propeller thrust available when power and advance ratio are known
Major Subroutines:		
Aerodynamics (AERO)	Main	Calculates wing spanwise loading efficiency and a series of coefficients which are used by the drag subroutine to calculate aircraft drag
Engine Sizing (ENGSZ)	Main	Calculates engine size (power or thrust) required to meet mission requirement
Size Trends (SIZTR)	Main	Calculates aircraft dimensions which are required for weight estimate and drag calculation
Weight Trends (WGHTR)	Main	Calculates aircraft weight summary including propulsion, structures, flight controls and fuel available

TABLE 3-1. CONTINUED

ROUTINE	CALLED BY	PURPOSE
Major Subprogram:	Main	
Performance Calculations (PRFRM)	Main	Monitors program flow during calculation of mission performance and calculates total fuel required at end of mission
General Performance Calculation (PRFRP; PRFRM)	Performance sub-routine with SGTIND=11	Program calculates general performance of aircraft for given altitude, temperature, and flight velocity.
Performance Subroutines		
Taxi (TAXI)	Performance subprogram	Calculates taxi performance
Takeoff, Hover & Landing (TOHL)	Performance subprogram	Calculates takeoff, hover or landing performance
Climb (CLIMB)	Performance subprogram	Calculates climb performance
Cruise (CRUS1, 2, 3)	Performance subprogram	Calculates cruise performance
Descent (DSCNT)	Performance subprogram	Calculates descent performance
Loiter (LOITR)	Performance subprogram	Calculates loiter performance
Change Fuel Weight (CHCFW)	Performance subprogram	Adds or subtracts fuel to aircraft
Change Payload (CHGPL)	Performance subprogram	Adds or subtracts payload to aircraft
Transfer Altitude (TRALT)	Performance subprogram	Changes altitude

### 3.4 SUBROUTINE CROSS REFERENCE

The following is a list of called subroutines by a specific subroutine.

MAIN: calls:

SIZTR	ATMOS	PRFRM
AERO	ROTPOW	
ENGSZ	WGTR	

AERO

does not call any other subroutine

ATMOS

does not call any other subroutine

CHGRW

does not call any other subroutine

CHGPL

does not call any other subroutine

CLIMB

calls:	ATMOS	ROTPOW	THRUST	THRAVL
	DRAG	POWER	POWAVI	CRUS 1, 2, 3

CRUS 1

calls:	ATMOS	ROTLIM	POWER	THREQ
	DRAG	ROTPOW	POWAVL	POWERI
	POWAVL	POWREQ	THRAVL	POWAVI
				SCRIBE

CRUS 2

calls:	ATMOS	ROTPOW	POWERI	THRUST	POWREQ
	DRAG	POWER	POWAVI	THRAVL	SCRIBE
	ROTLIM	POWAVL	POWRQI	THREQ	CRUS 1

CRUS 3

calls:	ATMOS	ROTPOW	POWREQ	POWRQI
	DRAG	POWER	POWERI	THREQ
	ROTLIM	POWAVL	POWAVI	SCRIBE

DESPOW

does not call any other subroutine

DRAG does not call any other subroutine

DSCNT  
calls:     ATMOS       POWRQI       POWAVL  
          DESPOW       THRAVL       POWREQ  
          POWAVI       THRREQ

ENGS2  
calls:     ROTPOW       ATMOS       THRUST  
          POWAVL       DRAG        THRAVL  
          POWAVI

ENG 1 does not call any other subroutine

ENG 1 I does not call any other subroutine

FORMS does not call any other subroutine

LOADER does not call any other subroutine

LOITR  
calls:     ATMOS       POWAVL       POWREQ  
          ROTLIM       POWAVI       THRREQ  
          ROTPOW       THRQVL       POWRQI

POWAVL  
calls:     Eng 1

POWAVI  
calls:     Eng 1 I

POWREQ  
calls:     Eng 1  
          POWRQI  
          ENG 1 I

POWER  
calls:     POWAVL       POWAVI  
          POWREQ       POWRQI  
          THRUST



POWERI

calls: POWAVI  
POWRQI  
THRUST

PRFRM

calls: LOADER CLIMB LOITR TRALT  
TAXI CRUS 1,2,3 CHGFW PRFRP  
TOHL DSCNT CHGPL

PRFRP

calls: ATMOS POWER POWRQI LOITR POWAVI  
DRAG ROTPOW POWREQ ROTLIM THRAVL  
ROTPOW POWER! POWAVL CRUS 1, 3

PRINT 1

calls: LOADER  
ATMOS  
PRINT 2

PRINT 2

calls: LOADER  
ATMOS

ROTLIM

calls: DRAG  
ROTPOW

ROTPOW

does not call any other subroutine

SCRIBE

does not call any other subroutine

SIZTR

calls: ATMOS AERO  
ROTPOW DRAG  
POWAVL POWAVI  
THRAVL

TAXI

calls: ATMOS POWAVL  
THRAVL  
POWAVI

THRAVL does not call any other subroutine

THREEQ does not call any other subroutine

THRUST does not call any other subroutine

TOHL  
calls:       ATMOS               ROTPOW       THRAVL  
              POWAVL            POWREQ  
              ROTLIM            POWAVI

TRACT  
calls:       CRUS 1  
              CRUS 2  
              CRUS 3

WGTR does not call any other subroutine

FUNCTIONS:

All functions do not call any other subroutine. For a complete list the functions are:

BIV	TRIV
PARA	XLINT
TABLE	XLKUP
	XIBIV

## 4.0 DETAILED PROGRAM DESCRIPTION

### 4.1 MAIN CONTROL LOOP

Figure 4-1 is a flow chart of the main control loop for the computer program. In the sizing option (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.

#### 4.1.1 Input Card Setup

The first five columns of an input card contains information used by the input routine LOADER. A card with 77777 punched in the first five columns indicates a title card follows. The following card is an alpha-numeric title card with information in columns seven through seventy-eight as shown on the input sheets in the User's Manual. All input data are assigned a unique location in the input data file. This is indicated by the location number of each variable on the input sheets in the User's Manual. Up to five variables may be input on a card. Columns 1 through 4 contain the location number of the first variable on the card and column five the number of variables on the card. A card with 88888 punched in the first five columns indicates the end of data for that case and starts program execution. A card with 99999 in the first five columns indicates the end of the run and causes program termination. Cases can be stacked in the following manner.

77777	Card
	Title Card
	Data Cards
88888	Card
77777	Card
	Title Card
	New Data Cards
88888	Card
99999	Card

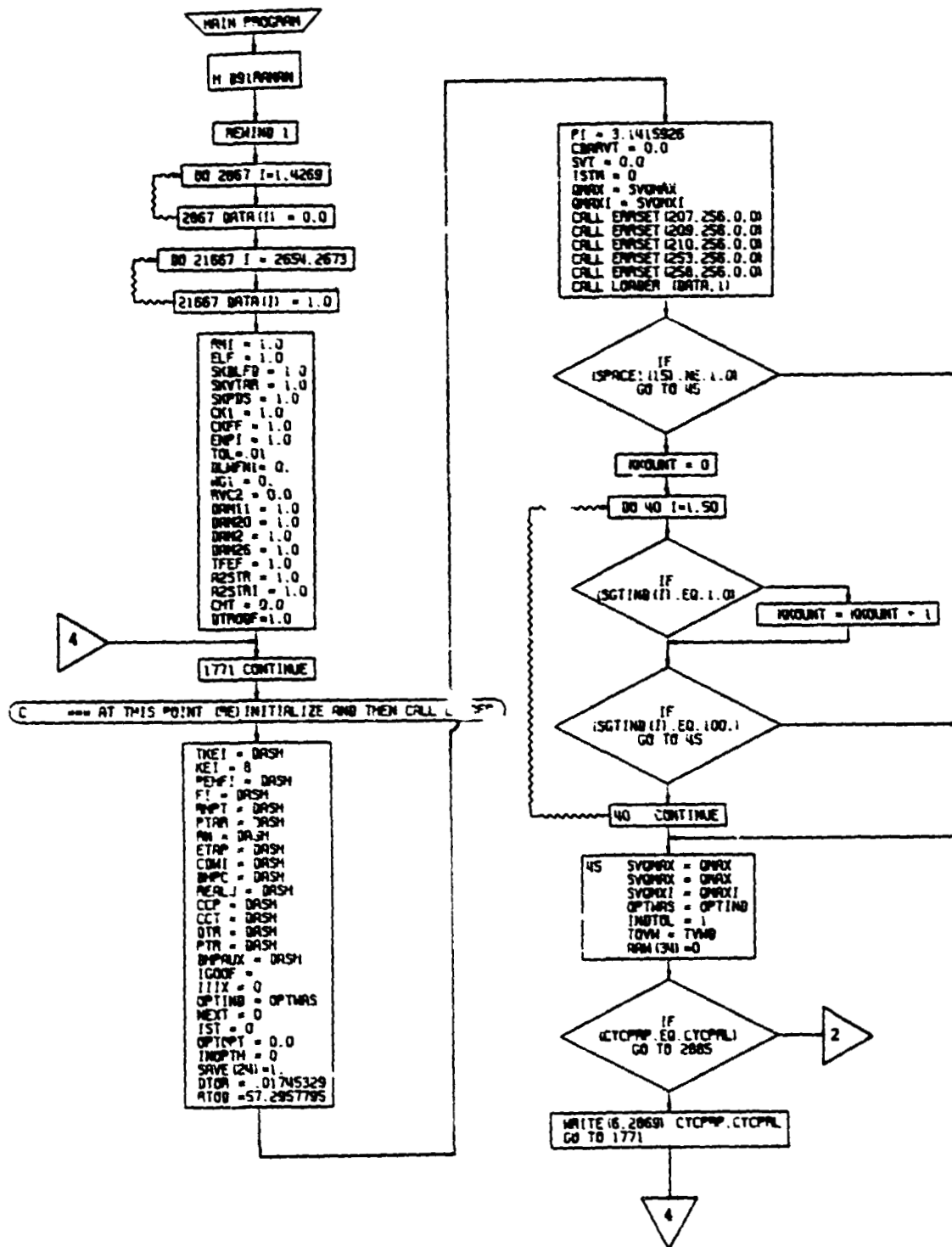


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 1 of 13)

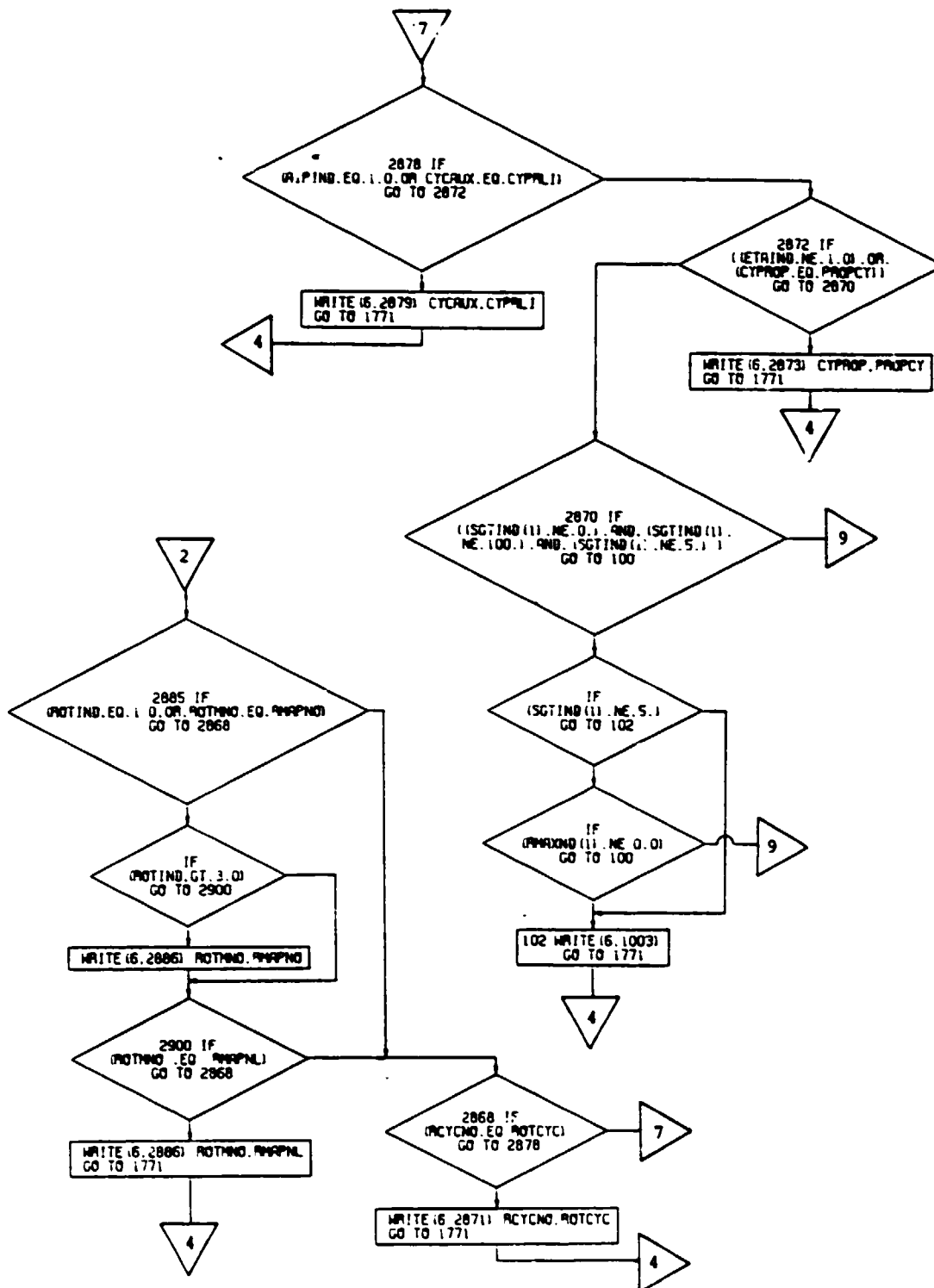


Figure 4-1. MAIN Control Loop Subroutine, Flow chart (Part 2 of 13)

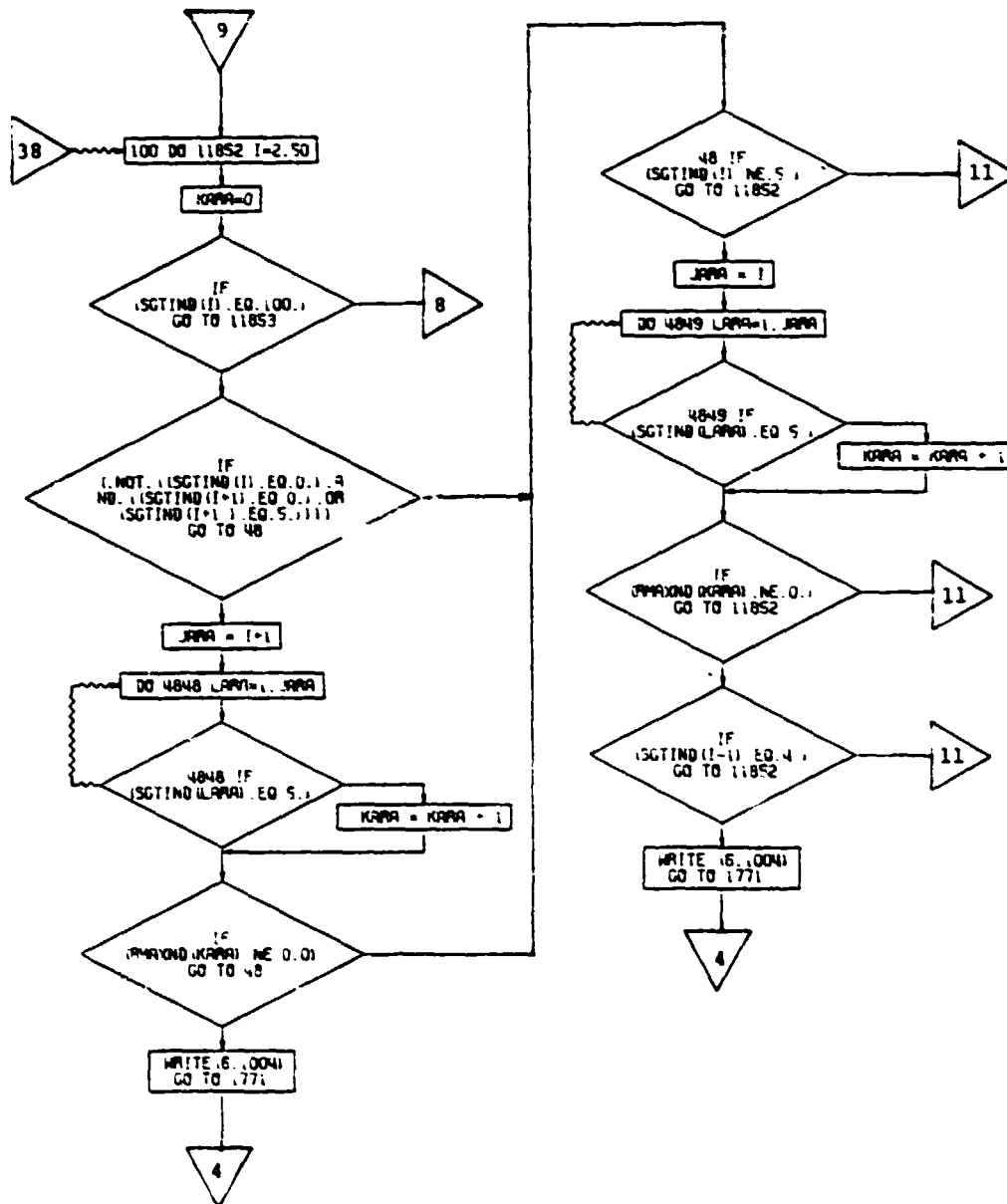


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 3 of 13)

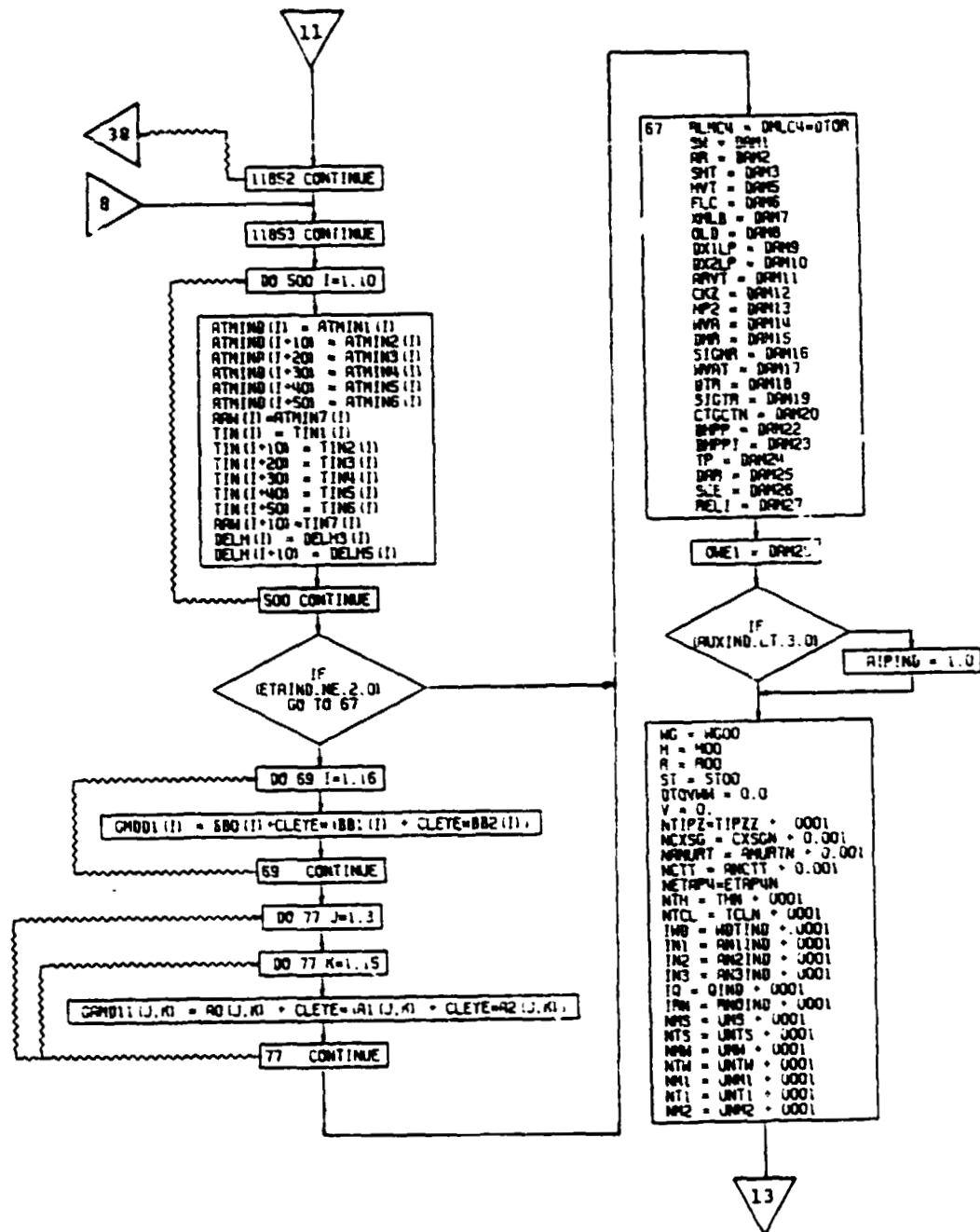


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 4 of 13)

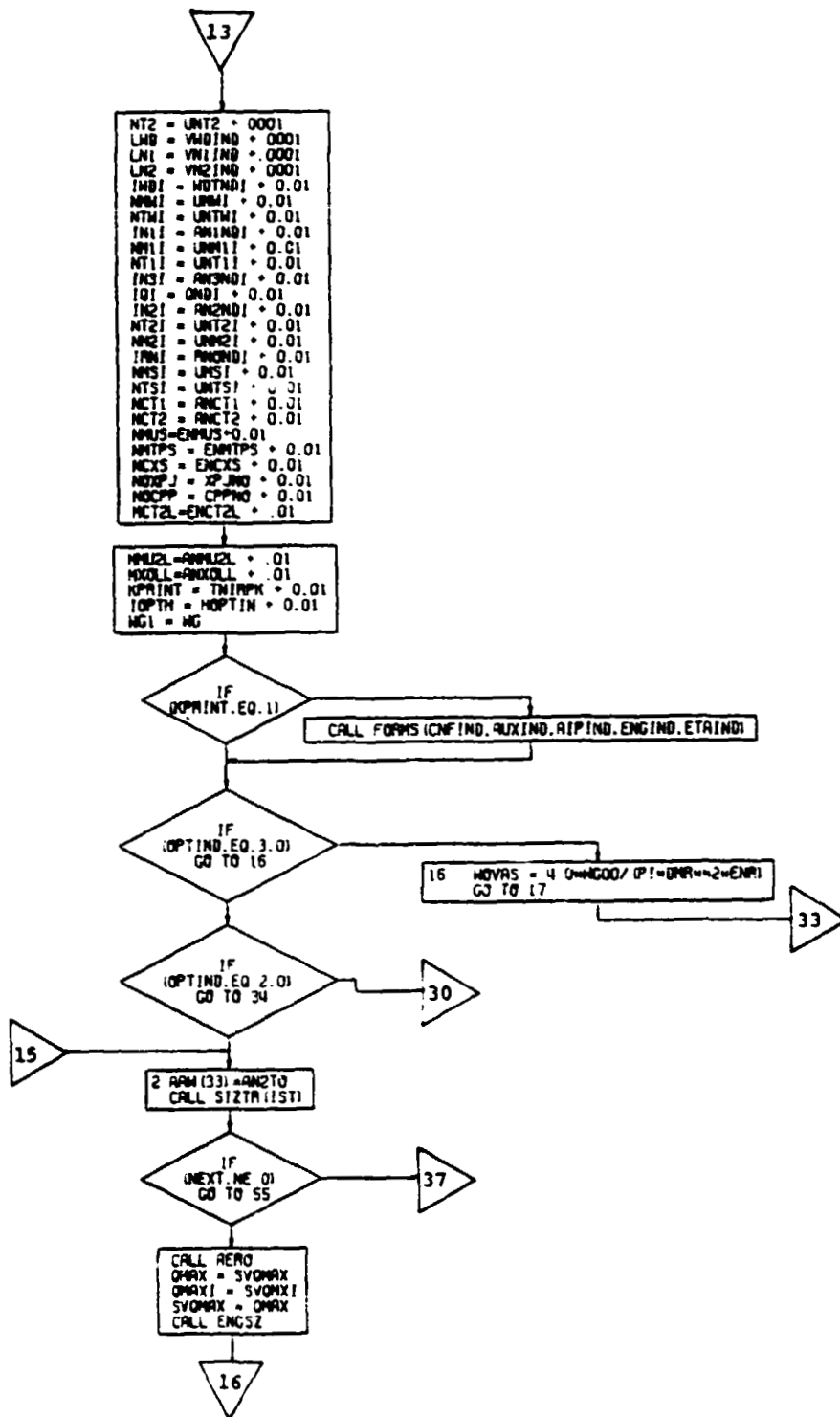


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 5 of 13)



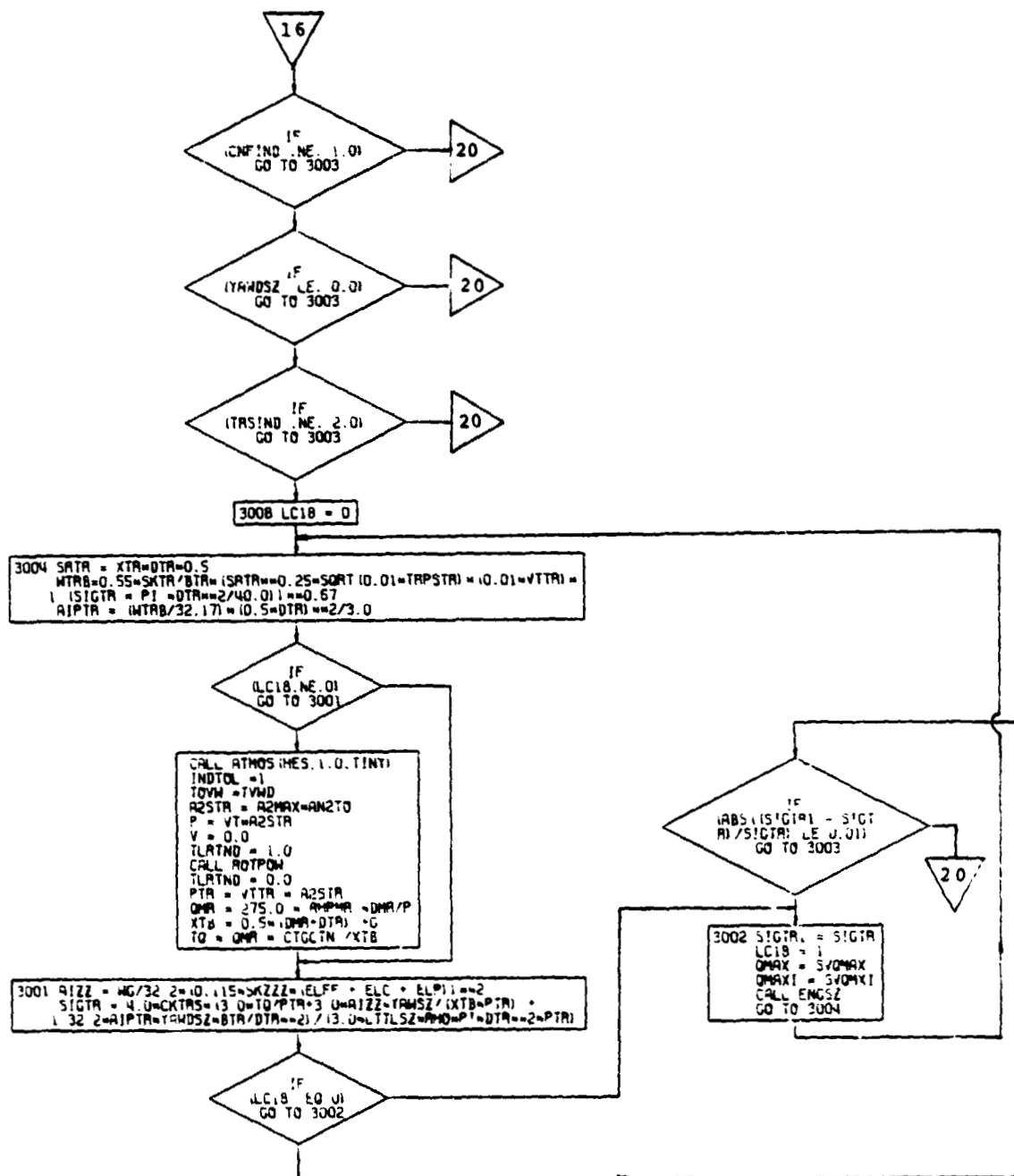


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 6 of 13)

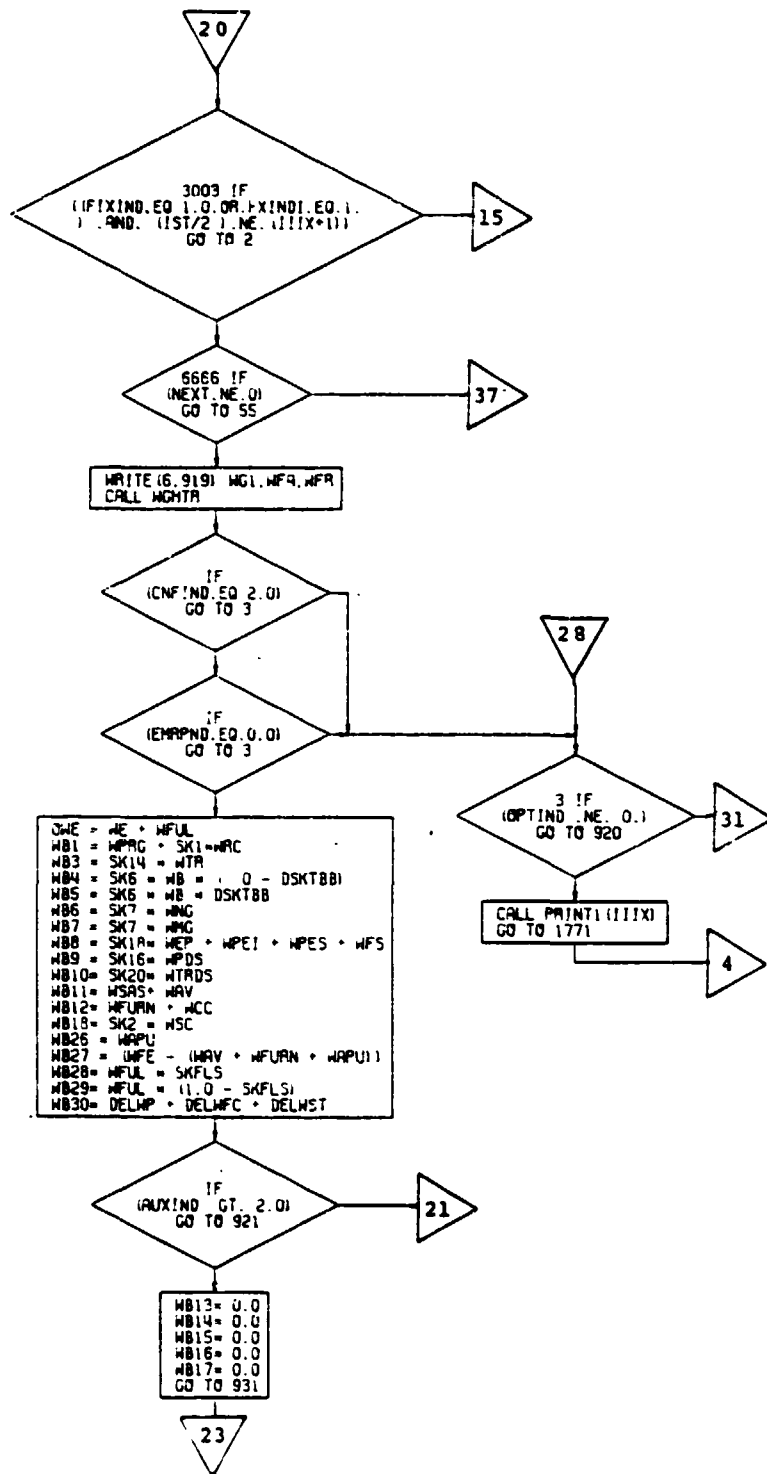


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 7 of 13)

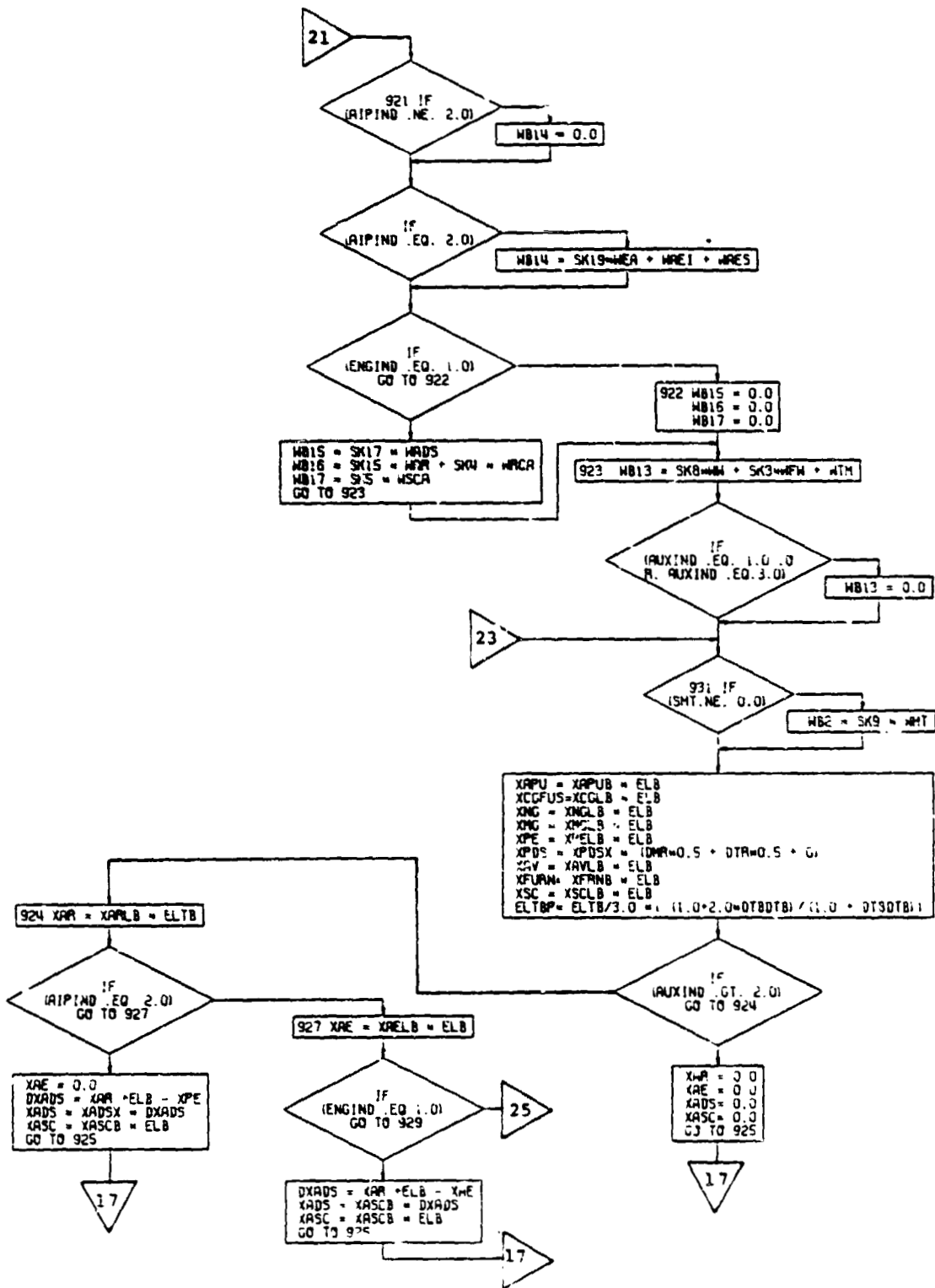


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 8 of 13)

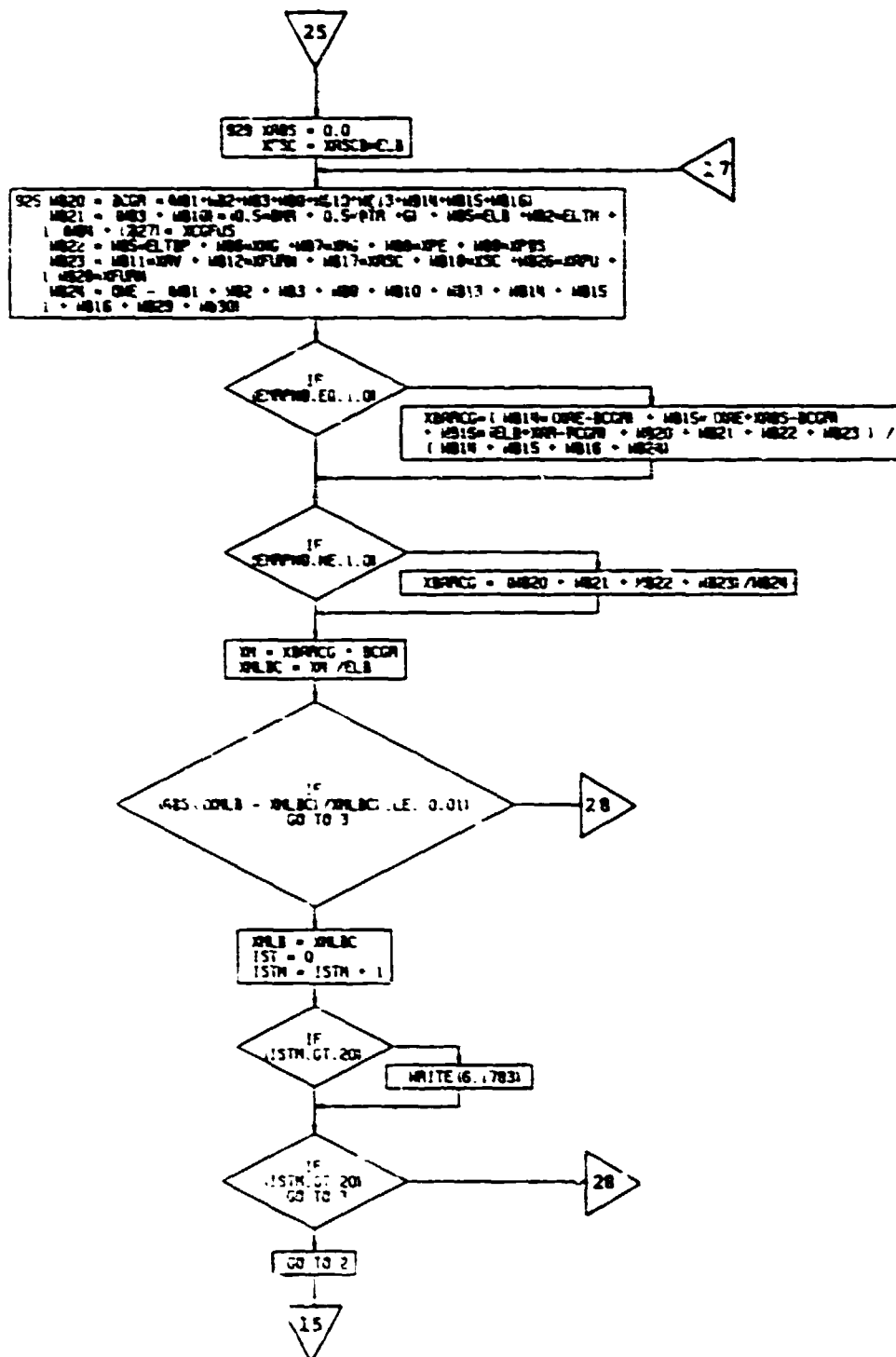


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 9 of 13)

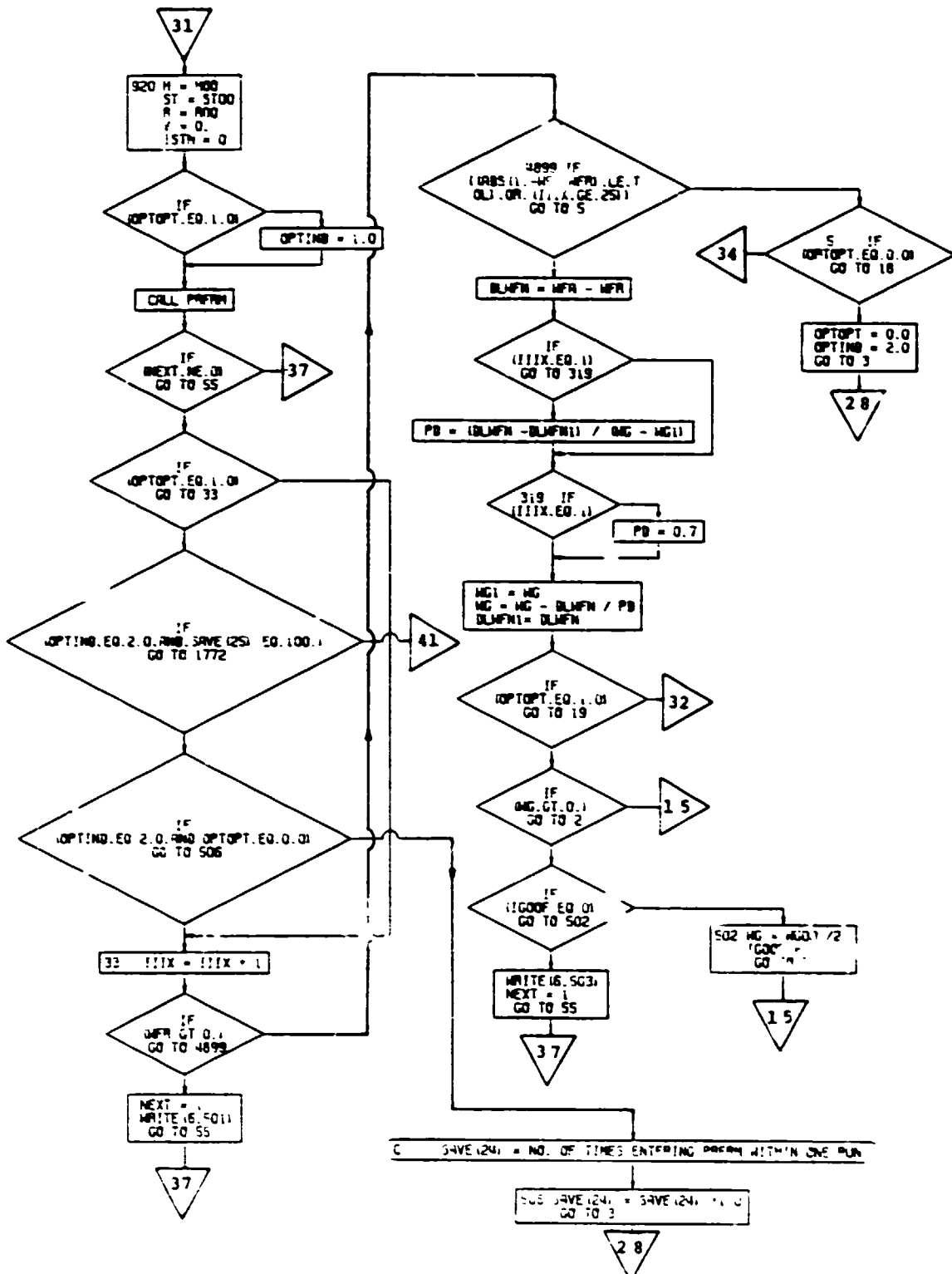


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 10 of 13)

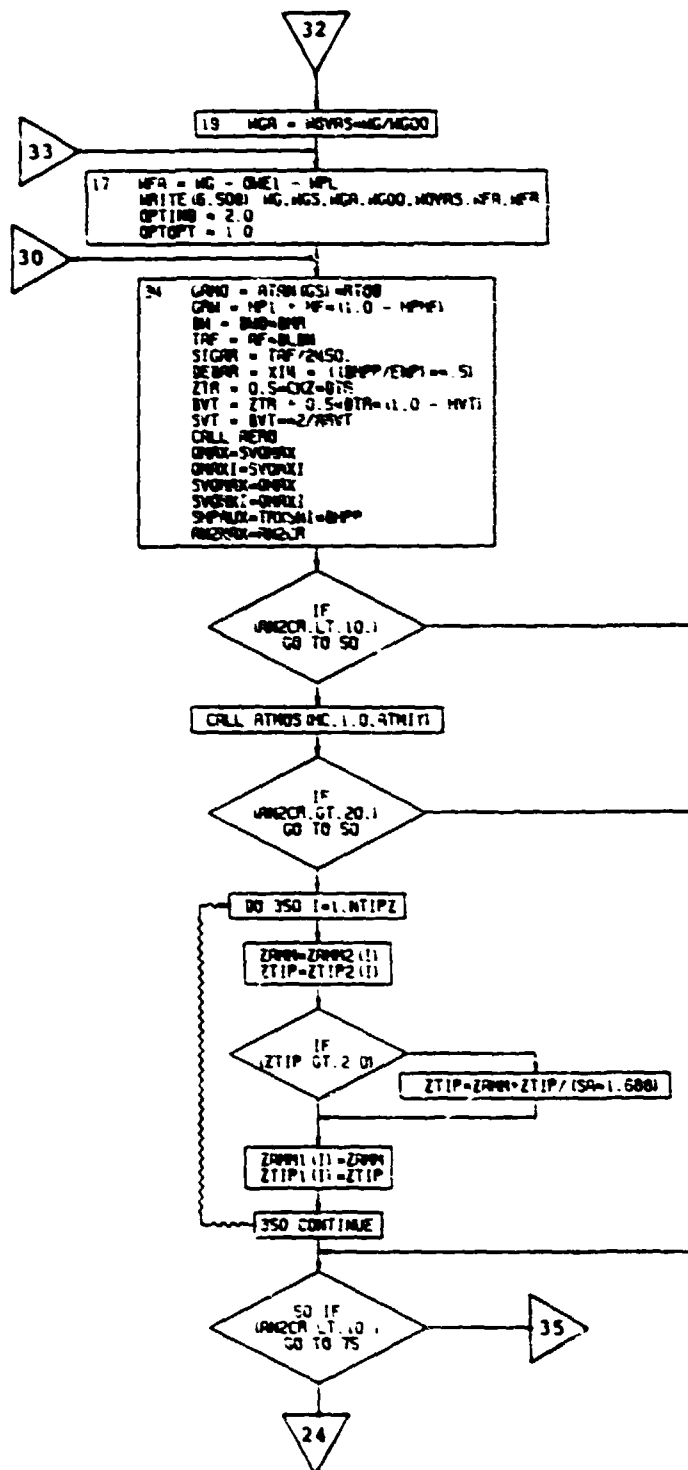


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 11 of 13)

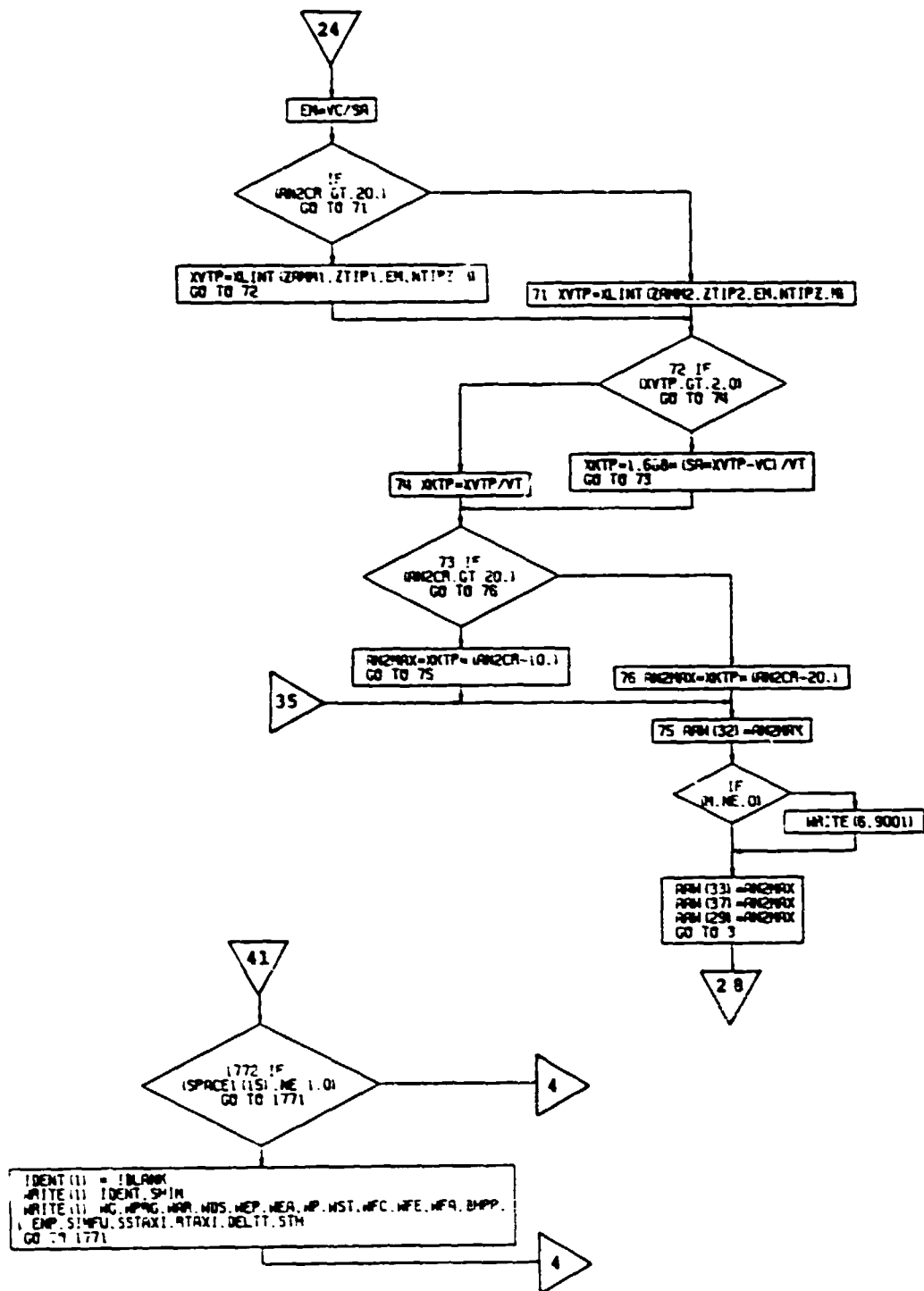


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 12 of 13)

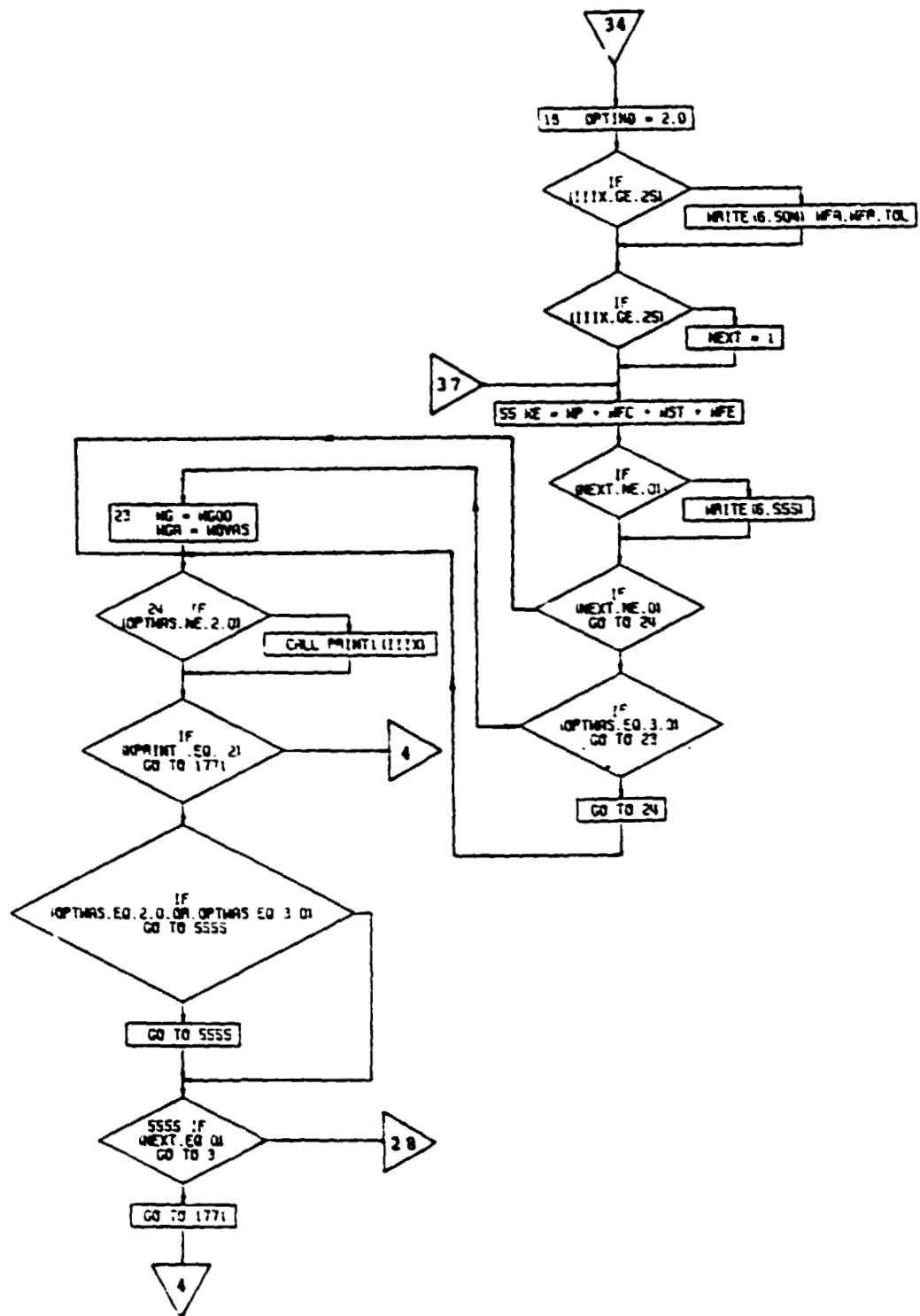


Figure 4-1. MAIN Control Loop Subroutine, Flow Chart (Part 13 of 13)



#### 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. Input locations 1650 -1670.

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

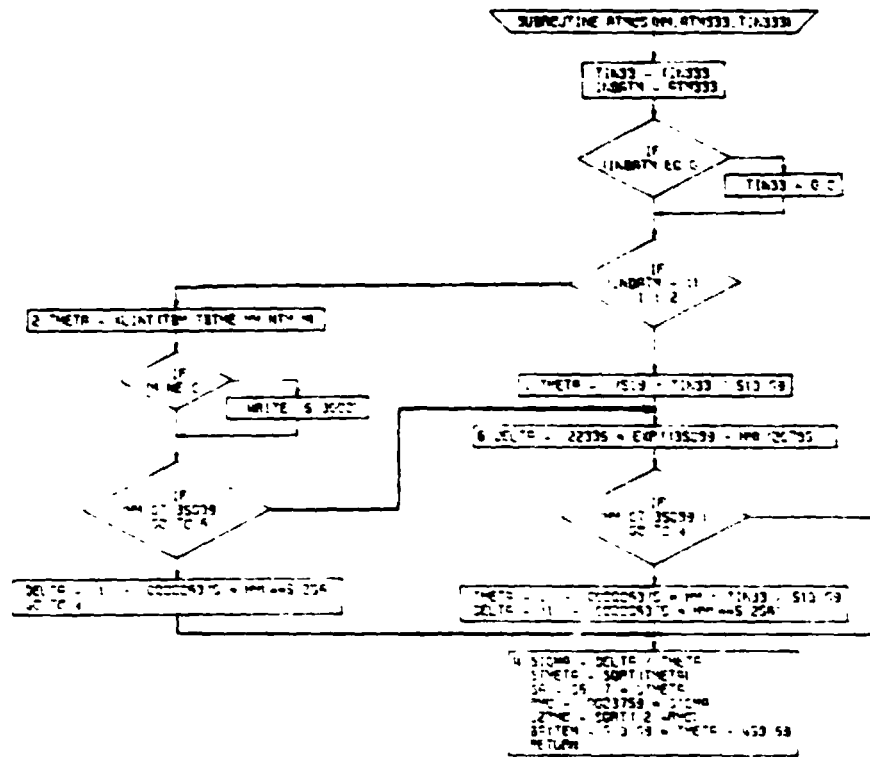


Figure 4-5. ATMOS Subroutine, Flow Chart

#### 4.3 DRAG CALCULATIONS SUBROUTINE

The drag calculations subroutine uses the factors  $a_5$  through  $a_9$ , as determined by the aerodynamics calculations subroutine to calculate the total drag of the helicopter. Besides parasite drag, in the case of compound or winged helicopters, total drag includes wing induced drag and rotor/wing interference drag, the latter being calculated using a simplified Prandtl Bi-Plane Theory approach. The total helicopter propulsive thrust coefficient ( $C_T$ ) is calculated as a function of forward flight helicopter advance ratio ( $\mu$ ). The subroutine flow chart is shown in Figure 4-3.

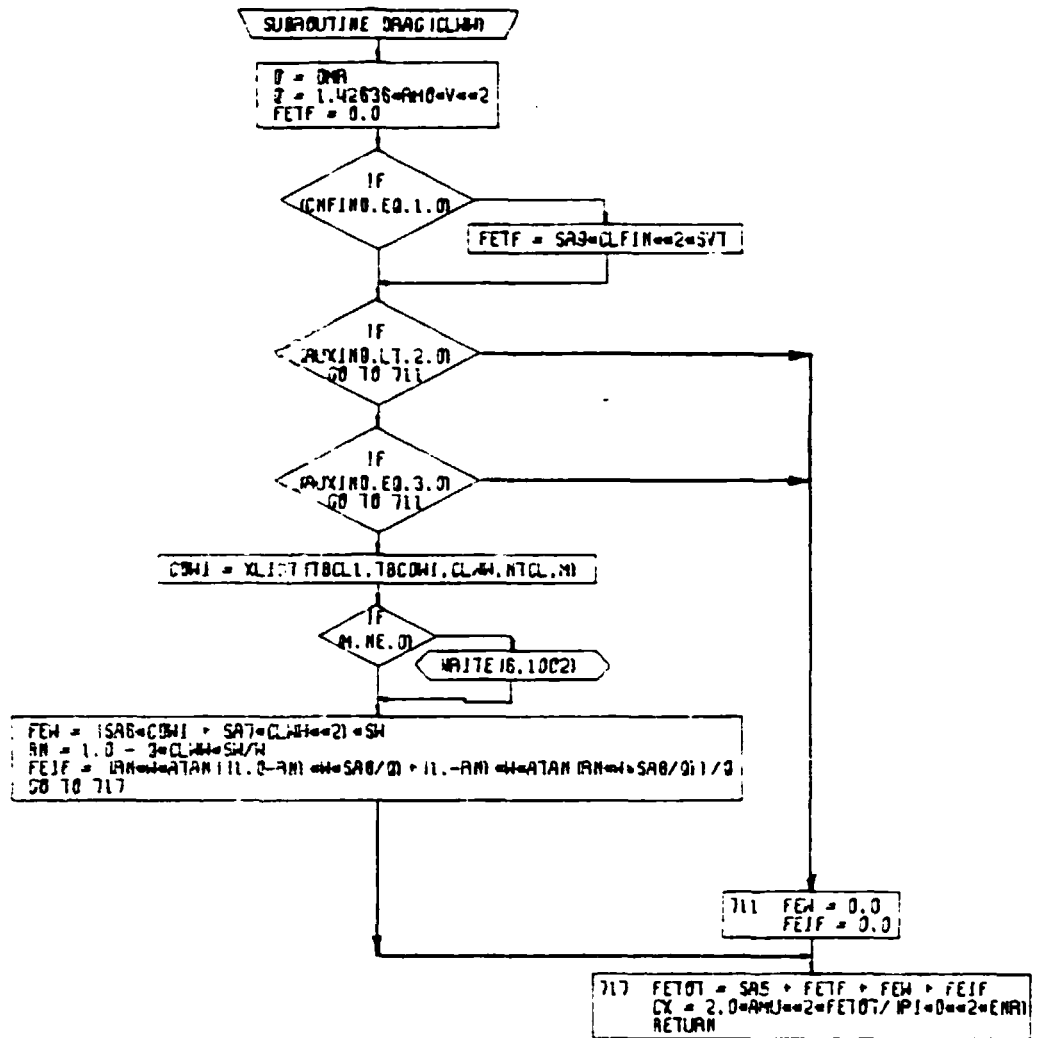


Figure 4-3. Drag Calculations (DRAG) Subroutine Flow Chart (Part 1 of 1).

#### 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

input locations 1326-1373

2. referred fuel flow

input locations 1390-1437

3. referred gas generator shaft RPM

input locations 1454-1501

4. referred power turbine shaft RPM

input locations 1518-1565

For the primary engine cycles, these tables are functions of Mach number and turbine inlet referred temperature. For lift engine cycles, the tables are functions only of turbine inlet referred 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  $\frac{N_{II}}{N_{II,MAX}}$  Loc (1238), is set equal

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

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	$\dot{W}_f$	$\left\{ \begin{array}{l} \dot{W}_f / \delta \sqrt{\theta} F_N^* \\ \dot{W}_f / \delta \sqrt{\theta} SHP^* \end{array} \right.$
Turbine Inlet Temperature	T	$T / \theta$
Where:	<p>* = Max. Power Setting, Static, Sea Level, Standard Day</p> <p><math>\theta</math> = Ambient Temperature (<math>^{\circ}R</math>) Divided by <math>518.69^{\circ}R</math></p> <p><math>\delta</math> = Ambient Pressure (psia) Divided by 14.696 psia</p>	

$$\frac{N_{II}}{N_{II\_OPT}} = 1.0 = \frac{\left( \frac{N_{II}}{N_{II\_MAX}} \right) \left( \frac{N_{II\_MAX}}{N_{II}^*} \right)}{\left( \frac{N_{II}}{N_{II\_OPT}} \sqrt{\theta} \right)} \frac{1}{\sqrt{\theta}}$$

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

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

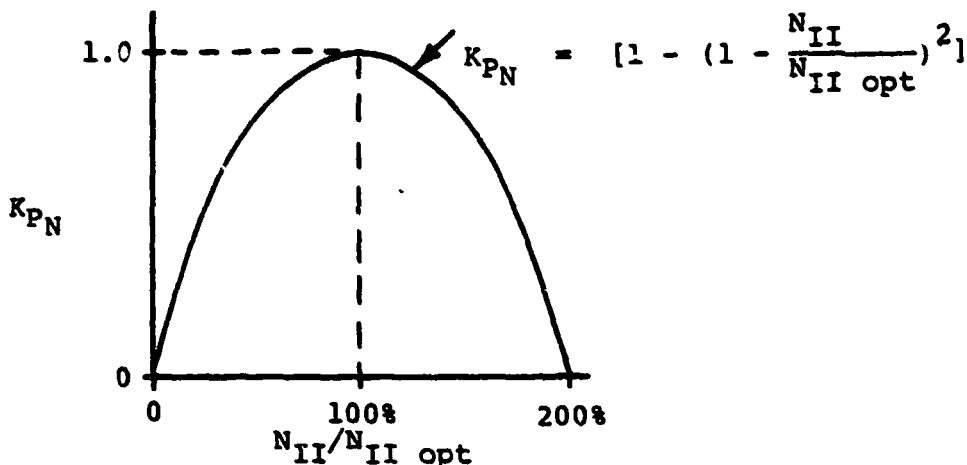
TABLE 4-2

HESCOMP ENGINE LIBRARY

		Engine Cycle Number	Maximum Turbine Inlet Tempera- ture - °R	Compressor Design Pressure Ratio	Fan Bypass Ratio						
↑ Primary Propulsion Engines ↓ Auxiliary Independent Propulsion Engines ↓	↑ Primary Propulsion Engines ↓	Turboshaft Engines	1 2 3 4 5 6 7 8 9	2600 2600 2900 2900 2900 3200 3200 3200 3200	13 16 13 16 19 13 16 19 22						
		↓ Auxiliary Independent Propulsion Engines ↓	↓ Auxiliary Independent Propulsion Engines ↓	Turbojet Engines	10 11 12 13 14 15 16 17 18	2600 2600 2900 2900 2900 3200 3200 3200 3200	13 16 13 16 19 13 16 19 22				
				↓ Auxiliary Independent Propulsion Engines ↓	↓ Auxiliary Independent Propulsion Engines ↓	↓ Auxiliary Independent Propulsion Engines ↓	Turbofan Engines	19, 20, 21 22, 23, 24 25, 26, 27 28, 29, 30 31, 32, 33 34, 35, 36 37, 38, 39 40, 41, 42 43, 44, 45	2600 2600 2900 2900 2900 3200 3200 3200 3200	16 20 16 20 24 16 20 24 28	2, 4, 6 2, 4, 6 2, 4, 6 2, 4, 6 2, 4, 6 2, 4, 6 2, 4, 6 2, 4, 6 2, 4, 6

where  $V_T$  is input Loc (0181). By setting N2IND = 2, Loc (1204), turboshaft engine power at nonoptimum  $N_{II}$  will be calculated by the program by multiplying power at optimum  $N_{II}$  by a correction factor,  $K_{PN}$ , which is a function of  $N_{II}/N_{II,MAX}$ . 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 inputs  $N_{II}/N_{II,MAX}$  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.

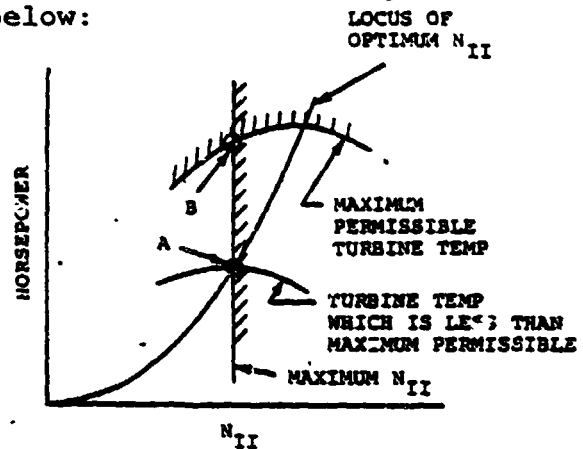
By setting N2IND = 0 or 1, the program will assume that the power turbine is always operating at optimum speed and no correction will be applied. N2IND = 0 will simulate an engine cycle which is operating at optimum  $N_{II}$  and for which no upper limit has been placed on  $N_{II}$ . For many applications, 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 slowed-rotor compound helicopter, 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.



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:

- A = Point of operation for aircraft flying at optimum  $N_{II}$ , limited by  $N_{II}$  MAX. (N2IND = 1)
- B = Point of operation for aircraft flying at non-optimum  $N_{II}$ , limited by same  $N_{II}$  MAX. (N2IND = 2)



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 WDTIND Loc (1201) =
  - 0. = no fuel flow cutoff
  - 1. = fuel flow cutoff specified by  $\frac{W_{MAX}}{W^*}$  Loc (1220).
- gas generator speed, N1IND Loc (1202) =
  - 0. = no ga. generator speed cutoff
  - 1. = gas generator speed cutoff specified by  $\frac{N_{I MAX}}{N_{I*}}$  Loc (1221)
- gas generator referred RPM, N10IND Loc (1203) =
  - 0. = no referred RPM cutoff
  - 1. = referred RPM cutoff specified by

Loc (1222)
- output shaft speed N2IND Loc (1204) =
  - 0. = no output shaft speed cutoff
  - 1. = output shaft speed cutoff specified by optimum Loc (1223).
  - 2. = output shaft speed cutoff specified by nonoptimum Loc (1233).

- torque, QIND Loc (1205) =
  0. = no torque limit
  1. = torque limit imposed on main and tail rotor transmission specified by  $Q_{MAX}/Q^*$  Loc (1224).
  2. = torque limit imposed on auxiliary propulsion transmission specified by  $Q_{MAX}/Q^*$  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,  $N_I$  limit, referred  $N_I$  limit,  $N_{II}$  limit, or fuel flow limit.

Manufacturers data on some engines show significant variations in both referred power ( $\text{shp}/\sigma\sqrt{\theta}$ ) 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

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

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  $K_{PR}$  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  $\xi_{4I}$ :

TURBOSHAFT ENGINE A

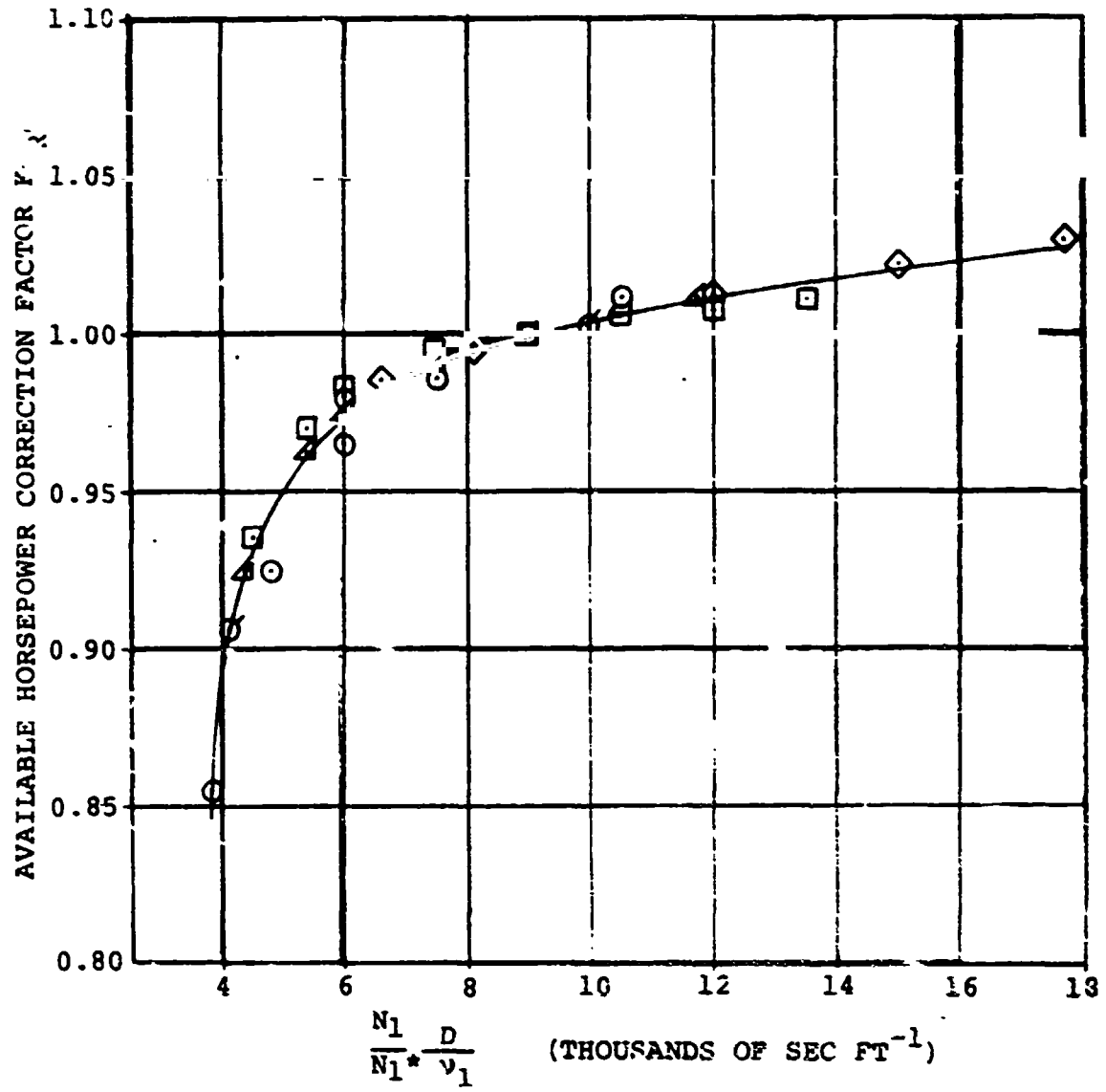


Figure 4-4. Typical Reynolds Number Correction Factor for a Turboshaft Engine Cycle.

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

$N_p = \text{number of primary engines}$

$$\text{Auxiliary Independent Engines} \left\{ \begin{array}{l} \text{weight (lb)} = k_{3I} \frac{F_N^*}{N_{p_i}} + k_{4I} \text{ or } k_{3I} \frac{\text{SHP}^*_i}{N_{p_i}} + k_{4I} \\ \text{diameter (ft)} = \xi_{4I} \left[ \frac{F_N^*}{N_{p_i}} \right]^{1/2} \text{ or } \xi_{4I} \left[ \frac{\text{SHP}^*_i}{N_{p_i}} \right]^{1/2} \end{array} \right.$$

$N_{p_i} = \text{number of independent auxiliary engines}$

It should be noted that auxiliary independent engine input data can be created from the engine cycle library data simply by the input of the applicable engine cycle IBM card deck, preceded and followed by a "66666" card. Nonstandard auxiliary independent engine performance is input using the sheet provided for that purpose.

Figures 4-5 through 4-12 are flow charts of the engine cycle subroutines. The purpose of these subroutines is described in Table 3-1 in Section 3.0 of this document.

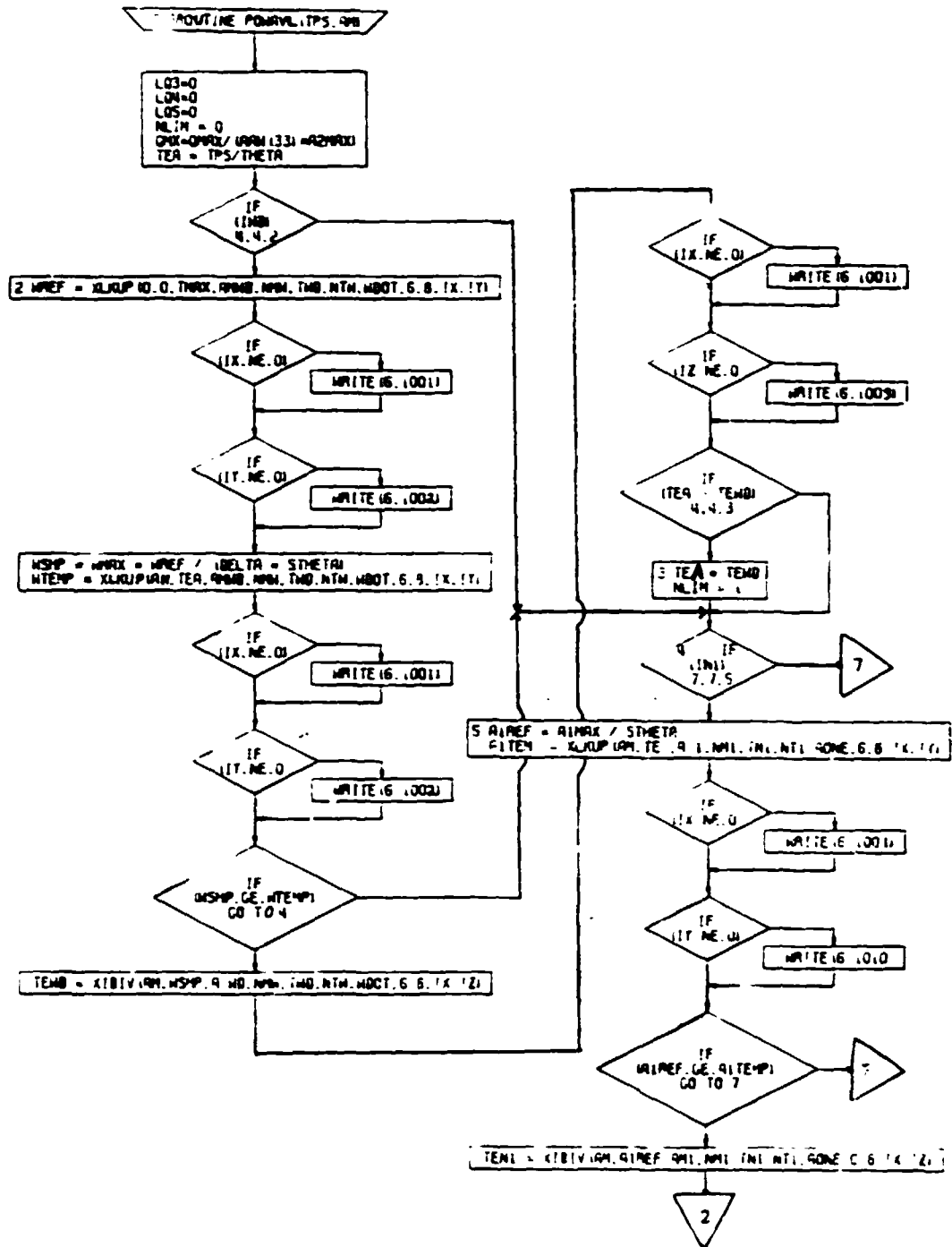


Figure 4-5. POWAVL Subroutine, Flow Chart (Part 1 of 5)

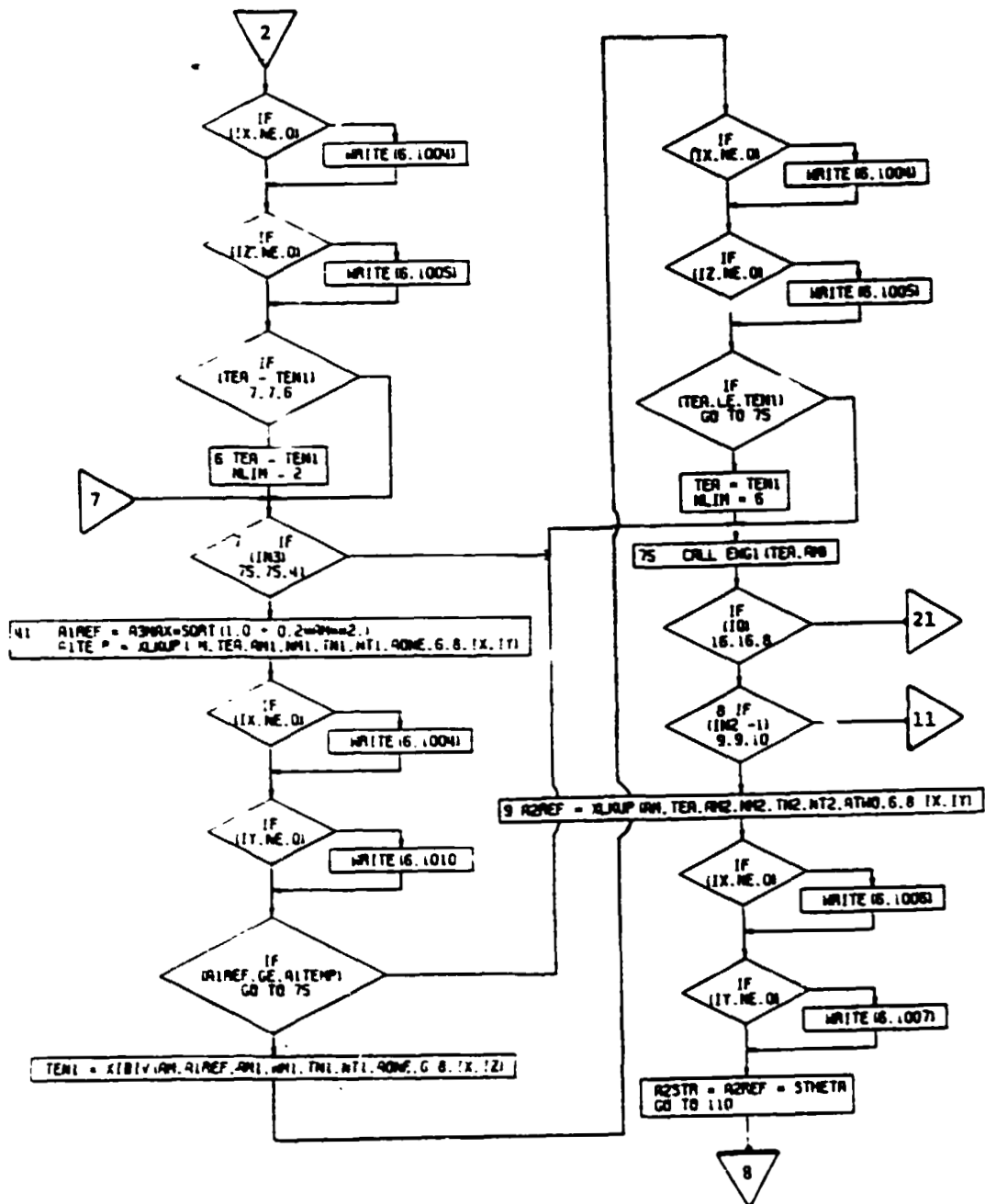


Figure 4-5. POWAVL Subroutine, Flow Chart (Part 2 of 5)

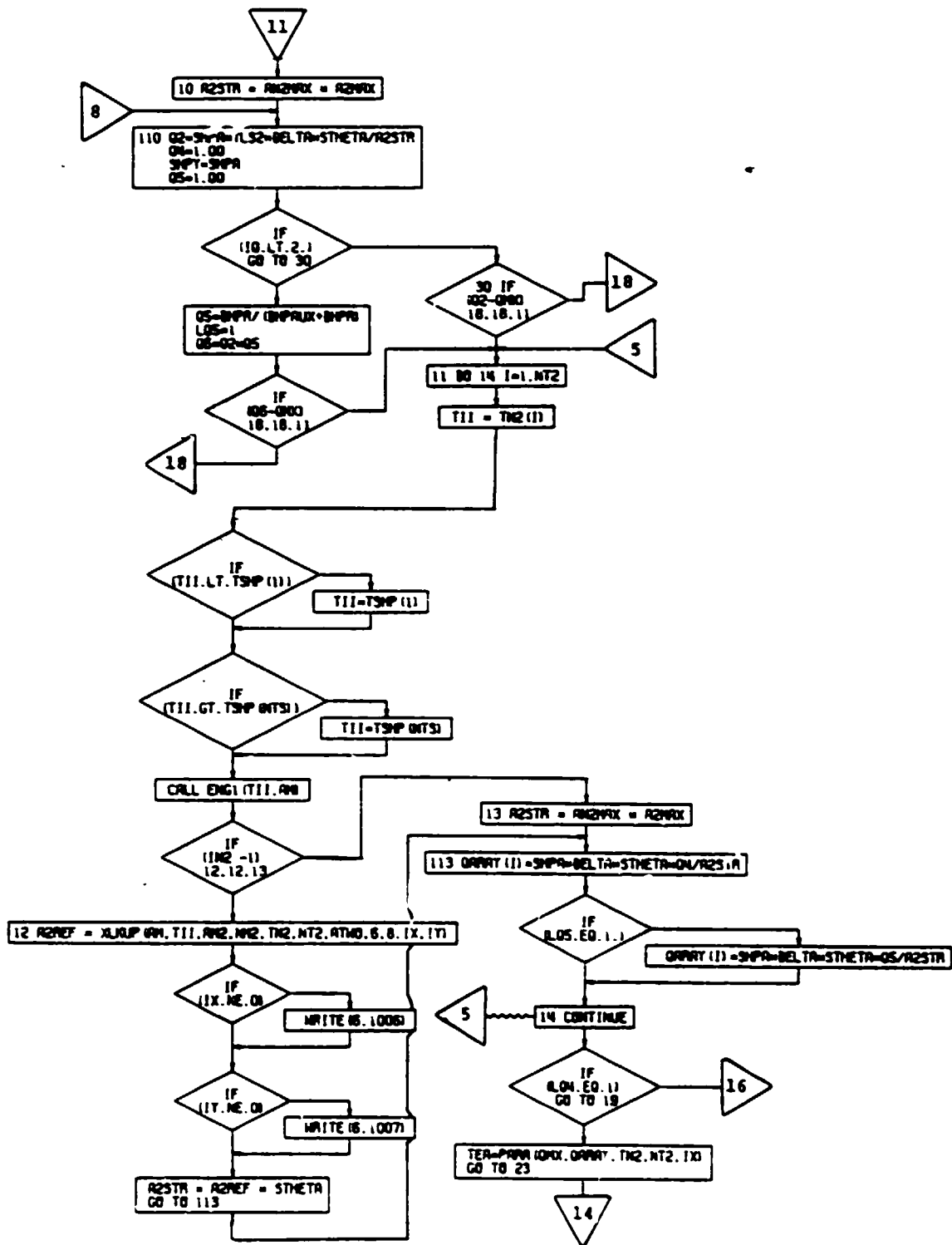


Figure 4-5. POWAVL Subroutine, Flow Chart (Part 3 of 5)

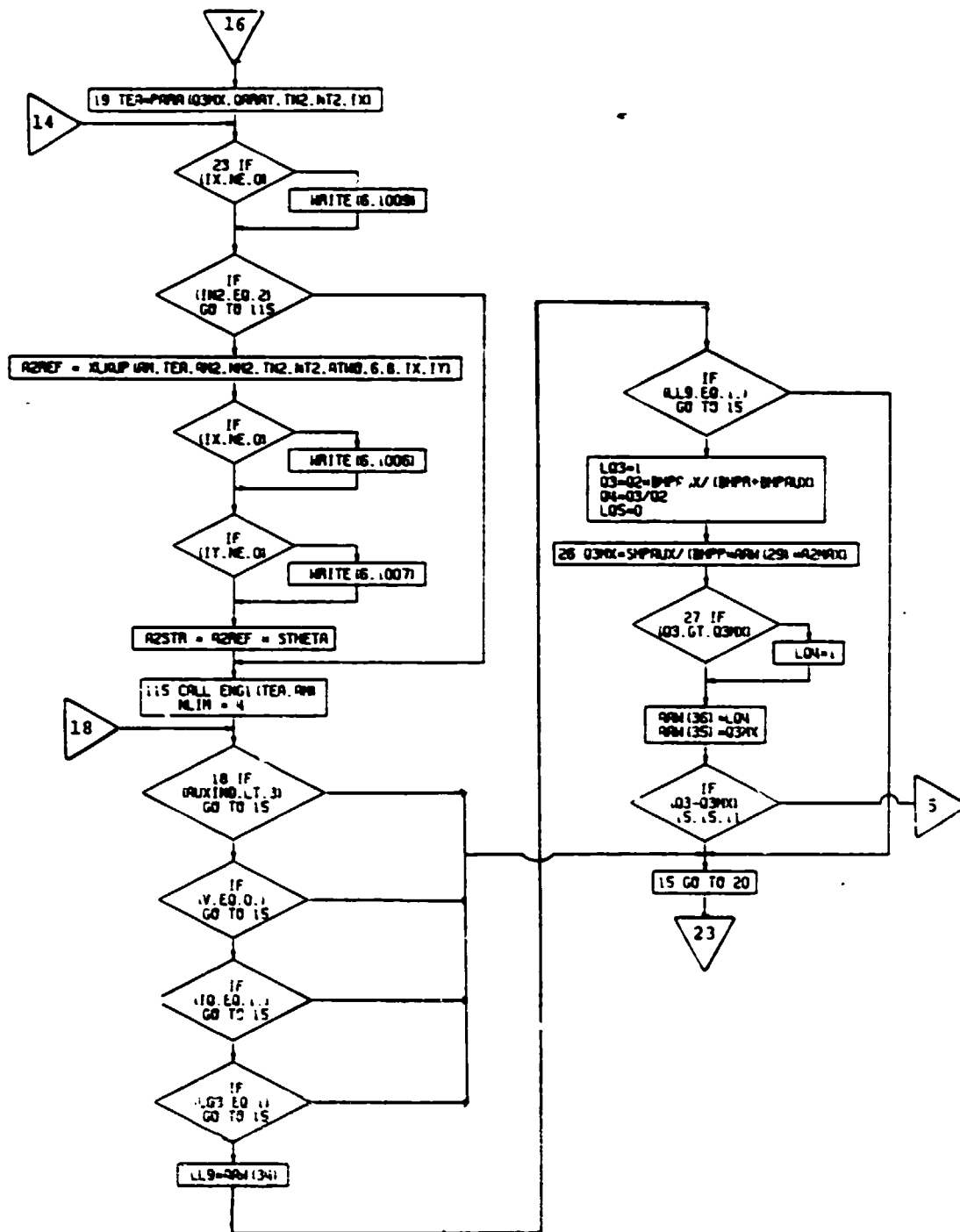


Figure 4-5. POKAVL Subroutine, Flow Chart (Part 4 of 5)



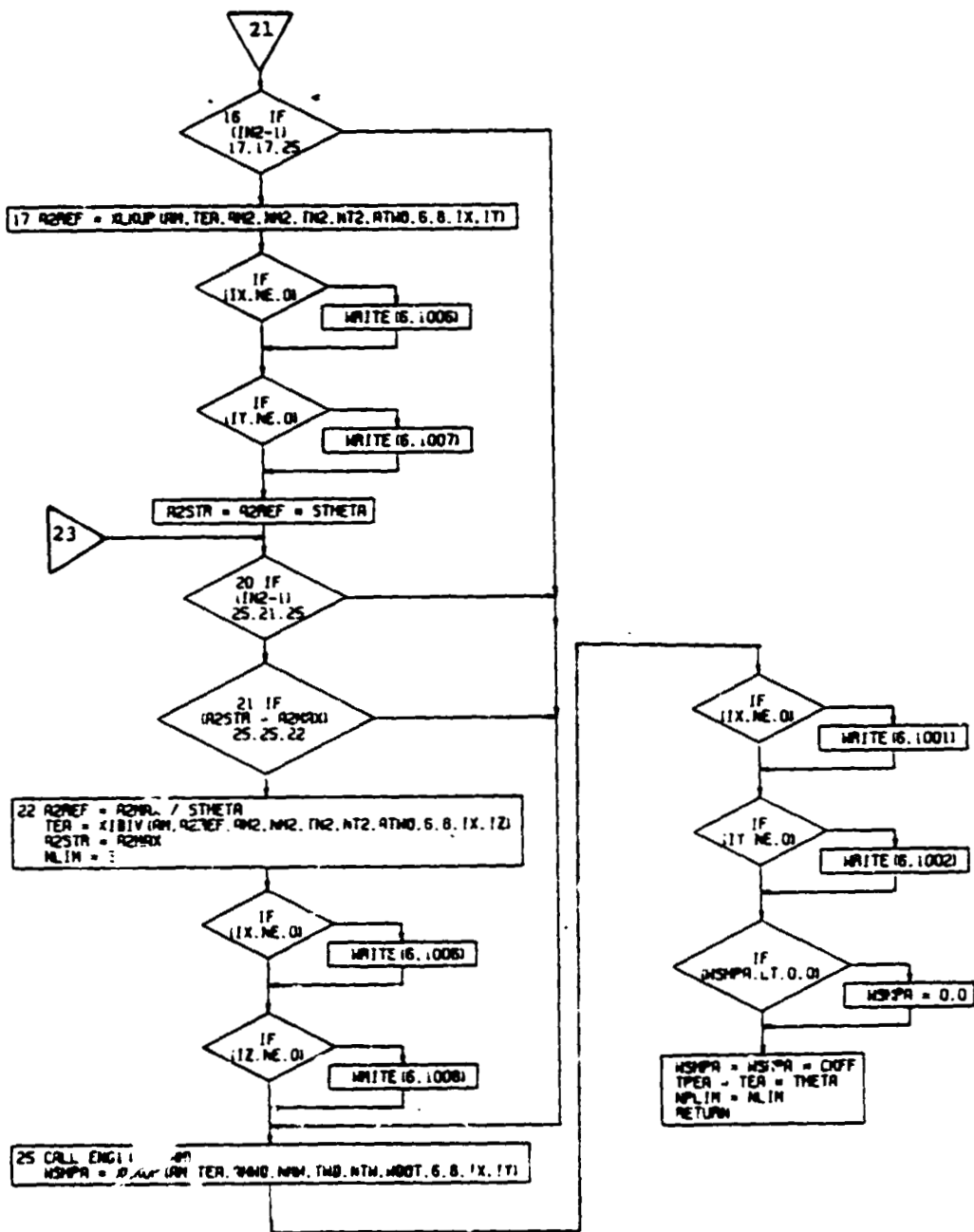


Figure 4-5. POWAVL Subroutine, Flow Chart (Part 5 of 5)

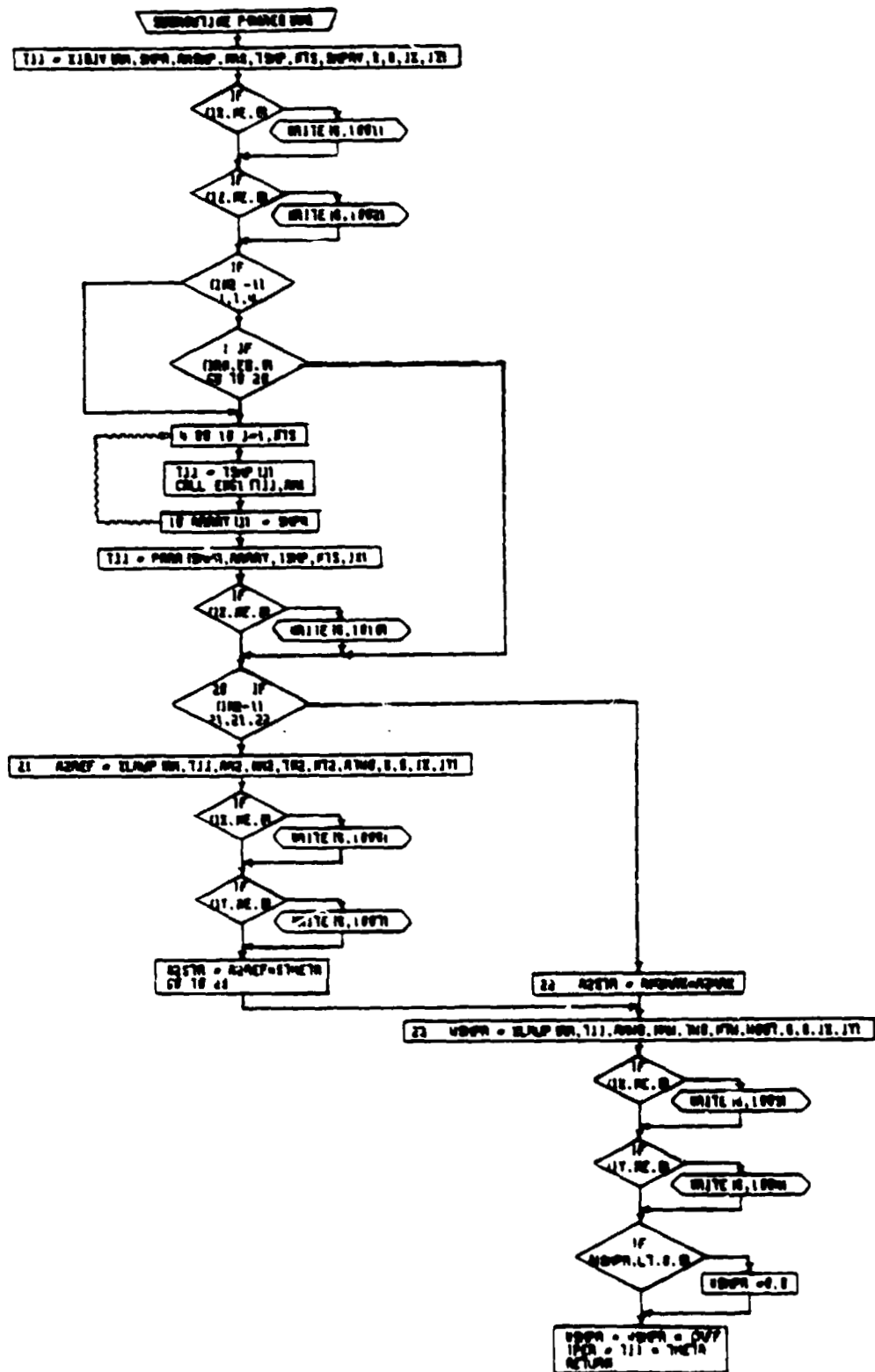


Figure 4-6. POWREQ Subroutine, Flow Chart.

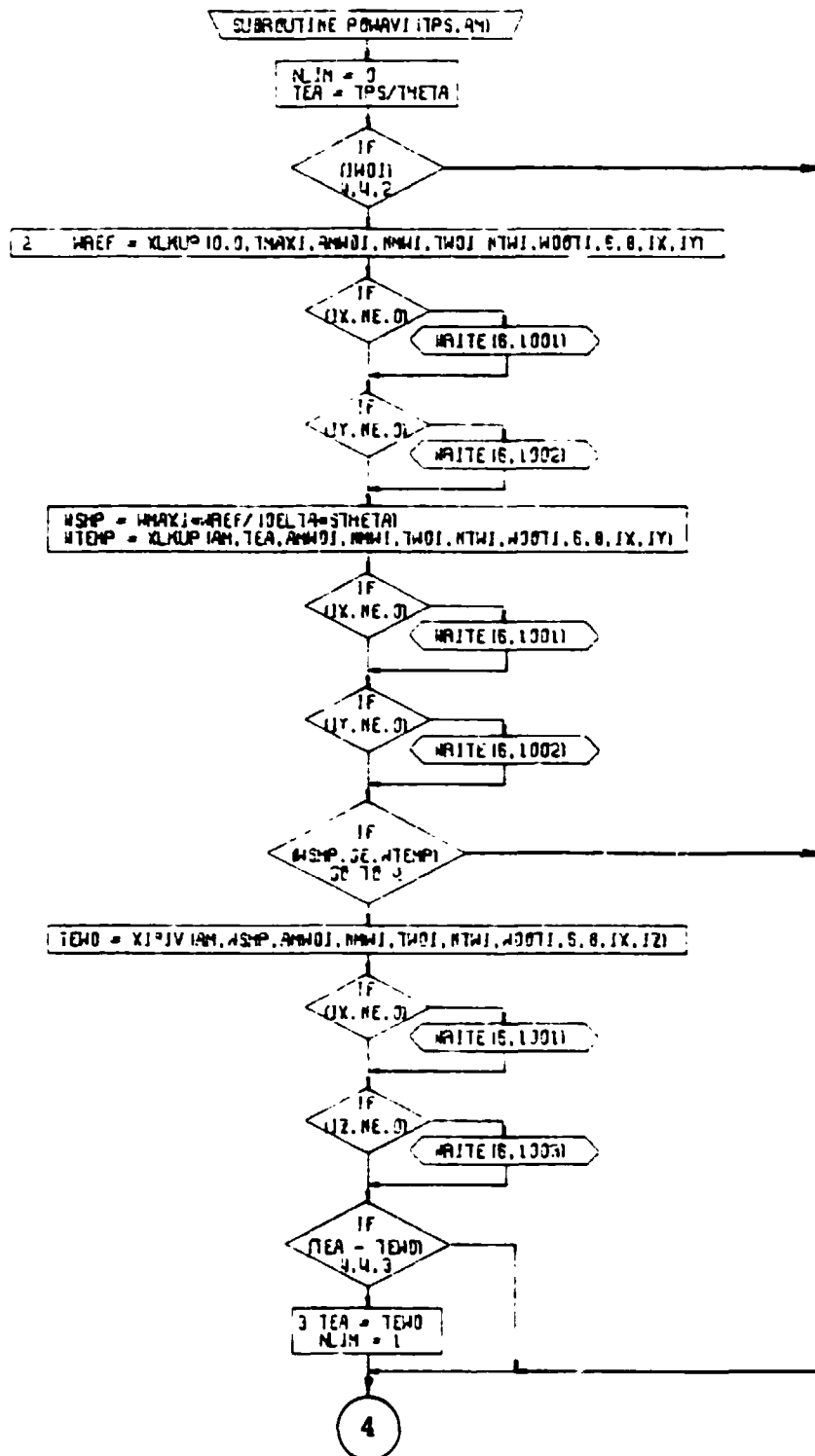


Figure 4-7. POWAVI Subroutine Flow Chart (Part 1 of 7).

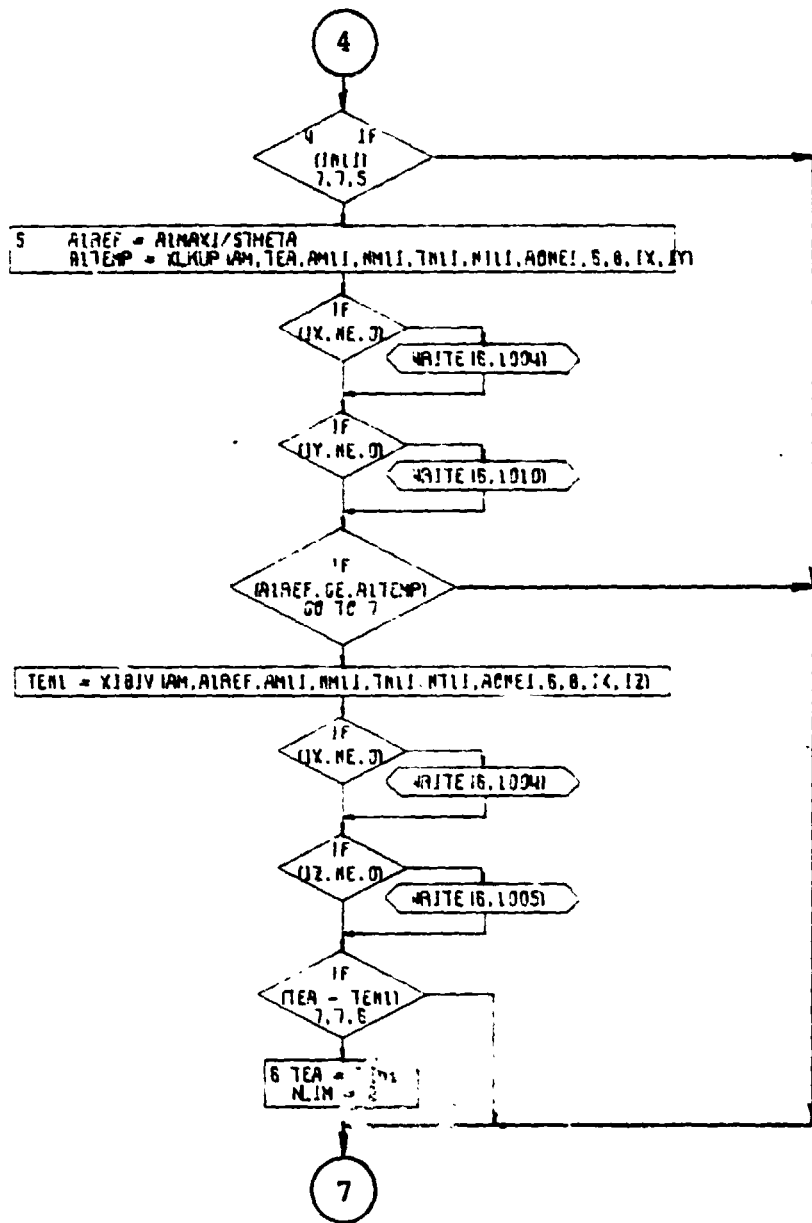


Figure 4-7. POWAVI Subroutine Flowchart (Part 2 of 7).

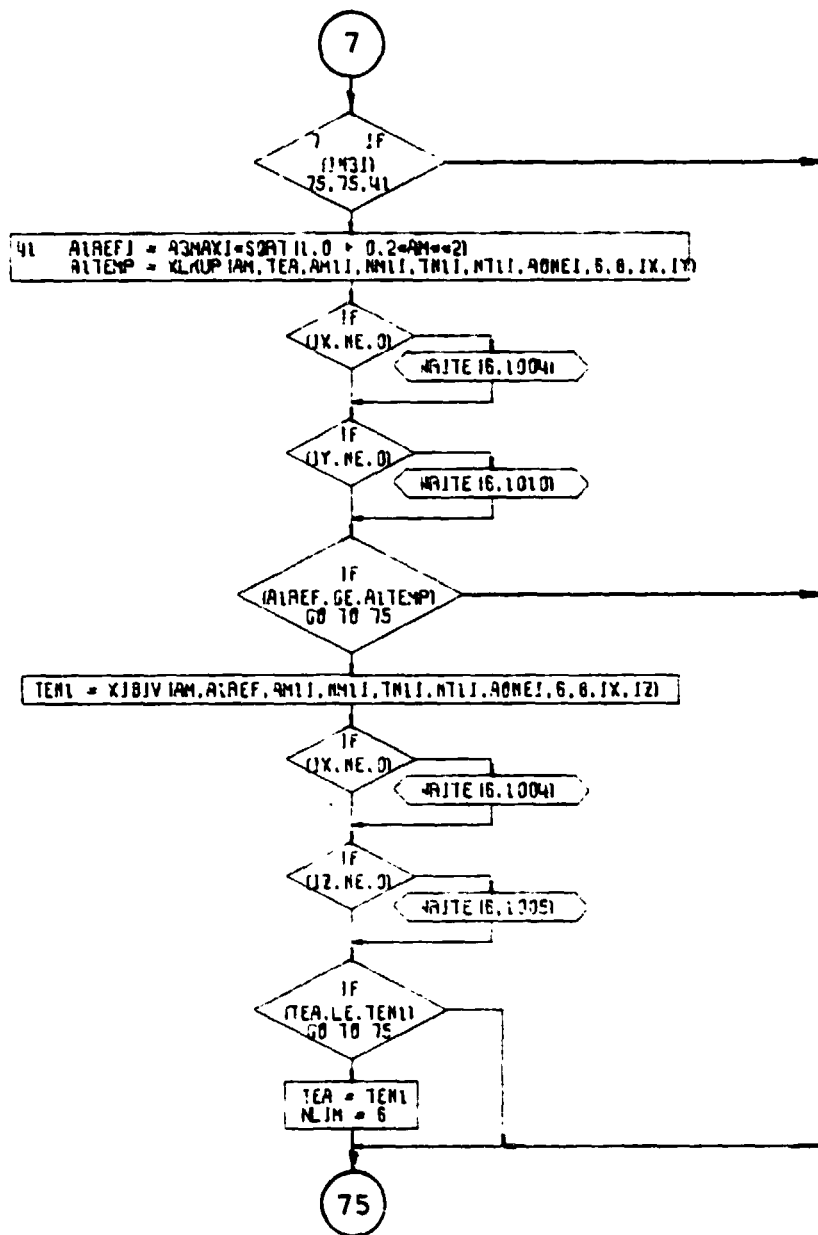


Figure 4-7. POWAVI Subroutine Flow Chart (Part 3 of 7).

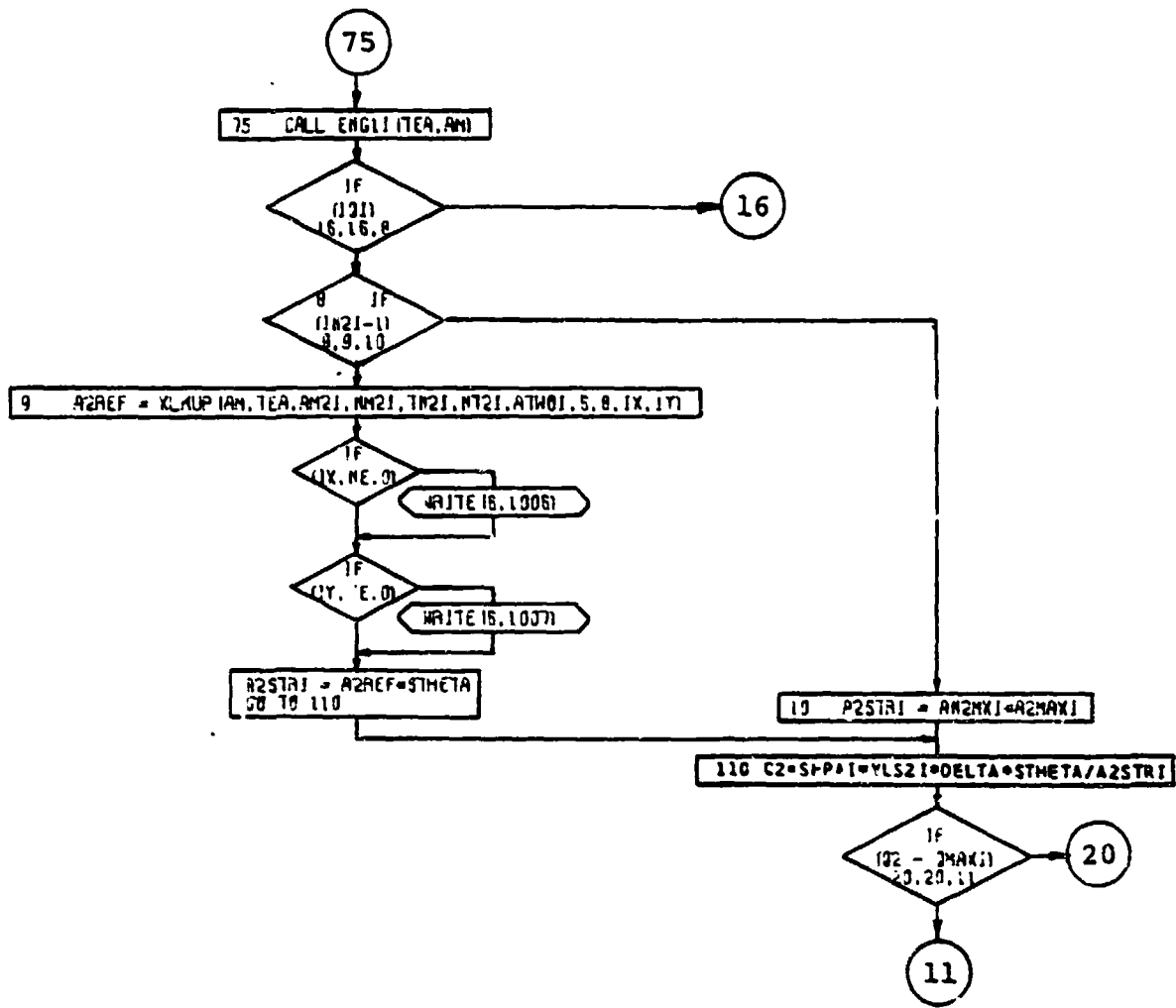


Figure 4-7. POWAVI Subroutine Flow Chart (Part 4 of 7).

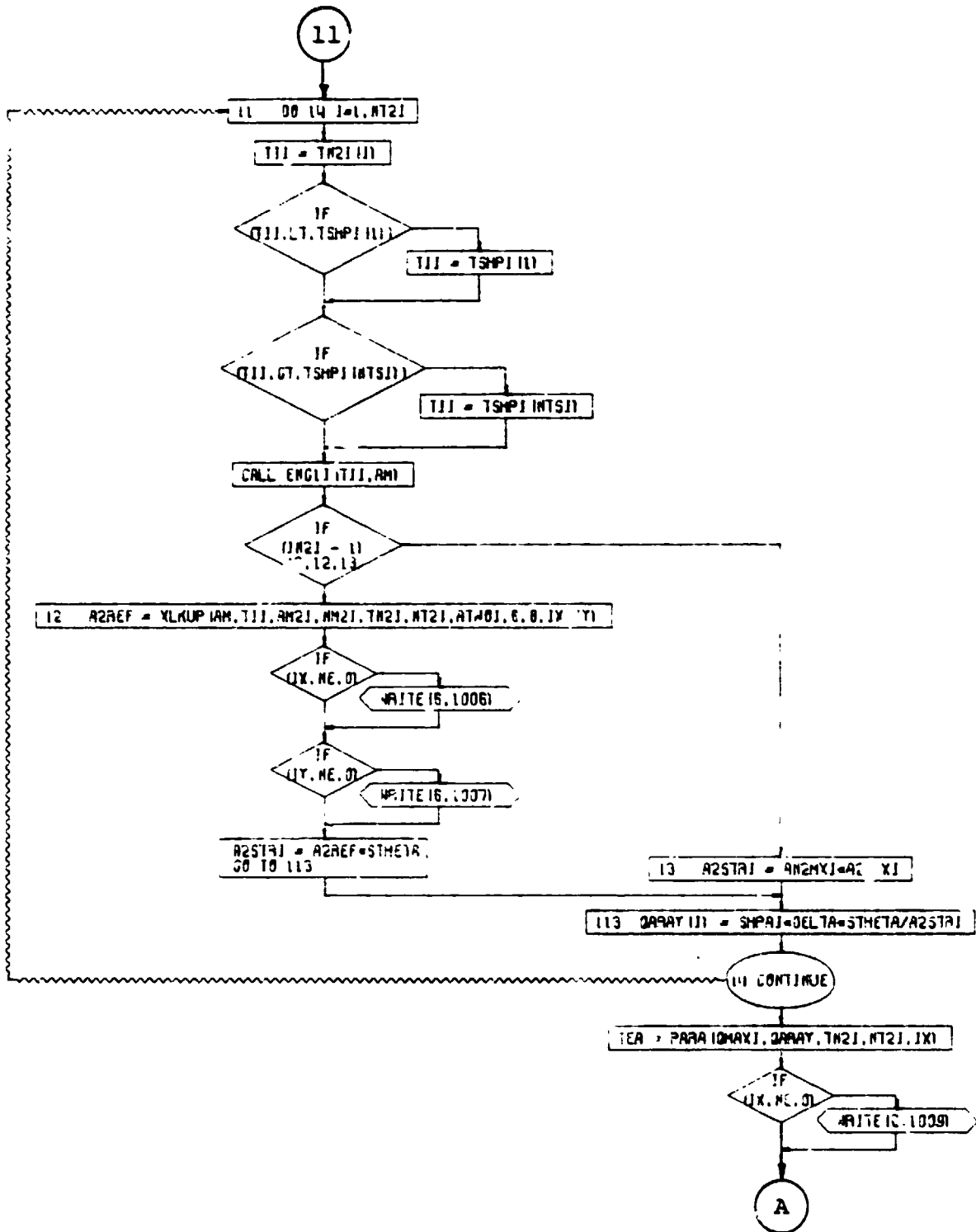


Figure 4-7. POWAVI Subroutine Flow Chart (Part 5 of 7).

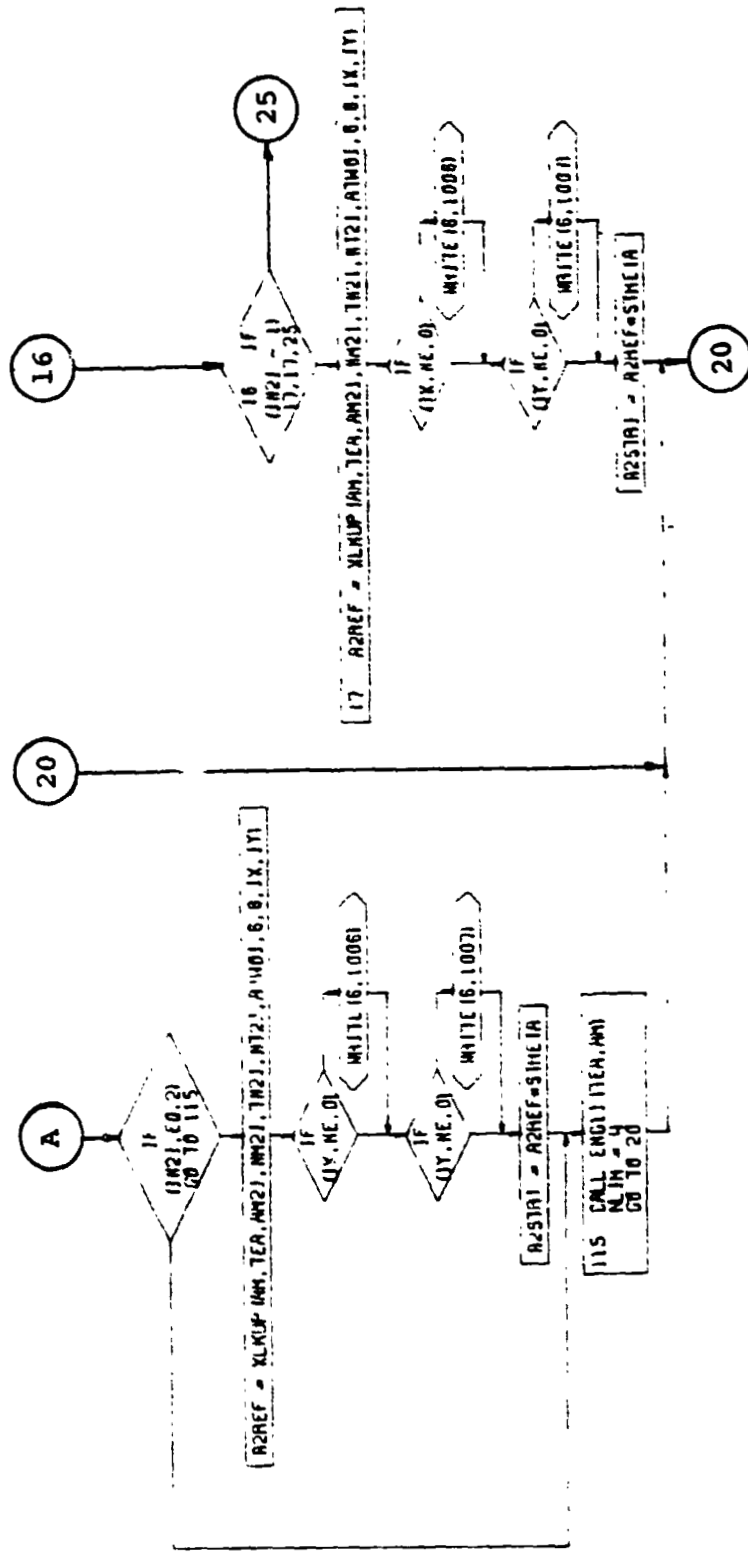


Figure 4-7. POWAVI Subroutine Flow Chart (Part 6 of 7).



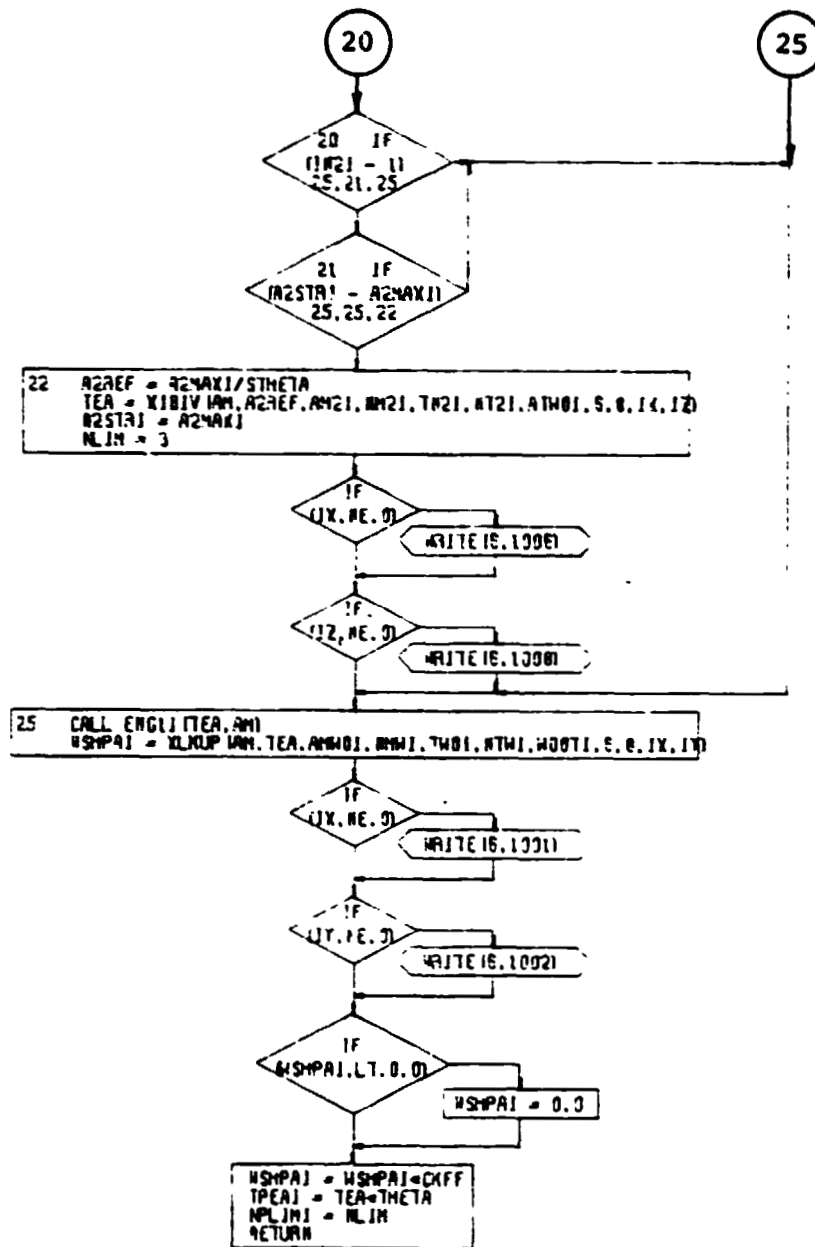


Figure 4-7. POWAVI Subroutine Flow Chart (Part 7 of 7).

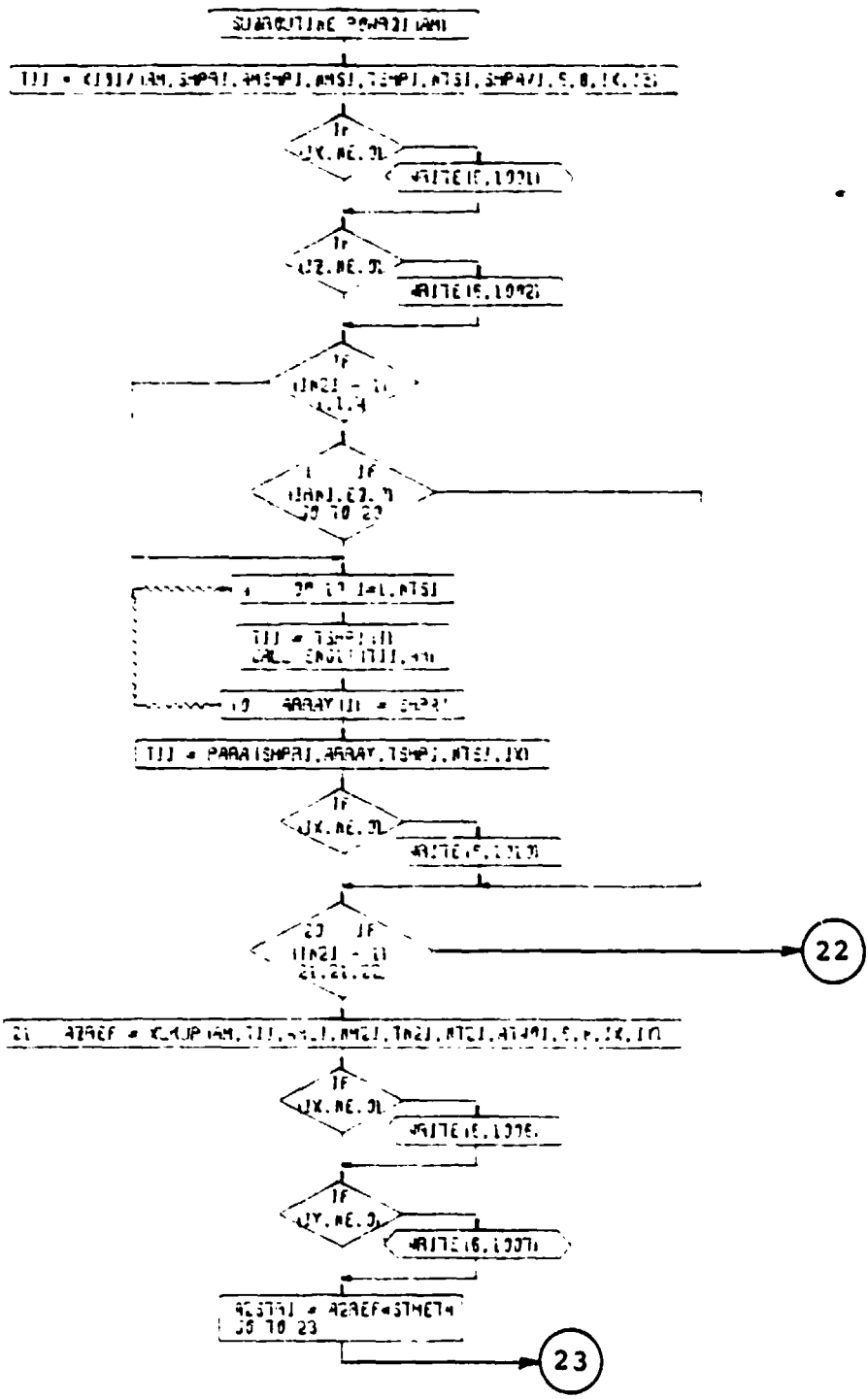


Figure 4-8. POWRQI Subroutine Flow Chart (Part 1 of 2).

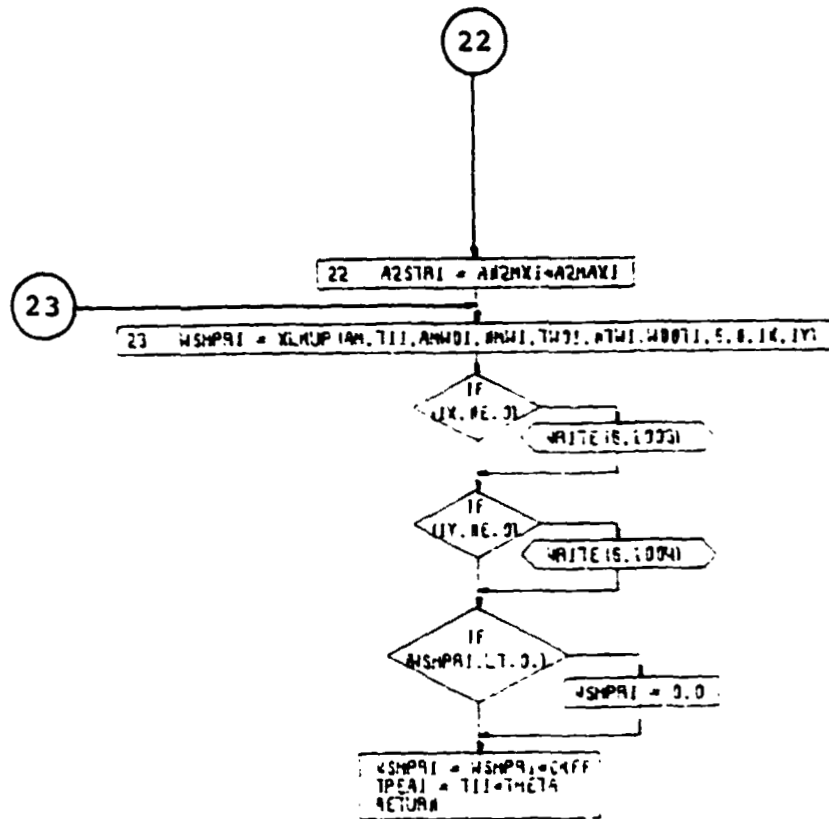


Figure 4-8. POWRQI Subroutine Flow Chart (Part 2 of 2).

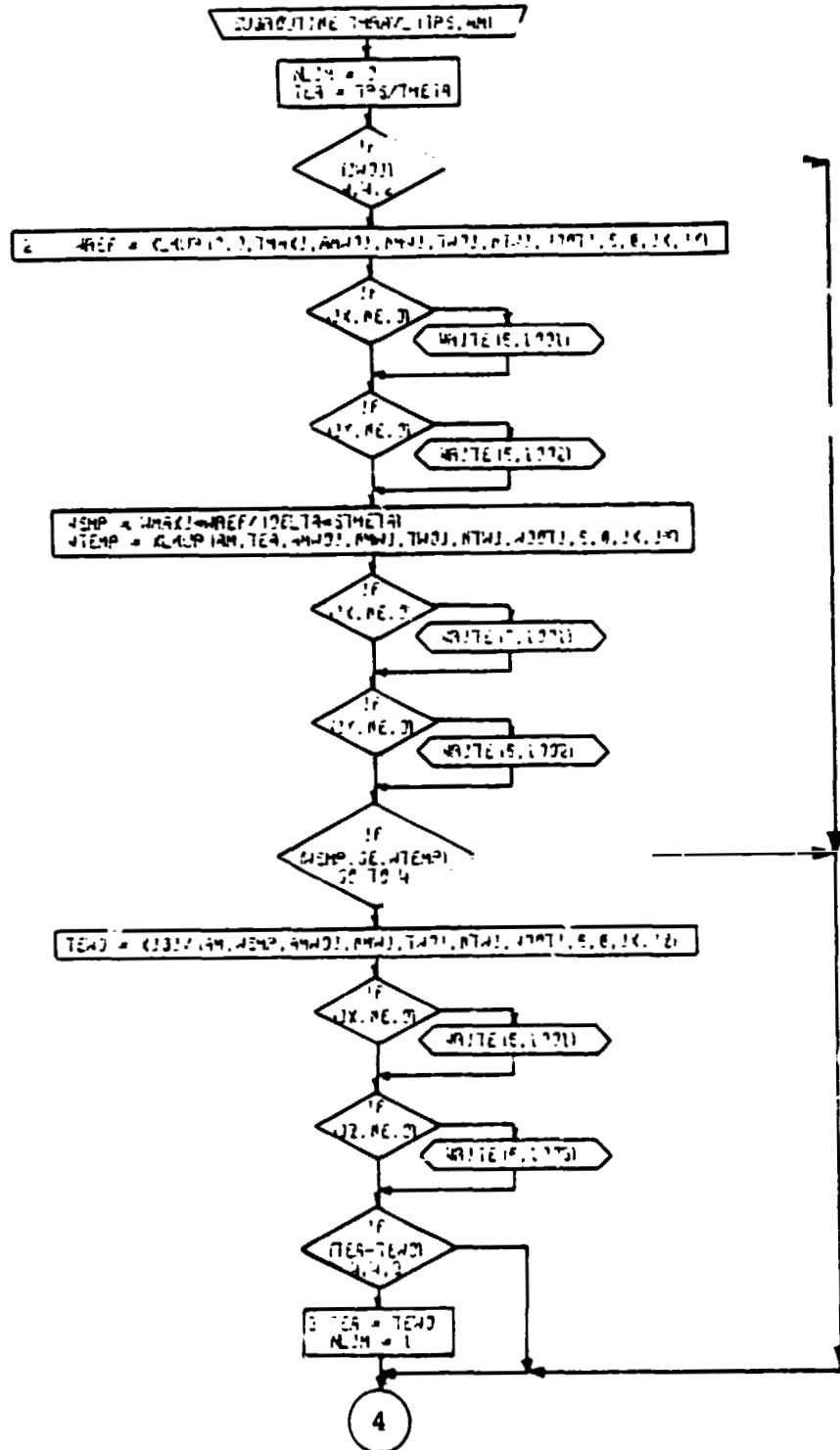


Figure 4-9. THRVL Subroutine Flow Chart (Part 1 of 3).

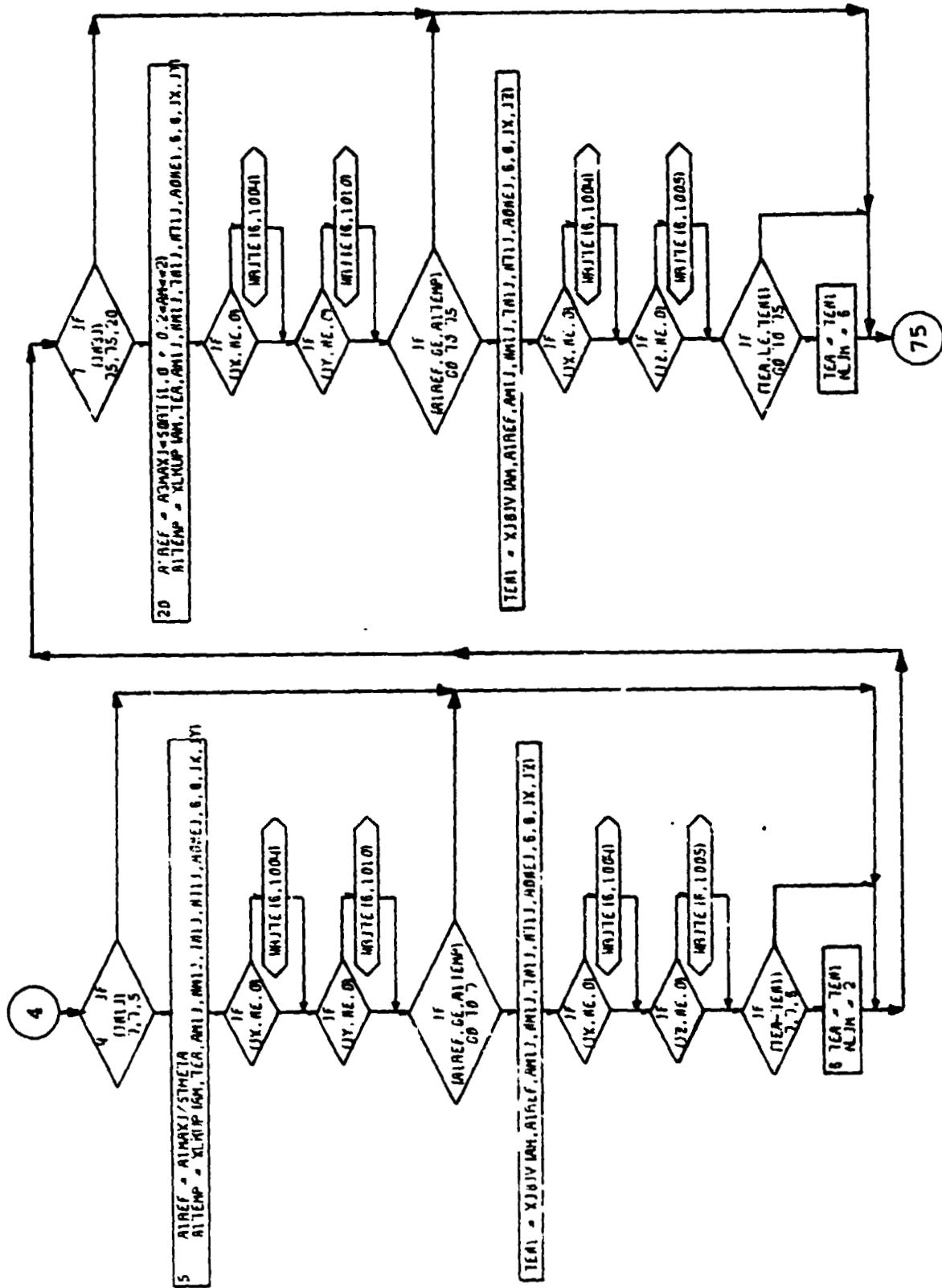


Figure 4-9. THRVL Subroutine Flow Chart (Part 2 of 3).

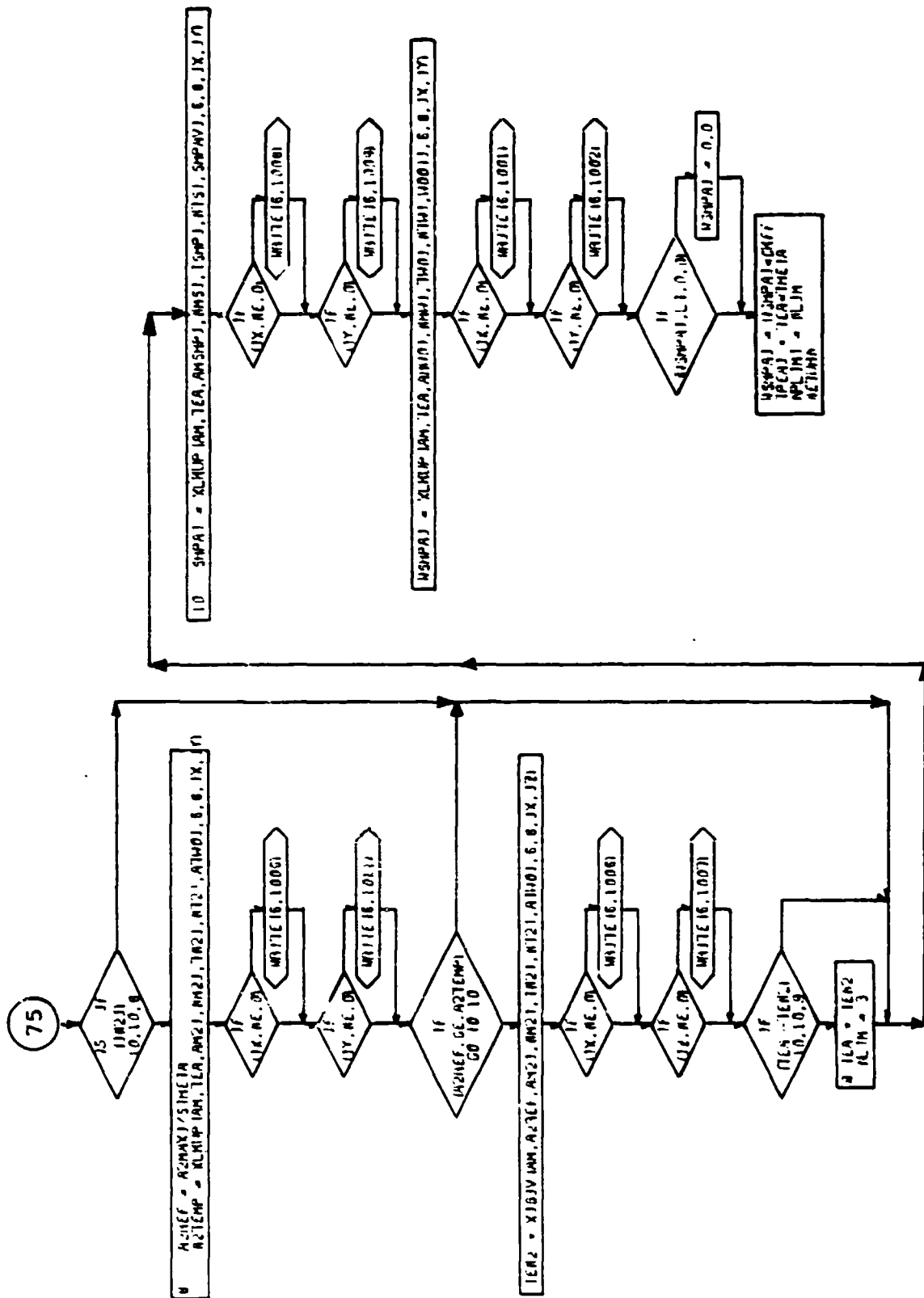


Figure 4-9. THRVL Subroutine Flow Chart (Part 3 of 3).

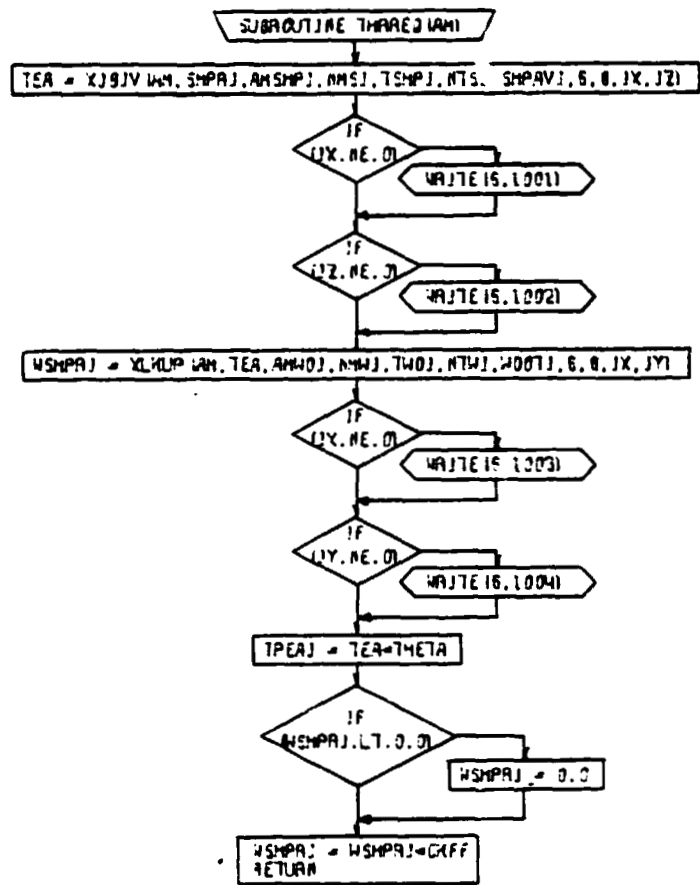


Figure 4-10. THREEQ Subroutine Flow Chart.

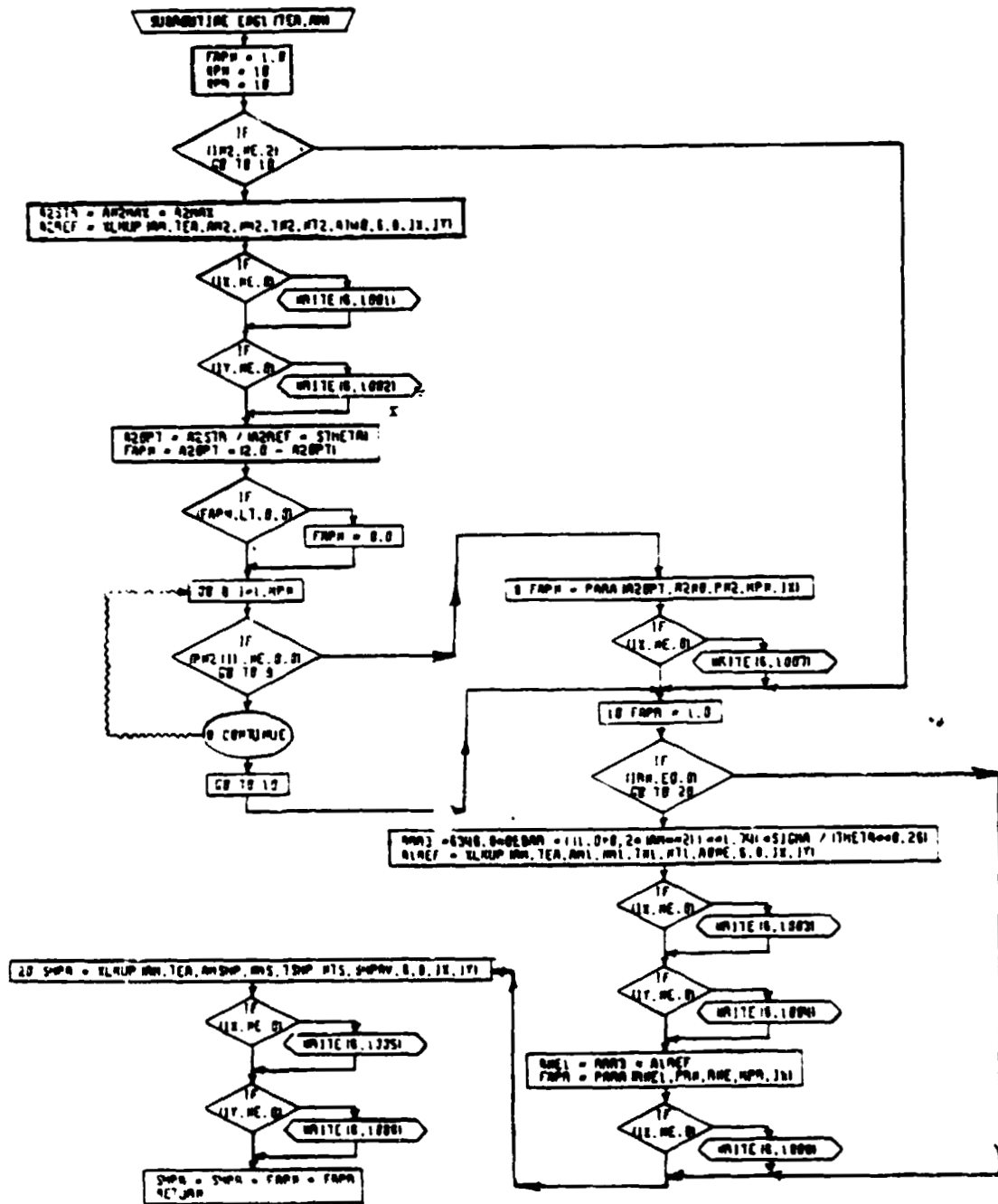


Figure 4-11. ENG 1 Subroutine, Flow Chart.



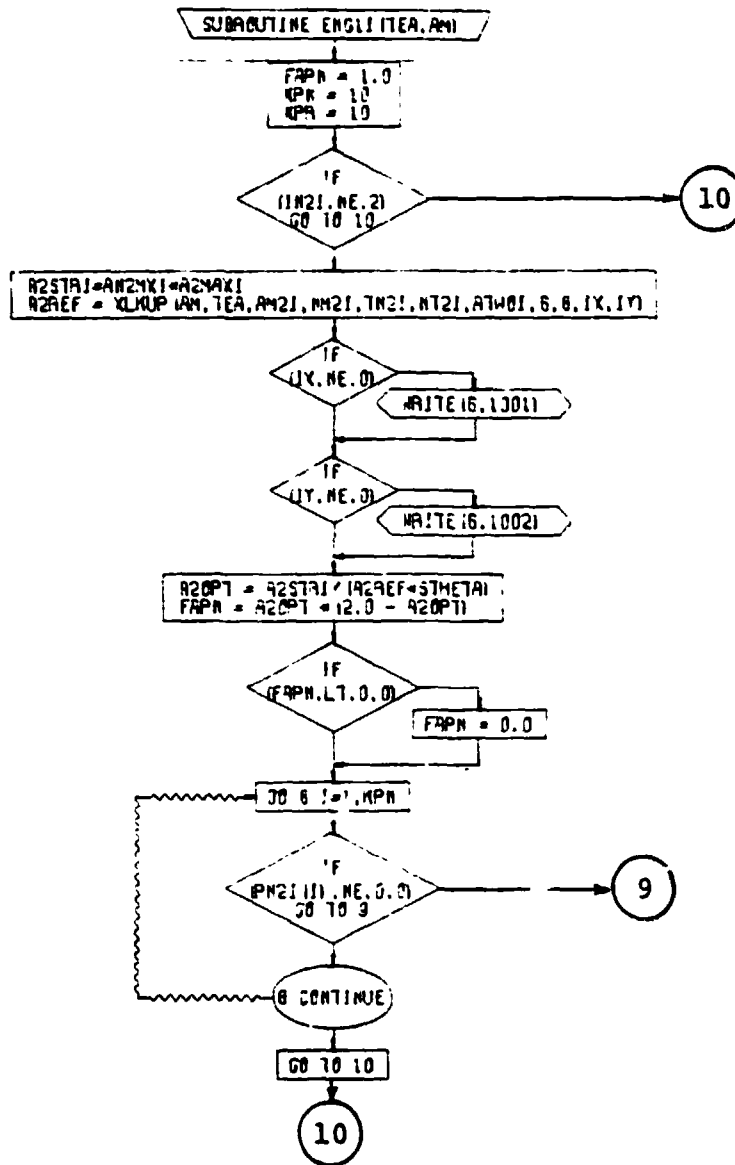


Figure 4-12. ENG 1 I Subroutine Flow Chart (Part 1 of 2).

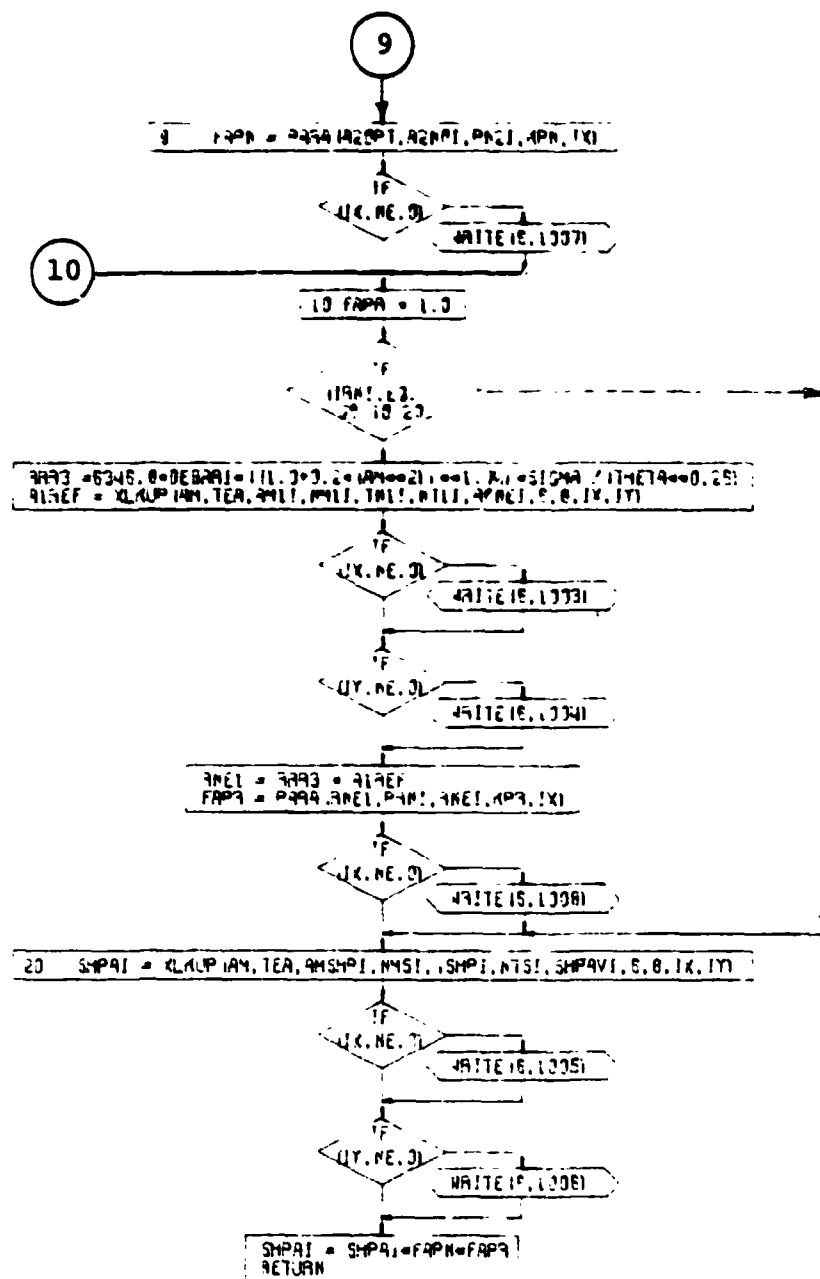


Figure 4-12. ENG 1 I Subroutine Flow Chart (Part 2 of 2).

#### 4.5 ROTOR PERFORMANCE SUBROUTINE

Six options are available to the user for calculating rotor performance. These are specified by the indicator ROTIND as follows:

##### ROTIND

- 1 Rotor performance calculated by the "short range aero" rotor performance methodology
- 2 Rotor map is input, corrections are applied
- 3 Rotor map is input, no corrections are applied
- 4 Rotor map ( $L/D_E$ ) is input. The program accepts  $V_{TIP}$  schedule and  $T_{AUX}/T$  schedule equal to 1000. Also, single point values of  $T_{AUX}/T$  are accepted.  $T_{AUX}/T$  schedule = 2000 cannot be used with this ROTIND = 4.
5. Rotor map ( $L/D_E$ ) is input. The rotor is operated at maximum rotor  $L/D_E$  with  $T_{AUX}/T$  as output. The program accepts  $V_{TIP}$  schedule and  $T_{AUX}/T$  schedule.  $T_{AUX}/T = 2000$  may be used with this option to define specified propulsive mode of operation up to a given value of  $M$ . Above this value of  $M$ , the rotor is operated at maximum  $L/D_E$  with  $T_{AUX}/T$  as output. ROTIND = 5 can be used only when  $AUXIND$  (Loc 006) > 2. and  $\eta_{PIND}$  (Loc 0253) = 0.
6. Rotor map ( $L/D_E$ ) is input. This option is similar to ROTIND = 5. except that the rotor is operated at maximum configuration  $L/D_E$  with  $T_{AUX}/T$  as output.

The first option (ROTIND = 1), using the short form aero methodology, allows the user to calculate rotor performance for a wide range of rotors with a minimum amount of input. The user is required to input a rotor cycle (a list of currently available cycles is illustrated in Table 2-4) and such blade characteristics as blade number, twist, and cutout. In the case of a single rotor helicopter, tail rotor blade characteristics must also be input. The short form aero methodology, developed at Boeing (References 2, 3, and 4), combines momentum theory and empirical corrections through coefficients found in the rotor cycles.

The four elements of the rotor power required are:

- a) induced power (power required to generate lift)
- b) profile power (power required to turn the rotor)
- c) parasite power (power required to supply propulsive thrust in forward flight).
- d) nonuniform downwash power (power correction due to nonuniform inflow and downwash effects in forward flight).

The data used in this approach has been derived and correlated for rotors operating within the following parametric ranges:

Blade Number	=	2 - 9
Blade Twist	=	0 - -18°
Blade Root Cutout	=	0.20R
Rotor Solidity	=	0.055 - 0.150
Rotor Advance Ratio	=	0 - 0.4

No appreciable loss in accuracy is likely for cases involving more than eight blades, less than 20 percent root cutout or a solidity lower than 0.055. The level of confidence will be reduced, however, for those cases in which the rotor parameters greatly exceed the ranges shown above. Figure 4-13 illustrates a typical comparison of short form aero predicted performance and flight test data.

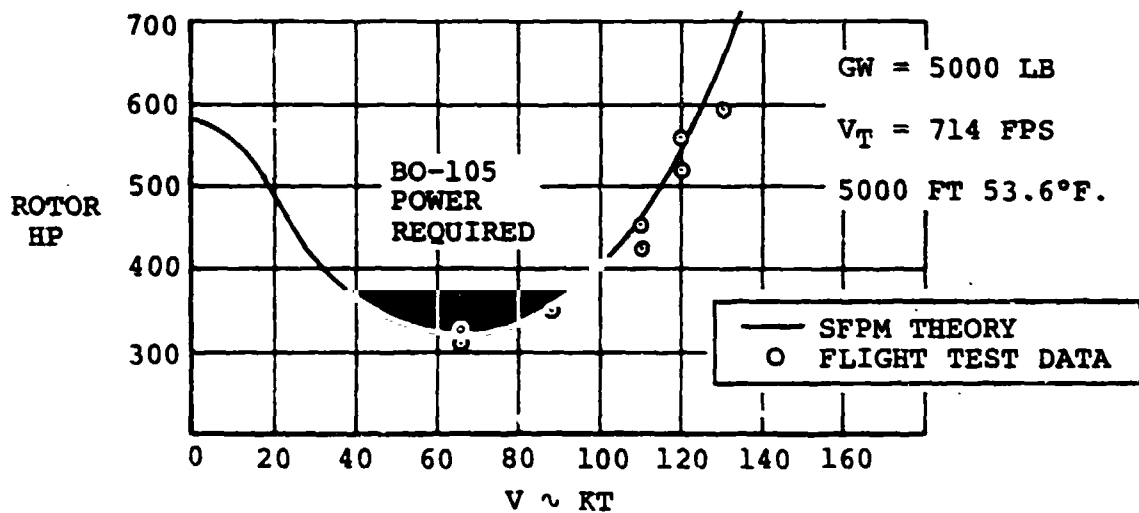
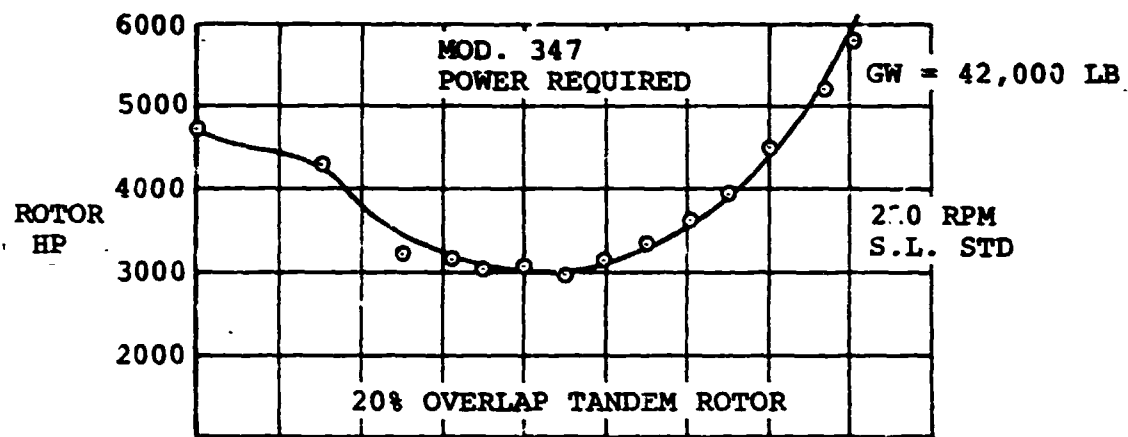
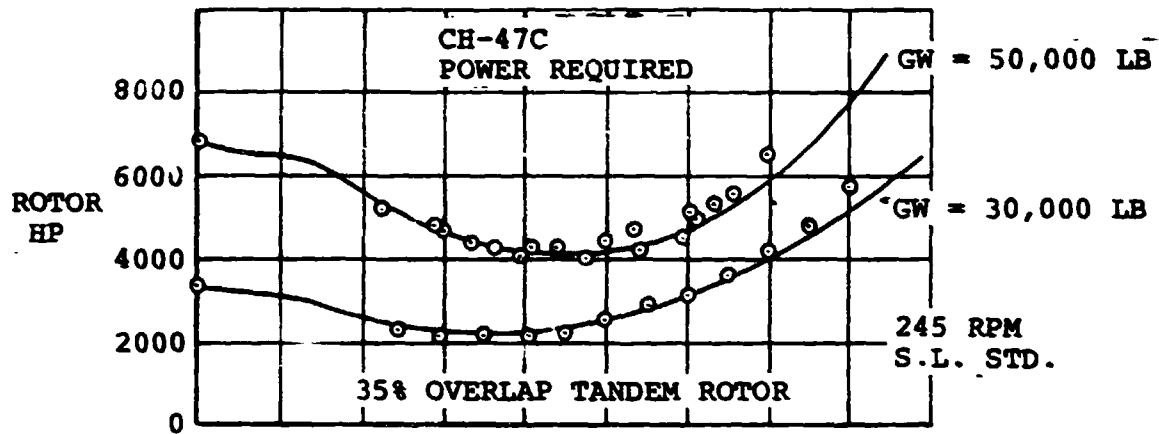


Figure 4-13. COMPARISON OF "SHORT FORM AERO" ROTOR PERFORMANCE AND FLIGHT TEST DATA

Figure 4-14 is a summary of the major equations used in this methodology. A brief description of their applications follows:

In hover, the rotor power required is composed of only two parts, induced and profile power. The induced power as represented by the equations in Figure 4-14 is a function of the variables  $K_{HOV}$ ,  $K_{OL}$ , and  $C_T$ .  $K_{HOV}$  is the adjustment for nonuniform inflow and wake contraction effects and is a function of  $C_T$ , blade number, and blade twist.  $K_{OL}$  is the correction for overflapping rotors (as in the case of a tandem rotor helicopter.)

The profile power is simply a function of the integrated blade drag coefficient (including compressibility effects) at a specified operating  $C_T/\sigma$  and blade solidity.

In cruise, the rotor power is composed of all four of the components listed initially. The induced power, as represented by the equations in Figure 4-14, is a function of the quantities  $K_{IND}$ ,  $K_{INT}$ ,  $C_T'$ , and  $\mu'$ .  $K_{IND}$  is the induced power adjustment factor which accounts for blade tip and other losses.  $K_{INT}$  is the induced power adjustment for interference between tandem rotors. Thus, for single rotor helicopters,  $K_{INT}$  is equal to 1. For tandem rotors, the value of  $K_{INT}$  is calculated based on tandem rotor overlap and an empirically derived wake separation angle,  $\xi'$ . Profile power is simply a function of the integrated blade drag coefficient (corrected for retreating blade stall and advancing blade compressibility effects) at specified operating conditions ( $C_T'/\sigma$ ,  $\mu$ ,  $C_\mu$ ), blade solidity, and advance ratio ( $\mu$ ). The parasite power is a function of the propulsive thrust required and the efficiency of the rotor in converting power into that propulsive thrust (in addition to providing lift). The nonuniform downwash (NUD) power is a correction which has been empirically derived from a comparison of uniform and nonuniform downwash rotor analyses. The term  $K_{NUD}$ , which is a function of the advancing rotor, is stored as BLOCK DATA in this program, and is graphically represented in Figure 4-15.

MAIN ROTOR IN HOVER SUMMARY	MAIN ROTOR IN CRUISE FLIGHT SUMMARY
$RHP_{TOT} = \frac{\rho AV_T^3 C_{PTOT}}{550}$	$RHP_{TOT} = \frac{\rho AV_T^3 C_{PTOT}}{550}$
<p>where: <math>C_{PTOT} = C_{PPRO} + C_{PIND}</math></p>	<p>where: <math>C_{PTOT} = C_{PPRO} + C_{PND} + C_{PPAR} + C_{PNUD}</math></p>
<p>(PROFILE POWER)</p> $C_{PPRO} = C_{D_0} \frac{\sigma}{8} (1 - X_C)$	<p>(PROFILE POWER)</p> $C_{PPRO} = \frac{C_{D_0} \sigma}{8} (1 + 4.65\mu^2) (1 - X_C)$
<p>(INDUCED POWER)</p> $C_{PIND} = .707 K_{HOV} K_{OL} C_T^{3/2}$	<p>(INDUCED POWER)</p> $C_{PIND} = \frac{K_{IND} K_{INT} C_T^2}{2\mu}$
$C_T = \frac{\text{HOVER THRUST REQ'D}}{\rho AV_T^2}$	<p>(PARASITE POWER)</p> $C_{PPAR} = \mu X_C (K_{PER})$
$A = \frac{\pi D^2}{4} N_{ROT}$	<p>(NUD POWER)</p> $C_{PNUD} = \frac{2K_{NUD} C_T^2 \sigma}{B^2 (1 + D.L. \sin^2 \epsilon)}$
$X_C = 2r_{cutout}/D$	$C_T' = \frac{L_{ROT}}{\rho AV_T^2} (1 + D.L. \sin^2 \epsilon)$
	$C_X = \frac{X_{TOT}}{\rho AV_T^2} \quad A = \frac{\pi D^2}{4} N_{ROT}$
	$\epsilon = \tan^{-1} (2V/V \times 1.689)$
	$v_i = V_T \sqrt{[(\mu^4 + C_T^2) / 2 - \mu^2] / 2}$
	$\mu' = \frac{\sqrt{(1.689V)^2 + v_i^2}}{V_T}$
	$K_{PER} = \frac{\mu_{PRY}}{\mu_{PRR}} = 1 + 12.8\mu^4$
	$K_{NUD} = f(\mu)$

Figure 4-14. Short Form Aero Rotor Performance Equations Summary.

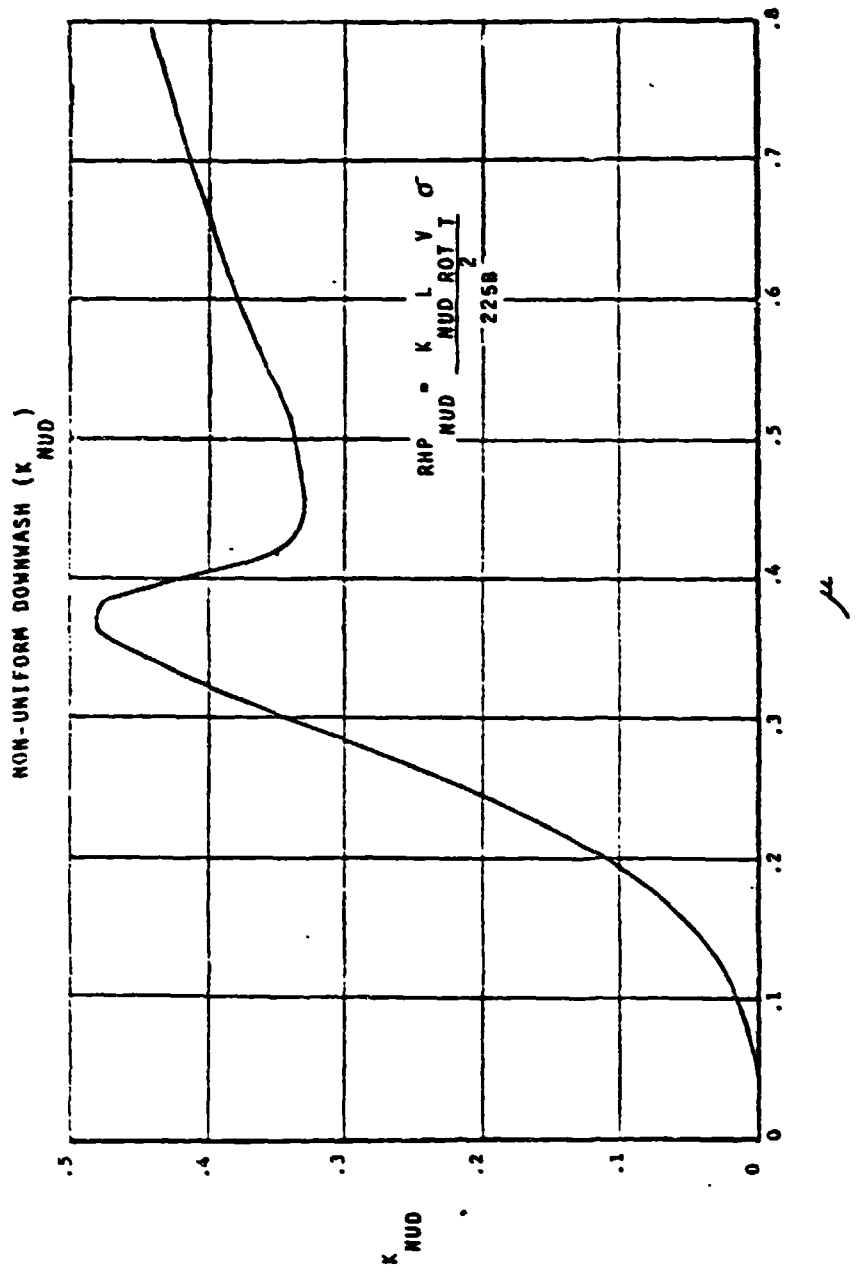


Figure 4-15. Non-Uniform Downwash as Stored in Block Data



In order to obtain a reasonable estimation of power required at very low advance ratios ( $\mu < 0.1$ ) where neither normal cruise nor hover rotor characteristics totally describe the operating environment of the rotor, an empirical fairing technique is used. The method is based on the contracted induced wake angle  $\xi$  :

$$\xi = \tan^{-1}((2V_i - 1)(0.689V))$$

The relationship:

$$\sin^2 \xi + \cos^2 \xi = 1$$

is used to provide a smooth transition between hover and cruise characteristics for the affected coefficients while insuring that the resulting values will lie within the boundaries set by hover and cruise limiting conditions.

A detailed description of the equations used in this methodology is provided by inspection of Figure 4-19 (subroutine ROTPOW flow chart) and the input variable list included in paragraph 5.3.1 of Section 5.0. The empirical factors used in this methodology are input as noted earlier, in "rotor cycle" format. The input sheet used for this purpose is included in the specimen input sheets of Section 5.2. It should be noted that since the factors specified in a "rotor cycle" represent integrated blade characteristics, then a given "rotor cycle" implicitly represents a given spanwise chord and airfoil distribution. Thus, it would ultimately be possible to build up an extensive library of "rotor cycles" with varying combinations of planform and airfoil distributions.

The second option (ROTIND = 2) utilizes isolated rotor data (Type I rotor map) derived for a specified rotor configuration, but corrected by the program for the specific rotor and helicopter configuration being analyzed. It should be noted that this option, in the case of the single rotor helicopter, utilizes the short form aero methodology for calculating tail rotor power. Thus, the same tail rotor blade information required in the first option must be input.

Option three (ROTIND = 3, Type I rotor map) uses total configuration rotor data; that is, in the case of a single rotor helicopter, this would include both main and tail rotor power and applies no corrections to the data. Input locations 2700-3410 are provided for the input of Type I rotor maps. Values of  $C_p/\sigma$  input as functions of up to ten values of  $C_T/\sigma$  at up to six values of  $M_{TIP}$  can be used for hover performance; and cruise  $C_p/\sigma$  values can be input as functions of up to ten values of  $C_T/\sigma$  and ten values of  $C_X/\sigma$  at up to six values of  $\mu$ .

Options four (ROTIND = 4), five (ROTIND = 5), and six (ROTIND = 6) utilize the Type II rotor map data in the same manner as the second option (ROTIND = 2). Input locations 3420-4130 are provided for the input of Type II rotor maps. Values of F.M. input as functions of up to ten values of  $C_T/\sigma$  at up to six values of  $M_{TIP}$  can be used for hover performance; and cruise  $L/D_E$  values can be input as functions of up to ten values of  $C_T/\sigma$  and six values of  $X/L$  at up to six values of .

A detailed description of the equations and variables used for ROTIND = 1,2,3,4,5, and 6 is available by inspection of Figure 4-16 and section 5.3.1, Program Variables. Figures 4-16 and 4-17 show the corrections ( $K_{DL}$ , TIGE/TOGE) for hover inground effect applied to the equations:

$$T/W = 1 + DL(K_{DL})$$

$$C_T = \frac{4W(T/W)}{\rho W D_{MR}^2 N_R V_{TIP}^2 (TIGE/TOGE)}$$

used in calculating hover power.

Care must be exercised in the preparation of input data for both Type I and II rotor maps. The performance subroutines employ search procedures which require input data to be specified considerably above and below the final operating point of a configuration. Therefore, "map" data should be provided over a wide range on either side of expected operating points.

For the calculation of vertical climb power, the subroutine uses the simple potential energy relationship:

$$RHP_{VRC} = \frac{W(VRC)}{33,000 (V_{CEH1} + V_{CEH2} (\sqrt{VRC}))}$$

The vertical climb efficiency factors ( $V_{CEH1}$  and  $V_{CEH2}$ ) can be derived from flight test data.

The quantity ALPHA D/L printed out in all forward flight performance segments reflects the propulsive thrust-lift vector of the main rotor. The following simple sketch illustrates the sign convention employed.

$$\text{DLD CORR. FACT} = 1.028 - 1.25e^{-(2h_{B_F}/\text{DIA.})}$$

SINGLE ROTOR

$$\text{DLD CORR. FACT} = 1.36771 - 1.57913e^{-h_{B_F}/\text{DIA.}}$$

TANDEM ROTOR

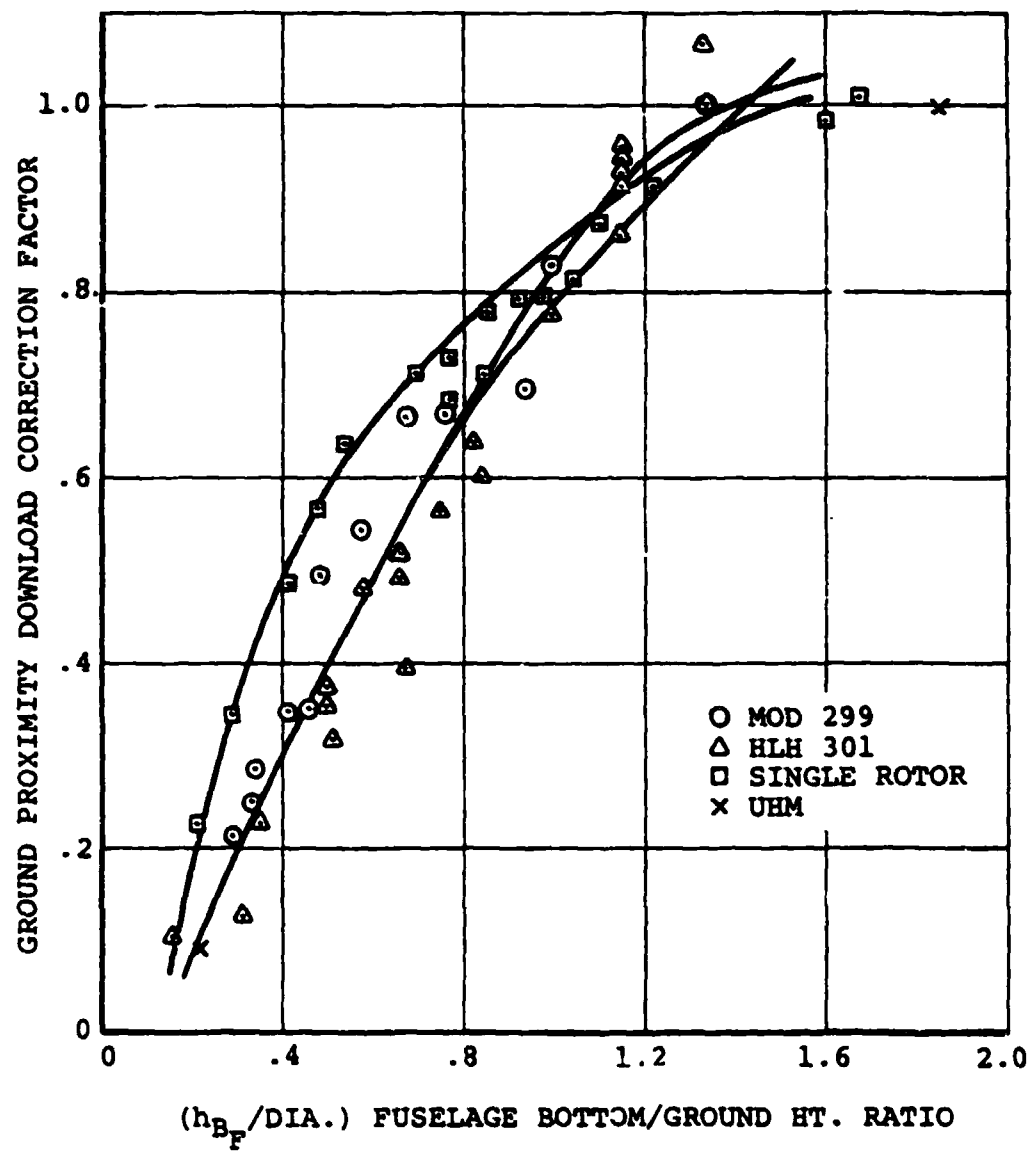


Figure 4-16. Download Sensitivity to Ground Proximity.

$$\text{THRUST}_{\text{IGE}}/\text{THRUST}_{\text{OGE}} = .06907(1/X) + .03364(X) + .90186$$

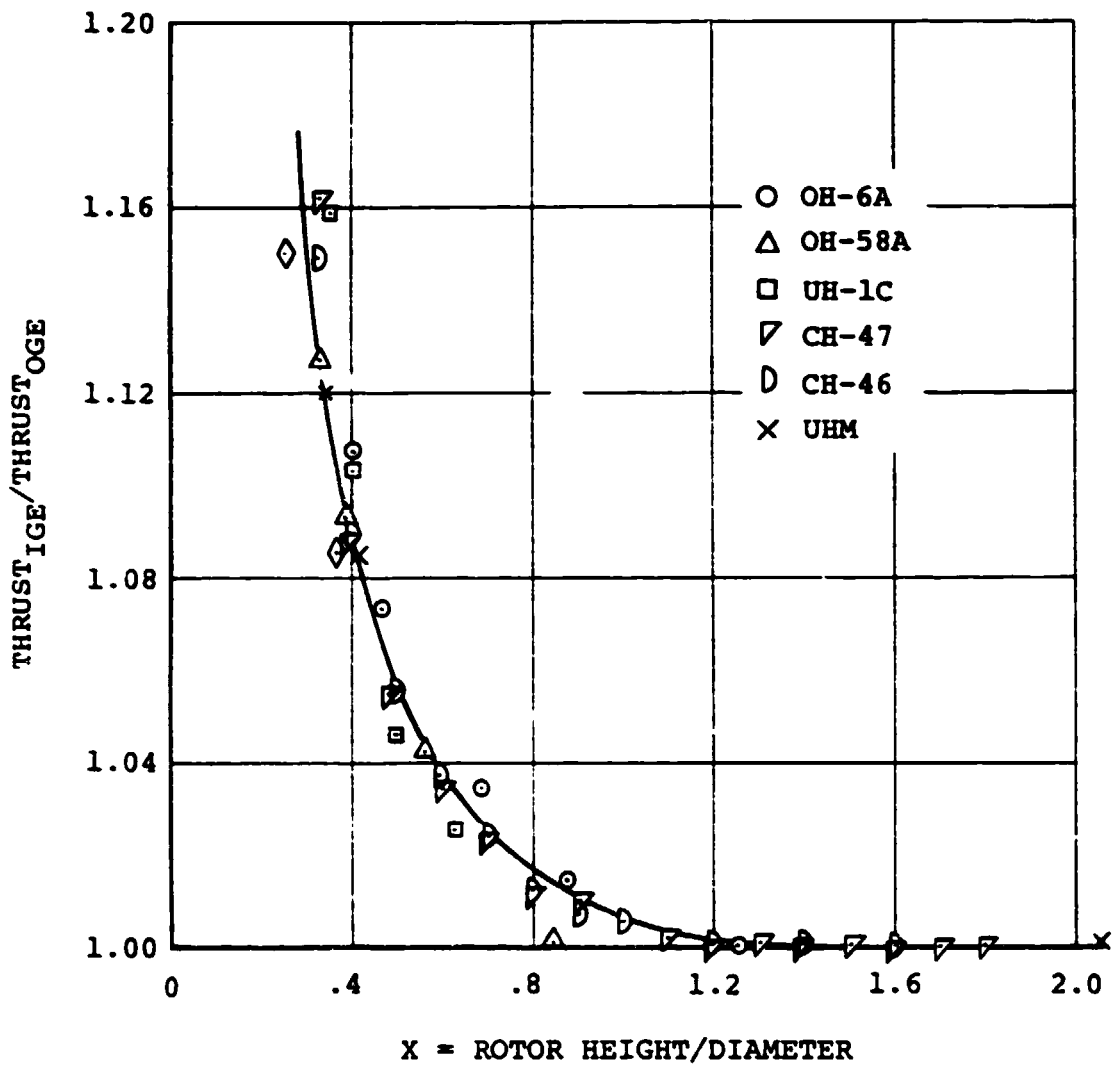
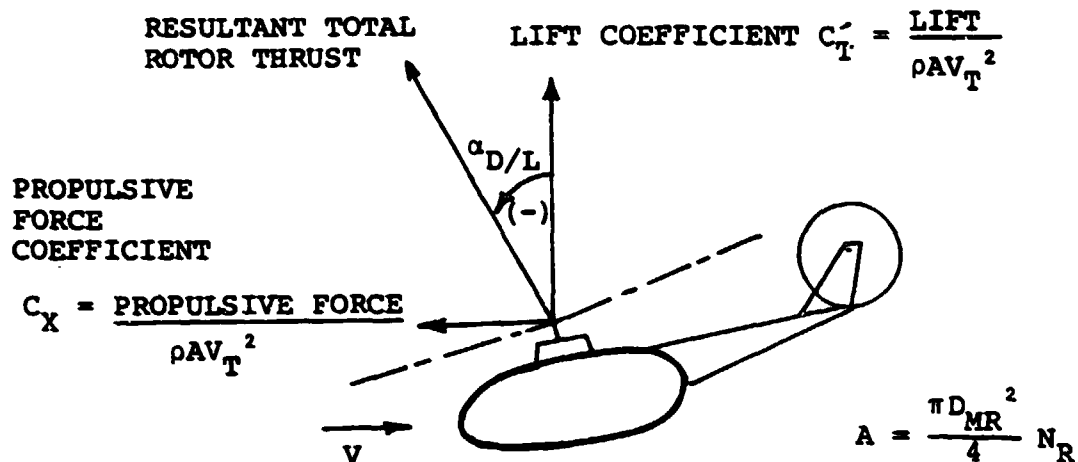


Figure 4-17. Thrust Augmentation in Ground Effect.



Rotor performance is calculated by HESCOMP utilizing the rotor maps of  $L/D_E$  vs  $\mu$ ,  $C'_T/\sigma$  and  $X/L$ . Using these maps, three types of rotor operations can be specified. These are:

- (1) Flight at a fixed rotor propulsive force ( $T_{AUX}/T$ ) level.
- (2) Flight at maximum rotor  $L/D_E$ . In this case, rotor propulsive force (drag) is an output.
- (3) Flight at maximum configuration  $L/D_E$ . In this case, rotor propulsive force (drag) is an output.

The configuration  $L/D_E$  is calculated from:

$$(L/D_E)_{\text{CONFIG}} = \frac{GW \times V_{\text{KTAS}}}{325.8 \times \text{BHP}}$$

Operation in either modes (2) or (3) includes a search for the  $X/L$  at which either maximum rotor or configuration  $L/D_E$  occurs. To accomplish this, HESCOMP interpolates the input rotor map data at the particular operating point ( $\mu$  and  $C'_T/\sigma$ ) and generates a data array of rotor  $L/D_E$  vs  $X/L$ . Figure 4-18 illustrates a typical plot of such data. In the case of operations in mode (3), an additional array of configuration  $L/D_E$  vs  $X/L$  is generated.

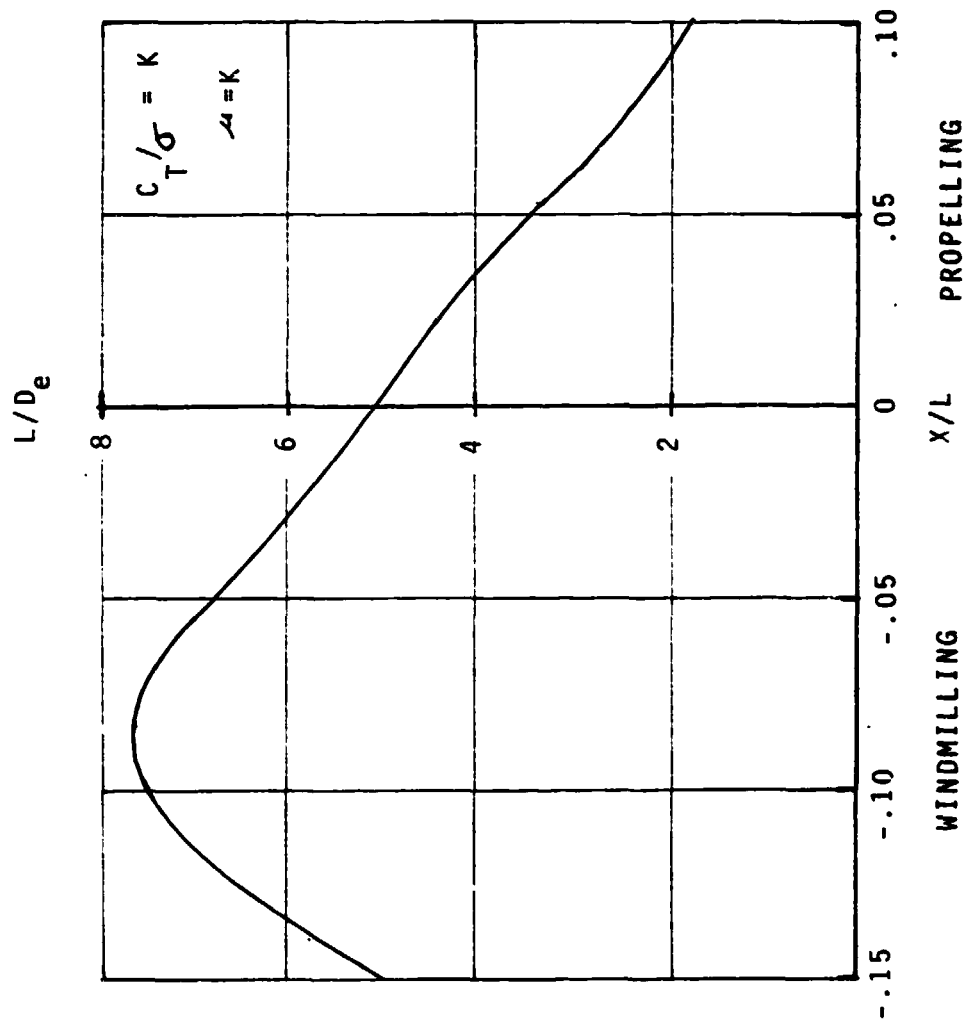


Figure 4-18. HESCOMP Interpolation of Rotor  $L/D_e$  vs.  $X/L$

The search begins at the lowest value of X/L input and continues until the maximum value of  $L/D_E$  is obtained. For the maps used in HESCOMP, the range of X/L extends from -0.15 to +0.10. It is in this search procedure that the rotor maximum lift limits described earlier are employed. As noted previously, these maximum rotor lift limits are input as function of  $\mu$  and  $C_x/\sigma$ . For a given operating point ( $\mu$  and  $C_T'/\sigma$ ), the limiting value of X/L can be defined as:

$$X/L = \frac{(C_x/\sigma) RL}{(C_T'/\sigma) RL}$$

Thus, if the limiting value of X/L is exceeded in such a search, rotor X/L is reduced until the operating point and the rotor lift limit are matched.

The flow chart for the rotor power subroutine is illustrated by Figure 4-19.

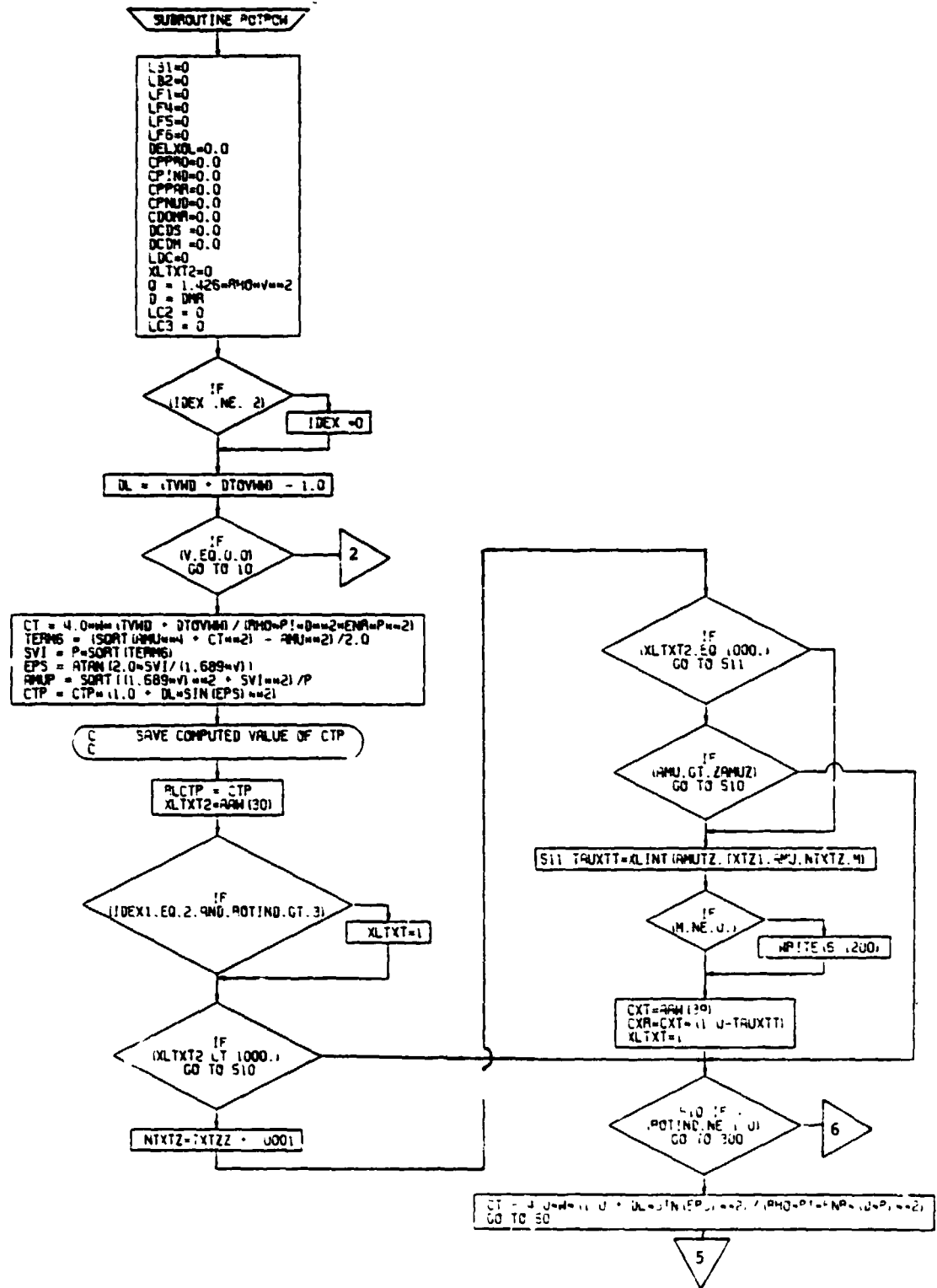


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 1 of 23)



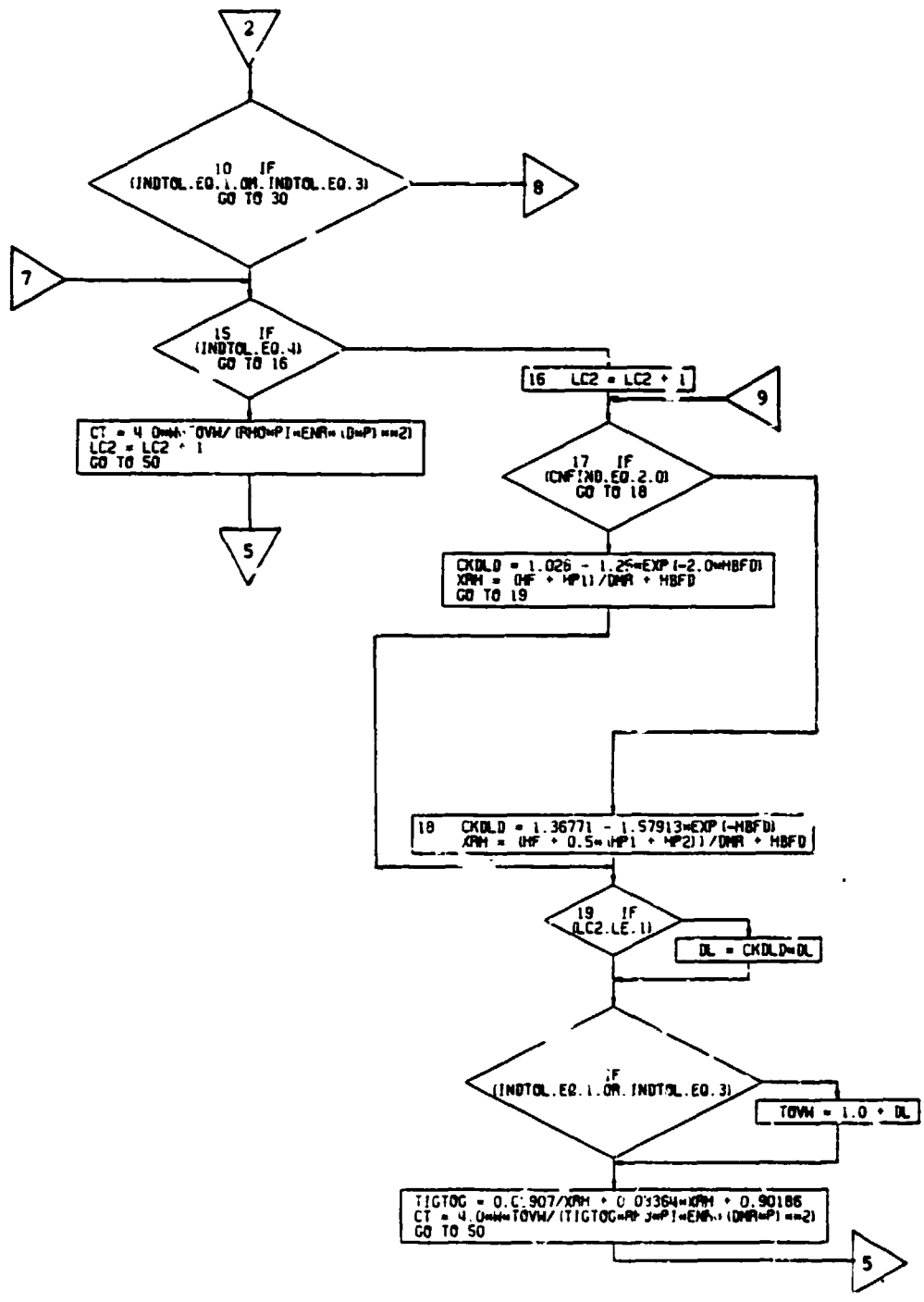


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 2 of 23)

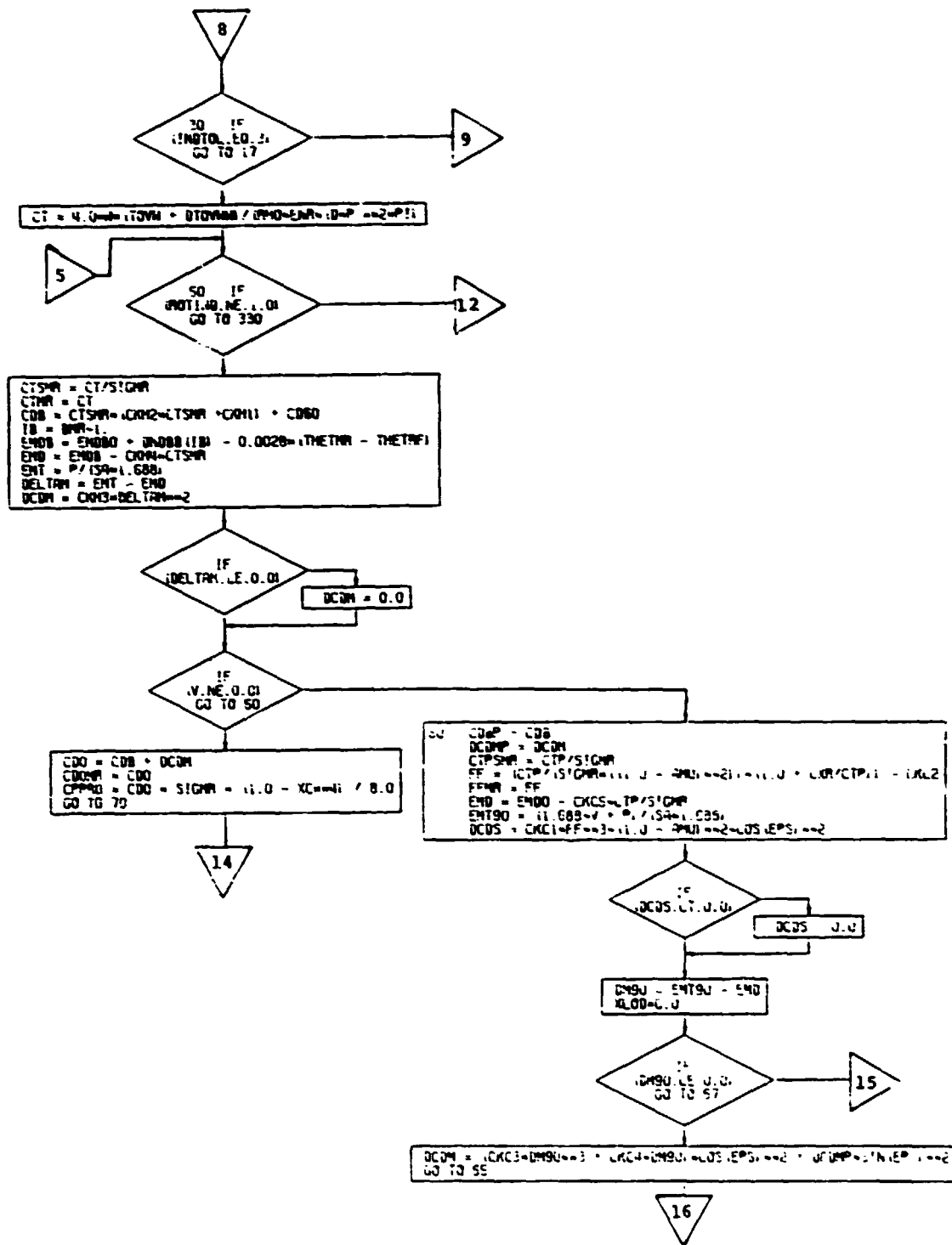


Figure 4-19. ROTPOW Sub

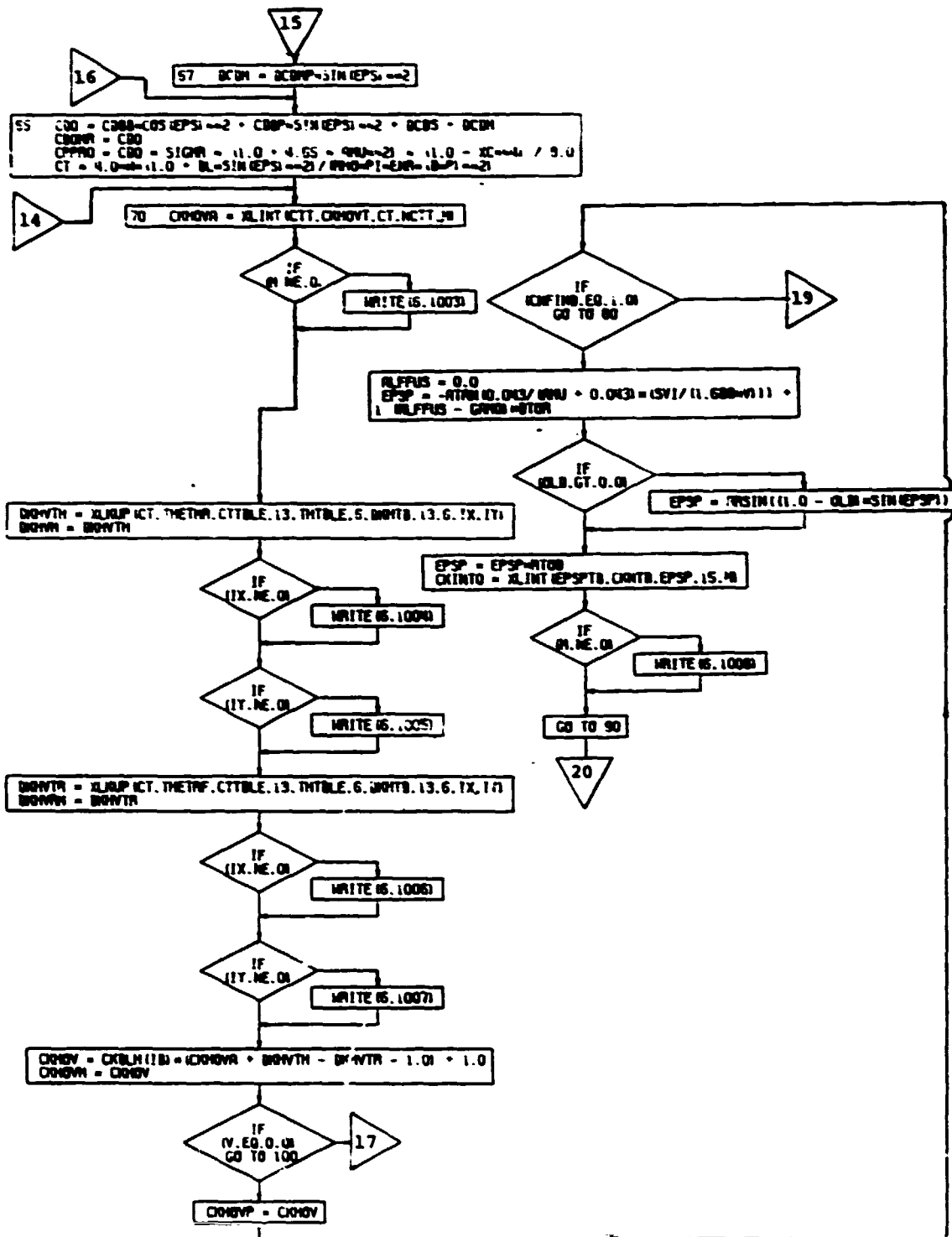


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 4 of 23)

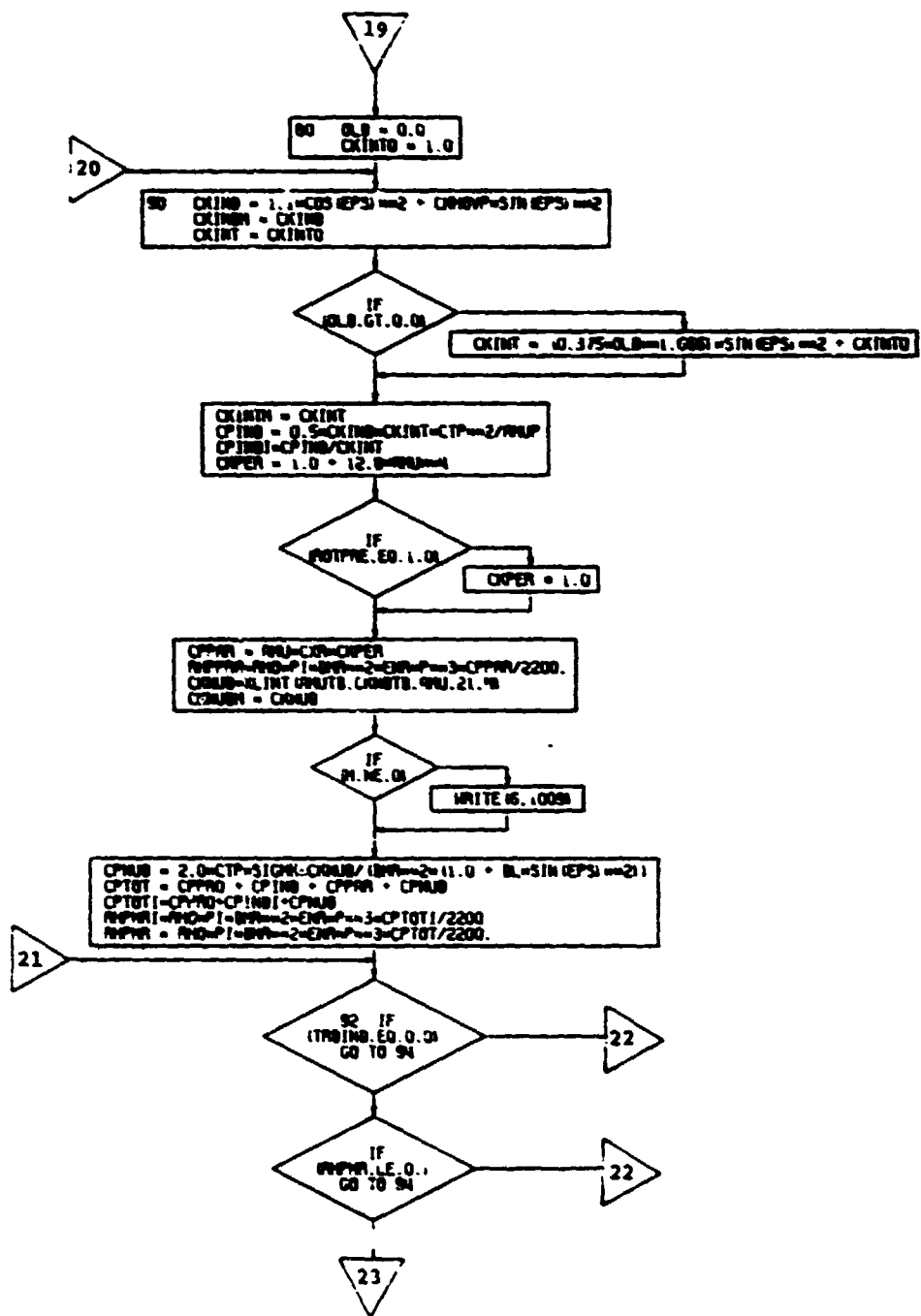


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 5 of 23)

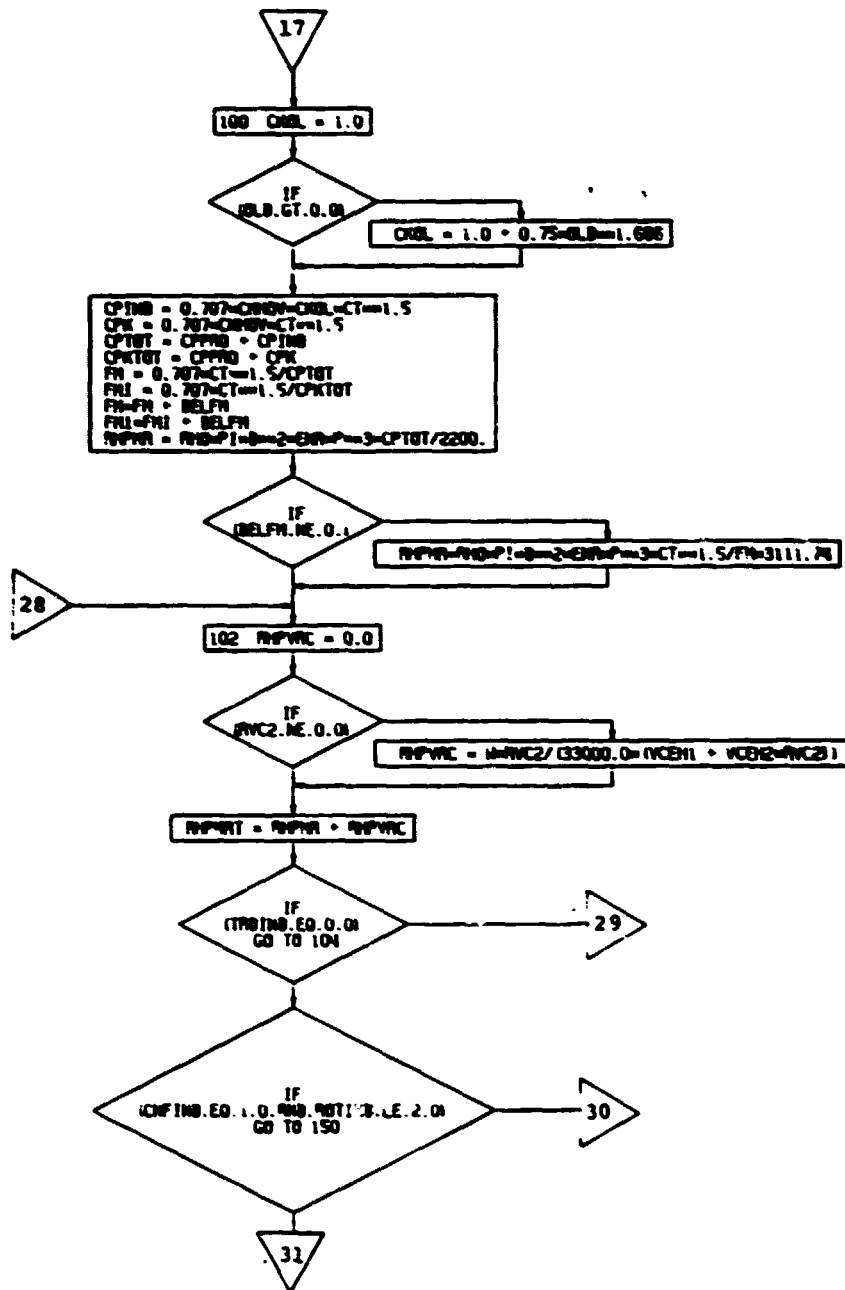


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 6 of 23)

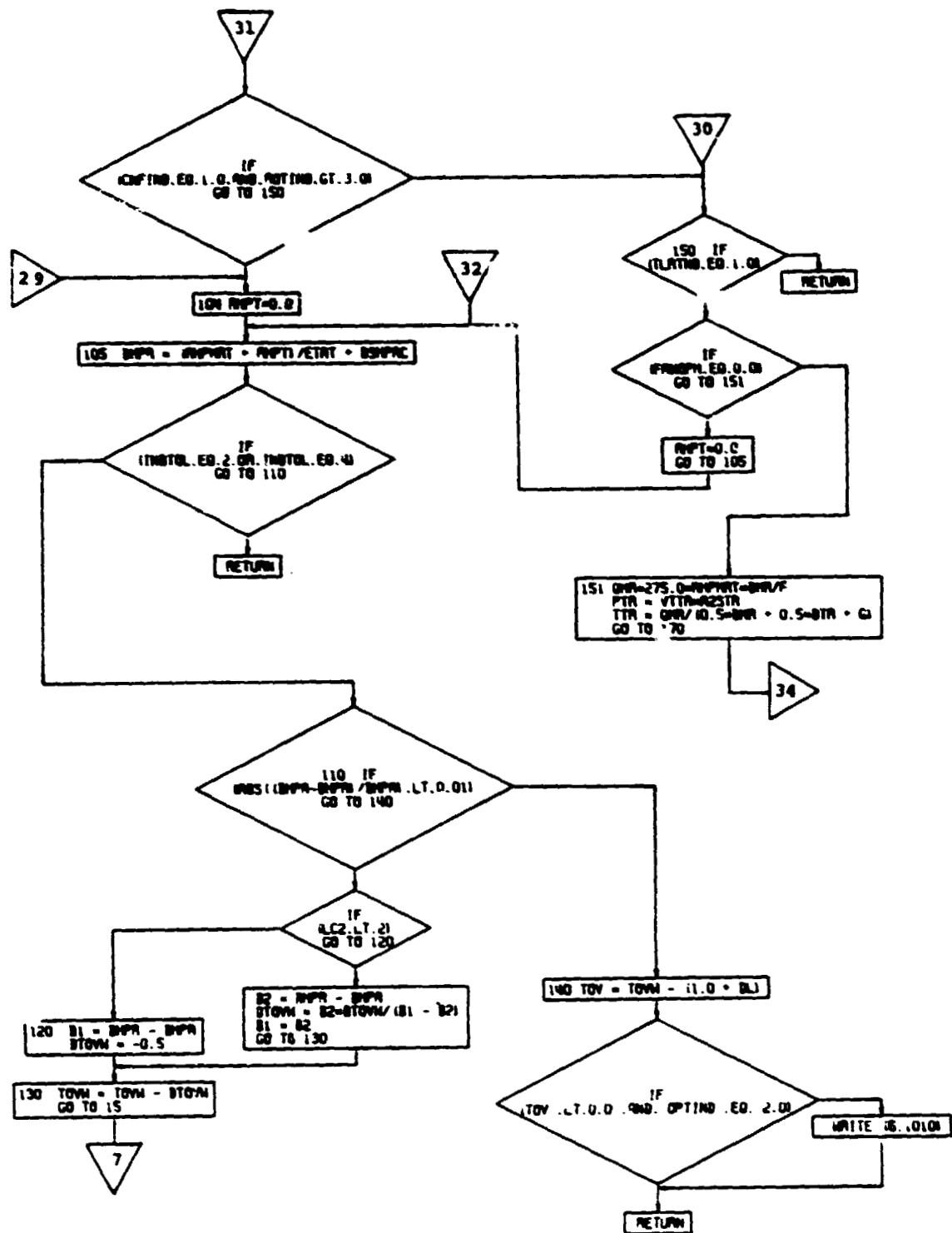


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 7 of 23)

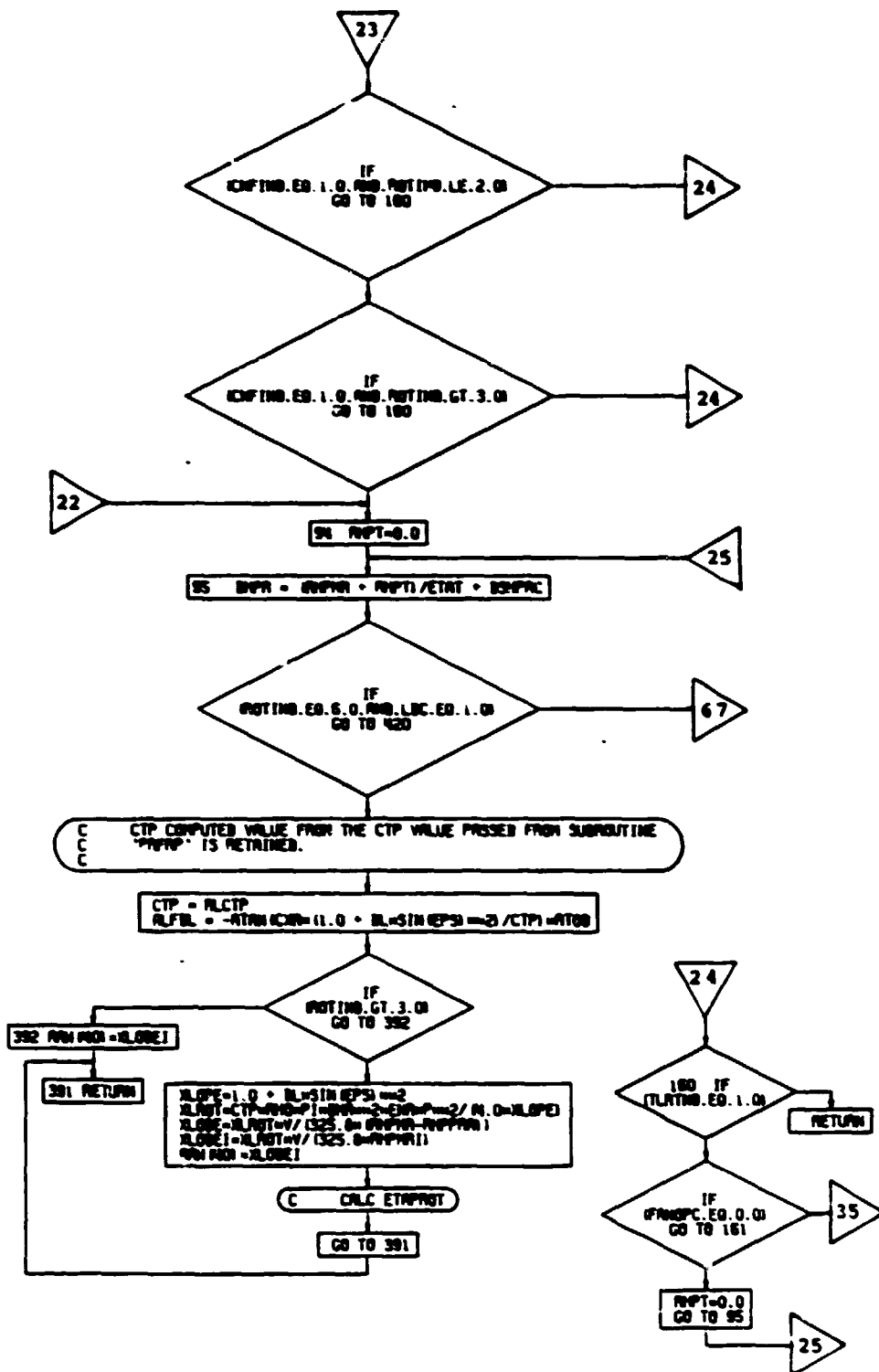


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 8 of 23)

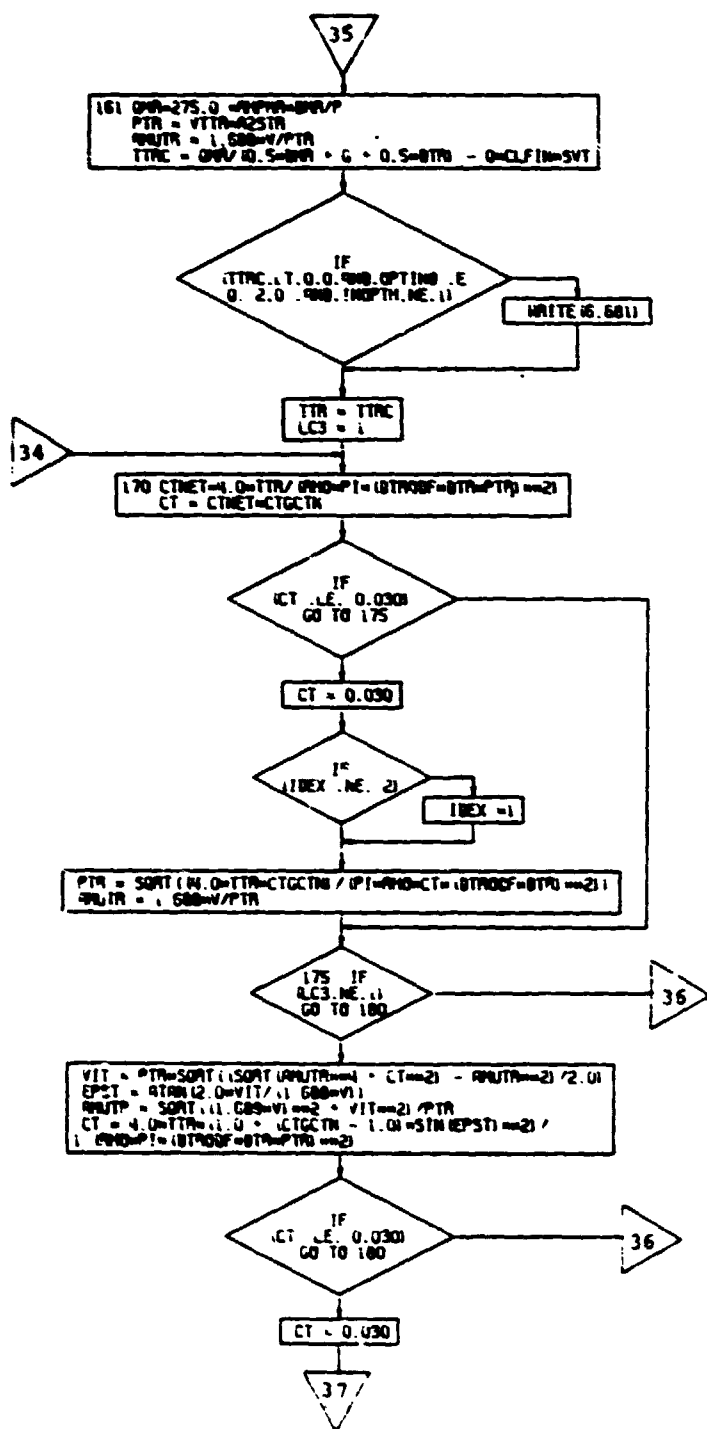


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 9 of 23)



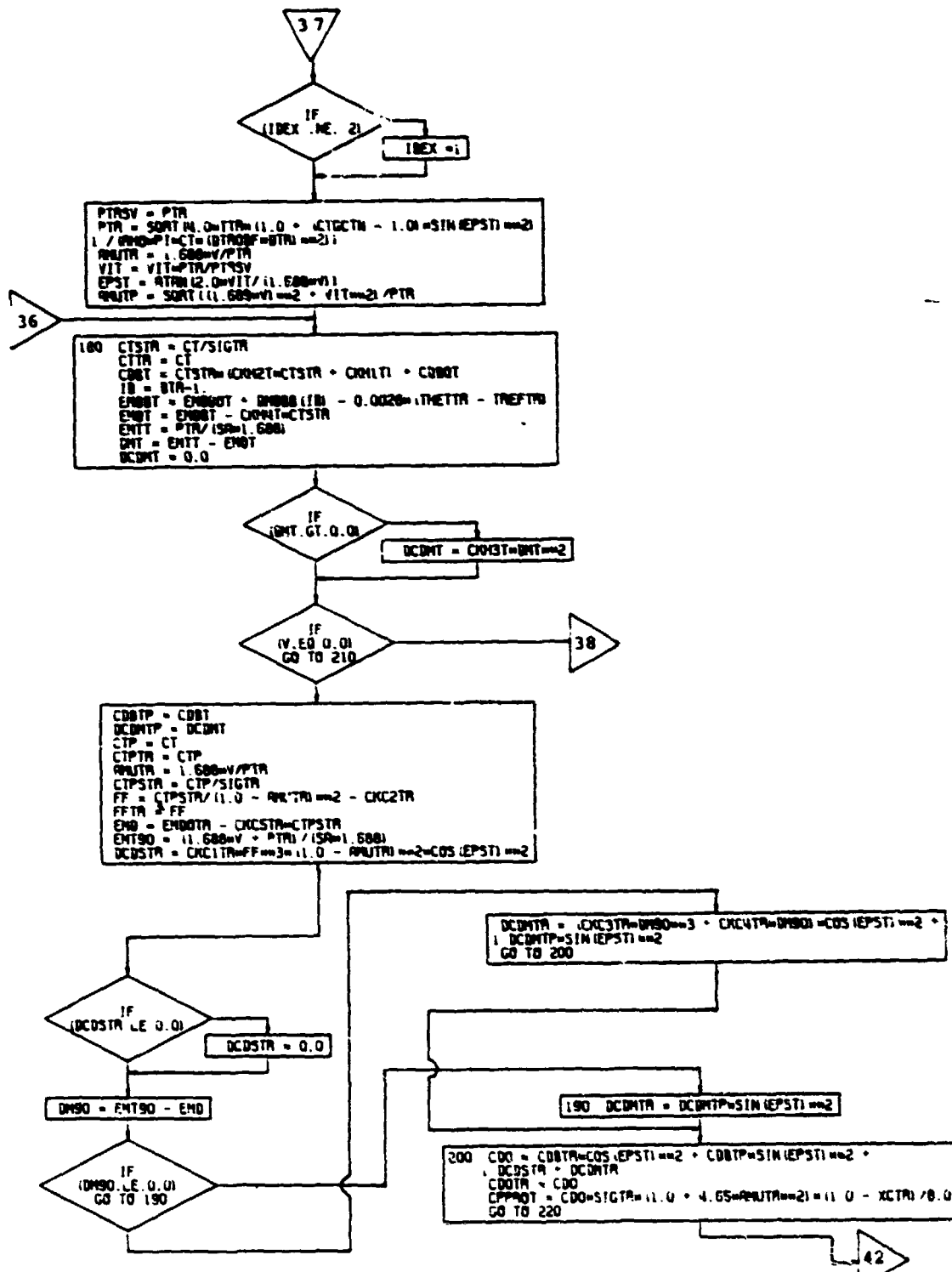


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 10 of 23)

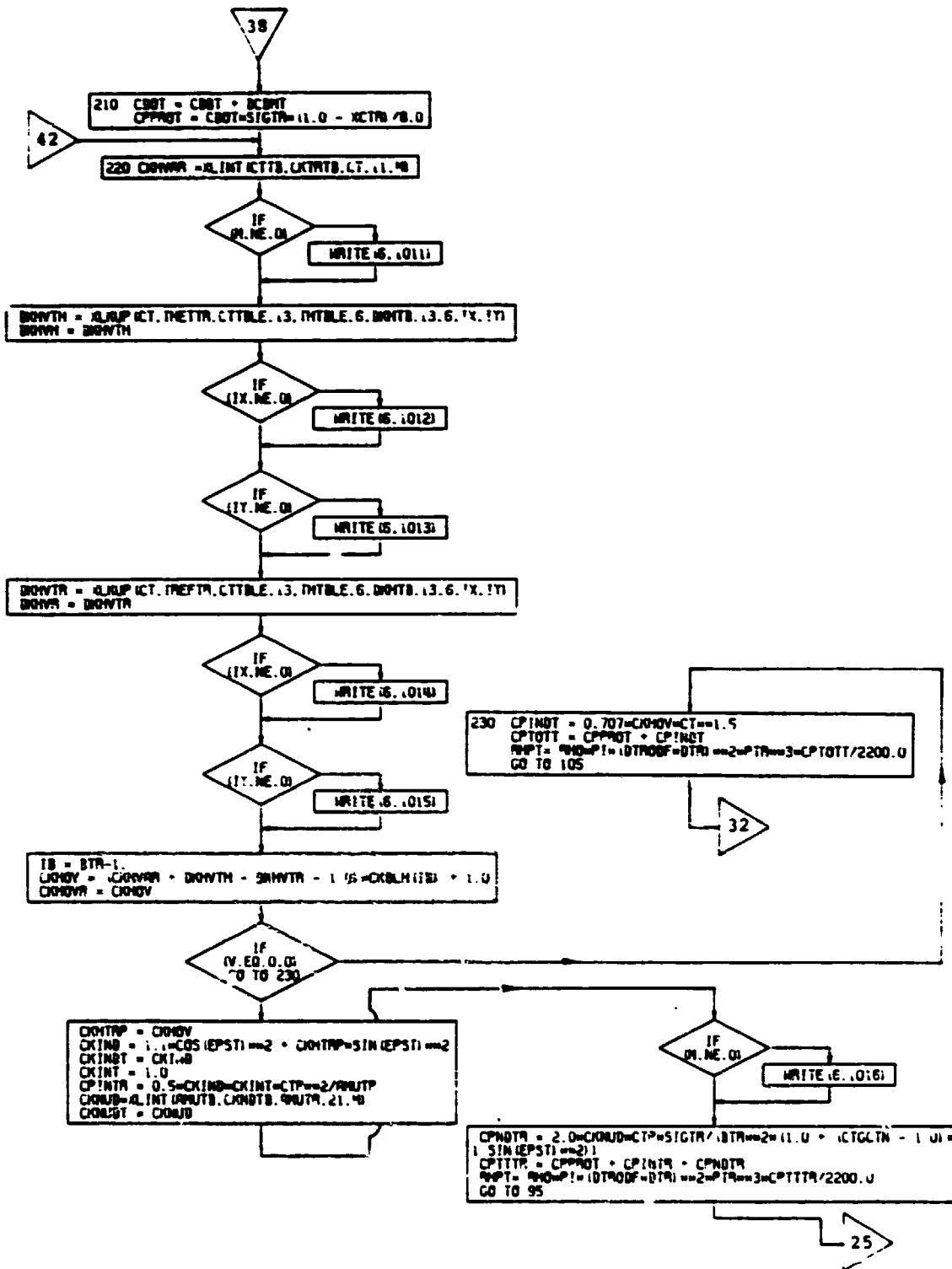


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 11 of 23).

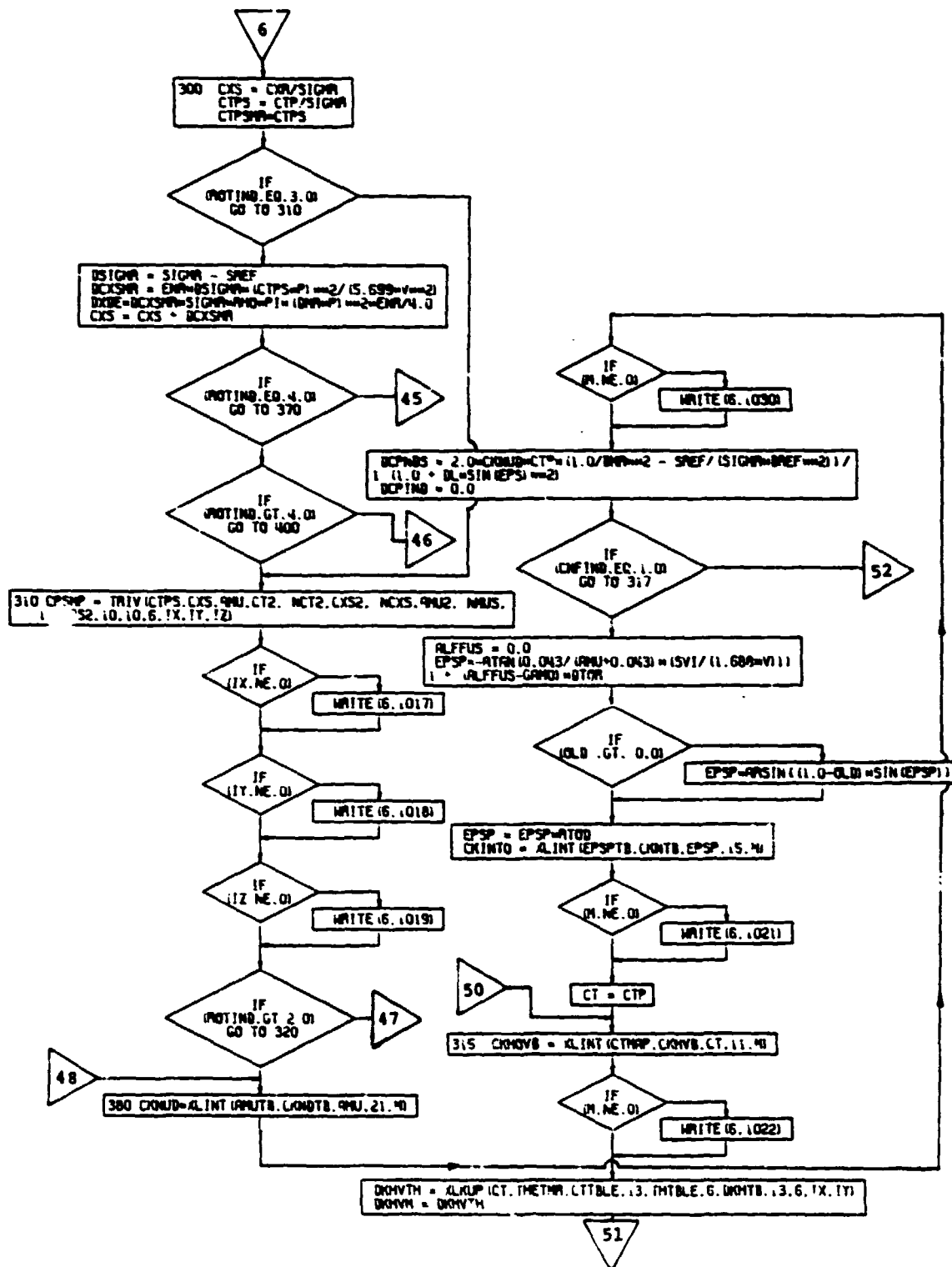


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 12 of 23)

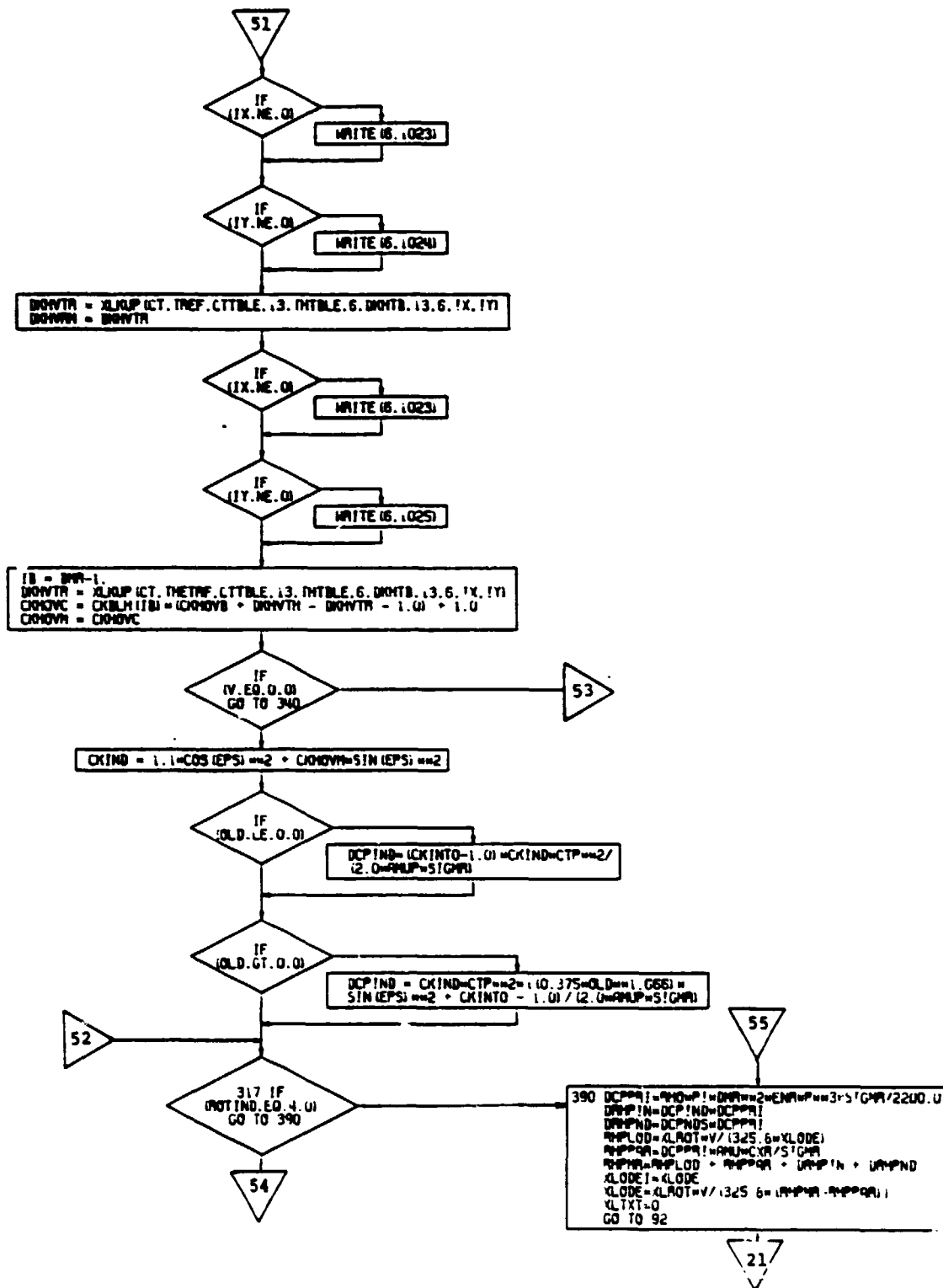


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 13 of 23)

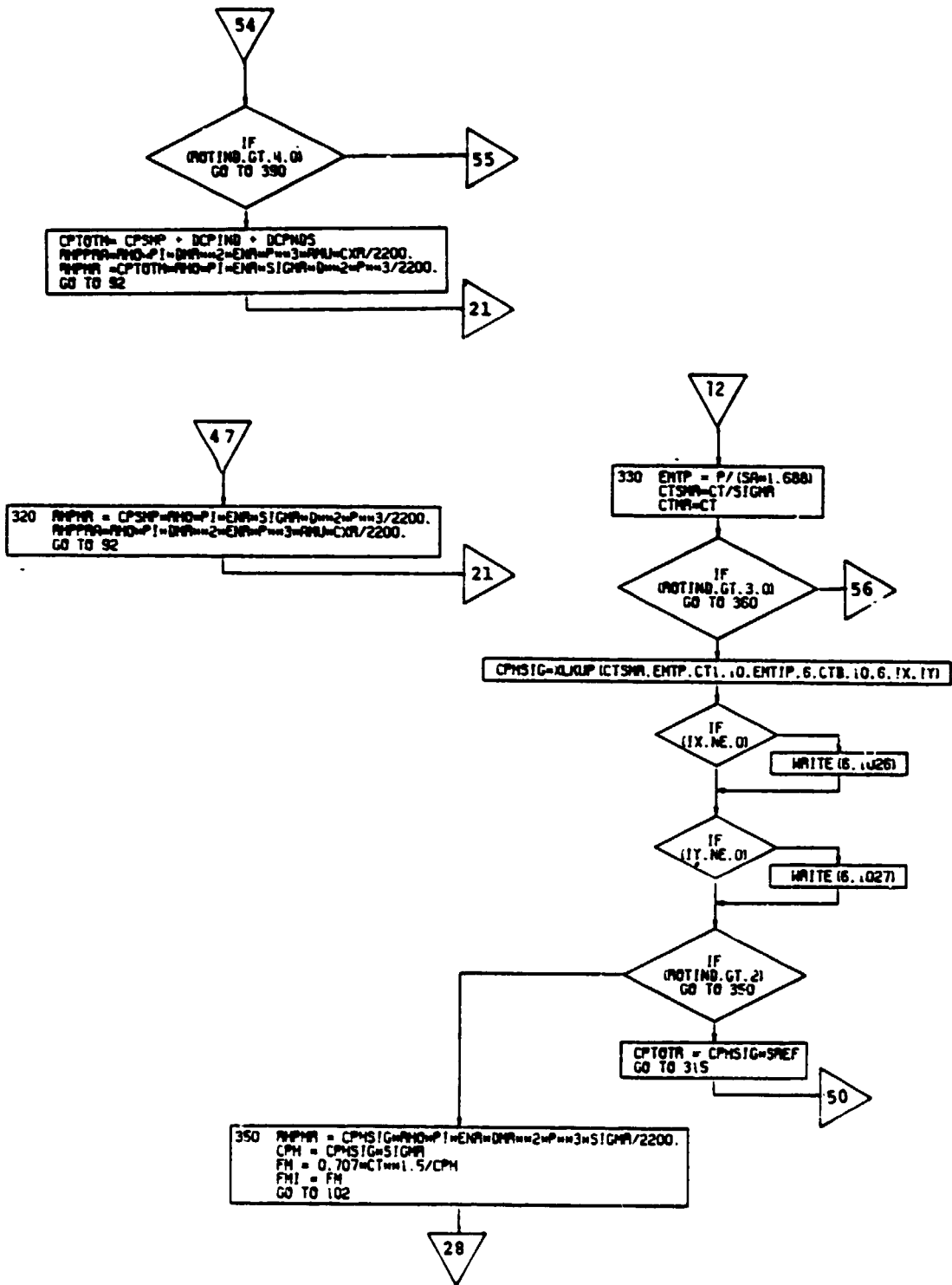


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 14 of 23)

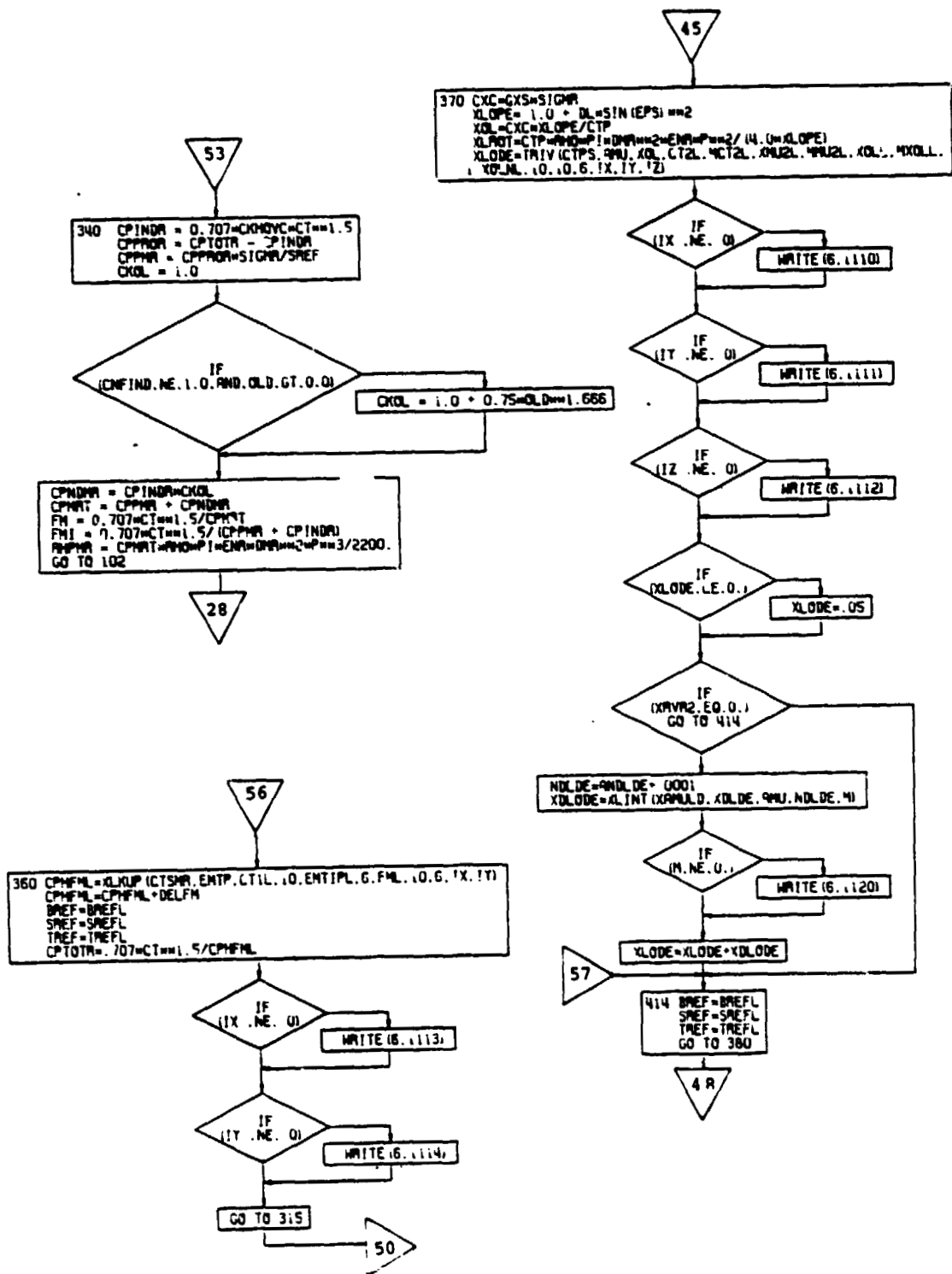


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 15 of 23)

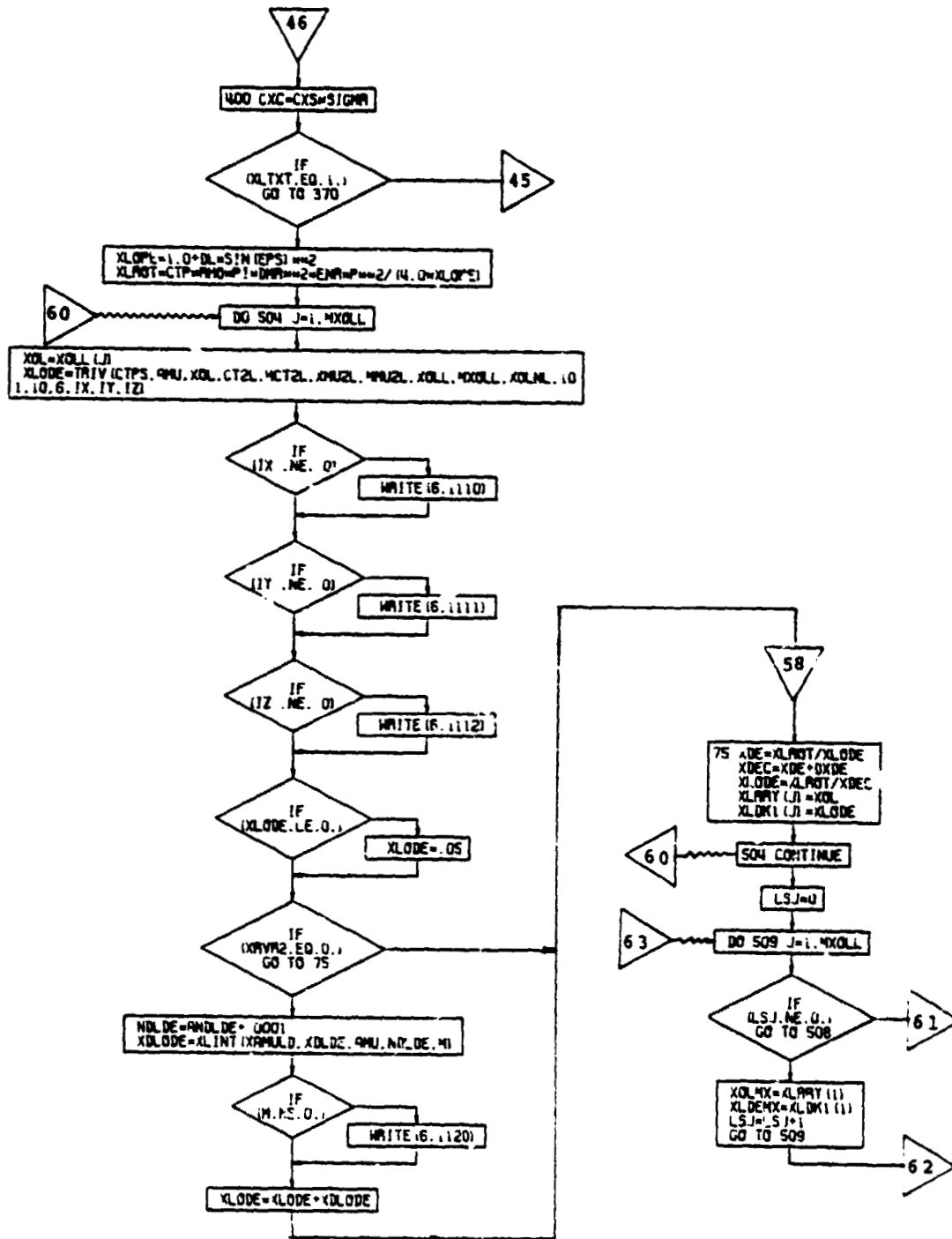


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 16 of 23)

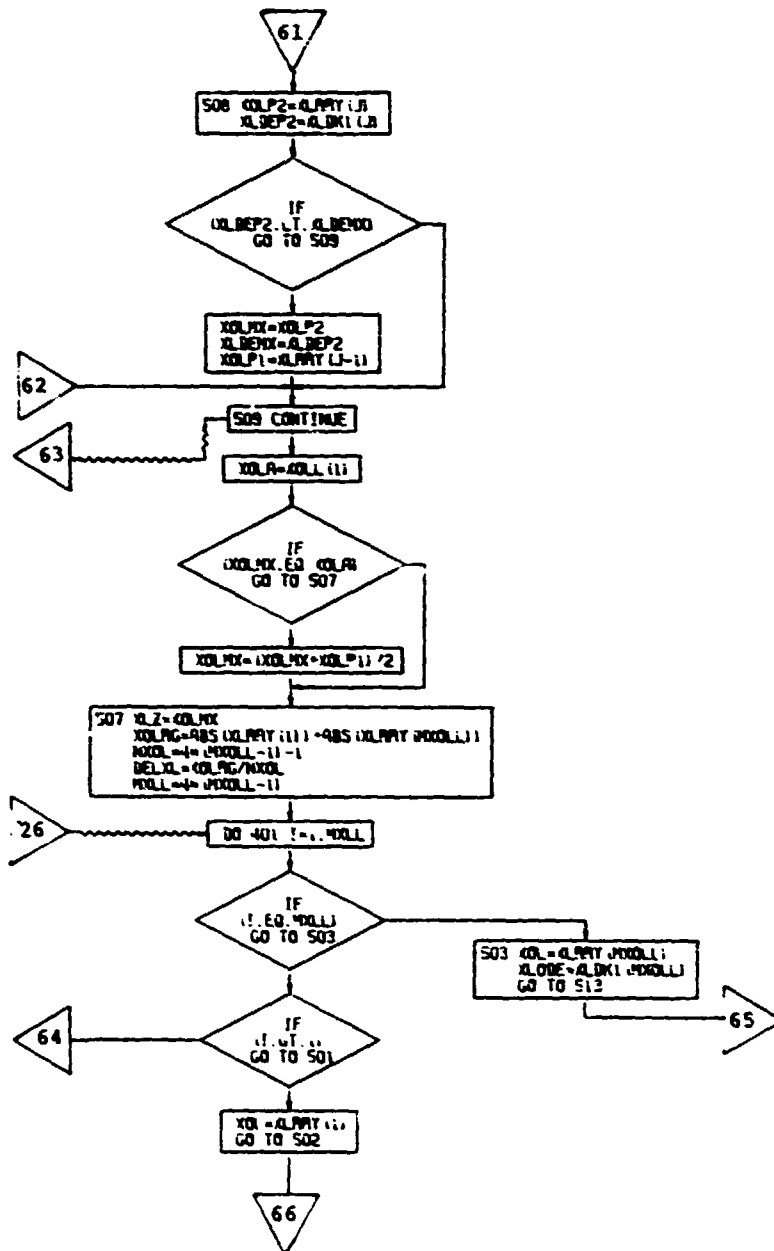


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 17 of 23)



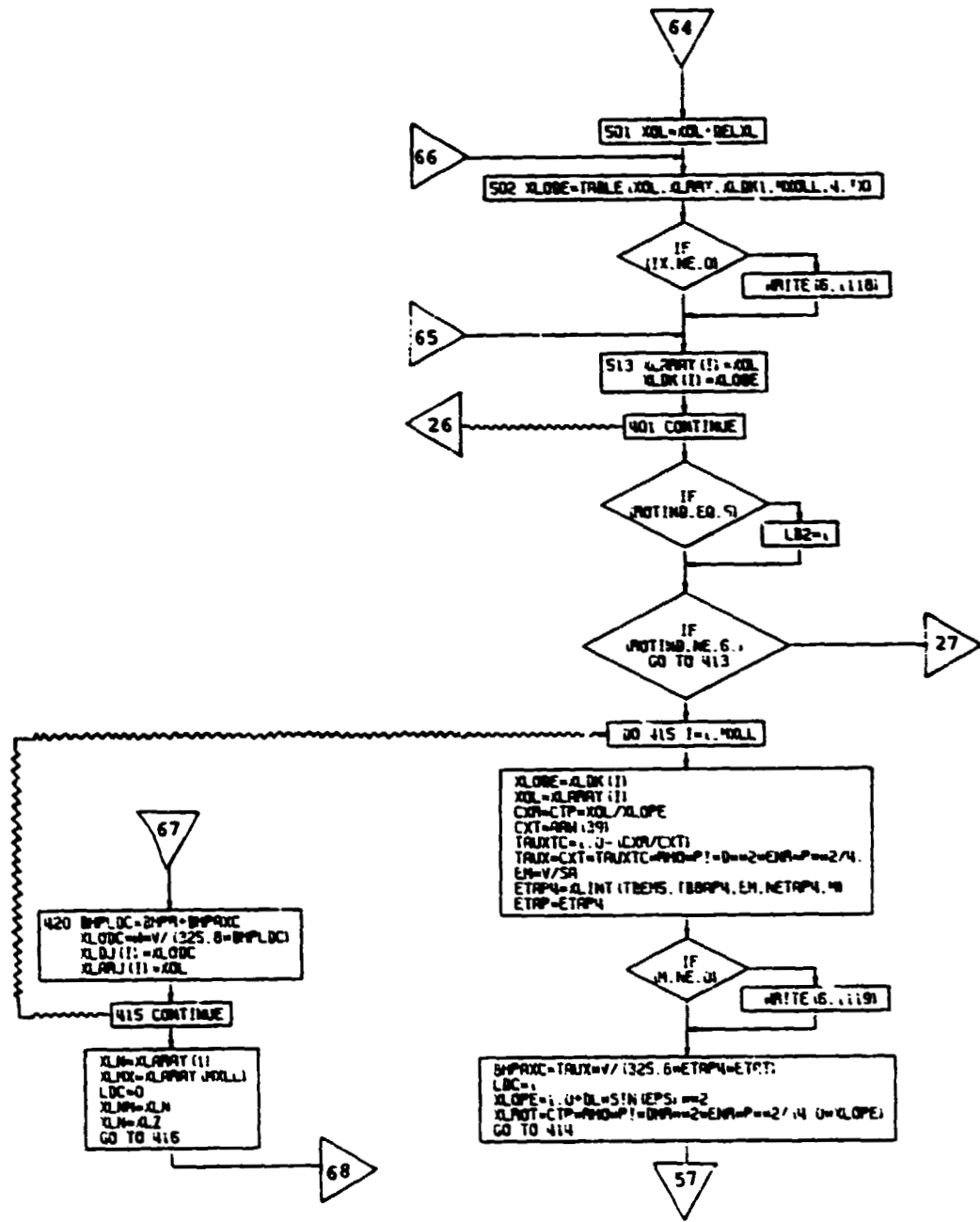


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 18 of 23)

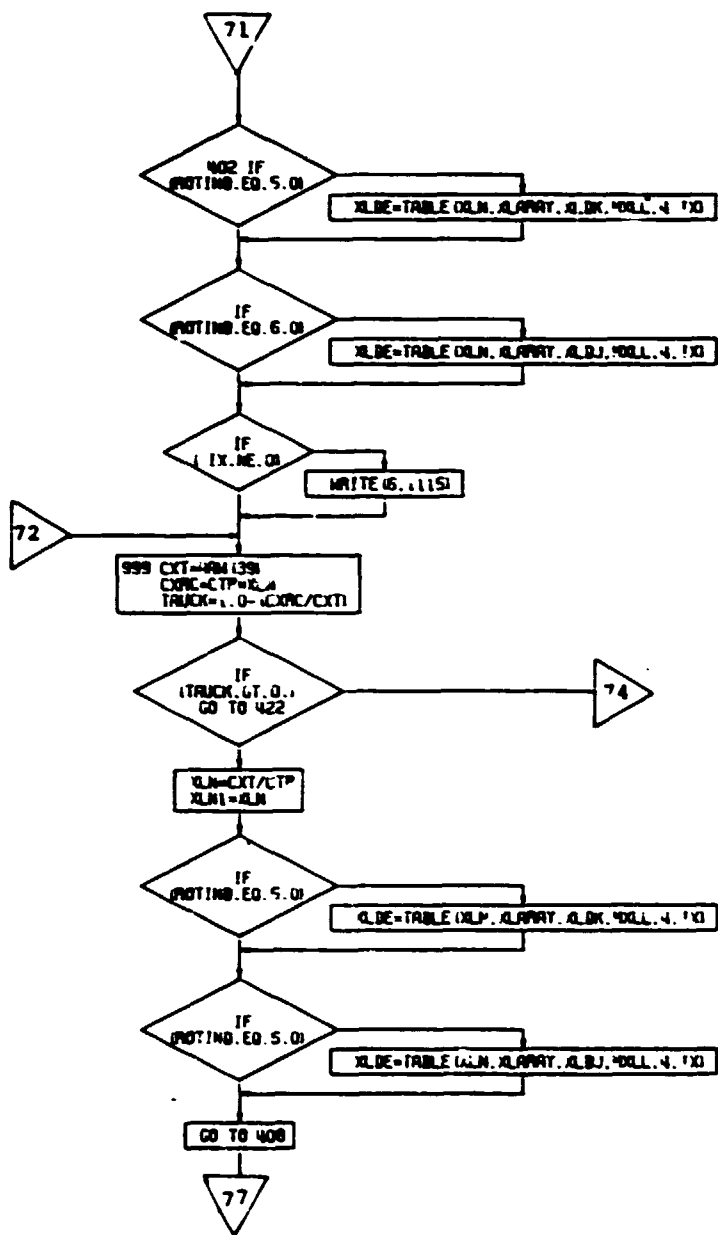


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 19 of 23)

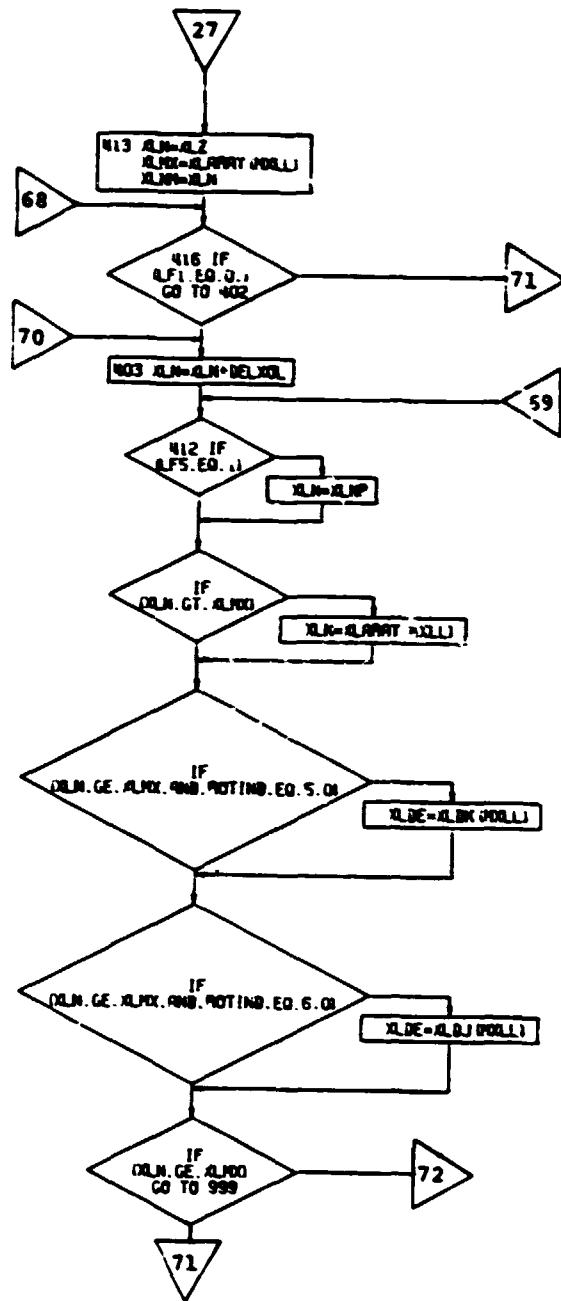


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 20 of 23)

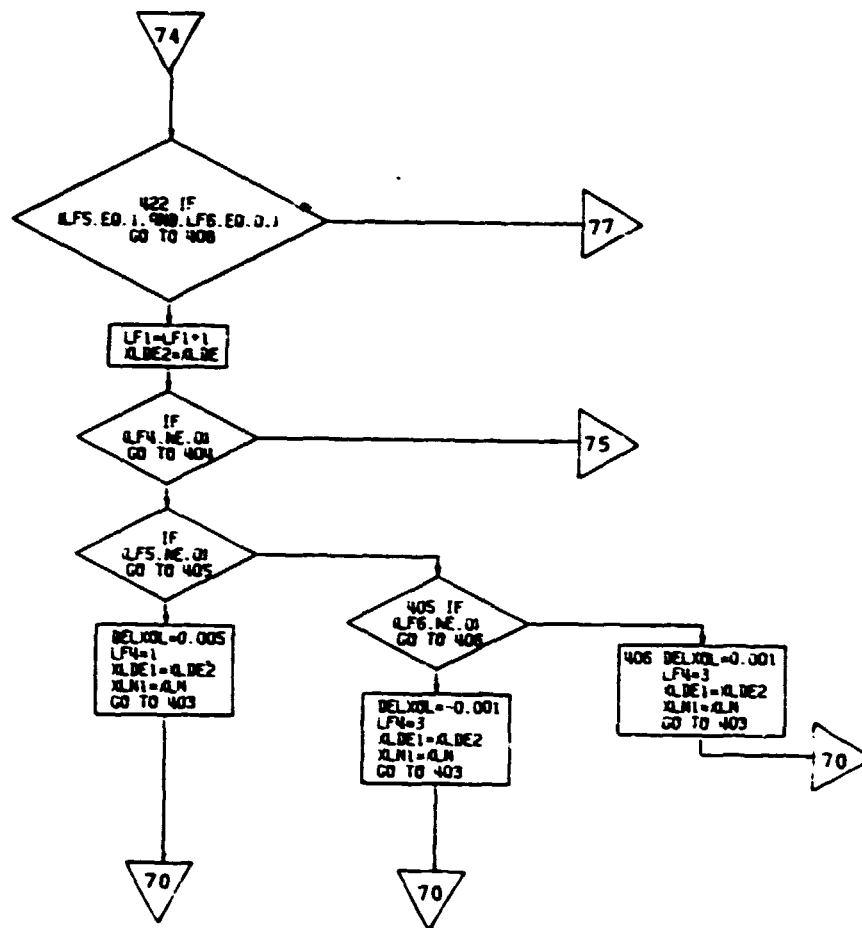


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 21 of 23)

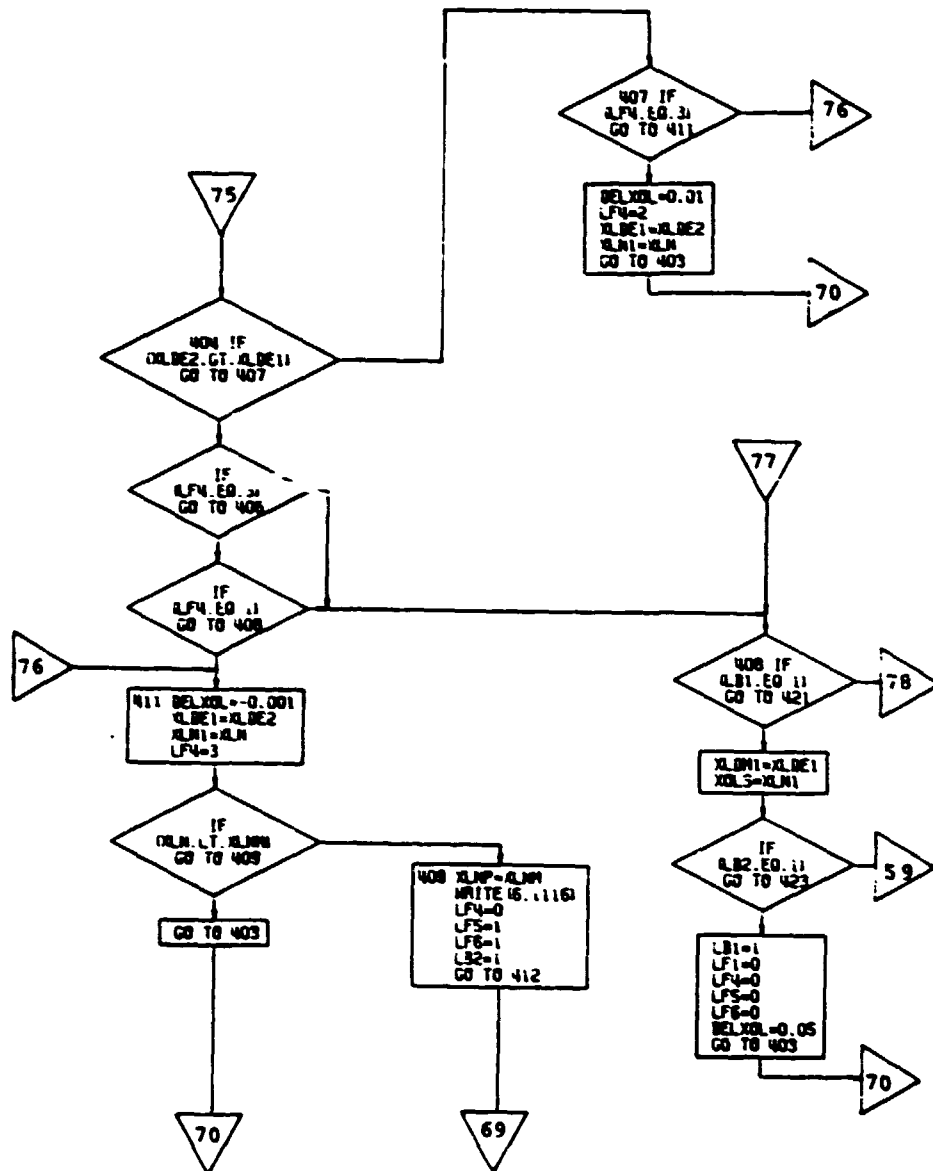


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 22 of 23)

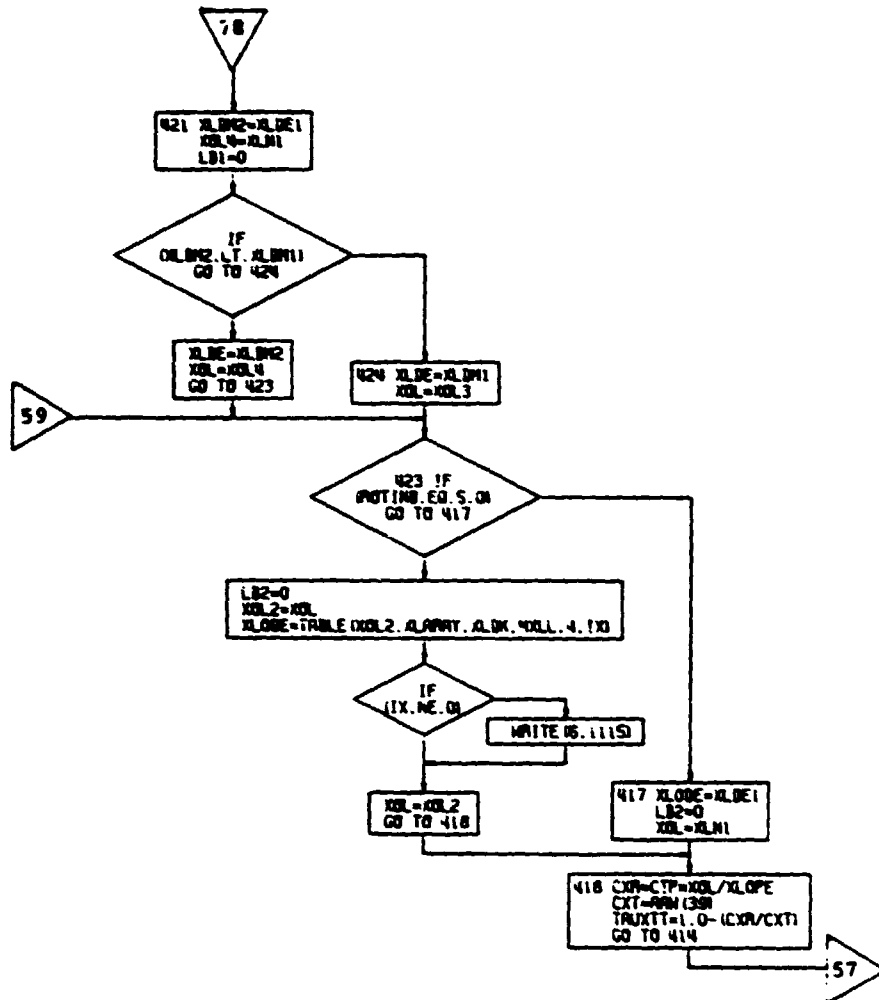


Figure 4-19. ROTPOW Subroutine, Flow Chart (Part 23 of 23)

#### 4.6 ROTOR LIMITS SUBROUTINE

The rotor limits subroutine compares the main rotor operating values of  $\mu$ ,  $\frac{C_{X_R}}{\sigma}$ , and  $C_T'/\sigma$  to those input in the rotor limits

information table (LOC 0347-0395). In the takeoff, hover, and landing subroutine, if the main rotor operating value of  $C_T'/\sigma$  exceeds the table value, the following statement is printed out:

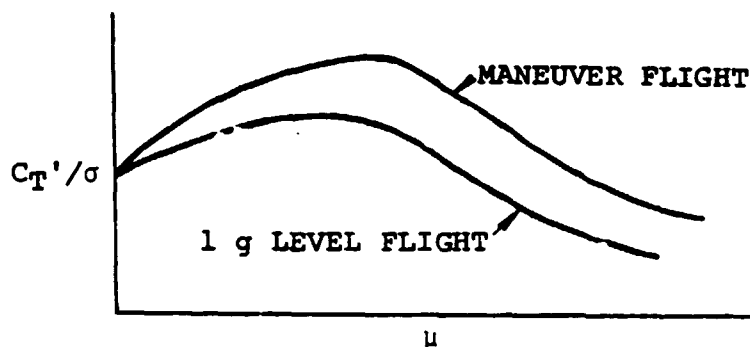
**WARNING: ROTOR LIMIT HAS BEEN EXCEEDED. EITHER REDUCE MAIN ROTOR THRUST REQUIREMENTS AT THESE OPERATING CONDITIONS, OR INCREASE MAIN ROTOR TIP SPEED. CHECK ALL VALUES OF  $C_T'/\sigma$  IN THIS PERFORMANCE LEG.**

In the climb, cruise, descent, and loiter subroutines, if the main rotor operating value of  $C_T'/\sigma$  for a given  $\frac{C_{X_R}}{\sigma}$  and  $\mu$  ex-

ceeds the table value, cruise speed is reduced until the operating and table values of  $C_T'/\sigma$  coincide and the following message is printed out:

**WARNING: ROTOR LIMIT HAS BEEN EXCEEDED. FORWARD FLIGHT SPEED HAS BEEN REDUCED ACCORDINGLY. CHECK ALL VALUES OF TAS, MU,  $C_T'/\sigma$ , AND CXR IN THIS PERFORMANCE LEG.**

The function of the rotor limits table input is to provide realistic (1g) level flight boundaries for helicopter rotor operation. This is important because, although the rotor performance calculation (whether using rotor "cycles" or maps) reflects operation near stall through rapidly increasing power required levels, it would still be possible, using a greatly oversized engine, to operate in this region, even though in actual fact the rotor could be overstressed or subject to structural failure. A typical rotor limits plot is illustrated by the sketch below:

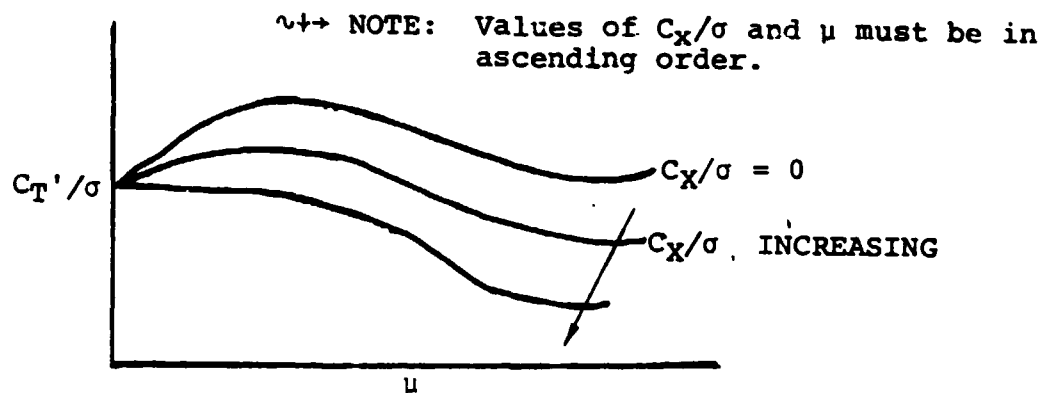


For purposes of defining the tabular rotor limits input, the level flight conditions are of interest only, although single point values  $(C_T/\sigma)_H$ ,  $(C_T/\sigma)_{CR}$  from the maneuver flight curve are necessary for determining (sizing) main rotor solidity. Rotor limits then can be based on:

- a) incipient rotor blade stall limits (lg level flight), or
- b) incipient rotor blade stall and/or rotor blade structural limits for maneuver flight.

Figure 4-20 shows a summary of miscellaneous rotor limits data (theoretical and flight test), for both the lg level flight and maneuver conditions. The rotor limit value  $(C_T/\sigma)_H$  encountered in hover is typically due to stall flutter. This is primarily an aeroelastic/control system stiffness problem. Level flight rotor limit values, as noted earlier, are a function of incipient stall and/or stall flutter. Rotor limits in maneuver flight are more complex to understand because of the interaction of various rotor configurations and rotor parameters on the result. For example, a rotor system with relatively high rotor blade inertia in the flapwise direction should potentially (in a maneuver) exhibit a higher maneuver g capability (due to gyroscopic precessional effects) than a rotor with less inertia in the flapwise direction. Other factors influencing rotor limits include the torsional natural frequency of the blade as it interacts with stall flutter, chordwise bending stresses of the blade, the type of maneuver performed, etc. For a more detailed discussion of this matter, see References 12 to 15.

Provision has been made in the rotor limits table for inclusion of rotor limits which are a function of  $C_X/\sigma$  (based on rotor propulsive thrust) as well as  $\mu$  (see the sketch below).





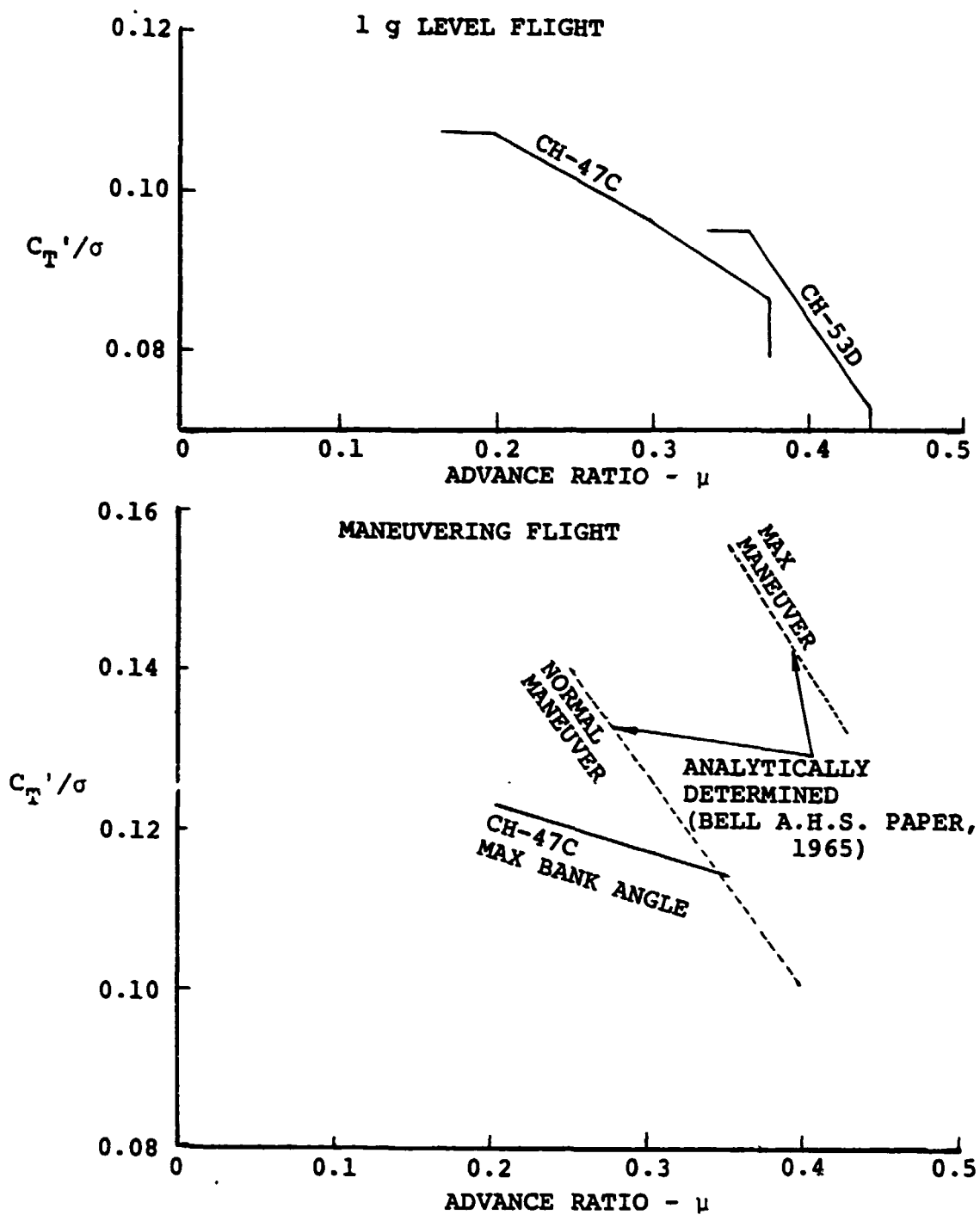


Figure 4-20. Summary of Typical Rotor Limits.

In those instances where  $C_X/\sigma$  is not a variable, the user simply inputs  $C_T'/\sigma$  versus  $\mu$  a dummy values of  $C_X/\sigma$  (0 and 1.0). If the user wishes to operate the program without using rotor limits, large "dummy" values of  $C_T'/\sigma$  (say 1.0) are input at  $C_X/\sigma = 0$  and 1.0.

Figure 4-21 is a flow chart of this subroutine.

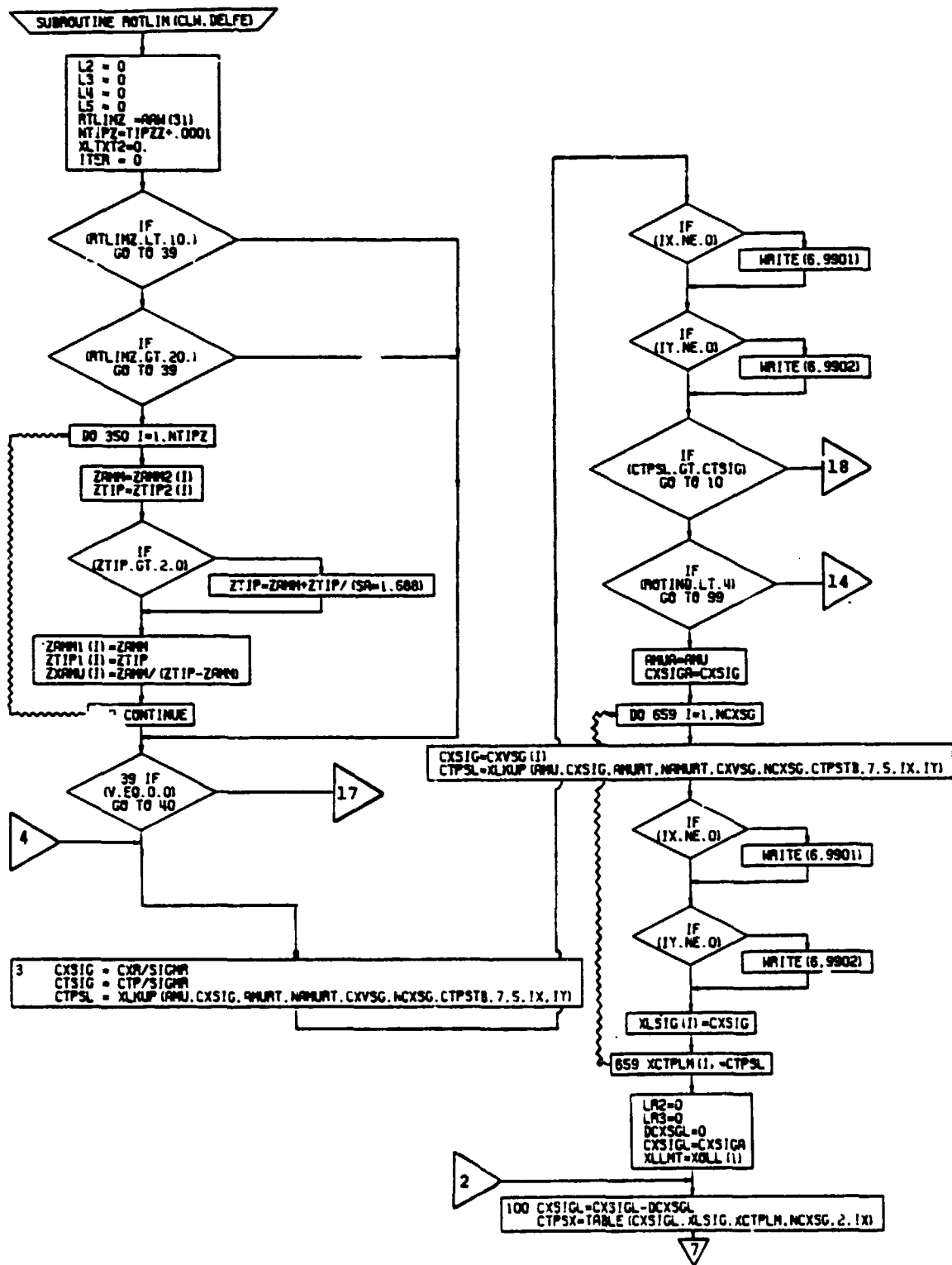


Figure 4-21. ROTLIM Subroutine, Flow Chart (Part 1 of 7)

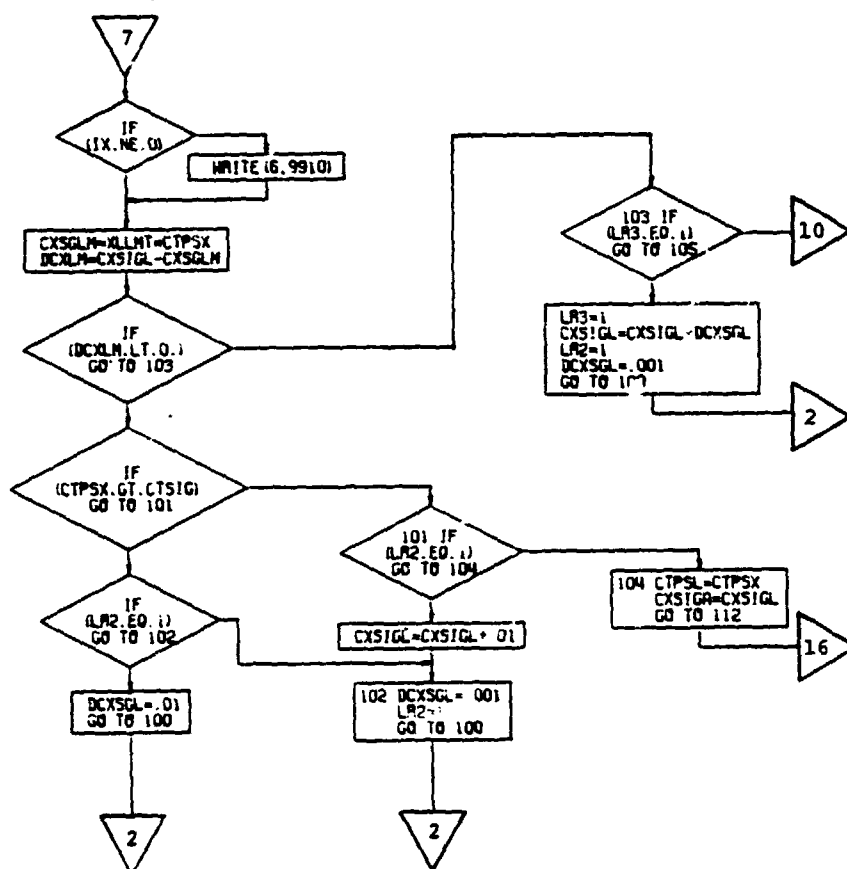


Figure 4-21. ROTLIM Subroutine, Flow Chart (Part 2 of 7)

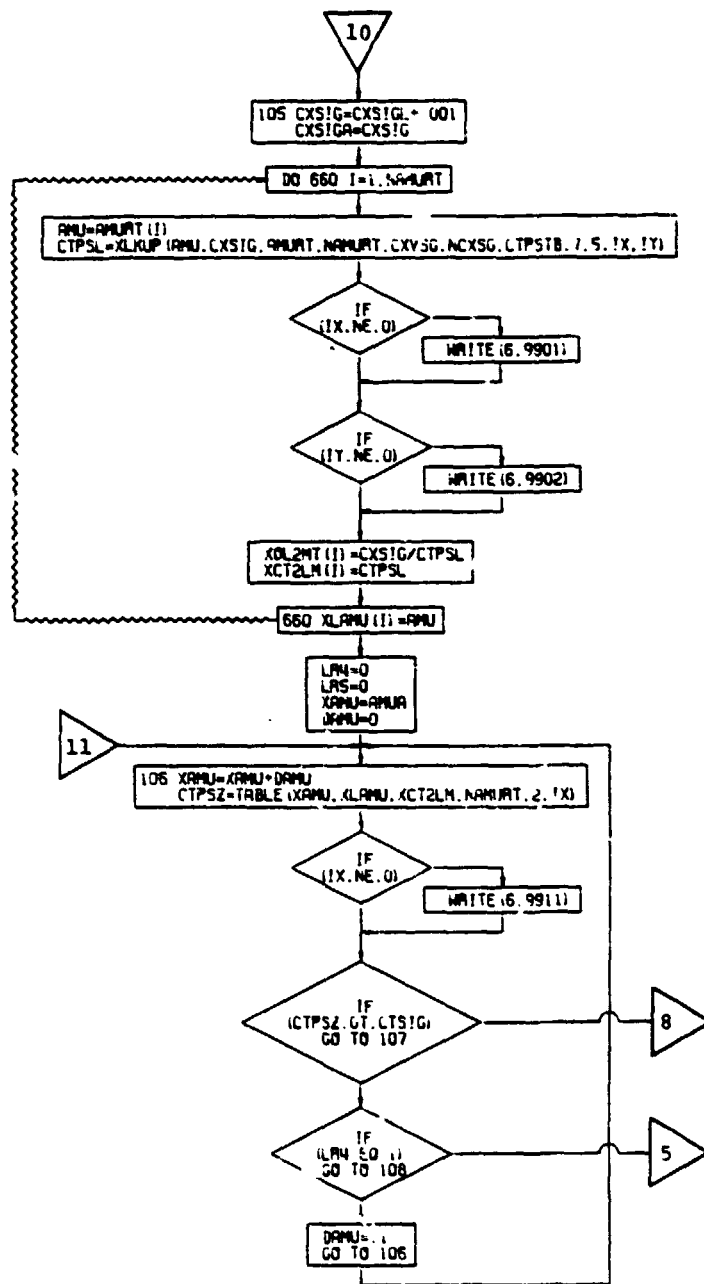


Figure 4-21. ROTLIM Subroutine Flow Chart (Part 3 of 7)

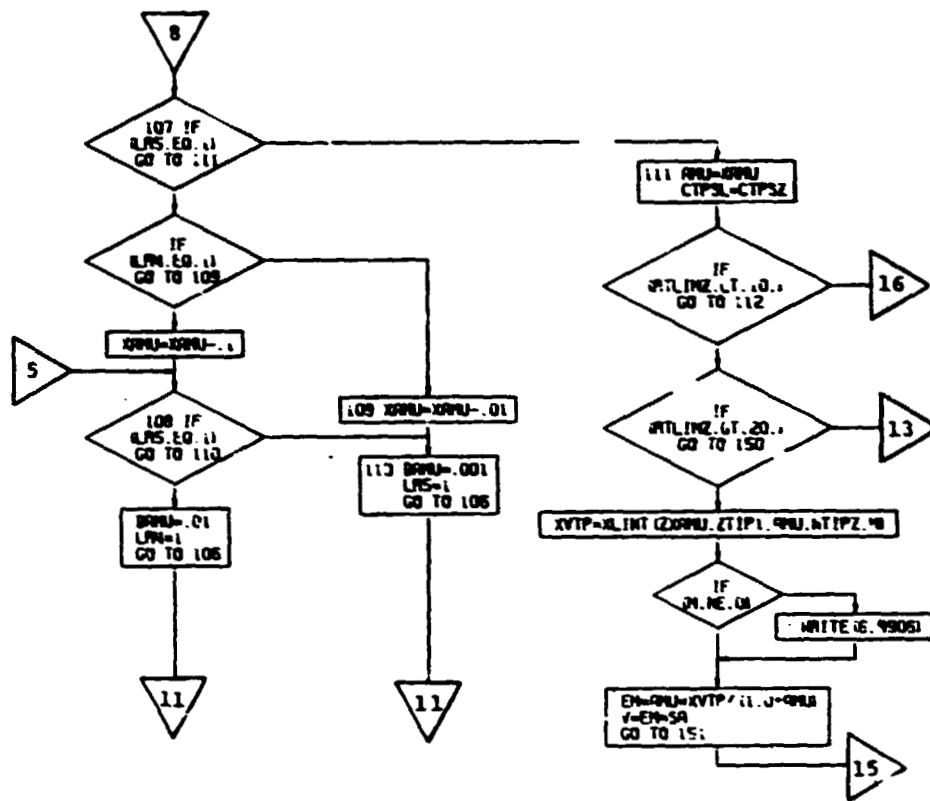


Figure 4-21. ROTLIM Subroutine, Flow Chart (Part 4 of 7)

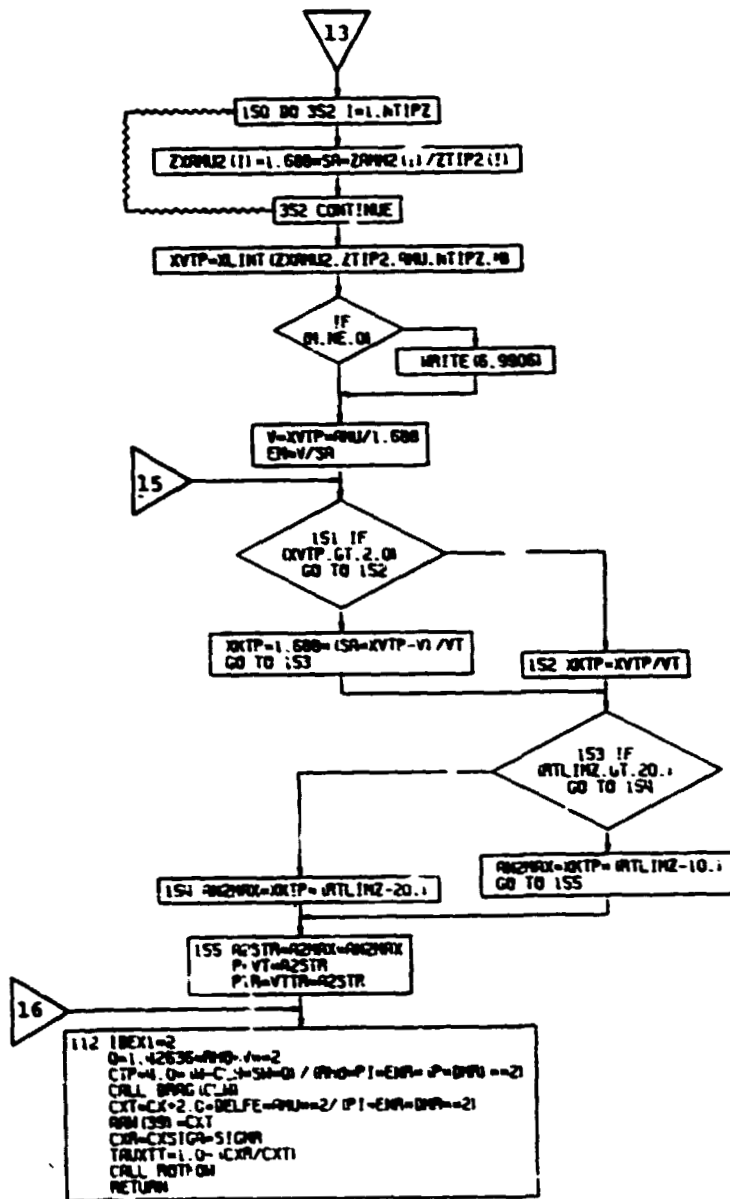


Figure 4-2'. ROTLIM Subroutine, Flow Chart (Part 5 of 7)

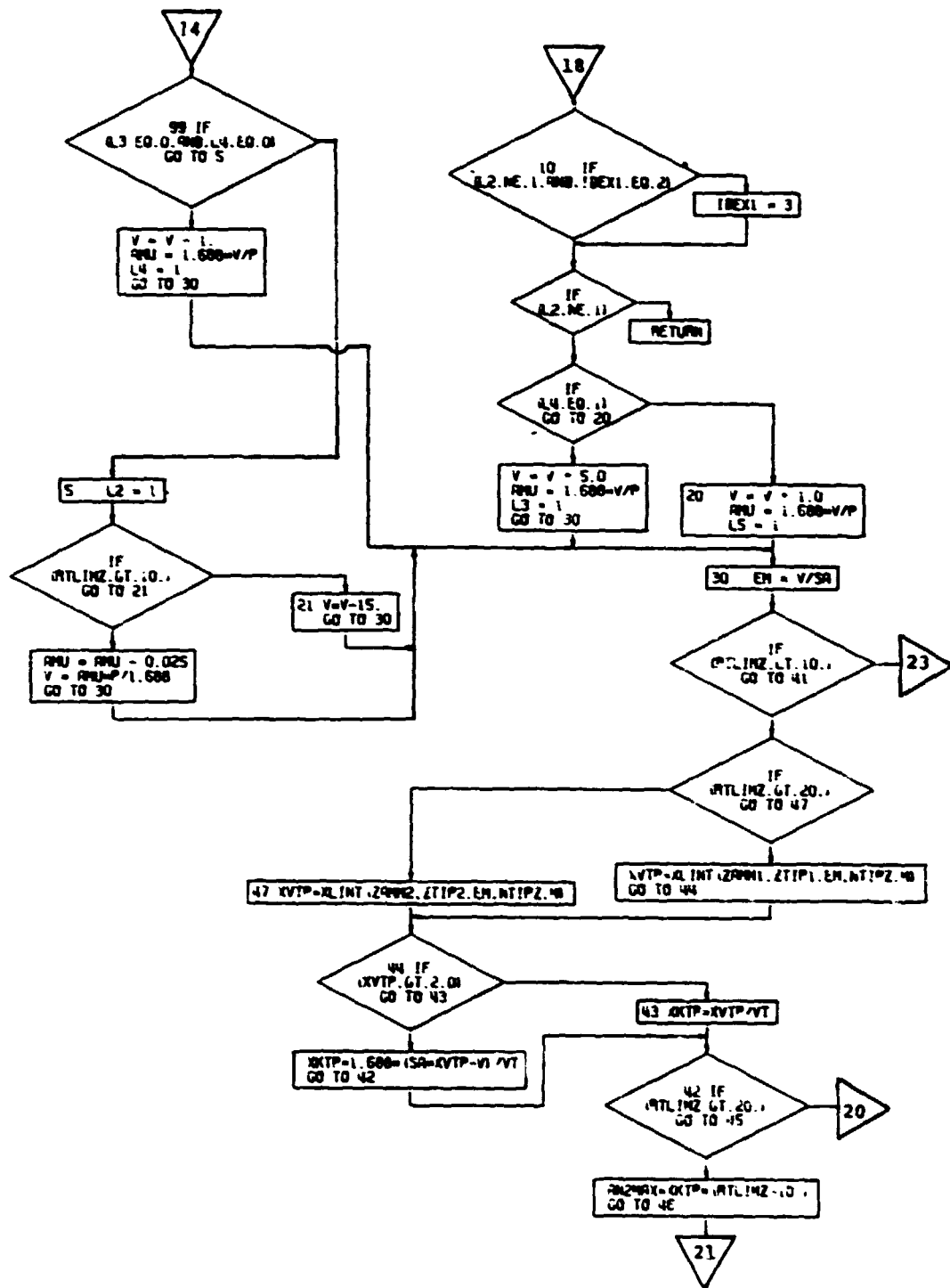


Figure 4-21. ROTLIM Subroutine, Flow Chart (Part 6 of 7)



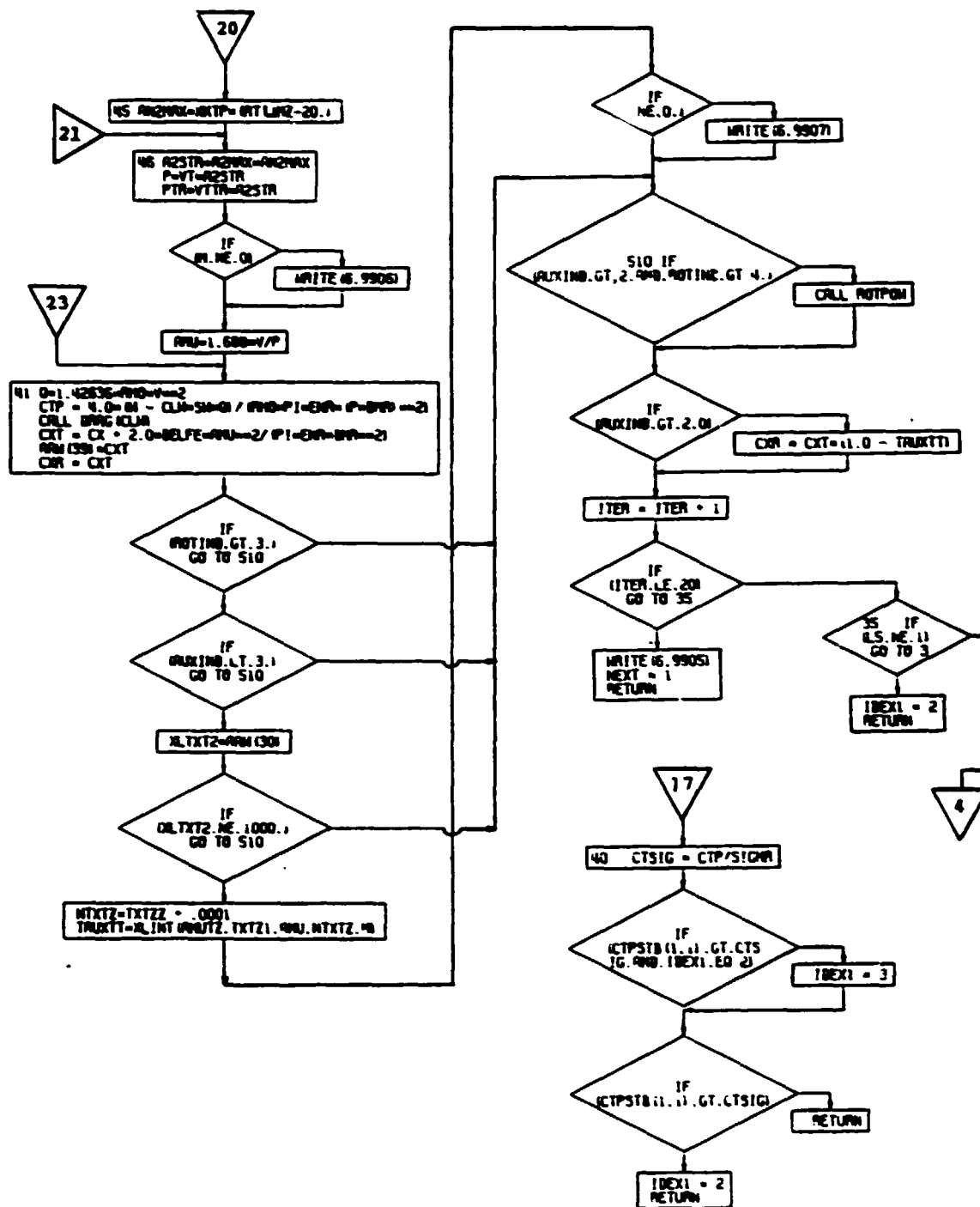


Figure 4-21. ROTLIM Subroutine, Flow Chart (Part 7 of 7)

#### 4.7 PROPELLER PERFORMANCE CALCULATIONS

The final selection of a propeller blade design to best suit a given compound helicopter 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 requirement.

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  $C_L$  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 will help the designer cope with blade loading problems and result in better mission efficiency. This can be done whether 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 powerplants. 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. Engine power does fall off at nonoptimum turbine speed, 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 performance over most of the flight envelope. Performance prediction capability is generally inadequate in the following areas: 1) static thrust, 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 manufactures' 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.

Three 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 - " $\eta_{IND}$ "

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

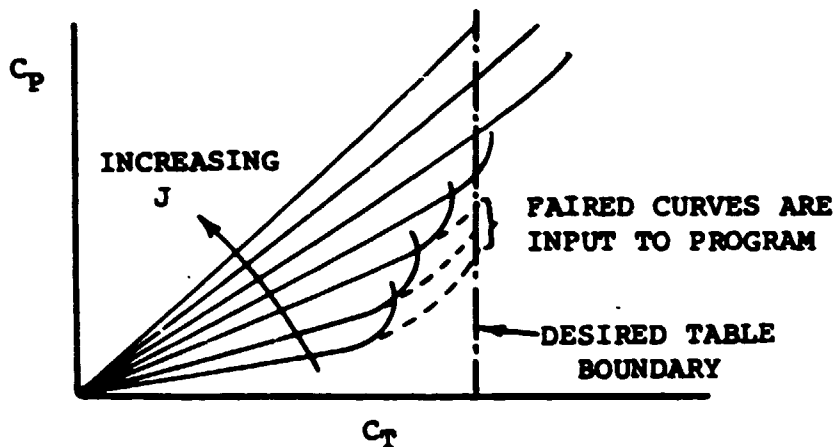
$\eta_{P2}$  - The static propeller efficiency (Figure of Merit) to be used in calculation of Takeoff, Hover and Landing (SGTIND=2) is input as a single point value. It should be noted that  $\eta_{P2}$  is also a required input for jet engines (ENGIND=1) or for convertible engines (ENGIND=2). In the 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 prop<sup>s</sup> 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.

$\eta_{pIND} = 1$  - 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  $\eta_{p5}$  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.

$\eta_p$  IND = 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,  $C_{L_i}$ . The method used for the calculation of

propeller performance is the "short method" originated at the Curtiss-Wright Corporation's Propeller Division (Reference 10). 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  $C_{L_i}$  being considered.

That is, for a given  $C_{L_i}$  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. These detailed calculations covered the following range of parameters:

Number of blades:	3 and 4
Activity factor/blade:	60 - 220
Integrated lift coefficient, $C_{L_i}$ :	0.3 - 0.7

Although the user is permitted to input values of activity factor and  $C_{L_i}$  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 4-22a and 4-22b are characteristic of the level of accuracy obtained from the short method when compared to the detailed calculations.

FIGURE OF  
MERIT  
%

NOTE: SYMBOLS ARE FROM  
DETAILED CALCUTATIONS  
BASED ON "EXPLICIT VORTEX  
INFLUENCE TECHNIQUE".  
SOLID LINES ARE PREDICTIONS  
USING "SHORT METHOD".

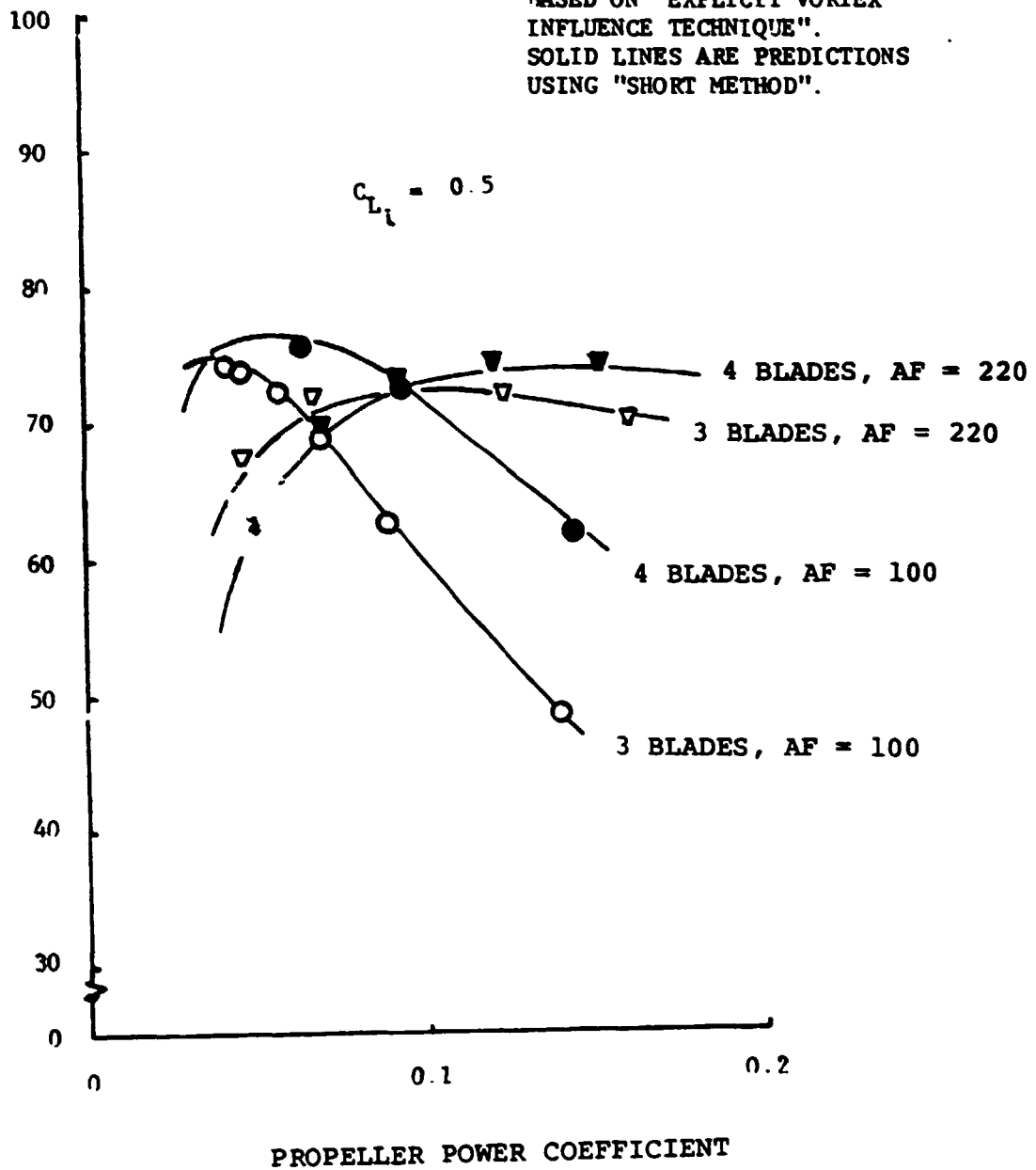


Figure 4-22a. Comparison of "Short Method" and Detailed Calculation for Propeller Hover Efficiency.

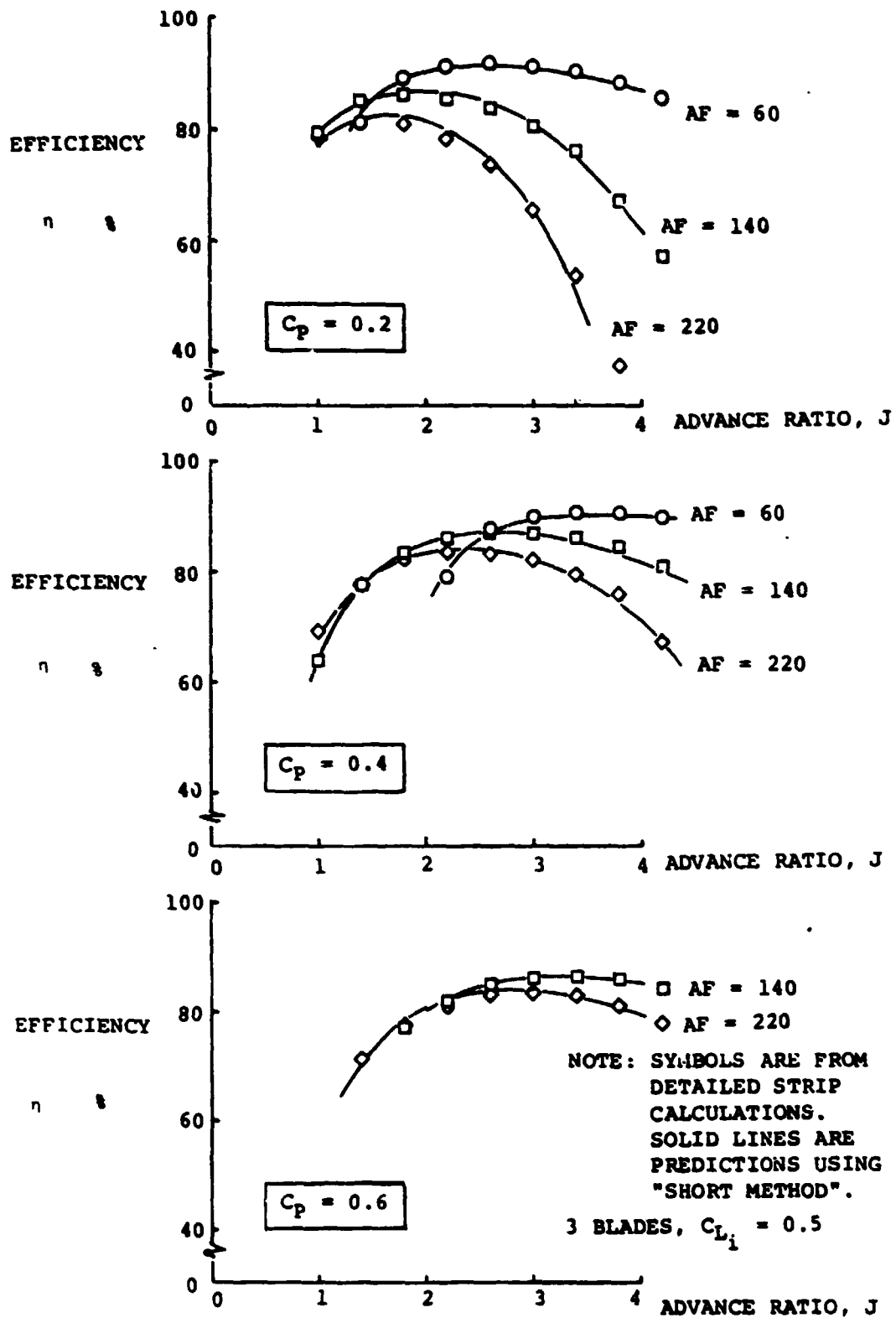


Figure 4-22b. Comparison of "Short Method" and Detailed Calculations for Propeller Cruise Efficiency.

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 4-23 is a flow chart of subroutine THRUST which calculates the propeller thrust available for known values of power and flight speed. Figures 4-24 and 4-25 are flow charts for subroutines POWER and POWERI 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,  $C_{L_i}$ , being studied

from the following equations:

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

$M_H$  = helical Mach number @  $3/4$  r/R

$C_L$  = equivalent lift coefficient at which prop is operating

$C_{L_i}$  = integrated lift coefficient of prop

For Cruise

$$\gamma = a_0 + a_1 C_{L_i} + a_2 C_{L_i}^2$$

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

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

The calculations of propeller performance for  $\eta_p$  IND = 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.



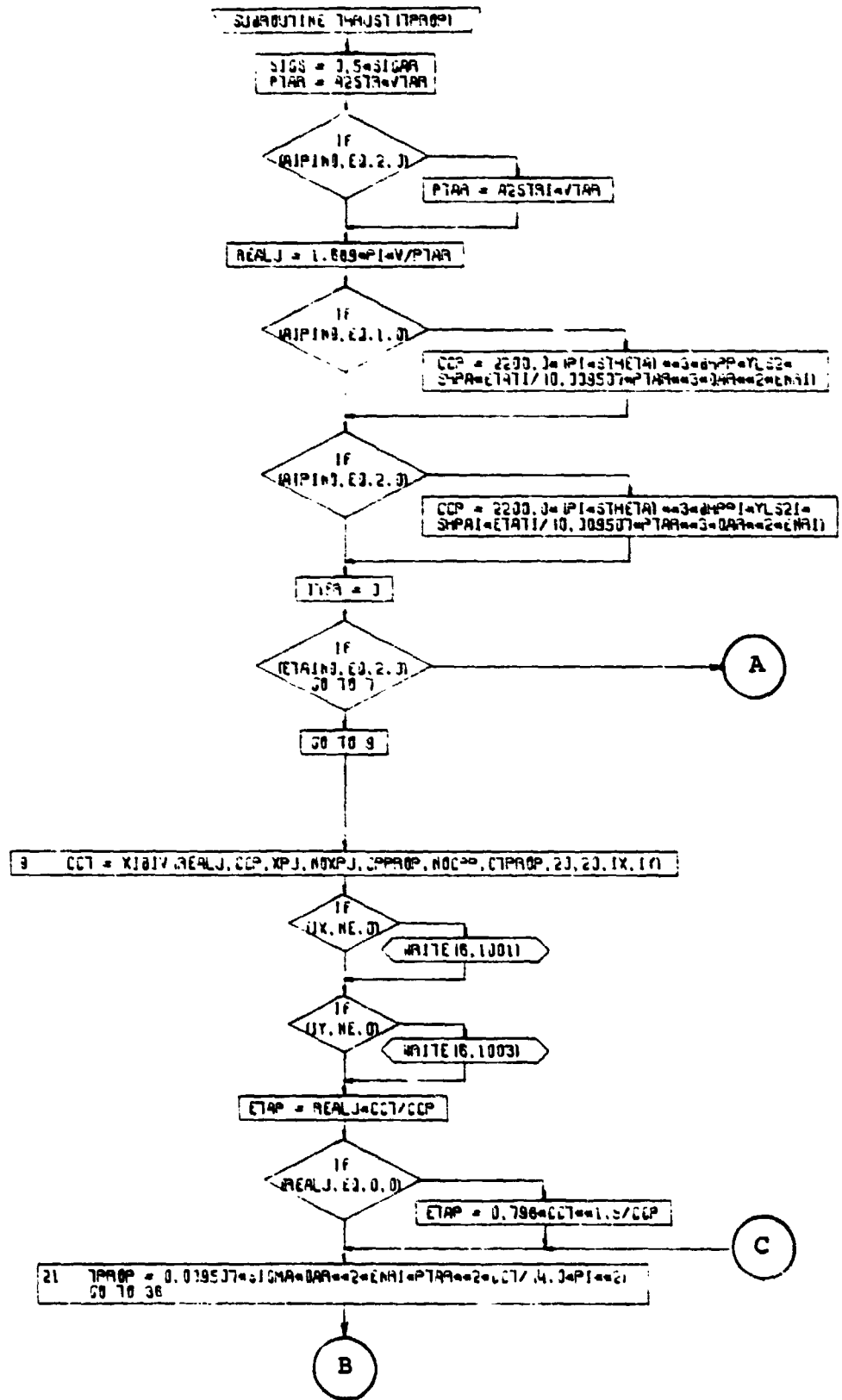


Figure 4-23. THRUST Subroutine Flow Chart (Part 1 of 4).

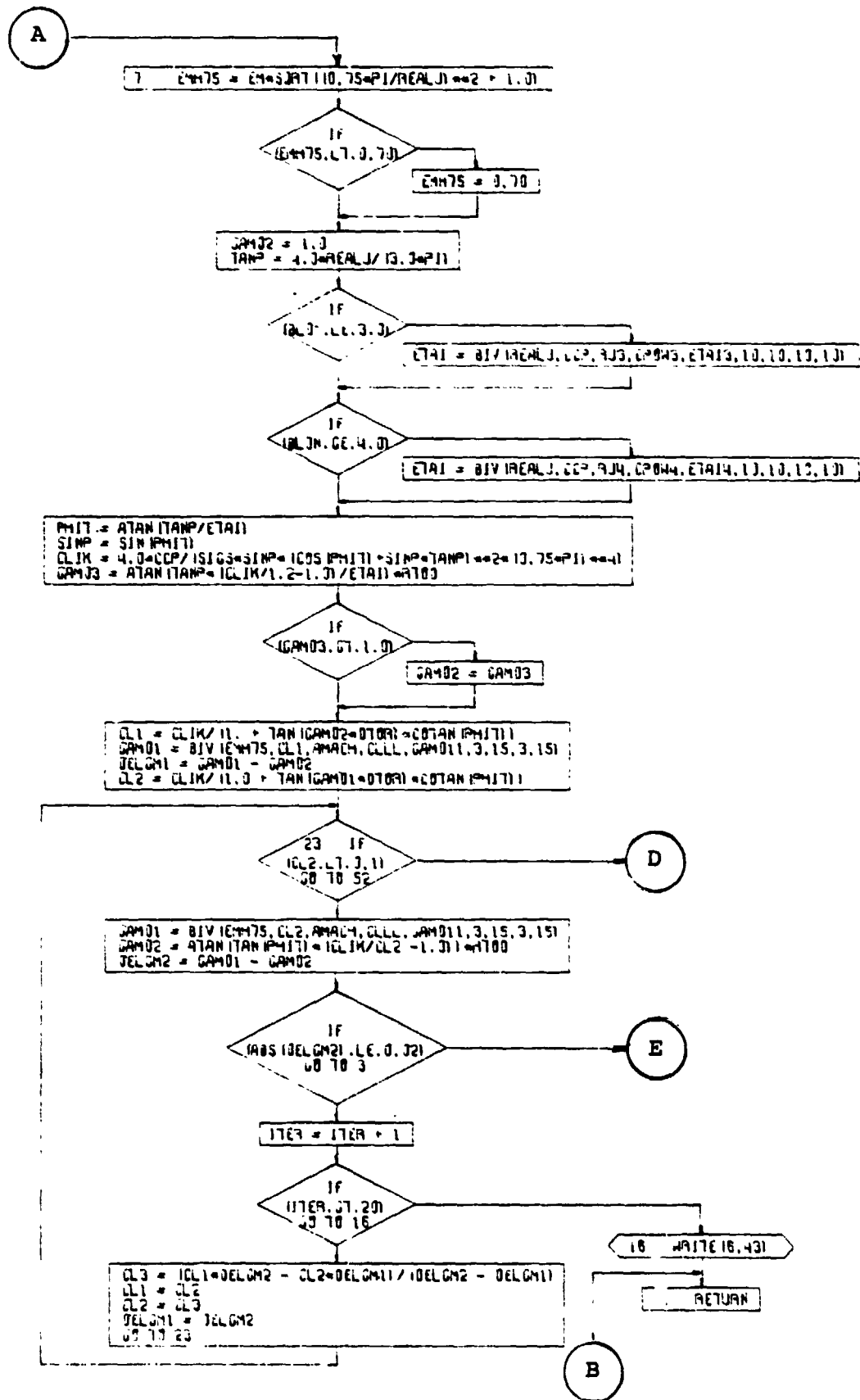


Figure 4-23. THRUST Subroutine Flow Chart (Part 2 of 4).

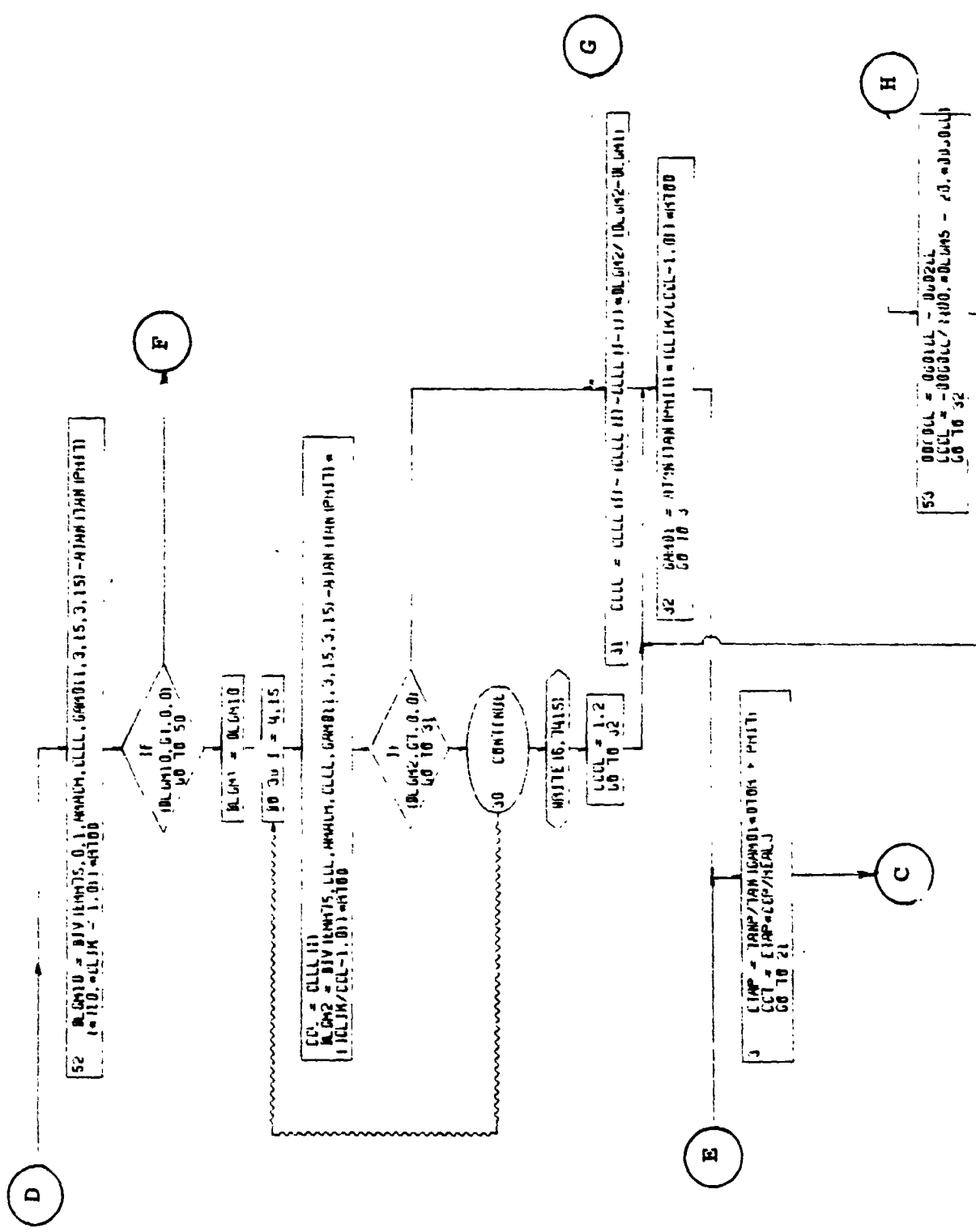


Figure 4-23. THRUST Subroutine Flow Chart (Part 3 of 4).

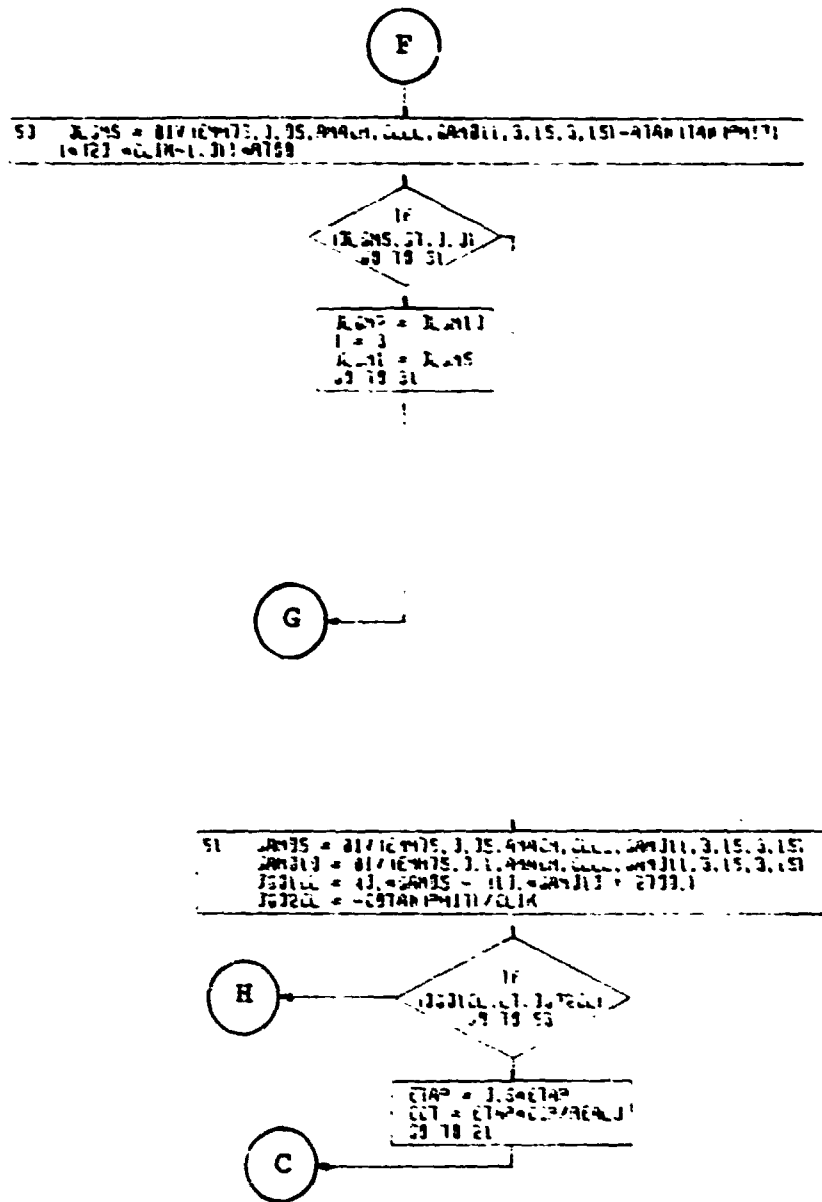


Figure 4-23. THRUST Subroutine Flow Chart (Part 4 of 4).

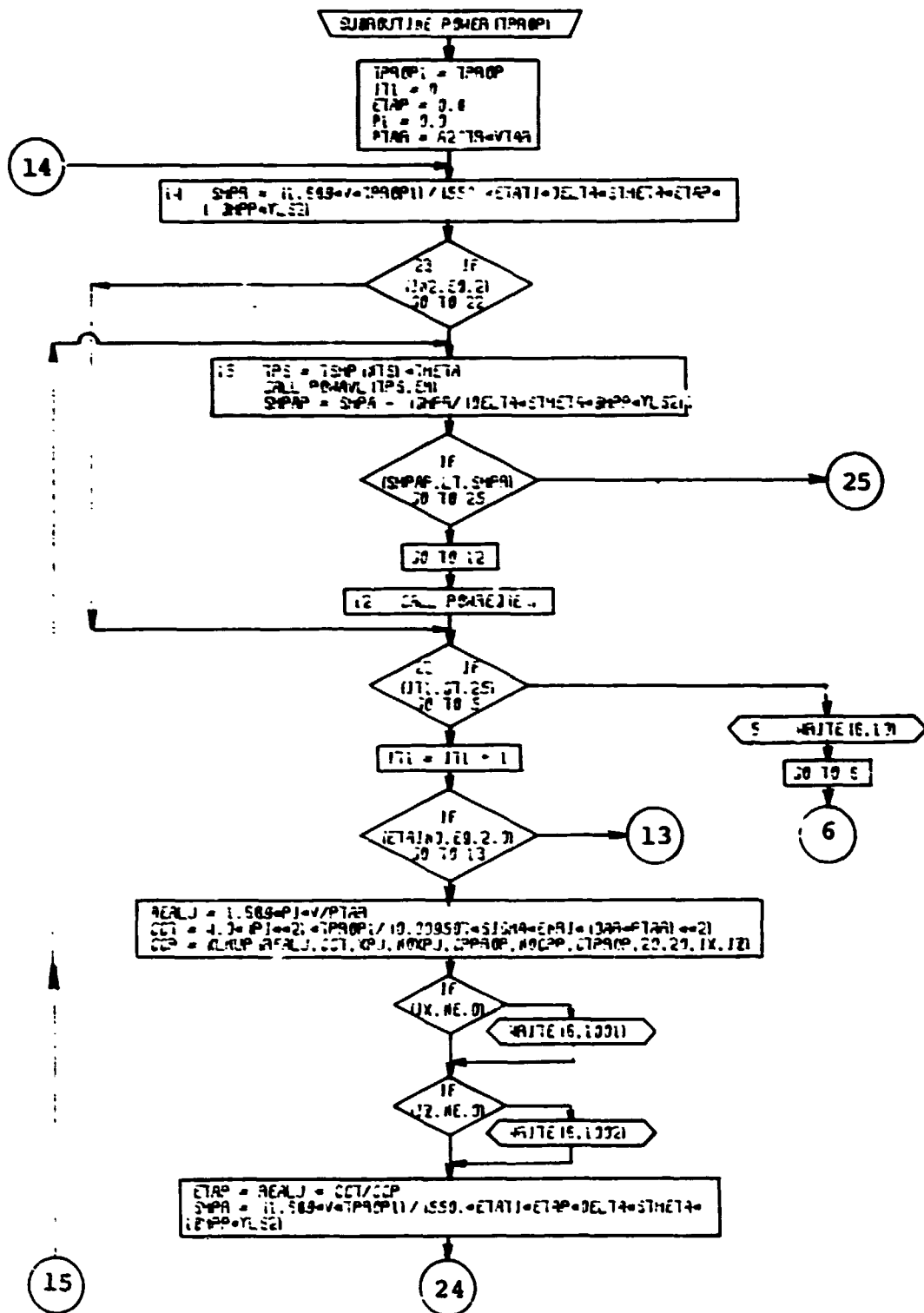


Figure 4-24. POWER Subroutine Flow Chart (Part 1 of 3).

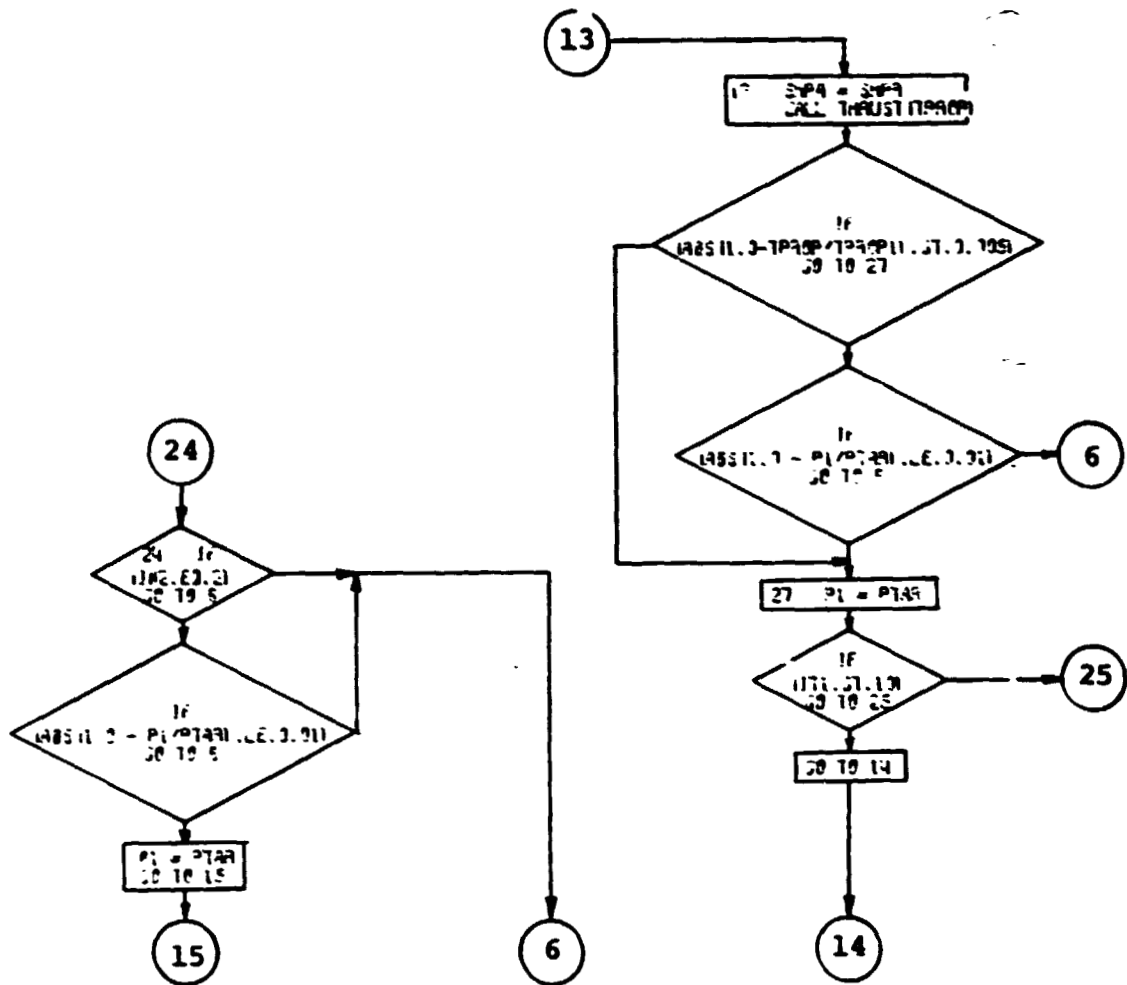


Figure 4-24. POWER Subroutine Flow Chart (Part 2 of 3).

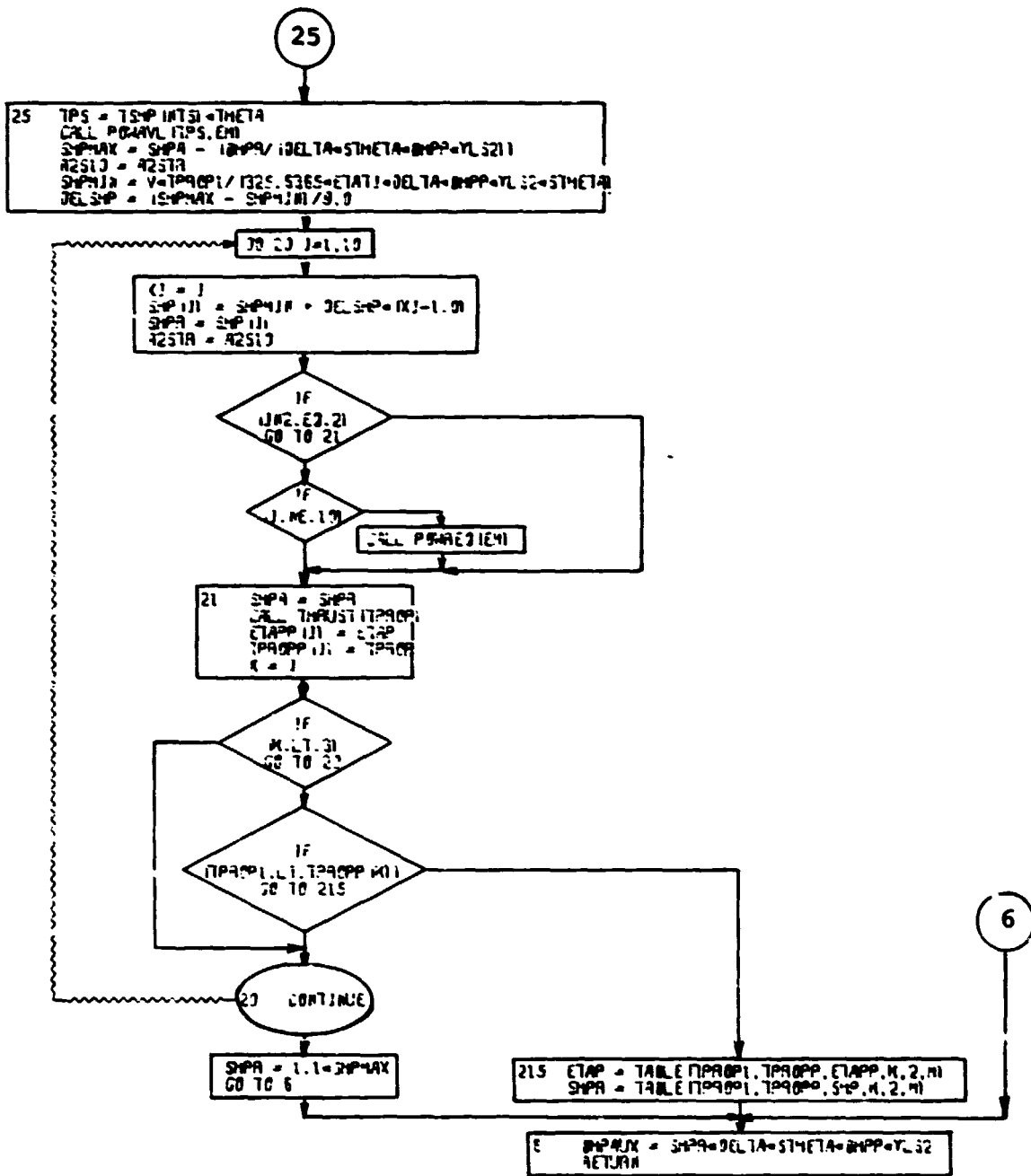


Figure 4-24. POWER Subroutine Flow Chart (Part 3 of 3).

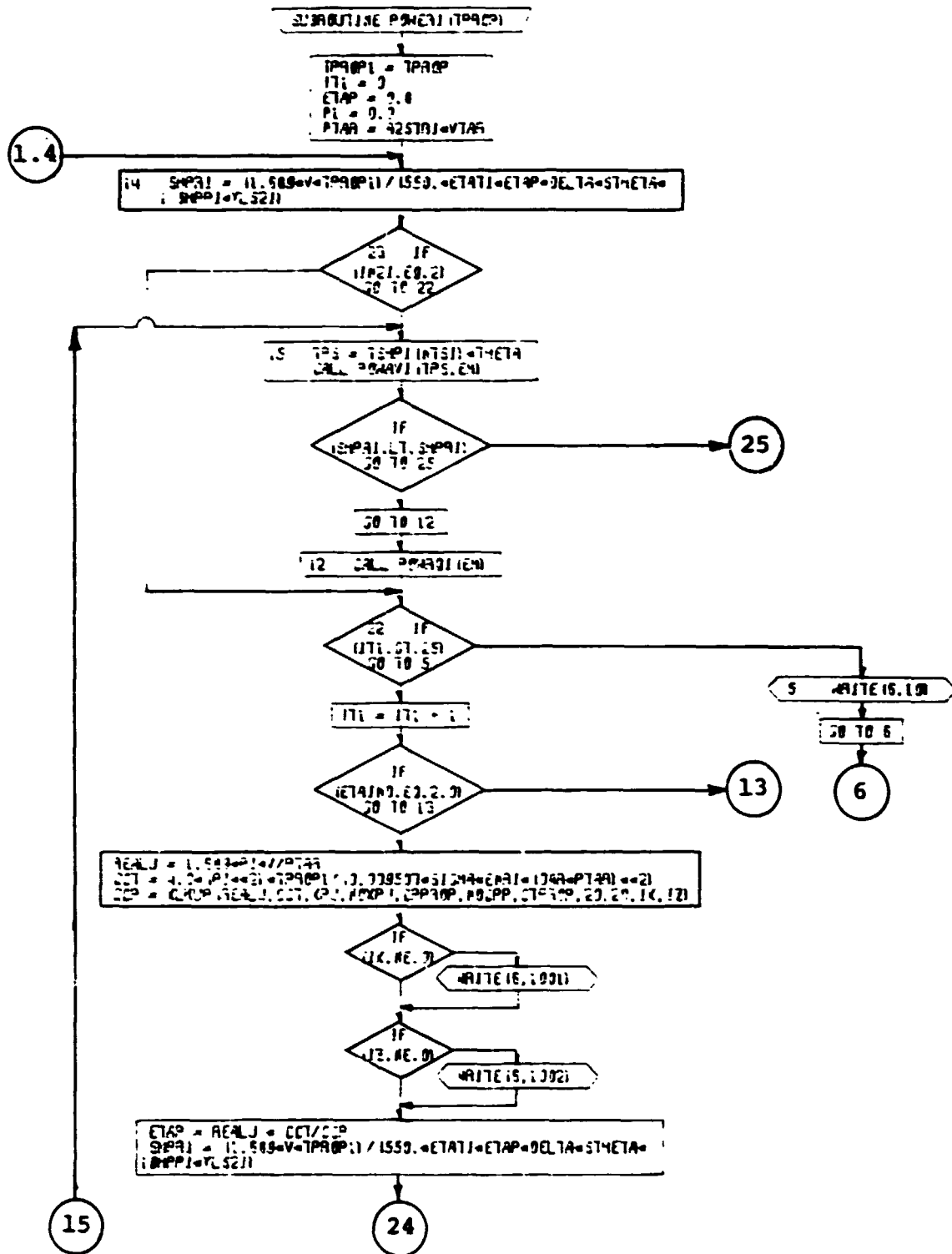


Figure 4-25. POWER1 Subroutine Flow Chart (Part 3 of 3).



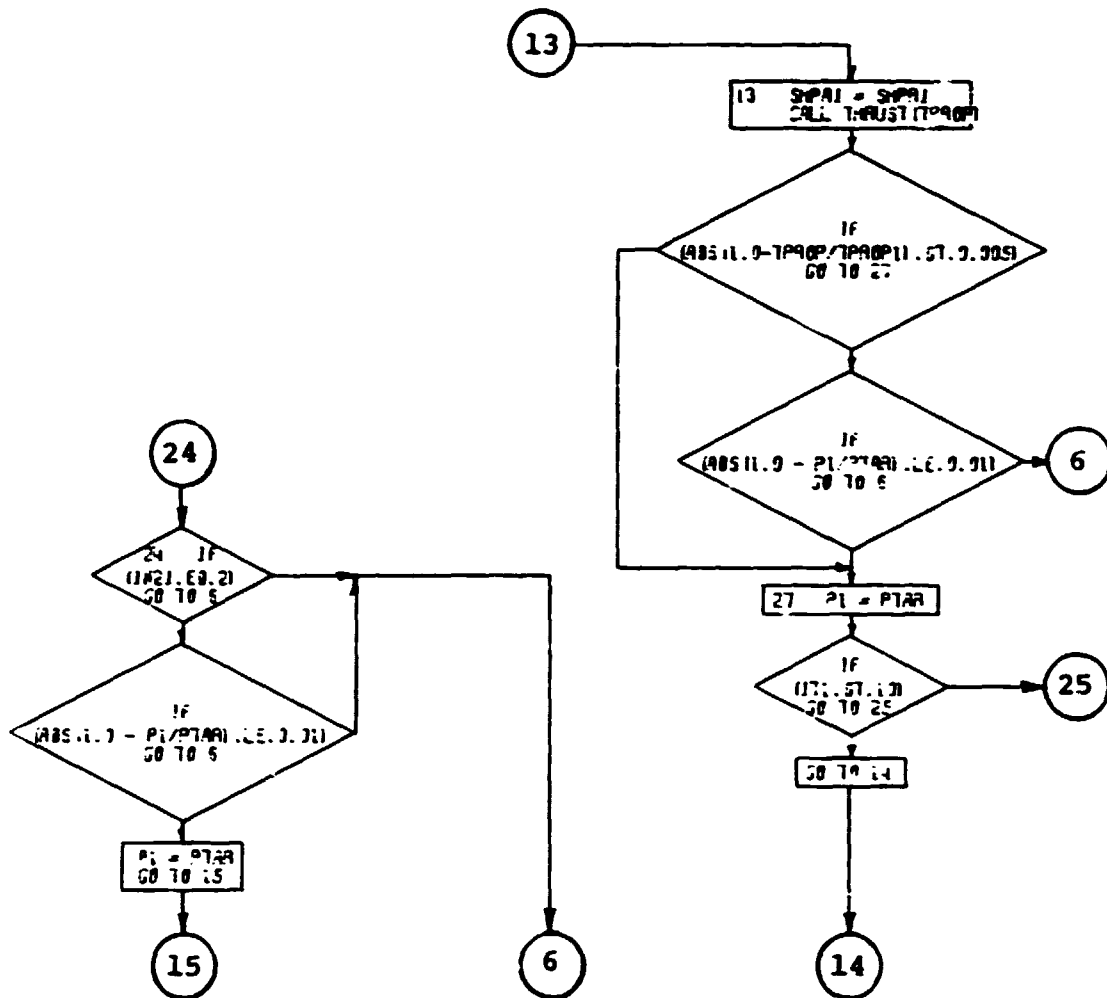


Figure 4-25. POWER1 Subroutine Flow Chart (Part 2 of 3).

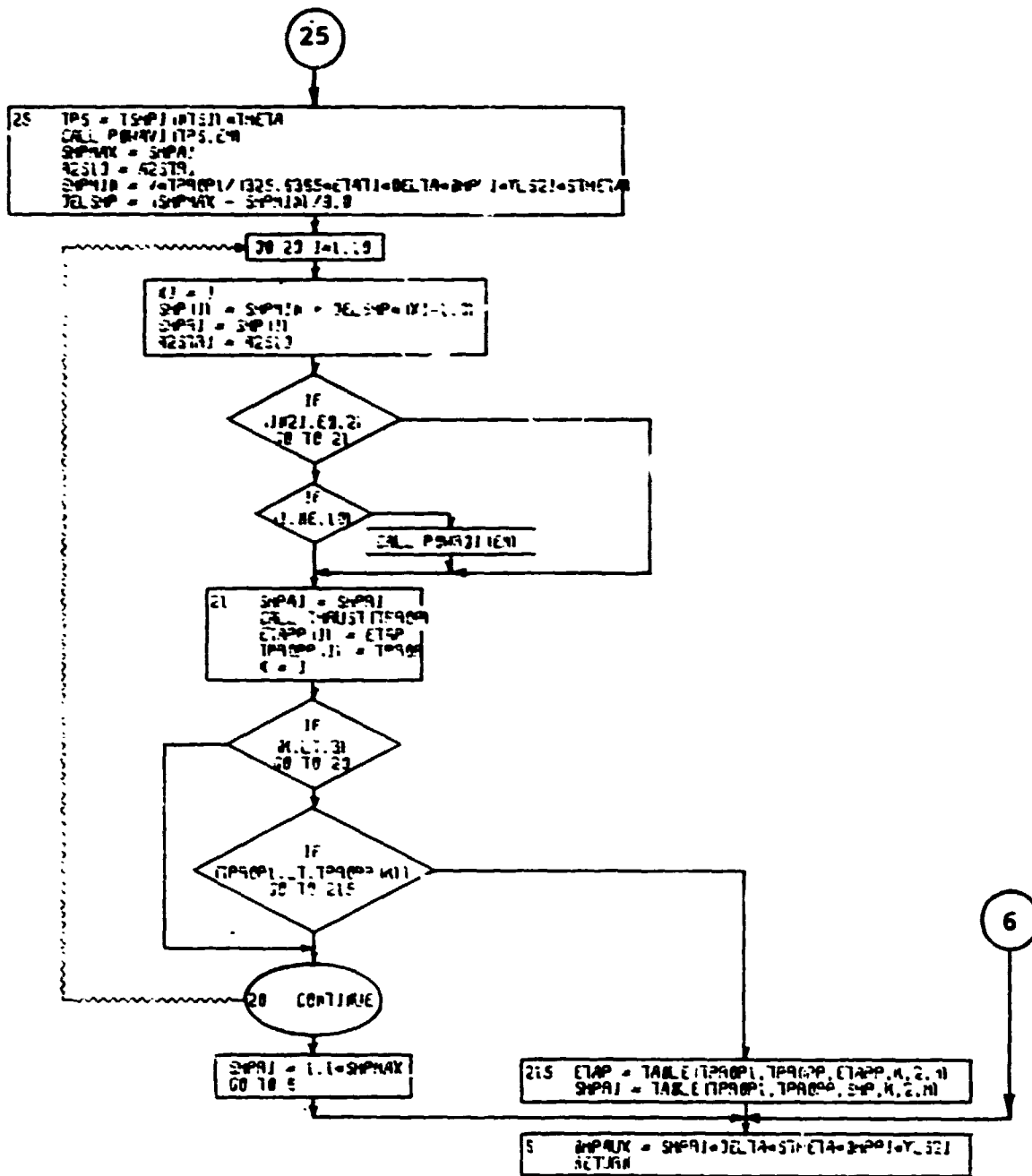


Figure 4-25. POWER1 Subroutine Flow Chart (part 3 of 3).

TABLE 4-3. COEFFICIENTS FOR PROPELLER EQUIVALENT POLARS

CL	COEFFICIENTS FOR CRUISE:															
	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>	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	0.	90.	0	0
.05		7.0392	1.9949	61.2416		10.2148	2.4433	86.4731		11.3227	2.4433	86.4731		11.3227	2.4433	86.4731
.10		4.8350	-4.1639	19.2195		8.3106	-22.6338	56.0		11.3355	-22.6338	56.0		11.3355	-22.6338	56.0
.15		3.2218	-1.7030	8.291		5.4623	-14.9997	35.3636		8.3676	-14.9997	35.3636		8.3676	-14.9997	35.3636
.20		2.7551	-2.5322	7.0366		4.0458	-9.9837	23.0606		6.5856	-9.9837	23.0606		6.5856	-9.9837	23.0606
.3		2.481	-4.5422	7.3774		3.9439	-13.0524	22.0028		5.3862	-13.0524	22.0028		5.3862	-13.0524	22.0028
.4		2.4521	-5.4949	7.4251		3.6769	-11.7146	17.3803		5.2054	-11.7146	17.3803		5.2054	-11.7146	17.3803
.5		2.8149	-7.092	8.3407		3.8766	-12.0044	16.0882		6.1902	-12.0044	16.0882		6.1902	-12.0044	16.0882
.6		3.8725	-10.861	11.467		4.5901	-13.8756	17.2451		8.153	-13.8756	17.2451		8.153	-13.8756	17.2451
.7		5.6653	-16.2691	15.8095		6.1044	-18.2607	21.8349		10.1745	-18.2607	21.8349		10.1745	-18.2607	21.8349
.8		8.5799	-24.8115	22.6773		8.9031	-26.0958	30.7056		13.0822	-26.0958	30.7056		13.0822	-26.0958	30.7056
.9		12.25	-33.6185	28.7271		12.2042	-29.4588	34.1515		16.5344	-29.4588	34.1515		16.5344	-29.4588	34.1515
1.0		17.0496	-43.061	33.8798		17.0398	-37.3809	43.697		20.8089	-37.3809	43.697		20.8089	-37.3809	43.697
1.1		21.8332	-47.8821	33.6322		22.784	-47.3791	55.5455		25.6453	-47.3791	55.5455		25.6453	-47.3791	55.5455
1.2		31.7062	-49.6246	26.4923		28.7851	-57.8217	68.2121		33.5049	-57.8217	68.2121		33.5049	-57.8217	68.2121

#### 4.8 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 4-29 displays a flow chart showing the options available within the size trends subroutine.

The first of these is the option which determines main rotor diameter and solidity. It is possible to input diameter and solidity directly, or combinations of disc loading, design  $C_T/\sigma$ , diameter, and solidity. The following choices, specified by the main rotor sizing indicator, RDMIND, are available:

<u>RDMIND</u>	<u>INPUT</u>
1	Diameter and solidity
2	Disc loading and solidity
3	Diameter and $C_T/\sigma$
4	Disc loading and $C_T/\sigma$

If main rotor solidity is calculated, the program will choose the solidity satisfying the most critical of the three groups of requirements specified by input locations 0182 - 0190. These solidity sizing requirements are:

- (a) Solidity sized for hover conditions (Input  $(C_T/\sigma)_H$ , T/W)
- (b) Solidity sized for maneuver conditions (Input cruise speed, atmospheric conditions, maneuver  $C_T/\sigma$ , and rotor g loading)
- (c) Solidity sized for cruise conditions (Input cruise speed, atmospheric conditions, cruise  $C_T/\sigma$ , and rotor loading (N))

If so desired, the user may dictate which of these solidity choices the program makes simply by manipulating the inputs. For example:

If the solidity  
sizing choice  
desired is:

Then input:

Hover

Desired value for  $(C_T/\sigma)_H$ ,  $(C_T/\sigma)_{CR} =$   
1.0,  $g_{ROTOR} = .001$ ,  $N(\text{Rotor Loading}) =$   
0.1

Maneuver  $(C_T/\sigma)_H = 1.0$ , Desired values for  $(C_T/\sigma)_{CR}$   
and  $g_{ROTOR}$ ,  $N(\text{Rotor Loading}) = 0.1$

Cruise  $(C_T/\sigma)_H = 1.0$ , Desired value of  $(C_T/\sigma)_{CR}$ ,  
 $G_{ROTOR} = 0.001$ , Desired value of  $N(\text{Rotor Loading})$

As noted earlier, two basic types, the single and tandem rotor helicopter, can be sized using this program. The following (beginning with the single rotor helicopter) provides a brief description of the options available to the user.

Tail rotor diameter may be input directly, or calculated. The choices open to the user are:

TRDIND

- 0 No tail rotor used on this configuration
- 1 Tail rotor diameter calculated using a trend
- 2 Tail rotor diameter input directly
- 3 Tail rotor diameter calculated based on an input tail rotor disc loading

TRDIND = 0 signifies a single rotor helicopter without a tail rotor (e.g., a coaxial rotor, or a single rotor configuration employing main rotor torque cancellation by means other than a tail rotor or fan).

The tail rotor diameter trend used when TRDIND = 1 is illustrated in Figure 4-26 (see also Reference 6). The tail rotor disc loading input when TRDIND = 3 does not include vertical fin sideload losses.

Tail rotor solidity may be input directly or calculated. If calculated (TRDIND = 2), the tail rotor solidity is determined by either hover-antitorque requirements or hovering-turn requirements (including tail rotor precession effects, see References 5 and 6). The former is obtained by setting  $\dot{\psi}$  (yaw rate) and  $\ddot{\psi}$  (yaw acceleration) equal to zero.

Yaw moment inertia ( $I_{ZZ}$ ) is required in calculating the tail rotor solidity for the single rotor helicopter in a hovering turn. The following equation is included in the size trends subroutine to determine the aircraft yaw inertia.

$$I_{ZZ} = \frac{W}{32.2} (0.115K_{ZZZ} e)^2$$

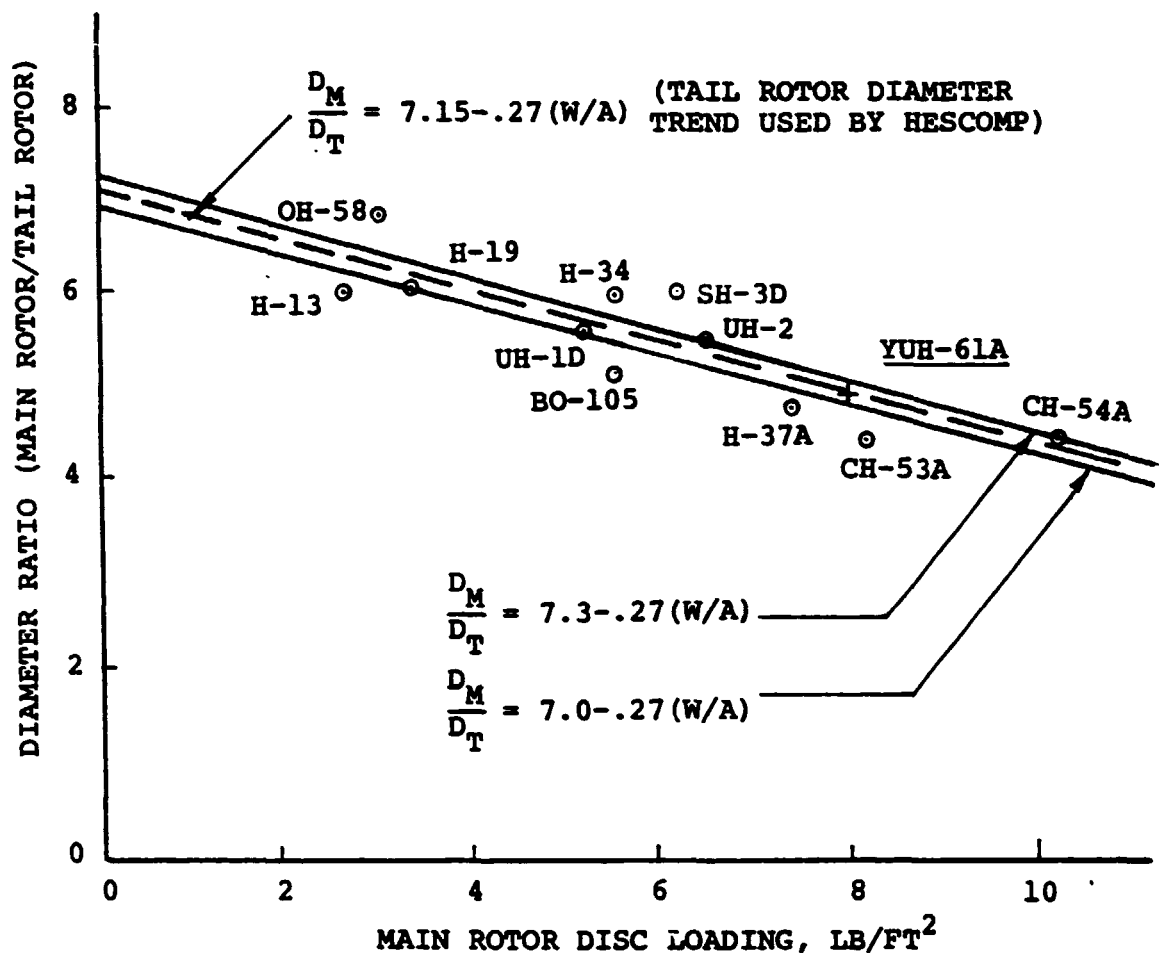


Figure 4-26. Tail Rotor Diameter Sizing Trend.

Where  $I_{ZZ}$  = Yaw moment of inertia, slug ft<sup>2</sup>

$W$  = Aircraft design gross weight, lb

$K_{ZZZ}$  = Inertia adjusting factor (nominally = 1.0)

$e$  = The combined sum of the study aircraft fuselage length and the cabin length measured from the nose of the aircraft to the end of the cabin.

0.115 = Trend constant for determining the single rotor helicopter yaw moments of inertia.

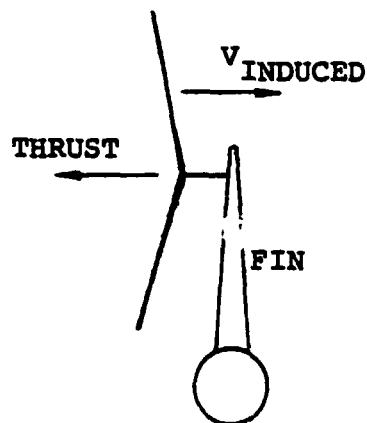
To modify the equation inertia value, enter a fractional input in the  $K_{ZZZ}$  block (LOC 0213) (entering 1.1 will increase the 0.115 constant by 10 percent, entering 0.9 will decrease it by 10 percent, etc.)

$K_{TRS}$  (LOC 0215) is tail rotor solidity multiplicative factor.

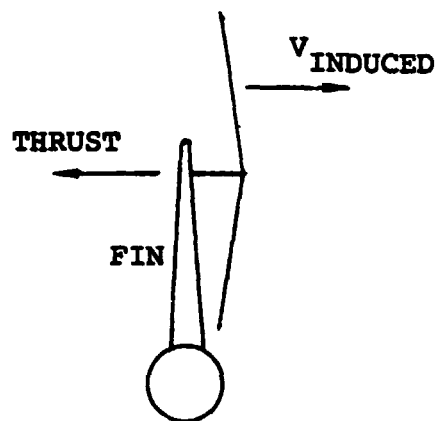
It should be noted that the tail rotor gross/net thrust ratio ( $C_{TG}/C_{TNET}$ ) may either be input directly or calculated. In

the latter instance,  $C_{TG}/C_{TNET}$  is set equal to 1.00 and a

value of the induced velocity ratio ( $\bar{C}$ ) is input. Figure 4-27 illustrates typical values of  $\bar{C}$  for both tractor and pusher tail rotor (see sketch below).



Tractor Tail Rotor



Pusher Tail Rotor

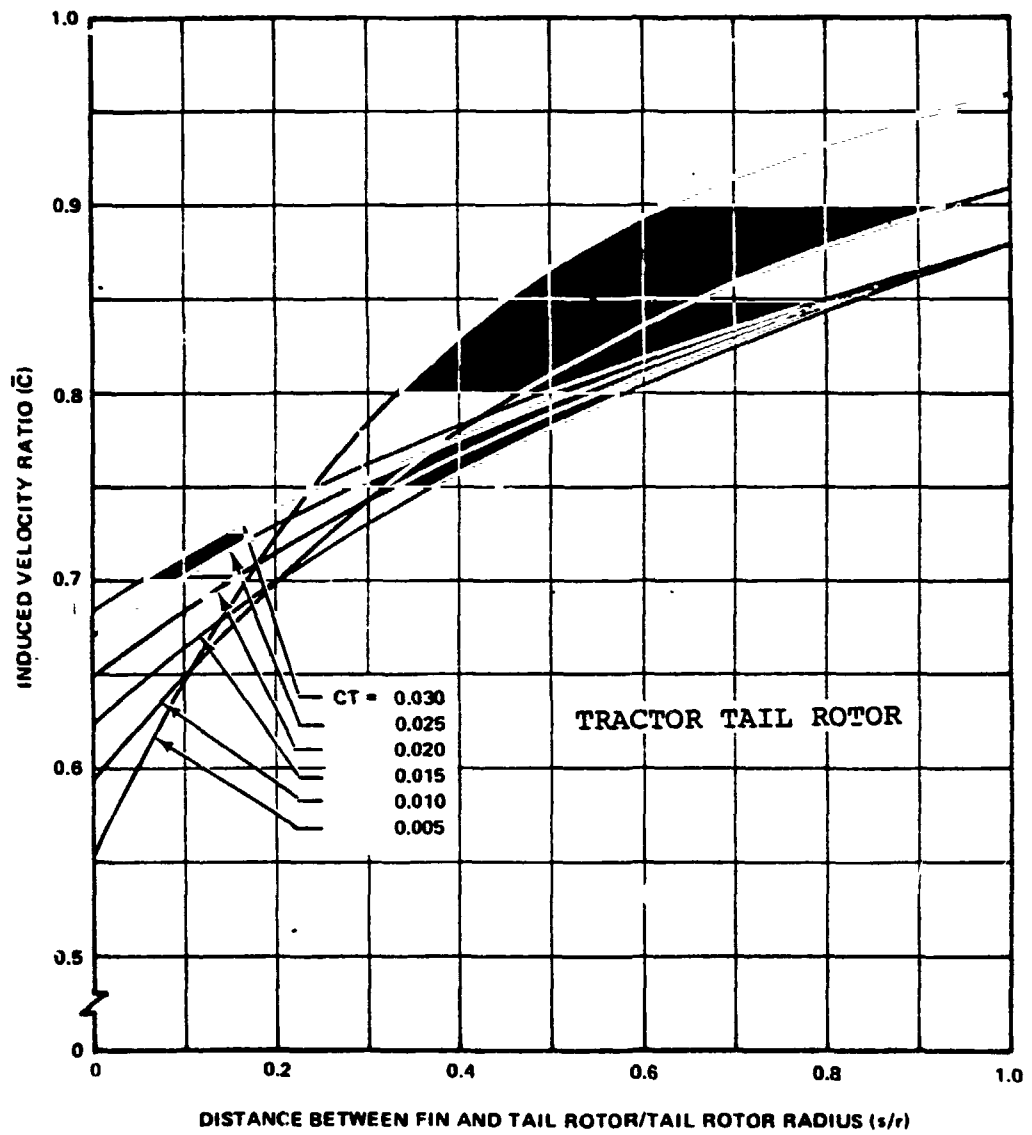


Figure 4-27. Tail Rotor/Vertical Tail Fin Interference Data (Part 1 of 2).



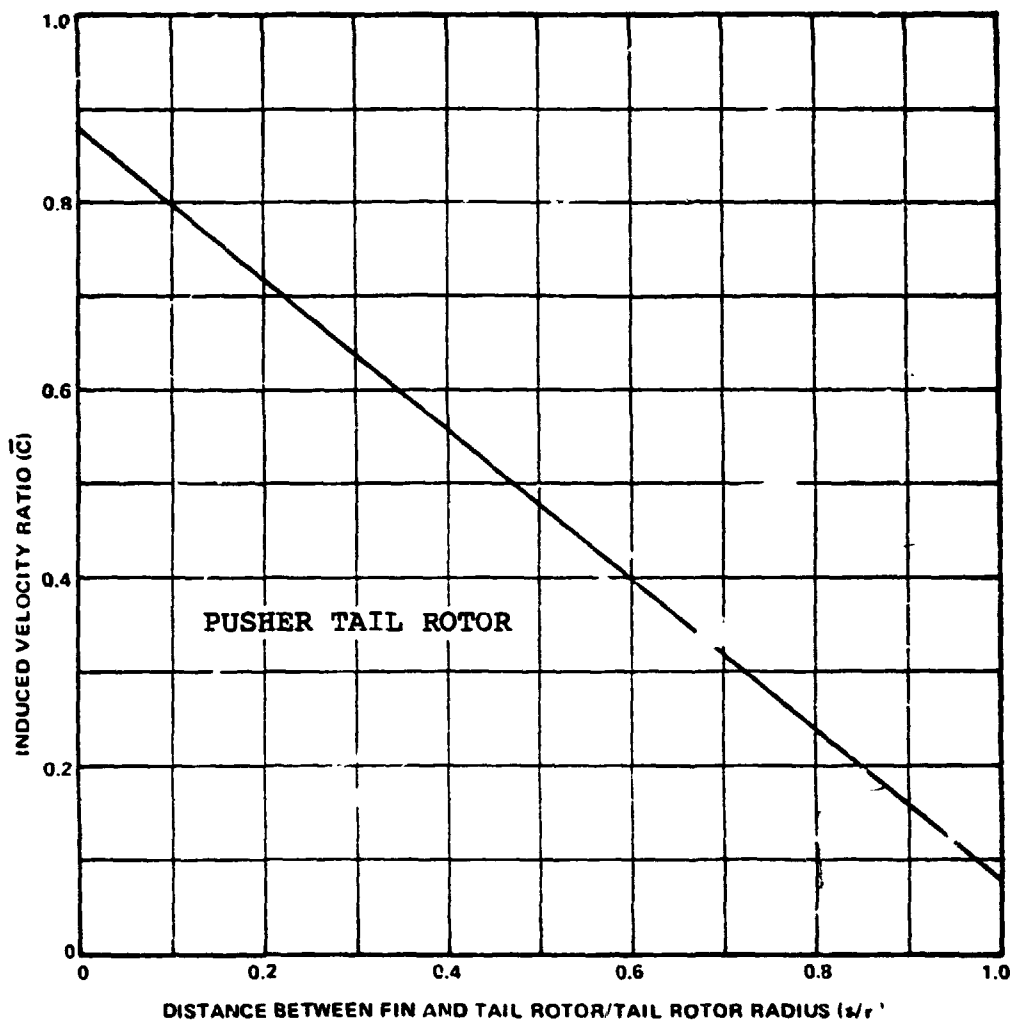


Figure 4-17. Tail Rotor/(Pusher Tail Rotor) Vertical Tail Fin Interference Data (Part 2 of 2).

Note the difference in variations of  $\bar{C}$  for the two different configurations. At low tail fin/rotor separation distances, the "tractor" values of  $\bar{C}$  are sensitive to variations in tail rotor  $C_T$ . Thus, the closer the tractor tail rotor is located to the fin, the larger the error (admittedly small to begin with) involved in calculating  $C_{T_G}/C_{T_N}$ , since the user must "guess" what tail rotor  $C_T$  to use in selecting  $\bar{C}$ . The "pusher"  $\bar{C}$  on the other hand is a function only of the fin/tail rotor separation distance.

In any event, use of this option is desirable in that tail rotor/fin sideload losses are matched to the vertical tail area calculated in the sizing process. Detailed explanations of all the factors involved in tail rotor design and sizing are contained in References 5 and 6.

Representation of a single rotor helicopter utilizing a "Fenestron" shrouded tail rotor/fan is provided by the use of inputs  $D_{TRE}/D_{FAN}$  (LOC 0282),  $FANOP_H$  (LOC 0283), and  $FANOP_C$  (LOC 0284).

Such shrouded tail rotor/fans can provide the same thrust as a larger diameter unshrouded rotor for a given power input. This is achieved by "sharing" the total tail rotor thrust requirement between the rotor and the shroud, the fractional split ( $T_{SHROUD}/T_{TOTAL}$ ) depending on such factors as shroud length/fan diameter, duct inlet lip shape, etc. The ratio of the equivalent diameter unshrouded rotor to the shrouded rotor/fan diameter can be related to the rotor/shroud thrust split by the following relationship:

$$D_{TRE}/D_{FAN} = \sqrt{\frac{1}{1 - \frac{T_{SHROUD}}{T_{TOTAL}}}}$$

Typical values of  $T_{SHROUD}/T_{TOTAL}$  range from .3 to .5 (resulting in values of  $D_{TRE}/D_{FAN} = 1.2 - 1.4$ ).

Setting  $FANOP_H$  or  $FANOP_C$  equal to 1.0, allows representation of tail rotor/fan shutdown in hover and cruise flight respectively.

The vertical tail size may be determined in three ways. If VTFIND = 1, aspect ratio and tail fin/tail rotor overlap is input. If VTFIND = 2, tail fin/tail rotor overlap and configuration directional stability requirements are input. If VTFIND = 3, the input is the same as with VTFIND = 2, with the exception that  $AR_{VT}$  is specified instead of tail rotor/fin overlap. These latter two options are important in that they allow the user to size the vertical tail to meet cruise anti-torque requirements at specified conditions ( $C_{L_{Des}}$ ,  $V_{Des}$ ) in the event of tail rotor loss. It should be noted that  $C_{L_{Des}}$  is assumed to represent the total lift coefficient developed by a conventional tail fin in sideslip, or a tail fin with a variable camber device (i.e., a rudder or flap) deployable under these circumstances.

The horizontal tail size is an input and must be specified as planform area  $S_{HT}$  (option HTIND = 1) or tail volume  $\bar{V}_H$  (option HTIND = 2) defined as follows:

$$\bar{V}_H = \frac{16 l_{TH} S_{HT}}{\pi 2 D_{MR}^3}$$

Where:  $l_{TH}$  = distance from the main rotor hub to the aerodynamic center of the horizontal tail - ft

$D_{MR}$  = main rotor diameter - ft

The horizontal tail is designed to achieve angle of attack as well as speed stability of the helicopter. The planform area required to achieve an acceptable longitudinal stability level is a function of the design gross weight, type of rotor system, tail rotor cant angle and tail moment arm as illustrated by the sizing trends for current helicopters presented in Figure 4-28. These trends represent a design criteria of approximately neutral static longitudinal stability at  $\mu > .2$ . As illustrated in this figure, aircraft with hingeless or articulated rotor systems require larger tail areas than aircraft with teetering rotors due to the larger destabilizing hub moment associated with locating the flapping hinge outboard of the center of rotation. The largest tail size is required for configurations employing canted tail rotors because of their large aft c.g. range.

For preliminary design studies, the sizing trends shown in Figure 4-28 can be used to define the inputs  $S_{HT}$  or  $\bar{V}_H$ ; however an estimate of design gross weight and moment arm is required. As noted in Table 4-4, the ratio  $l_{TH}/R_{MR}$  for current helicopters is on the order of 1.0 to 1.2. The main rotor radius ( $R_{MR}$ ) can be defined from gross weight and disk loading estimates.

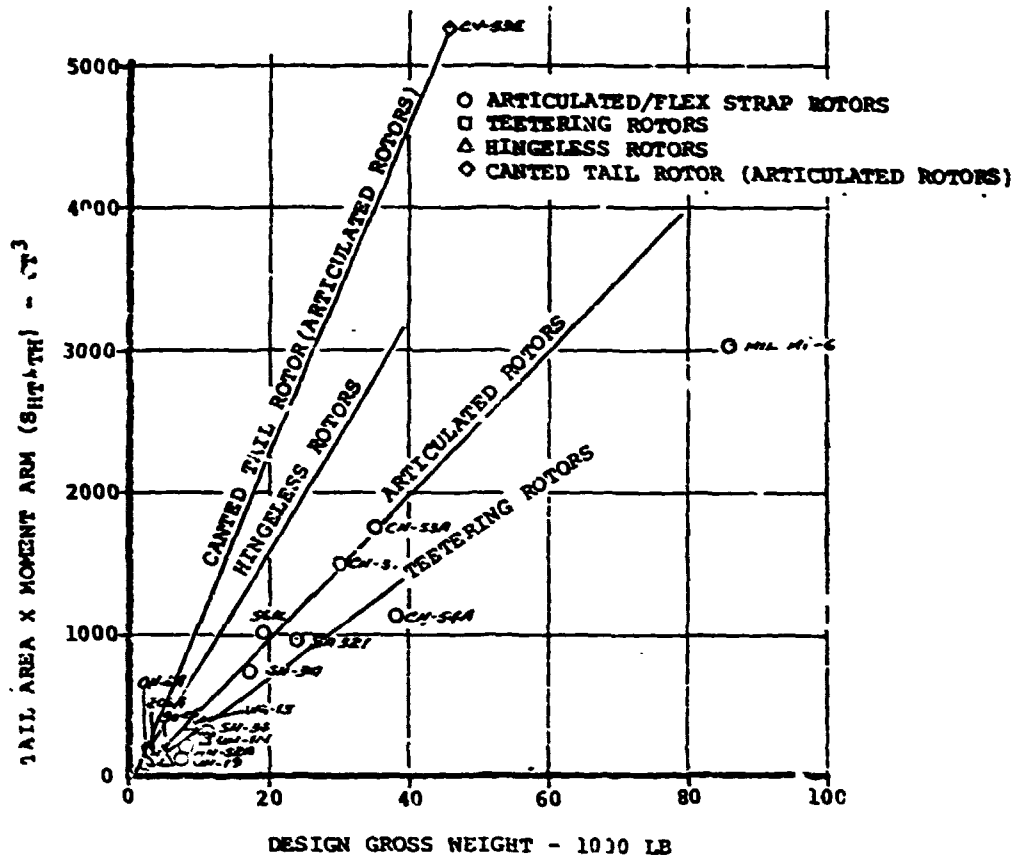


Figure 4-28. Horizontal Tail Sizing.

TABLE 1-4. PRODUCTION HELICOPTER HORIZONTAL TAIL PARAMETERS.

TYPE OF ROTOR	AIRCRAFT	DESIGN GROSS WEIGHT-LB	MAIN ROTOR DIAMETER-FT	TAIL AREA - FT <sup>2</sup>	L <sub>T</sub> /R <sub>MR</sub>
ARTICULATED & FLEXSTRAP	OH-6A	2200	26.3	6.7	1.09
	UH-19	7200	53	4.5	1.09
	HH-52A	7900	53	7.2	1.17
	SH-34	11000	56	10.7	1.01
	SH-3A	17000	62	20	1.21
	S-61L	19000	62	27	1.21
	SA321	24000	62	25.5	1.23
	CH-37	30000	72	34.2	1.22
	CH-53A	35000	72	40	1.22
	CH-54A	38000	72	26	1.22
	MIL Mi-6	86000	114.8	53	1.0
HINGELESS	BO-105	5070	32.2	8.6	.93
	NG-12	9520	42	12	1.23
ARTICULATED WITH CANTED TAIL ROTOR	CH-53E	46000	79	121	1.10
TEETERING	206A	3000	33.3	9.4	.75
	UH-1H	10000	48	23.5	.70

For detailed design studies, further analyses of aircraft longitudinal stability is required prior to finalizing the tail design. This is particularly true for winged and compound helicopters where wing and auxiliary propulsion effects must be considered.

Forward rotor pylon dimensions are specified directly (input LOCS 0152 - 0156).

The computer program calculates the length and wetted area of the fuselage based upon input values of cabin length, cabin mean diameter, fineness ratios of the pilots section and tail section, and calculated tail boom dimensions. The tail boom length is established by the tail rotor diameter, the need to maintain a reasonable gap between the main and tail rotor discs and the relative position of the main rotor on the fuselage. This position ( $X_m/l_B$  - LOC 0128) may either be input (MRPIND = 0) or calculated (MRPIND = 1, 2), using a simple weight-balance subroutine. If MRPIND = 1, the program calculates main rotor positions based on simple mass balance. The relative positions (from the aircraft nose) of the various aircraft components (engines, primary drive system, etc.), must be input (LOCS 2678-2696). If MRPIND = 2, the program calculates main rotor positions based on simple mass balance as in MRPIND = 1, except for the case of a compound helicopter, the auxiliary drive system, propeller and auxiliary independent engines are assumed to be located on the wing. Additional increments of fuselage wetted area (to account for miscellaneous bulges, fairings, etc.) may be input through the use of  $\Delta S_{wet}/S_F$  (LOC 0120) and  $\Delta S_{wet}$  (LOC 0121).

A single rotor helicopter without a tail rotor (e.g., a coaxial rotor) may be sized by setting TRDIND = 0. In this case, fuselage dimensions are input as before, with the exception of the tail boom. Tail boom length is determined by the relative position of the main rotor on the fuselage and the horizontal distance between the tip of the tail boom and the main rotor disc. This distance is input in the location (LOC 0214) used for specifying the main/tail rotor disc gap for conventional single rotor helicopters. Note that this dimension can be either positive or negative, the latter defining a configuration where the empennage carried by the tail boom lies under the main rotor disc. In addition, VTFIND (LOC 0017) must be input as 1, vertical tail area being calculated from input values of  $AR_{VT}$  (LOC 0135) and vertical tail span (when TRDIND = 0, vertical tail span (in feet) is input in LOC 0139 ( $K_2$ )).

Three options are available for sizing a tandem rotor helicopter fuselage. These options, specified by the indicator **FDMIND**, are:

<u>FDMIND</u>	<u>Input</u>	<u>Calculated</u>
1	((O/L)/D), forward aft rotor positions	fuselage length ( $l_F$ )
2	((O/L)/D), cabin length ( $l_C$ )	fuselage length ( $l_F$ ) forward & aft rotor positions
3	cabin length ( $l_C$ ), forward and aft rotor positions	((O/L)/D), fuselage length ( $l_F$ )

In cases (**FDMIND** = 1) where the calculated cabin length is less than zero, an error statement is printed and the case terminated. Likewise, if the rotor overlap/diameter ratio exceeds either +0.5 or -0.5, the case is terminated.

The aft rotor pylon dimensions may either be input directly (**APHIND** = 1) or calculated (**APHIND** = 2) based on an input of rotor gap/stagger ratio. The forward pylon dimensions are input directly as in the case of the single rotor helicopter.

In the case of a compound helicopter, propeller dimensions and characteristics (i.e., **AF**, blade number,  $C_{L_i}$ , etc.) are input directly.

Wing sizing options are divided into two groups, those for determining wing area (**S<sub>W</sub>IND**) and those for determining wing span (**b<sub>W</sub>IND**). Wing area may either be input directly (**S<sub>W</sub>IND** = 1), calculated based on an input wing loading (**S<sub>W</sub>IND** = 2), or sized to meet a maneuver requirement. In the latter case, the wing size is dictated by the need to carry the difference between the overall g requirement (LOC 0188) and the maneuver g's (LOC 0189) carried by the main rotor(s). Wing span may be determined on the basis of an input wing span/rotor diameter ratio (**b<sub>W</sub>IND** = 1), an input aspect ratio (**bWIND** = 2); or, in the case of a compound helicopter with wing mounted propellers, on the basis of propeller tip/fuselage clearance considerations (**b<sub>W</sub>IND** = 3).

The dimensions of the primary and auxiliary independent engine nacelles are determined by the horsepower or thrust level of the engines. Separate input constants  $z_1$ ,  $z_2$ ,  $z_3$ ,  $z_4$ ,  $z_5$  and  $z_6$  are used to calculate the size of the nacelles.

Primary engine nacelles

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

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

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

Auxiliary independent engine nacelles

$$\text{diameter (ft)} = z_4 \left[ \frac{\text{SHP}^*_i}{N_{p_i}} \right]^{1/2} \quad \text{or} \quad z_4 \left[ \frac{\text{FN}^*}{N_{p_i}} \right]^{1/2}$$

$$\text{length (ft)} = z_5 + z_6 \left[ \frac{\text{SHP}^*_i}{N_{p_i}} \right]^{1/2} \quad \text{or} \quad z_5 + z_6 \left[ \frac{\text{FN}^*}{N_{p_i}} \right]^{1/2}$$

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

Figure 4-29 shows a flow chart of this subroutine.

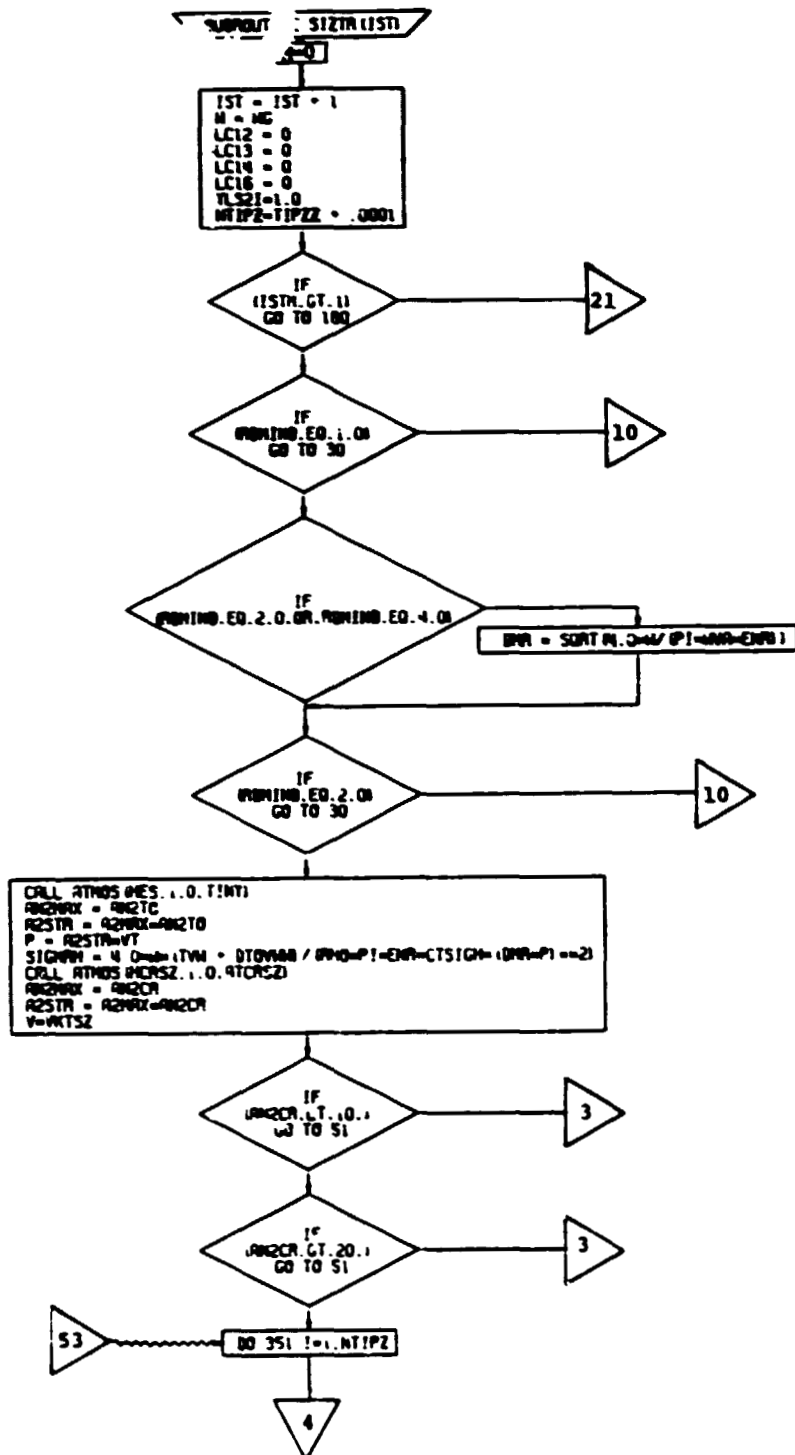


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 1 of 12)



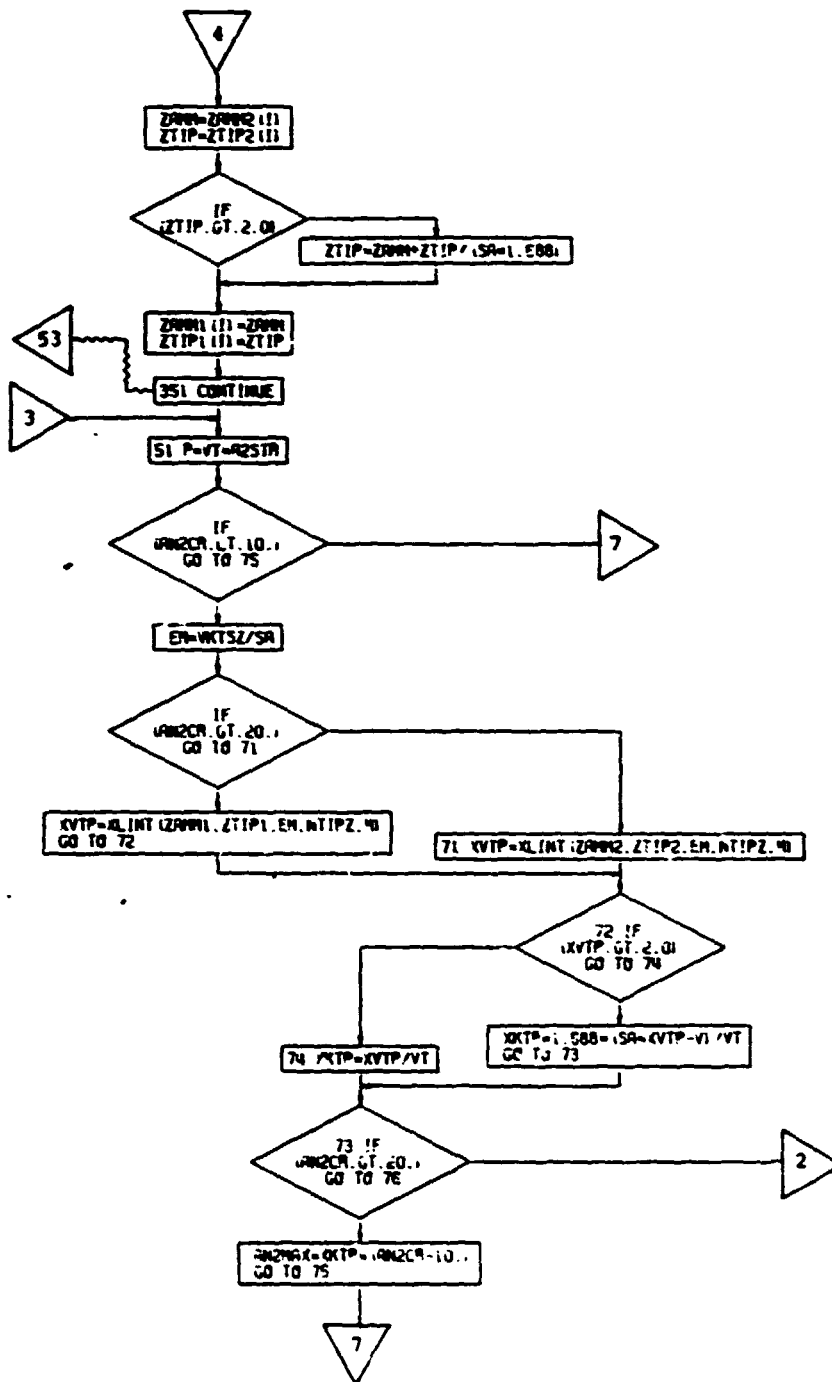


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 2 of 12)

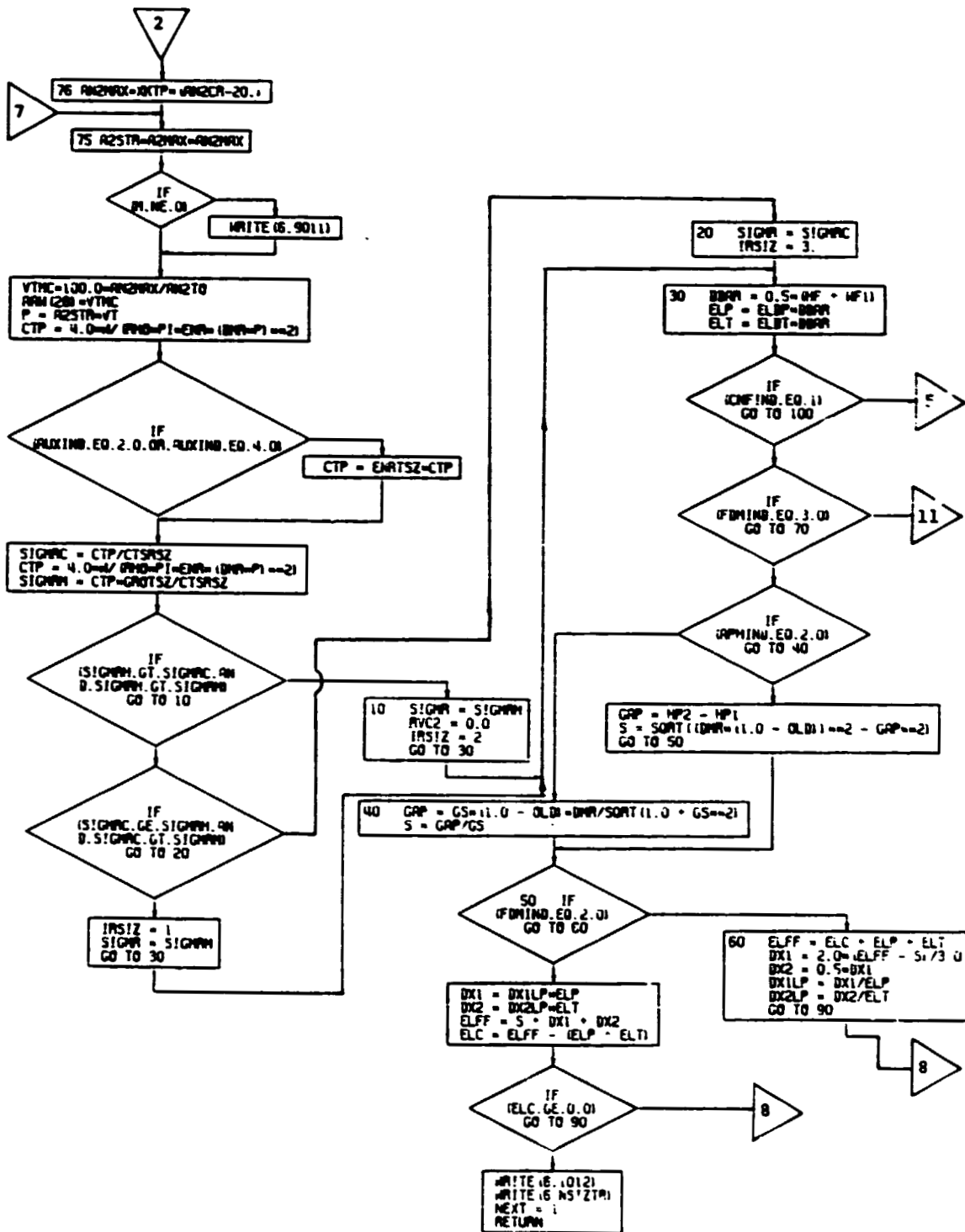


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 3 of 12)

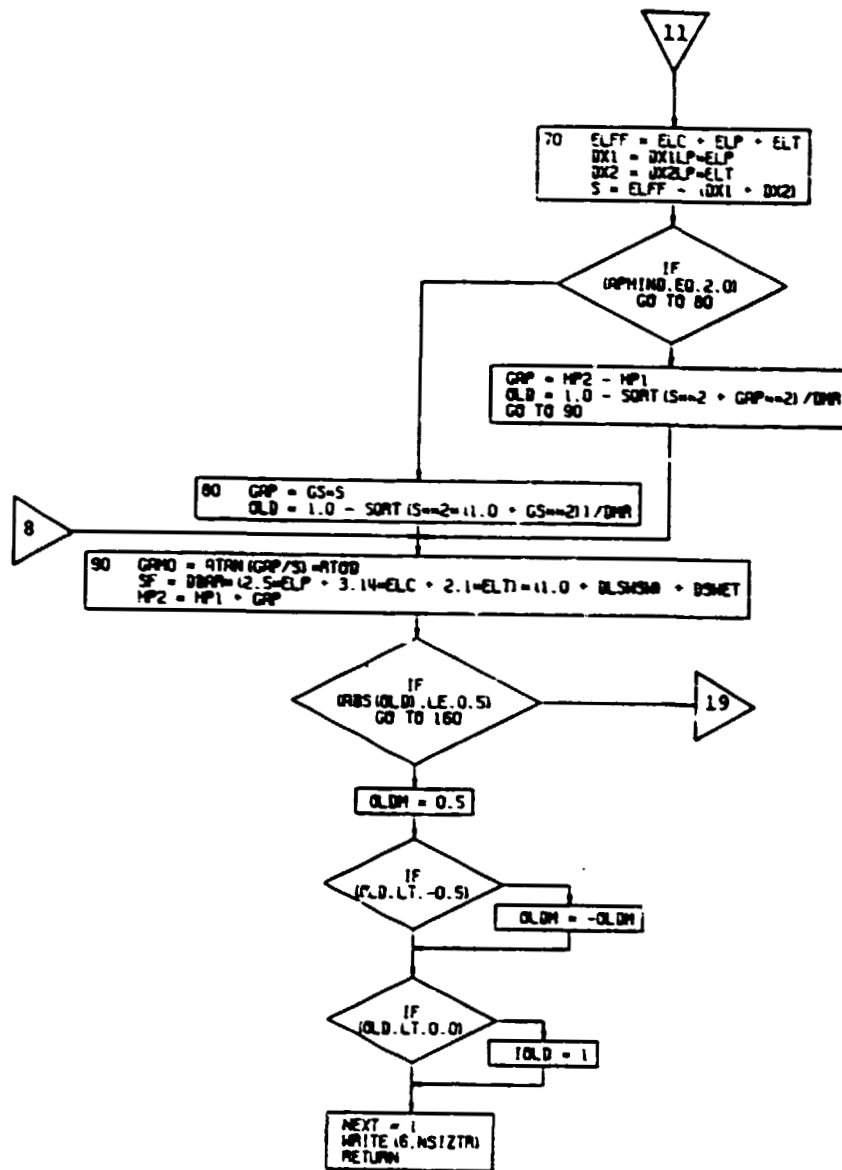


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 4 of 12)

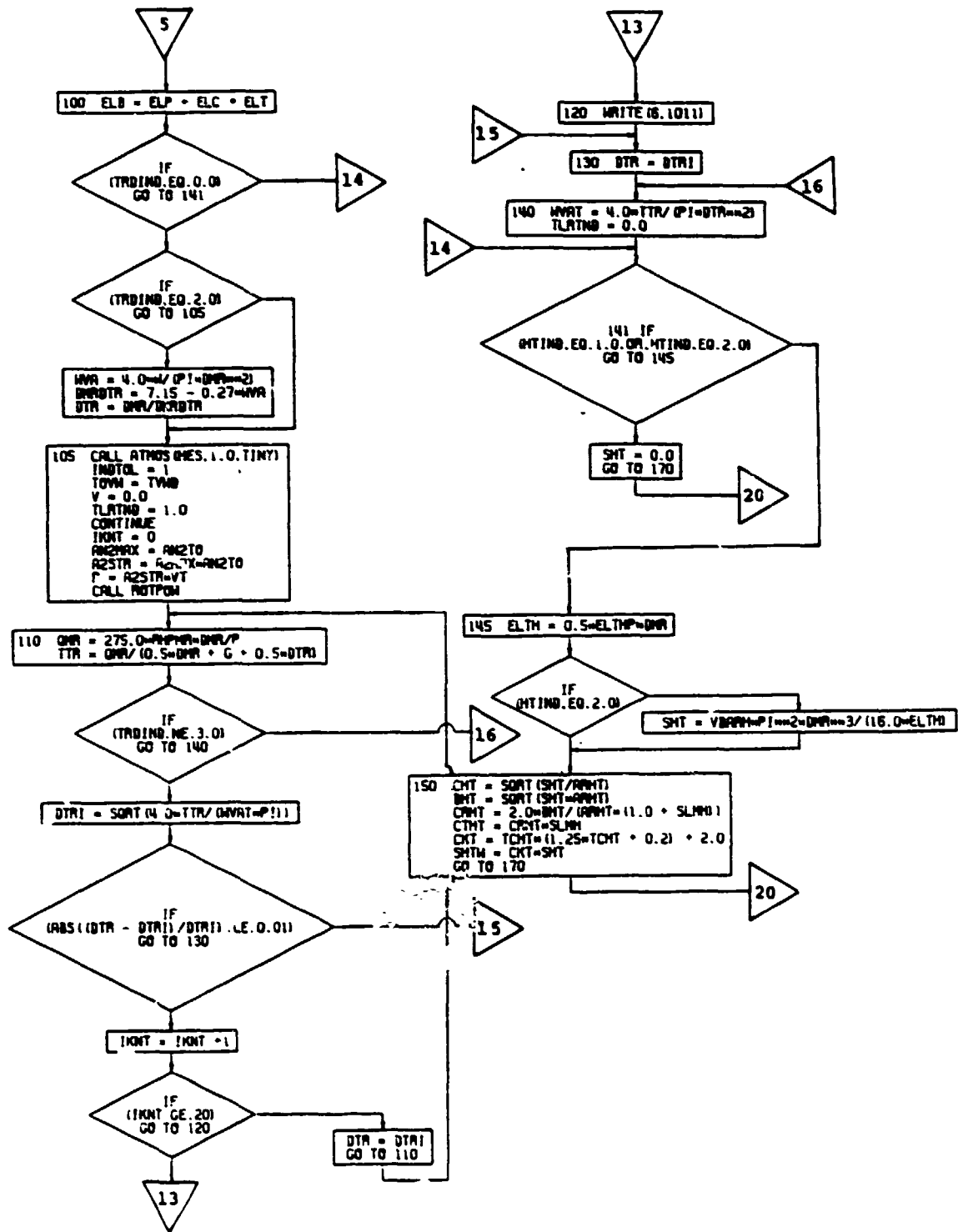


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 5 of 12)

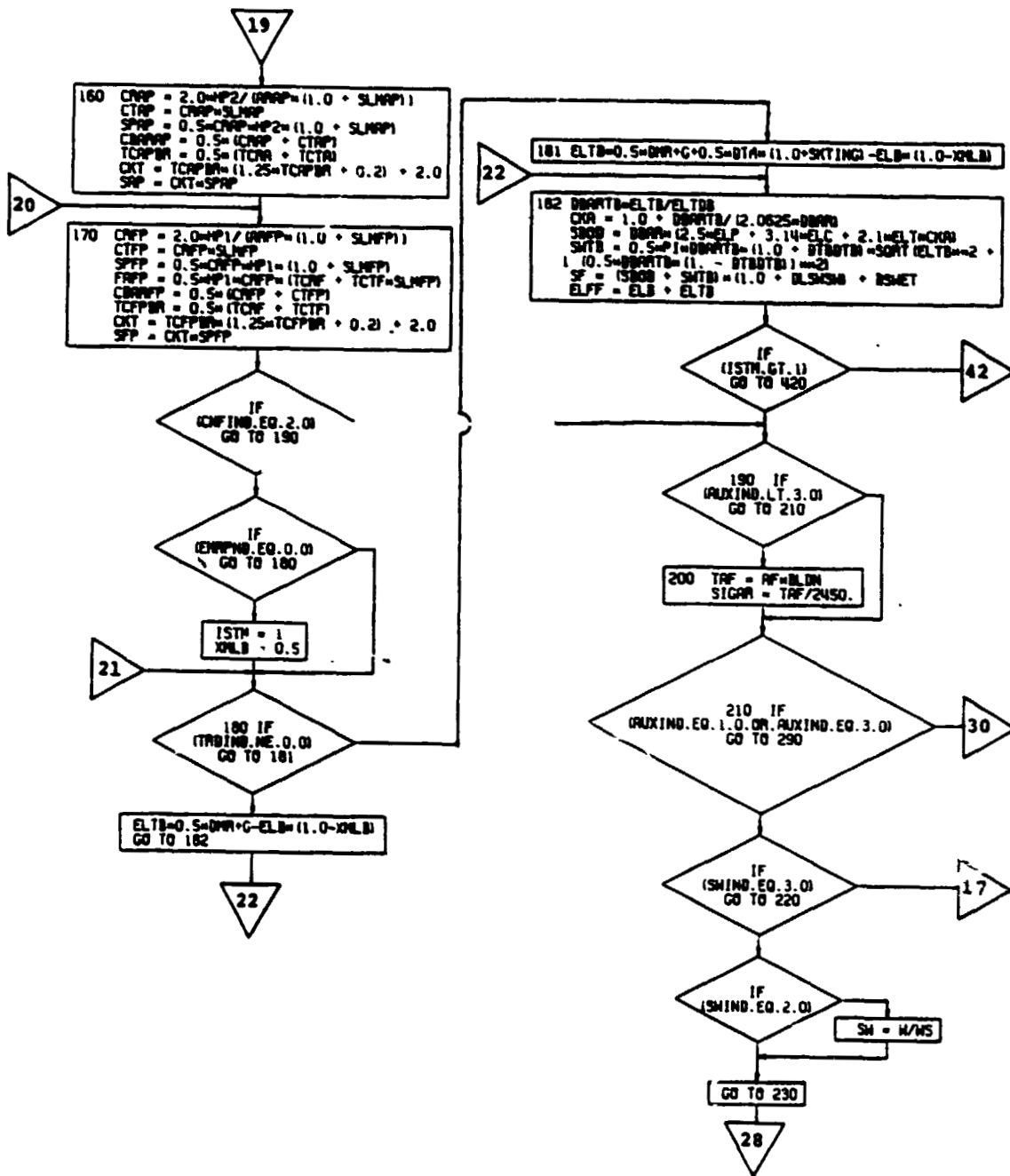


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 6 of 12)

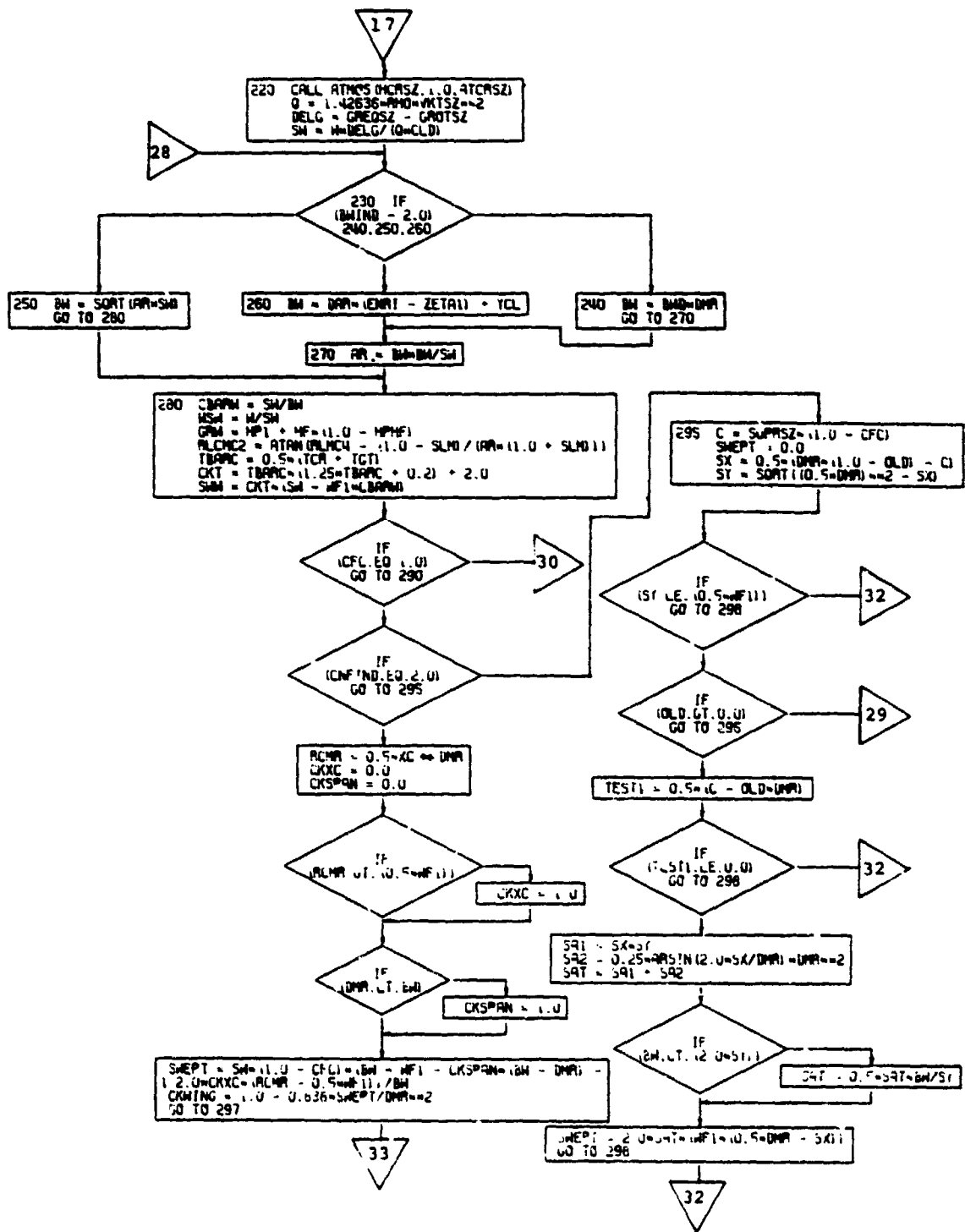


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 7 of 12)

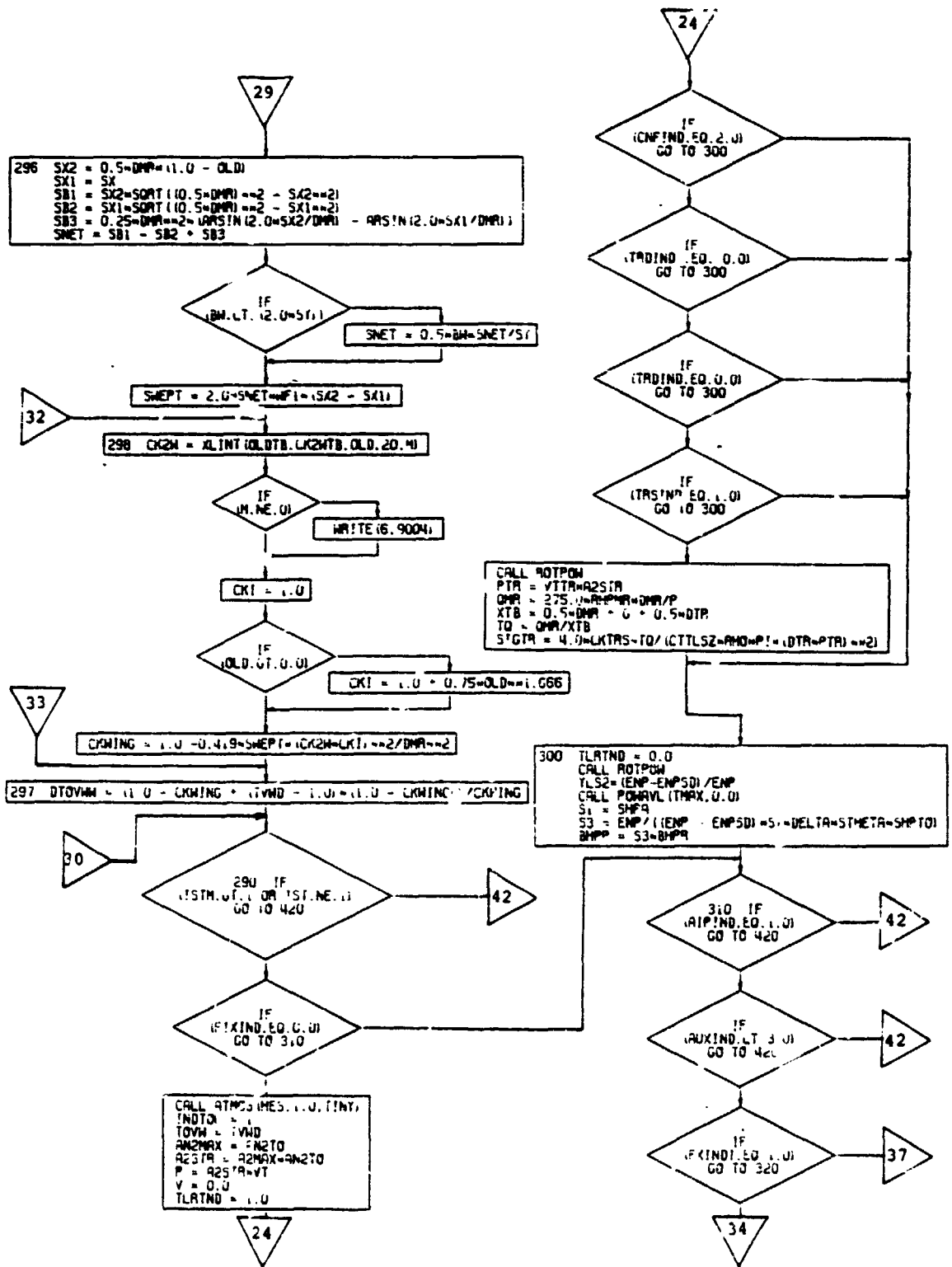


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 8 of 12)

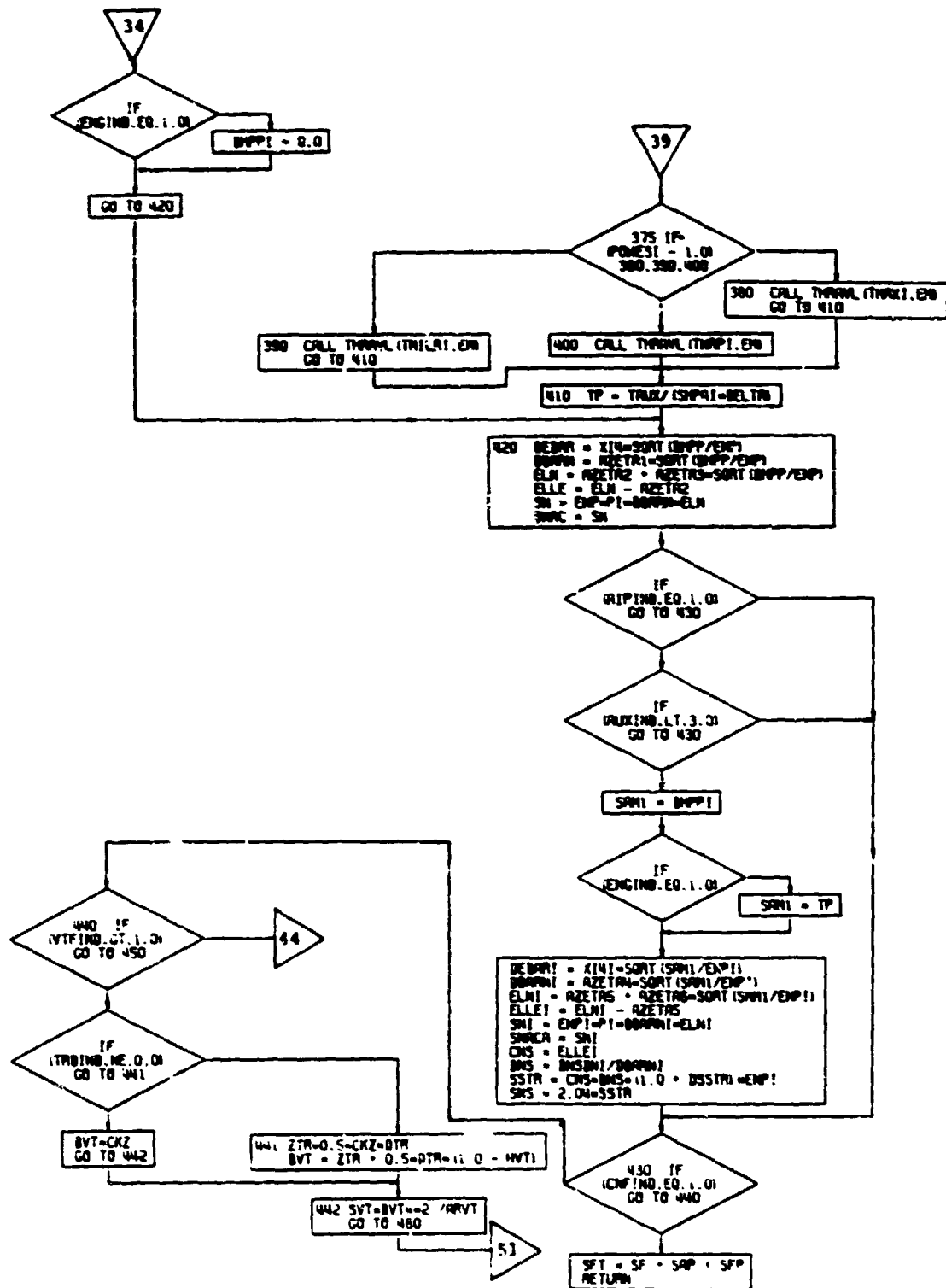


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 9 of 12)



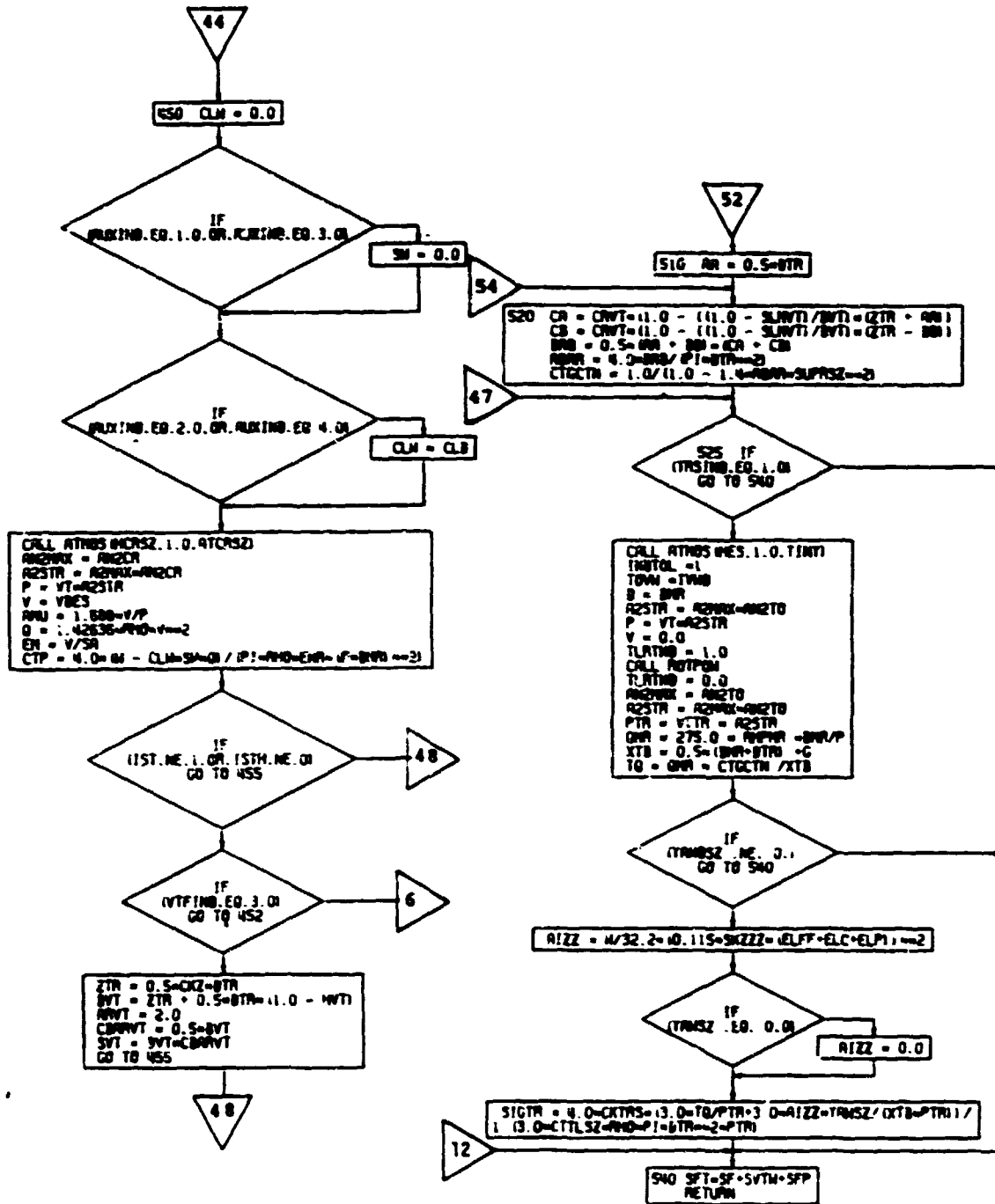


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 10 of 12)

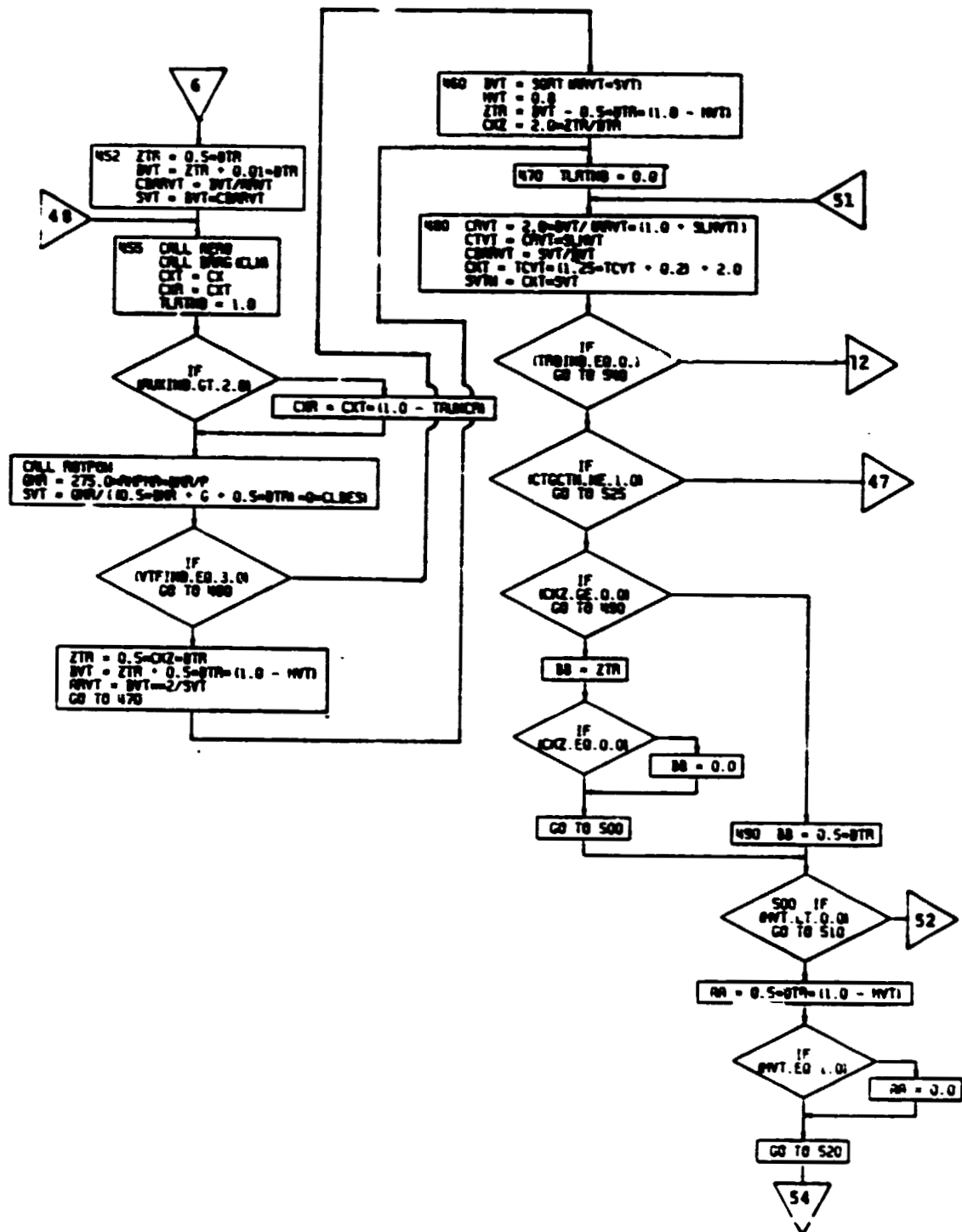


Figure 4-29. SIZTR Subroutine. Flow Chart (Part 11 of 12)

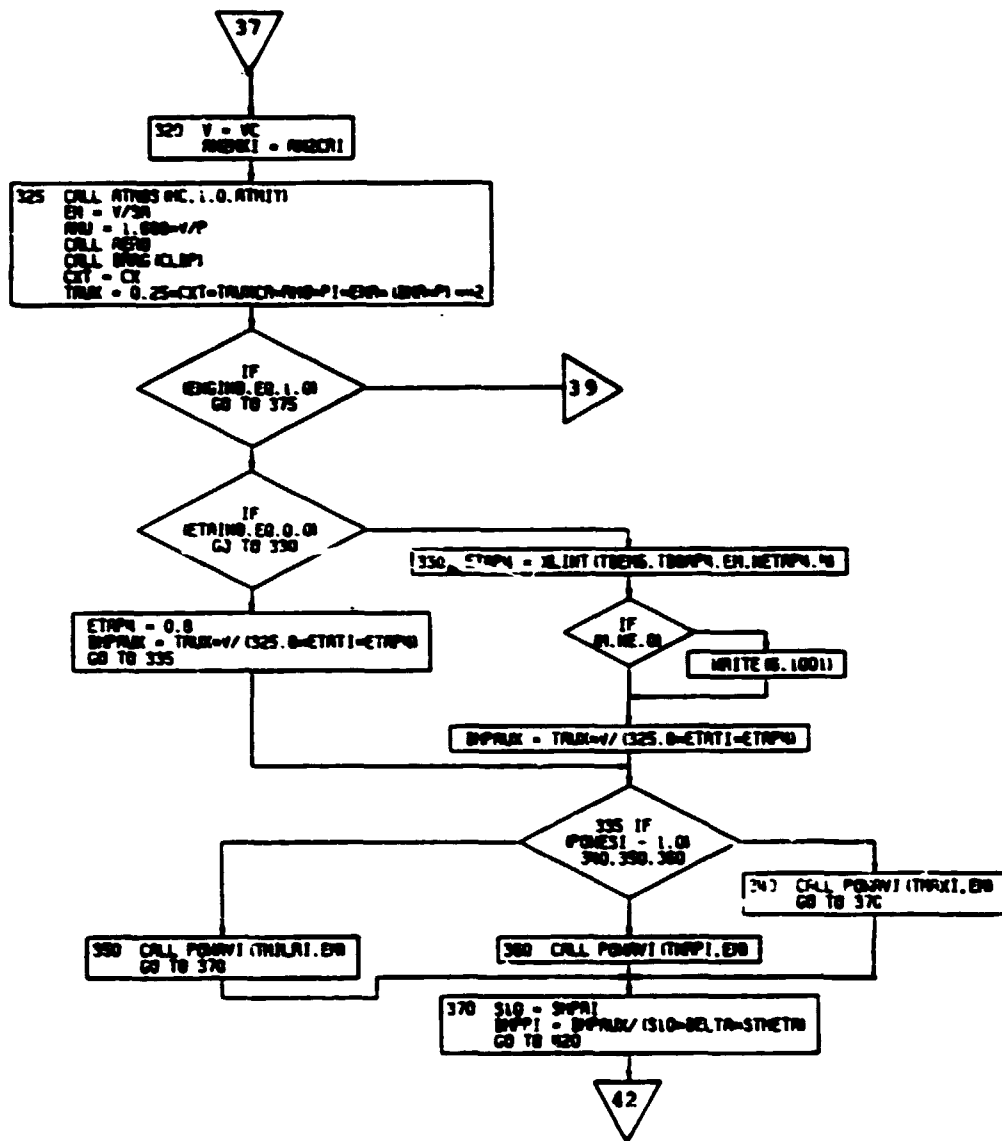


Figure 4-29. SIZTR Subroutine, Flow Chart (Part 12 of 12)

#### 4.9 AERODYNAMICS CALCULATIONS SUBROUTINE

The aerodynamics subroutine calculates a series of factors ( $a_5$ ,  $a_6$ ,  $a_7$ ,  $a_8$ , and  $a_9$ ) which are used in the calculation of drag. The drag calculation has been written in the most general manner possible. Drag is assumed to be divided into profile, induced, and interference components; namely,

$$F_{TOT} = a_5 + \underbrace{a_6 C_{D_{Wi}} S_W}_{\text{Wing Profile Drag}} + \underbrace{a_7 C_{L_W}^2 S_W}_{\text{Wing Induced Drag}} + \underbrace{a_9 C_{L_{FIN}}^2 S_{VT}}_{\text{Vertical Tail Induced Drag}} + F_{eIF}$$

where,

$F_{TOT}$  = Total configuration equivalent flat plate drag area

$a_5$  = Basic configuration flat plate drag area (including fuselage, rotor hubs, rotor pylons, etc).

$a_6$  =  $K_W [f_w (Re)]$

$a_7$  =  $1/\pi e AR$

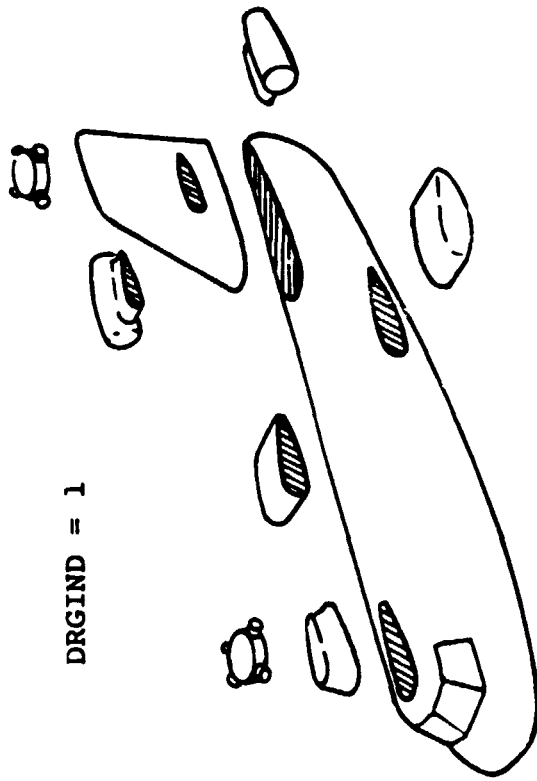
$a_9$  =  $1/\pi e_{VT} AR_{VT} TFEF$

$F_{eIF}$  = Rotor/wing interference equivalent flat plate drag area (calculated by the program using simplified Prandtl Bi-Plane Theory).

The basic configuration flat plate drag area may be calculated in two different ways: by a detailed build up, or by a trend (see Figure 4-30). The wing profile drag is assumed to be a function of lift coefficient, as specified by an input table.

If the user elects to determine the basic configuration flat plate drag area ( $a_5$ ) by build up ( $DRGIND = 1$ ), then profile drag coefficients ( $C_{D_{HT}}$ ,  $C_{D_{VT}}$ , etc.) and form factors ( $K_{HT}$ ,  $K_{VT}$ , etc.) for each component are input to the program,  $a_5$  then being calculated from the following relationship:

$$a_5 = \underbrace{.00287 K_F S_F [f_F (Re)]}_{\text{Fuselage Profile Drag}} + \underbrace{K_{FP} C_{D_{FP}} F_{APP}}_{\text{Forward (Main) Rotor Pylon Profile Drag}}$$

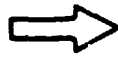
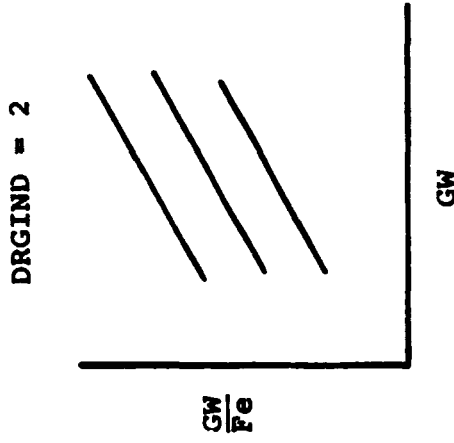


$$F_{eTOT} = [K C_D S f (Re) + \Delta F^2]_{HUB} (S)$$

where:

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

$$Re = (Re/\lambda)^{\lambda}_{CHAR}$$



$$Fe_{TOT} = \left( \frac{W_{GO}}{GW/Fe} \right) \left[ \frac{W_G}{W_{GO}} \right]^{K_{FED}}$$

Figure 4-30. Parasite Drag Buildup Options.

$$\begin{array}{l}
+ K_{AP} C_{DAP} S_{AP} [f_{AP} (Re)] + K_{VT} C_{DVT} S_{VT} [f_{VT} (Re)] \\
\text{Aft Rotor Pylon Profile Drag} \qquad \text{Vertical Fin Profile Drag} \\
+ K_{HT} C_{DHT} S_{HT} [f_{HT} (Re)] + K_N C_{DN} S_N [f_N (Re)] \\
\text{Horizontal Tail Profile Drag} \qquad \text{Primary Engine Nacelle(s) Profile Drag} \\
+ K_{NI} C_{DNI} S_{NI} [f_{NI} (Re)] + K_{NS} C_{DNS} S_{NS} [f_{NS} (Re)] \\
\text{Auxiliary Independent Engine Nacelle Profile Drag} \qquad \text{Auxiliary Independent Engine Nacelle Strut Profile Drag} \\
+ \underbrace{\Delta F_{MRH} N_R}_{\text{Main Rotor Hub(s) Total Drag}} + \underbrace{\Delta F_{TRH}}_{\text{Tail Rotor Hub Total Drag}} + \underbrace{\Delta F_e [f_F (Re)]}_{\text{Miscellaneous Drag}}
\end{array}$$

NOTE: If OPTIND=2,  $A5 = \Delta F_e$

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:

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

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  $10^7$ .

Particular care must be exercised in the input of data required for calculating the hub drag, as this particular component can typically account for as much as 1/2 to 2/3 of the

total parasite drag of a helicopter. The hub drag calculation method (Reference 8) used in this program is based on the following relationships:

$$\Delta Fe_{HUB} = \underbrace{Fe_{HUB_{CS}}}_{\text{Hub center}} + \underbrace{Fe_{SH}}_{\text{Rotor shanks}} + \underbrace{Fe_{INT}}_{\text{Misc hub/shank Interference}}$$

where:

$$Fe_{HUB_{CS}} = f \left\{ C_{D_{CS}} \text{ (Hub projected frontal area)} \right\}$$

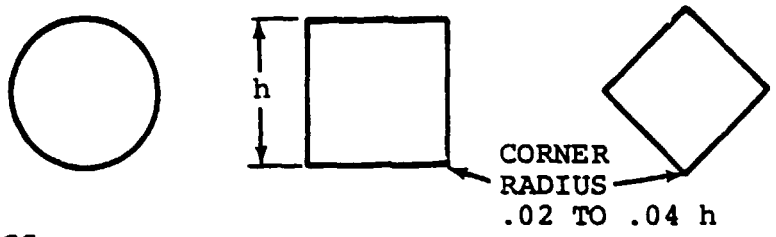
$$Fe_{SH} = f \left\{ C_{D_{SH}}, \text{ Number of shanks, shank projected frontal area, and local advance ratios at the hub/shank and shank/rotor blade interfaces} \right\}$$

Typical values of hub center section and shank drag coefficients are illustrated in Figure 4-31. A few notes of caution on the use of values such as are contained in Figure 4-31 is in order. First, estimates of the Reynolds number of the hub or shank sections to be used should be made in order to establish whether the sections are sub or super critical. Second, while 2-dimensional section drag coefficients are appropriate for use with shanks of extended length, test data indicates that 3-dimensional coefficients are more representative for low aspect ratio shanks bounded by lower drag shapes (for example, a short stubby shank bounded on one side by a faired hub and on the other side by the root end of the rotor blade). Figure 4-32 illustrates the hub geometry and interference drag factors implicitly assumed in this program. If the actual hub geometry or interference drag variation desired by the user differs appreciably from these, the differences can be reflected by ratioing the input drag coefficients  $C_{D_{CSMR}}$ ,  $C_{D_{SHMR}}$ ,  $C_{D_{CSTR}}$ , and  $C_{D_{SHTR}}$  accordingly. Table 4-5 summarizes these corrections.

If it is desired to calculate  $a_5$  by use of a drag trend (DRGIND = 2), the following relationship then obtains:

$$a_5 = \left[ \frac{W_{G0}}{(G_W/Fe)} \right] \left[ \frac{W_G}{W_{G0}} \right]^{K_{FED}}$$

**INFLUENCE OF CROSS SECTION SHAPE ON SHANK DRAG COEFFICIENTS (CYLINDERS AT SUPERCRITICAL REYNOLDS NO.)**



FINENESS RATIO		$C_{D \square}$				
1:2		1.00		2.30		1.80
1:1		.35		2.00		1.50
2:1		.15		1.40		1.10

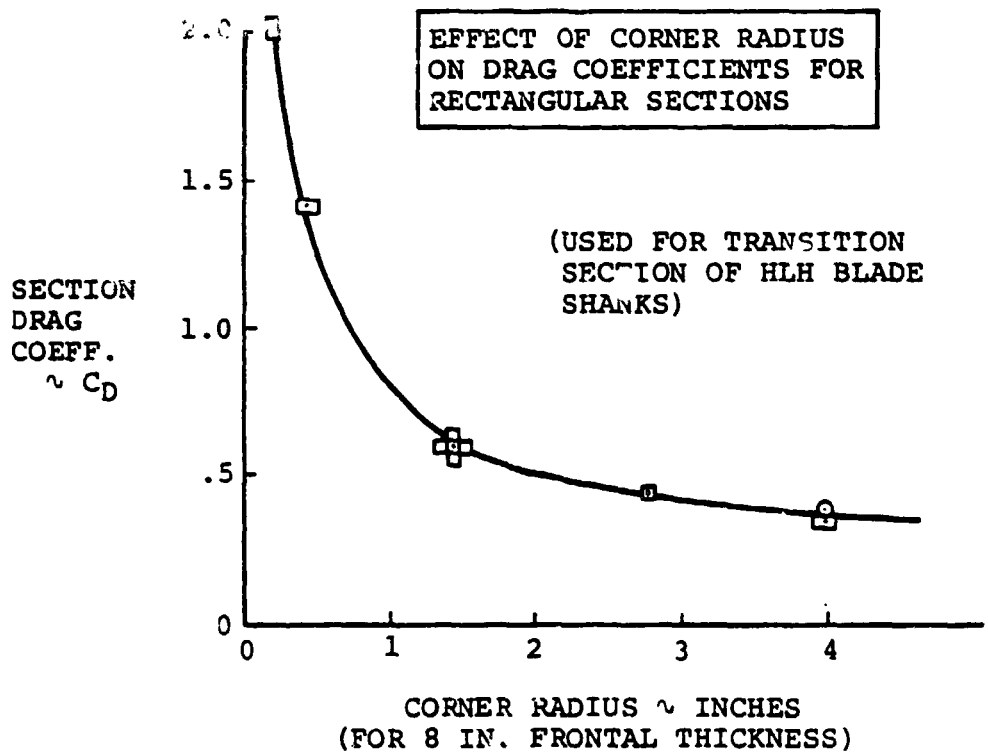


Figure 4-31. Typical Hub and Shank Drag Coefficients (Part 1 of 2).



**HUB CENTERSECTION DRAG COEFFICIENTS**

CH-47 HUB (INCLUDING INTERFERENCE)

@  $\alpha_{\text{FUSE}} = 0$       $C_D = 1.61$   
 @  $\alpha_{\text{SHAFT}} = 0$       $C_D = 1.91$

CH-47 HUB (WITH INTERFERENCE CORRECTION)

BASED ON STATIC AREA      $C_D = 1.03$   
 BASED ON ROTATING AREA      $C_D = .88$

DRTS/12' DIA. - 3/6 BLADED ROTOR HUB (NO INTERFERENCE)

BASED ON STATIC AREA      $C_D = 1.03$   
 BASED ON ROTATING AREA      $C_D = .88$

NASA MEMO 1-31-59L (NO INTERFERENCE)

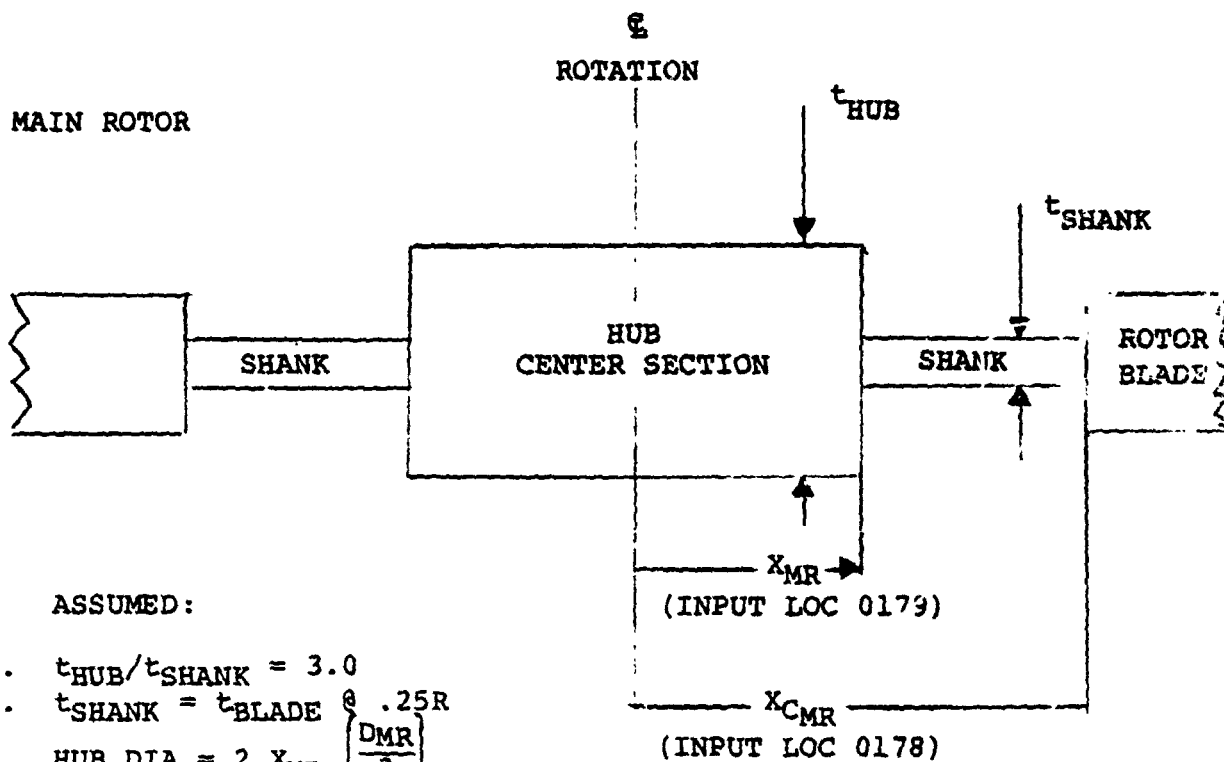
BASED ON ROTATING AREA

HUB 1	CYLINDRICAL HUB	$C_D = .65$
HUB 2	TWO BLADED TEETERING HUB	$C_D = .63$
HUB 3	HILLER SERVO ROTOR HUB	$C_D = .70$
HUB 4	H-19 HUB	$C_D = .72$
HUB 5	HUP-2 HUB	$C_D = .55$

NOTE: HUB CENTERSECTION COEFFICIENTS ARE GENERALLY LOWER THAN MIGHT BE EXPECTED SINCE CENTERSECTION IS USUALLY MORE TYPICAL OF 3 DIMENSIONAL RATHER THAN 2 DIMENSIONAL FLOW

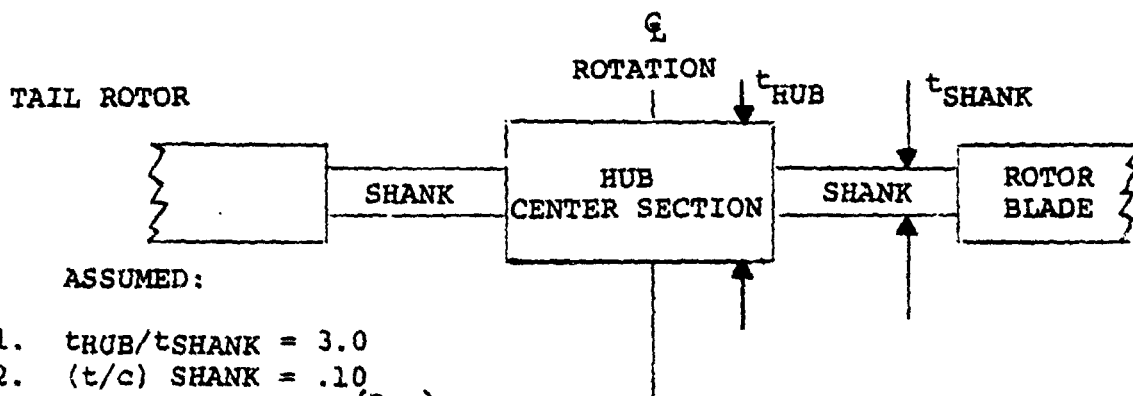
<u>SHAPE</u>	<u><math>C_D</math> @ SUBCRITICAL REYNOLDS NO.</u>	
	3-DIMENSIONAL TYPICAL OF CENTERSECTION	2-DIMENSIONAL TYPICAL OF SHANKS
○	.47	1.17
◇	.80	1.55
□	1.05	2.05
	1.17	1.98

Figure 4-31. Typical Hub and Shank Drag Coefficients (Part 2 of 2).



ASSUMED:

1.  $t_{HUB}/t_{SHANK} = 3.0$
2.  $t_{SHANK} = t_{BLADE} @ .25R$
3.  $HUB\ DIA = 2 X_{MR} \left( \frac{DMR}{2} \right)$
4.  $HUB\ FRONTAL\ AREA = HUB\ DIA \times t_{HUB}$
5.  $SHANK\ FRONTAL\ AREA = (X_{CMR} - X_{MR}) \left( \frac{DMR}{2} \right) t_{SHANK}$
6.  $K_{INT} = 1.00$



ASSUMED:

1.  $t_{HUB}/t_{SHANK} = 3.0$
2.  $(t/c)\ SHANK = .10$
3.  $HUB\ DIA = 2 X_{TR} \left( \frac{D_{TR}}{2} \right)$
4.  $HUB\ FRONTAL\ AREA = HUB\ DIA \times t_{HUB}$
5.  $SHANK\ FRONTAL\ AREA = (X_{CTR} - X_{TR}) \left( \frac{D_{TR}}{2} \right) t_{SHANK}$
6.  $K_{INT} = 1.00$

Figure 4-32. Rotor Hub/Shank Geometry Used in Program for Hub Drag Calculations.

TABLE 4 5. HUB AND SHANK DRAG COEFFICIENTS CORRECTION SUMMARY

MAIN ROTOR

$$C_{DCSMR} = C_{DCSMR} \left[ \frac{(t_{HUB}/t_{SHANK}) MR}{3.0} \right] \left[ \frac{(t/C) SHANK}{(t/C) .25R} \right] \left[ \frac{X_{MR}}{X_{MR}} \right] \left[ \frac{K_{INT}}{1.00} \right]^*$$

OBT FROM FIG 4-25

$$C_{DSHMR} = C_{DSHMR} \left[ \frac{(t/C) SHANK}{(t/C) .25R} \right] \left[ \frac{(X_{CMR} - X_{MR})}{(X_{CMR} - X_{MR})} \right] \left[ \frac{K_{INT}}{1.00} \right]^*$$

OBT FROM FIG 4-25

TAIL ROTOR

$$C_{DCSTR} = C_{DCSTR} \left[ \frac{(L_{HUB}/t_{SHANK}) TR}{3.0} \right] \left[ \frac{(t/C) SHANK}{.10} \right] \left[ \frac{K_{INT}}{1.00} \right]^*$$

OBT FROM FIG. 4-25

$$C_{DSHTR} = C_{DSHTR} \left[ \frac{(t/C) SHANK}{.10} \right] \left[ \frac{K_{INT}}{1.00} \right]^*$$

\*NUMERATORS SHOW ACTUAL HUB/SHANK CHARACTERISTICS DESIRED. DENOMINATORS SHOW FIXED CHARACTERISTICS.

where,

$W_{G0}$  = Initial "guess" at iterated helicopter gross weight (input LOC 0023). Note, this is also the value of gross weight at which the input value of (GW/Fe) is obtained. (See sketch below)

$W_G$  = "Iterated" or final design gross weight of the aircraft.

(GW/Fe) = "Drag Loading" input at a given gross weight (in this case  $W_{G0}$ ).

$K_{FED}$  = Exponent defining the slope of a typical logarithmic drag trend.

The following sketch should serve to illustrate these facts more clearly.

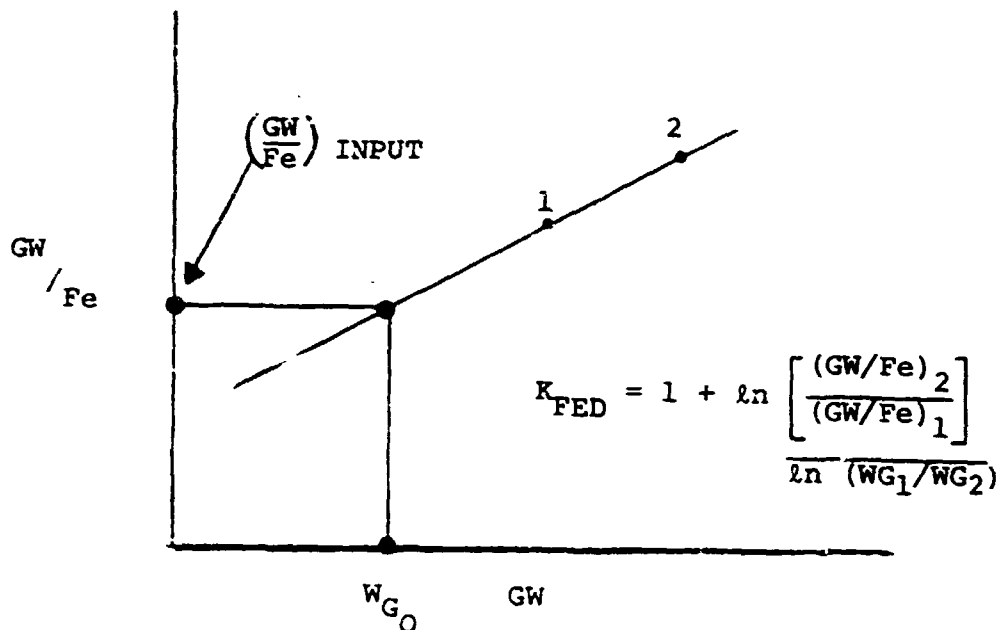
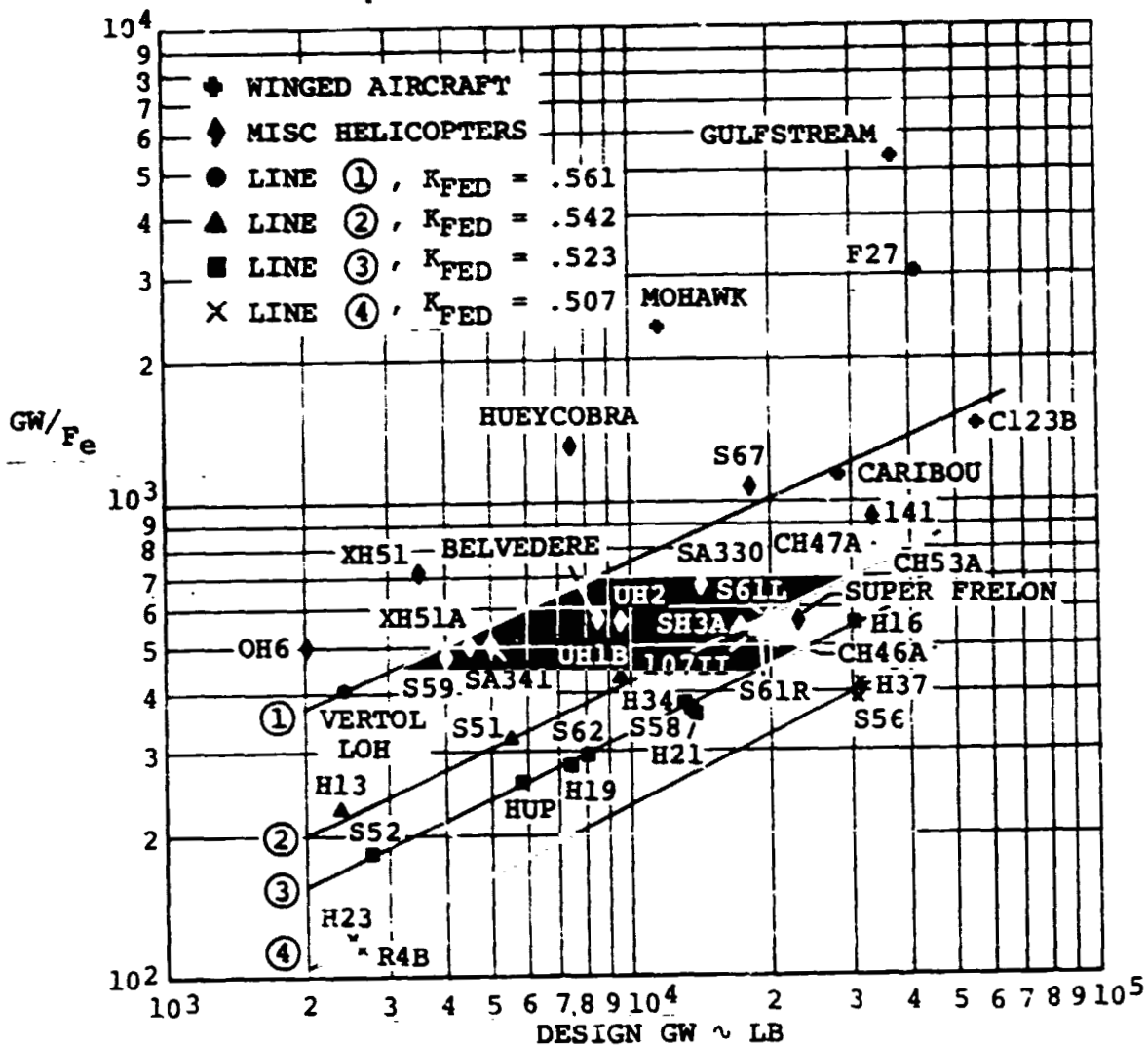


Figure 4-33 illustrates typical parasite drag area trend for various helicopters and fixed-wing aircraft.

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 breakdowns of the hypothetical helicopters shown in Tables 4-6 and 4-8. The input  $C_D$  for each component ( $C_{Dwi}$ ,  $DHTi$ ,



1. Advanced drag cleanup (e.g. faired hubs, low drag or retractable landing gear etc.).
2. Current standard of landing gear, hub design, skin finish etc.
3. Unfaired landing gear, hubs, protuberances, poor body shape, etc.
4. Exceptionally dirty configuration due to such things as open construction, exceptionally dirty engine installation, landing gear, etc.

NOTE: The drag area for the winged aircraft excludes the  $C_{DA}$  of the wings, to be compatible with the helicopters.

Figure 4-33. Typical Parasite Drag Trends.

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.). Miscellaneous drag increments can be summed and input as  $\Delta Fe$ . 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 inputs for the hypothetical helicopters of Tables 4-6 and 4-8 are shown in Tables 4-7 and 4-9.

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  $\Delta fe$ .
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  $\Delta fe$ .
4. Simplified Drag Model for Parametric Studies - The program is often used to study the influence of variations of parameters, such as disc loading, solidity, etc. on the size of a helicopter. During these studies, it is often not desirable to go into the design depth required in the three applications above. Use of the drag trends (DRGIND = 2) is therefore dictated by this requirement.

Figure 4-34 is a flow chart of this subroutine.

TABLE 4-6. DRAG BREAKDOWN FOR HYPOTHETICAL SINGLE ROTOR COMPOUND HELICOPTER  $R_e/FT = 1.56 \times 10^6$  ( $V = 189$  KT)

COMPONENT	WETTED AREA	$C_f$	INCREMENT		$f_d$ FT <sup>2</sup>
			$\Delta$	$\Delta f_d$	
FUSELAGE	1949.	0.00191		3.72	6.60
3-Dimensional Effects			12.3	0.46	
Excrescences			7.0	0.29	
Canopy				0.20	
Afterbody				1.93	
WING	345.	0.0030		1.04	1.59
3-Dimensional Effects			29.3	0.31	
Excrescences			2.0	0.03	
Flaps, Slats, Ailerons, Spoilers				-	
Body Interference			15.6	0.21	
MAIN ROTOR PYLON	286.				3.19
Basic $f_d$ (including interference and 3-D effects) $C_{D_0}$ (Based on frontal area) = 0.10	Frontal Area = 26.6 Ft <sup>2</sup>			2.66	
Excrescences				20.0 0.53	
HORIZONTAL TAIL	246.	0.00305		0.75	1.60
3-Dimensional Effects			43.4	0.33	
Excrescences			7.0	0.08	
Interference			40.7	0.44	
VERTICAL TAIL	210.	0.00270		0.57	1.03
3-Dimensional Effects			22.3	0.13	
Excrescences			7.0	0.05	
Interference			40.7	0.28	
PRIMARY ENGINE NACELLES	188.	0.00278		0.2	1.72
3-Dimensional Effects			40.4	0.21	
Excrescences			25.0	0.18	
Interference			75.0	0.55	
Inlets				0.26	
ROTOR HUBS (TOTAL)					14.82
Main Rotor Hub (center section)				6.22	
Main Rotor Hub (shanks)				5.85	
Tail Rotor Hub (center section)				0.48	
Tail Rotor Hub (shanks)				0.67	
Total Interference (main & tail rotor)				1.60	
MISC					1.34
Roughness (50% of $C_f A_{WET}$ )				0.54	
Cooling				0.50	
Trim				-	
Air Conditioning				0.30	
TOTALS	ft <sup>2</sup>				31.89
NOTES: (1) Basic $f_d = (C_f A_{WET}) + (3-D \text{ Effects } \Delta f_d)$ (2) Excrescences and interference are $\Delta$ of basic $f_d$					

TABLE 4-7. SUMMARY OF AERODYNAMICS INPUT FOR COMPOUND HELICOPTER OF TABLE 4-6

GENERAL	
$C_{DHI} = C_{DHT} = C_{LHT} = C_{DN} = C_T = 0.00287 \sigma \tau = 10^7 (R_0/4)_1 = 1.56 \times 10^6$	
COMPONENTS	
S <sub>F</sub> = 1949 FUSELAGE WETTED AREA	
FUSELAGE	$K_F = (1 + 0.123) (1 + 0.07) + 0.05 = 1.25$ $AP_0 = \left( \frac{0.00287}{0.00191} \right) (1.93 + 0.20 + 0.26 + 0.50 + 0.30) = 4.80$ 3-D effects    encl    roughness    Body C <sub>F</sub> Afterbody    Canopy    Nacelle inlets    Cooling    Air Condit.
WING	$K_M = (1.80) (1 + 0.293) (1 + 0.02 + 0.156) + 0.05 = 2.83$ $(A_{wet}/S_M)$ 3-D effects    encl    interf    roughness
MAIN PYLON	$K_{FP} = 1 + 0.20 + 0.05 = 1.25$ C <sub>DPP</sub> = 0.10 encl    roughness
HOR & VERTICAL TAIL	$K_{HT} = 2.02 (1 + 0.434) (1 + 0.07 + 0.407) + 0.05 = 4.38$ $(A_{wet}/S_{HT})$ 3-D effects    encl    interf    roughness $(A_{wet}/S_{VT})$ $K_{VT} = 2.06 (1 + 0.223) (1 + 0.07 + 0.407) + 0.05 = 3.83$
PRIMARY ENGINE NACELLES	$K_N = (1 + 0.404) (1 + 0.25 + 0.75) + 0.05 = 2.86$ 3-D effects    encl    interf    roughness
ROTOR HUBS	$C_{DCHNR} = 0.77$ C <sub>DCEFR</sub> = 0.75 $C_{DBNHR} = 1.4$ K <sub>HPIM</sub> = 1.3    C <sub>DBNFR</sub> = 1.4    K <sub>HPBM</sub> = 0.3
MISC	Cooling, Airconditioning, and nacelle inlets included in fuselage AP <sub>0</sub>



**TABLE 4-8. TYPICAL DRAG SUMMARY  
DRAG BREAKDOWN FOR HYPOTHETICAL TANDEM ROTOR  
WINGED HELICOPTER  $R_e/ft = 1.49 \times 10^6$  ( $V = 181$  KT)**

COMPONENT	WETTED AREA	$C_f$	INCREMENT		$f_e$ FT <sup>2</sup>
			$\delta$	$f_e$	
<b>FUSELAGE</b>	<b>1640.</b>	<b>0.00208</b>		<b>3.41</b>	<b>6.52</b>
3-Dimensional Effects			12.2	0.42	
Excrescences			7.0	0.27	
Canopy Afterbody				0.20 2.22	
<b>WING</b>	<b>389.</b>	<b>0.0030</b>		<b>1.16</b>	<b>1.77</b>
3-Dimensional Effects			29.3	0.34	
Excrescences			2.0	0.03	
Flaps, Slats, Ailerons, Spoilers Body Interference			15.2	0.24	
<b>FORWARD PYLON</b>	<b>41.5</b>				<b>1.69</b>
Basic $f_e$ (including interference and 3-D effects) $C_{D_0}$ (Based on Frontal Area) = 0.15 Excrescences	(Frontal Area = 9.5 Ft <sup>2</sup> )			1.41 20.0 0.28	
<b>AFT PYLON</b>	<b>421.</b>	<b>0.00252</b>		<b>1.06</b>	<b>2.38</b>
3-Dimensional Effects			46.4	0.49	
Excrescences Interference			20.0 33.5	0.31 0.52	
<b>PRIMARY ENGINE NACELLE</b>	<b>188.</b>	<b>0.00278</b>		<b>0.52</b>	<b>1.72</b>
3-Dimensional Effects			40.4	0.21	
Excrescences			25.0	0.18	
Interference Inlets			75.0	0.55 0.26	
<b>ROTOR HUBS (TOTAL)</b>					<b>19.48</b>
Main rotor hub (center section, total)				10.4	
Main rotor hub (shanks, total) Hub/Shank Interference (total)				7.78 1.30	
<b>MISC</b>					<b>1.25</b>
Roughness (5.0% of $C_f A_{WET}$ )				0.45	
Cooling Trim Air Conditioning				0.50 - 0.30	
<b>TOTALS</b> ft <sup>2</sup>	<b>2679.5</b>				<b>34.81</b>
NOTES: (1) Basic $f_e = (C_f A_{WET}) + (3-D \text{ Effects } \delta f_e)$ (2) Excrescences and interference are % of basic $f_e$					

TABLE 4-9. SUMMARY OF AERODYNAMICS INPUT FOR HELICOPTER OF TABLE 4-8

GENERAL		$C_{D_{W1}} = C_{D_{AP}} = C_{DN} = C_P = 0.00287 \theta R_0 = 10^7 \quad (Re/l)_1 = 1.49 \times 10^6$	
COMPONENTS	$S_F = 1640$	FUSELAGE WETTED AREA	cooling air condit ✓
FUSELAGE	$K_F = (1+0.122) (1+0.07) + 0.05 = 1.25$	$\Delta P_0 = \left( \frac{0.00287}{0.00708} \right) (2.22+0.20+0.26+0.50+0.30) = 4.81$	Body $C_P$ Afterbody Canopy Nacelle inlets
WING	$K_W = (1.80) \left( \frac{S_{PAP}}{A_{wet}} \right) [(1 + 0.34) (1 + 0.02 + 0.152) + 0.05] = 2.92$	3-D effects excr roughness	interf roughness
FORWARD PYLON	$K_{FP} = 1 + 0.20 + 0.05 + 1.25$	excr roughness	$C_{D_{FP}} = 0.15$
AFT PYLON	$K_{AP} = (0.455) [(1 + 0.464) (1 + 0.20 + 0.335) + 0.05] = 1.045$	3-D effects excr roughness	interf roughness
PRIMARY ENGINES NACELLES	$K_N = (1 + 0.404) (1 + 0.25 + 0.75) + 0.05 = 2.86$	3-D effects excr roughness	interf roughness
ROTOR HUBS	$C_{D_{CSMR}} = 0.75$ $C_{D_{SHMR}} = 1.4$	$K_{HPIM} = 1.3$	
MISC	Cooling, air conditioning and nacelle inlets included in fuselage $\Delta P_0$		

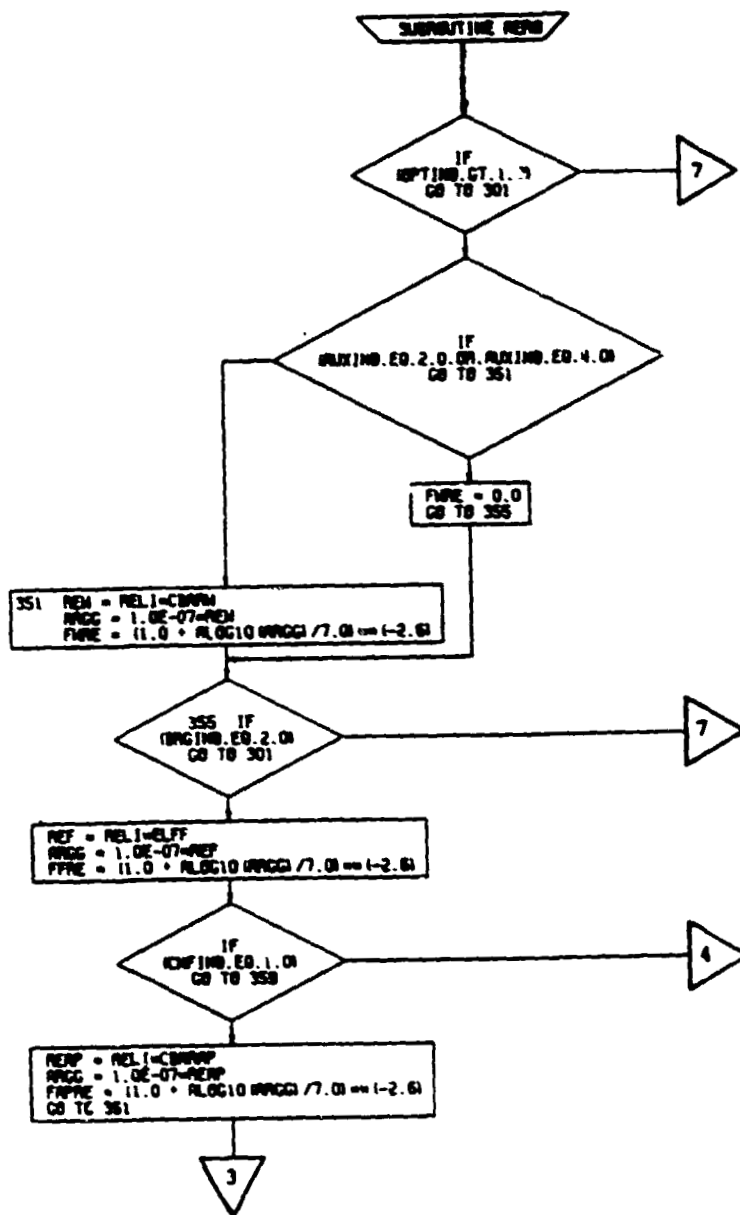


Figure 4-34. AERO Subroutine, Flow Chart (Part 1 of 4)

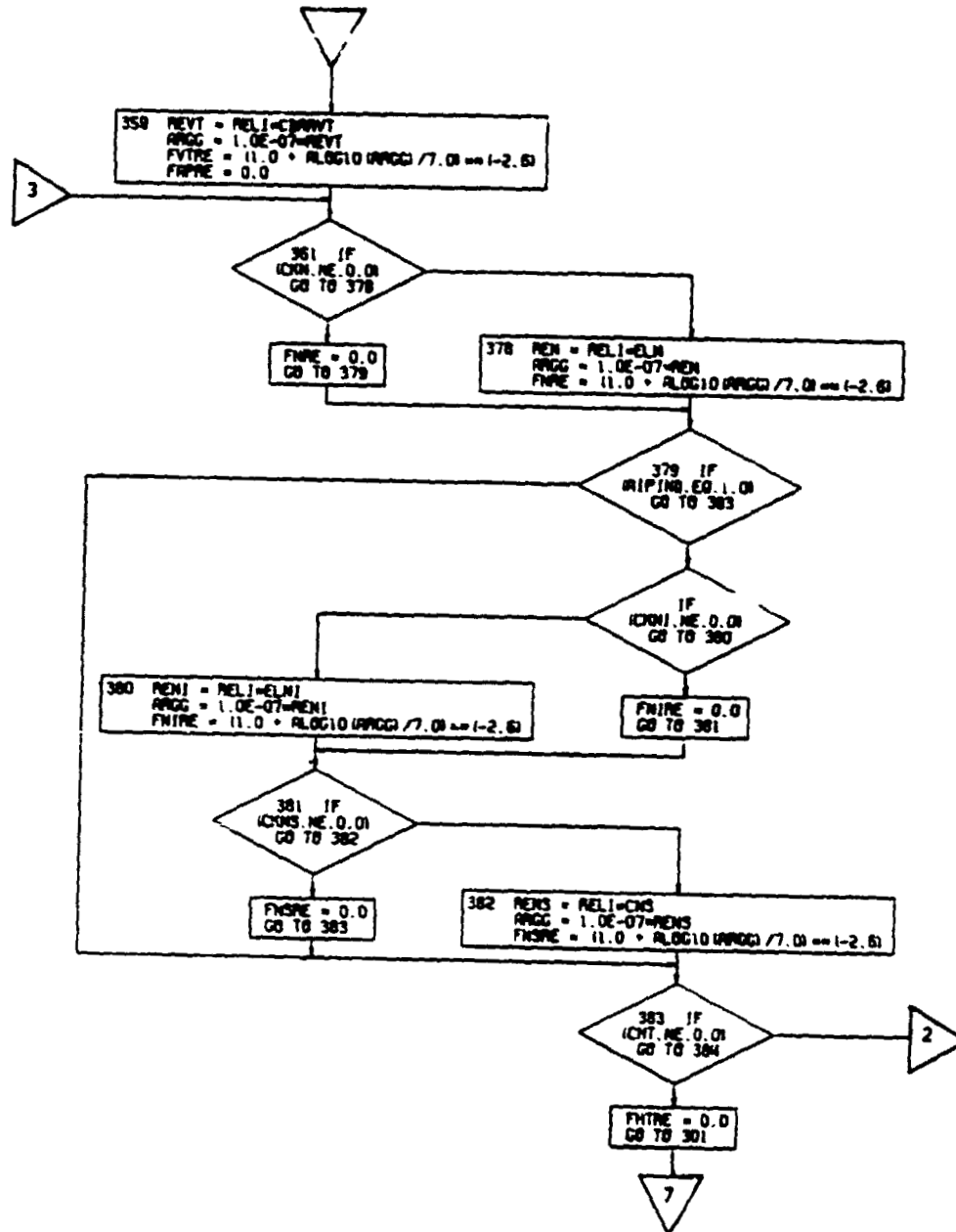


Figure 4-34. AERO Subroutine, Flow Chart (Part 2 of 4)

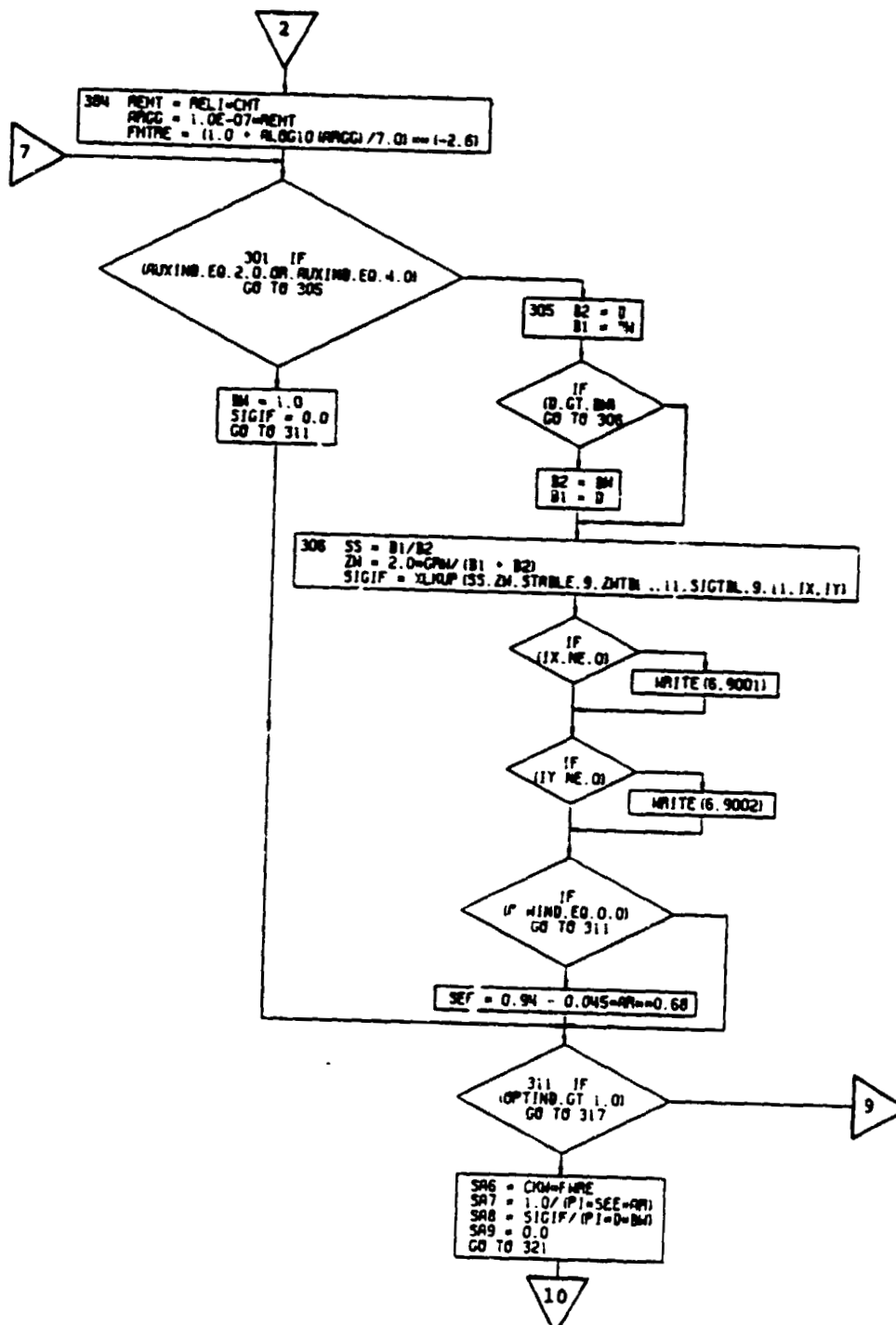


Figure 4-34. AERO Subroutine, Flow Chart (Part 3 of 4)

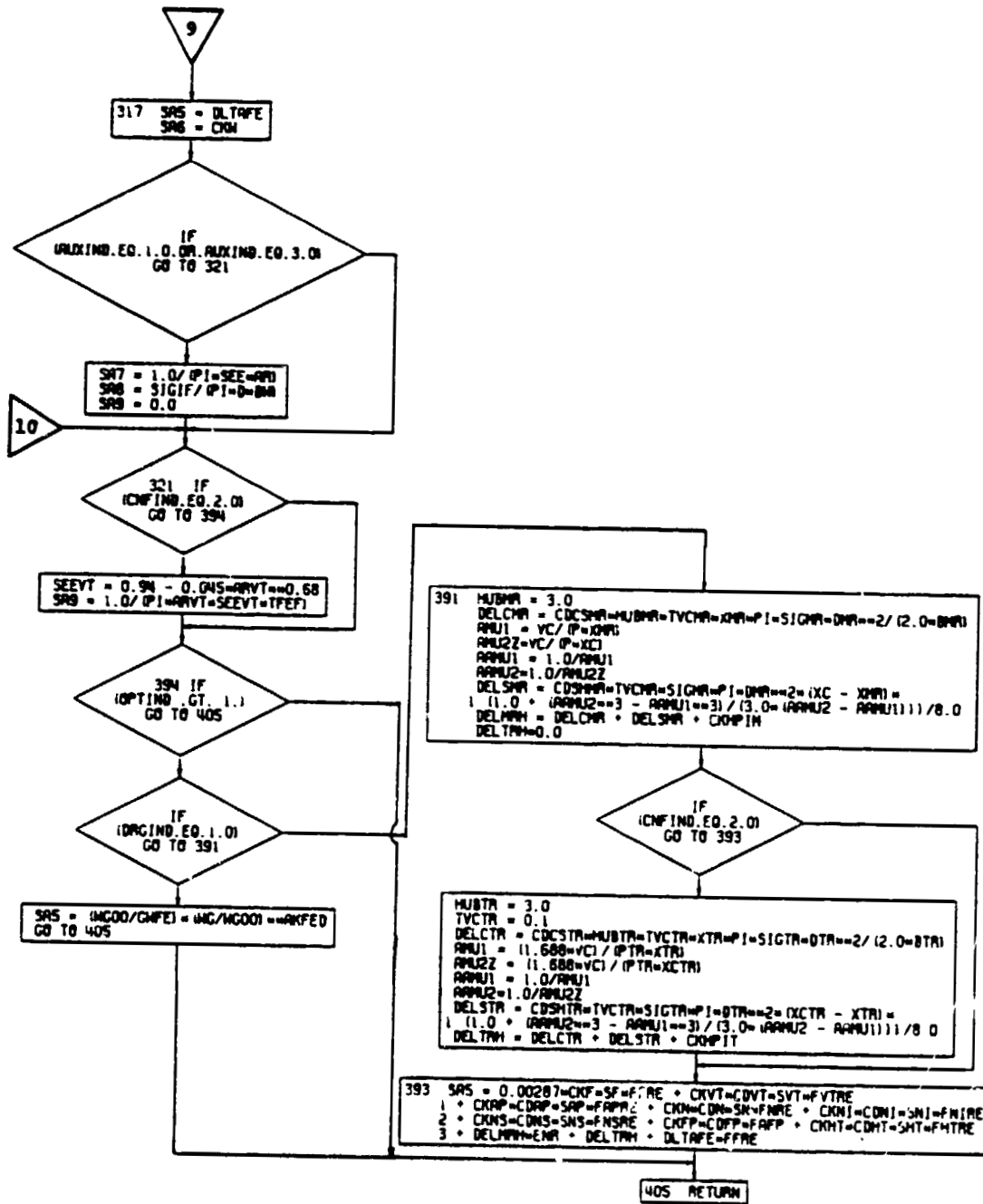


Figure 4-34. AERO Subroutine, Flow Chart (Part 4 of 4)

#### 4.10 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 for standard day.

The engine sizing subroutine calculates the value of the scaling factors; namely, the maximum static thrust or power (S.L., std.). If so desired, the user may study a helicopter with fixed rather than "rubberized" primary engines. This is accomplished by means of the indicator FIXIND. If FIXIND = 0, the user inputs the maximum (installed) power of the primary engines. If FIXIND = 1, the engine sizing subroutine calculates the installed power.

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.

Engine sizing requirements for helicopters are generally set by takeoff conditions, and less frequently by forward flight conditions. The program, therefore, permits the user two options of calculation. The first option (ESCIND = 1) will calculate engine size for takeoff conditions only; the second option (ESCIND = 2) 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, at a specified fraction ( $SHP_E/SHP^*$ ) of the maximum power the specified sizing condition.

Cruise conditions are specified by means of altitude ambient temperature, true airspeed; and in the case of a compound helicopter, the propulsive thrust split ( $T_{AUX}/T_{TOT}$ )<sub>C</sub>, LOC 0239, between the auxiliary propulsion and the main rotor. When the engine is sized for cruise the program will accept the  $T_{AUX}/T_{TOT}$  schedule input, LOCS 1671-1692. In addition, the user may select the power setting to be used; maximum, military, or normal, input LOC 0234.

In case of a configuration having auxiliary independent cruise engines (APIND = 2), these engines may either be fixed or sized independently of the primary engines. The auxiliary independent engines can only be sized for cruise. For example, it would be possible to study a configuration with fixed size primary engines (FIXIND = 0) while sizing the auxiliary engines to meet cruise requirements. NOTE: in a case like this, input locations 0234-0241 must be filled out to allow sizing for the auxiliary engines, even though the primary engines are fixed in size.

In addition to sizing the primary and auxiliary engines, this subroutine calculates the main rotor, tail rotor (in the case of a single rotor helicopter) and auxiliary propulsion drive system rating (in the case of a compound helicopter). The options available to the user for this purpose are:

XMSNIND = 0 Main, tail and auxiliary drive system ratings specified as fraction of primary engine installed power (in the case of a compound helicopter with auxiliary independent propulsion, the auxiliary independent drive system rating is specified as a fraction of the auxiliary independent engine installed power).

XMSNIND = 1 The drive system ratings calculated are equal to the product of the applicable multiplicative factors ( $SHP_{MRX}/SHP^*_{MR}$ ,  $SHP_{TRX}/SHP^*_{TR}$ ,  $SHP_{AUX}/SHP^*_{AUX}$ ) and the component (main tail, and auxiliary) power obtained from the proportional split (based on power required) of the total sea level standard maximum (installed) engine power. NOTE: IF FIXIND = 0, user must input proper power split between main rotor and tail rotor.

$$SHP_{MRX} = \left( \frac{SHP_{MXR}}{SHP^*_{MR}} \right) \left( \frac{SHP^*_{MR}}{SHP^*} \right) SHP^*$$

$$SHP_{TRX} = \left( \frac{SHP_{TXR}}{SHP^*_{TR}} \right) \left( \frac{SHP^*_{MR}}{SHP^*} \right) SHP^*$$

XMSNIND = 2 Main, tail, and auxiliary drive system ratings specified at fraction of power required to hover or cruise at design conditions (more critical of the two conditions is selected).



- XMSNIND = 3 Same as 2, except the most critical of the two design conditions is compared to the drive system rating required at an alternate payload/gross weight hover at the design point conditions. The most critical of these three conditions is selected.
- XMSNIND = 4 Same as 2, except that tail rotor drive system rating is selected independently of the main rotor drive system to match a specified fraction of power required to hover or cruise at design conditions (more critical of the two conditions is selected).
- XMSNIND = 5 Same as 3, except that the tail rotor drive system rating is selected independently of the main rotor drive system as in 4, and the most critical of the two design conditions is compared to the tail rotor drive system rating required at an alternate payload/gross weight hover at the design point conditions. The most critical of these three conditions is selected.

It should be noted that when FIXIND = 0 or FIXINDI = 0; i.e., fixed size engines, any of the six transmission sizing options (XMSNIND = 0 - 5) may be used. If drive system ratings calculated based on meeting specified flight conditions (XMSNIND = 2 - 5) exceed the installed power rating of the fixed size engines, the drive system ratings are reset to "match" the fixed size engines.

The use of separate engine and transmission sizing options provides great flexibility in meeting conflicting engine/drive system requirements. For example, using XMSNIND = 2, it is possible to size a helicopter's primary engines to meet an engine inoperative in hover requirement, while only rating the drive system for the actual power required to hover at that design point, thus effecting a considerable saving in drive system weight. Or, using XMSNIND = 3, it is possible to rate the drive system for the power required at an alternate gross weight/payload hover point, while still meeting the original engine out sizing criteria. Note that XMSNIND = 4, 5 are of use only when sizing single rotor helicopters (CNFIND = 1.0).

The drive system ratings determined in the sizing process may be used to limit helicopter performance by setting  $Q_{IND}$  (LOC 1205) = 1, 2. The first option,  $Q_{IND} = 1$ , imposes a torque limit on the main and tail rotor transmission. The second option,  $Q_{IND} = 2$ , imposes a torque limit on the auxiliary propulsion transmission.  $Q_{IND} = 2$  is only used with  $AUX_{IND}$  (LOC 0006) = 2.0 and  $M_{PIND}$  (LOC 0253) = 0.0, and  $AIPIND$  (LOC 0012) = 1.0.

Note that when OPTIND (LOC 0001) = 0, 1 and Q<sub>IND</sub> (LOC 1205) = 1, 2, Q<sub>MAX</sub>/Q\* (LOC 1224) must be set =  $\frac{1}{N_{IIMAX}/N_{II}^*}$

When OPTIND = 2, 3 and Q<sub>IND</sub> = 1, the main transmission rating input LOC 1224  $\frac{Q_{MAX}}{Q^*} = \frac{SHP_{rating}}{SHP^*}$

If OPTIND = 2, 3 and Q<sub>IND</sub> = 2, the main transmission rating is the same as Q<sub>IND</sub> = 1, however the auxiliary propulsion transmission rating is input as

$$\frac{SHP_{AUX}}{SHP^*_{AUX}} = \frac{SHP_{AUX} \text{ PROP RATING}}{SHP^*} \quad \text{where,}$$

$\frac{SHP_{AUX}}{SHP^*_{MX}}$  IS INPUT LOC 0226.

$\frac{SHP_{AUX}}{SHP^*_{MX}}$

The auxiliary drive system rating is input in a similar manner as the primary drive system. There are only 2 options for torque limit, input as Q<sub>INDI</sub> (LOC 2205) = 0, 1. If Q<sub>INDI</sub> = 1,

Q<sub>MAX</sub>/Q\* (LOC 2224) must be set =  $\frac{1}{N_{II} \text{ MAX} / N_{II}^*}$

Helicopter performance transmission limits are applied in the power available subroutines, Figures 4-5 through 4-12.

Figure 4-35 contains a flow chart of the engine sizing subroutine.

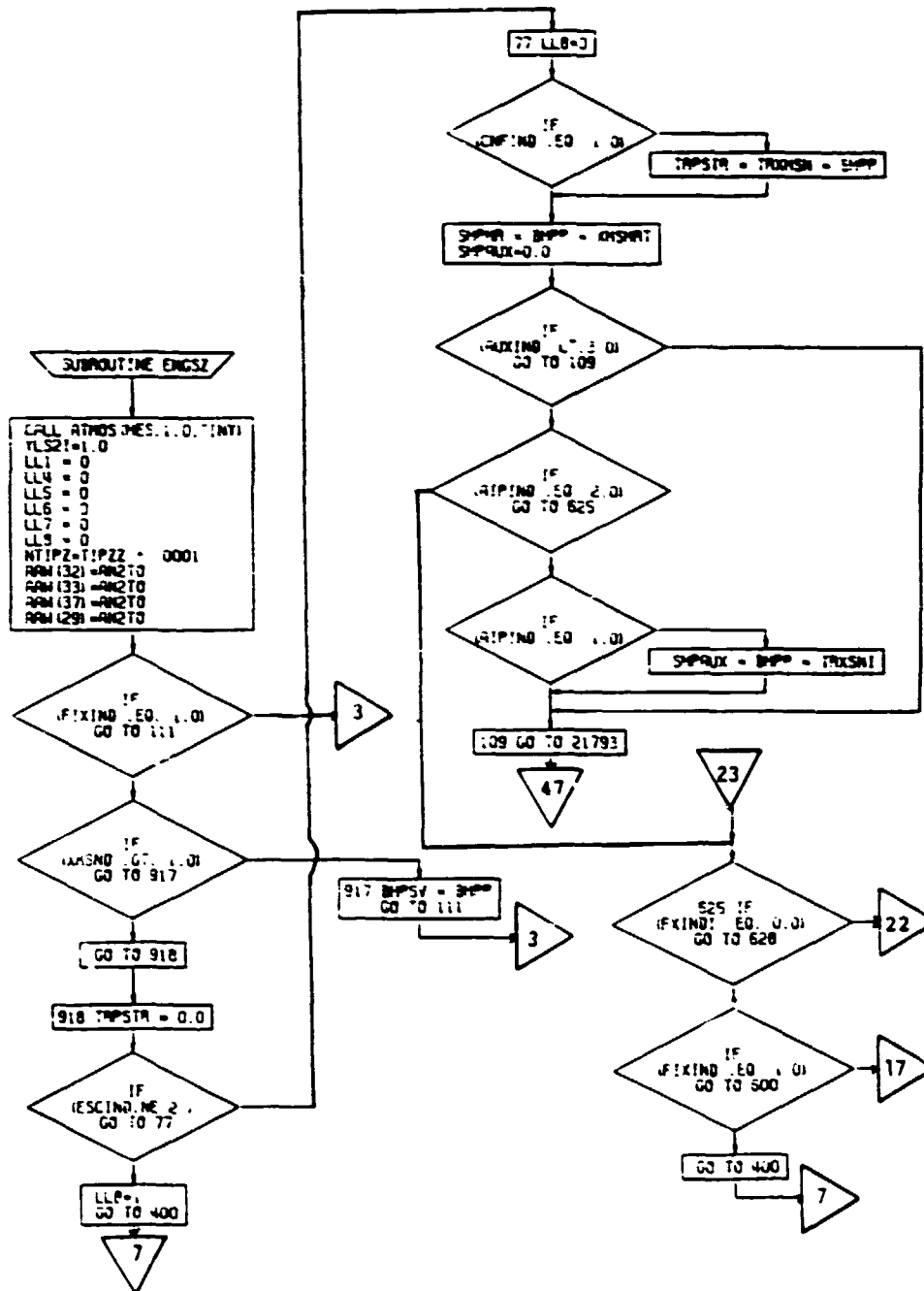


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 1 of 13)

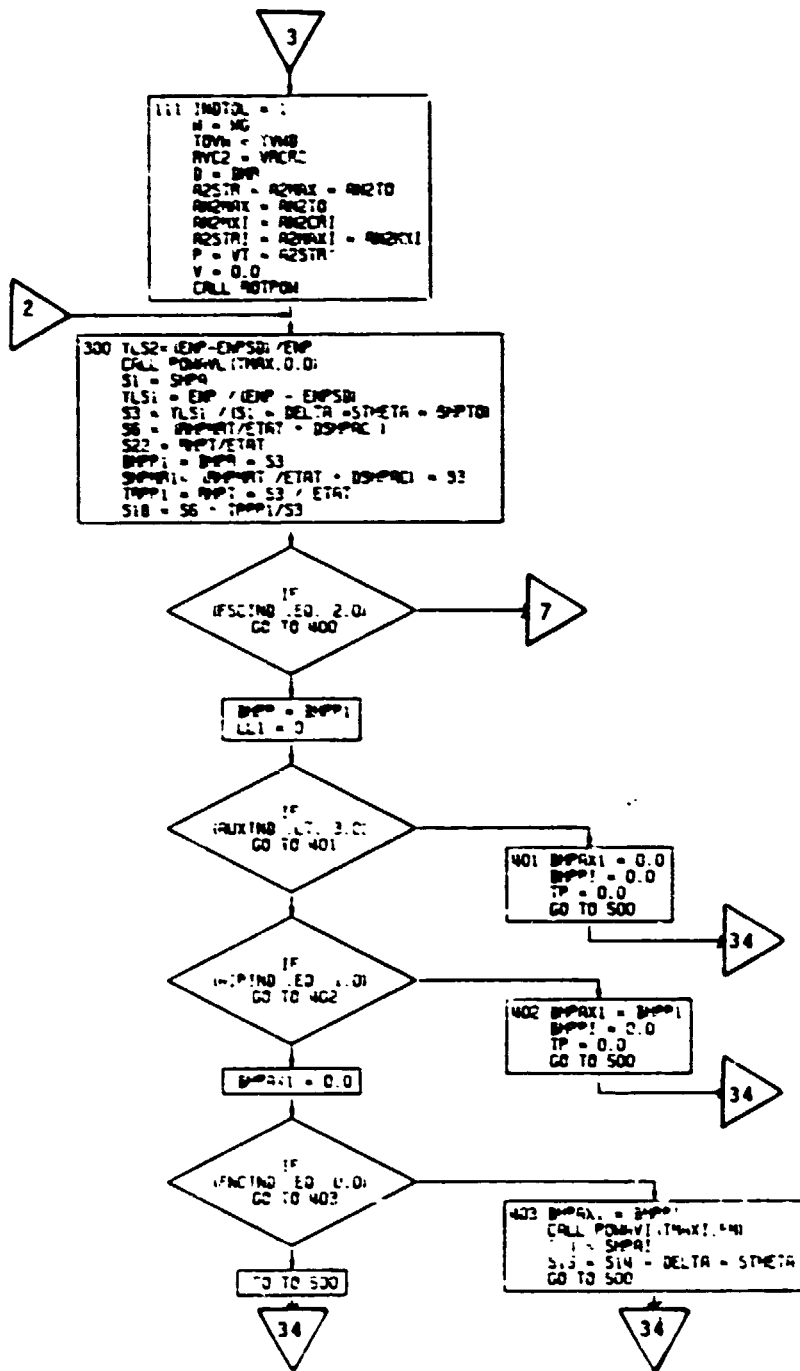


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 2 of 13)

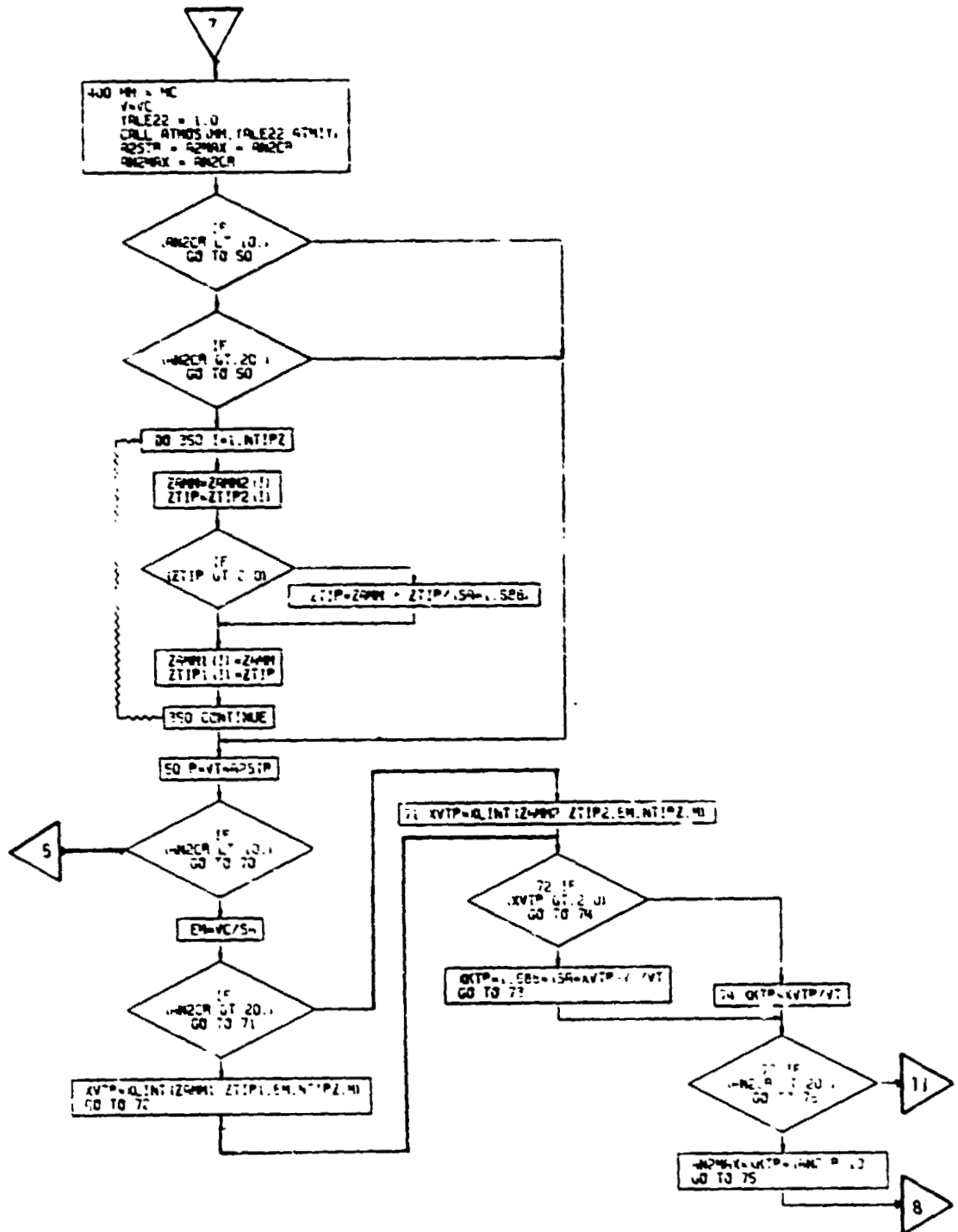


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 3 of 13)

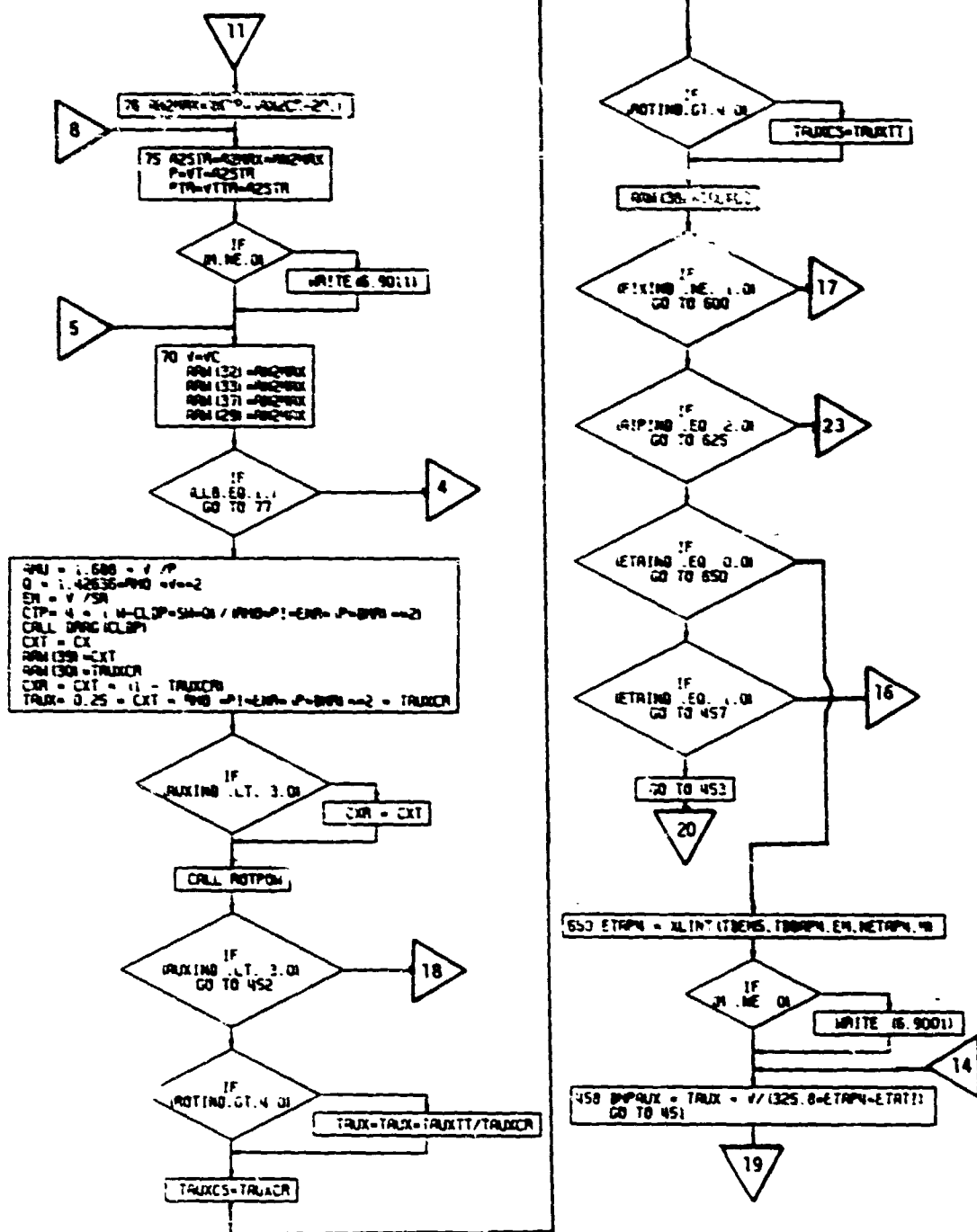


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 4 fo 13)

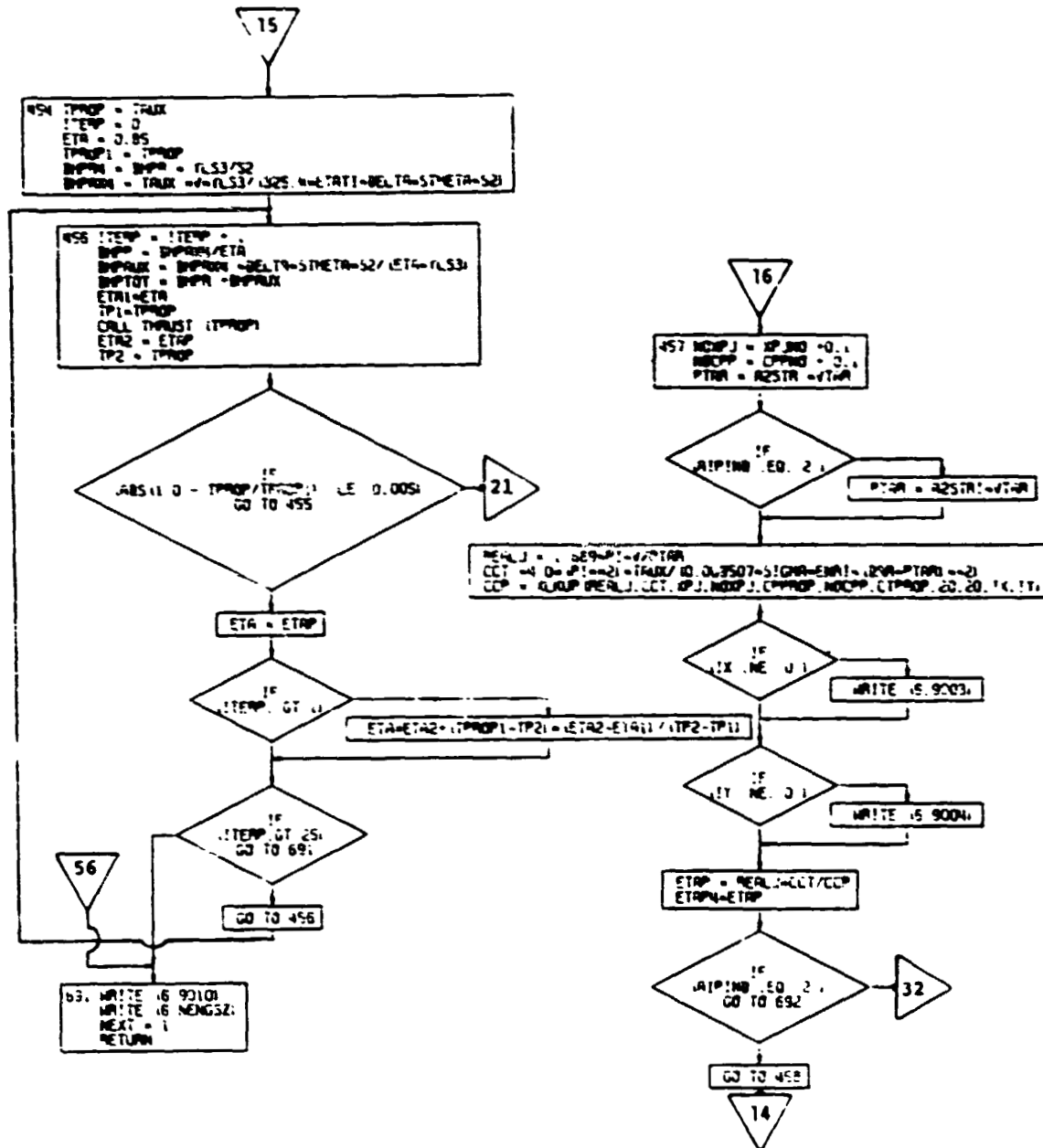


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 5 of 13)

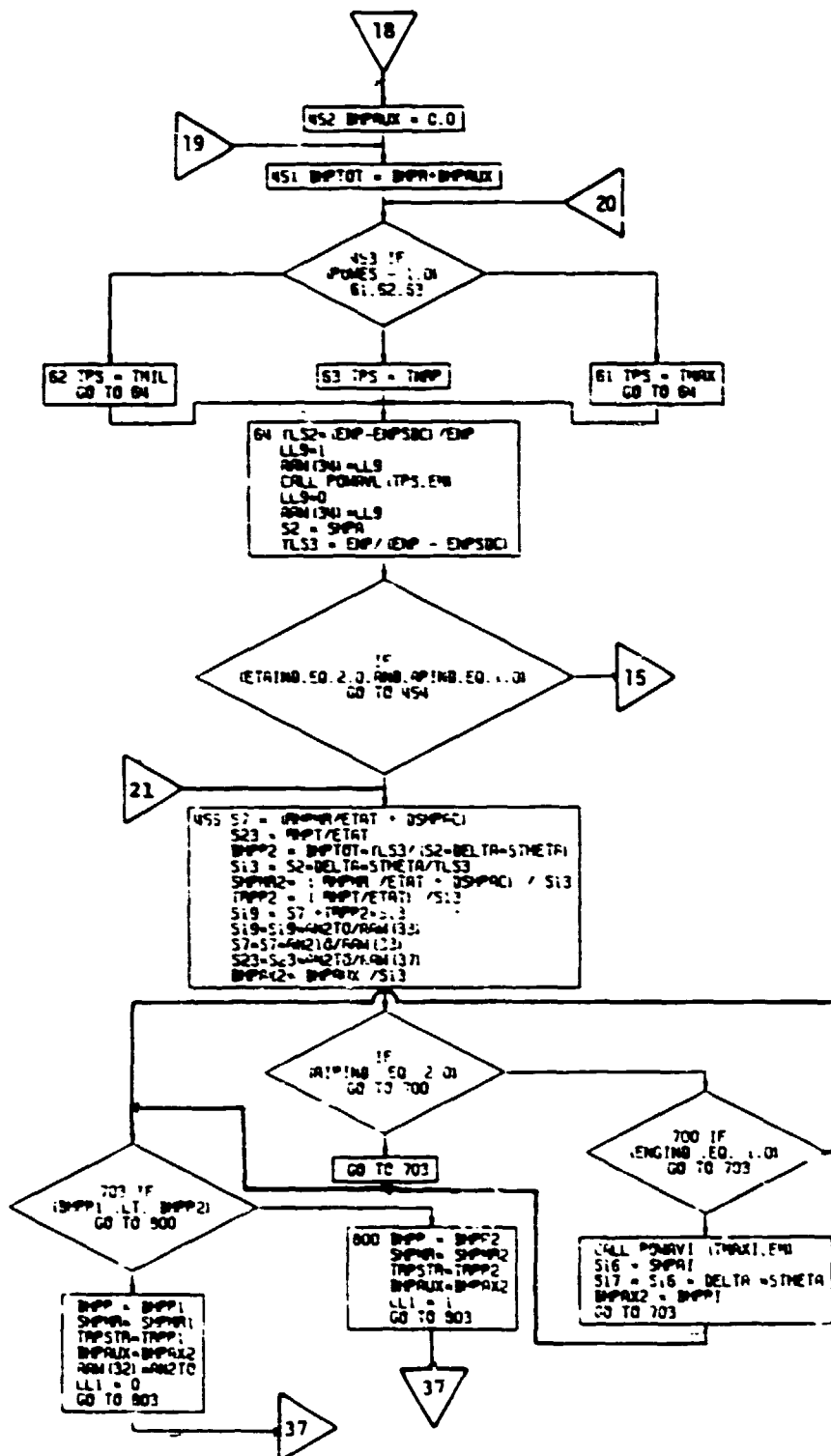


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 6 of 13)



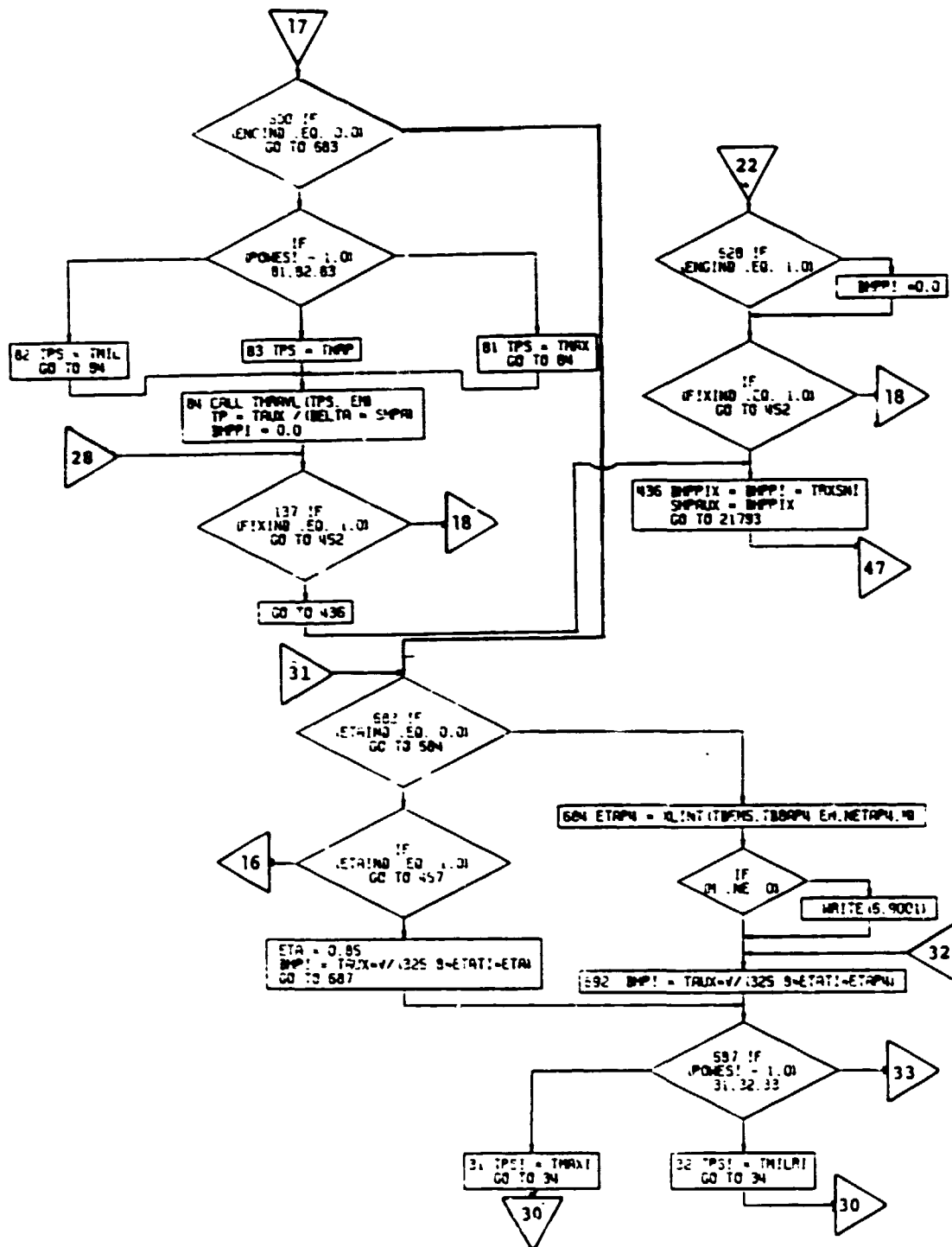


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 7 of 13)

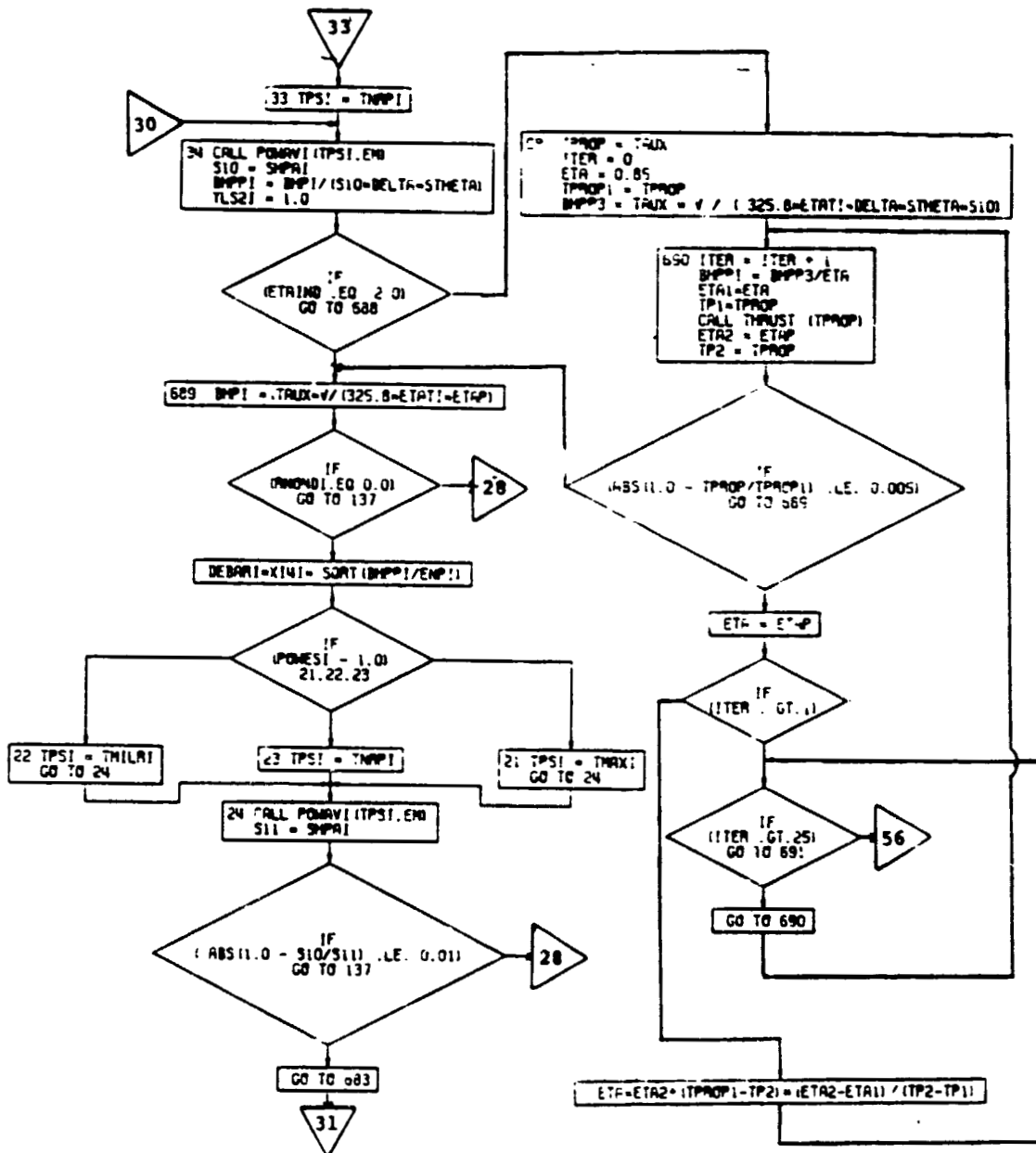


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 8 of 13)

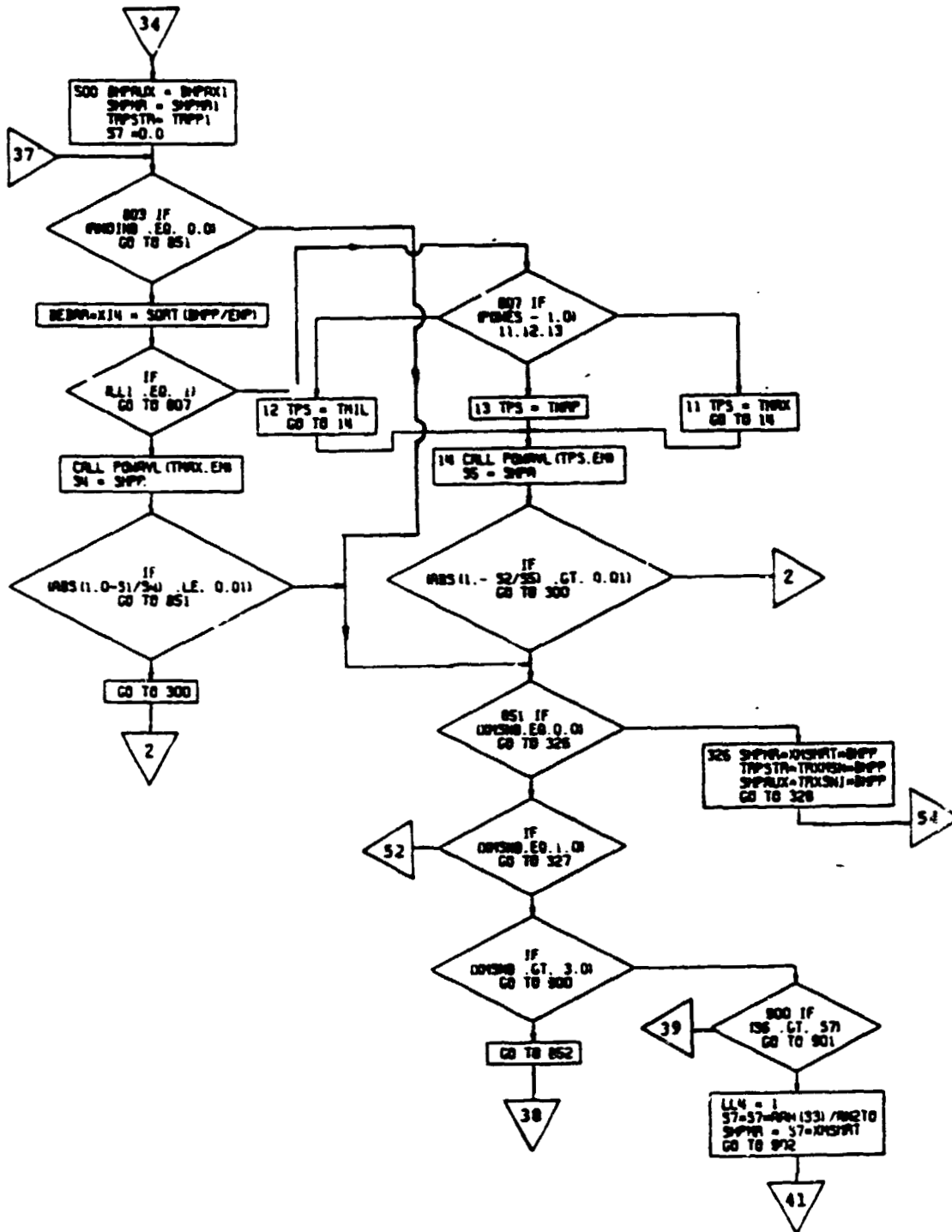


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 9 of 13)

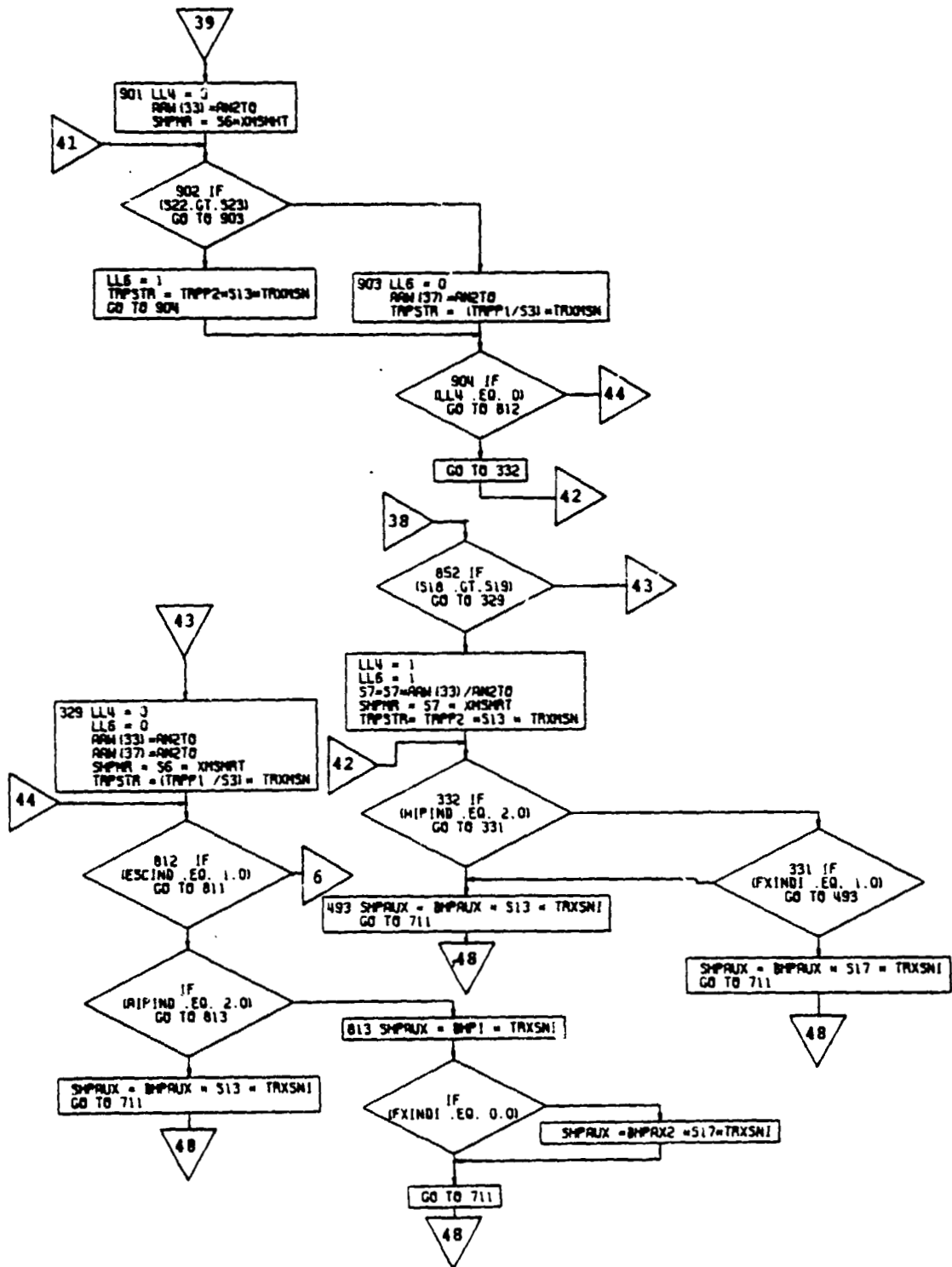


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 10 of 13)

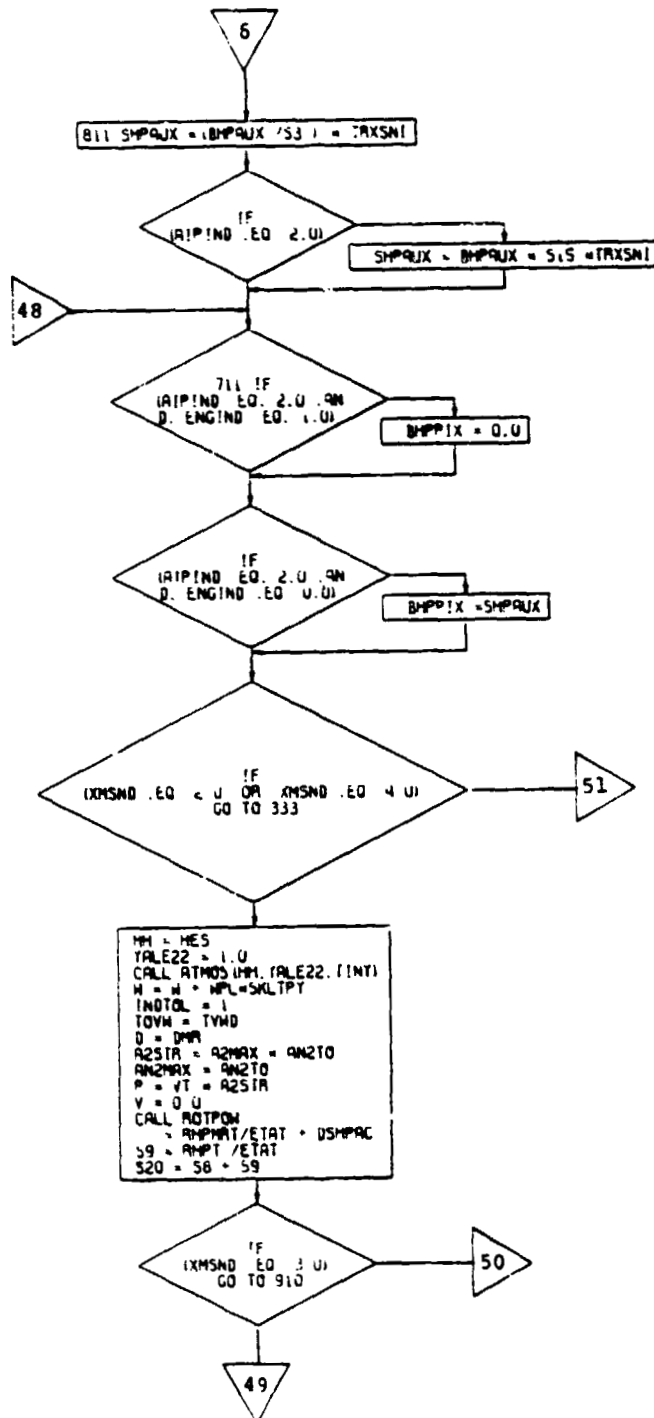


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 11 of 13)

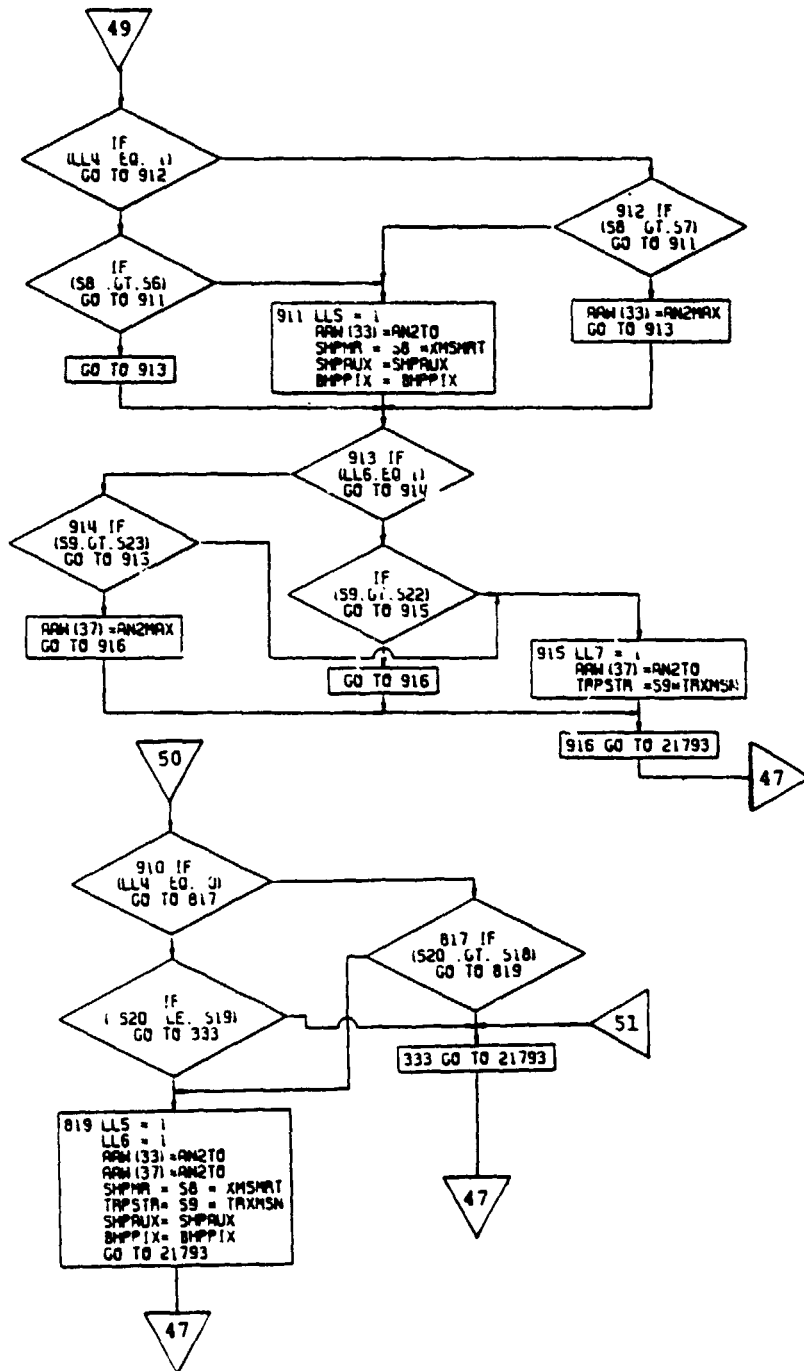


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 12 of 13)

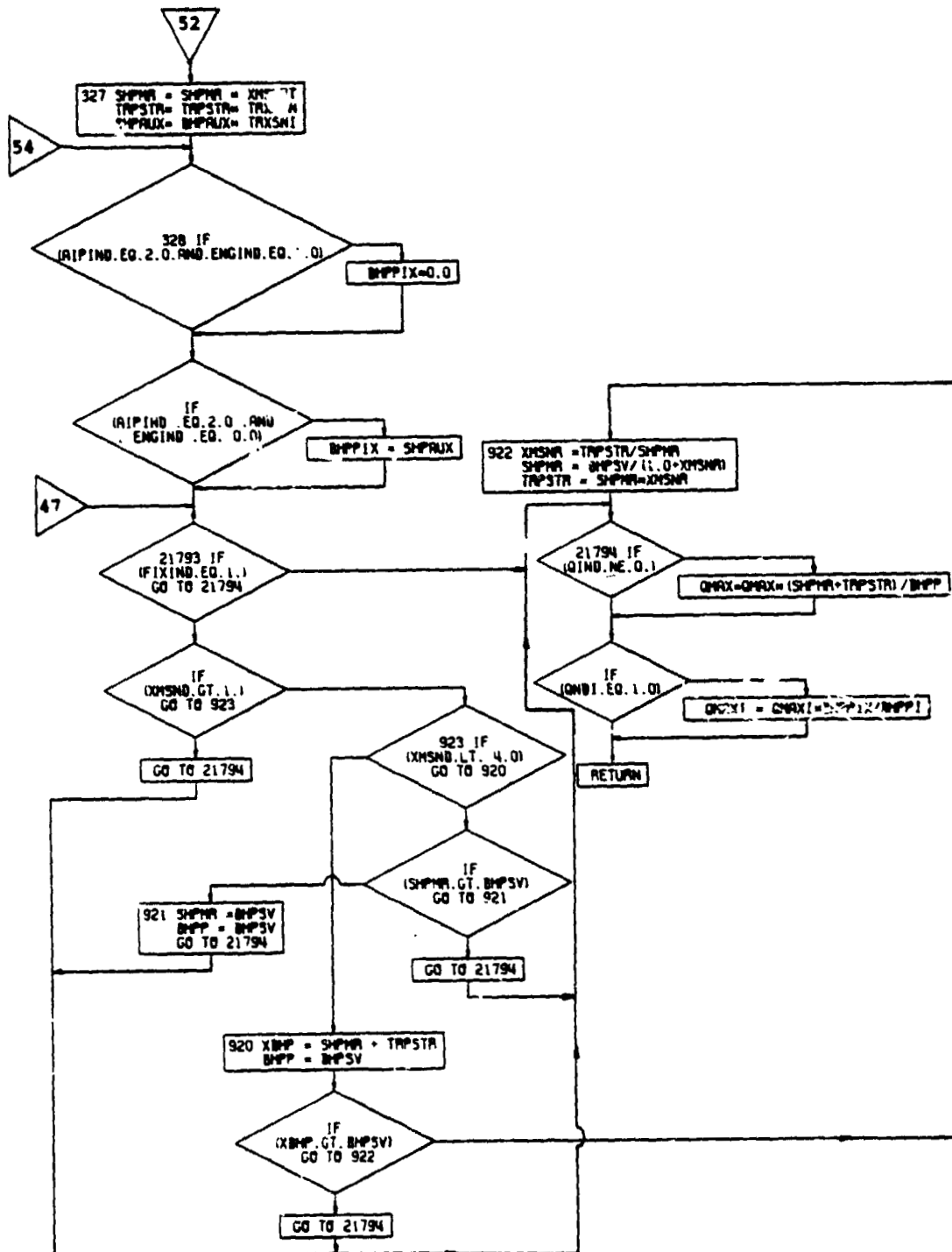


Figure 4-35. ENGSZ Subroutine, Flow Chart (Part 13 of 13)

#### 4.11 WEIGHT TRENDS SUBROUTINE

The weight trends subroutine calculates the group weights for the propulsion system, the structures 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 4-36). 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  $W_p$  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  $K_{18}$  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. For pure and auxiliary propulsion helicopters (without wings), the program uses the input value of maneuver load factor. In the case of a wing or compound helicopter, 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,

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

The gust load factor is calculated at the speed  $V_C$  (see Reference 11) which is taken to be equal to  $V_{MO}/M_{MO}$ . 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.

##### 4.11.1 Weight Trend Data

The weights subroutine section of HESCOMP 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 subgroups, as shown in Table 4-10, 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 4-37.



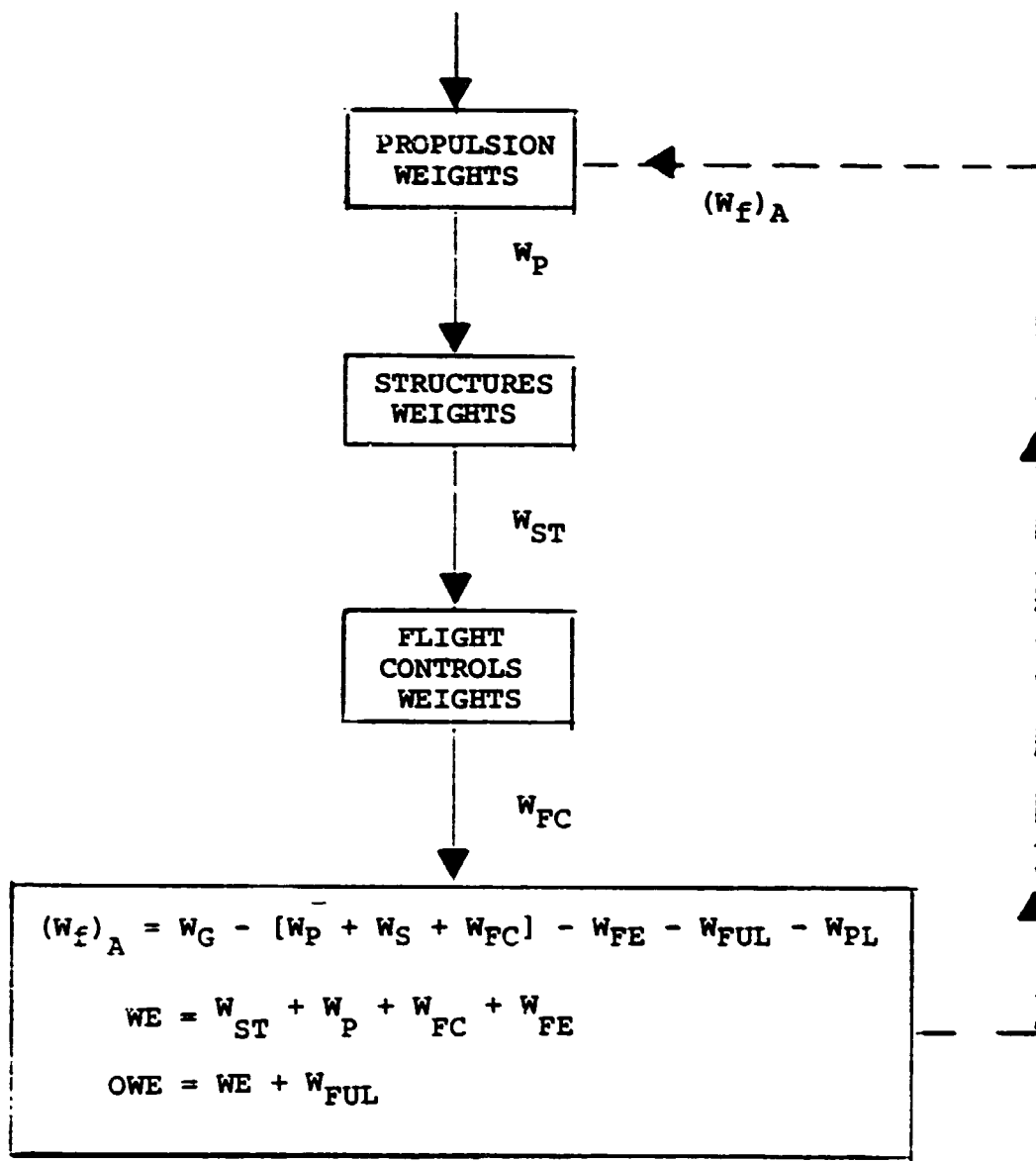


Figure 4-36. Weight Trends Subroutine.

TABLE 4-10. WEIGHT SUMMARY FORM

WING	1				
ROTOR	2				
TAIL	3				
SURFACES	4				
ROTOR	5				
BODY	6				
BASIC	7				
SECONDARY	8				
ALIGNING GEAR GROUP	9				
ENGINE SECTION	10				
	11				
PROPULSION GROUP	12				
ENGINE INST'L	13				
EXHAUST SYSTEM	14				
COOLING	15				
CONTROLS	16				
STARTING	17				
PROPELLER INST'L	18				
LUBRICATING	19				
FUEL	20				
DRIVE	21				
FLIGHT CONTROLS	22				
	23				
AUX. POWER PLANT	24				
INSTRUMENTS	25				
HYDR. & PNEUMATIC	26				
ELECTRICAL GROUP	27				
AVIONICS GROUP	28				
ARMAMENT GROUP	29				
FURN. & EQUIP. GROUP	30				
ACCOM. FOR PERSON.	31				
MISC. EQUIPMENT	32				
FURNISHINGS	33				
EMERG. EQUIPMENT	34				
AIR CONDITIONING	35				
ANTI-ICING GROUP	36				
LOAD AND HANDLING GP.	37				
	38				
	39				
	40				
	41				
WEIGHT EMPTY					
REV. CREW					
TRAPPED LIQUIDS					
ENGINE OIL					
FUEL					
GROSS WEIGHT					

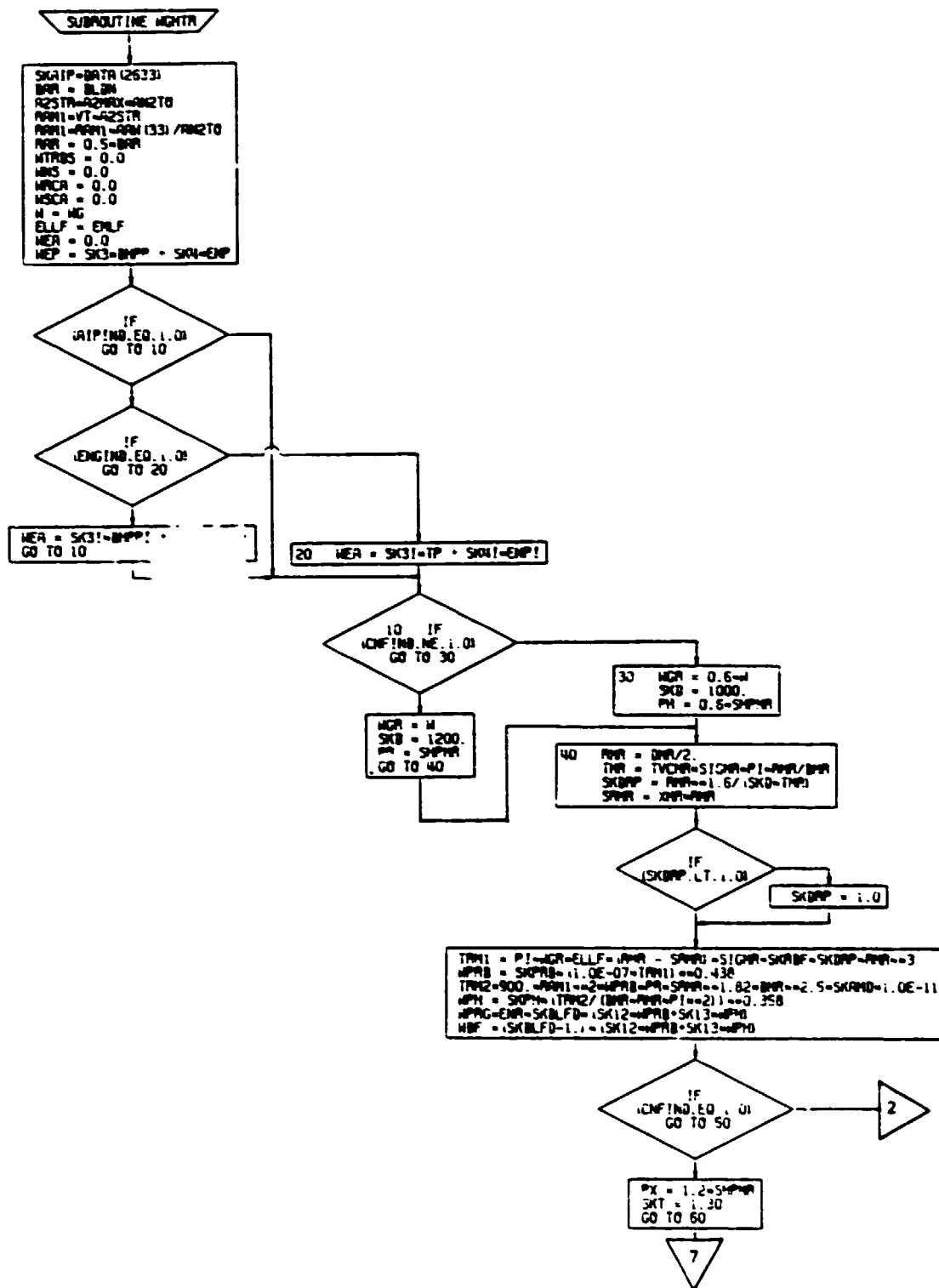


Figure 4-37. WGHTR Subroutine, Flow Chart (Part 1 of 5)

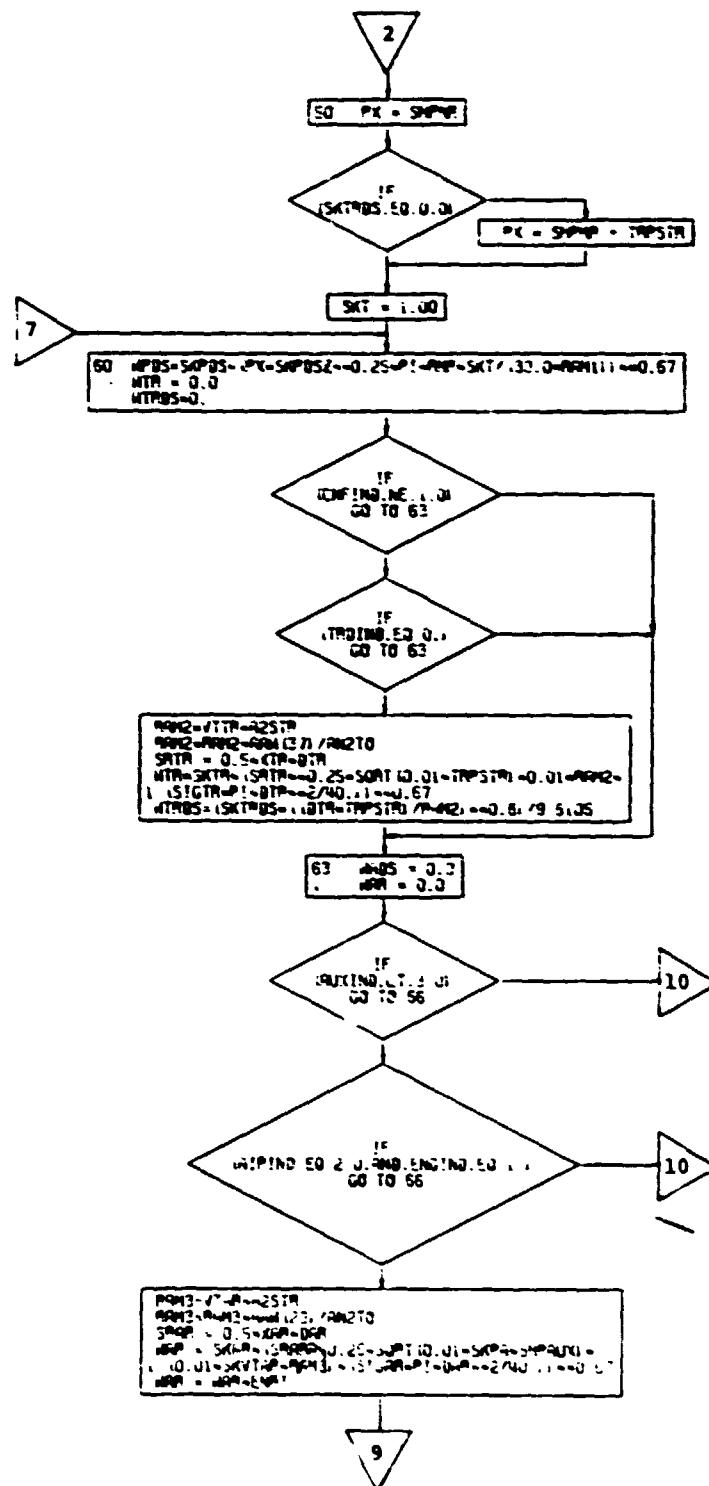


Figure 4-37. WGTR Subroutine, Flow Chart (Part 2 of 5)

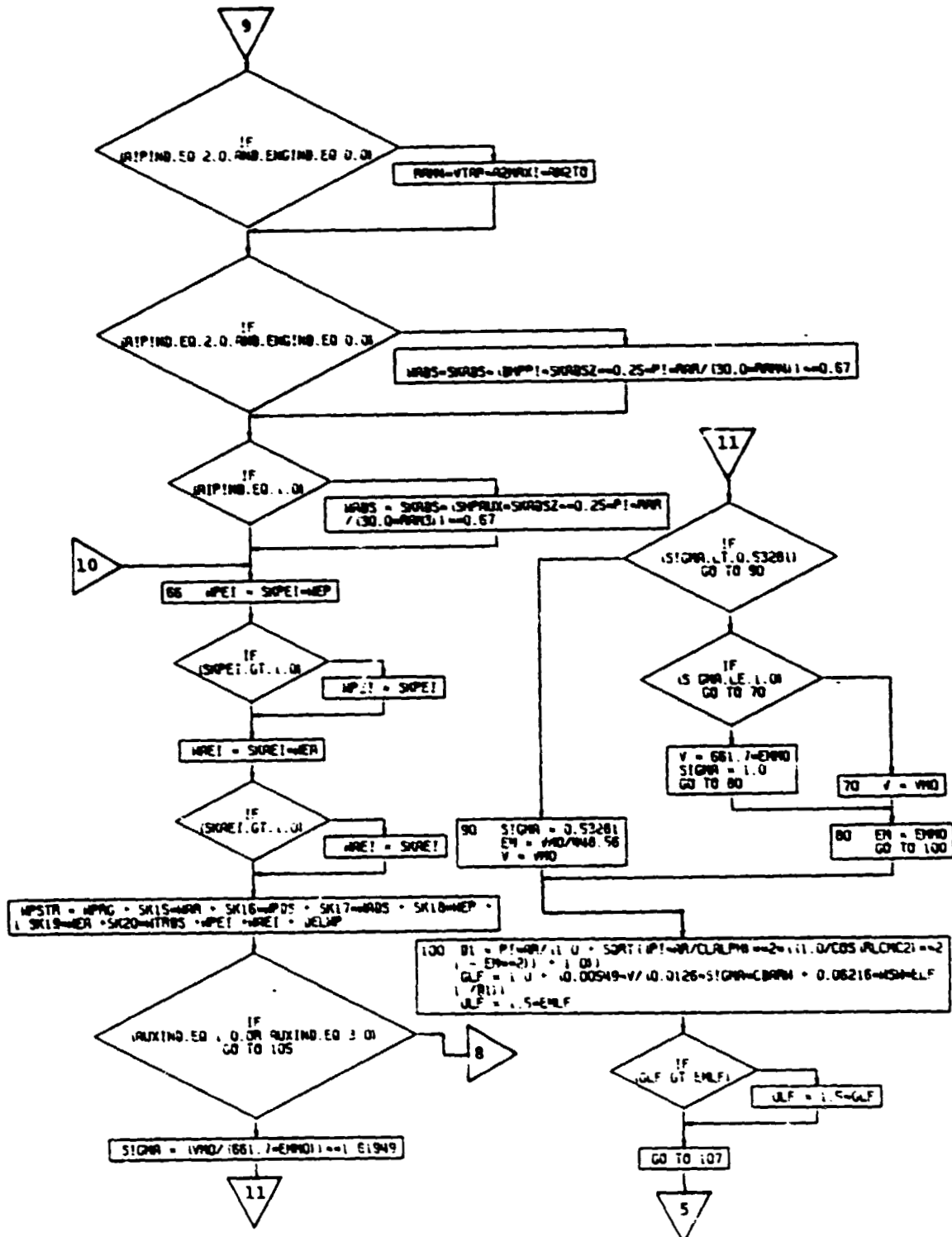


Figure 4-37. WGTR Subroutine, Flow Chart (Part 3 of 5)

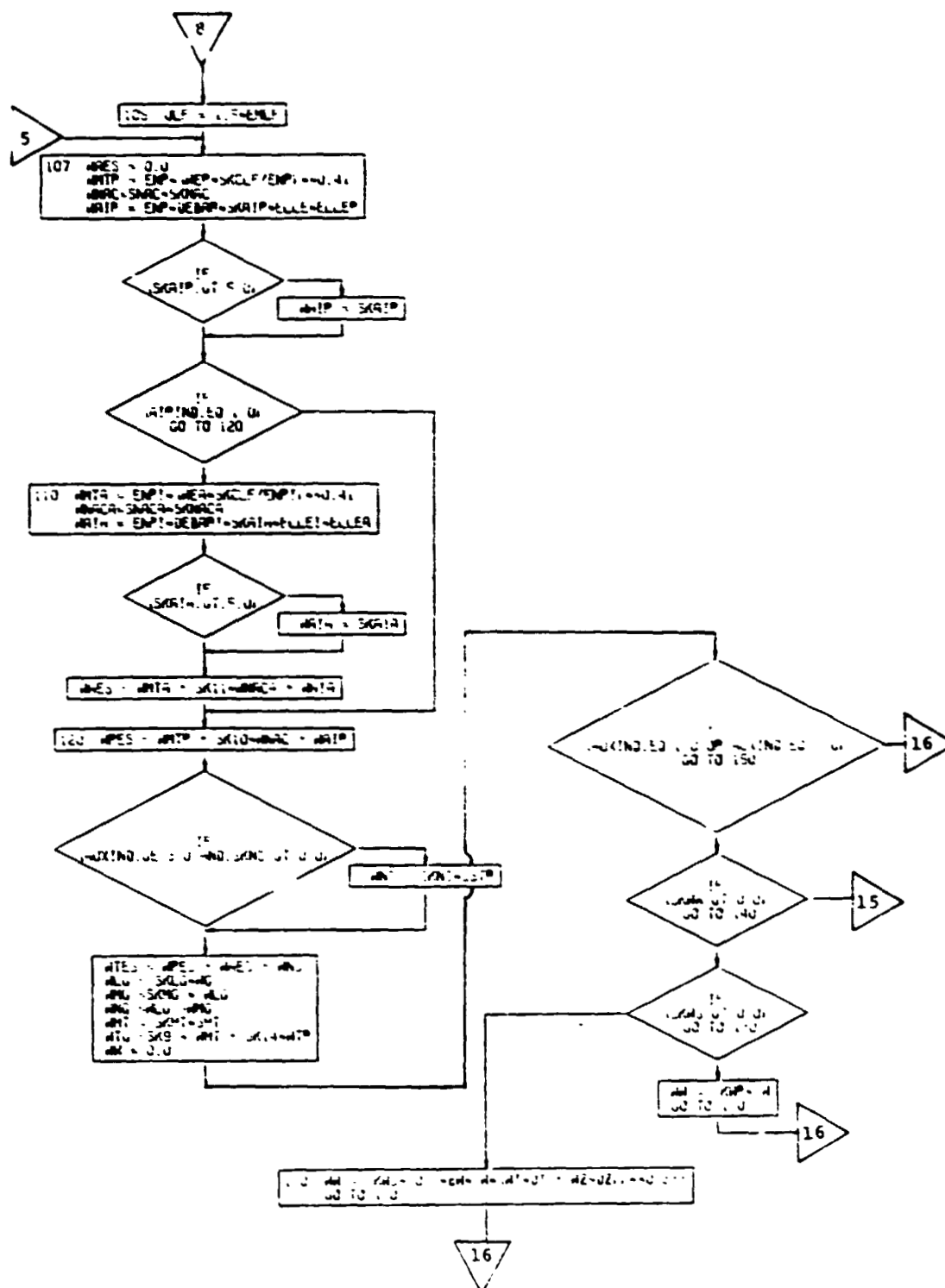


Figure 4-37. WGTR Subroutine, Flow Chart (Part 4 of 5)

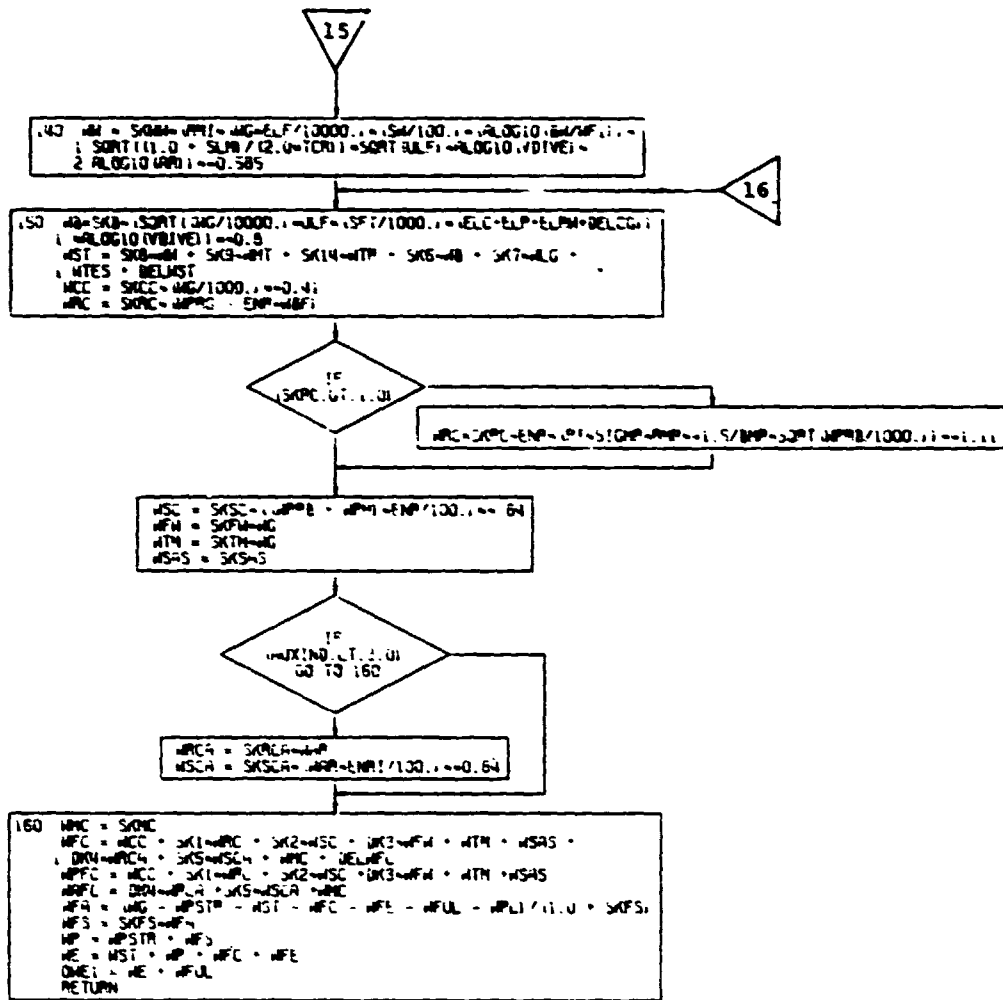


Figure 4-37. WGTR Subroutine, Flow Chart (Part 5 of 5)

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 term 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 helicopters. The results obtained from the trend equations will depend largely on engineering experience and the judgment exercised in selecting the various trend constants. The weight trend equations were developed by A. H. Schmidt and R. H. Swan of Boeing Vertol Company.

An explanation of the weight trends and instructions for completing the weight input sheet 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 4-11.

Weight trends developed at Boeing were used to determine the structure weights, Table 4-10, items 1, 6, and 10; flight control weights, item 22; and the control and propulsion system weights, items 2, 5, 18 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 compound, winged and propulsive tail helicopters, the trend constants have been adjusted to account for the design features typical of the particular configuration. Alighting gear weights, item 9, are a function of the design 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 installation weights, items 14, 15, 16, 17 and 19, are expressed as a percentage of the dry engine weight. Fuel system weight, item 20, is determined on a pound per gallon of fuel required basis. Fixed equipment weights, items 24 through 41, are discussed in the text.

The "a" term identified as "adjustment factor" in the description of the rotor, body and drive system weight trends is a simple aid for selecting the trend slope that most closely describes the study configuration. Example: If you desire a rotor blade that compares with the criteria and design of the BO-105 rotor blade the adjustment factor "a" would be 1.1 since the BO-105 point falls midway between  $a = 1.0$  and  $a = 1.20$  in Figure 4-38. The value of 48.4 ( $44 \times 1.1$ ) would be placed in the  $K_{PRB}$  (Loc. 2637) block on the weight input sheet (Table 4-11).



Table 4-10 is representative of a typical weight summary form used for military aircraft. Weight definitions as used in MIL-STD-1374 and weight handbooks follow.

6.2.3 Weight Definitions - As used in MIL-STD-1374 and Weight Handbooks.

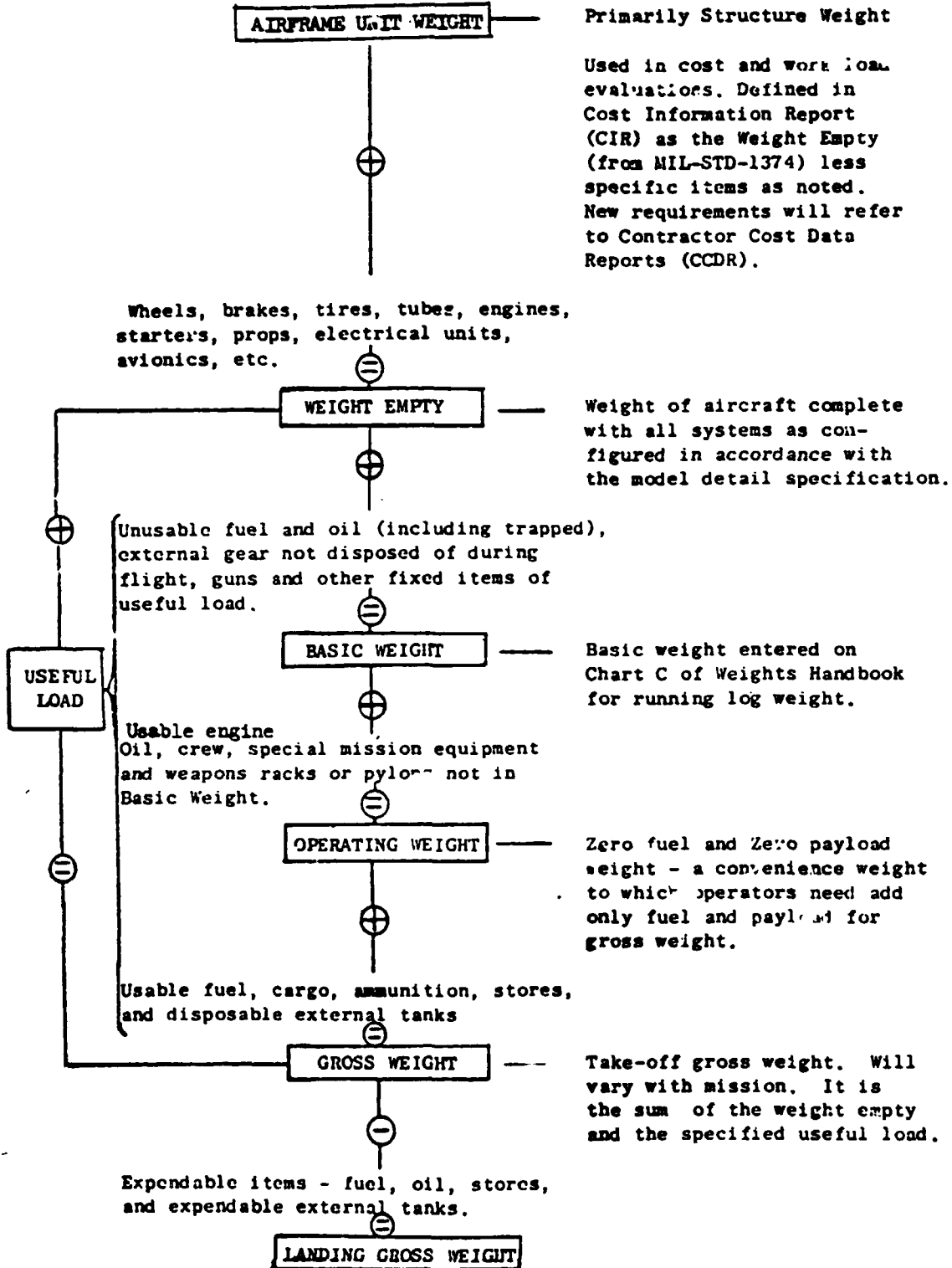


TABLE 4-11. HELICOPTER WEIGHT INFORMATION

Incremental Group Wts Nom = 0

Variable	LOC	Value*	Variable	LOC	Value*	Variable	LOC	Value*
OWE**	2601	4-174	$\Delta W_{FC}$	2605	4-214	$R_{M_I}$	2608	4-186
$W_{FE}$	2602	4-211	$\Delta W_P$	2606	4-214	$W_i$	2609	4-187
$W_{FUL}^{***}$	2603	4-211	$\Delta W_{ST}$	2607	4-214	$W_{Lo}$	2610	4-187
$W_{PL}$	2604	4-214				$L_i$	2611	4-187
						$L_o$	2612	4-187

Group Weight Information

Flight Controls			Structural			Propulsion		
$k_{CC}$	2613	4-207	$k_B$	2622	4-195	$k_{PRB}$	2637	4-189
$k_{RC}$	2614	4-207	$\Delta_{CG}$	2623	4-195	$k_{RBF}$	2638	4-189
$k_{SC}$	2615	4-207	$k_{LG}$	2624	4-197	$k_{PH}$	2639	4-189
$k_{FW}$	2616	4-207	$k_{MG}$	2625	4-197	$k_{amd}$	2640	4-189
$k_{TM}$	2617	4-207	$k_{WW}$	2626	4-186	$k_{BLDF}$	2641	4-189
$k_{SAS}$	2618	4-211	$LF$	2627	4-186	$k_{TR}$	2642	4-194
$k_{RCA}$	2619	4-211	$k_{WS}$	2628	4-187	$k_{AR}$	2643	4-192
$k_{SCA}$	2620	4-211	$k_{WP}$	2629	4-187	$k_{PA}$	2644	4-192
$k_{MISC}$	2621	4-211	$k_{HT}$	2630	4-192	$k_{VTAR}$	2645	4-192
			$k_{CLF}$	2631	4-201	$k_{PDS}$	2646	4-205
			$k_{NAC}$	2632	4-201	$k_{PDSZ}$	2647	4-205
			$k_{AIP}$	2633	4-201	$k_{TRDS}$	2648	4-207
			$k_{NACA}$	2634	4-201	$k_{ADS}$	2649	4-205
			$k_{AIA}$	2635	4-201	$k_{ADSZ}$	2650	4-205
			$k_{NS}$	2636	4-201	$k_{FS}$	2651	4-203
						$k_{PEI}$	2652	4-202
						$k_{AEI}$	2653	4-202
$k_1$	2654	4-214	$k_6$	2659	4-214	$k_{12}$	2665	4-214
$k_2$	2655	4-214	$k_7$	2660	4-214	$k_{13}$	2666	4-214
$k_3$	2656	4-214	$k_8$	2661	4-214	$k_{14}$	2667	4-214
$k_4$	2657	4-214	$k_9$	2662	4-214	$k_{15}$	2668	4-214
$k_5$	2658	4-214	$k_{10}$	2663	4-214	$k_{16}$	2669	4-214
			$k_{11}$	2664	4-214	$k_{17}$	2670	4-214
						$k_{18}$	2671	4-214
						$k_{19}$	2672	4-214
						$k_{20}$	2673	4-214

MULTIPLICATIVE FACTORS NOMINALLY = 1.0

\*Page numbers in this document  
 \*\*OWE is not necessary when OPTIND = 1,2  
 \*\*\* $W_{PL}$  is not necessary when OPTIND = 2

## Wing

The weight of the wing is determined using one of the following three methods:

● Method I

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

Where

$$k = \left[ \frac{R_M}{M} \right] \left[ \frac{W_g LF}{10^4} \right] \left[ \frac{S_w}{10^2} \right] \left[ \log \frac{b}{B} \right] \left[ \sqrt{\frac{1+\lambda}{2K}} \right] \left[ \sqrt{N} \right] \left[ \log_{10} V_D \right] \left[ \log_{10} AR \right]$$

### Legend

$W_W$  = weight of wing - lb

$R_M$  = wing relief as a fraction of design gross weight

$W_g$  = design gross weight

LF = helicopter lift factor as a fraction of gross weight

$S_w$  = planform area of wing (taken from  $C_L$  of aircraft) - ft<sup>2</sup>

b = wingspan - ft

B = maximum fuselage width - ft

$\lambda$  = taper ratio

N = ultimate load factor

$V_D$  = dive velocity - kn

$A_R$  = aspect ratio

$k_r$  = wing root thickness  $\div$  root chord

Method I is used when a conventional aircraft wing is employed. It considers basic geometry, design criteria, and relief terms. The 220 constant represents a wing employing simple control surfaces. The 220 adjusted up or down depending on the complexity of the surface controls (200-240) must be placed in the  $k_{ww}$  location on the weight input sheet. LF, representing the wing unloading factor, due to rotor lift, and  $R_M$ , a wing relief value (0.5 to 0.75) must be entered as a fraction of the design gross weight. The factors LF and  $R_M$  are nominally 1.0.

Method II

$$W_W = 3.15(k)^{0.333}$$

Where

$$K = S_W (W_i L_i + W_o L_o)$$

Legend

$W_W$  = weight of wing - lb

$S_W$  = planform area of wing -  $ft^2$

$W_i$  = inboard wing store weight, lb/per side

$W_o$  = outboard wing store weight, lb/per side

$L_i$  = distance from side of fuselage to inboard store - ft

$L_o$  = distance from side of fuselage to outboard store - ft

Method II is used when a sponson or stub type wing is used to carry stores or weapons. The trend constant 3.15 must be placed in  $k_{ws}$  of the weight input sheet.  $W_i$  and  $W_o$  must be entered in their respective locations in pounds per side.  $L_i$  and  $L_o$  must be entered as a fractional part of the wing semi-span.

● Method III

$$W_W = S_W \times PSF$$

Where

$W_W$  = weight of wing - lb

$S_W$  = planform area of wing -  $ft^2$

PSF = pounds per  $ft^2$

Method III is used when a single sponson or stub is employed. The estimated unit weight of the wing in pounds per square foot is placed in  $k_{wp}$  on the weight input sheet.

Main Rotors

The weight of the main rotor includes the combined weights of the blades and hub and hinge. The weights are derived from the following equations:

● Blades (per rotor)  $W_B = 44 a (k)^{0.438}$

where

$$k = \left[ \frac{W_g}{10^4} \right] \left[ \frac{LLF}{100} \right] \left[ \frac{R^2}{100} \right] \left[ \frac{R-r}{10} \right] \left[ \frac{b c k}{b} \right] ; \left[ \frac{R^{1.6}}{k_d t} \right]$$

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

● Hub and Hinge (per rotor)  $W_{HH} = 61 a (k)^{0.358}$

Where

$$k = \left[ \frac{W_b}{10^4} \right] \left[ \frac{R}{10} \right] \left[ \frac{N_R}{10} \right]^2 \left[ \frac{P_R}{10} \right] \left[ \frac{r}{10} \right]^{1.82} \left[ \frac{b}{10} \right]^{2.5} \left[ \frac{k_{amd}}{10} \times 10^{-11} \right]$$

Legend

$W_b$  = blade weight per rotor (including root end fitting)-lb

$a$  = adjustment factor

$W_g$  = design gross weight per rotor (X 0.6 for tandem)-lb

LLF = design limit load factor at dgw

$R$  = rotor radius-ft

$r$  = rotation to blade attachment-ft

$c$  = blade chord-ft

$b$  = number of blades per rotor

$t$  = maximum blade thickness at 25% R-ft

$k_b$  = rotor type factor: 1.00 articulated, 2.2 hingeless or teetering

$k_d$  = droop constant: 1000 tandem, 1200 single rotor

$N_r$  = rotor rpm

$P_r$  = takeoff power X (0.6 for tandem) per rotor-hp

$k_{amd}$  = a x m x d

a = design concept: 0.53 hingeless, 1.00 other

m = material: steel = 1.00, titanium = 0.54

d = development stage: early = 1.0, Developed - 0.62

In the trend equations the constants 44 (blade trend) and 61 (hub and hinge trend) represent the average for the rotor weights presented in Figure 4-38 and 4-39. The blade weights are most representative of the all metal blades. The adjustment factor a is used to adjust the k factor when special design features are considered, such as high modulus materials (boron, graphite, etc.) or special features associated with the hub and/or hinge. Refer to Figures 4-38 and 4-39 to select the a term which most closely approximates the configuration being analyzed. The revised constants 44a and 61a must be placed in the  $k_{PRB}$  and  $k_{PH}$  locations on the weight input sheet along with the factors  $k_{PRB}$  ( $k_b$  in legend) and  $k_{amd}$ . If blade folding is required the  $k_{BLFD}$  block on the input sheet must also be filled in. Blade folding is entered as a fractional part of the total rotor weight. The blade fold penalty usually runs between 1.15 to 1.25 of the rotor weight depending on the folding requirements. The nominal value for  $k_{BLFD}$  is 1.0.

#### Auxiliary Rotors or Propellers

When auxiliary rotors or propellers are required, as in the case of compounds or propulsive tail helicopters, the following rotor/propeller equation is used:

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

Where

$$k = \left[ \frac{r}{1} \right]^{0.25} \left[ \frac{H_{pr}}{100} \right]^{0.5} \left[ \frac{V_{tl}}{100} \right] \left[ \frac{R.b.c.}{10} \right]$$

#### Legend

$W_R$  = weight of rotor or propeller-lb

R = rotor radius-ft

b = number of blades per rotor

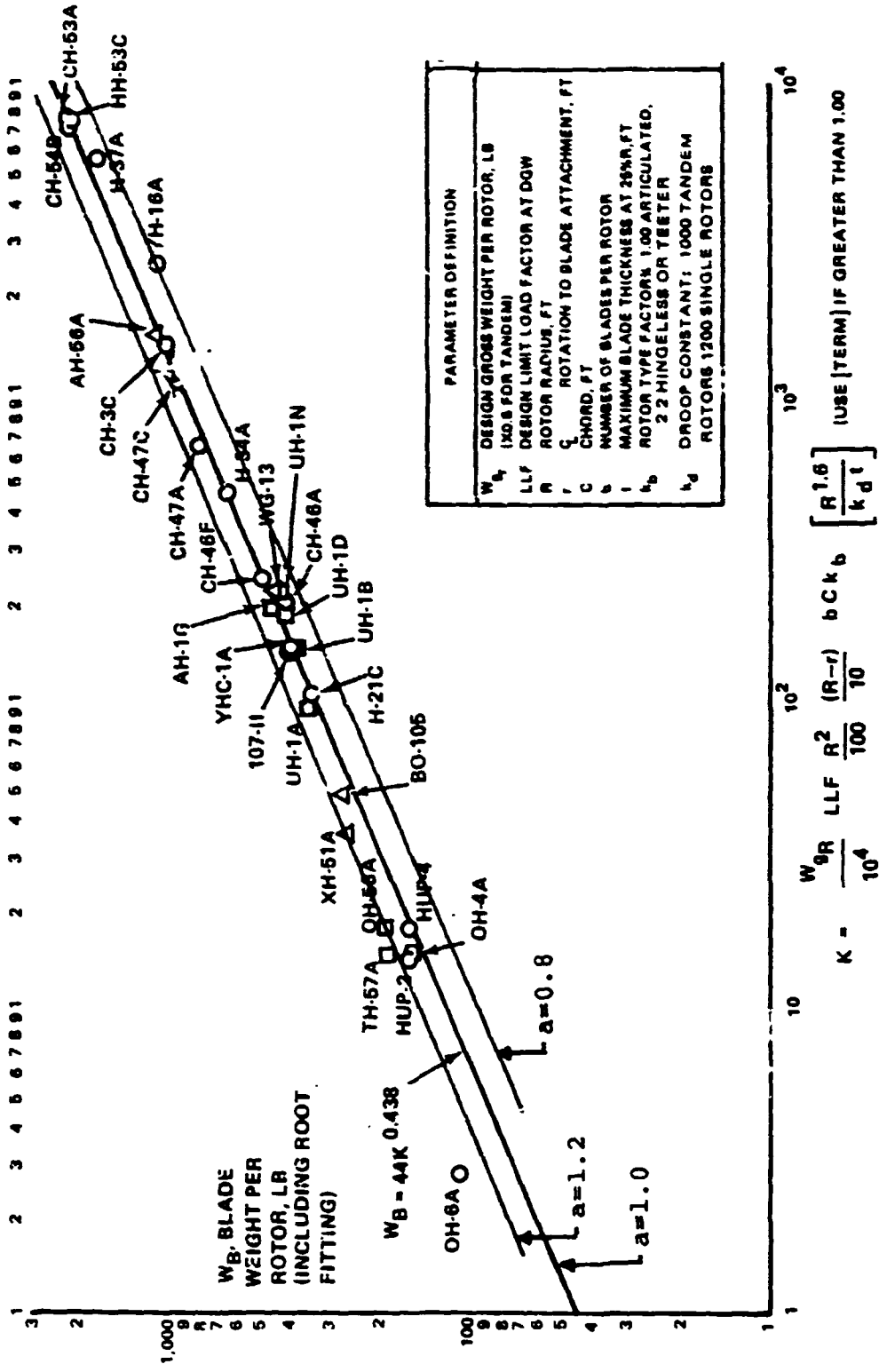


Figure 4-38. Rotor Blade Weight Trend.



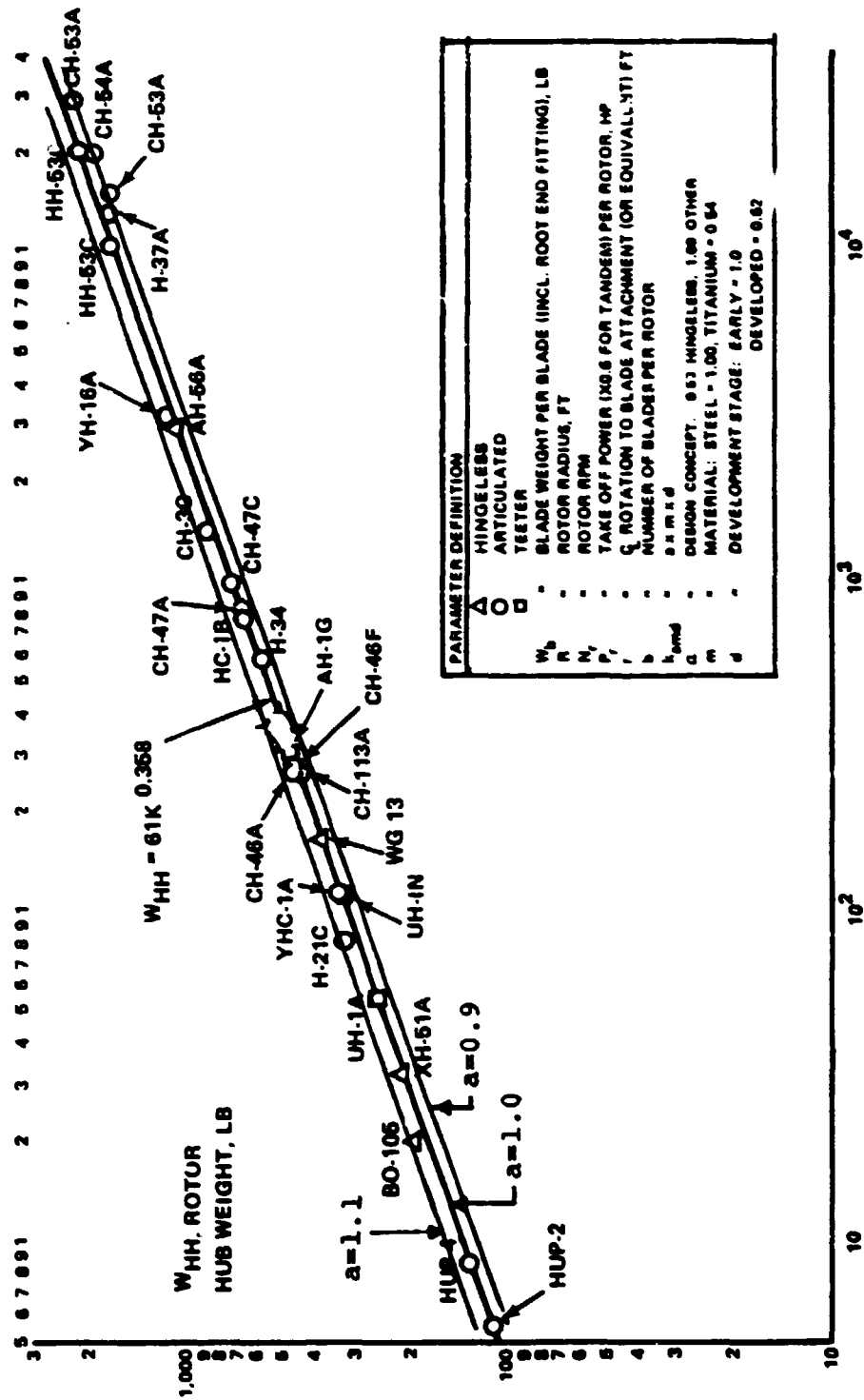


Figure 4-39. Rotor Hub and Hinge Weight Trend.

- $c$  = blade chord (average) -ft  
 $HP_R$  = horsepower (xmsn limit per rotor)  
 $V_{tl}$  = design limit tip speed-ft/sec  
 $r$  = center line of rotation to average blade attachment point-ft  
 $a$  = adjusting factor for type of system (see Figure 4-40)

In the trend equation the constant 14.2 is the average for the various rotor group weights presented in Figure 4-40. The expression  $a$  is the adjustment factor for the type of system; i.e., semirigid, pressure cycle, etc. To determine the value of  $k_{AR}$  in the propulsion block of the weight input sheet, multiply the type of system desired  $a$  by the constant 14.2. Blade folding, if required, is entered in  $k_{15}$  as a percentage factor of the total computed rotor weight. The input value would be between 1.15 to 1.25 depending on the folding requirements.

The  $k_{pA}$  block on the weight input sheet allows the auxiliary rotor input power to be increased or decreased as a fractional part of input power. ( $k_{pA} = 0.9$  would decrease the power by 10 percent, 1.1 would increase the power by 10 percent.)

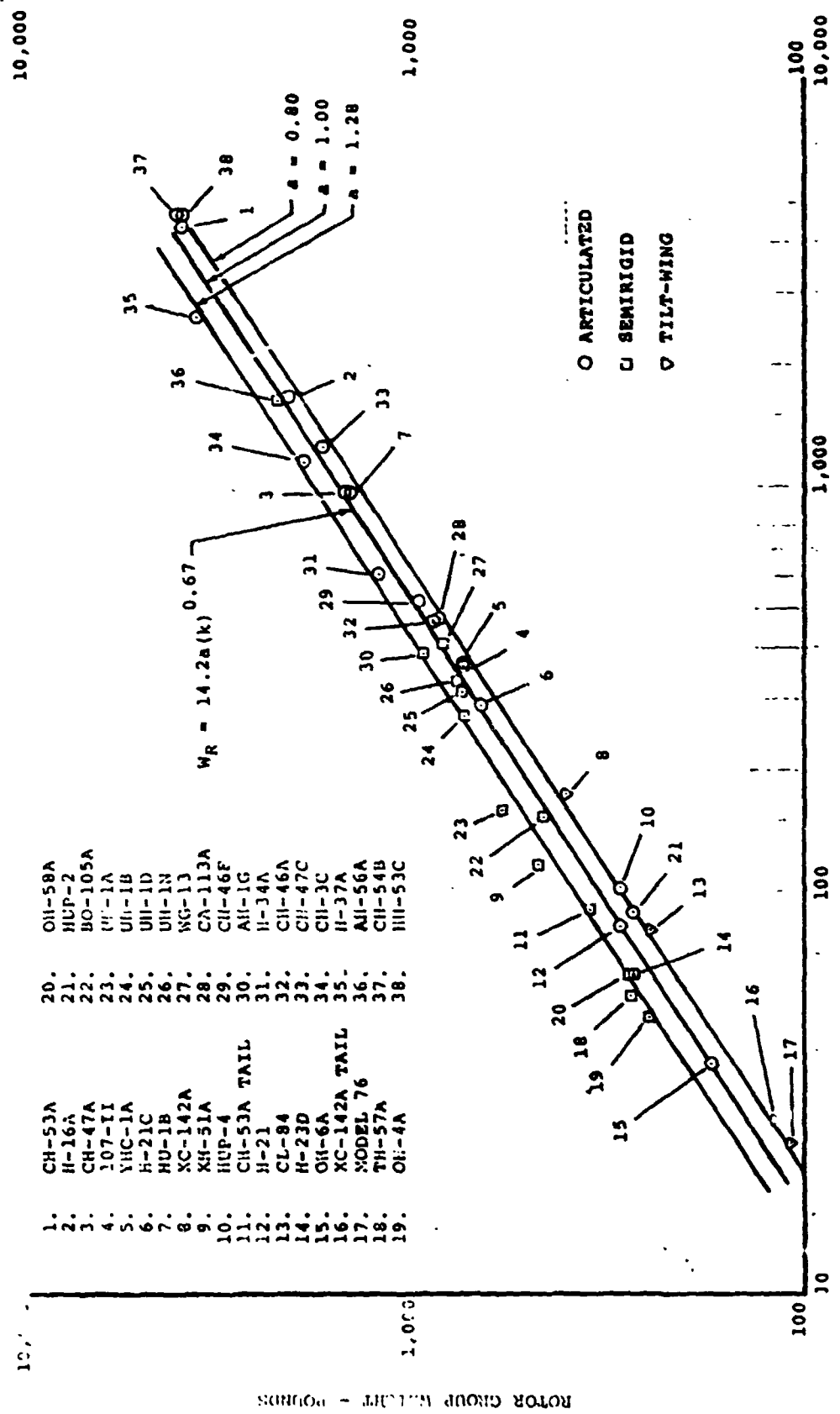
The  $k_{VTAR}$  block on the weight input sheet allows the auxiliary tail rotor tip speed to be increased or decreased as a fractional part of the input tip speed ( $k_{VTAR} = 0.9$  would decrease the tip speed by 10 percent, 1.1 would increase it by 10 percent). The nominal input values for  $k_{pA}$  and  $k_{VTAR}$  is 1.0.

### Tail Group

The tail group consists of the horizontal tail, vertical tail, ventral and tail rotor. Tail weights are determined as follows:

- Horizontal Tail - Its weight is based on a unit weight per square foot (PSF). The unit weight will normally vary between 1.0 and 2.0 PSF, depending on the type of tail being employed. The unit weights of the horizontal tails of some existing helicopters are presented as a guide for inputting the unit value in the  $k_{HT}$  block of the weight input sheet.

OH - 58A	1.1 lb/ft <sup>2</sup>	- fixed
UH - 1H	1.3 lb/ft <sup>2</sup>	- movable
UH - IN	1.6 lb/ft <sup>2</sup>	- stabilizer



- |     |              |     |         |
|-----|--------------|-----|---------|
| 1.  | CH-53A       | 20. | OH-58A  |
| 2.  | H-16A        | 21. | HUP-2   |
| 3.  | CH-47A       | 22. | BO-105A |
| 4.  | 107-II       | 23. | UH-1A   |
| 5.  | YHC-1A       | 24. | UH-1B   |
| 6.  | H-21C        | 25. | UH-1D   |
| 7.  | HU-1B        | 26. | UH-1H   |
| 8.  | XC-142A      | 27. | WG-13   |
| 9.  | XH-51A       | 28. | CA-113A |
| 10. | HUP-4        | 29. | CH-46F  |
| 11. | CH-53A TAIL  | 30. | AH-1G   |
| 12. | H-21         | 31. | H-34A   |
| 13. | CL-84        | 32. | CH-46A  |
| 14. | H-23D        | 33. | CH-47C  |
| 15. | OH-6A        | 34. | CH-3C   |
| 16. | XC-142A TAIL | 35. | H-37A   |
| 17. | MODEL 76     | 36. | AH-56A  |
| 18. | TH-57A       | 37. | CH-54B  |
| 19. | OH-4A        | 38. | HH-53C  |

Figure 4-40. Rotor Group Weight Trend.

If horizontal tail fold is required, input this as a percentage of the total horizontal tail weight in the  $k_9$  block of the input sheet (refer to Table 4-15).

- Vertical Tail and Ventral - The combined weights of vertical tail and ventral are included in the weight of the fuselage. The combined wetted area of both must be added to the fuselage wetted area.
- Tail Rotor - The weight of the tail rotor is derived from the following overall rotor trend equation:

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

Where

$$k = \left[ \frac{r}{10} \right]^{0.25} \left[ \frac{HP_R}{100} \right]^{0.5} \left[ \frac{V_{t1}}{100} \right] \left[ \frac{R.b.c.}{10} \right]$$

#### Legend

$W_R$  = weight of rotor or propeller-lb

$R$  = rotor radius-ft

$b$  = number of blades per rotor

$c$  = blade chord (average)-ft

$HP_R$  = horsepower (max limit per rotor)

$V_{t1}$  = design limit tip speed-ft/sec

$r$  = center line of rotation to average blade attachment point-ft

$a$  = adjusting factor for type of system (see Figure 4-40)

This is the same equation used to determine the weight of the auxiliary rotors. The trend is explained above under Auxiliary Rotors or Propellers. If blade folding is required, a factor as a fraction of the computed tail rotor weight must be placed in  $k_{14}$  on the weight input sheet. Fold penalties normally vary between 0.15 and 0.25 of total rotor weight depending on the fold requirements. A value for  $k_{TR}$  must be inserted in its proper location on the weight input sheet.

### Body Group

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

$$W_{BG} = 125 a (k)^{0.8},$$

Where

$$k = \left\{ \left[ \frac{W_g}{10^4} \right] \left[ \eta \right] \left[ \frac{S_f}{10^3} \right] \left[ L_c + L_{rw} + \Delta CG \right] \right\}^{0.5} \left[ \text{Log } V_{MAX} \right]$$

### Legend

$W_g$  = structural design gross weight - lb

$\eta$  = ultimate load factor

$S_f$  = wetted area of fuselage - ft<sup>2</sup> (includes fairings, pod, vertical tail and ventral)

$L_c$  = length of cabin (measured from nose to end of cabin floor) - ft

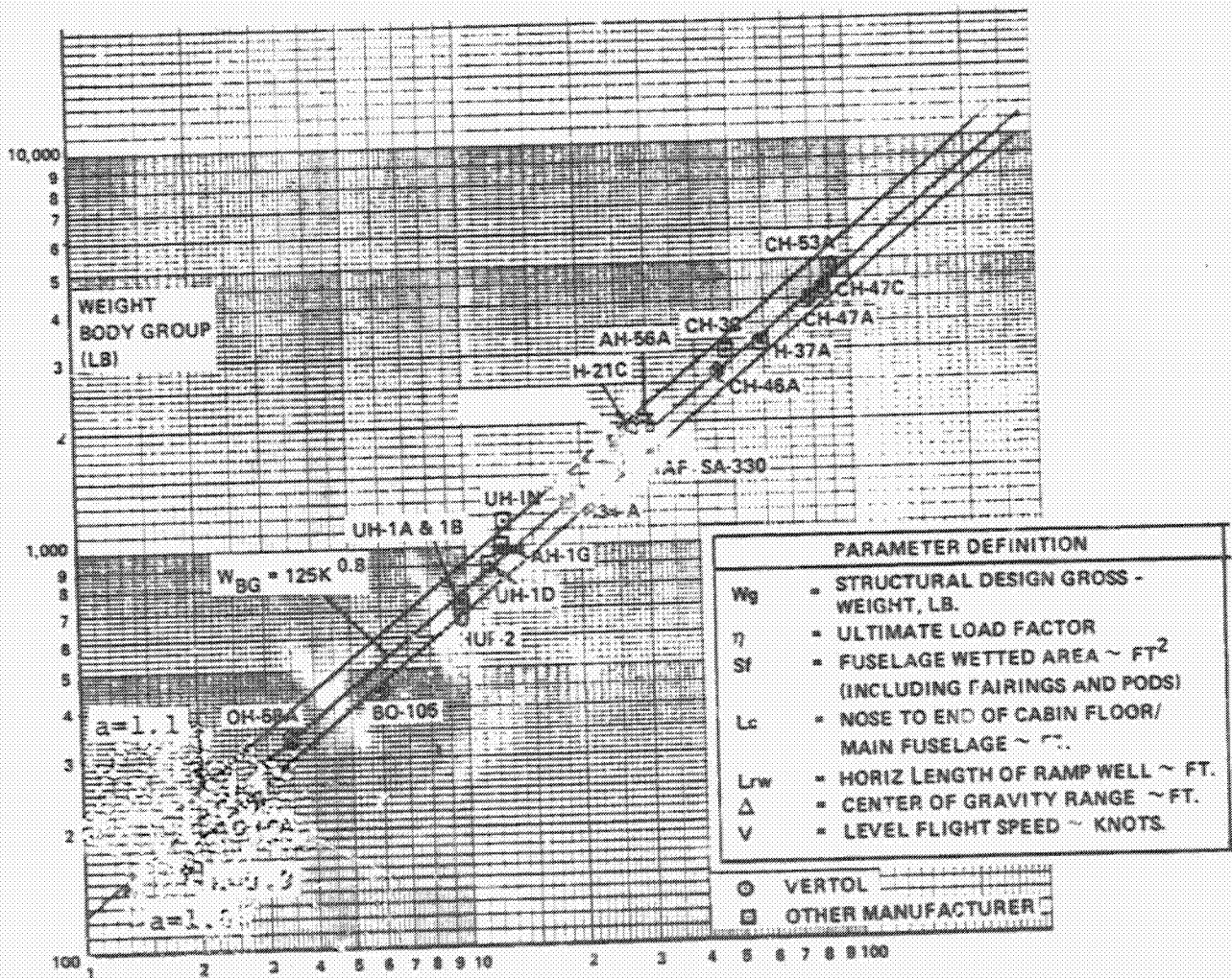
$L_{rw}$  = length of rampwell - ft

$\Delta CG$  = center of gravity range at design gross weight - ft

$V_{MAX}$  = maximum speed - kn

$a$  = body correction factor

Figure 4-41 presents a group of commercial and military single and tandem rotor helicopters. A mean line of 125 has been selected as the average for all the aircraft shown. The body correction factor  $a$  permits the 125 constant to be corrected in accordance with the configuration being analyzed. When a large number of cutouts are required as in the case of large doors, many windows, large floor cutouts, etc., the  $a$  term would be greater than 1. Where the fuselage is relatively clean, the  $a$  could be less than 1. Refer to Figure 4-41 to select the  $a$  term which best describes the configuration. The revised constant 125a is the  $k_b$  term to be inserted in the appropriate box on the weight input sheet. The center of gravity range, in feet, must also be placed in the  $\Delta CG$  block on the input sheet.



$$K = \left[ \frac{W_g}{10^4} \eta \frac{S_f}{10^3} (L_c + L_{rw} + \Delta) \right]^{0.5} \text{Log } V_{\max}$$

Figure 4-41. Body Group Weight Trend.

### 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 (including tail bumper)

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

$W_g$  = design gross weight

The percentage will normally vary between 0.015 to 0.050 depending on the design limit sink speed and the complexity of the system. Conventional landing gear without retraction, operating on improved runways normally run between 0.015 to 0.04. Adding retraction usually adds another 0.005 to 0.01. Skid type landing gear usually weigh about 0.015 times design gross weight.

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, or your estimate of the main gear weight as a fraction of the total gear weight, in the  $k_{MG}$  location on the weight input sheet.

Table 4-12 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 helicopters.

### Engine Section (Primary and Auxiliary)

The engine section weight appears as item 10 in Table 4-10. It is basically the engine mounts, engine nacelle structure and firewalls, air induction and support structure.

- Engine mounts - The weight of the engine mounts is determined from the expression

$$W_{EM} = N_E \left( W_E \times N_{CLE} \right)^{0.41}$$

TABLE 4-12. LANDING GEAR WEIGHTS

AIRCRAFT	GROSS WEIGHT (LB)	TOTAL GEAR WEIGHT (LB)	PERCENT OF GROSS WEIGHT
OH-6A	2400	58	.024
XH-51A	3500	134	.038
BO-105	4410	96	.022
UH-1B	6600	112	.017
UH-1D	6600	118	.018
UH-1N	10000	121	.012
UH-34D	11291	413	.036
AH-56A	16995	605	.036
CH-46A	19000	589	.031
CH-3C	19500	690	.035
CH-46D	20800	587	.028
CH-46E	20800	655	.031
HH-3B	21187	700	.033
CH-47A	28550	1060	.037
CH-47B	33000	1086	.033
CH-47C	33000	1076	.033
CH-53A	35042	1014	.029
CH-54A	38000	1794	.047
CH-54B	64700	2277	.035



Enter the crash load factor  $N_{CLF}$  in the  $k_{CLF}$  block of the weight input block. (This considers both the primary and/or auxiliary engine sections.)

- Engine nacelle structure, supports and firewalls

These items are determined from the expression

$$W_{NAC} = N_E (S_{NAC}) \text{ (PSF)}$$

Enter the estimated unit weight in pounds per square foot (PSF) in the  $k_{NAC}$  and/or the  $k_{NACA}$  blocks of the input sheet. This value normally varies between 0.75 and 1.25 PSF. It could go as high as 2.0 psf if the cowling is used as a walkway or work platform.

- Air induction - The weight of the air induction system is determined from the expression

$$W_{AIP} = N_E (\pi E_{DIA} \times L_{AIP}) \text{ (PSF)}$$

Enter the estimated unit weight in pounds per square foot (PSF) in the  $k_{AIP}$  and/or the  $k_{AIA}$  blocks of the input sheet. This value normally varies between 0.7 to 1.0 PSF. An option is provided for determining the weight of the air induction system. If  $k_{AIP}$  or  $k_{AIA}$  is greater than 5.0 the program automatically assumes the value is the weight of the air induction system in pounds.

The  $k_{NS}$  term on the input sheet is a nacelle strut factor used when an engine is suspended from an aircraft employing a wing. Enter a unit weight value in PSF in the  $k_{NS}$  box. The nominal value is 0.

### Legend

$W_{EM}$  = weight of engine mounts - lb

$N_E$  = number of primary engines

$W_E$  = weight of each primary engine - lb

$N_{CLF}$  = aircraft crash load factor

$W_{NAC}$  = weight of each primary engine nacelle - lb

$S_{NAC}$  = wetted area of each nacelle - sq. ft.

PSF = pounds per square foot

$W_{AIP}$  = weight of air induction system - feet

$E_{DIA}$  = primary engine DIA - feet

$L_{AIP}$  = length of air inlet duct

The weight of the primary and/or auxiliary engines is determined as part of the engine sizing routine considered elsewhere in the program. There is no provision for determining the engine weight(s) on the weight input sheet. The  $\Delta_{WP}$  and  $K_{18}$  and  $K_{19}$  blocks of the input sheet provide a method for adding weight to the engine(s) if desired. (Refer to Table 4-13.

The engine installation weights represent the total weight of items 14, 15, 16, 17, and 19 shown on the weight summary form, Table 4-10. The weights of engine (primary and auxiliary) installation items will vary depending on the type and power-plant arrangement of the configuration being sized. No attempt is made here to describe all the various approaches that may be used to evaluate their weights, but instead a simple method of taking a percentage of the weight of the dry engines is used to define the weight of the engine installation. The percentages applied will depend on the judgment of the user. Table 4-13 presents the engine installation weights as a percentage of the engine weight for a group of existing helicopters. This may be used as a guide for selecting the weight fraction to be placed in  $k_{PEI}$  and/or  $k_{AEI}$  on the weight input sheet. An option is provided for determining the weight of the engine installation. If  $k_{PEI}$  or  $k_{AEI}$  is greater than 1.0, the program automatically assumes the value is the weight of the engine installation in pounds.

#### 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 aircraft having simple fuel systems located in the fuselage, sponsons or 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. The fuel system factors represent fuel system weight per pound of mission fuel required.

#### Drive System (Primary and Auxiliary)

The weight of the drive system (primary and auxiliary) including gear boxes, accessory drives, shafting, oil, supports, etc., is derived from the following equation:

$$W_{DS} = 250 a (k_D)^{0.67},$$

where

$$k_D = \left[ \frac{P_X}{N_R} \right] \left[ Z \right]^{1/4} \left[ K_t \right]$$

TABLE 4-13. ENGINE INSTALLATION WEIGHTS

AIRCRAFT	AIRCRAFT ENG. WEIGHT (LB)	ENG. INSTAL. WEIGHT (LB)	PERCENT OF ENGINE WEIGHT
OH-6A	142	36	.254
XH-51A	244	97	.398
BO-105	424	81	.191
UH-1B	474	148	.312
UH-1D	501	147	.293
UH-1N	727	164	.226
UH-34D	1387	260	.187
AH-56A	695	337	.485
CH-46A	600	161	.268
CH-3C	611	130	.213
CH-46D	678	187	.276
CH-46E	886	207	.234
HH-3E	649	136	.210
CH-47A	1160	173	.149
CH-47B	1188	175	.147
CH-47C	1350	244	.181
CH-53A	1432	283	.198
CH-54A	1804	193	.107
CH-54B	2094	394	.188

Note: Engine installation weights include the total weight of the following items:

- Engine Exhaust System
- Engine Cooling
- Engine Control
- Engine Starting
- Engine Lubrication

### Legend

- $W_{DS}$  = weight of the drive system - lb (excluding tail rotor boxes and shafting)
- $P_X$  = drive system horsepower rating (tandem rotor  $P_X = 1.2 \times$  takeoff rating)
- $N_R$  = rotor rpm at takeoff
- $Z$  = number of stages in main rotor drive
- $K_t$  = configuration factor: 1.00 for single rotor, 1.30 for tandem
- $a$  = drive system correcting factor

The drive system adjusting factor  $a$  is used to account for type, number of boxes, special features, etc., included in the drive system. Figure 4-42 gives typical examples of the  $a$  factor. To determine the  $k_{PDS}$  and/or the  $k_{ADS}$  figure to place on the weight input sheet, multiply the 250 constant by your selection of  $a$ . The  $k_{PDSZ}$  and/or  $k_{ADSZ}$  (number of stages) must also be placed in their respective locations on the input sheet. As a guide for determining the number of stages to input the following is offered:

	<u>Stages</u>
● Lightweight helicopters (less than 10,000 pounds gross weight)	2
● Medium weight helicopters (10,000 pounds to 30,000 pounds gross weight)	3-4
● Heavy weight helicopters (more than 30,000 pounds gross weight)	4-5

An additional guide in determining the number of stages is to assume one stage for each gear reduction in the drive system. This would include angle boxes. (Assume  $\frac{1}{2}$  of a stage for 1:1 angle boxes.) The total additive sum of the stages resulting from this approach would then be placed in their respective  $k$  locations on the input sheet.

### Tail Rotor Drive System

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

$$W_{DS} = 300 a (k)^{0.8},$$

Where

$$k = \frac{HP_{Total} \times 1.1}{RPM_{Rotor}}$$

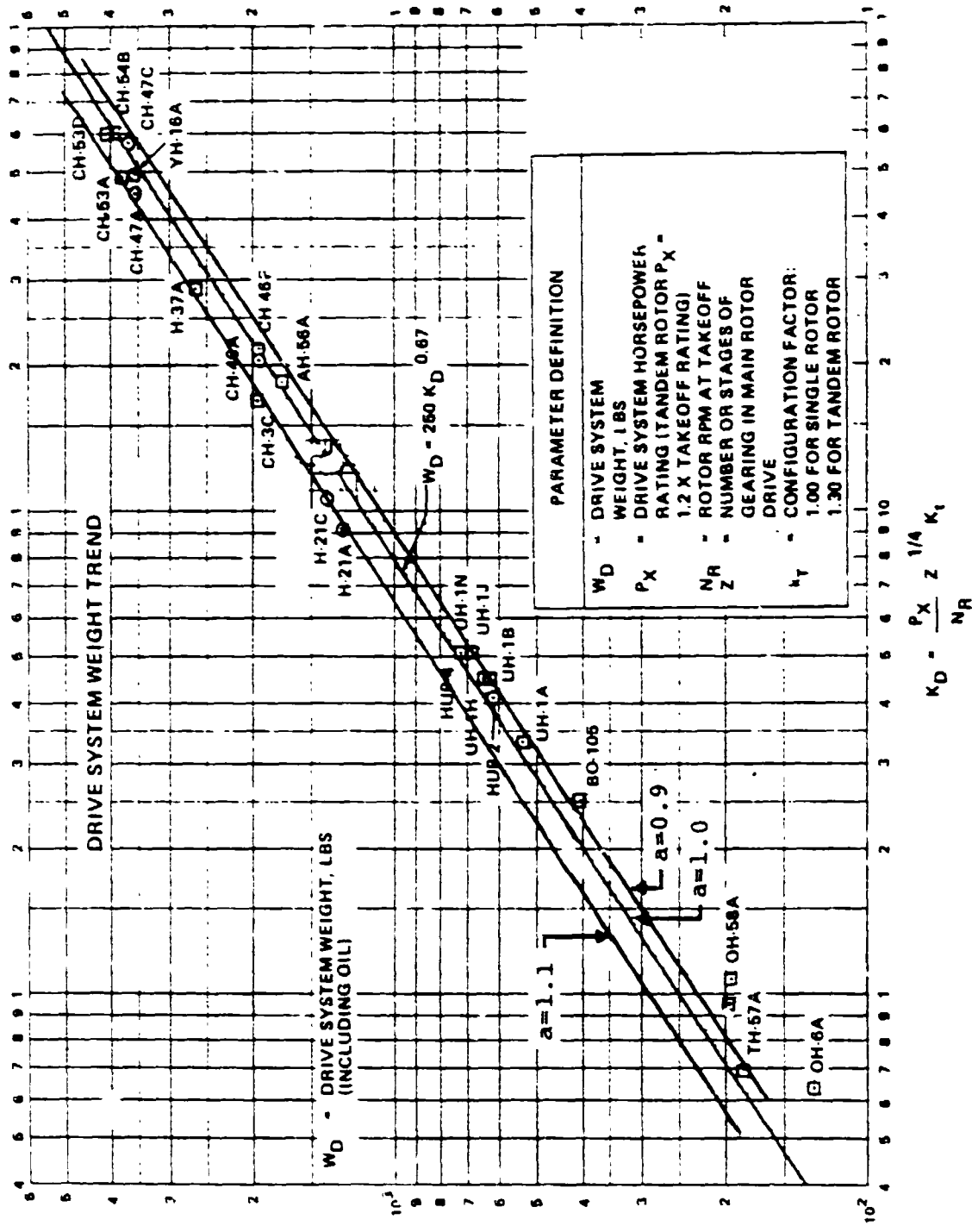


Figure 4-42. Drive System Weight Trend-Primary and Auxiliary.

### Legend

- $W_{DS}$  = weight of drive system - lb  
 $HP_{Total}$  = total tail rotor horsepower  
 $RPM_{Rotor}$  = tail 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  $a$ .

### Flight Controls

The weight of the flight control system will vary depending on the type and system required (manual, power assisted, redundant, dual redundant, etc.) and the type of helicopter being configured (pure, winged, compound, propulsive tail, etc.). Aircraft control systems requiring power assistance and dual or triple redundant components will weigh more than configurations having simple, non-redundant systems. Considerations must be given to these factors when determining the flight control constants to insert on the weight input sheet.

An equation which includes a combined series of weight trend expressions applicable to most any type of helicopter configuration is presented below. It includes factors which can be isolated and applied to the particular vehicle being analyzed. Values for the various  $k$  factors described must be put in their proper locations on the weight input sheet. A description of the items comprising each of the control sub-groups is included along with a range of  $k$  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.

$$W_{FC} = k_{CC} \left[ \frac{W_g}{1000} \right]^{0.41} + k_{RC} \left[ \frac{C \sqrt{R W_B}}{1000} \right]^{1.11} + k_{SC} \left[ \frac{W_R}{100} \right]^{0.84} \\ + k_{FW} [W_g] + k_{TM} [W_g] + k_{SAS} + k_{RCA} [W_R] \\ + k_{SCA} \left[ \frac{W_R}{100} \right]^{0.84} + k_{Misc.}$$

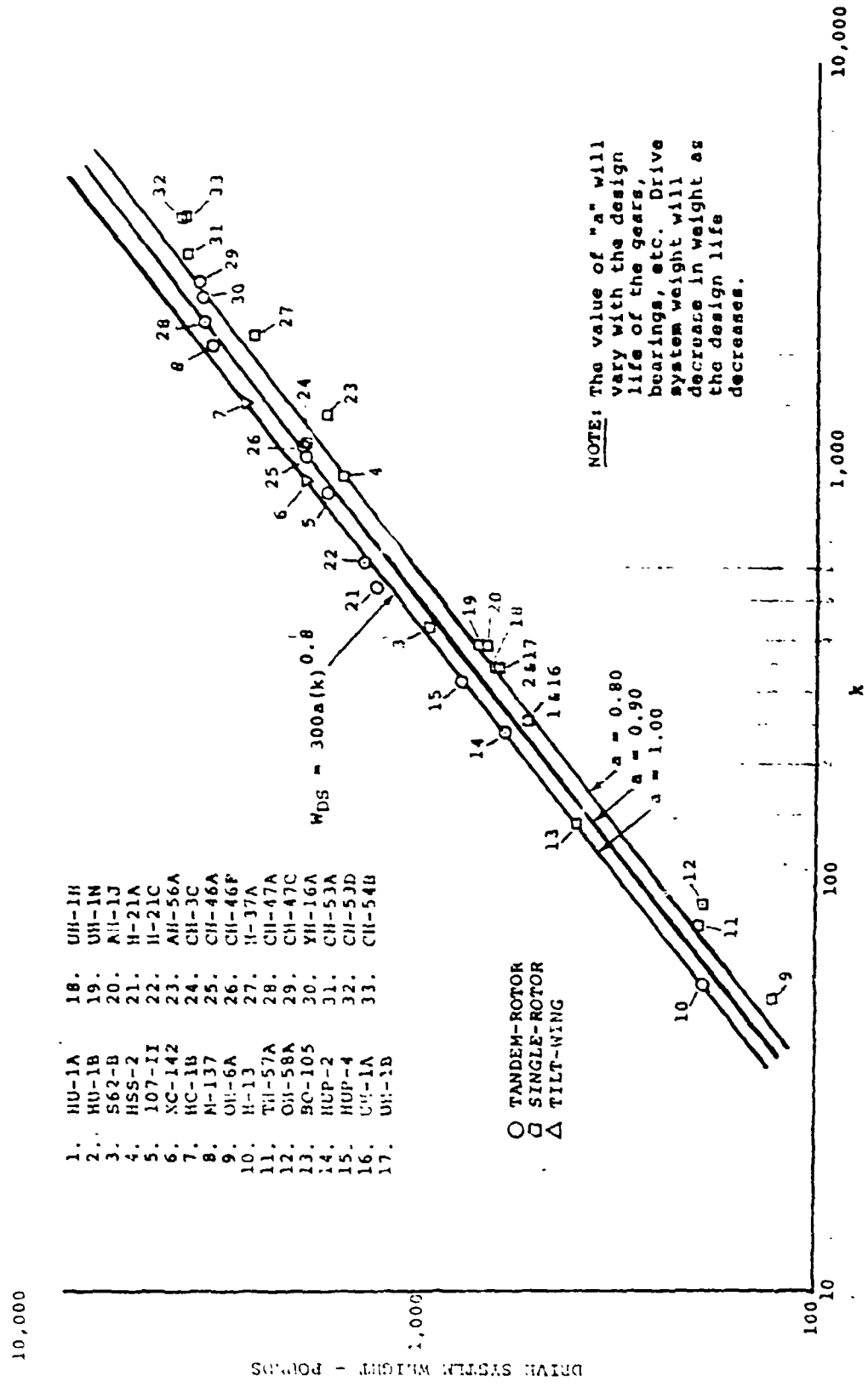


Figure 4-43. Drive System Weight Trend-Tail Rotor.



Legend

$W_{FC}$  = weight of flight controls - lb

$W_g$  = design gross weight - lb

$C$  = rotor blade chord - ft

$R$  = rotor radius - ft

$W_b$  = rotor blade weight per rotor - lb

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

Cyclic and collective control sticks and linkages, pedals, cables and rods (Figure 4-44)

$k_{RC}$  = constant for main rotor controls

All components from and including the power actuators up through the pitch links. Major items included are the actuators, swashplate, and pitch links (Figure 4-45).

If  $k_{RC} \geq 1.0$ , the following equation is used.

$$W_{RC} = k_{RC} C \frac{RW_b}{10000} \quad \text{typical values are } k_{RC} = 18 \text{ to } 23.$$

If  $k_{RC} < 1.0$ , the main rotor controls are weighed using the following:

$$W_{RC} = k_{RC} (W_R - N_R W_{BF}) \quad \text{where } W_R \text{ is total rotor weight and } NRW_{BF} \text{ is blade folding.}$$

$k_{SC}$  = constant for main rotor systems and hydraulics = 25 to 35

All components between the cockpit controls and the rotor controls including actuators, artificial feel system, mechanical programmer, bellcranks, rods, idlers, etc. (Figure 4-46)

Main hydraulic systems including pumps, reservoirs, accumulators, filters, valves, lines, fluid, and supports (Figure 4-46)

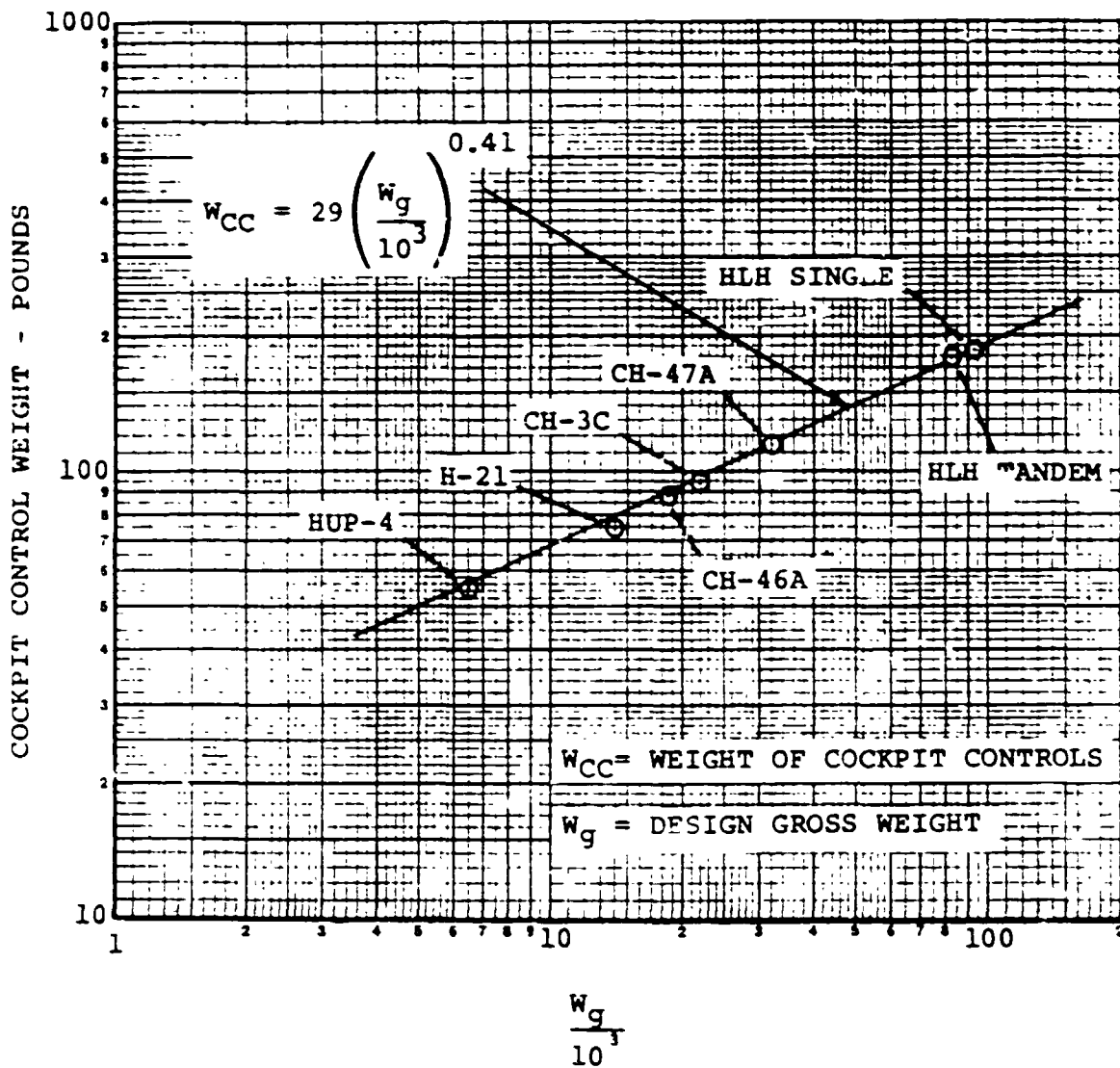


Figure 4-44. Cockpit Controls Weight Trend.

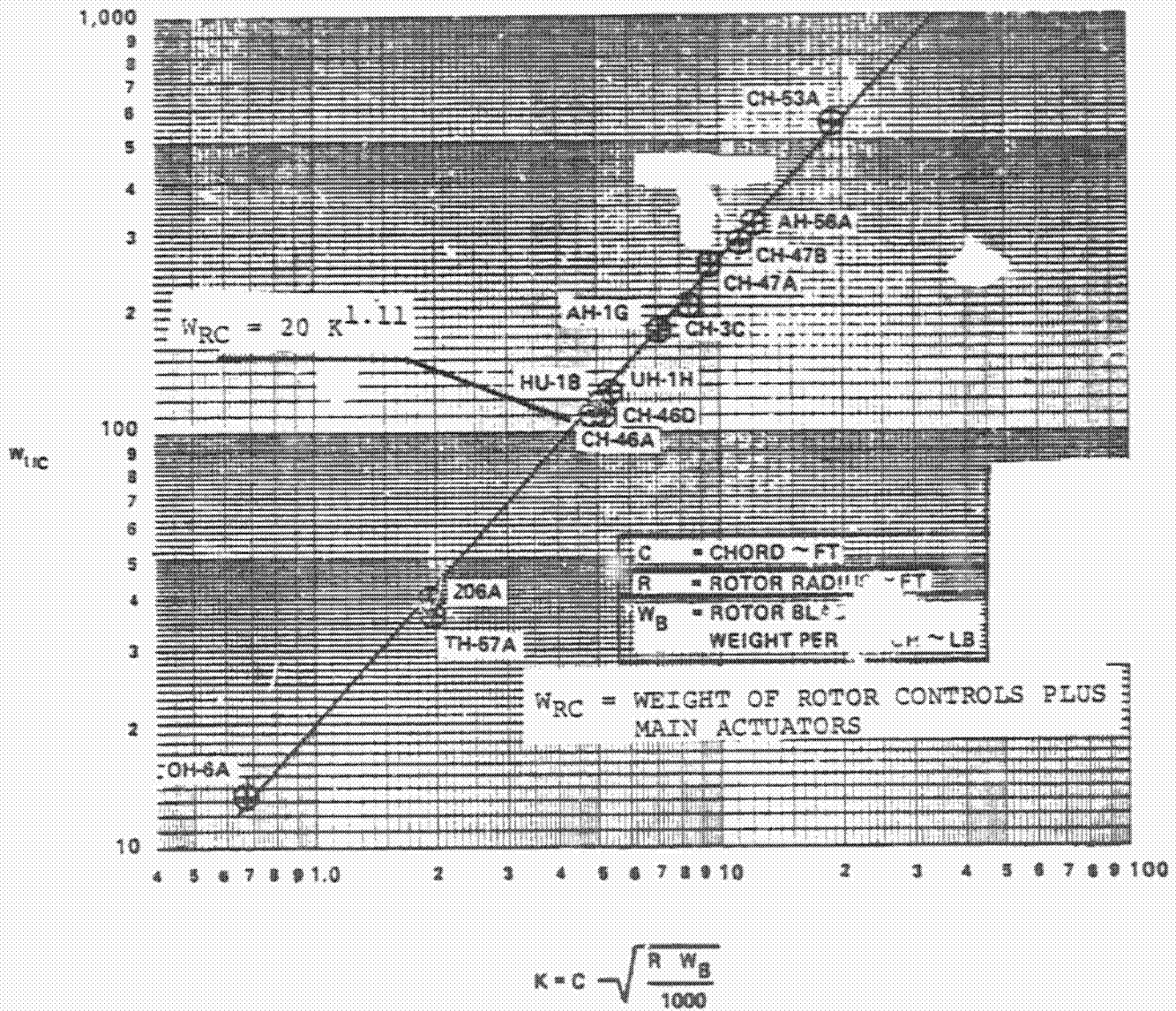


Figure 4-45. Rotor Controls Weight Trend.

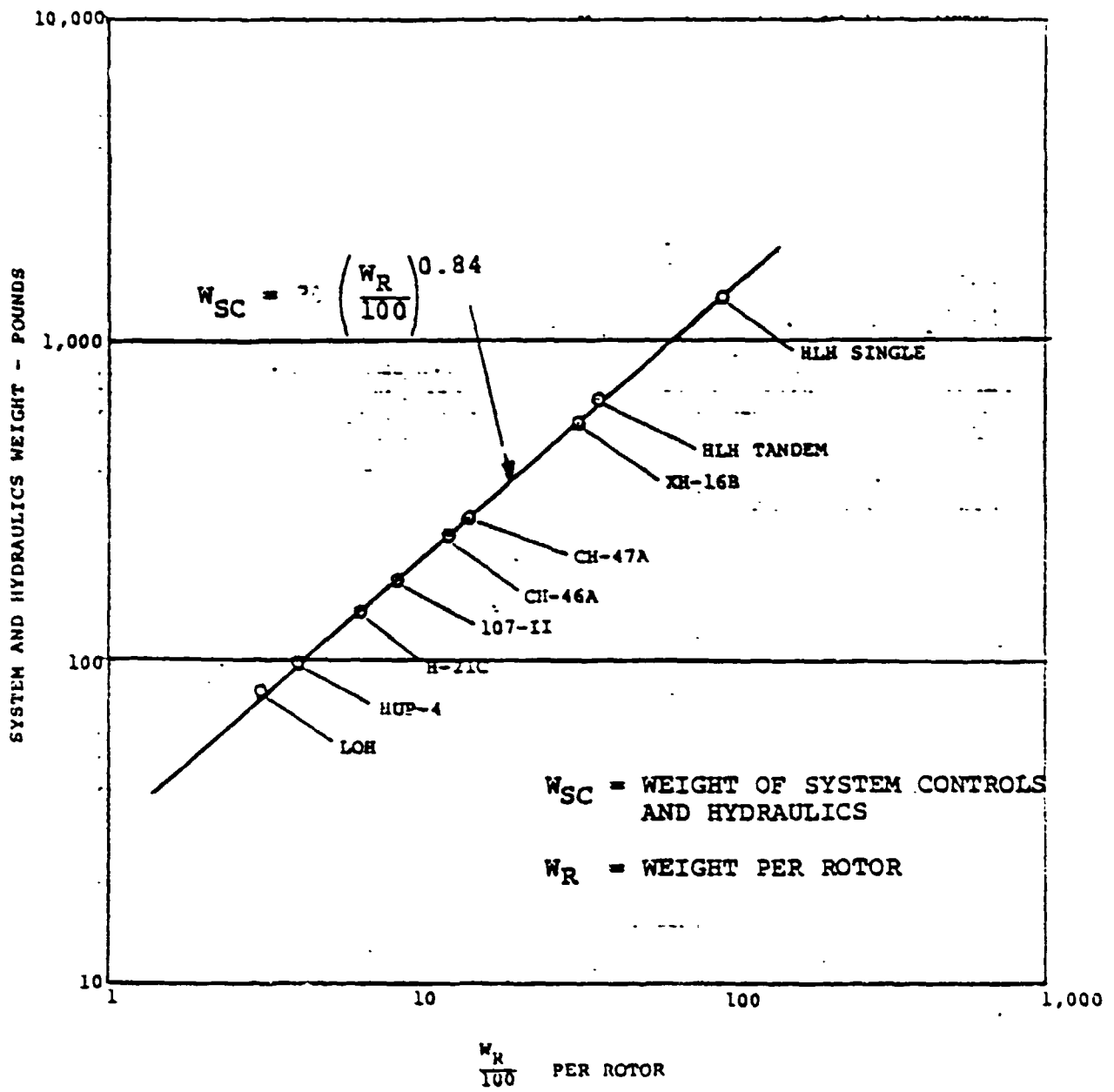


Figure 4-46. Rotor System and Hydraulics Weight Trend.

$k_{FW}$  = constant for conventional fixed-wing controls = 0.005 to 0.020, depending on complexity and number of functions required

All components, actuators, and supports associated with moving the control surfaces - LE umbrellas, flaperons, spoilers, and tail surfaces

$k_{TM}$  = constant for tilting mechanism - 0.005 to 0.015

All components and supports required to tilt the wing including actuators, power control units, mechanical system, fittings, and hardware. The  $k_{TM}$  value will vary proportionately with the hinge moment and/or wing transition rate required.

$k_{SAS}$  = constant for stability-augmented system = 20 pounds to 100 pounds, depending on system required

$k_{RCA}$  = constant for auxiliary rotor controls

Similar to  $k_{RC}$  - provides rotor control weights for auxiliary propulsive systems (pusher props, ducted fan, etc., Figure 4-47)

$k_{SCA}$  = constant for auxiliary rotor system controls

Similar to  $k_{SC}$  - provides rotor system control weights for auxiliary propulsive systems (pusher props, ducted fans, etc., Figure 4-46)

$k_{Misc.}$  = estimated weight input in pounds for any items not covered above

#### Fixed Equipment

The weight of the fixed equipment is included in the weight empty and consists of the following groups: auxiliary power-plant, instruments, hydraulics and pneumatics, electrical, avionics, armament, furnishings and equipment, air-conditioning, anti-icing and load and handling (Table 4-10).

The weight of the fixed equipment will vary with the type and requirements of the aircraft under study. The largest variation in fixed equipment weights usually appears in the avionics and the furnishings and equipment groups. The avionics group reflects communication and navigational requirements; the furnishings and equipment group normally reflects cabin size and personnel accommodations (pilots seats, troop seats, etc.). Table 4-14 presents some typical examples of the fixed equipment weights for some existing military helicopters.

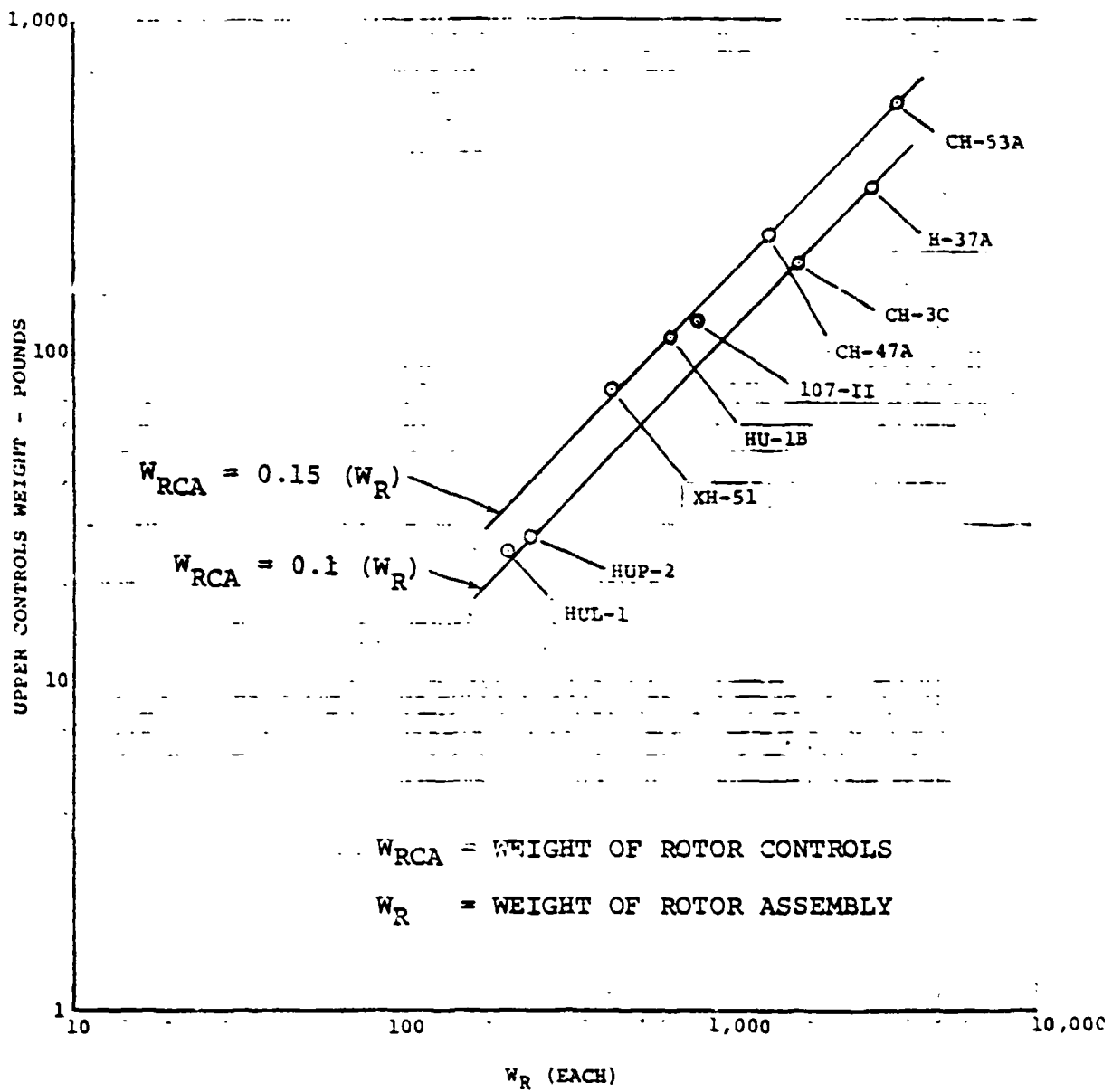


Figure 4-47. Auxiliary Rotor Controls Weight Trend.

TABLE 4-14.  
FIXED EQUIPMENT AND FIXED USEFUL LOAD WEIGHTS

	CH-46A	CH-47A	CH-53A	CH-3C	AH-56A	107-IF-10	
WING							
ROTOR							
TAIL							
SURFACES							
ROTOR							
BODY							
BASIC							
SECONDARY							
ALIGNING GEAR GROUP							
ENGINE SECTION							
PROPULSION GROUP							
ENGINE INST'L							
EXHAUST SYSTEM							
COOLING							
CONTROLS							
STARTING							
PROPELLER INST'L							
LUBRICATING							
FUEL							
DRIVE							
FLIGHT CONTROLS							
AUX. POWER PLANT	100	103	204	224	136	-	
INSTRUMENTS	169	161	393	232	126	98	
HYDR. & PNEUMATIC	163	227	112	66	86	-	
ELECTRICAL GROUP	620	560	594	450	377	583	
AVIONICS GROUP	386	274	512	437	609	602	
ARMAMENT GROUP	-	-	18	-	548	-	
FURN. & EQUIP. GROUP	788	896	971	569	273	1300	
ACCOM. FOR PERSON.		182	391	298	208	165	555
MISC. EQUIPMENT		77	107	384	87	73	601
FURNISHINGS		481	329	214	175	-	-
EMERG. EQUIPMENT		48	69	75	99	35	144
AIR CONDITIONING	128	145	237	123	75	128	
ANTI-ICING GROUP	186	4	77	37	42	13	
LOAD AND HANDLING GP.	305	260	358	189	-	14	
FIXED EQUIP, WEIGHT	2845	2660	3576	2327	2272	2738	
CREW	540	600	660	645	400	400	
TRAPPED LIQUIDS	20	41	18	20	31	28	
ENGINE OIL	30	28	48	33	32	31	
SURVIVAL KIT				63	-		
ARMOR					399		
GUNS					1235		
ATTENDANT						150	
BAGGAGE						370	
FUEL							
FIXED USEFUL LOAD	590	669	726	761	2097	979	

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. It includes the crew, trapped and unusable fuel and oil, guns, weapons, racks or pylons and any other fixed items of useful load which makes the aircraft operational. Typical weights for fixed useful load items are included in Table 4-14 as a guide for inputting a number in the  $W_{FUL}$  block of the weight input sheet.

#### 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 remains constant regardless of gross weight. The nominal value for any block in this section is 0, except for  $R_M$  which is nominally 1.0.

#### Group Weight Information

The nominal value for items in this section of the weight input sheet is 0, except as noted in the text. 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  $K_1$  through  $K_{20}$  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 multiplicative box. Refer to Table 4-15 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.

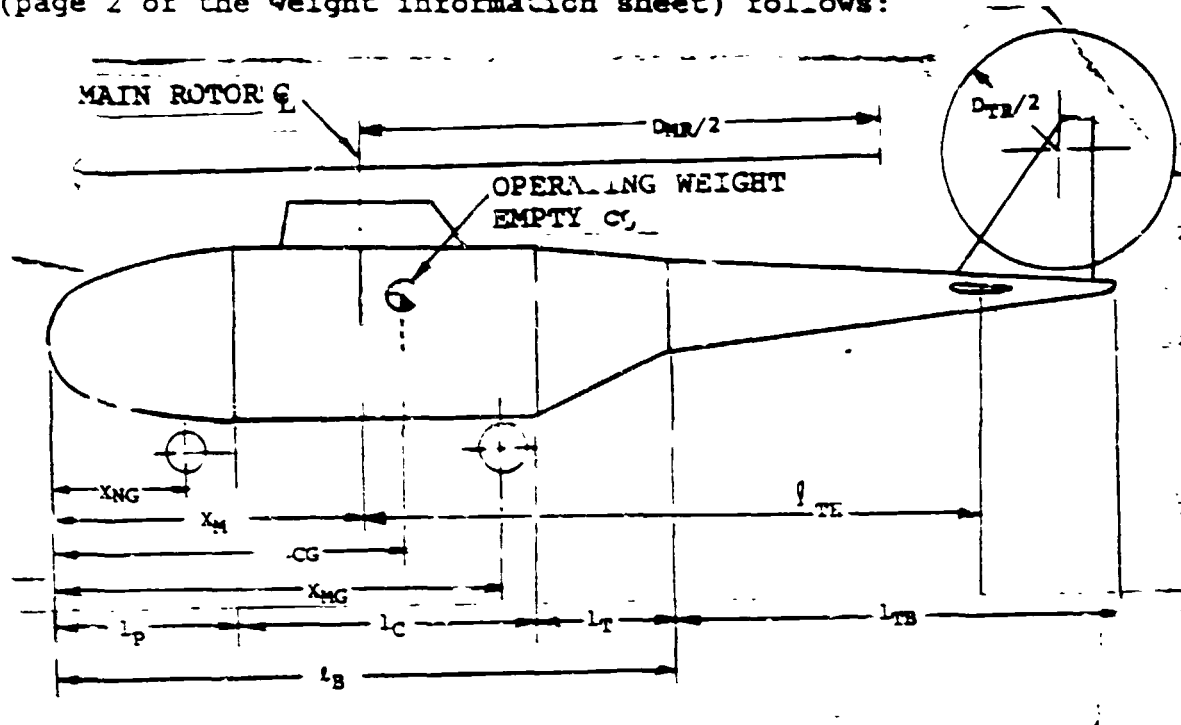


TABLE 4-15.  
MULTIPLICATIVE FACTORS

K	LOCATION	LETTER CODE	DESCRIPTION
K1	2654	W <sub>RC</sub>	WEIGHT OF MAIN ROTOR CONTROLS
K2	2655	WSC	WEIGHT OF MAIN ROTOR SYSTEM CONTROLS
K3	2656	W <sub>FW</sub>	WEIGHT OF FIXED WING CONTROLS
K4	2657	W <sub>RCA</sub>	WEIGHT OF AUXILIARY ROTOR CONTROLS
K5	2658	W <sub>SCA</sub>	WEIGHT OF AUXILIARY ROTOR SYSTEM CONTROLS
K6	2659	W <sub>B</sub>	WEIGHT OF BODY
K7	2660	W <sub>LG</sub>	WEIGHT OF LANDING GEAR
K8	2661	W <sub>W</sub>	WEIGHT OF WING
K9	2662	W <sub>HT</sub>	WEIGHT OF HORIZONTAL TAIL
K10	2663	W <sub>NAC</sub>	WEIGHT OF PRIMARY NACELLE
K11	2664	W <sub>NACA</sub>	WEIGHT OF AUXILIARY NACELLE
K12	2665	W <sub>PRB</sub>	WEIGHT OF PRIMARY ROTOR BLADES
K13	2666	W <sub>PH</sub>	WEIGHT OF PRIMARY ROTOR HUB
K14	2667	W <sub>TR</sub>	WEIGHT OF TAIL ROTOR
K15	2668	W <sub>AR</sub>	WEIGHT OF AUXILIARY ROTOR
K16	2669	W <sub>PDS</sub>	WEIGHT OF PRIMARY DRIVE SYSTEM
K17	2670	W <sub>ADS</sub>	WEIGHT OF AUXILIARY DRIVE SYSTEM
K18	2671	W <sub>PE</sub>	WEIGHT OF PRIMARY ENGINE
K19	2672	W <sub>AE</sub>	WEIGHT OF AUXILIARY ENGINE
K20	2673	W <sub>TRDS</sub>	WEIGHT OF TAIL ROTOR DRIVE SYSTEM

#### 4.11.2 Aircraft Balance

A preliminary aircraft balance for single rotor helicopters is included in the program which locates the main rotor system  $\bar{g}$  relative to the required center of gravity of the operating weight empty of the aircraft. A description of the input values to be included on the weight-balance information sheet (page 2 of the weight information sheet) follows:



LOC (2678)  $X_{CGF}/l_B$

Center of gravity of the fuselage, measured from the nose of the aircraft as a fractional part of  $l_B$ .

LOC (2679)  $\Delta CG_R$

Distance in feet between the OWE center of gravity and the main rotor center line (negative value (-) is forward of OWE cg, plus value (+) is aft of OWE cg).

LOC (2680)  $X_{NG}/l_B$

Center of gravity of the nose gear measured from the nose of the aircraft, as a fractional part of  $l_B$ .

LOC (2681)  $X_{MG}/l_B$

Center of gravity of the main gear, measured from the nose of the aircraft, as a fractional part of  $l_B$ .

- LOC (2682)  $X_{PE}/l_B$  Center of gravity of the primary engine package, measured from the nose of the aircraft as a fractional part of  $l_B$ . The engine package consists of the engine section, engine, engine installation and fuel system.
- LOC (2683)  $X_{PDS}/\Delta X_{PDS}$  Center of gravity of the primary drive system measured as a fractional part of the distance between the main rotor and tail rotor. The tail rotor drive system weight and balance are computed and located automatically.
- LOC (2684)  $X_{AV}/l_B$  Center of gravity of the avionics system, measured from the nose of the aircraft, as a fractional part of  $l_B$ .
- LOC (2685)  $X_{FURN}/l_B$  Center of gravity of the furnishings and equipment, cockpit controls and a portion of the useful load (pilot and copilot), measured from the nose of the aircraft as a fractional part of  $l_B$ .
- LOC (2686)  $X_{APU}/l_B$  Center of gravity of the APU, measured from the nose of the aircraft, as a fractional part of  $l_B$ .
- LOC (2687)  $X_{AE}/l_B$  Center of gravity of the auxiliary engine package, measured from the nose of the aircraft, as a fractional part of  $l_B$ . The auxiliary engine package consists of the auxiliary engine section, auxiliary engine and auxiliary engine installation.
- LOC (2688)  $X_{ADS}/\Delta X_{ADS}$  Center of gravity of the auxiliary drive system as a fractional part of the distance between the auxiliary engine and auxiliary rotor system.
- LOC (2689)  $X_{AR}/l_{TB}$  Center of gravity of the auxiliary rotor and auxiliary rotor controls, measured from the nose of the aircraft, as a fractional part of  $l_{TB}$ .
- LOC (2690)  $X_{SC}/l_E$  Center of gravity of the system controls, measured from the nose of the aircraft, as a fractional part of  $l_B$ .
- LOC (2691)  $X_{ASC}/l_B$  Center of gravity of the auxiliary system controls, measured from the nose of the aircraft, as a fractional part of  $l_B$ .

LOC (2692)  $W_{AV}$

Total weight of the avionics group weight plus SAS input from flight controls column of weight input sheet.

LOC (2693)  $W_{FURN}$

Total weight of furnishings and equipment group located in the pilot's compartment and the weight of the cockpit controls (CC) as determined from the input constant in flight controls column of weight input sheet.

LOC (2694)  $W_{APU}$

Total weight of auxiliary power unit (APU) installation.

LOC (2695)  $K_{FVLS}$

Fractional part of fixed useful load (pilot, co-pilot, etc.) located in the pilot's compartment.

LOC (2696)  $K_{TBBS}$

Tail boom weight expressed as a fractional part of the computed body weight. The center of gravity of the tail boom is automatically computed in the program.

Items of the operating weight empty not included in the location descriptions presented above are located at the aircraft center of gravity as computed by the balance subroutine. An example of a completed weight-balance information sheet for a typical single rotor helicopter is shown below.

WEIGHT-BALANCE INFORMATION  
(Required Only When MRPIND > 0)

Variable	Loc.	Value	Variable	Loc.	Value	Variable	Loc.	Value
$(X_{CCP}/l_B)$	2678	0.425	$(X_{FURN}/l_B)$	2685	0.134	$W_{AV}$	2692	469
$X_{CG}$	2679	0.10	$(X_{APU}/l_B)$	2686	0.424	$W_{FURN}$	2693	415
$(X_{MG}/l_B)$	2680	0.716	$(X_{AE}/l_B)$	2687	0	$W_{APU}$	2694	172
$(X_{PR}/l_B)$	2681	0.754	$(X_{ADS}/X_{ADS})$	2688	0	$K_{FVLS}$	2695	0.731
$(X_{PE}/l_B)$	2682	0.727	$(X_{AR}/l_B)$	2689	0	$K_{TBBS}$	2696	0.130
$(X_{POS}/X_{POS})$	2683	0.593	$(X_{SC}/l_B)$	2690	0.581			
$(X_{AV}/l_B)$	2684	0.485	$(X_{ASC}/l_B)$	2691	0			

MIL-STD-1374 PART I

Name \_\_\_\_\_

Date \_\_\_\_\_

Page \_\_\_\_\_

Mod. \_\_\_\_\_

Report \_\_\_\_\_

# 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.

MIL-STD-1374 PART I

GROUP WEIGHT STATEMENT  
WEIGHT EMPTY

Page \_\_\_\_\_

Name \_\_\_\_\_

Model \_\_\_\_\_

Date \_\_\_\_\_

Report \_\_\_\_\_

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	ADJUSTIONS (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	ALIGHTING GEAR GROUP (Type: _____)				
38	LOCATION	Bombing 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 Bomb & Struck for Water Type Gear.

GROUP WEIGHT STATEMENT  
WEIGHT EMPTY

MIL-STD-1374 PART I

Page \_\_\_\_\_

Name \_\_\_\_\_

Model \_\_\_\_\_

Date \_\_\_\_\_

Report \_\_\_\_\_

	Propulsion Group	Auxiliary	Other
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	PUMPING, etc.		
18	DRIVE SYSTEM		
19	GEAR BOXES, LUB BY A ROTOR BRK		
20	TRANSMISSION DRIVE		
21	ROTOR SHAFTS		
22	JET DRIVE		
23			
24	FLIGHT CONTROLS GROUP		
25	COCKPIT CONTROLS (Autopilot)	Libs	
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.)	Libs	
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		

MIL-STD-1374 PART I

GROUP WEIGHT STATEMENT  
USEFUL LOAD AND GROSS WEIGHT

Page \_\_\_\_\_

Name \_\_\_\_\_

Model \_\_\_\_\_

Date \_\_\_\_\_

Report \_\_\_\_\_

1	LOAD CONDITION				
2					
3	CREW (No.)				
4	PASSENGERS (No.)				
5	FUEL	Location	Type	Gals.	
6	UNUSABLE				
7	INTERNAL				
8					
9					
10					
11	EXTERNAL				
12					
13					
14	OIL				
15	TRAPPED				
16	ENGINE				
17					
18	FUEL TANKS (Location)				
19	WATER INJECTION FLUID (Gals.)				
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. Submunition Detection Expended)				
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	NET WEIGHT				

\*1 Removable and Specified or Useful Load.  
\*2 Lin. Staves, Mikes, Sonobuoys, etc. Followed by Rockets, Launchers, Chutes, etc. Not Part of Weight Empty.  
List Identifiers, Location, and Quantity for All Items Shown Including Installation.



GROUP WEIGHT STATEMENT  
DIMENSIONAL AND STRUCTURAL DATA

Name \_\_\_\_\_

Model \_\_\_\_\_

Date \_\_\_\_\_

Report \_\_\_\_\_

1	WING, ROTOR & TAIL GROUPS	Span or Chord (ft)	Span or Chord (in)	Max Root Chord (in)	Max Tip Chord (in)	Max Root Chord (in)	Max Tip Chord (in)
2	WING						
3							
4	MAIN ROTOR Blades/Rotor						
5	TAIL ROTOR Blades/Rotor						
6	HORIZ TAIL						
7	VERT TAIL						
8							
9	AREAS (Sq. Ft)	Wing	Main Rotor Blade Area	Tail Rotor Blade Area	Horiz. Tail	Vert. Tail	Dorsal
10	These for Wing & Rotor, All Others Exposed						
11		Speed Brns.	Flaps (L.E.)	Flaps (T.E.)	Slat	Spilers	Ailerons
12	AREAS (Sq. Ft)						
13	BODY & NACELLE GROUPS	Length (ft)	Depth (ft)	Width (ft)	Wing Area (sq ft)	Vol. (Cu. Ft)	Max Mass (lb)
14	FUSELAGE or HULL						
15	BOOMS						
16	NACELLES						
17							
18							
19	ALIGHTING GEAR GROUP	Length - Oleo Est.		Oleo Travel		Length - Arrest Hook	
20		Axle to $\epsilon$ Trunnion		Est. to Collapsed		Hook Trunnion to Pt.	
21	LOCATION						
22	DIMENSIONS inches						
23							
24	PROPULSION GROUP						
25	ENGINES	SLS Thrust in LBS (incl. water augmentation)		SLS Thrust in LBS (incl. water augmentation)		Max SLS Thrust in HP	Max HP at Max RPM
26	MAIN						
27	AUXILIARY						
28	ROTOR DRIVE SYSTEM	Design H.P.	Input R.P.M.	Output R.P.M. at rotor	Max Rotor HP	Number Gear Boxes	
29							
30		Protected		Unprotected		Integral	
31	FUEL - INTERNAL *** LOCATION	No. Tanks	Gallons	No. Tanks	Gallons	No. Tanks	Gallons
32	WING						
33	FUSELAGE						
34	EXTERNAL ***						
35							
36	OR						
37	ELECTRICAL & LOAD & HANDLING GROUPS	Power Avail. at Motor	Frequency Output - DC	Frequency Output - AC		Cargo Hook Area	
38							
39							
40	STRUCTURAL DATA - CONDITION	Max. Load at Control	Frequency at Control	Max. Load at Control		Max. Load at Control	Ult. L.F.
41	FLIGHT - MANEUVER						
42	GUST						
43	LANDING						
44							
45	MAX. GROSS WITH ZERO WING FUEL						
46	CATA-PULTING						
47	LIMIT LANDING SINK SPEED (sec)						
48	MAX. ALLOWED PER LANDING BRUSH (ft/sec)						
49	STALL SPD. - LDG. CONFIG. - POWER OFF						
50	RESERVE CAP. AT BRUSH (ft/sec)						
51	ROTOR TIP SPD AT DESIGN LIMIT	R.P.M.	Power	Ft./Sec.			
52							
53	% DESIGN LOAD	Wing		Rotor		Rotor	
54	DESIGN SPEED AT SL (Knot)	Level		Dive			
55	DESIGN SPD. AT OTHER ALTITUDES		AR		AR		
56							
57	DCPR WEIGHT (Arrested)						

\*\*\*None to aft tip of fuselage including equipment protrusions  
measured to  $\epsilon$  or  $\epsilon$  Armrest for Wing & Tail least inches from  $\epsilon$  Rotor for Rotors.  
measured inches from  $\epsilon$  Rotor to Blade Attachment for Rotors.

MIL-STD-1374 PART I  
Name \_\_\_\_\_  
Date \_\_\_\_\_

GROUP WEIGHT STATEMENT

Page \_\_\_\_\_  
Model \_\_\_\_\_  
Report \_\_\_\_\_

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

#### 4.12 PERFORMANCE CALCULATIONS SUBPROGRAM

The flow chart of the control loop for the performance calculations subprogram is shown in Figure 4-48. This routine monitors the flow during calculation of mission performance data and calculates the total fuel required at the end of the mission.

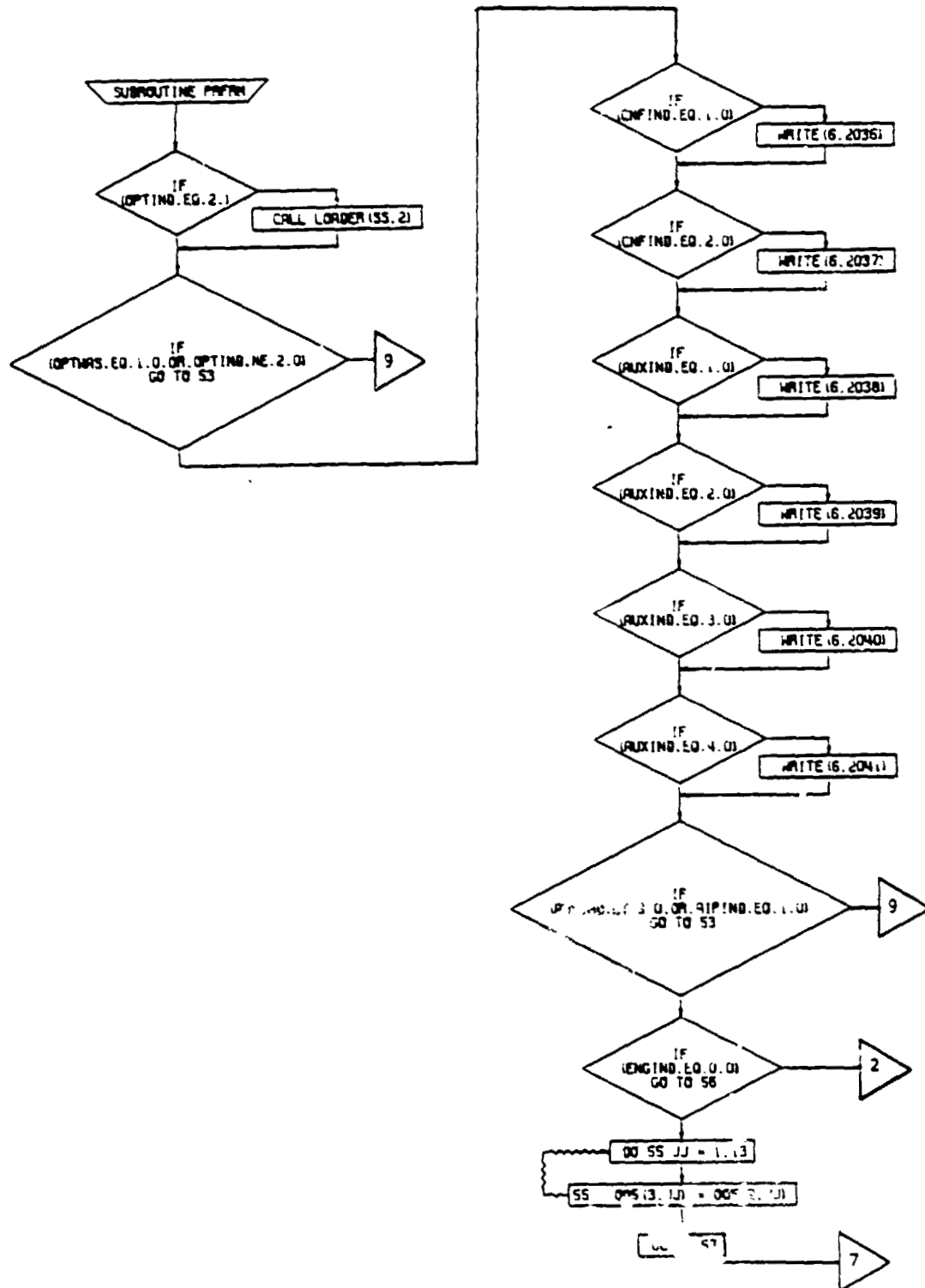


Figure 4-48. PRFRM Subroutine, Flow Chart (Part 1 of 6)

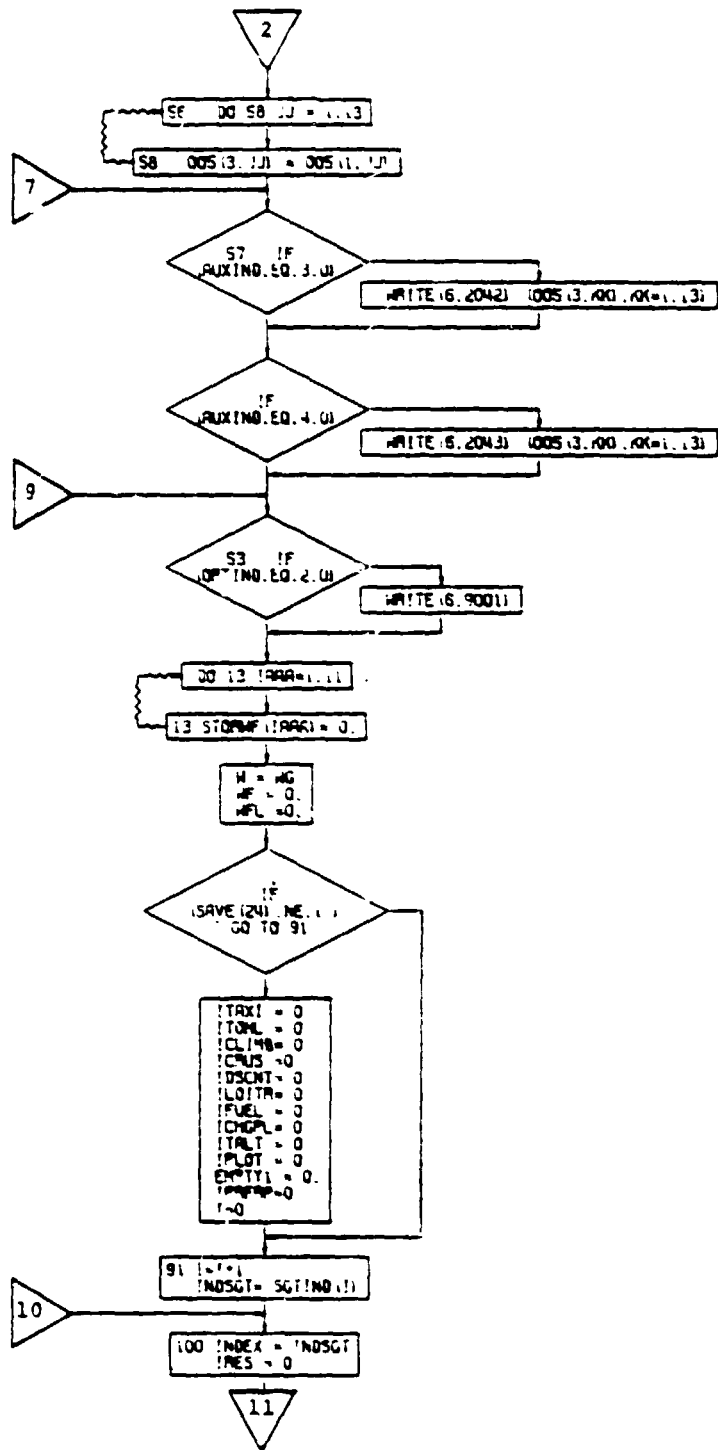


Figure 4-48. PRFRM Subroutine, Flow Chart (Part 2 of 6)

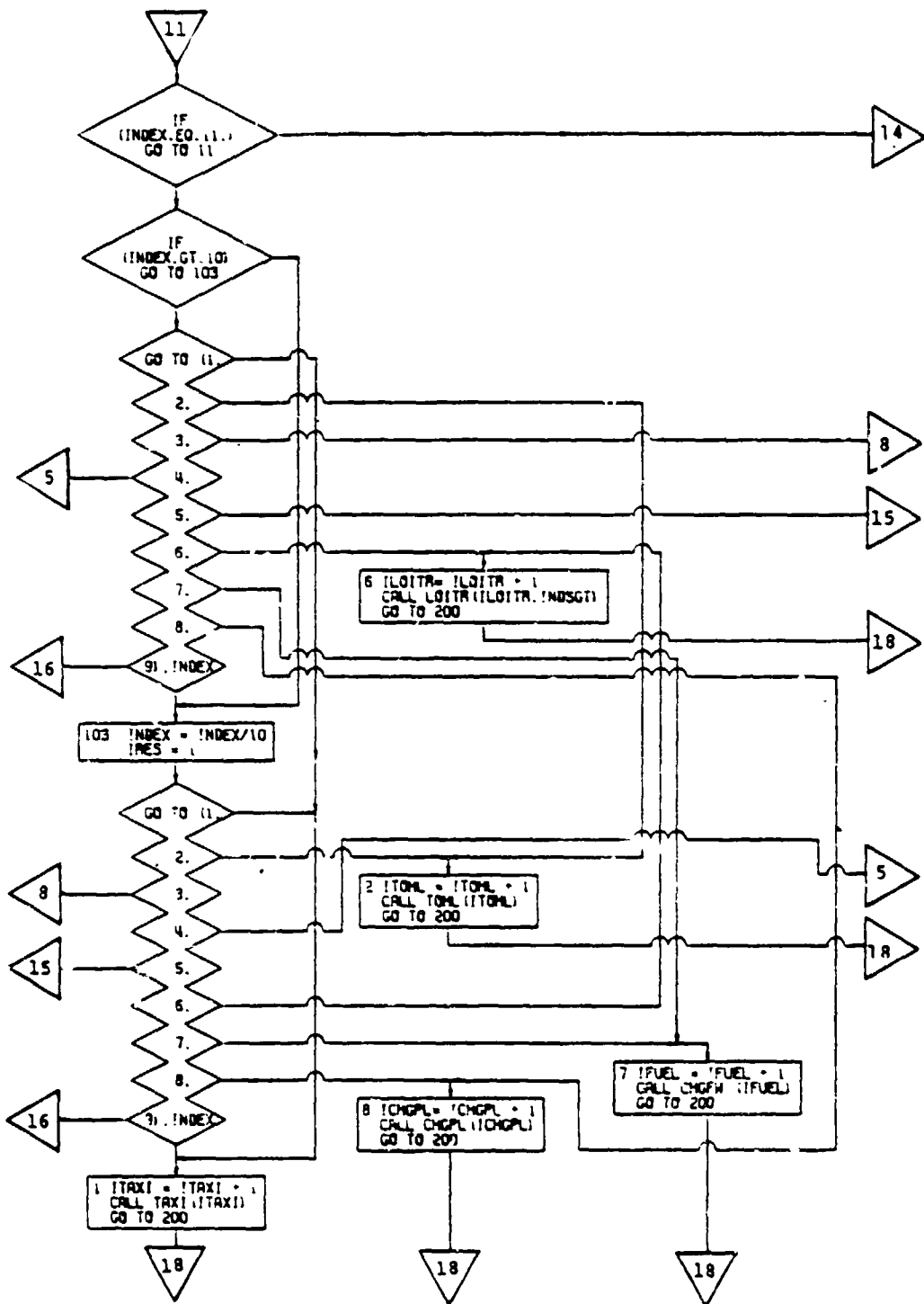


Figure 4-48. PRERM Subroutine, Flow Chart (Part 3 of 6)

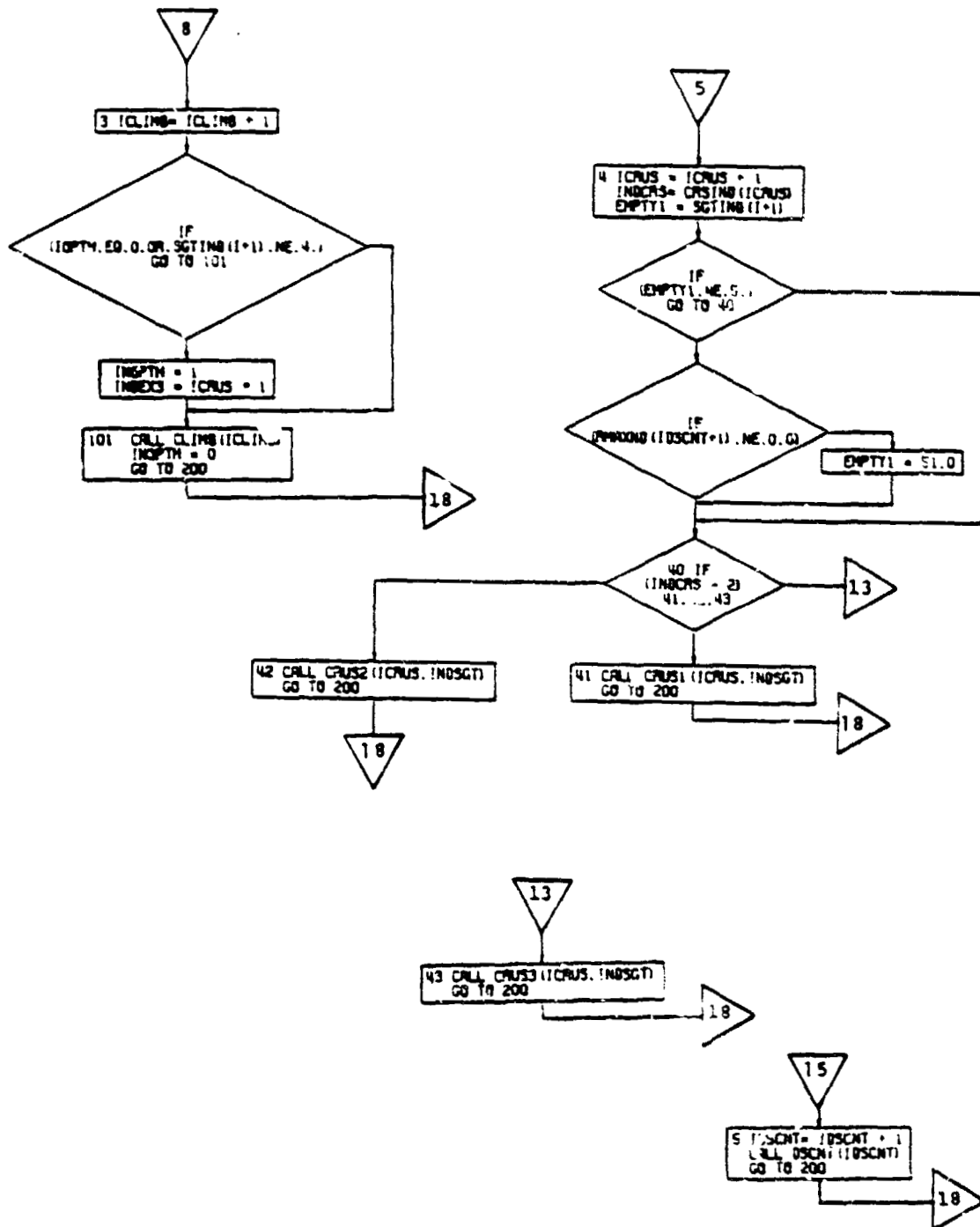


Figure 4-48. PRFRM Subroutine, Flow Chart (Part 4 of 6)

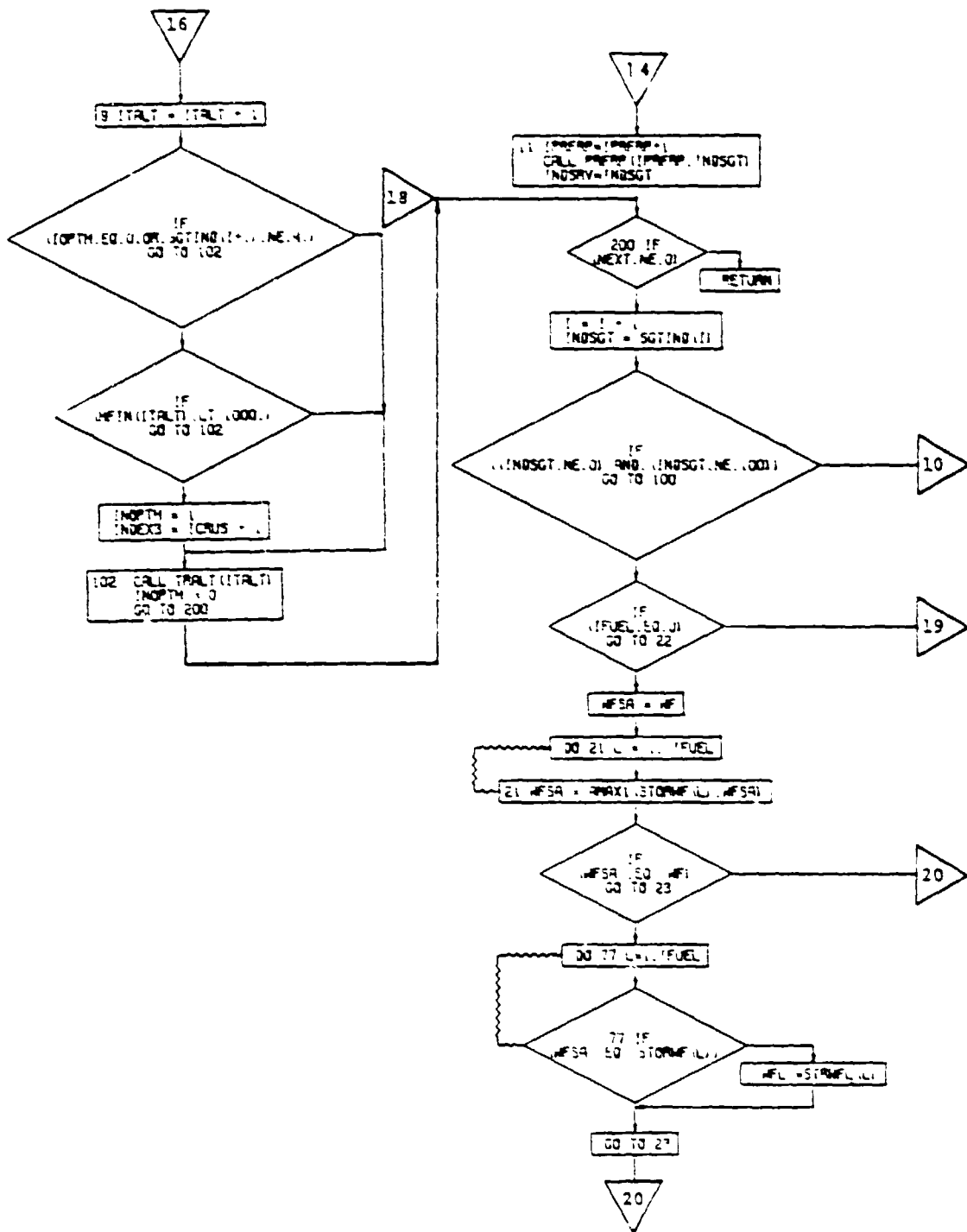


Figure 4-48. PRFRM Subroutine, Flow Chart (Part 5 of 6)



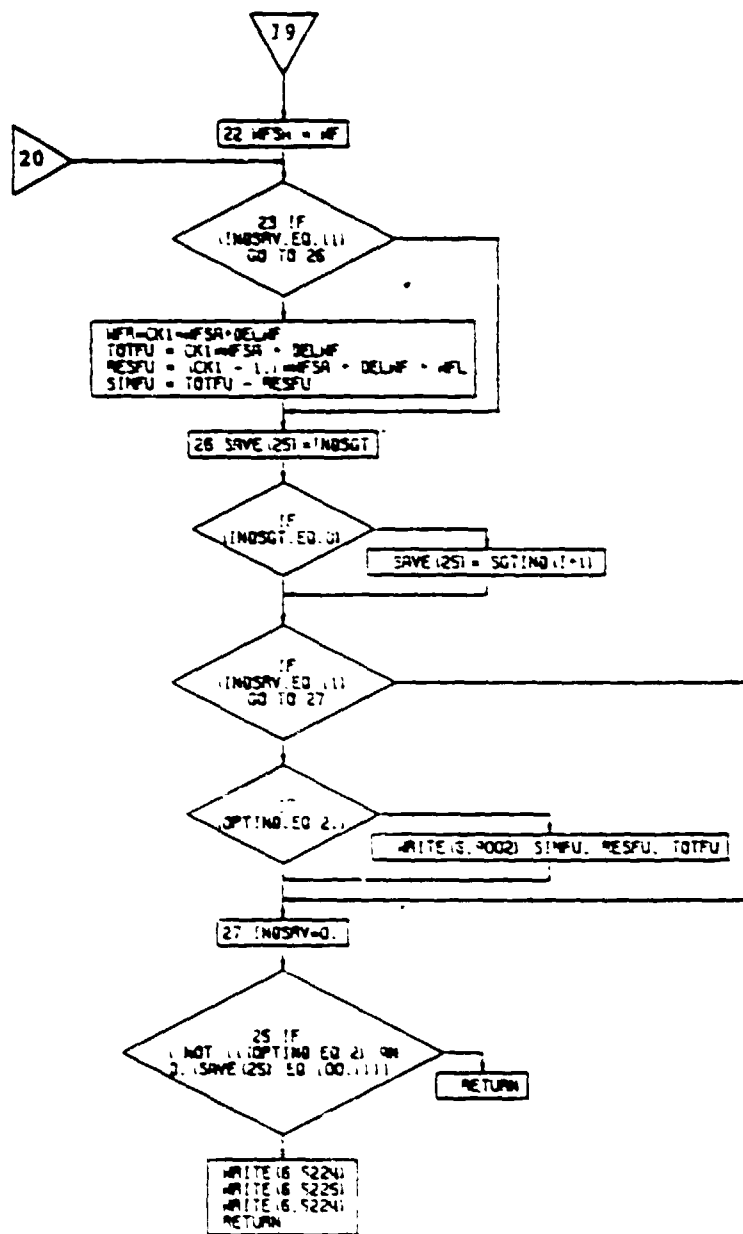


Figure 4-48. PRFRM Subroutine, Flow Chart (Part 6 of 6)

#### 4.12.1 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 auxiliary cruise propulsion systems (AIPIND = 2), the program will calculate taxi performance for either primary engines operating alone, or both primary and auxiliary cruise propulsion engines operating. This is accomplished by means of the input constant  $k_{PI}$ . If  $k_{PI} = 0$ , the program will consider only primary engines in operation in determining fuel flow rates. If  $k_{PI} = 1$ , 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 4-49 is a flow chart of this subroutine.

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

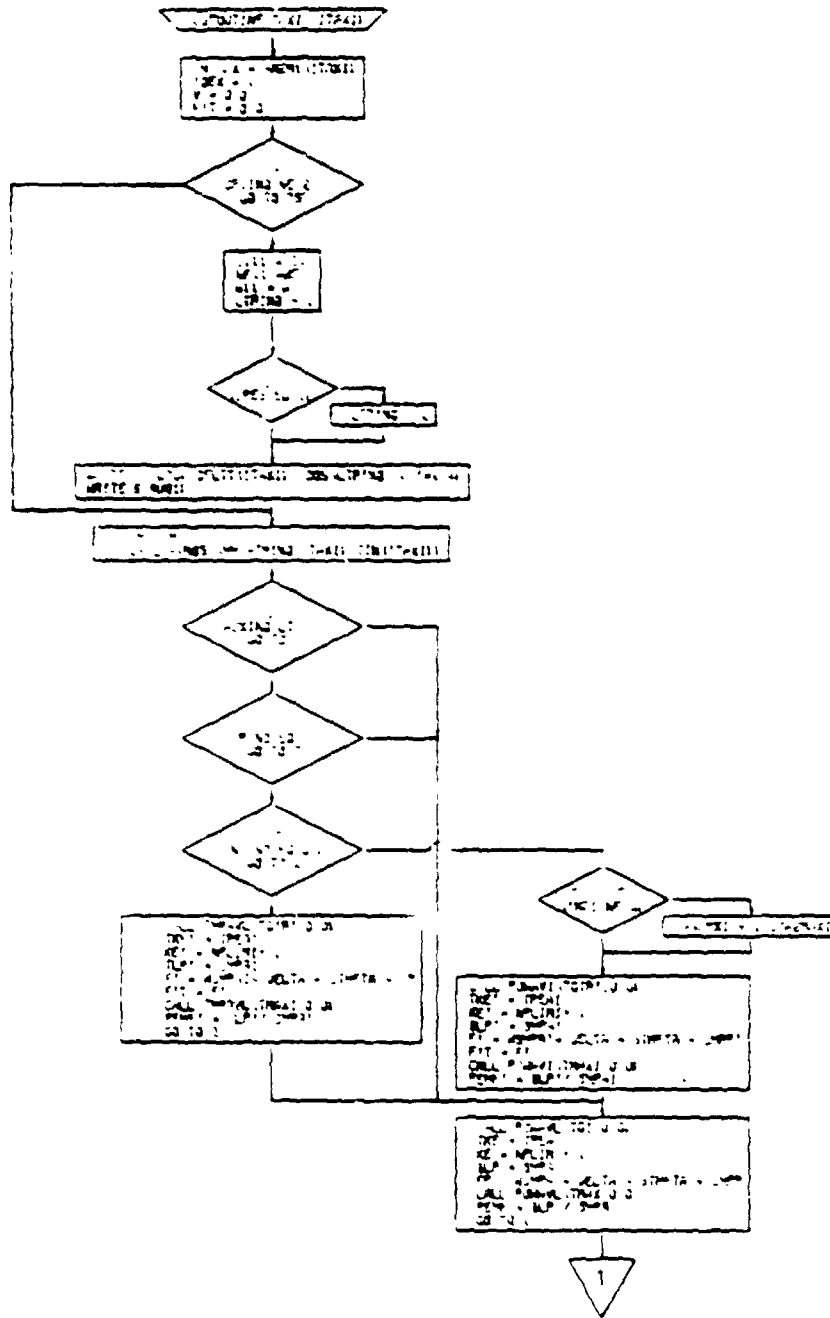


Figure 4-49. Taxi Calculations Subroutine, Flow Chart (Part 1 of 2)

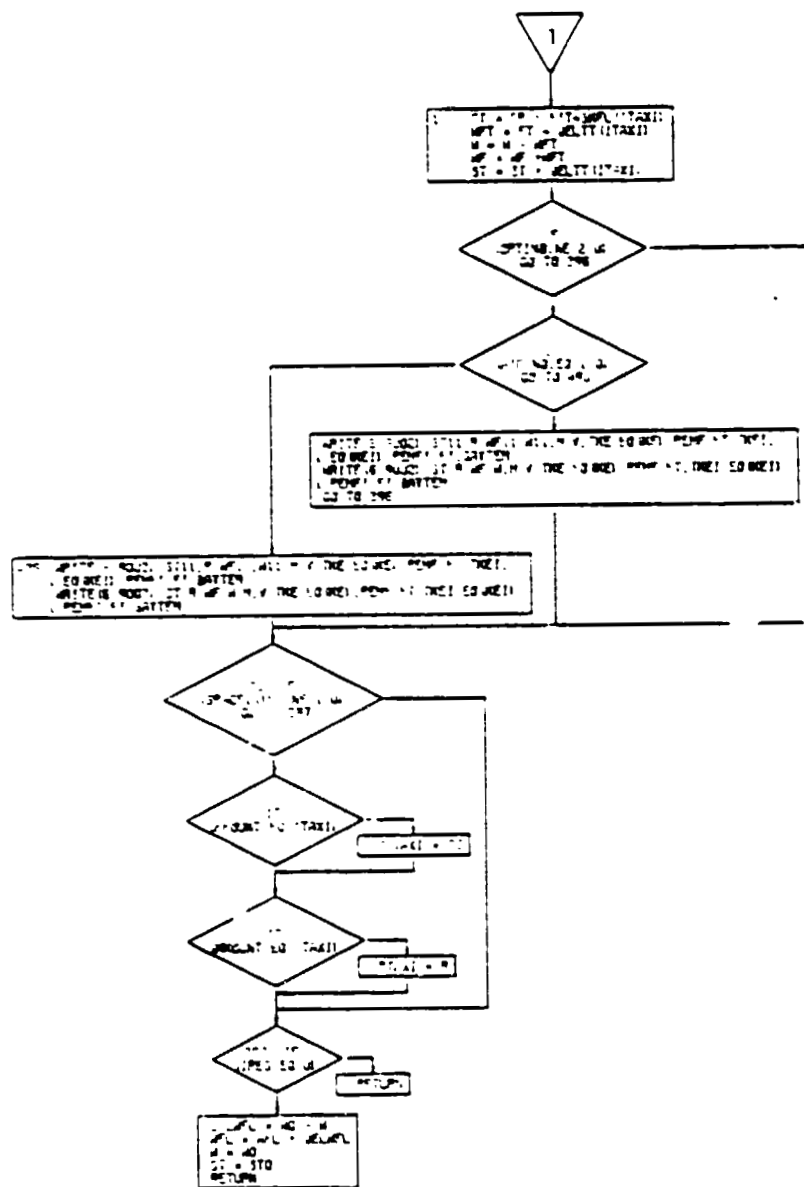


Figure 4-49. Taxi Calculations Subroutine, Flow Chart (Part 2 of 2)

#### 4.12.2 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. Four options are available, specified by the input indicator TOLIND:

- TOLIND = 1 - Input required thrust-weight ratio and vertical rate of climb. Program will calculate required power fractions.
- TOLIND = 2 - Input the required power fraction and vertical rate of climb. Program will calculate thrust-weight ratio.
- TOLIND = 3 - This option is the same as TOLIND = 1, except hover in ground effect is assumed, requiring the input of height of fuselage bottom above ground as a fraction of main rotor diameter.
- TOLIND = 4 - This option is the same as TOLIND = 2, except hover in ground effect is assumed, requiring the input of height of fuselage bottom above ground as a fraction of main rotor diameter.

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 as a site. The program will, however, print a cautionary note that power fraction exceeds 100 percent. In the case (TOHL = 2 or 4) where the required power fraction is input, if the calculated thrust-weight ratio is less than the design thrust-weight ratio input (LOC 0228), the following cautionary note will be printed: INSUFFICIENT POWER AVAILABLE TO HOVER. T/W AVAILABLE LESS THAN T/W REQUIRED AT DESIGN DOWNLOAD.

For a helicopter configuration having auxiliary independent engines, the program sets the auxiliary engine power setting at ground idle.

It is possible to use a hover segment in the mission profile to account for a reserve fuel requirement (SGTIND = 20), in such a case the helicopter weight at the end of hover is set back to the weight at the beginning of hover, or as a part of the basic mission (in this case the weight is not reset). In either case, the fuel used during hover is included in the total fuel required to size the helicopter.

Figure 4-50 is a flow chart for this subroutine.

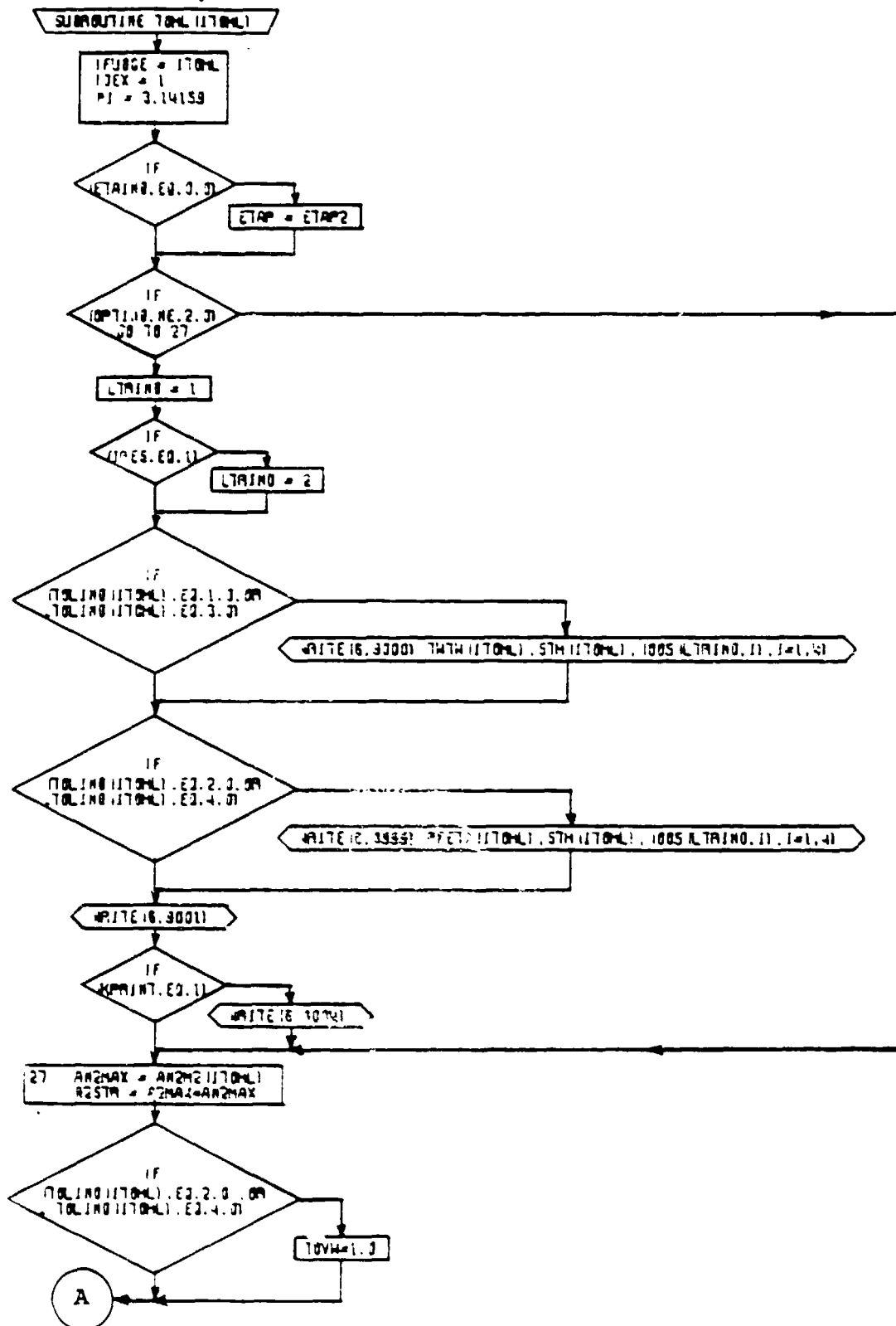


Figure 4-50. Takeoff, Hover, and Landing Subroutine Flow Chart (Part 1 of 4).

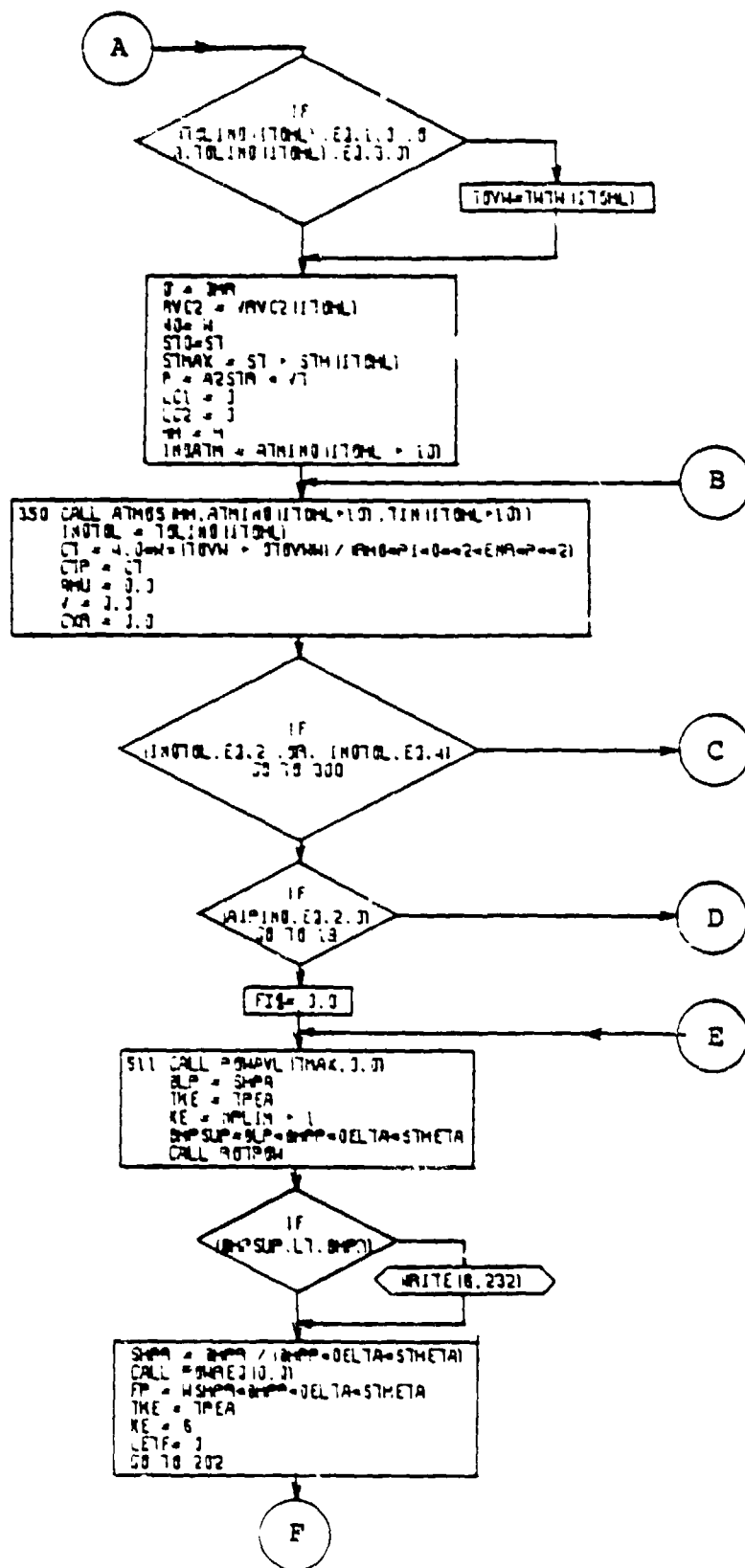


Figure 4-50. Takeoff, Hover, and Landing Subroutine Flow Chart (Part 2 of 4).

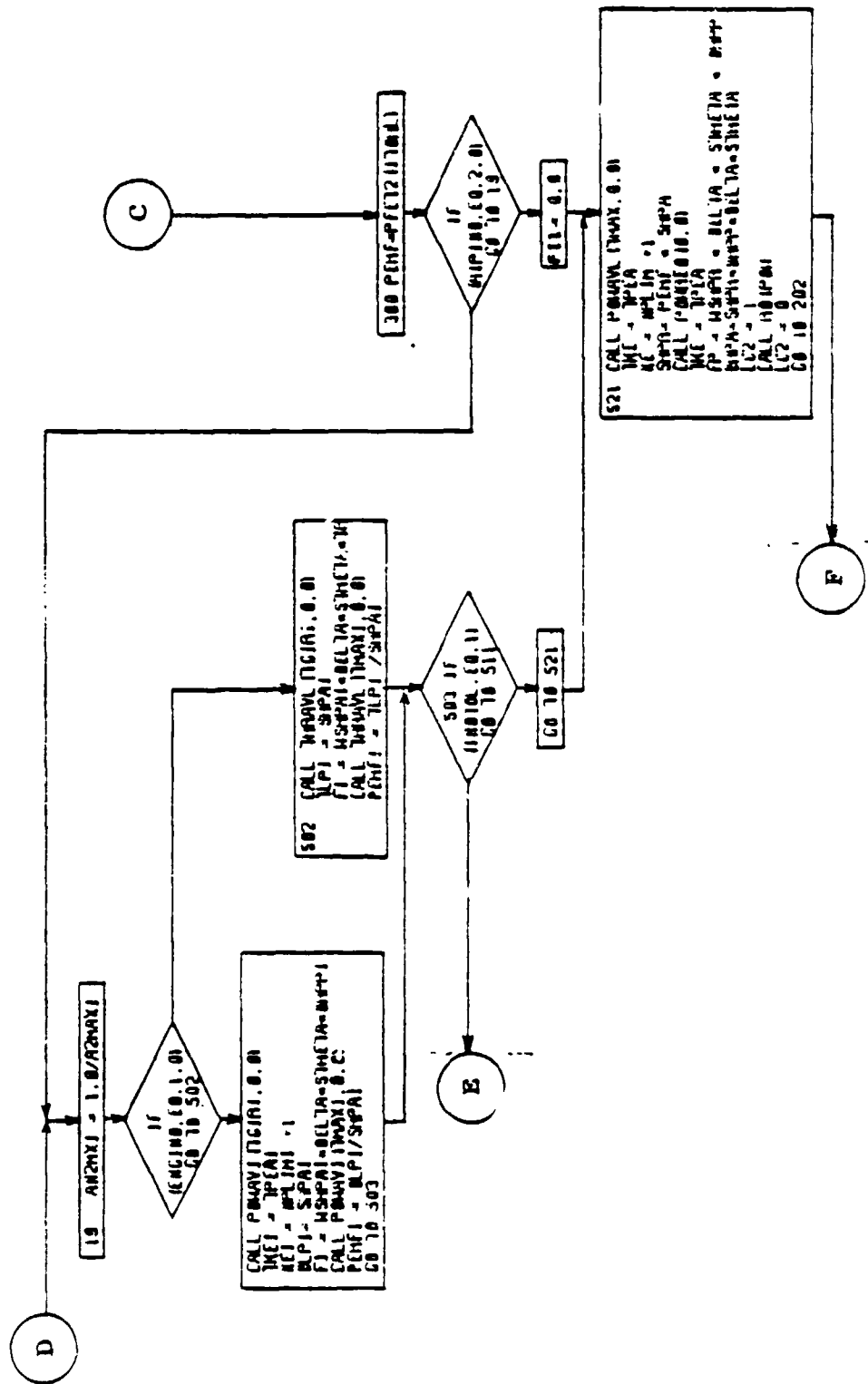


Figure 4-50. Takeoff, Hover, and Landing Subroutine Flow Chart (Part 3 of 4).



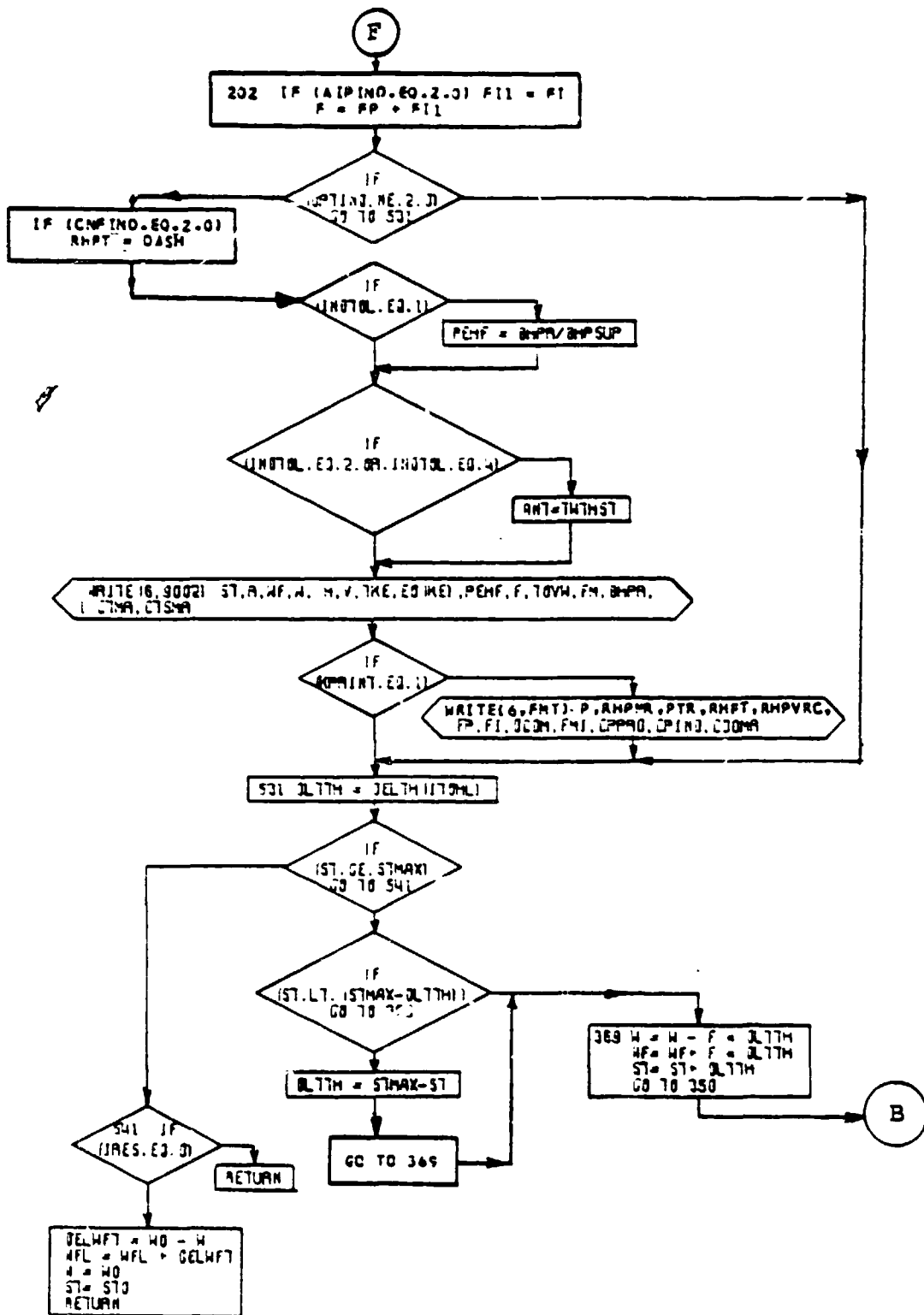


Figure 4-50. Takeoff, Hover, and Landing Subroutine Flow Chart (Part 4 of 4).

#### 4.12.3 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 and maximum operating Mach number. In no event will the aircraft be required to fly at an airspeed greater than the input maximum operating airspeed.

CLMIND = 2 - The program calculates the climb performance of the aircraft at specified constant equivalent airspeed limited, as before, by  $M_{MO}$  and  $V_{MO}$ .

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	

The user may specify a value for incremental equivalent flat plate area parasite drag during climb,  $\Delta F_{eCLIMB}$ , to represent variations in store drag.

Engine shutdown during climb may be simulated by inputs for  $N_{TSP}$  (primary engines) and  $N_{PSDI}$  (auxiliary independent engines). One or more engines may be shutdown.

If the flight path (climb) angle exceeds 90 degrees, the engine power setting is reduced and the program prints out:

CAUTION: CLIMB ANGLE TOO LARGE DUE TO EXCESSIVE POWER AVAILABLE AT THIS FLIGHT CONDITION. POWER SETTING REDUCED TO \_\_\_\_\_ ENGINE RATING.

If there is insufficient power available for climb, the engine power setting is increased and the program prints out:

CAUTION: INSUFFICIENT POWER AVAILABLE FOR CLIMB AT  
THIS FLIGHT CONDITION. POWER SETTING  
INCREASED TO \_\_\_\_\_ ENGINE RATING.

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.

It is possible to use a climb segment in the mission profile to account for a reserve fuel requirement ( $SGTIND = 30$ ) (in such a case the helicopter weight at the end of climb is set back to the weight at the beginning of climb) or as a part of the basic mission (in this case the weight is not reset). In either case, the fuel used during climb is included in the total fuel required to size the helicopter.

Figure 4-51 is a flow chart for this subroutine.

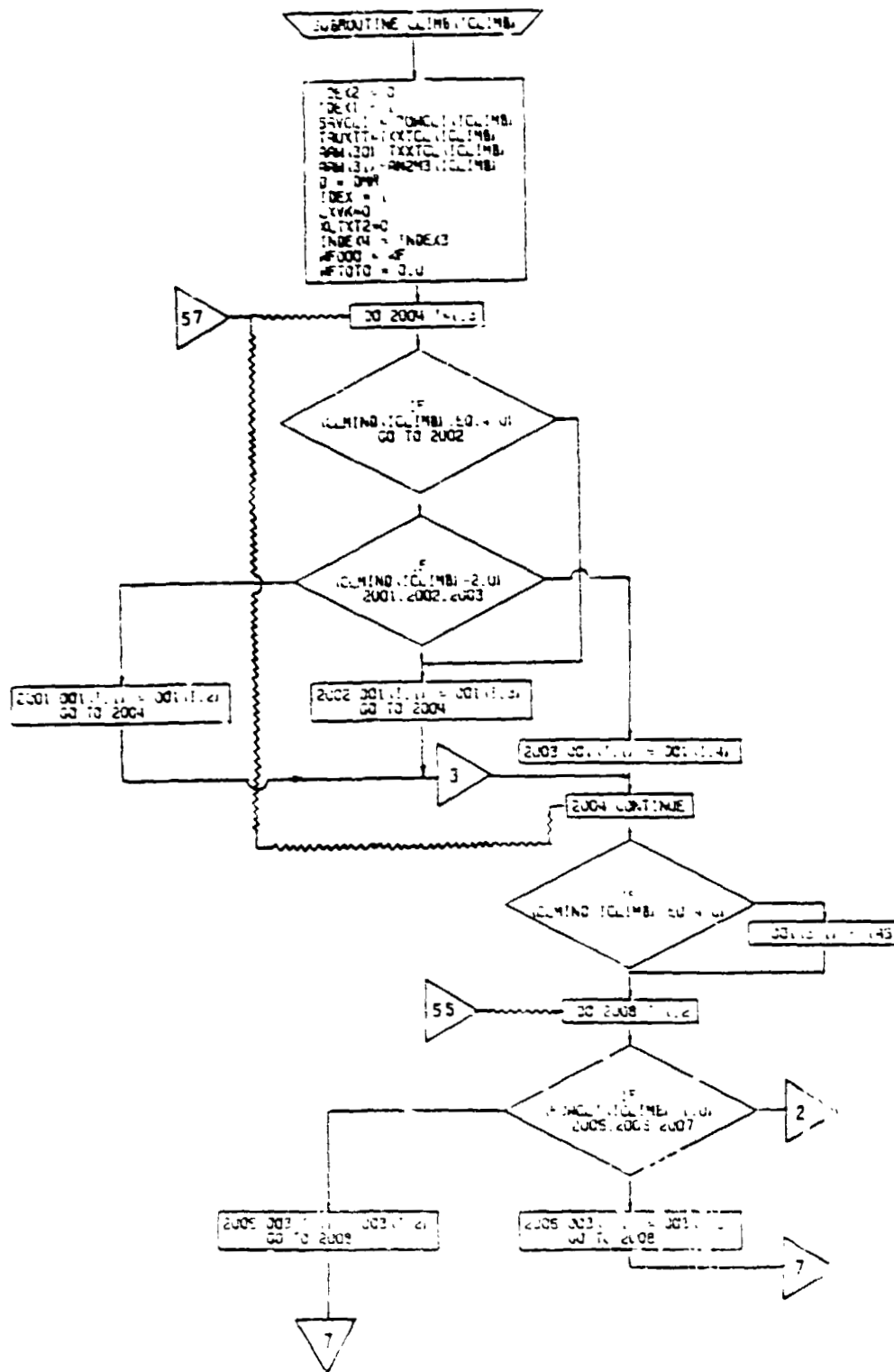


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 1 of 15)

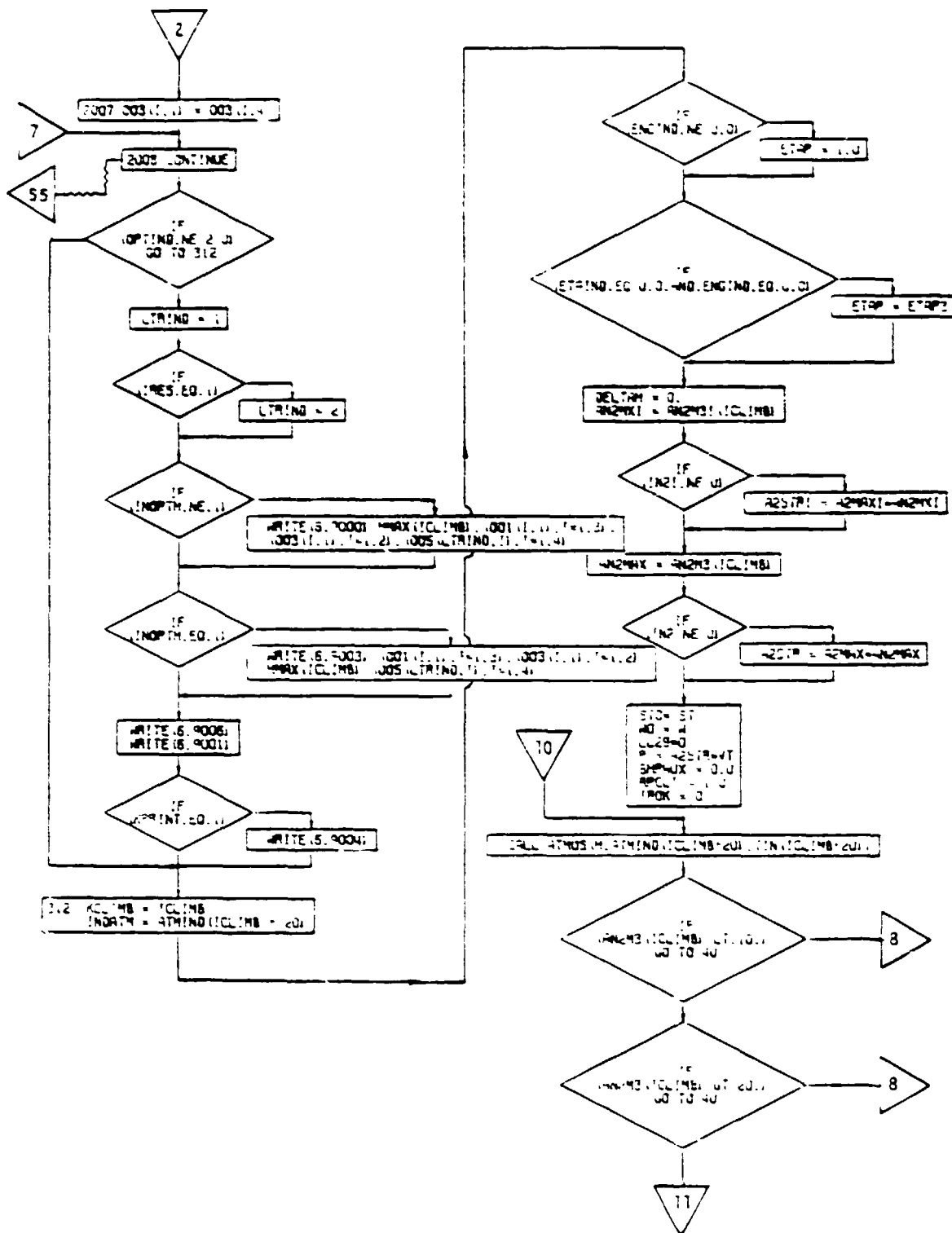


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 2 of 15)

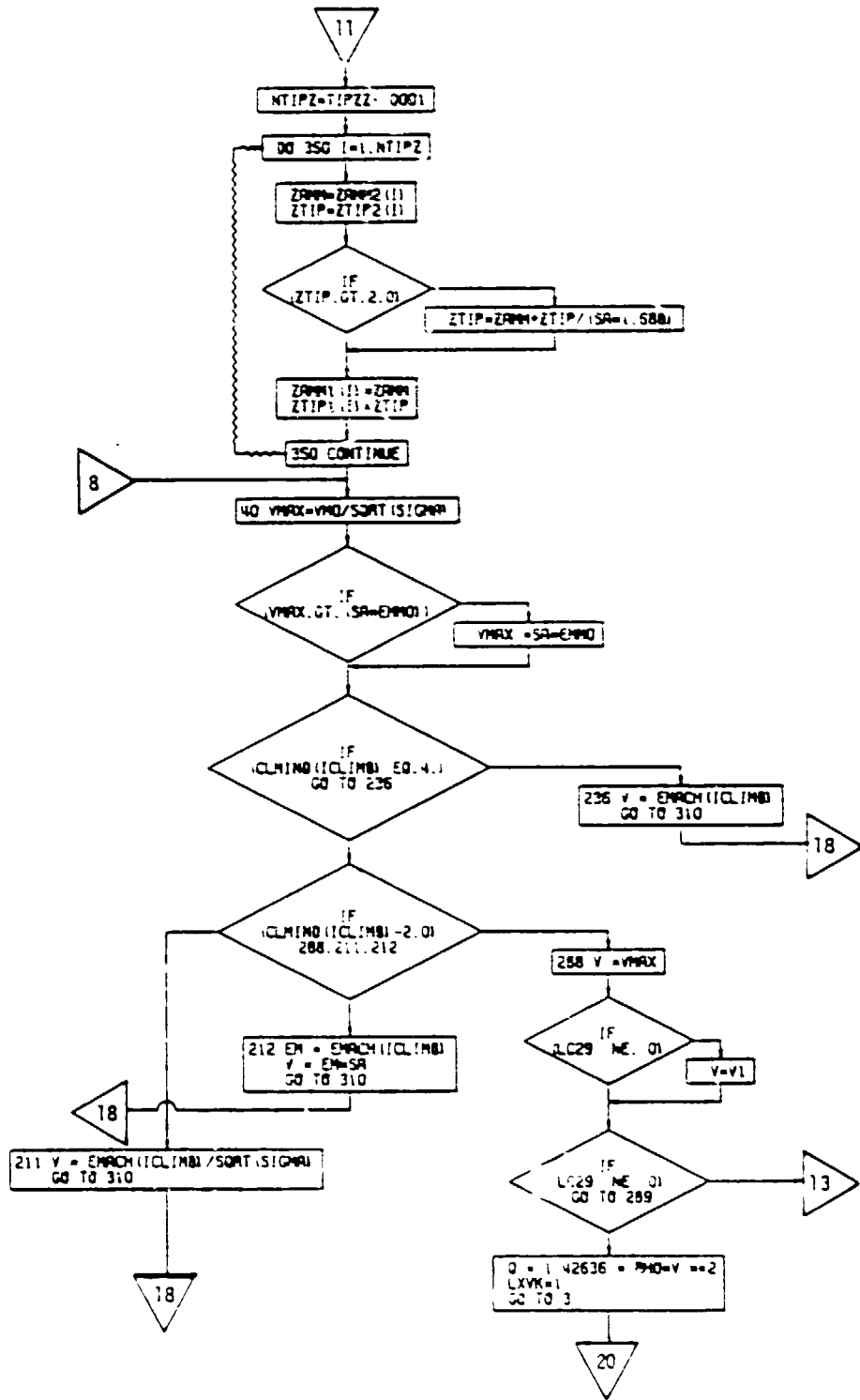


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 3 of 15)

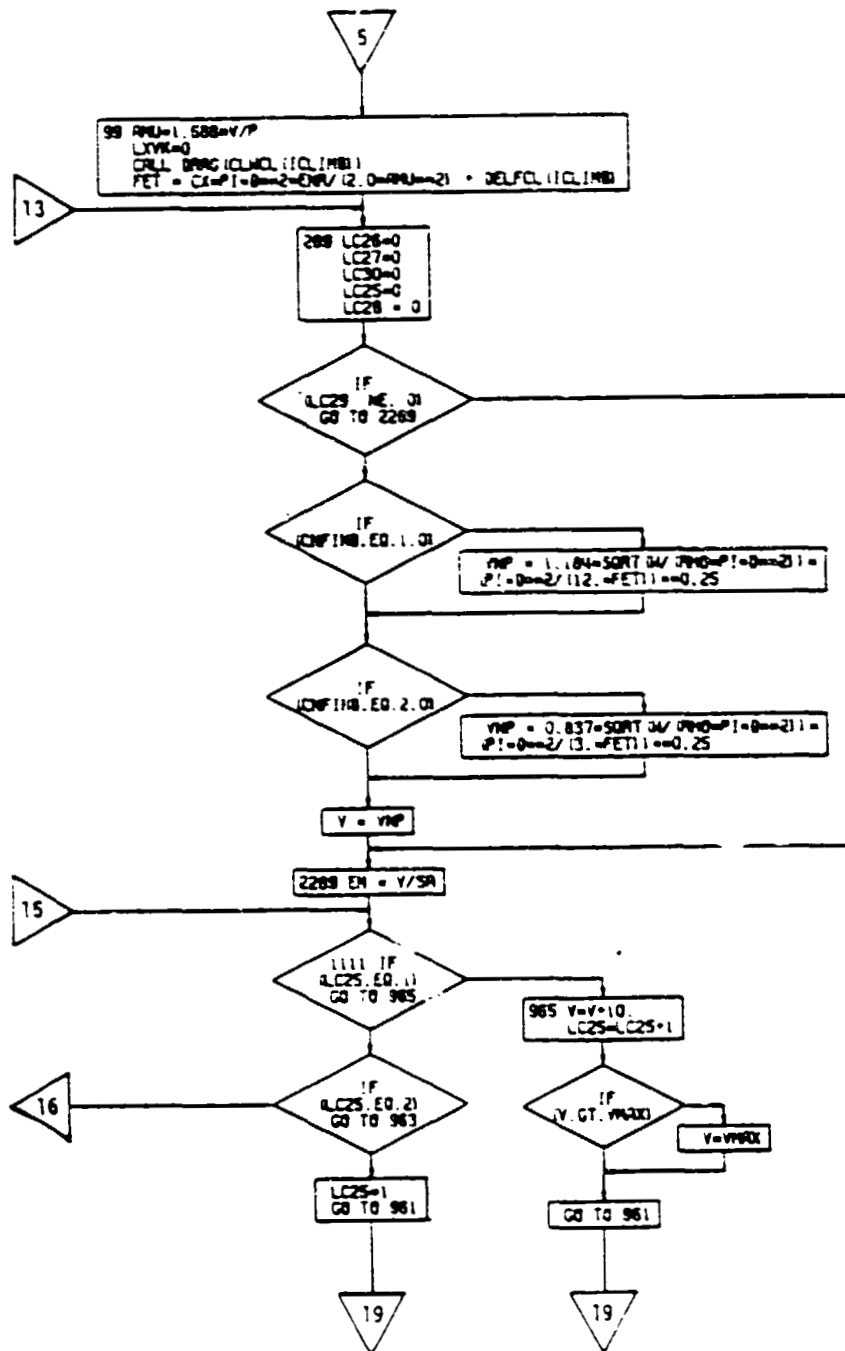


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 4 Of 15)

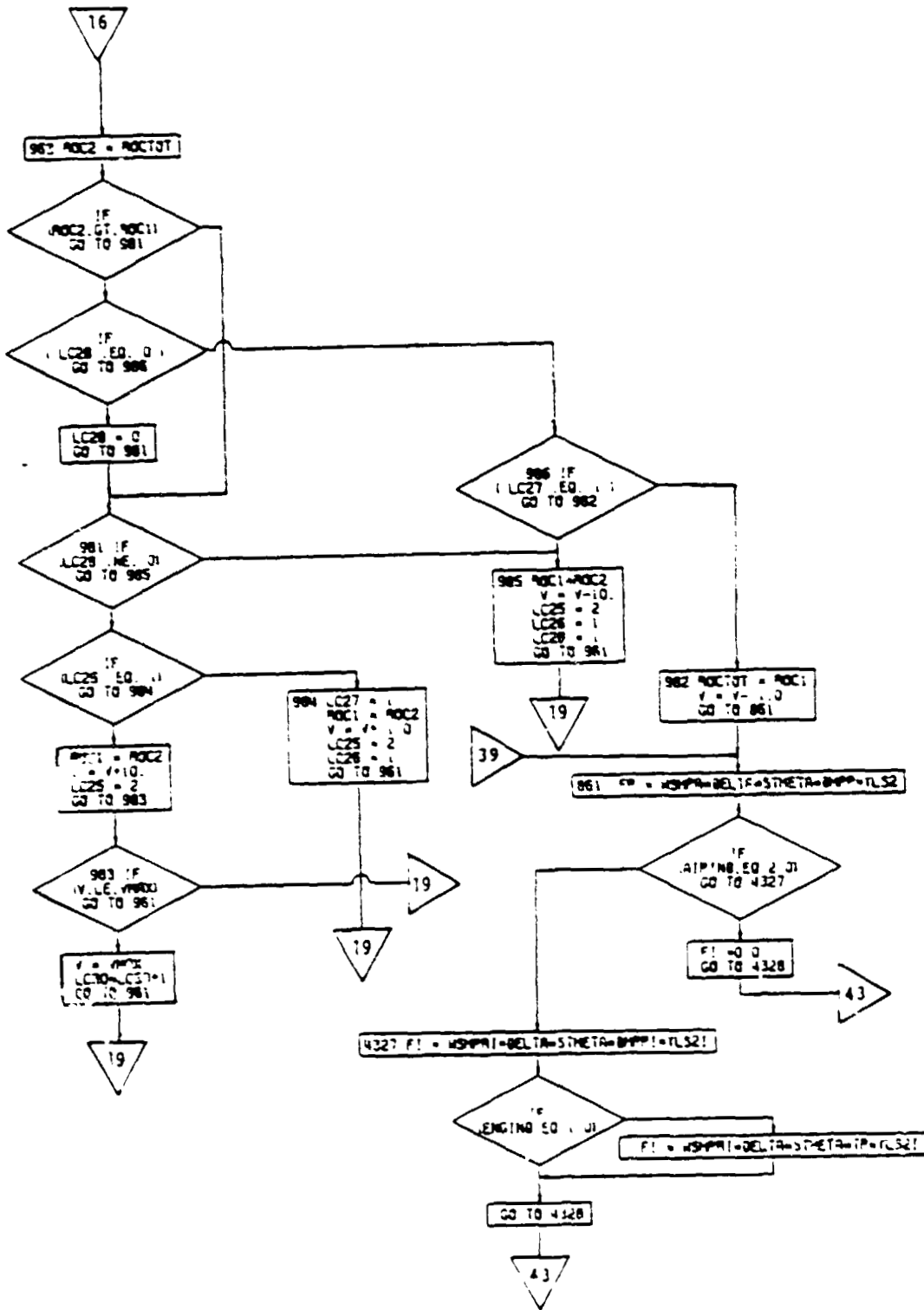


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 5 of 15)



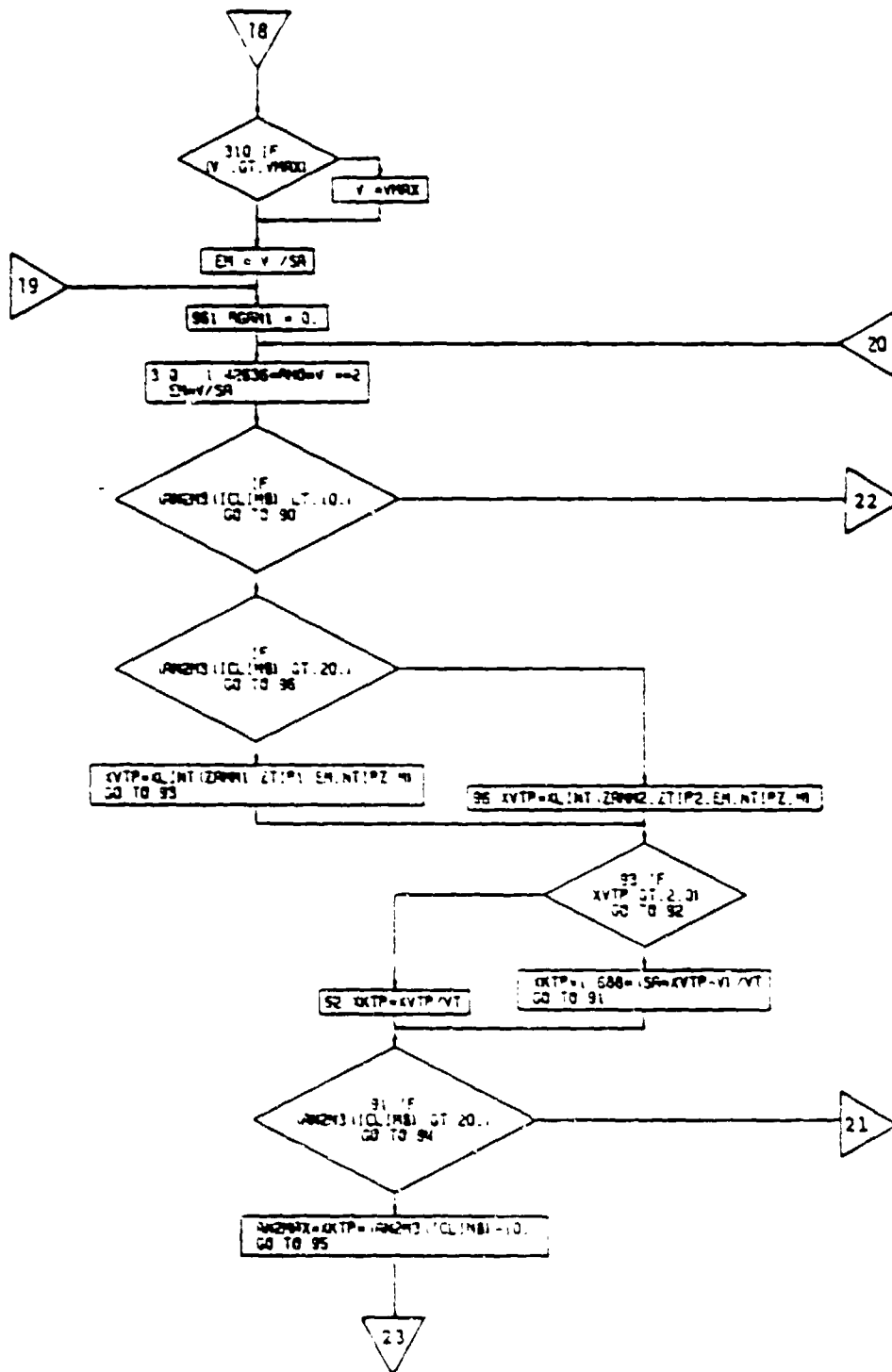


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 6 of 15)

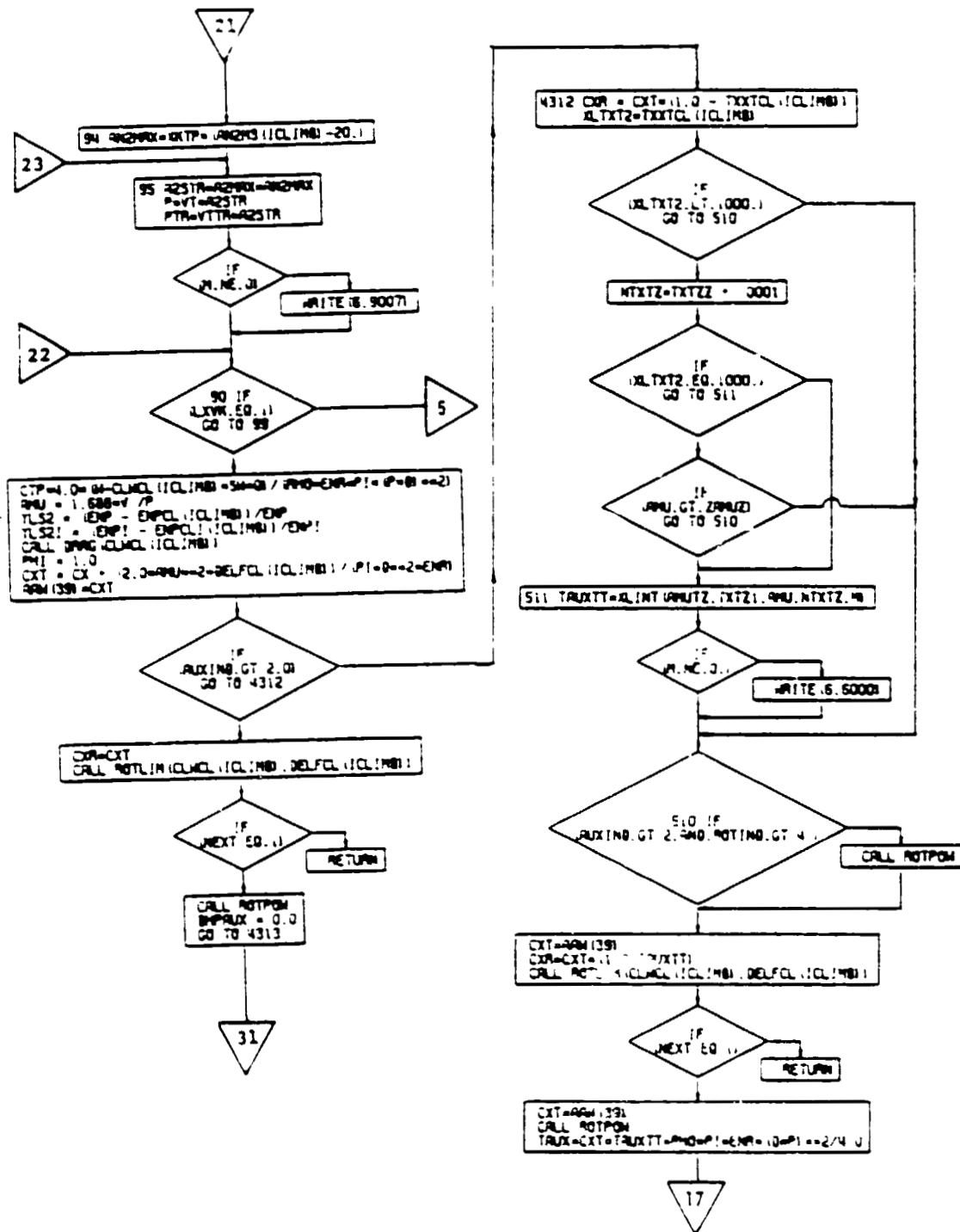


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 7 of 15)

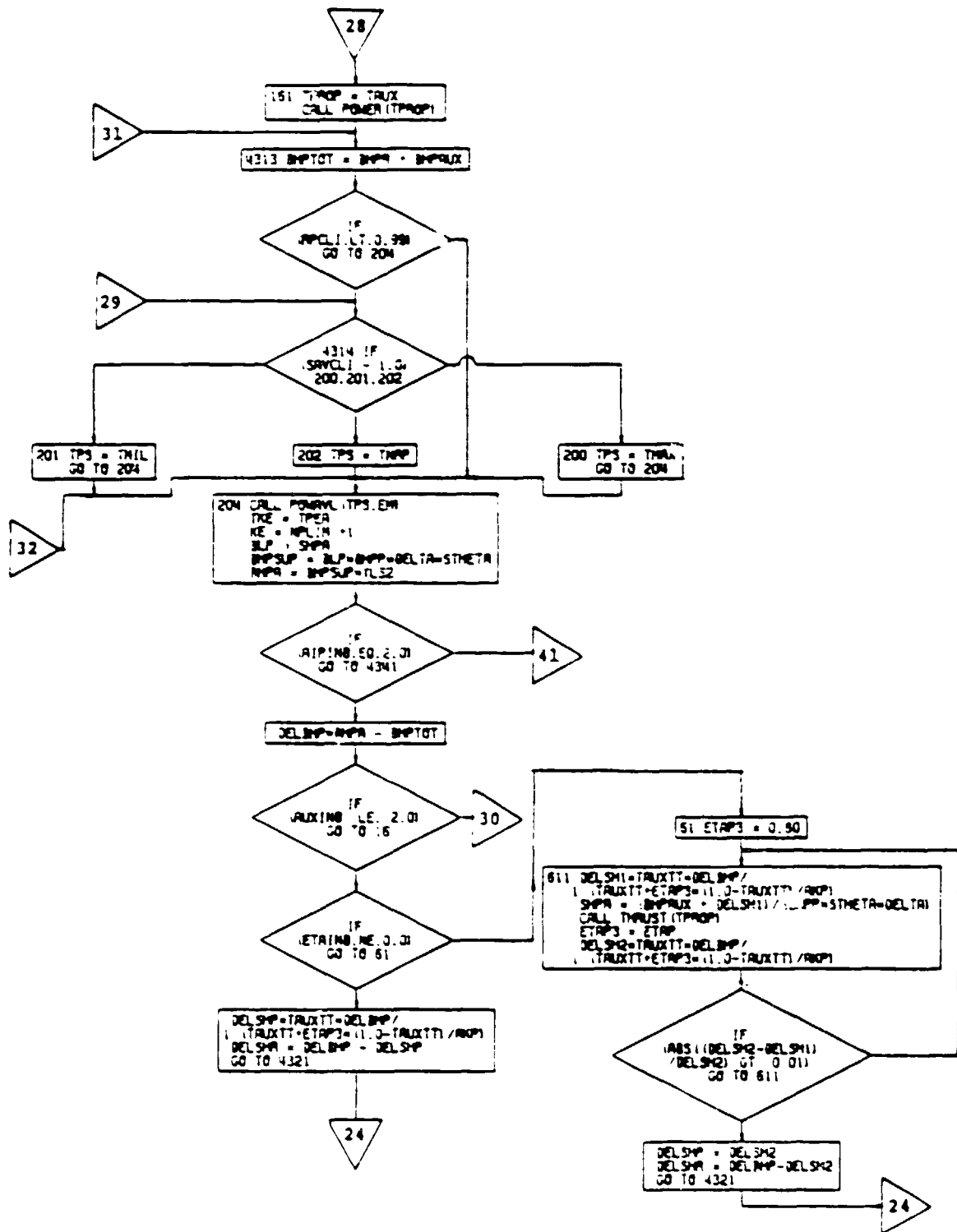


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 8 of 15)

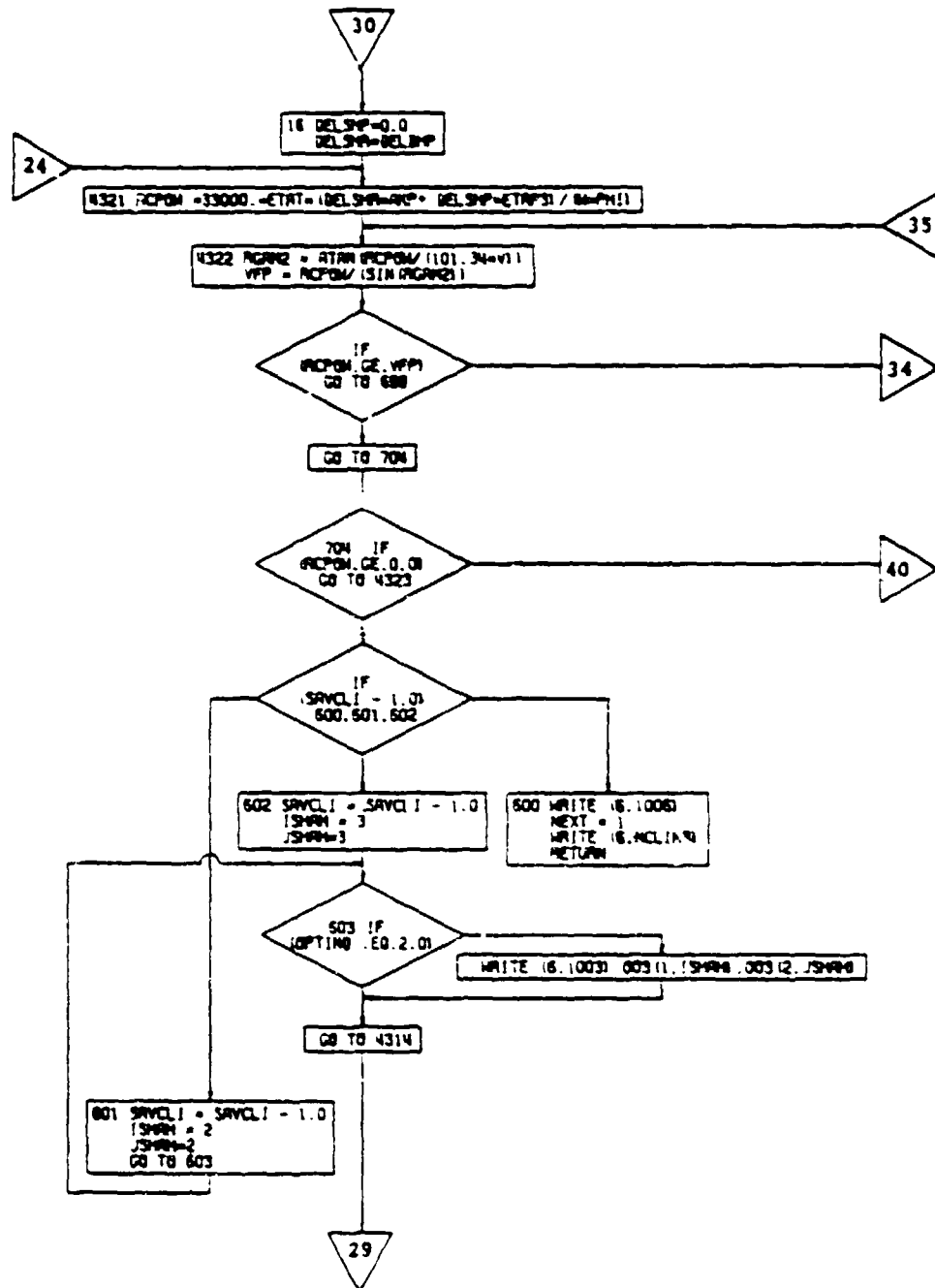


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 9 of 15)

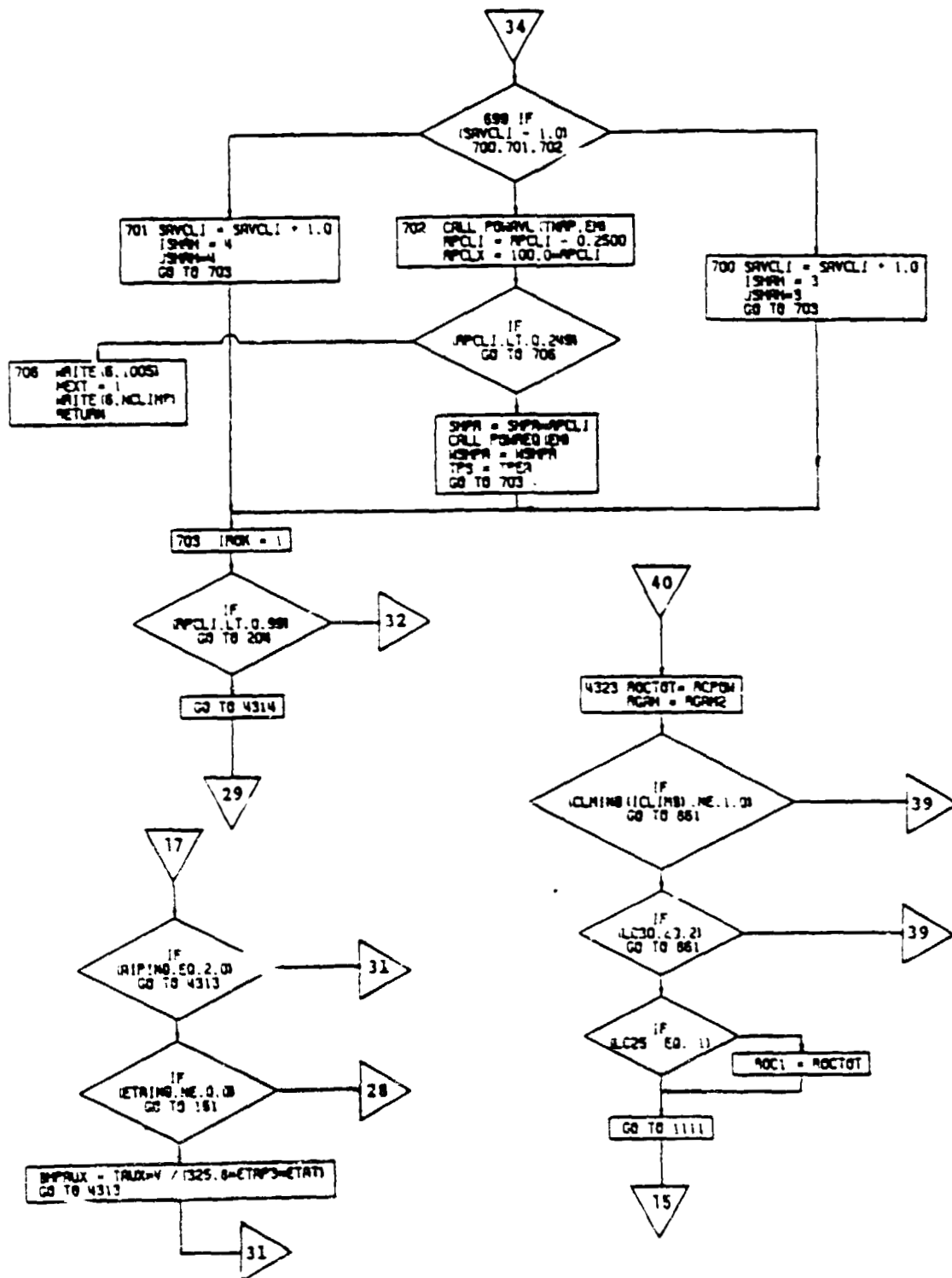


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 10 of 15)

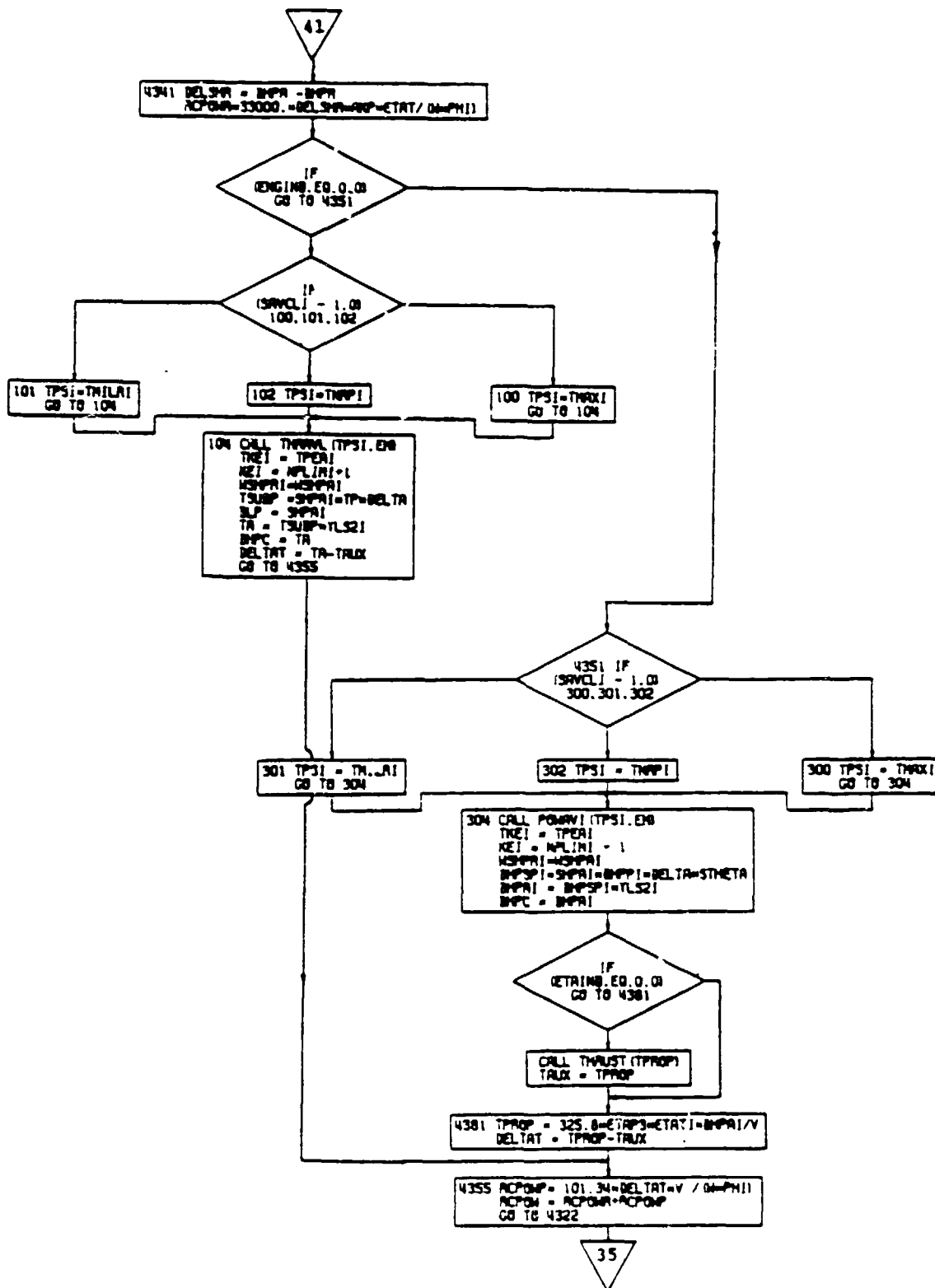


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 11 of 15)

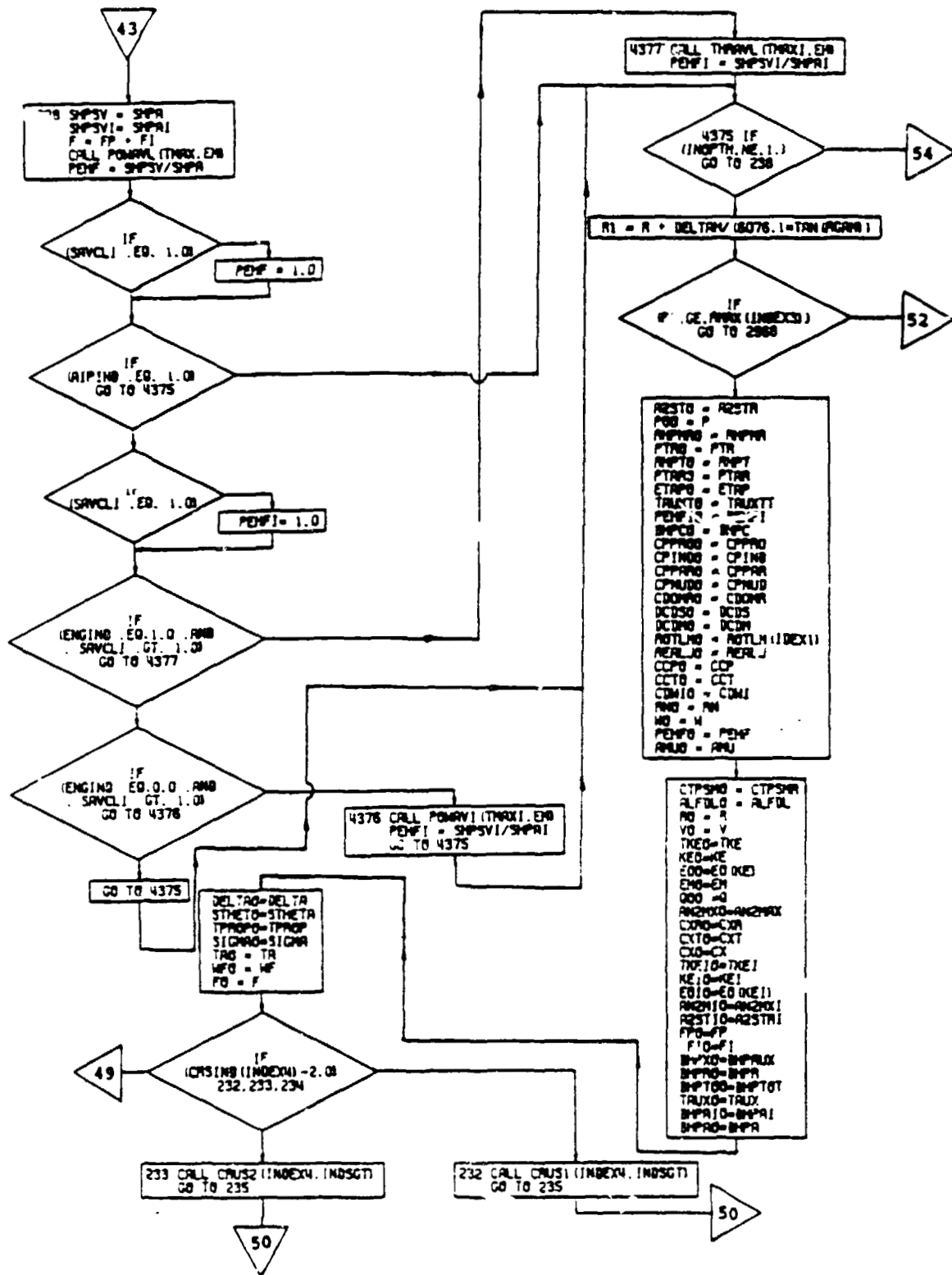


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 12 of 15)

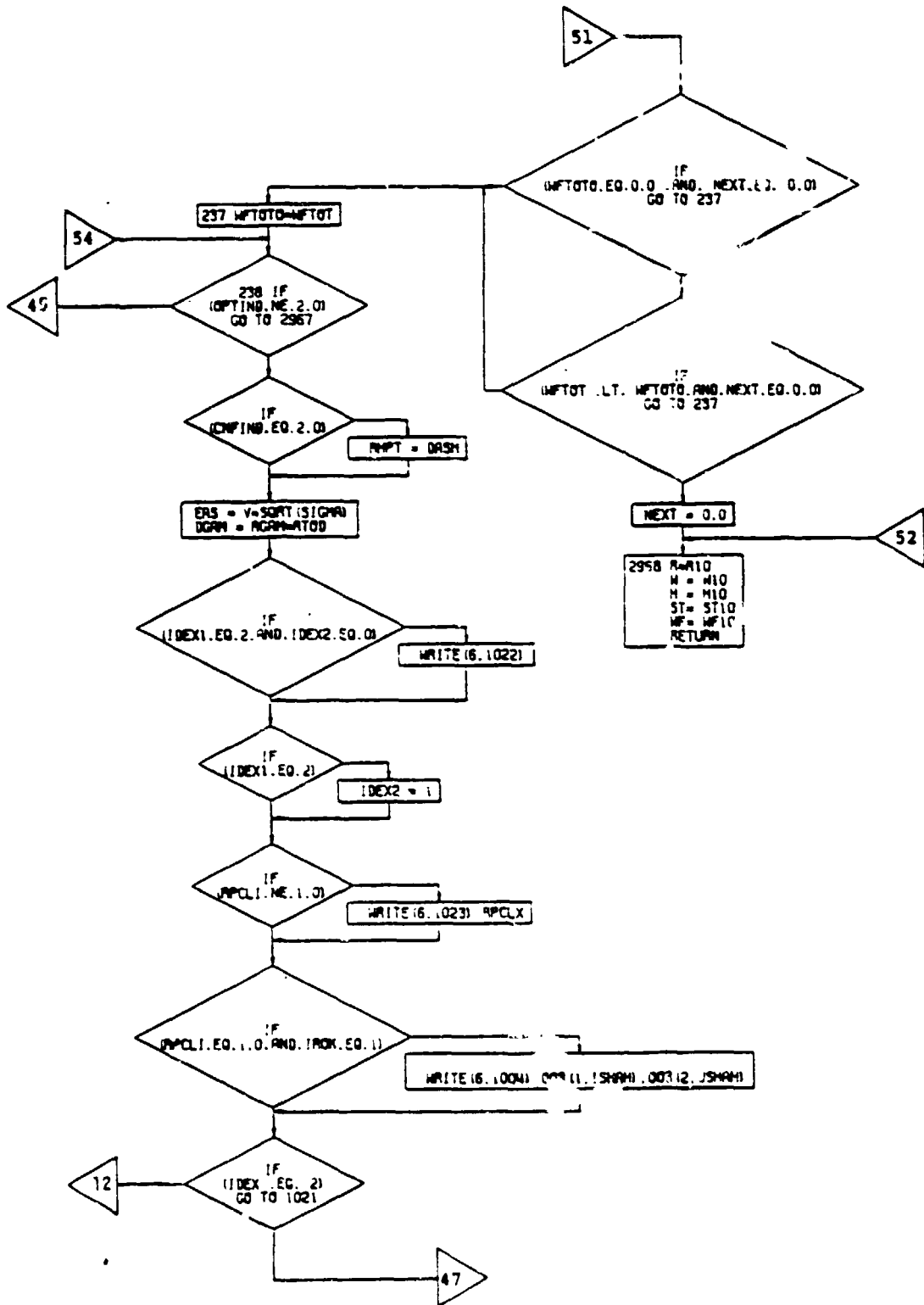


Figure 4-51. CLIMB Subroutine, Flow Chart (Part 13 of 15)



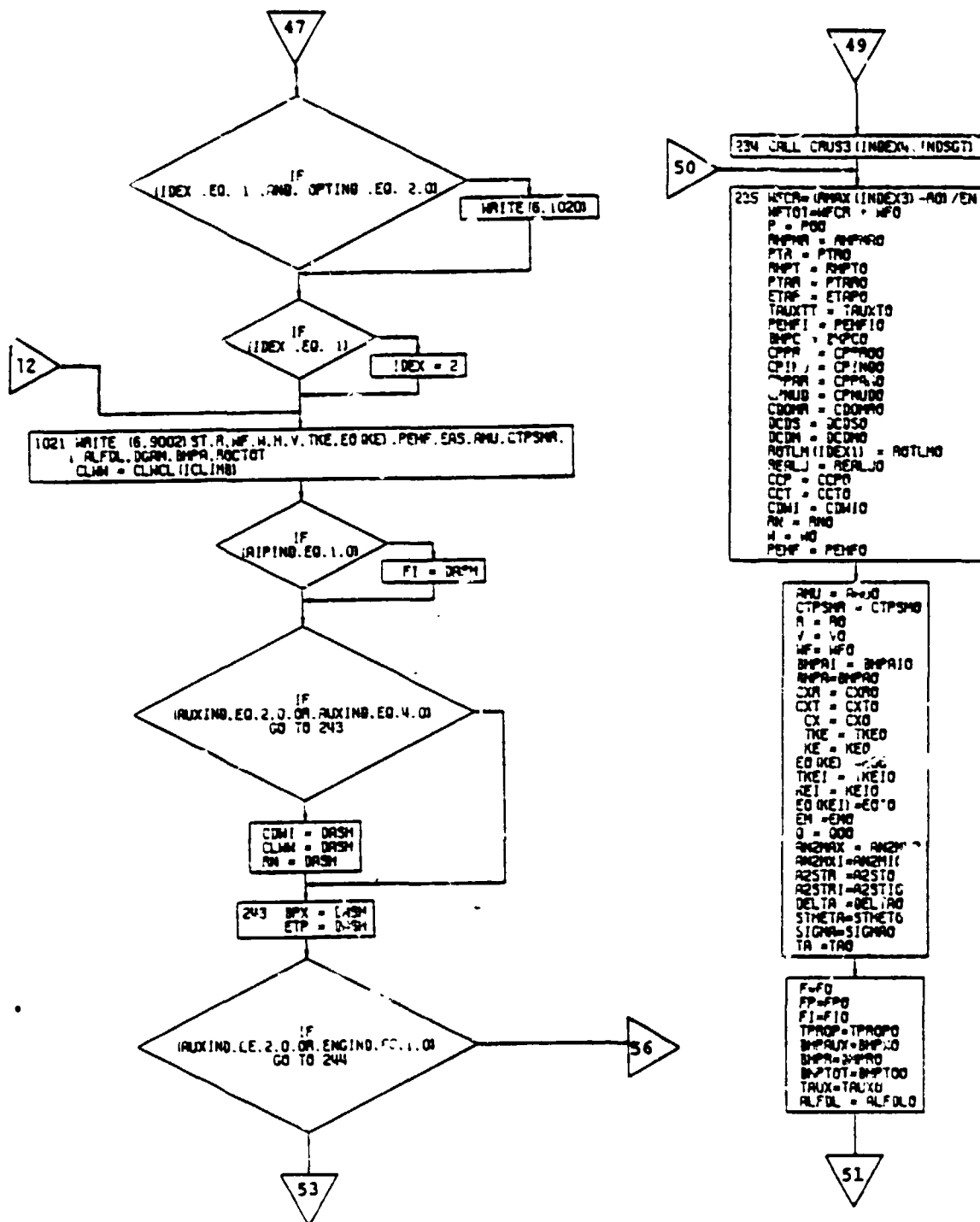


Figure 4-51.. CLIMB Subroutine Flow Chart (Part 14 of 15)

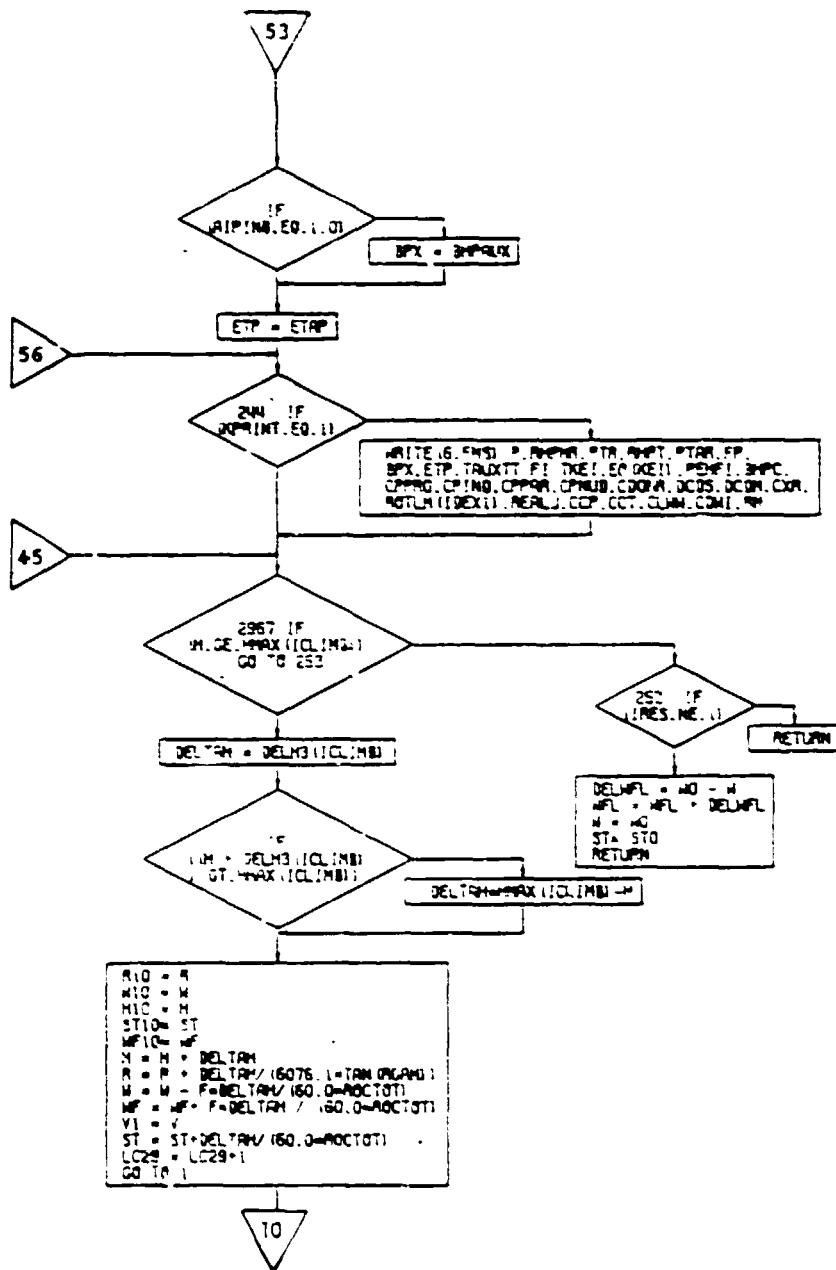


Figure 4-51. CLIMB Subroutine Chart (Part 15 of 15)

#### 4.12.4 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 helicopter 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, helicopter advance ratio, specific range, and reduction in gross weight during cruise. In the case of compound and auxiliary propulsion helicopters, if the auxiliary propulsion power required (to satisfy the input  $TAUX/T_{TOT}$ ) is greater than that available, as determined by POWIND,  $TAUX/T_{TOT}$  is readjusted to match the power requirements. It should be further noted that in the case of a configuration having auxiliary independent engines POWIND, which specifies the desired power setting for the primary engines, is used as a limiting factor for the auxiliaries.

CRSIND = 2 - This option will calculate the cruise performance constrained by cruise power and by limiting airspeed and Mach number of the aircraft at constant true airspeed and constant altitude. The program will calculate the power setting required, true airspeed, specific range, and corresponding reduction in gross weight of the aircraft during cruise. In the case of an auxiliary independent engine configuration, if either the primary or auxiliary engine power required is greater than that available,  $TAUX/T_{TOT}$  is readjusted accordingly. Then, if a power required-power available match is not achieved, cruise speed is reduced.

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. When auxiliary independent engines are employed, cruise speed is reduced ( $TAUX/T_{TOT}$  not being readjusted from its input value) until both auxiliary and primary power required are less than available.

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 (both primary and auxiliary) shut down.

The program user specifies the number of engines shut down and a corresponding increment in airplane equivalent flat plate area drag.

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

It is possible to use a cruise segment in the mission profile to account for a reserve fuel requirement (SGTIND = 40) (in such a case the helicopter weight at the end of cruise is set back to the weight at the beginning of cruise) or as a part of the basic mission (in this case the weight is not reset). In either case, the fuel used during cruise is included in the total fuel required to size the helicopter.

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 4-52 is a flow chart of this subroutine.

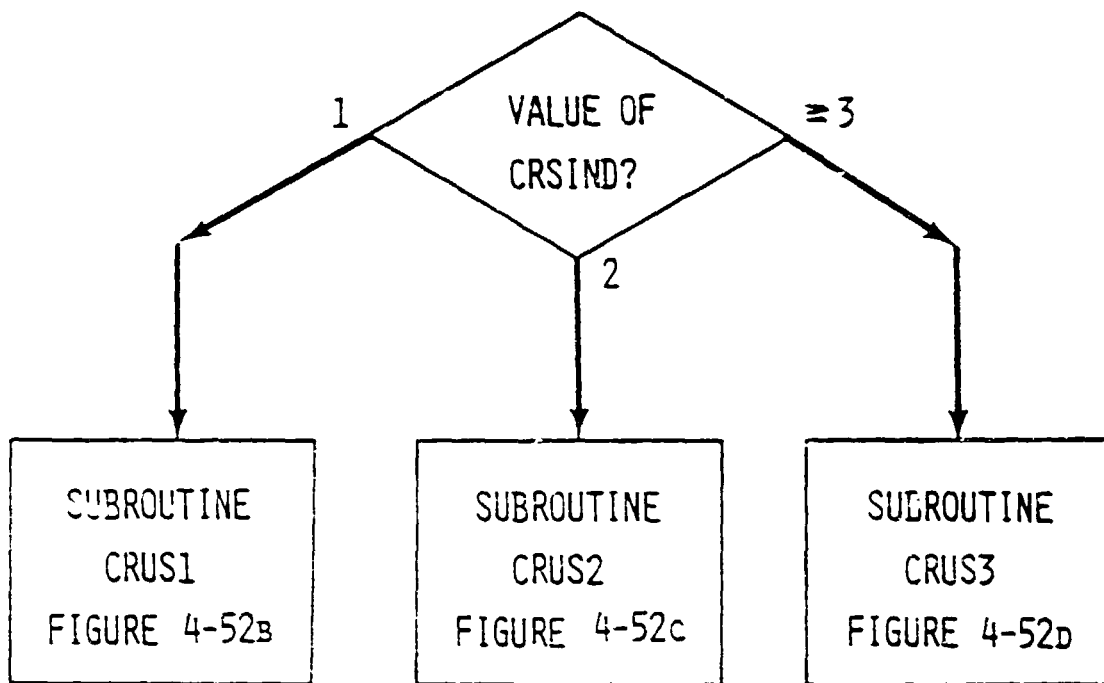


Figure 4-52a. Cruise Calculations Subroutine.

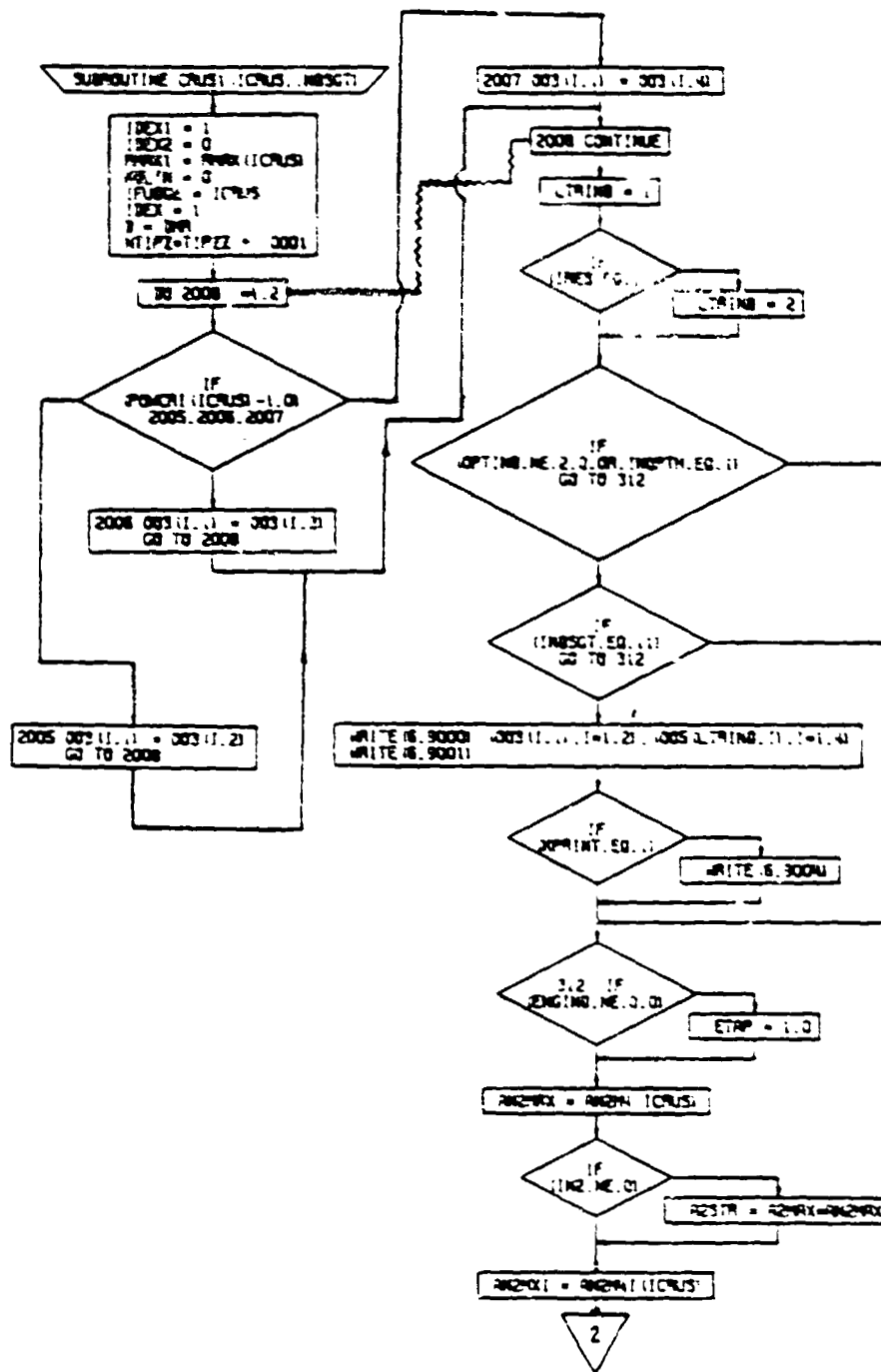


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 1 of 12)

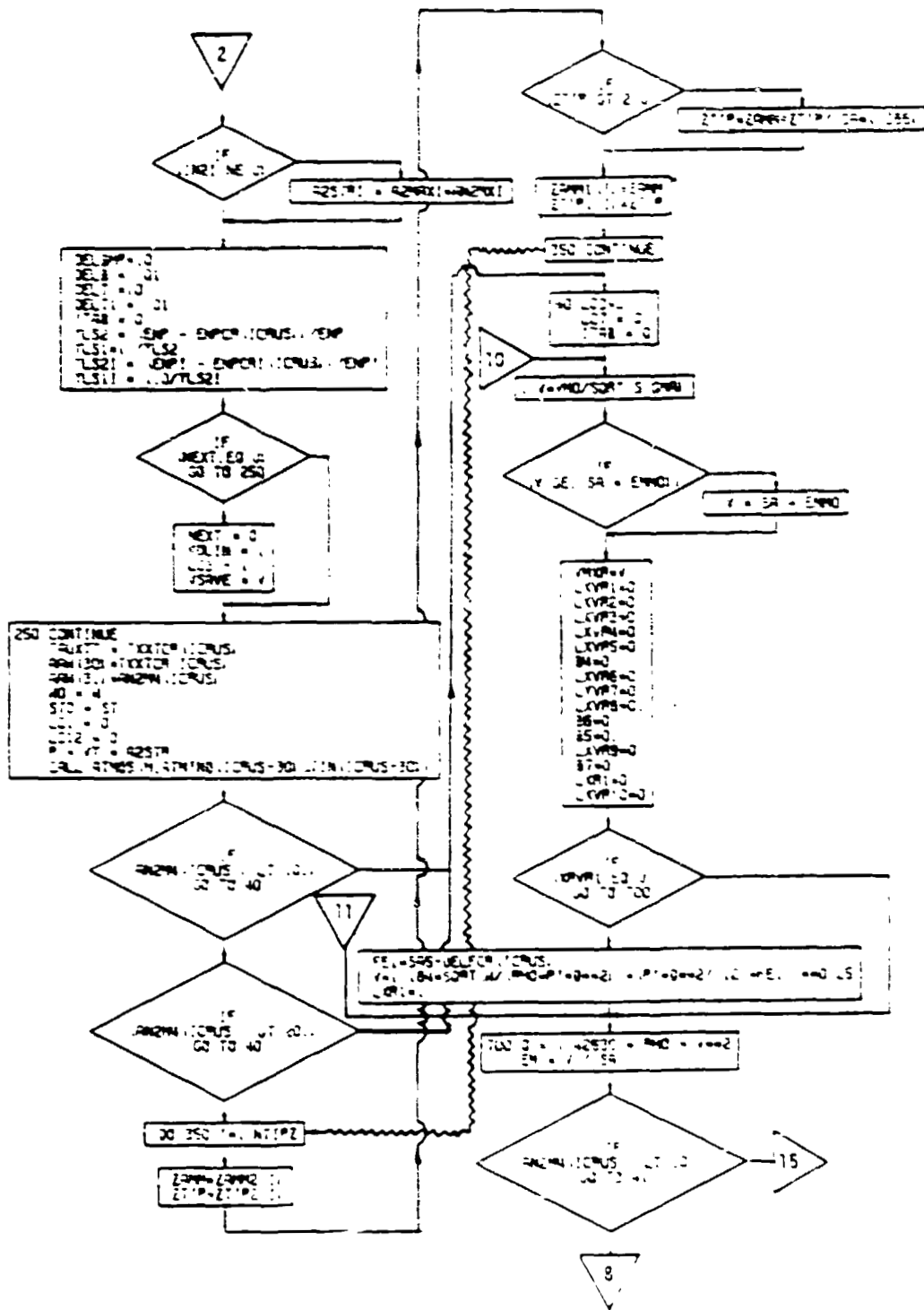


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 2 of 12)

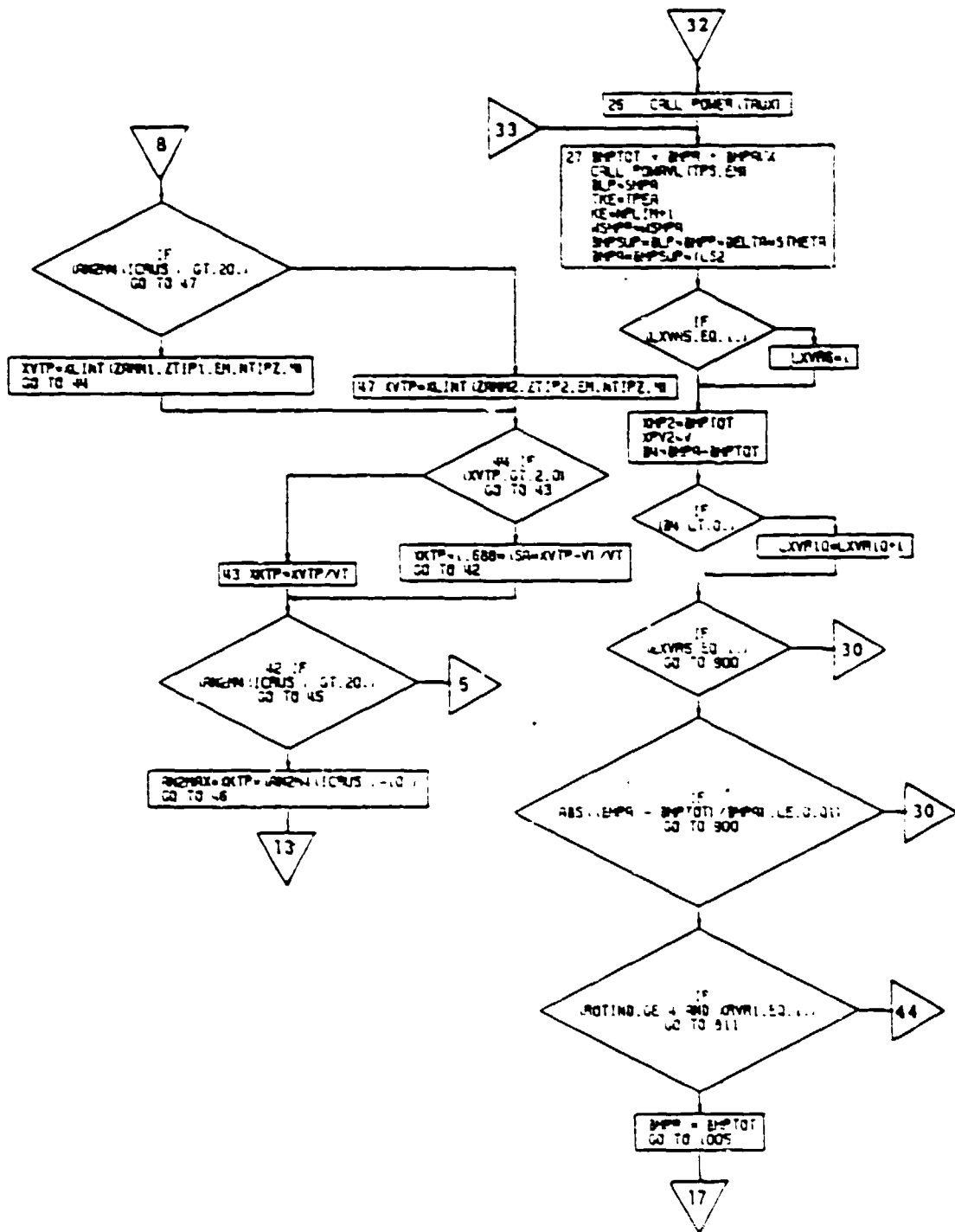


Figure 4-52b. Cruise 1 Subroutine, Flow Chart- (Part 3 of 12)



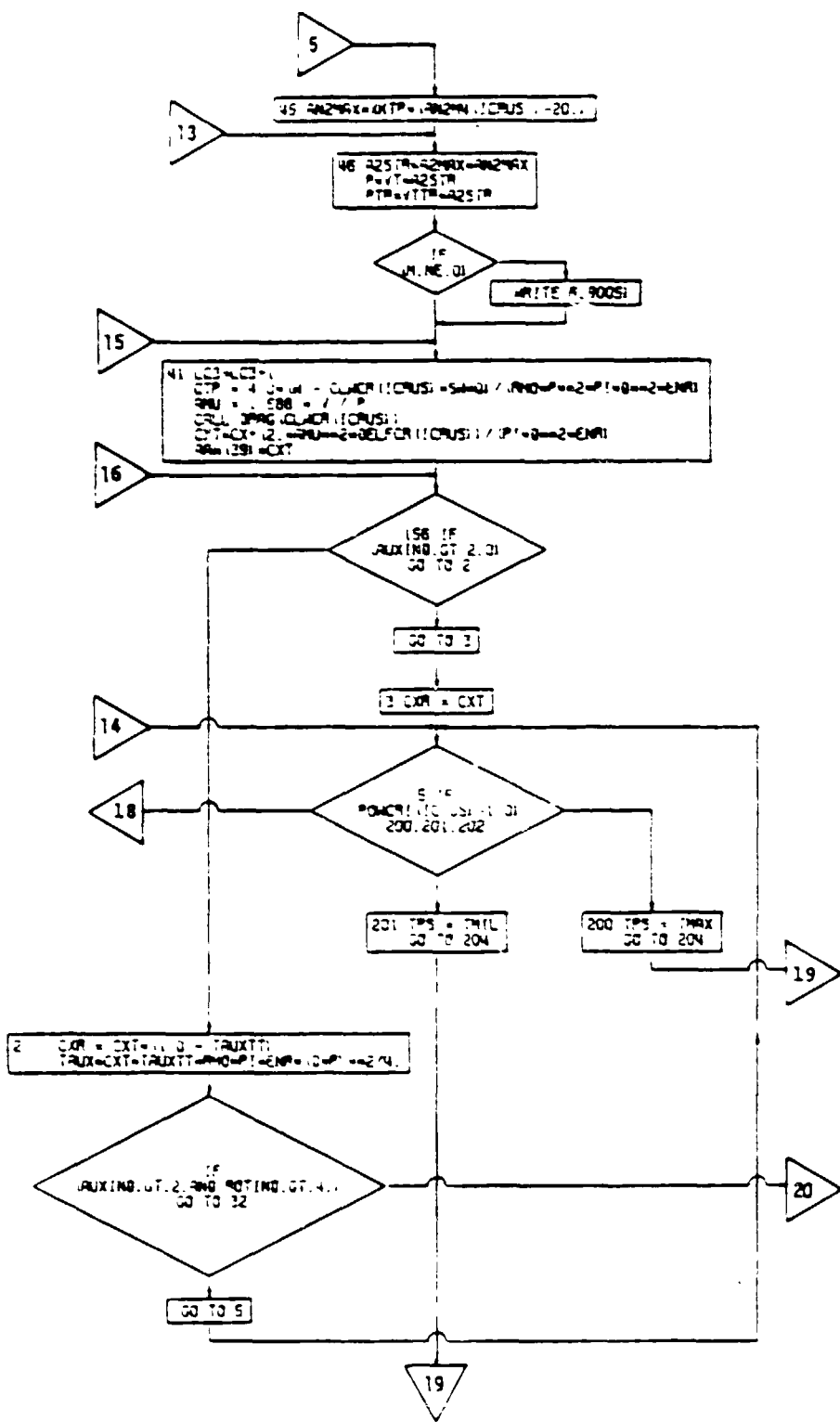


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 4 of 12)

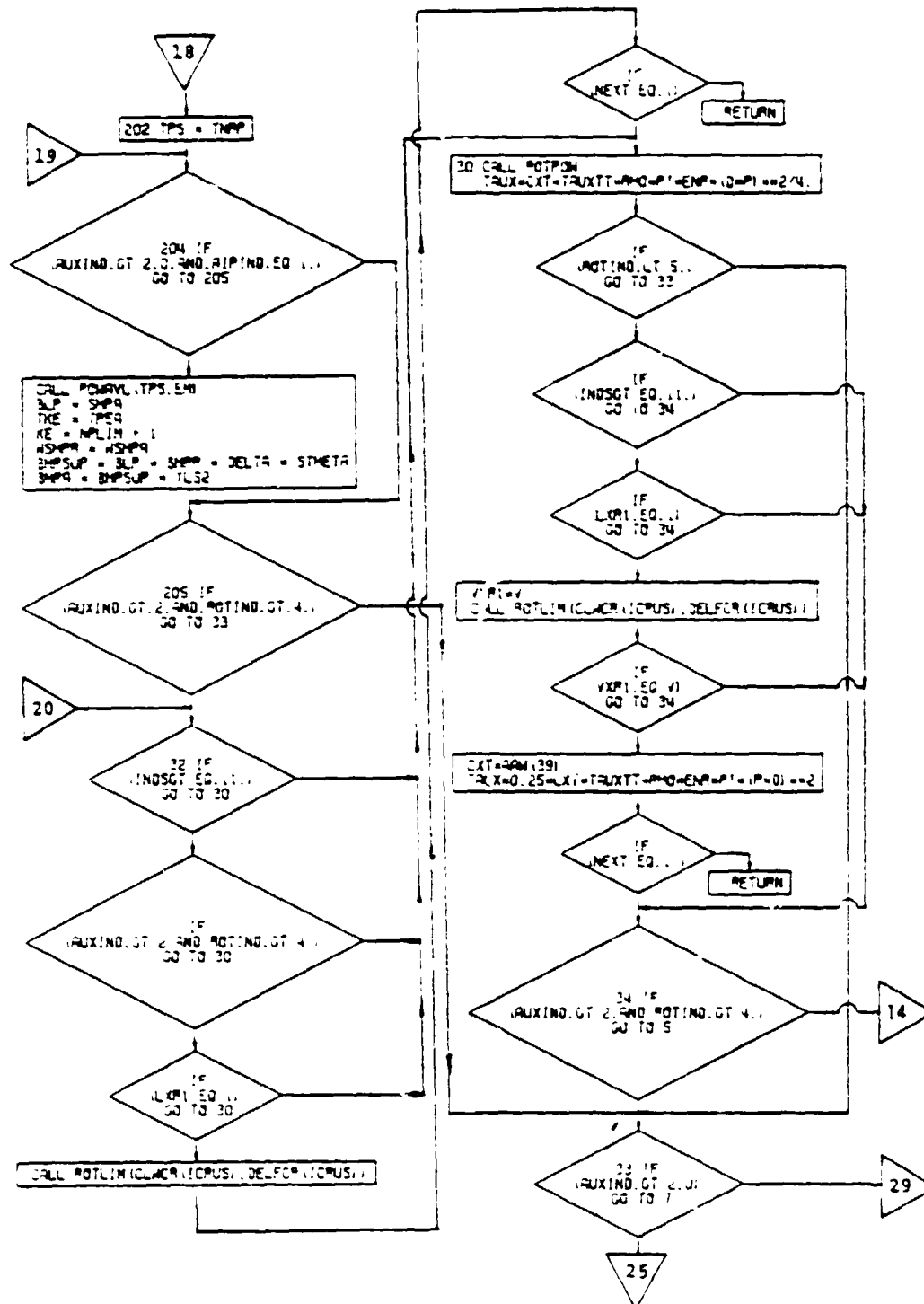


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 5 of 12)

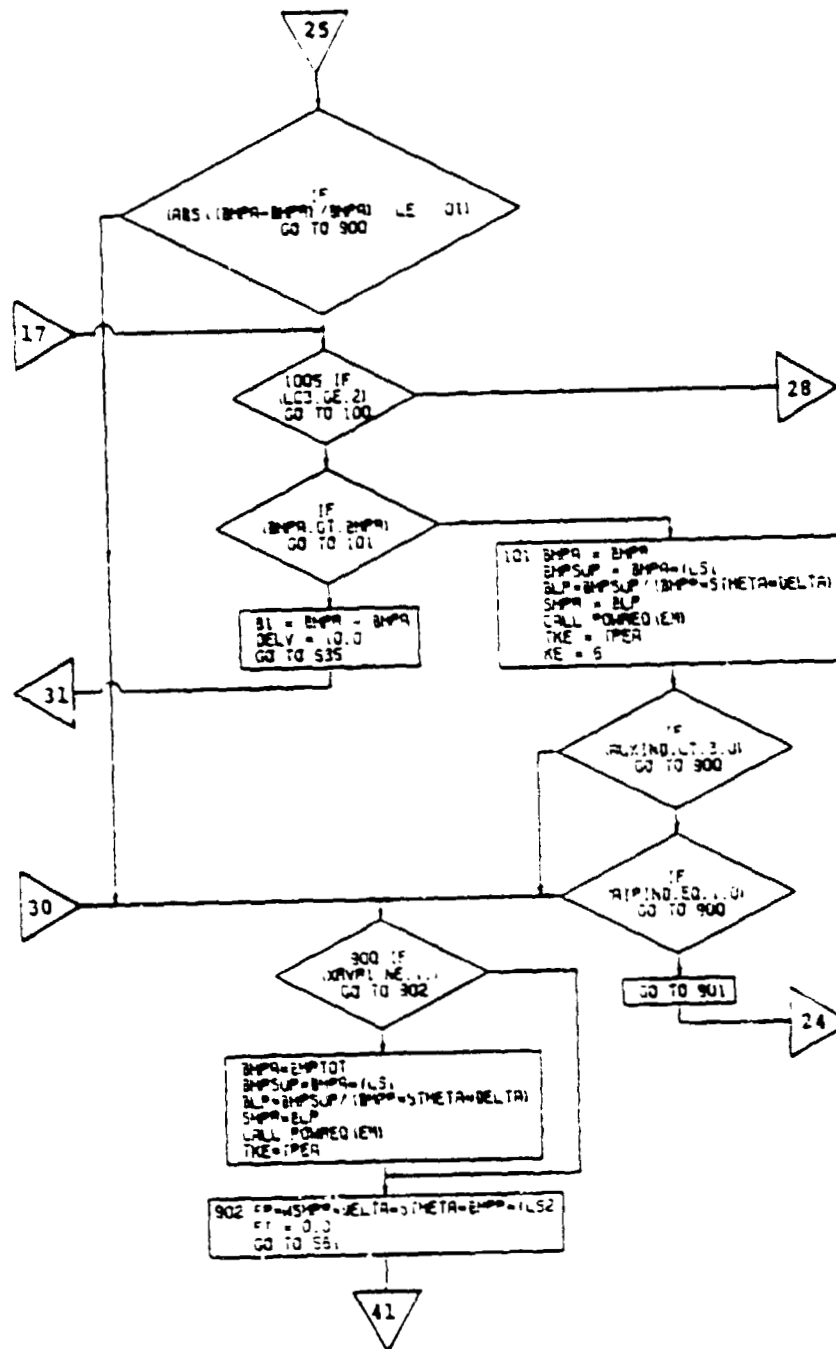


Figure 4-52b. Cruise-1 Subroutine, Flow Chart (Part 6 of 12)

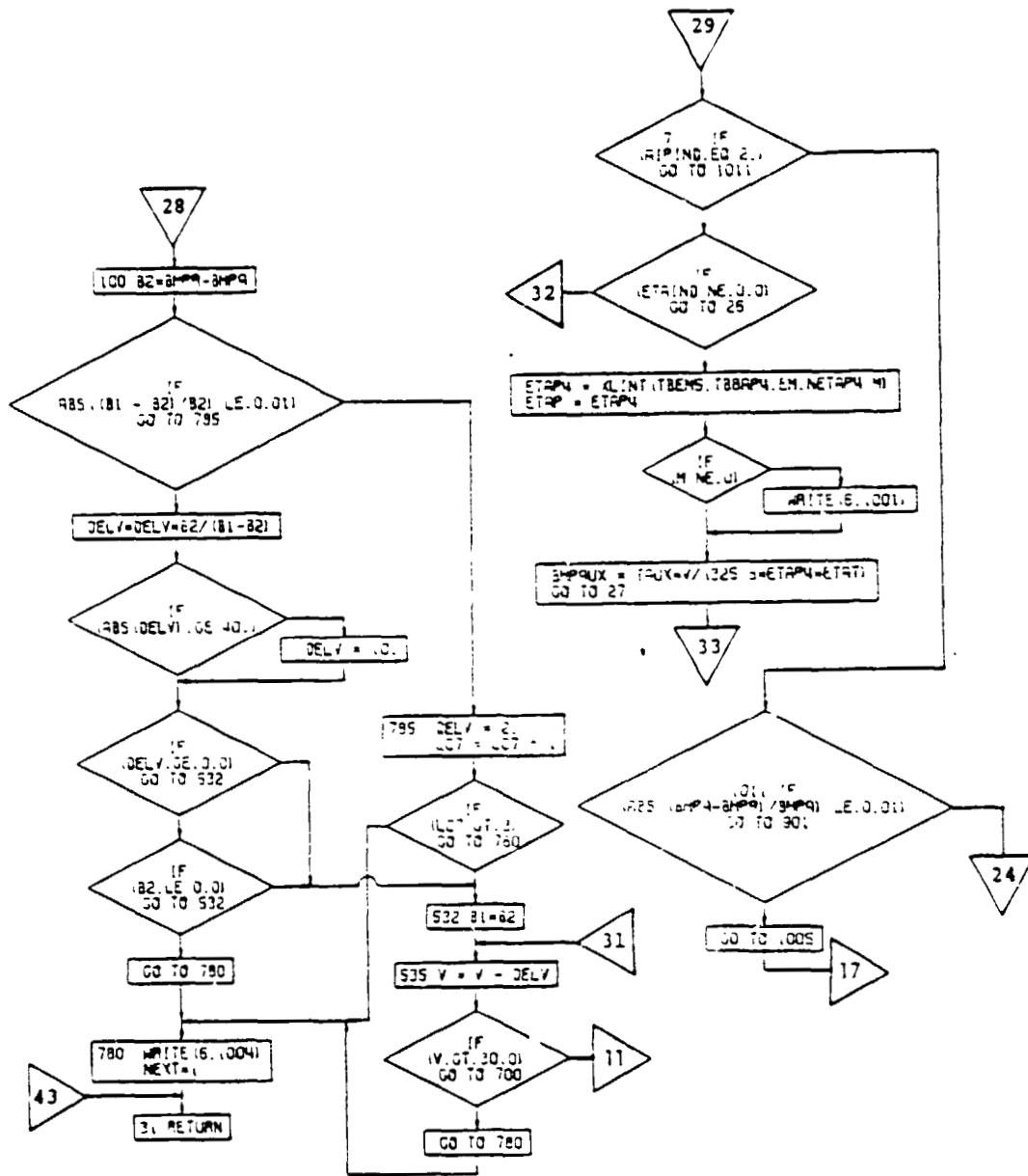


Figure 4-52b. Cruise-1-Subroutine, Flow Chart (Part 7 of 12)

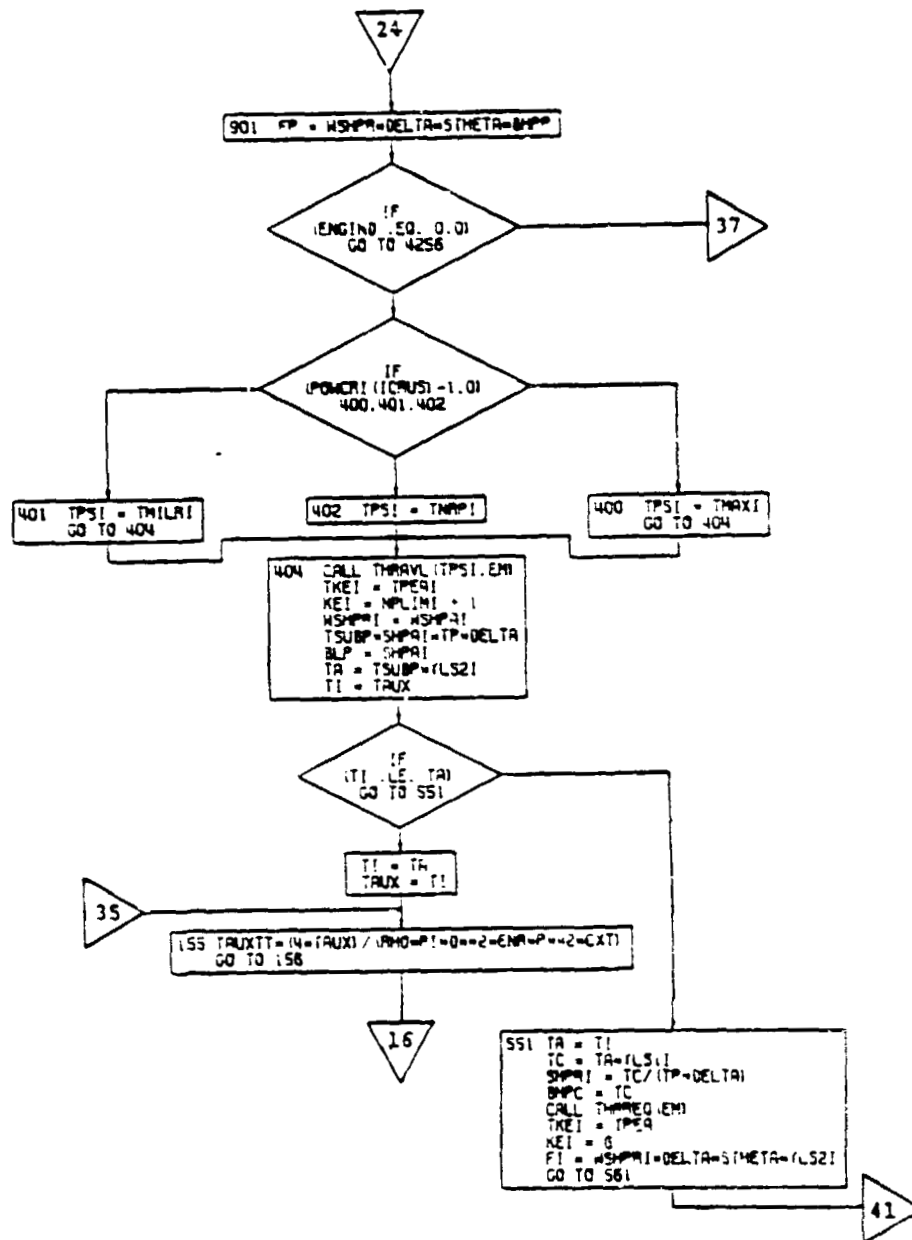


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 8 of 12)

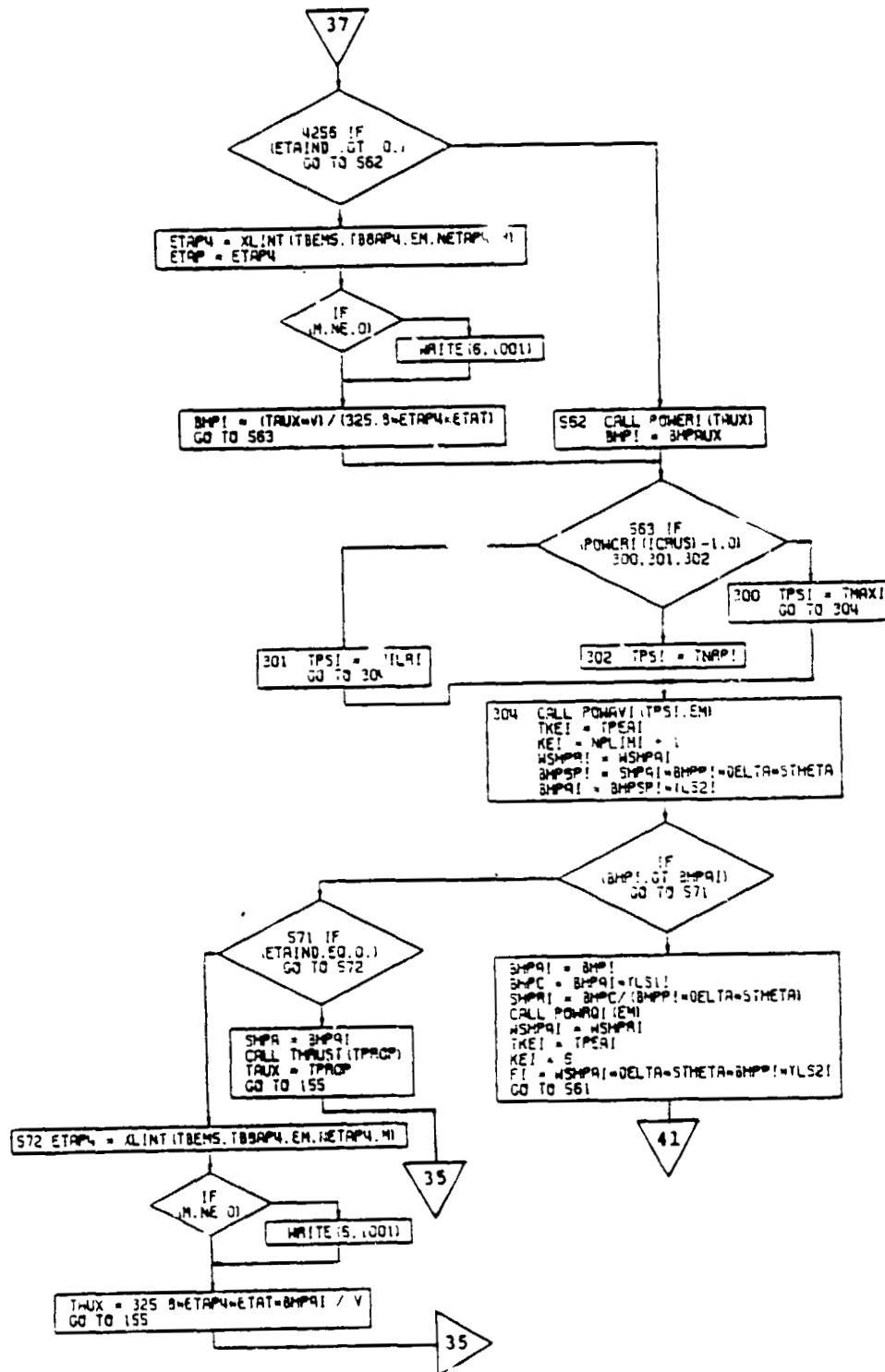


Figure 4-52b. Cruise 1-Subroutine, Flow Chart (Part 9 of 12)



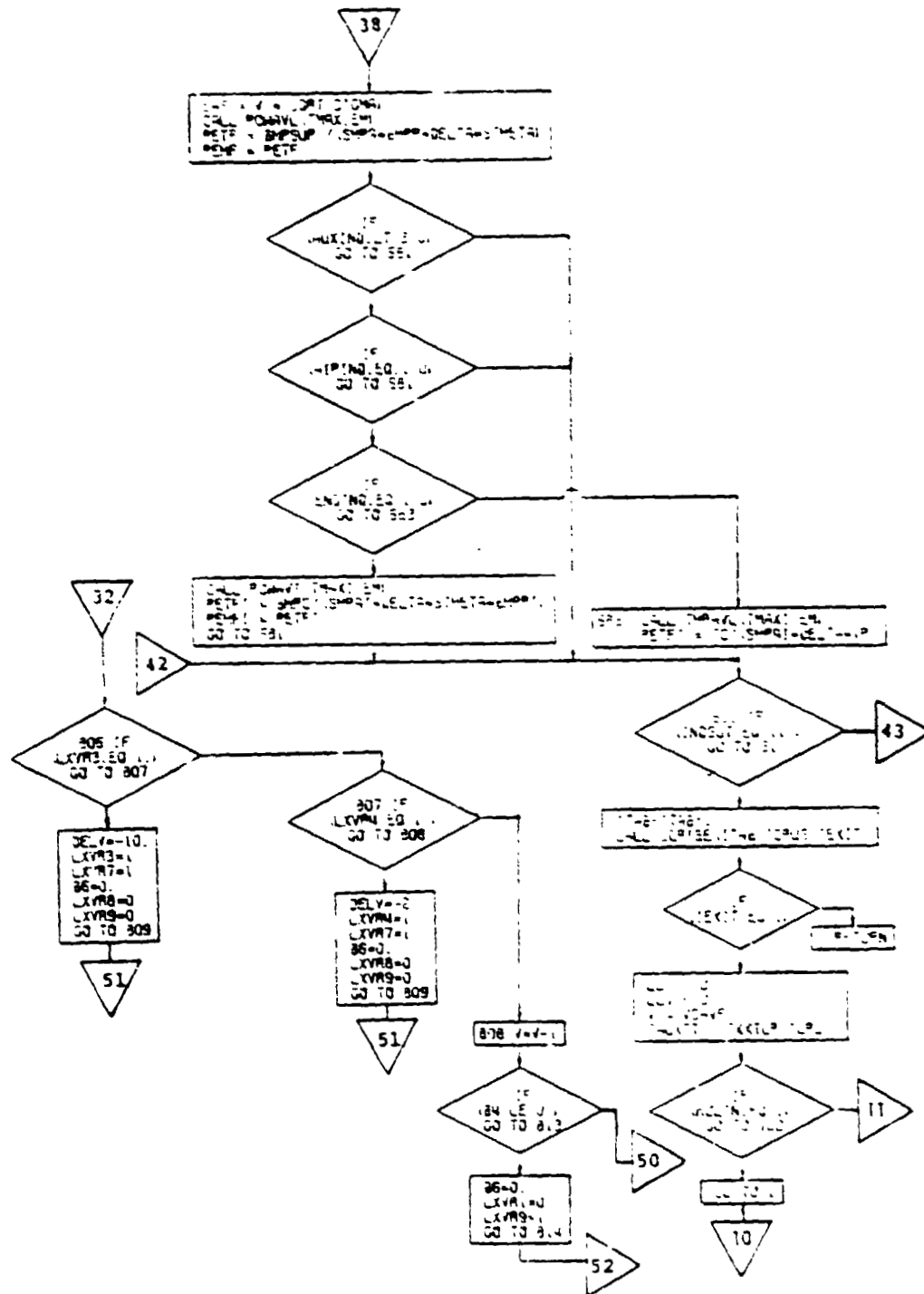


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 11 of 12)



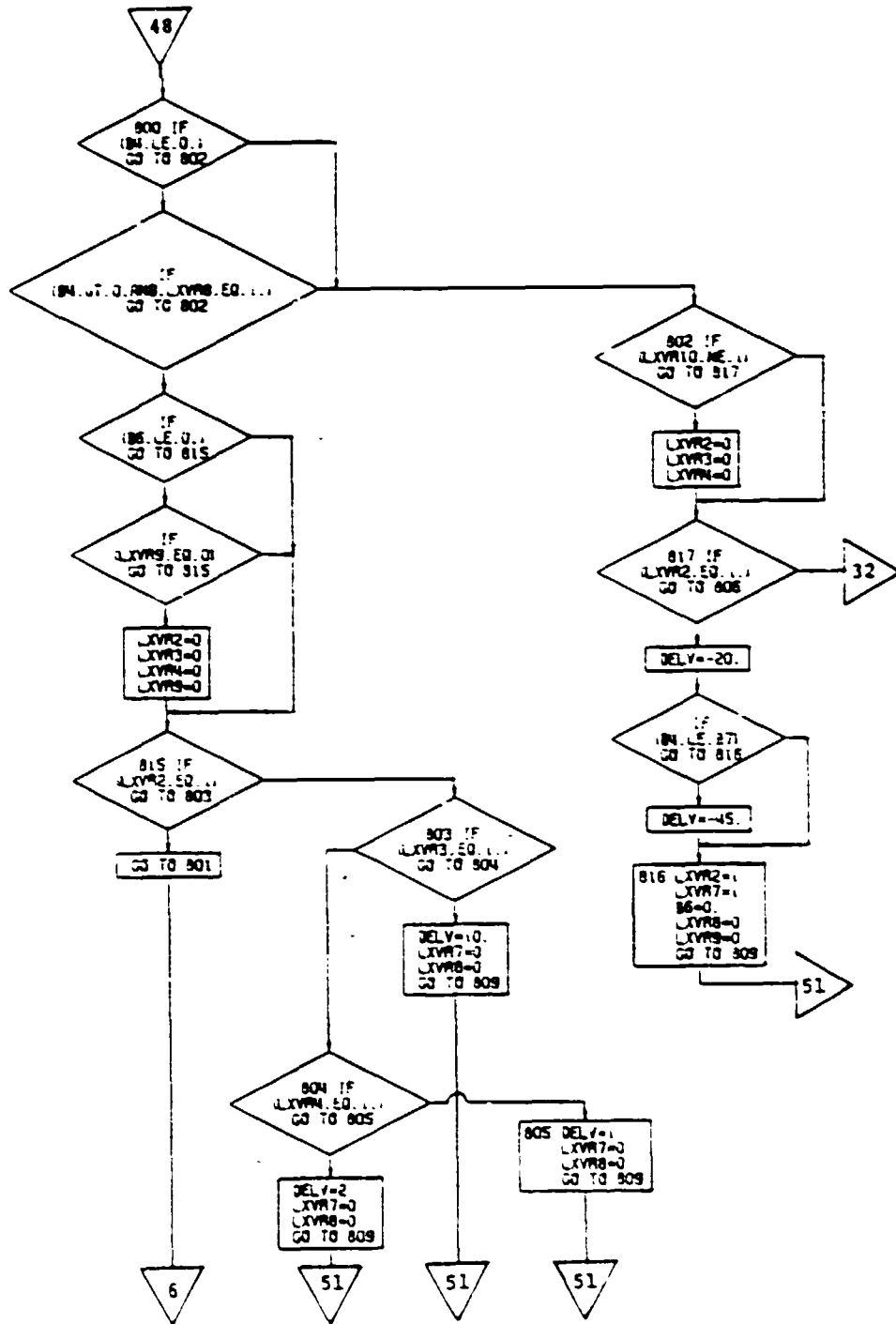


Figure 4-52b. Cruise 1 Subroutine, Flow Chart (Part 12 of 12)

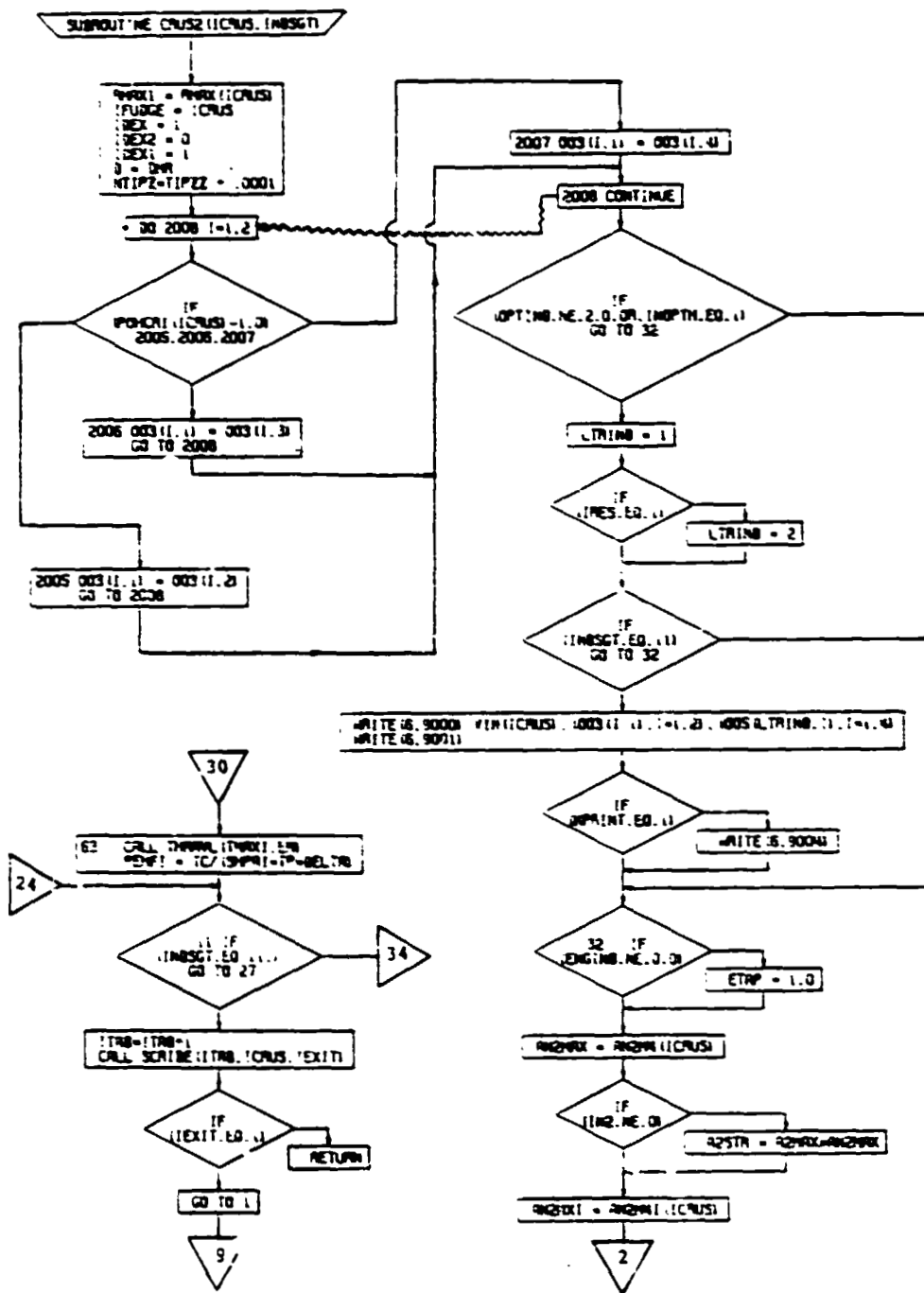


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 1 of 8)

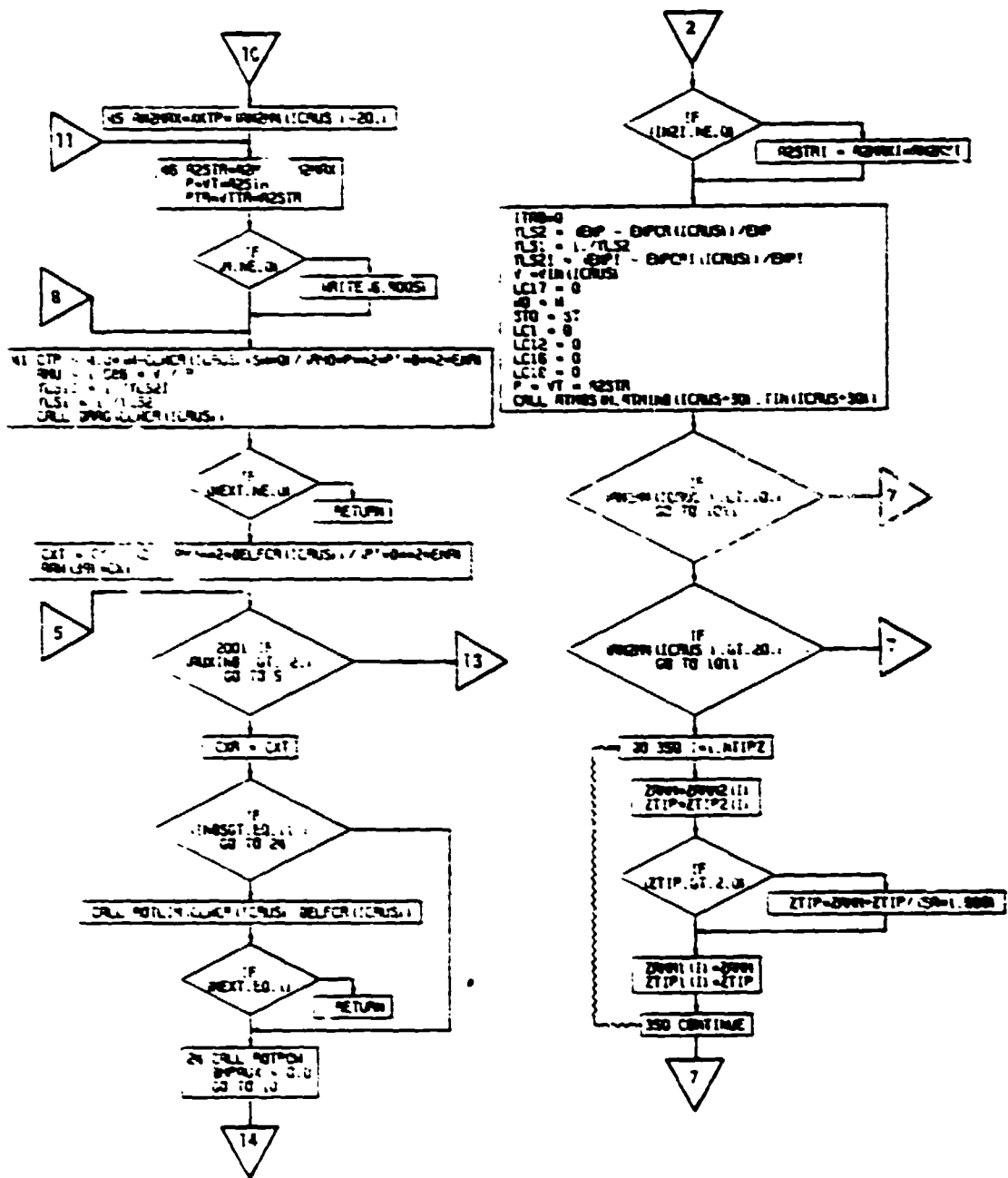


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 2 of 8)

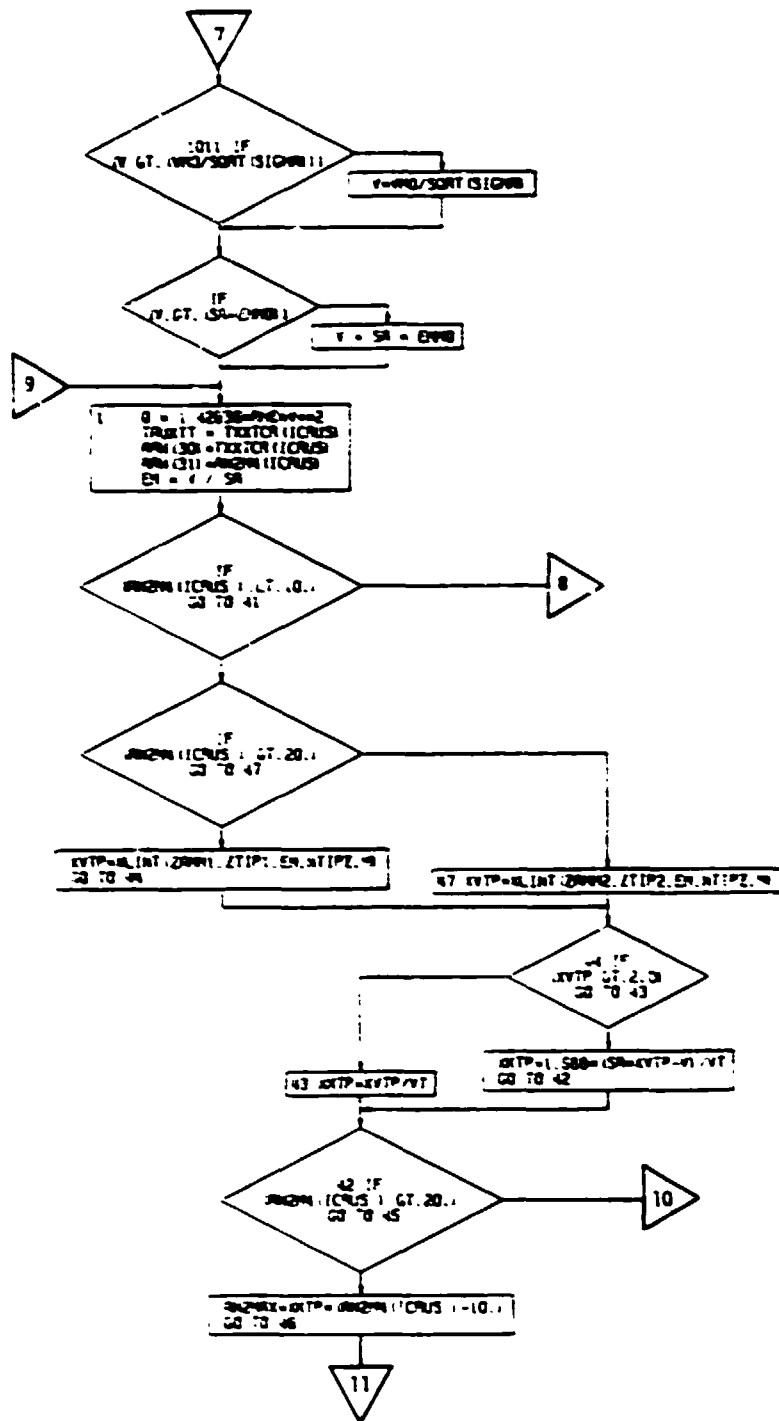


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 3 of 8)

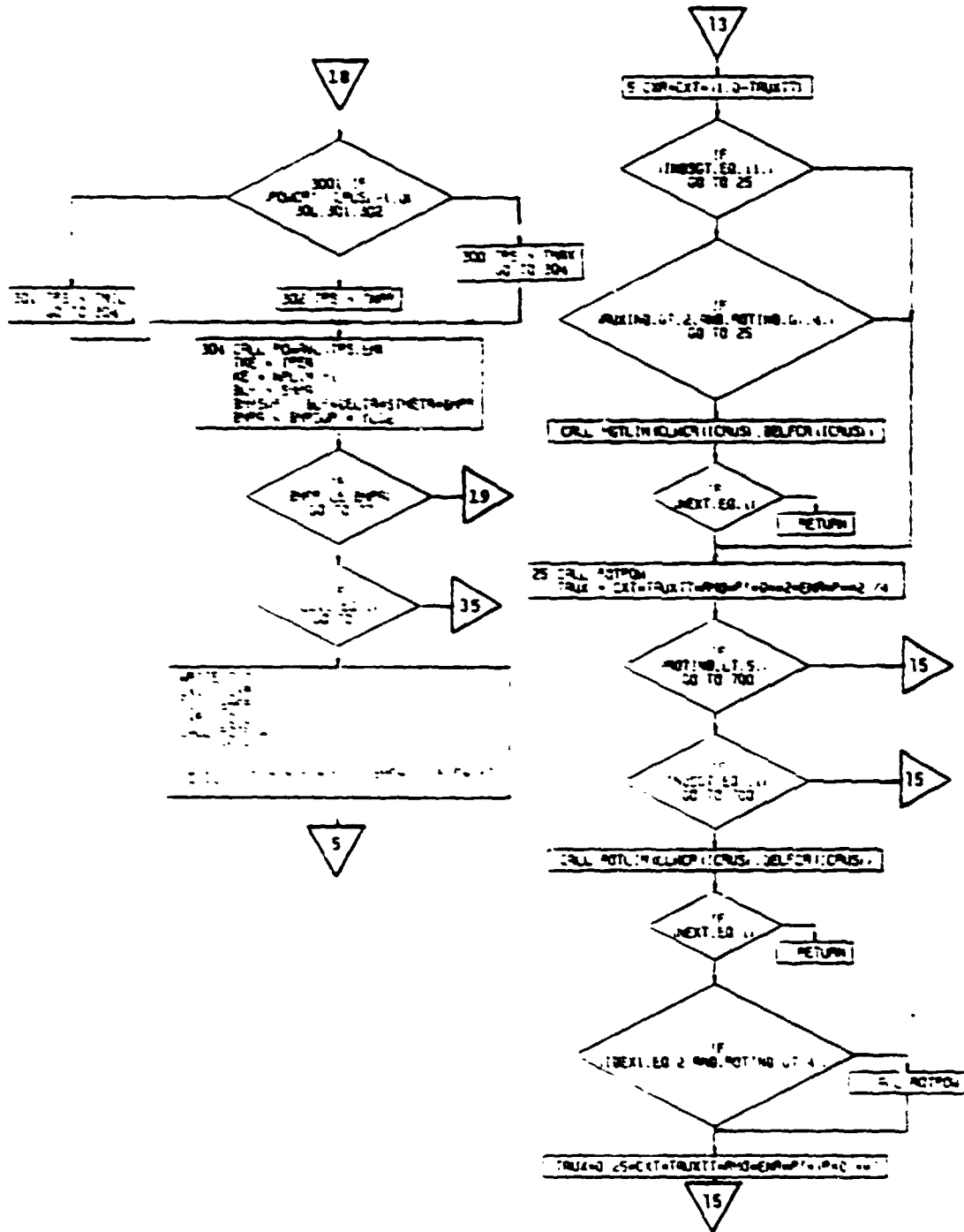


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 4 of 8)

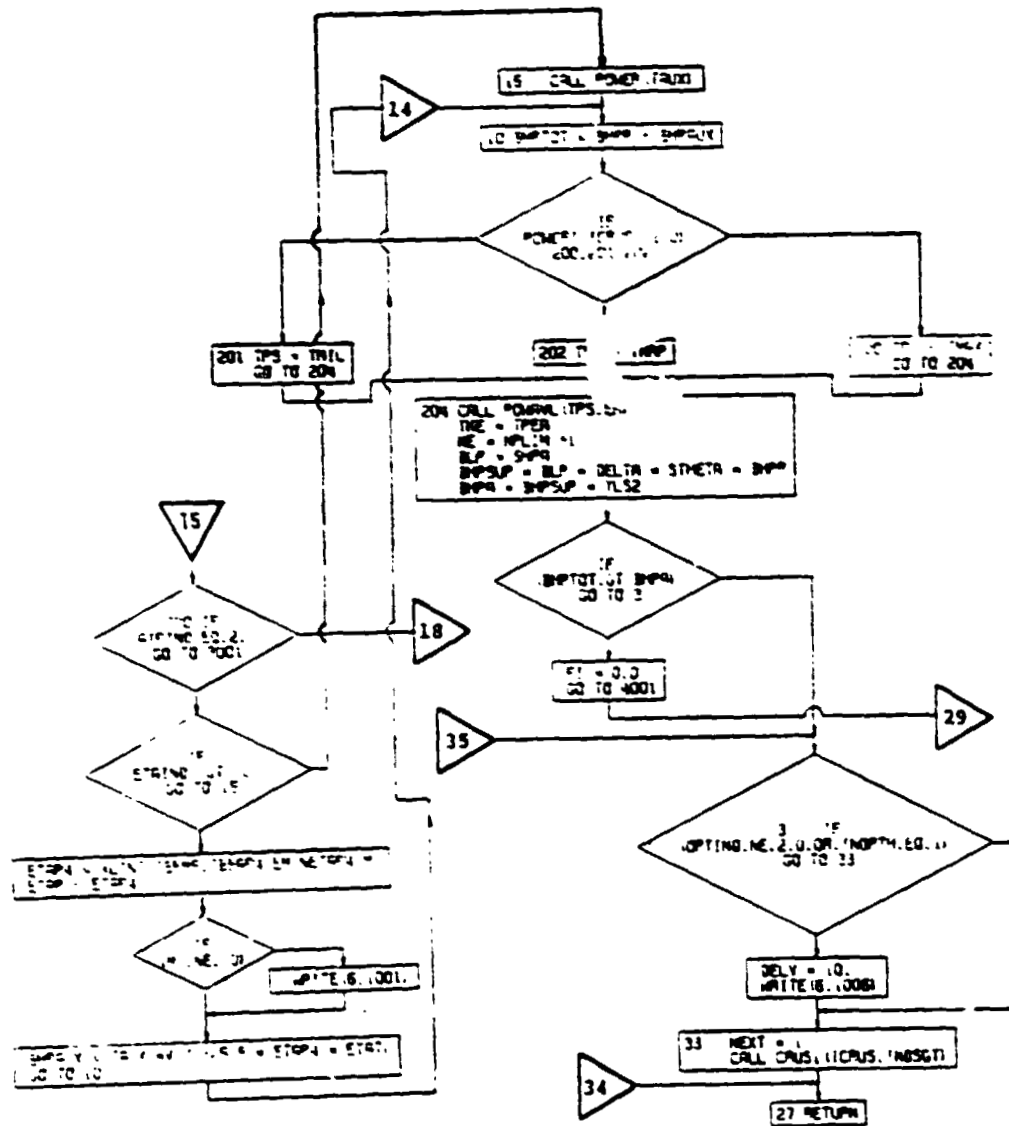


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 5 of 8)

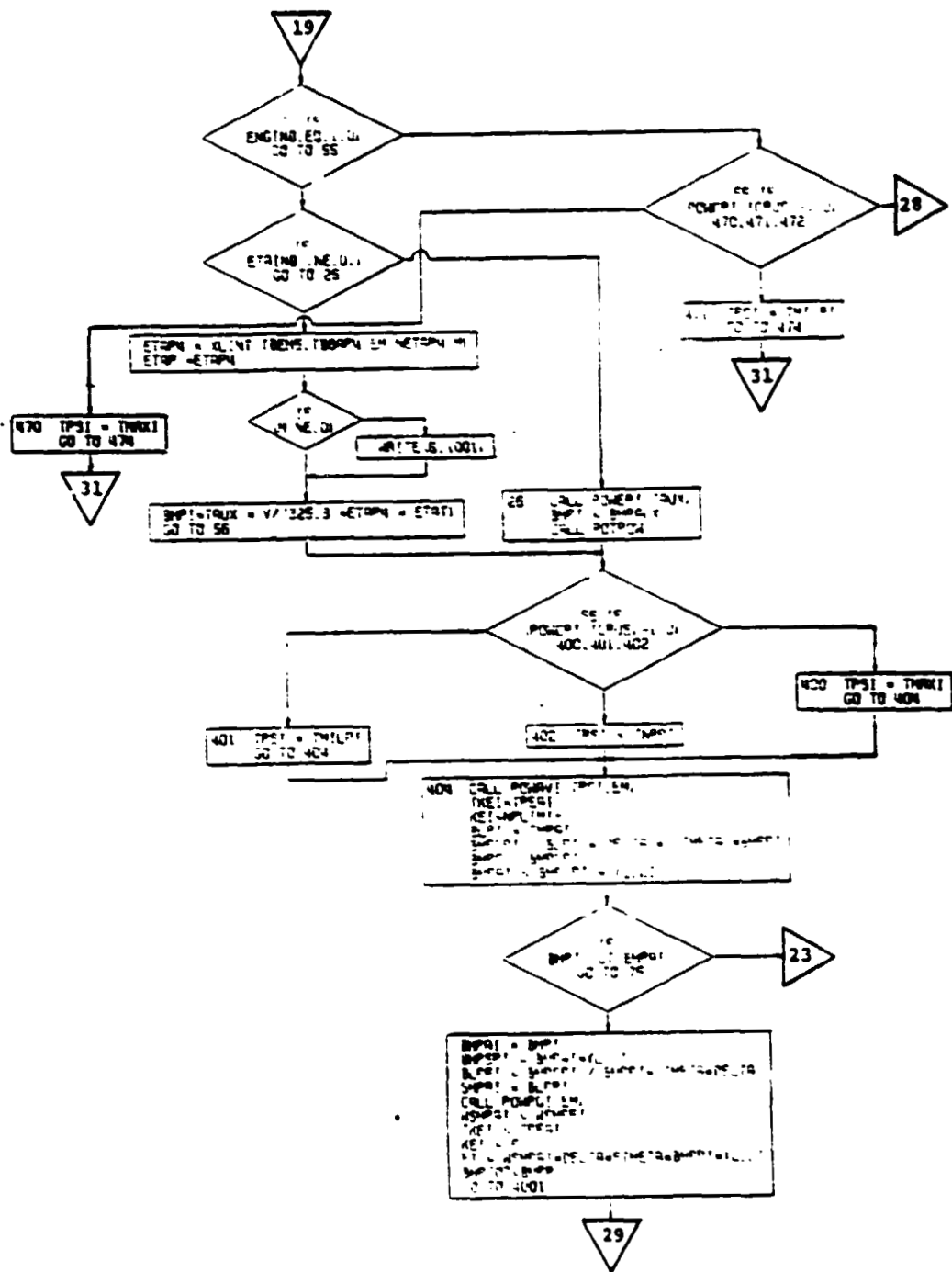


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 6 of 8)

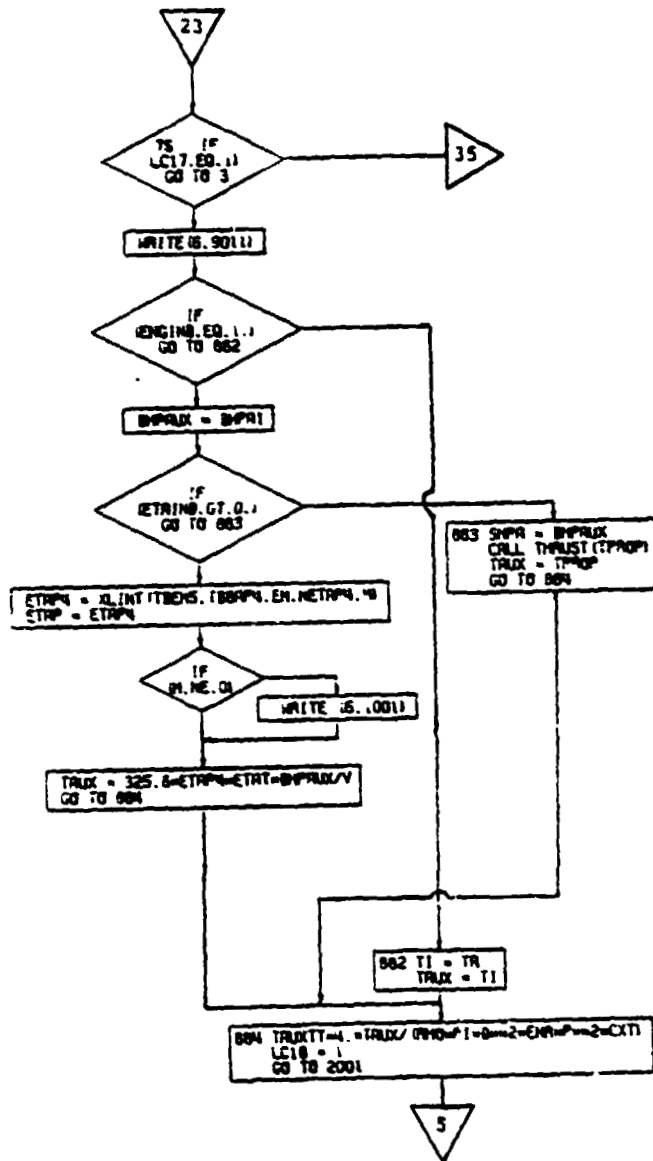


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 7 of 8)



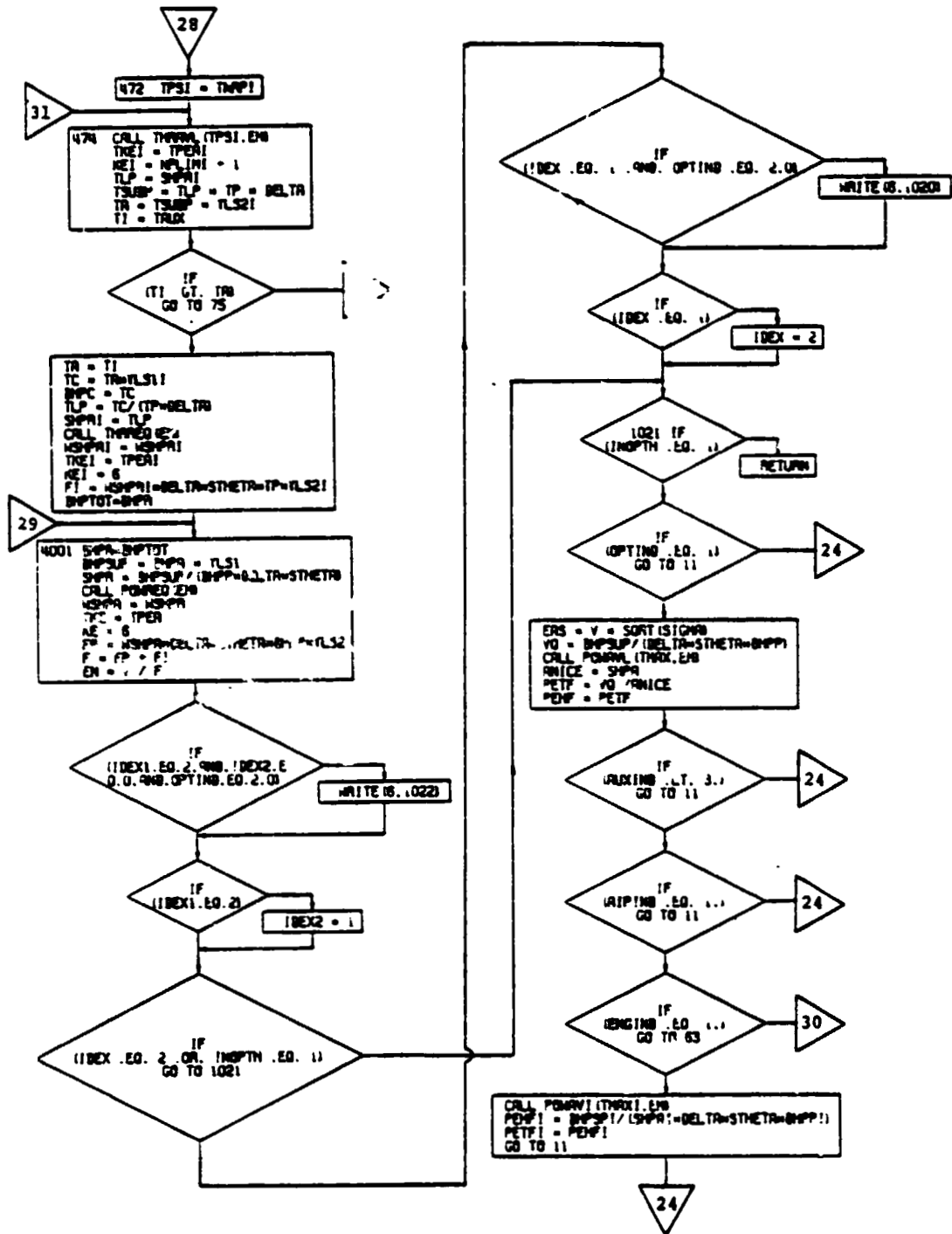


Figure 4-52c. Cruise 2 Subroutine, Flow Chart (Part 8 of 8)

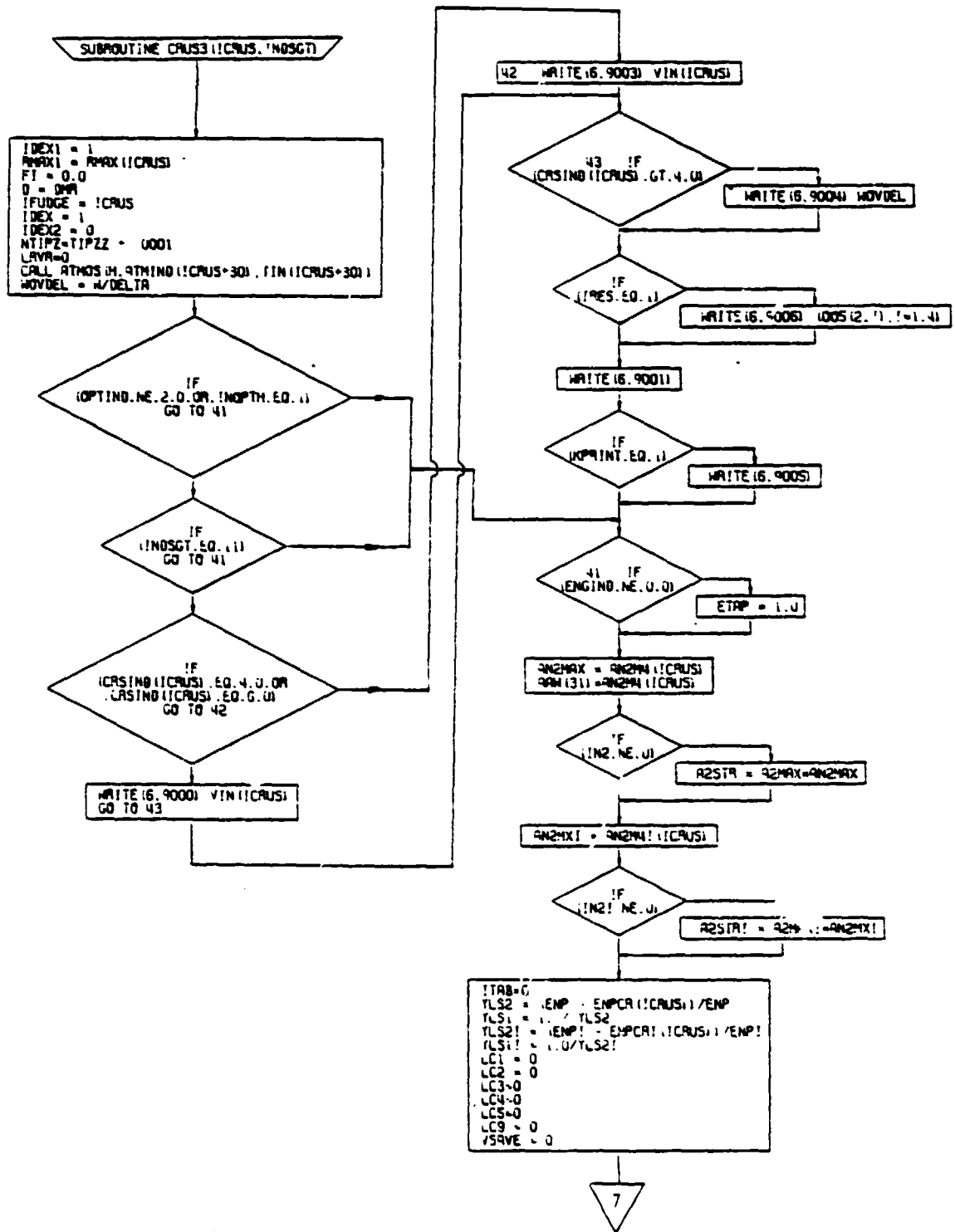


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 1 of 10)

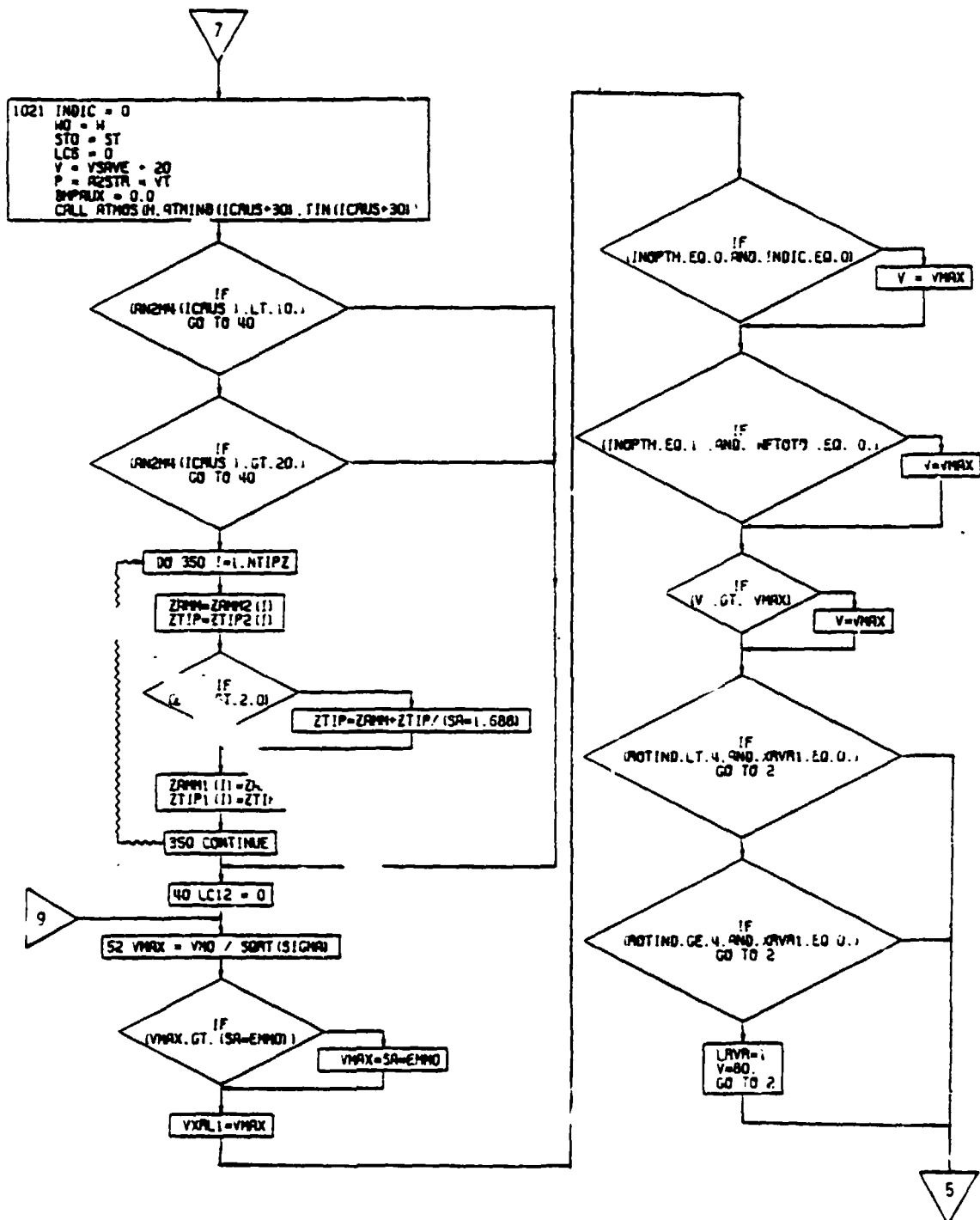


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 2 of 10)

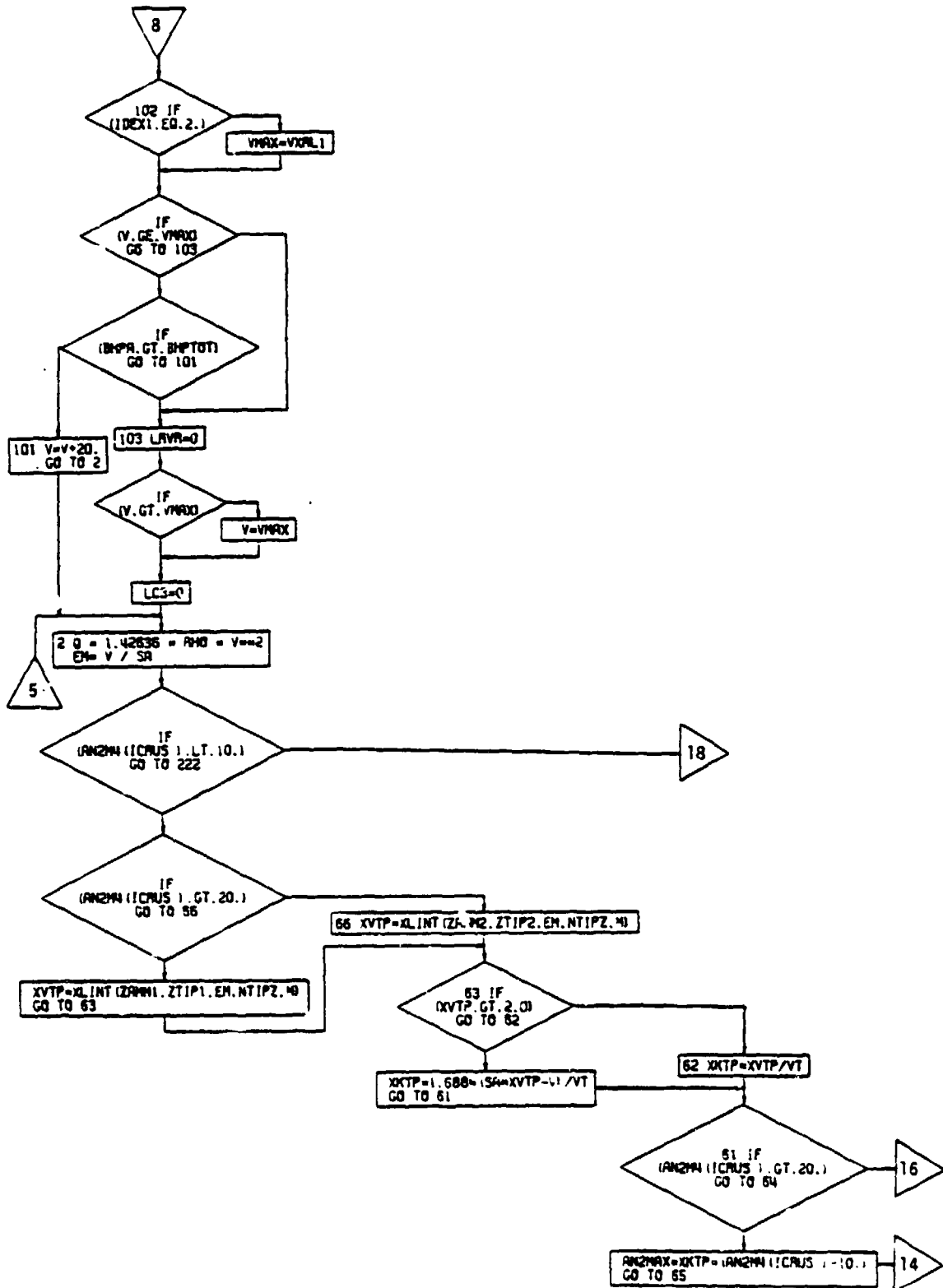


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 3 of 10)

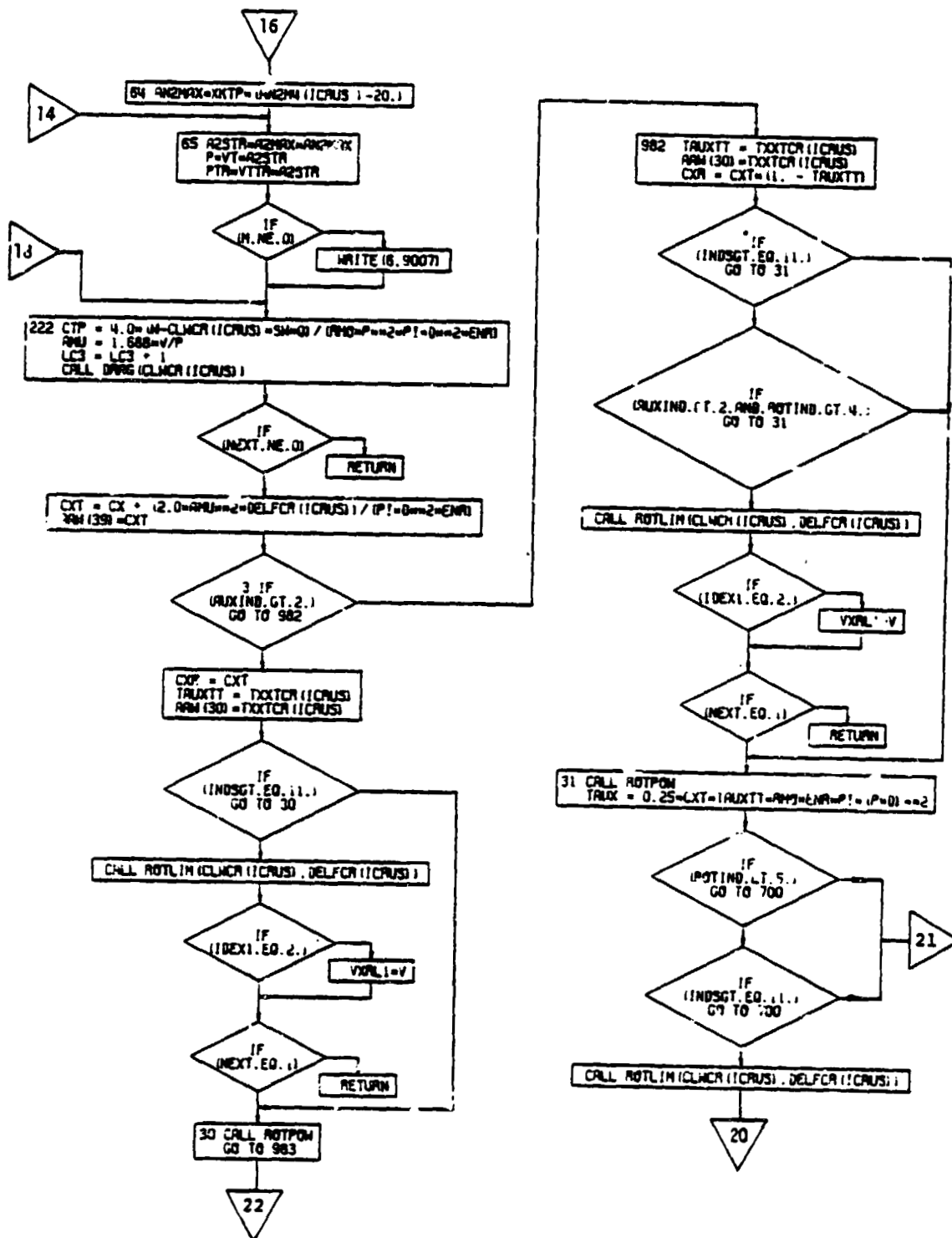


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 4 of 10)

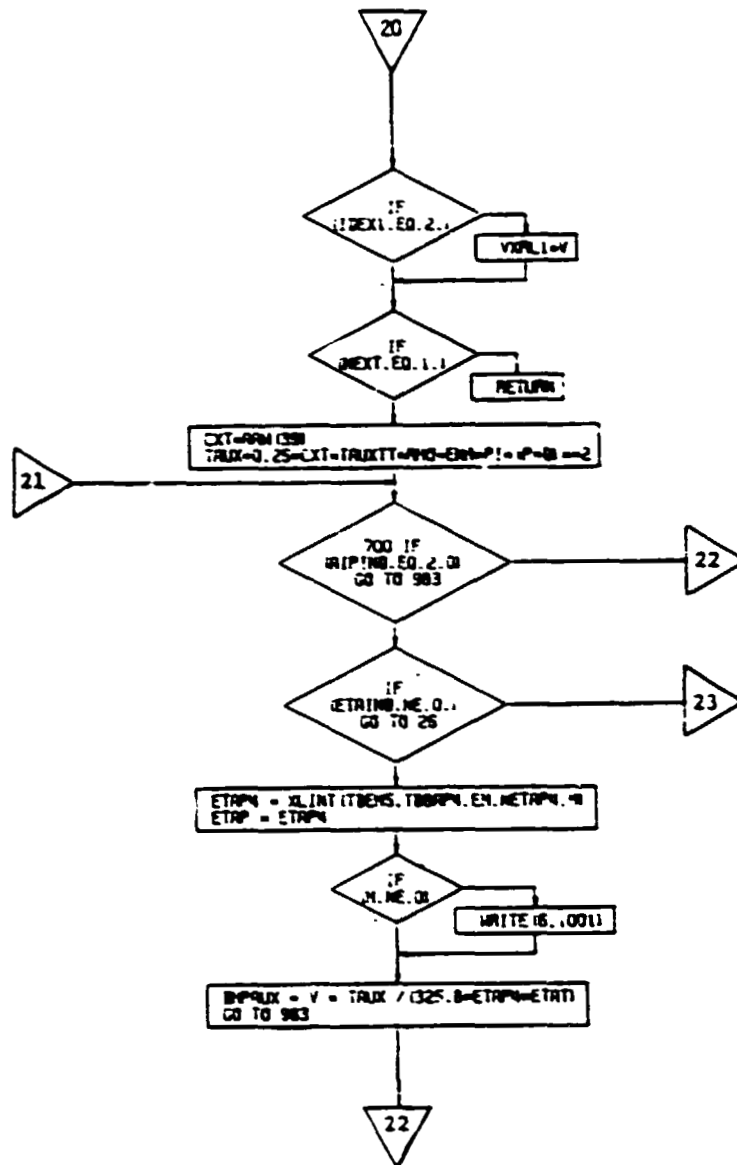


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 5 of 10)

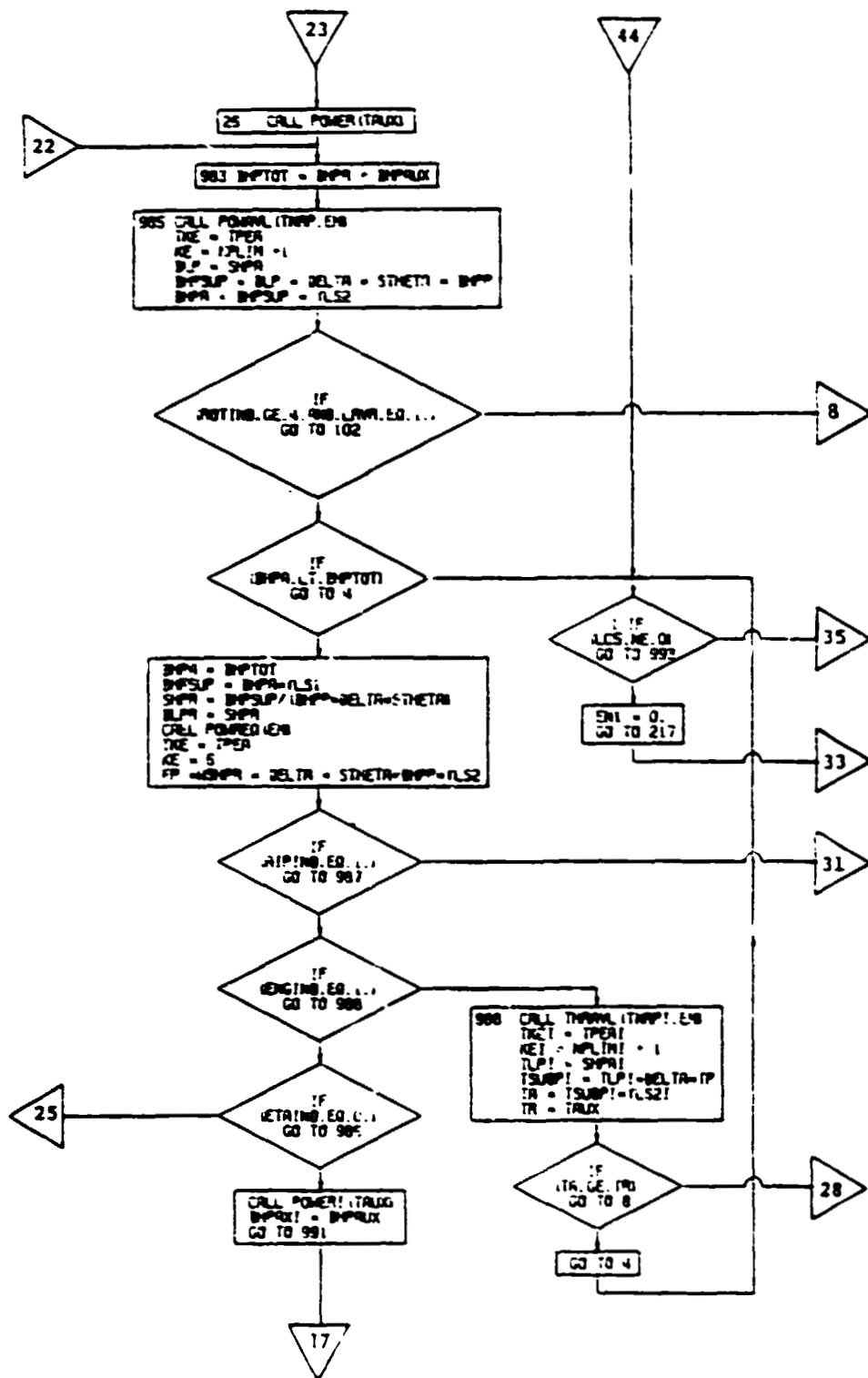


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 6 of 10)

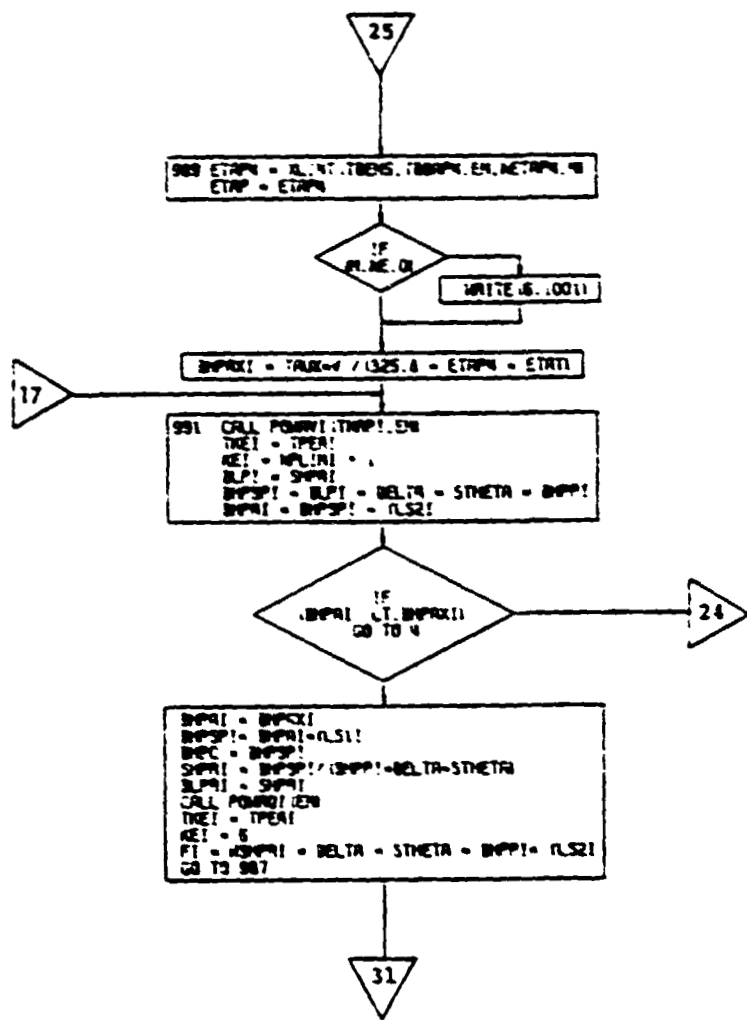


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 7 of 10)



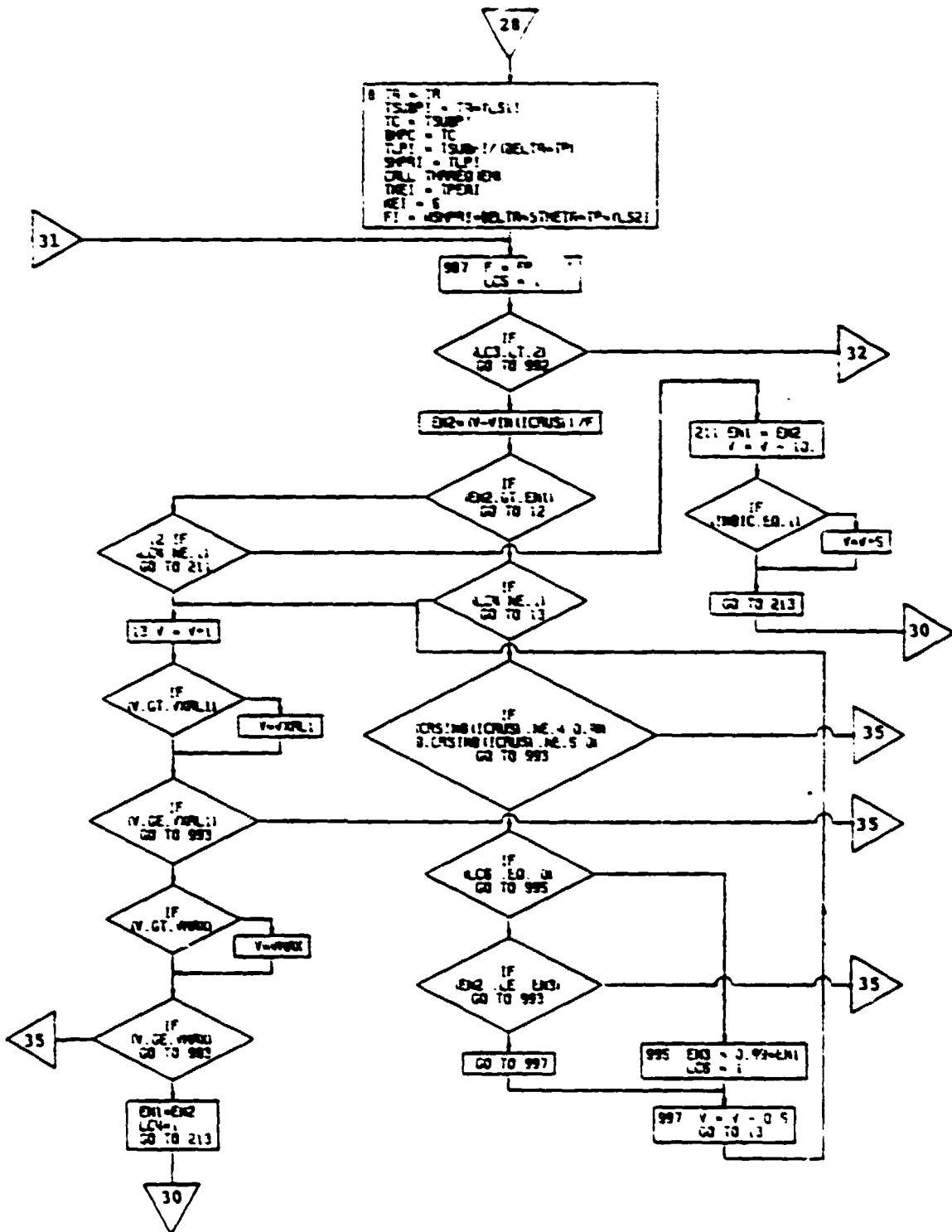


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 5)

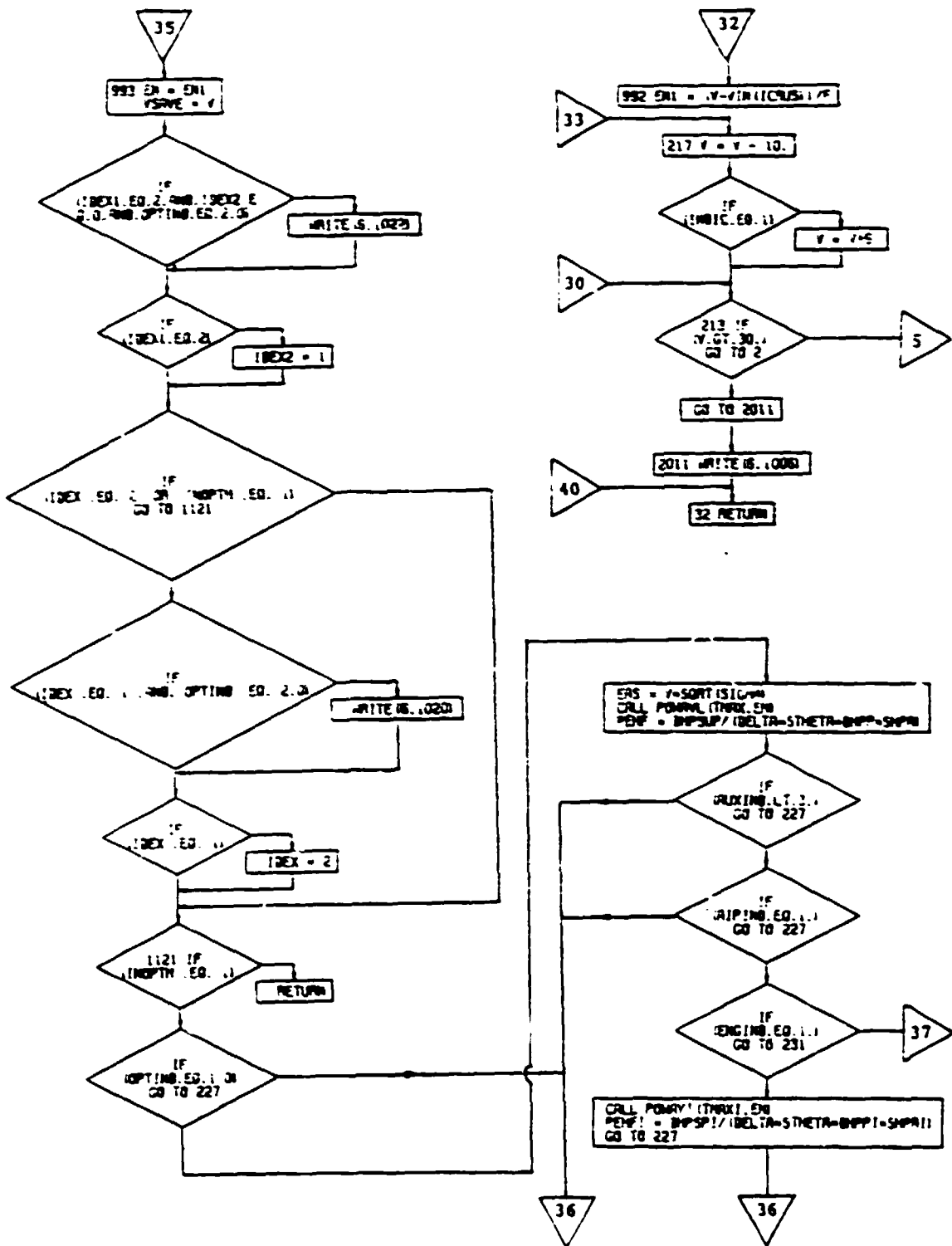


Figure 4-52d. Cruise\_3 Subroutine, Flow Chart (Part 9 of 10)

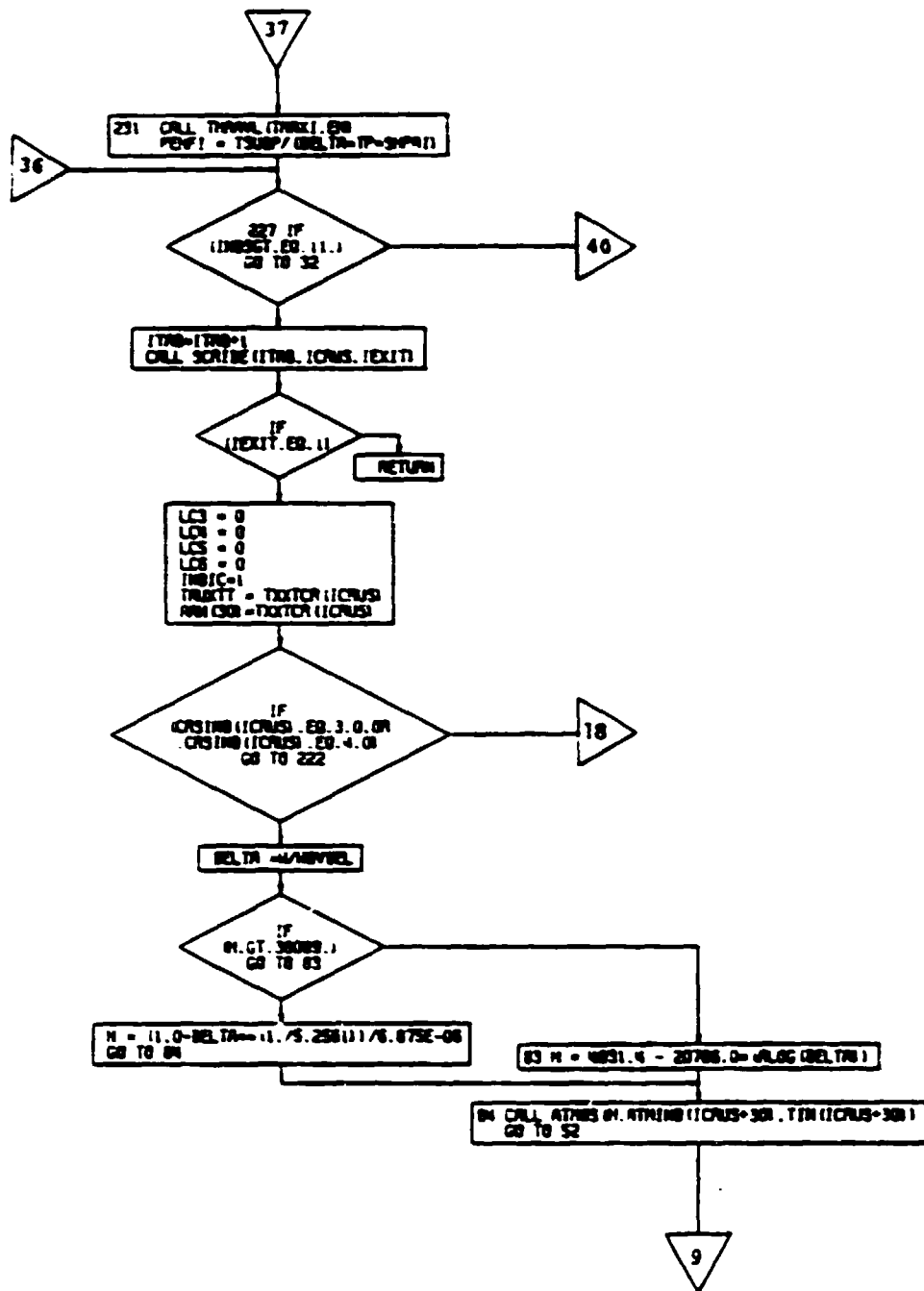


Figure 4-52d. Cruise 3 Subroutine, Flow Chart (Part 10 of 10)

#### 4.12.5 Descent Calculations Subroutine

Twelve different options for descent performance calculation are available. The options fall into three different categories: descent at constant true air speed (TAS), descent at constant equivalent air speed (EAS), and descent at constant Mach number. In addition, each type of descent may be calculated for a specified type of descent flight path, specified by RMAXND as follows:

<u>Value of RMAXND</u>	<u>Type of Flight Path</u>
0	Descent flight path ends at specified terminal range.
1	Program checks terminal range requirement, but does not match it.
2	Descent flight path ends at a specified minimum altitude, the terminal range requirement not being considered.
3	Fuel used and time required for descent are calculated, but no range credit is given (i.e., spiral descent path).

Rate of descent (R/D) is always input. If the airspeed-rate of descent combination (as specified by DESIND) exceeds the descent boundaries, the airspeed will be held constant, while the R/D is adjusted accordingly. Figure 4-47 in which R/D is plotted against flight speed, illustrates the descent boundaries. They are:

- (a) Vertical rate of descent boundary

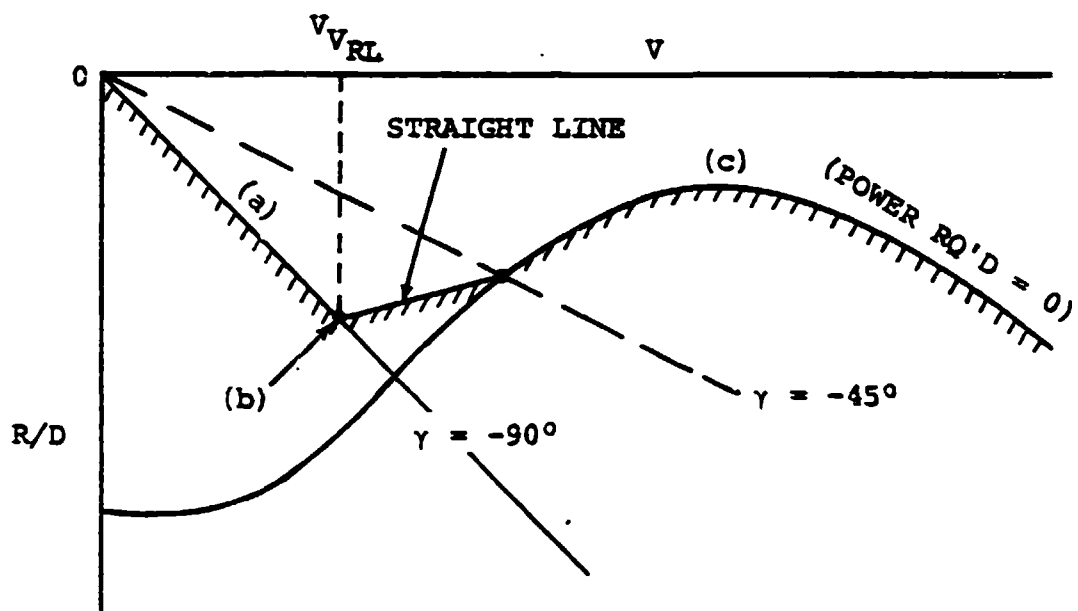
$$(\gamma = -90^\circ)$$

- (b)  $V_{VRL}$  (vortex ring state) limit descent speed - defined by the equation

$$V_{VRL} = \frac{2}{3} \sqrt{\frac{T}{2\rho A}}$$

where  $T$  = total rotor thrust  
 $A$  = disc area.

- (c) Autorotative descent (power required = 0).



- (a) Vertical rate of descent boundary
- (b) Vortex ring state limit descent speed
- (c) Autorotative descent boundary

Figure 4-53. Descent Boundaries.

The distinction between the first type of descent flight path (as specified by RMAXND = 0) and the last three (RMAXND = 1, 2, 3) in regard to the range at which the descent starts, when terminal range is specified, should be clearly understood.

- a. If RMAXND = 0, 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 this option (RMAXND = 0) is 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 the RMAXND = 0 option is 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.
- b. If RMAXND = 1, the descent will start at the current value for range and, as previously described, the aircraft will fly a straight-line path to the desired terminal point. If the predicted flight path (as checked against the specified terminal range by the program) ends beyond the specified terminal range, a spiral descent path from the altitude at that point to the final altitude is assumed. If the predicted flight path ends before reaching the specified terminal range point, the program prints "SHALLOWER DESCENT REQUIRED". The descent may follow any other segment (climb, cruise, etc.) or may start the mission.
- c. If RMAXND = 2 or 3, the descent will start at the current value for range; and, depending on the option chosen, will either end at the minimum altitude (RMAXND = 2) specified, with no constraint on the resulting range, or a spiral descent path (RMAXND = 3) will be assumed. As with RMAXND = 1, the descent options may follow any other segment, or may start the mission.

An increment in aircraft parasite drag may be input in order to simulate the effects of dive brakes, external stores, etc. It is possible to use a descent segment in the mission profile to account for a reserve fuel requirement (SGTIND = 50) (in such a case the helicopter weight at the end of descent is set back to the weight at the beginning of descent) or as a part of the basic mission (in this case the weight is not reset). In either case, the fuel used during descent is included in the total fuel required to size the helicopter.

Input to the subroutine consists of the settings for DESIND

and RMAXND, atmospheric conditions, R/D, the propulsive thrust split, the incremental parasite drag, the operating wing lift coefficient (winged and compound helicopters), the final altitude, the step size, the required TAS, EAS or Mach number, the terminal range requirement (RMAXND = 0, 1) and the number of engines shut down. Subroutine DESPOW (which is called by the Descent calculations subroutine) calculates the power required for descent at the desired flight conditions. Figure 4-54 is a flow chart of subroutine DESPOW and Figure 4-55 is a flow chart of the descent calculations subroutine.

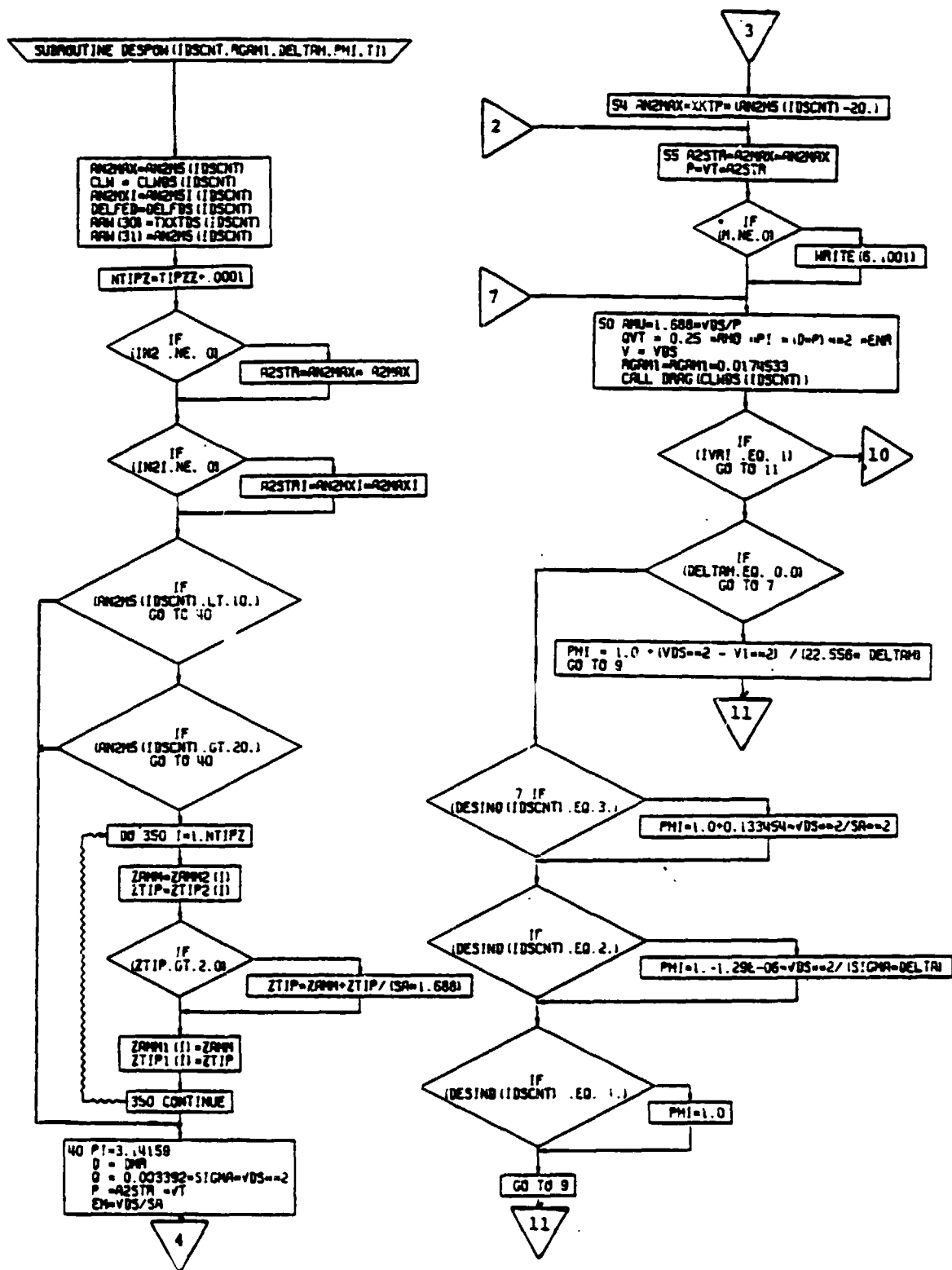


Figure 4-54. DESPOW Subroutine, Flow Chart (Part 1 of 3)  
4-294



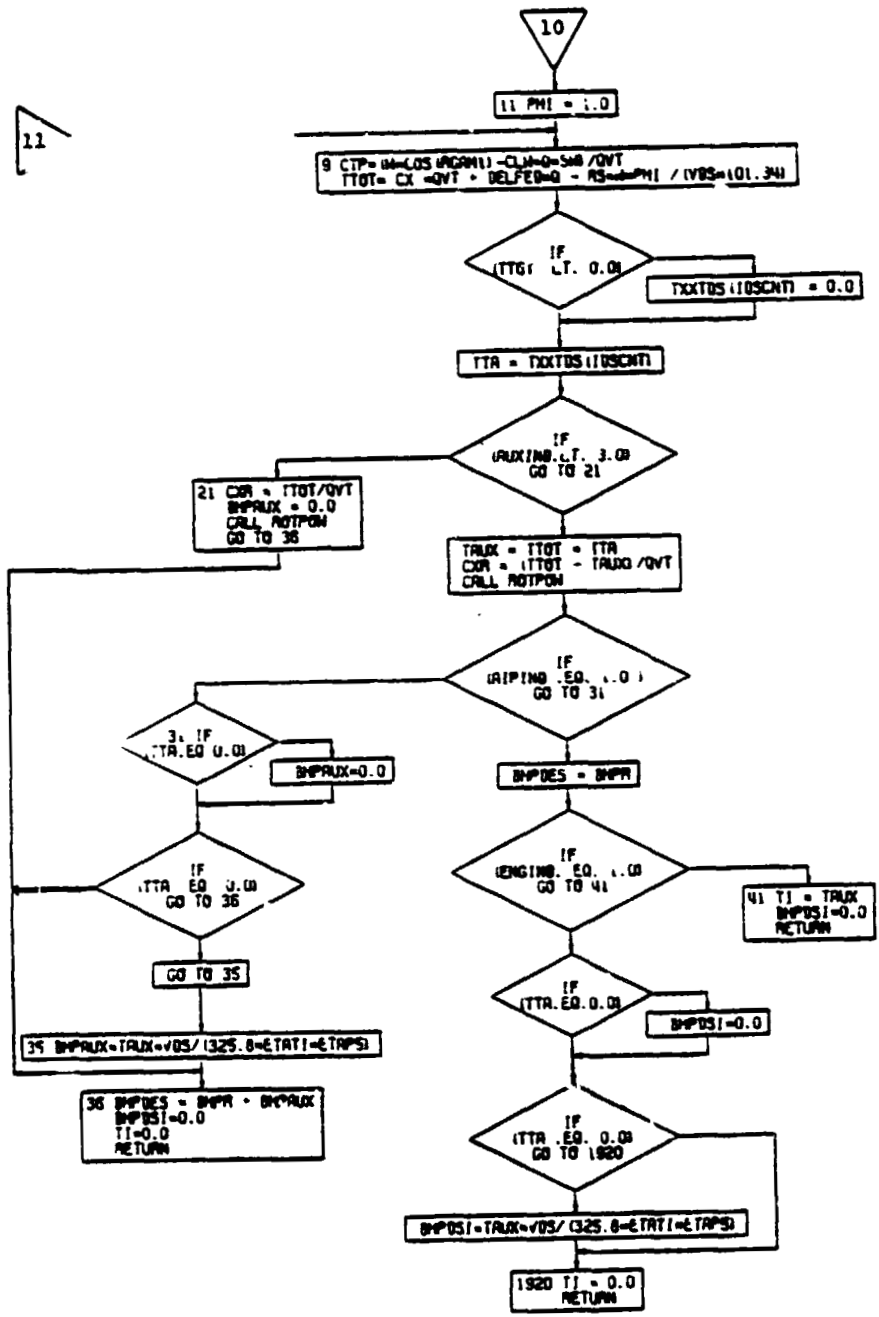


Figure 4-54. DESPOW Subroutine, Flow Chart (Part 2 of 3)

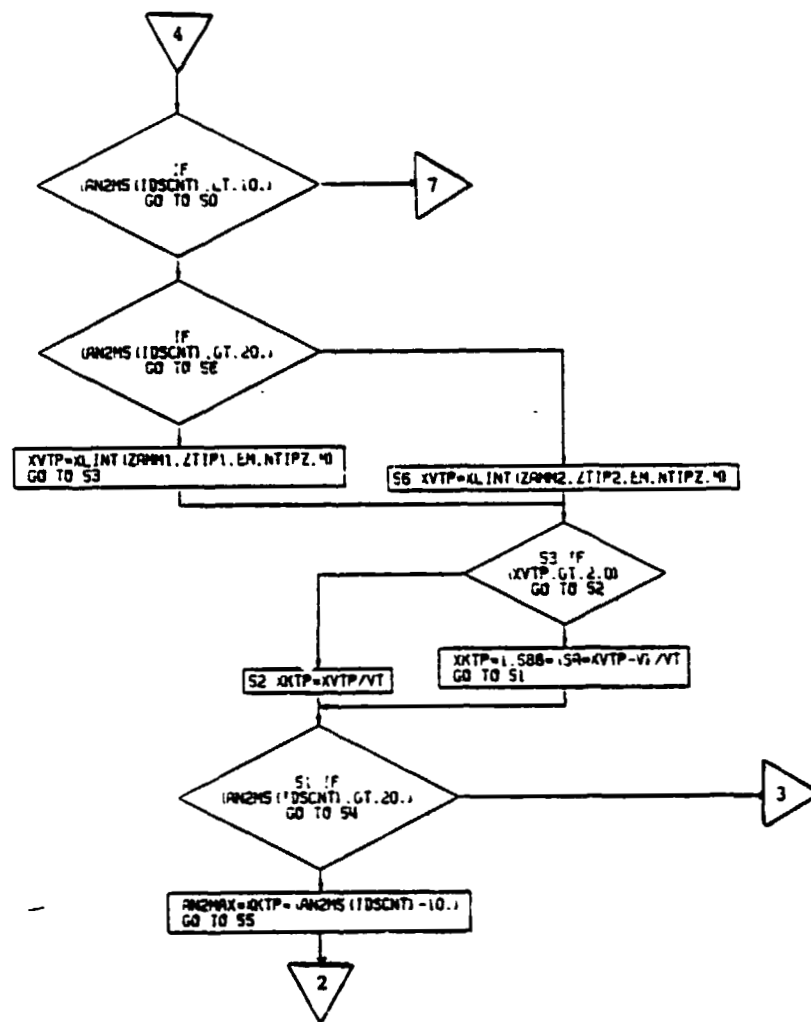


Figure 4-54. DESPOW Subroutine, Flow Chart (Part 3 of 3)

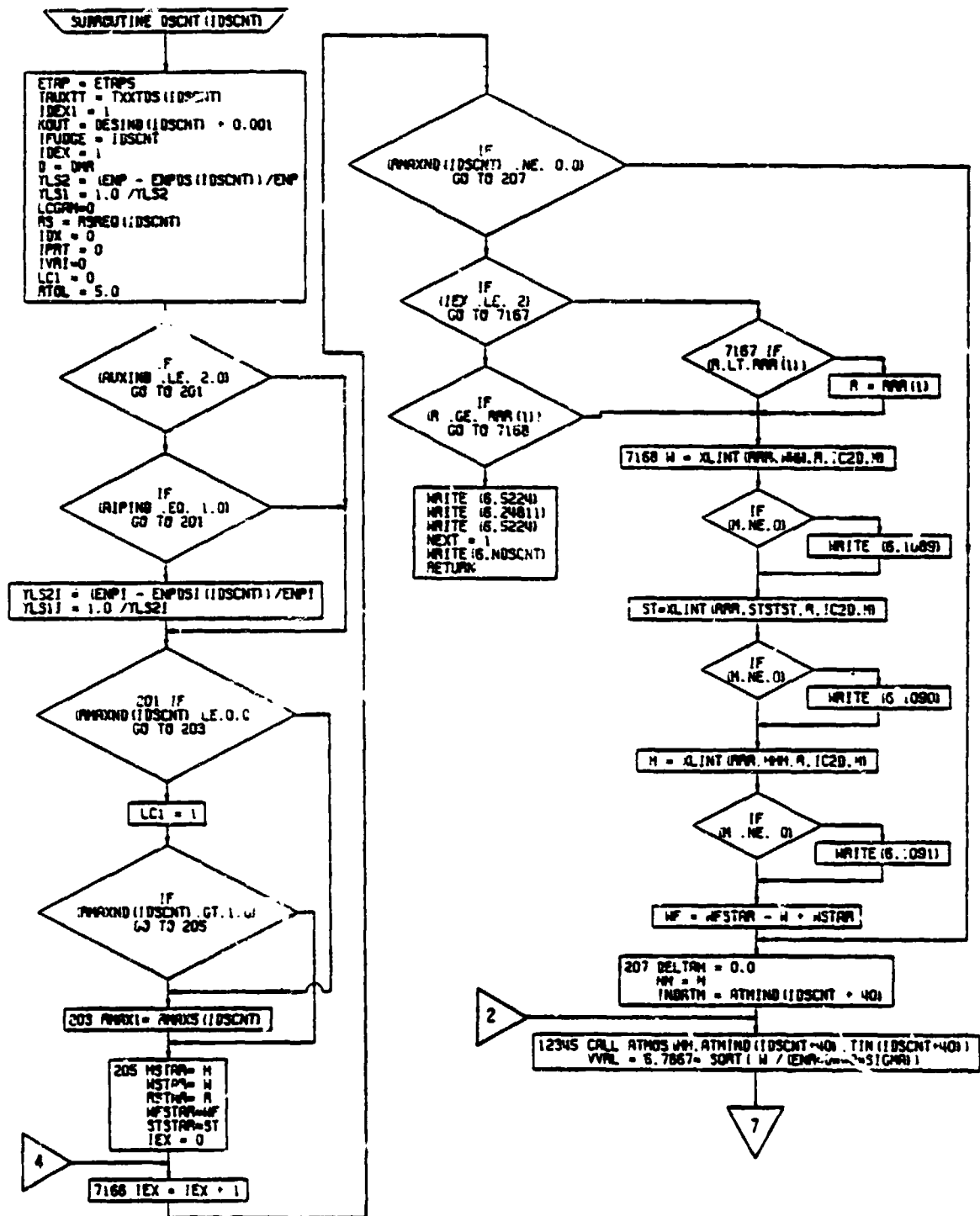


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 1 of 10)

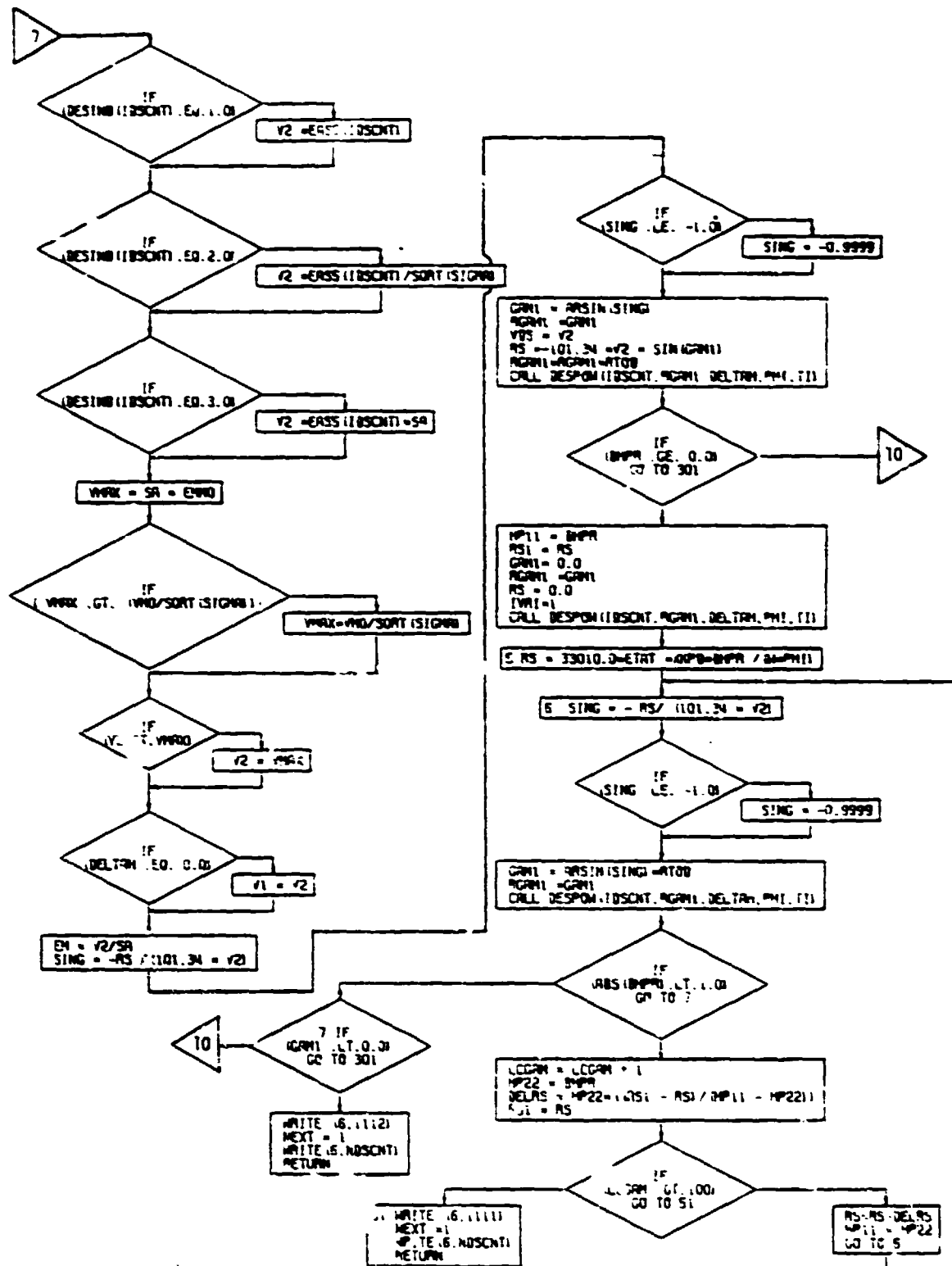


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 2 of 10)

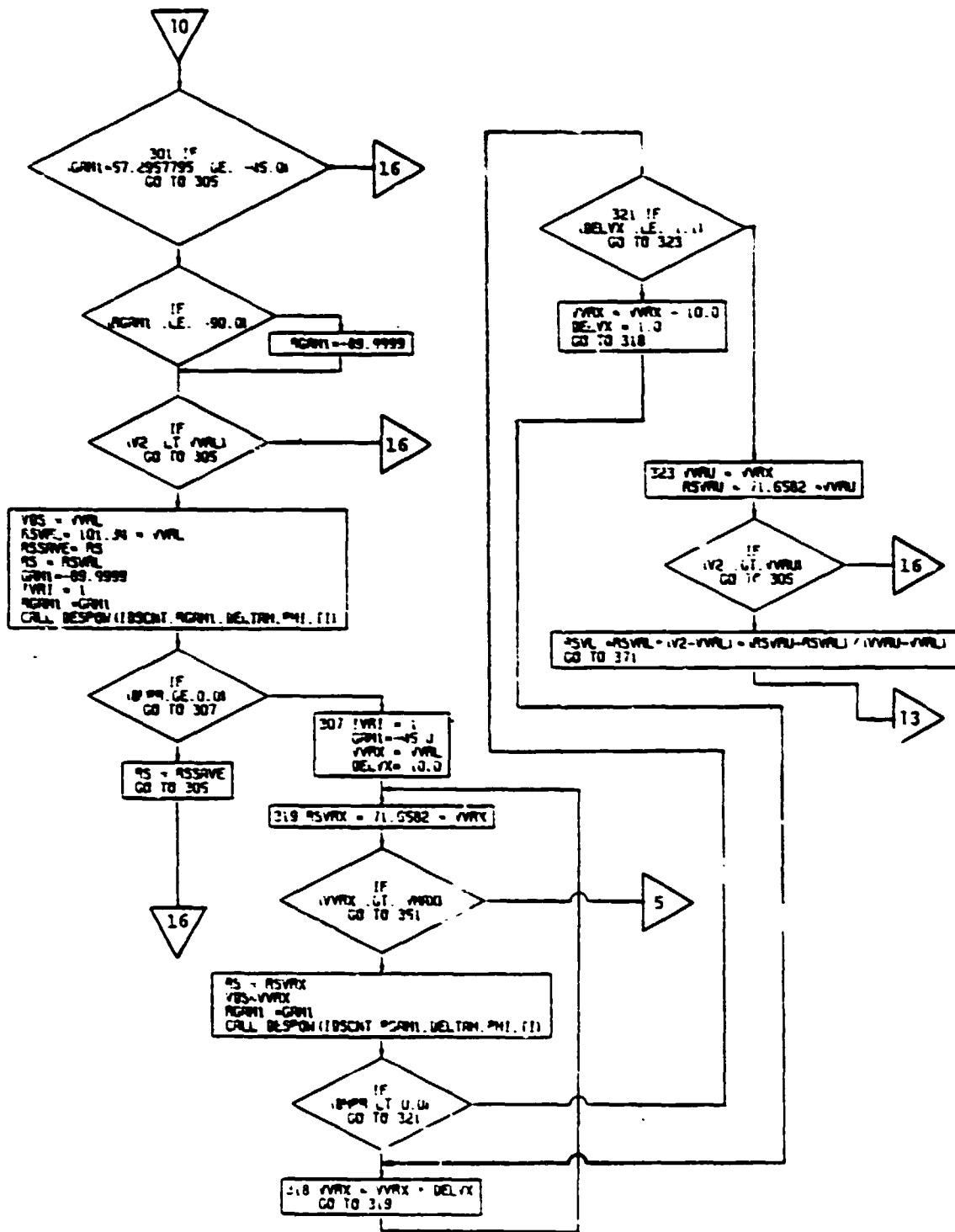


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 3 of 10)

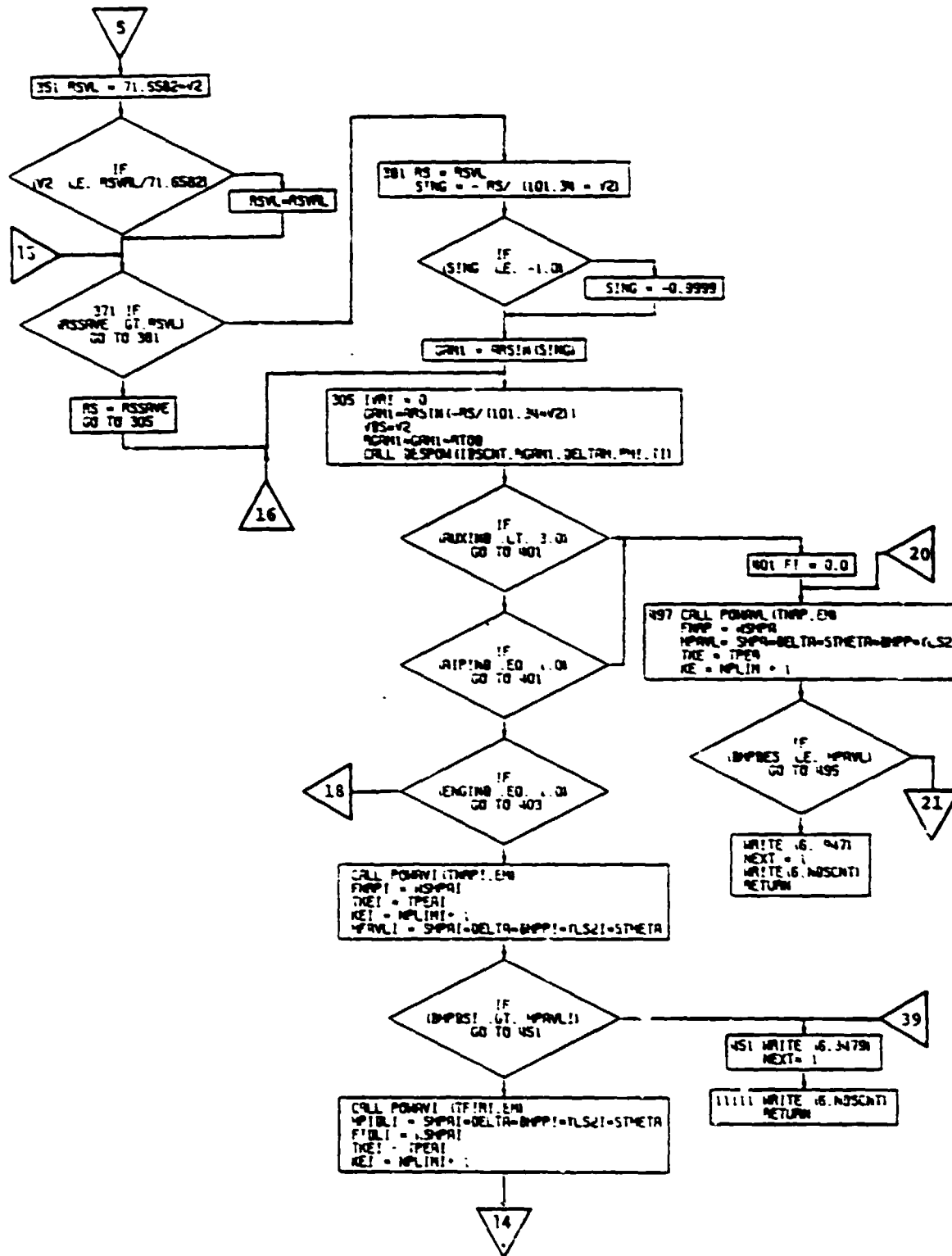


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 4 of 10)

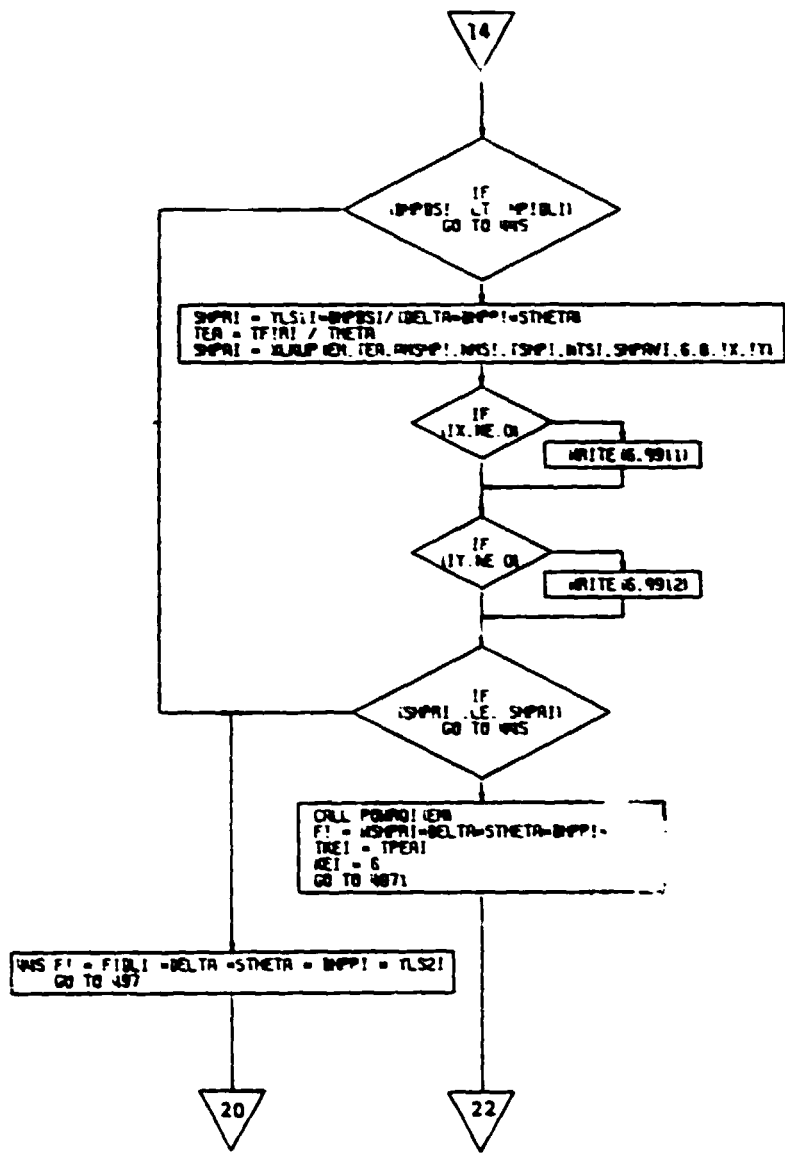


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 5 of 10)

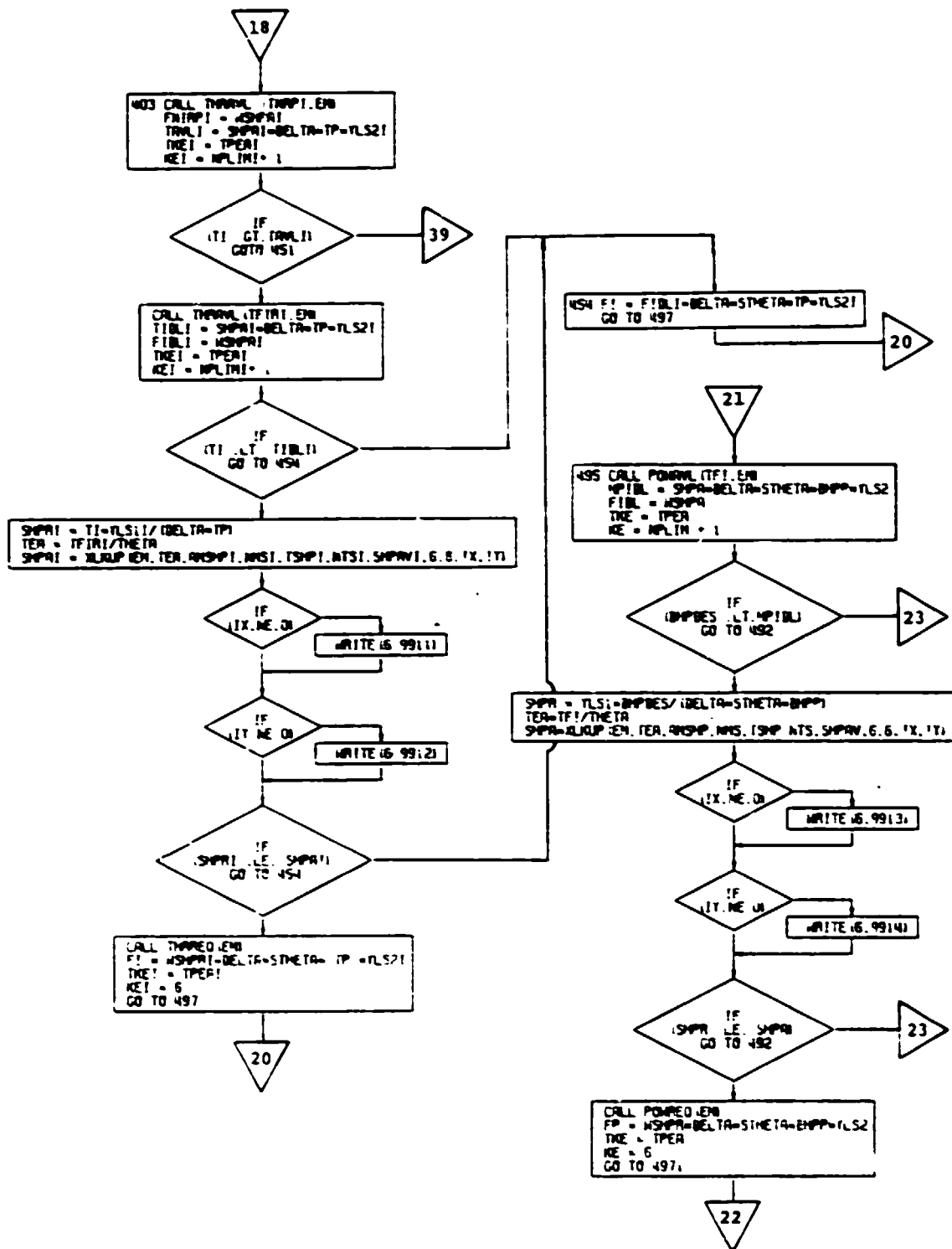


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 6 of 10)



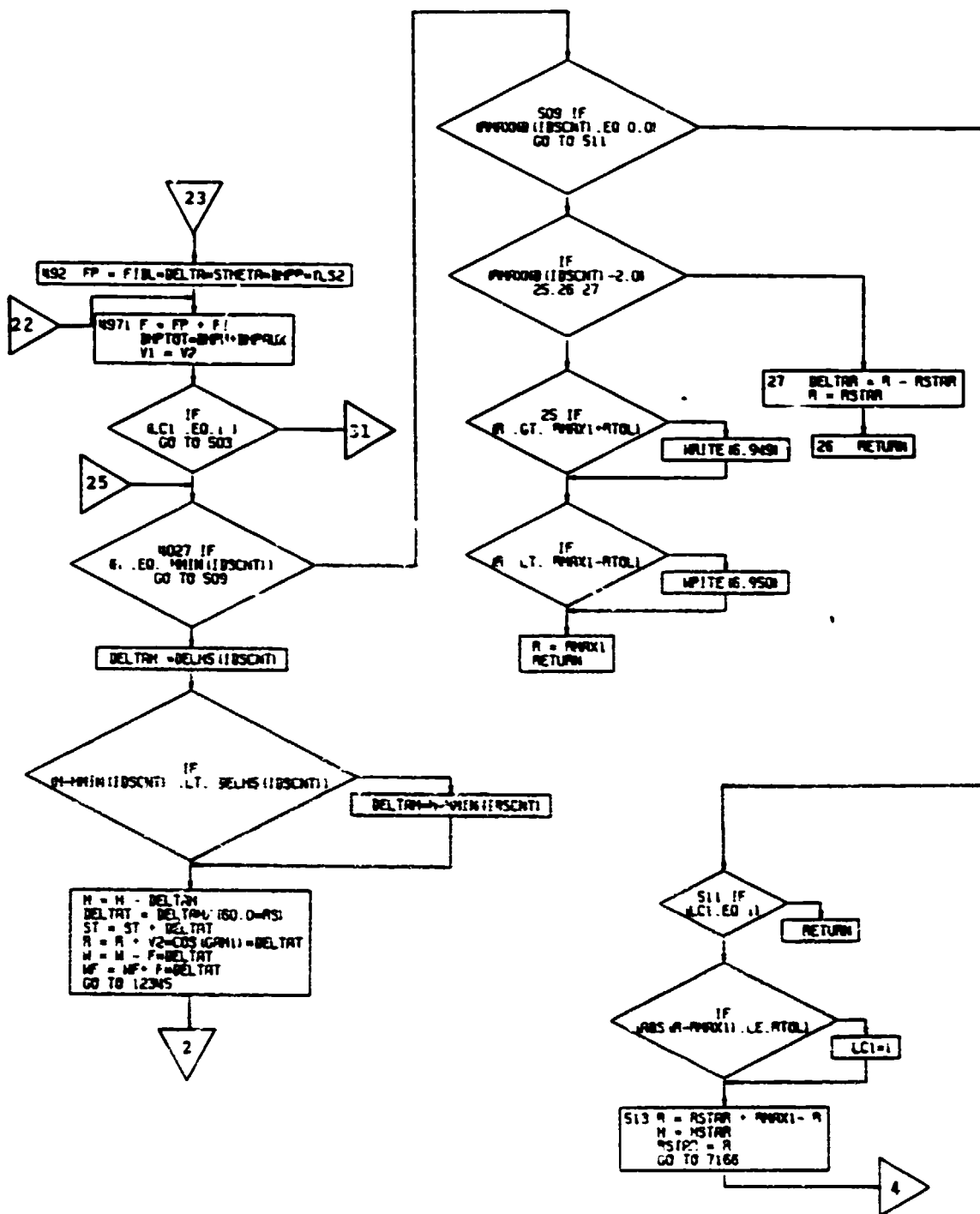


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 7 of 10)

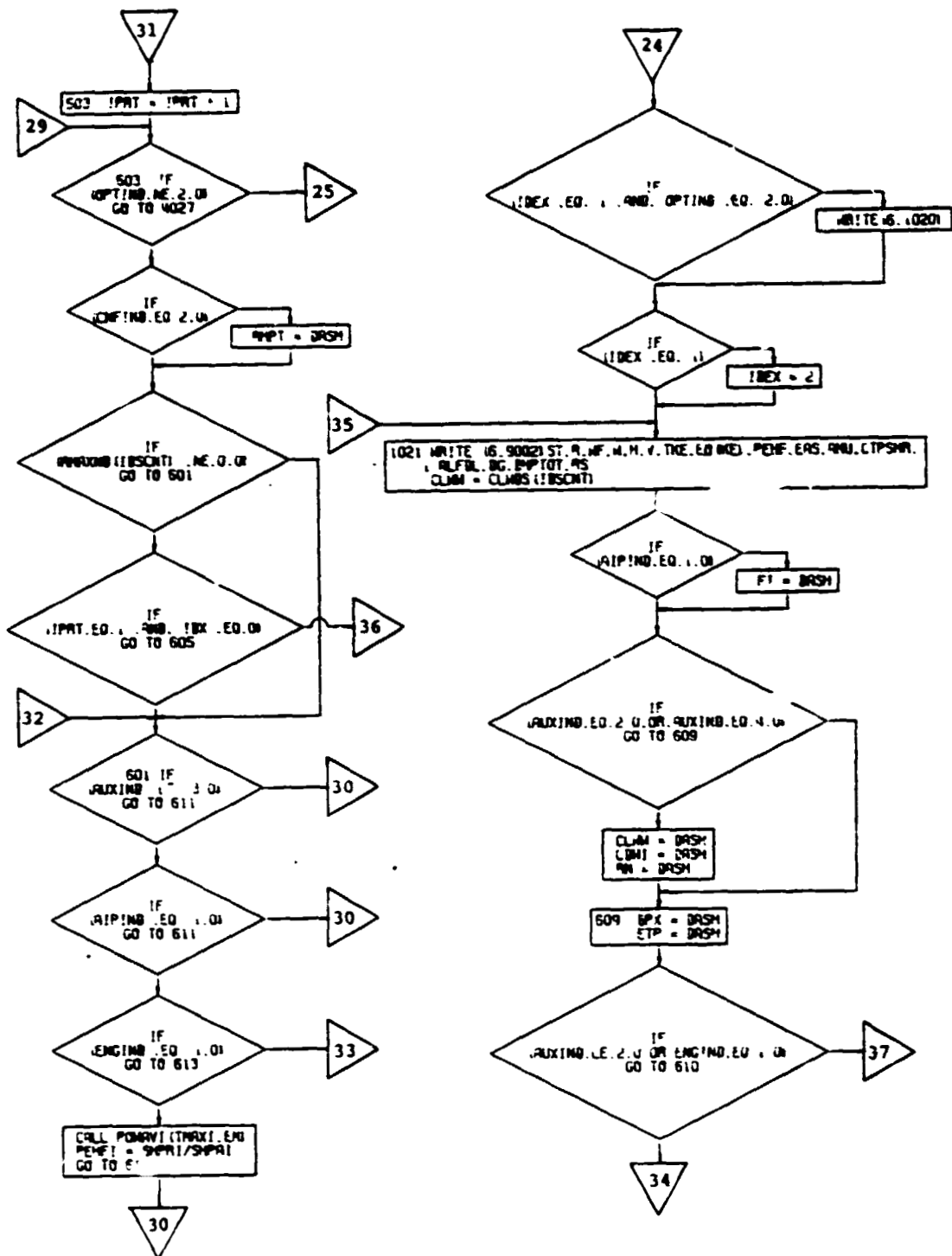


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 8 of 10)

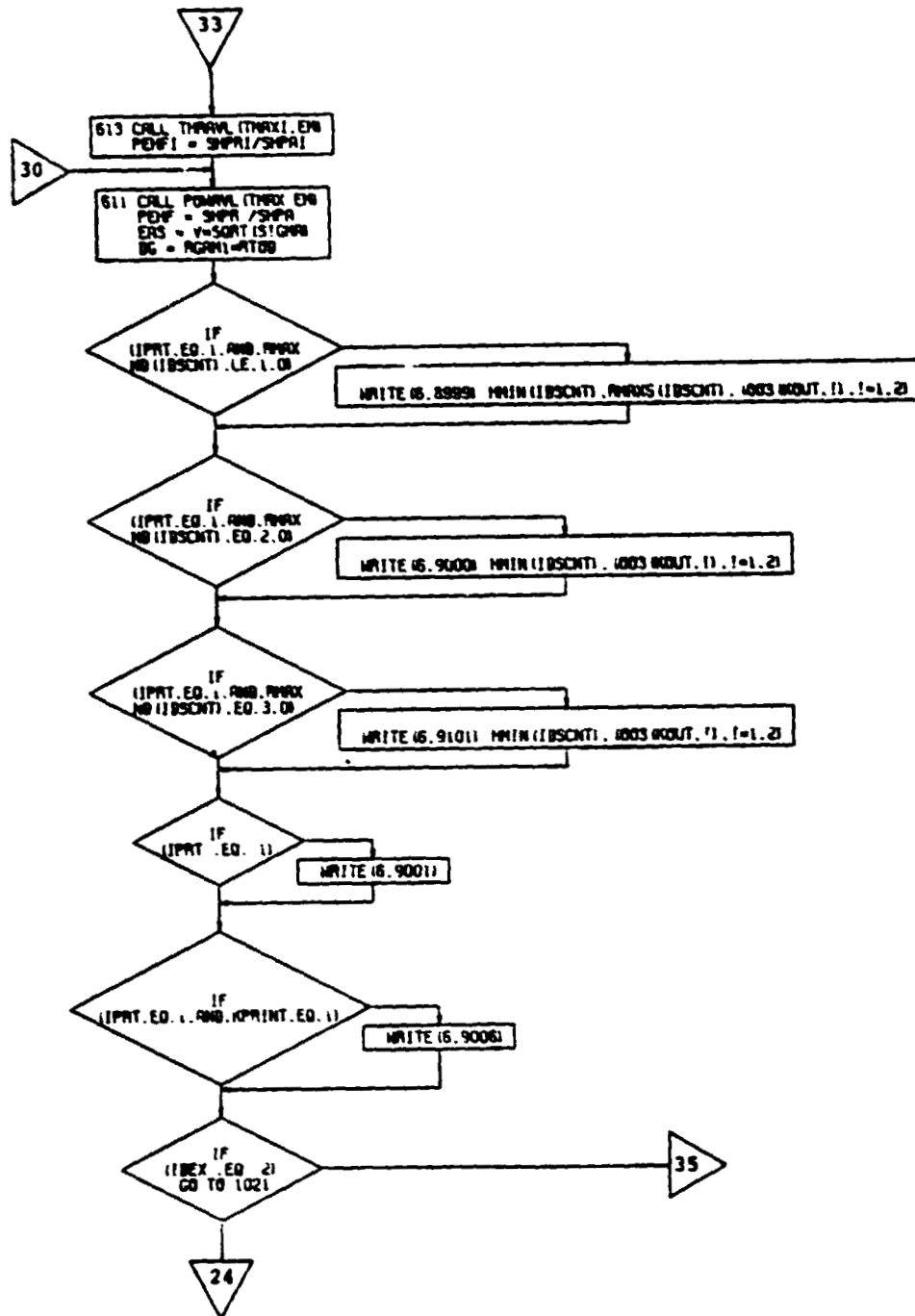


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 9 of 10)

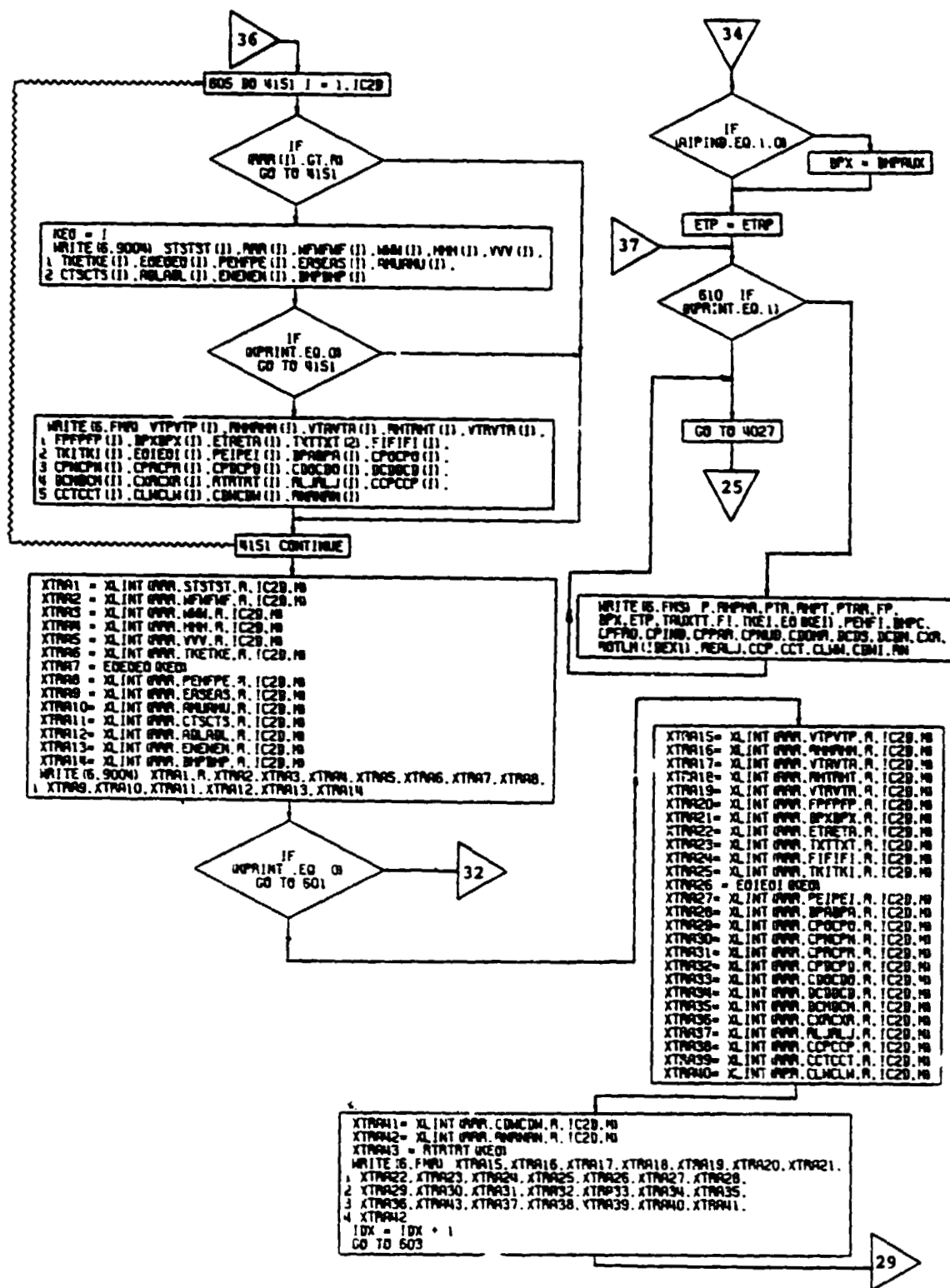


Figure 4-55. DSCNT Subroutine, Flow Chart (Part 10 of 10)

#### 4.12.6 Loiter Calculations Subroutine

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

Engine shutdown during loiter may be simulated by inputs for  $N_{PSD}$  (primary engines) and  $N_{PSDi}$  (auxiliary independent engines). One or more engines may be shutdown. An increment in helicopter drag ( $\Delta F_{e, LOITER}$ ) may be input to represent drag changes due to external stores, windmilling propellers (in the case of a compound helicopter using propellers), etc.

For a compound helicopter, the split of propulsive thrust required between the main rotor and the auxiliary propulsion system may be specified by an input for  $(T_{AUX}/T_{TOT})$ .

It is possible to use a loiter segment in the mission profile to account for a reserve fuel requirement ( $SGTIND = 60$ ) (in such case the helicopter 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 this case the weight is not reset). In either case, the fuel used during loiter is included in the total fuel required to size the helicopter.

The input to this subroutine consists of the time for loiter, step size (incremental time), the incremental parasite drag area, the number of engines (primary and auxiliary independent) shut down, the atmospheric conditions, the operating wing lift coefficient (in the case of compound and winged helicopters), and the propulsive thrust split. A flow chart of this subroutine is shown in Figure 4-56.

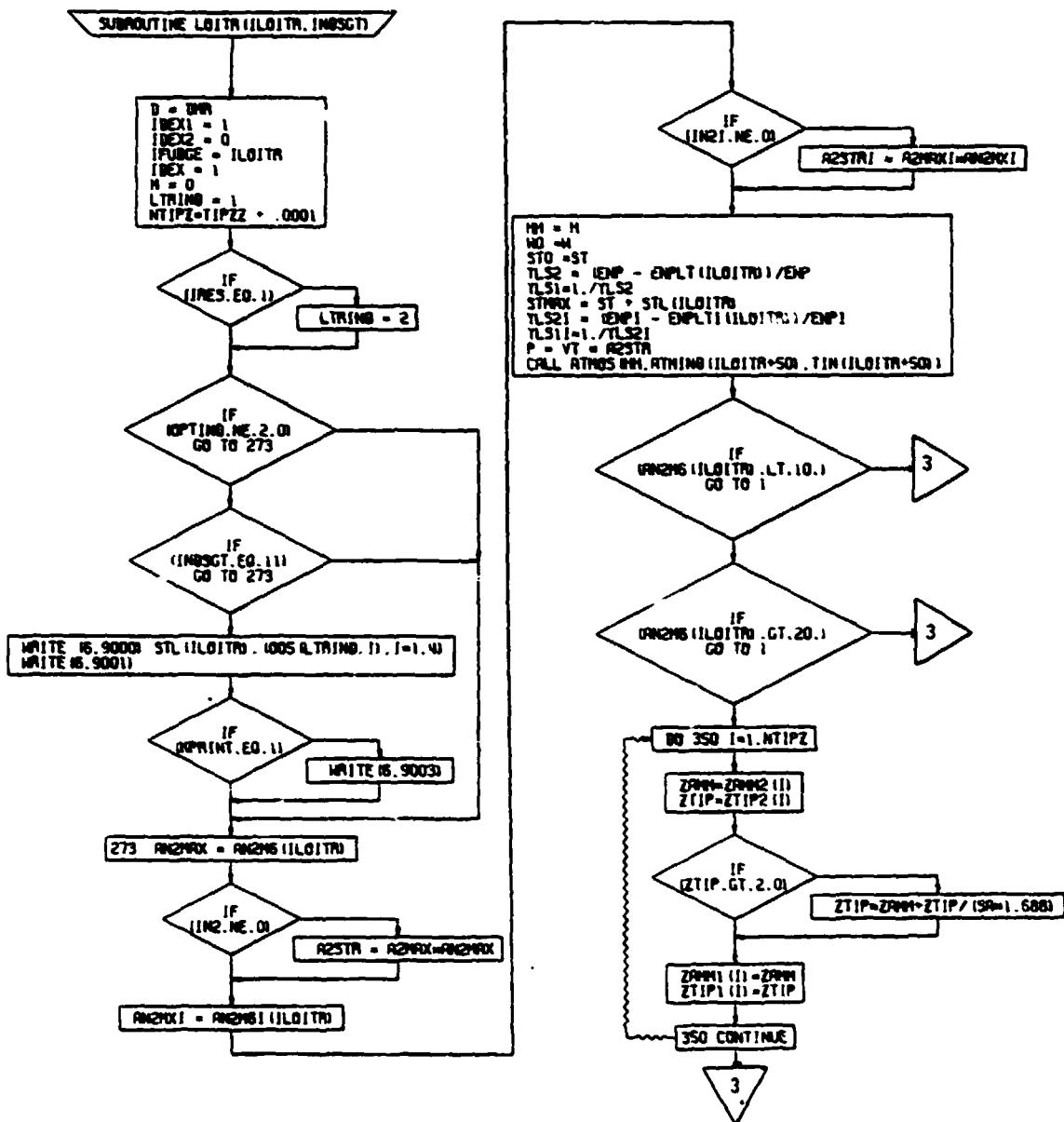


Figure 4-56. LOITR Subroutine, Flow Chart (Part 1 of 12)

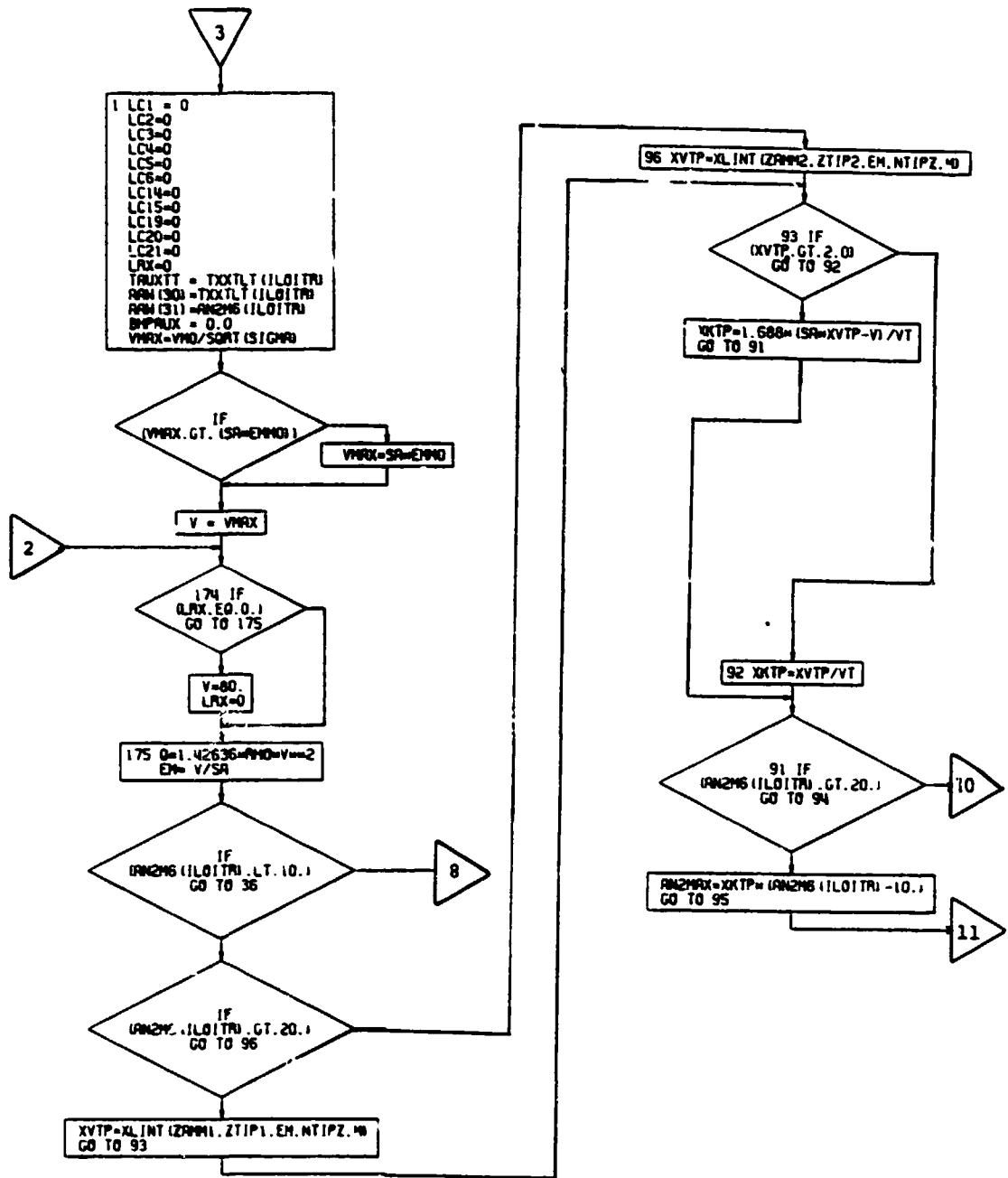


Figure 4-56. LOITR Subroutine, Flow Chart (Part 2 of 12)

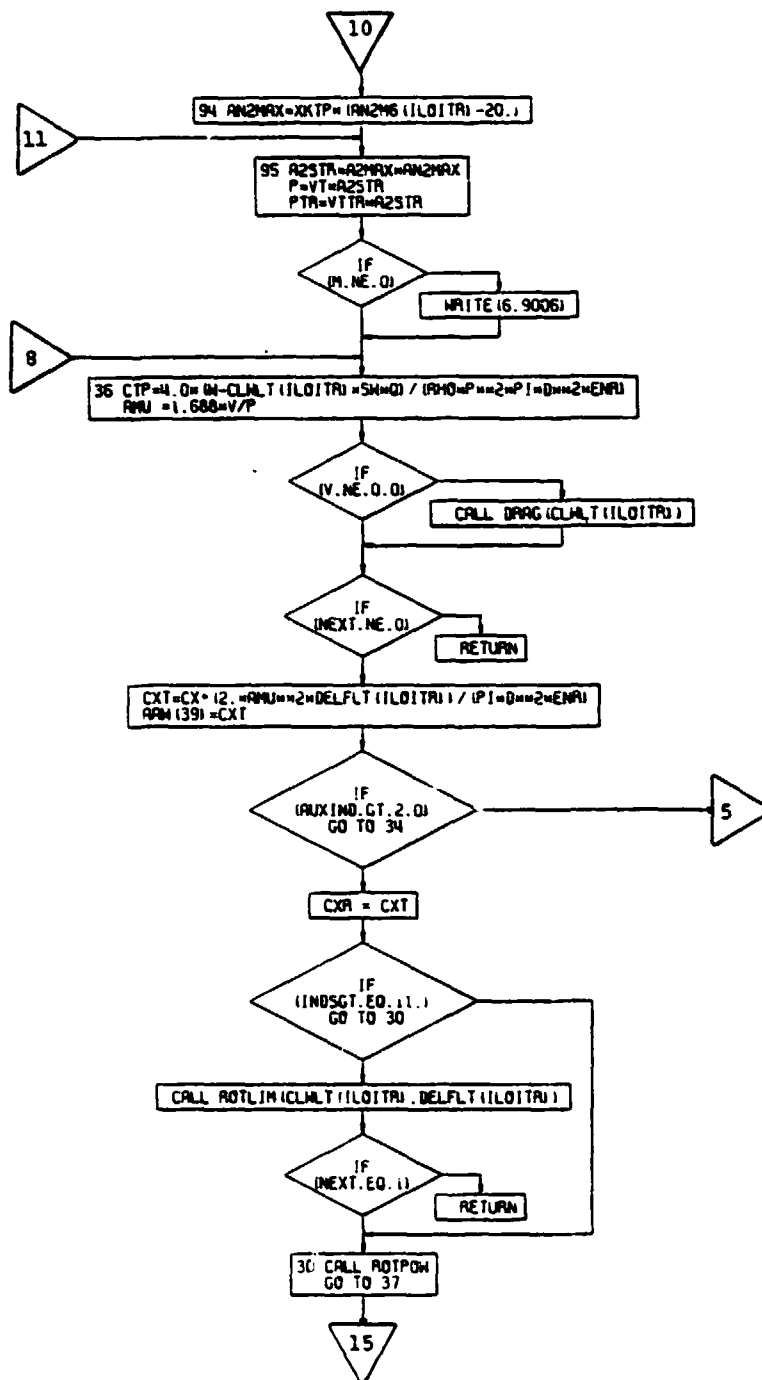


Figure 4-56. LOITR Subroutine, Flow Chart (Part 3 of 12)



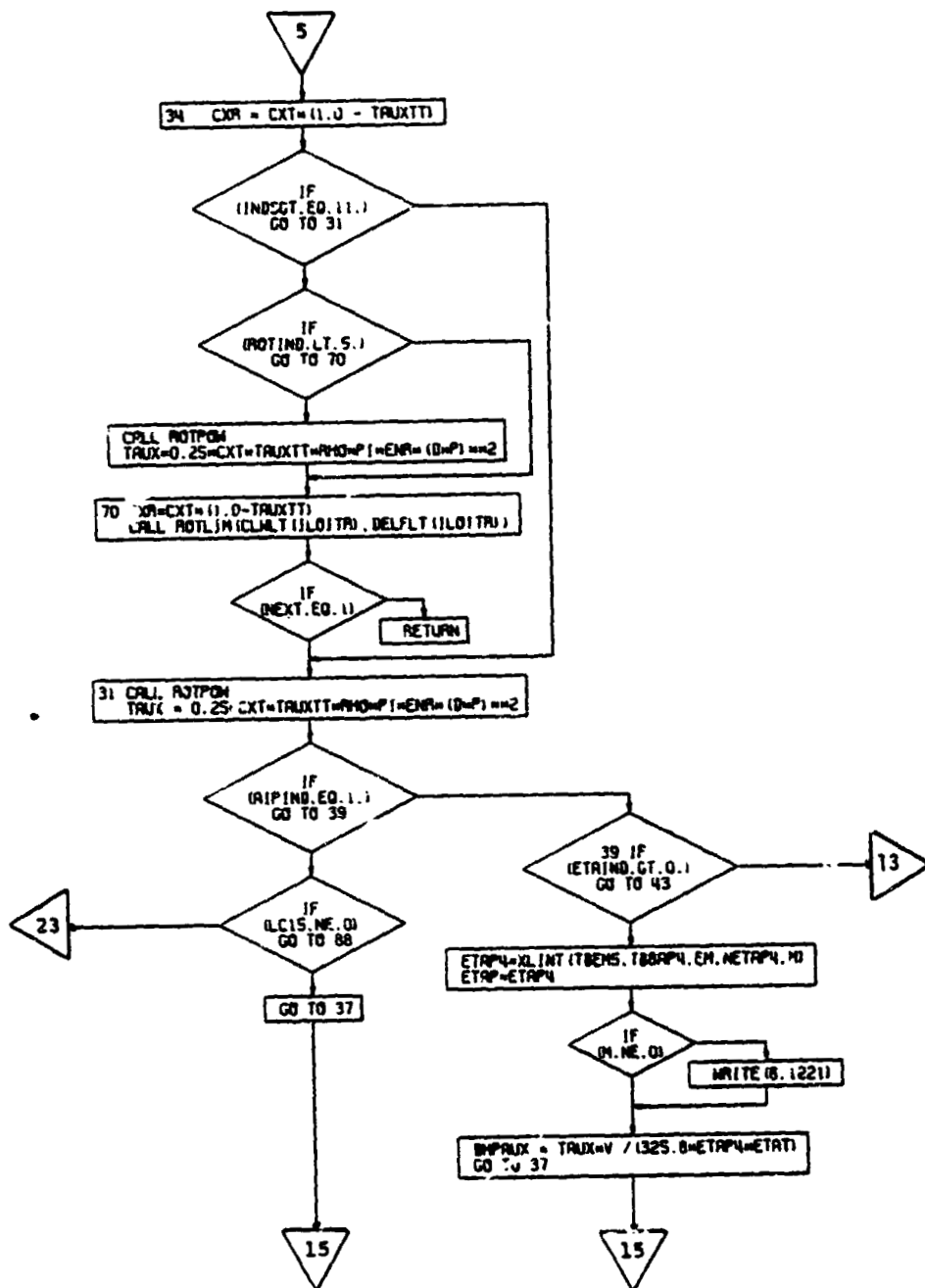


Figure 4-56. LOITR Subroutine, Flow Chart (Part 4 of 12)

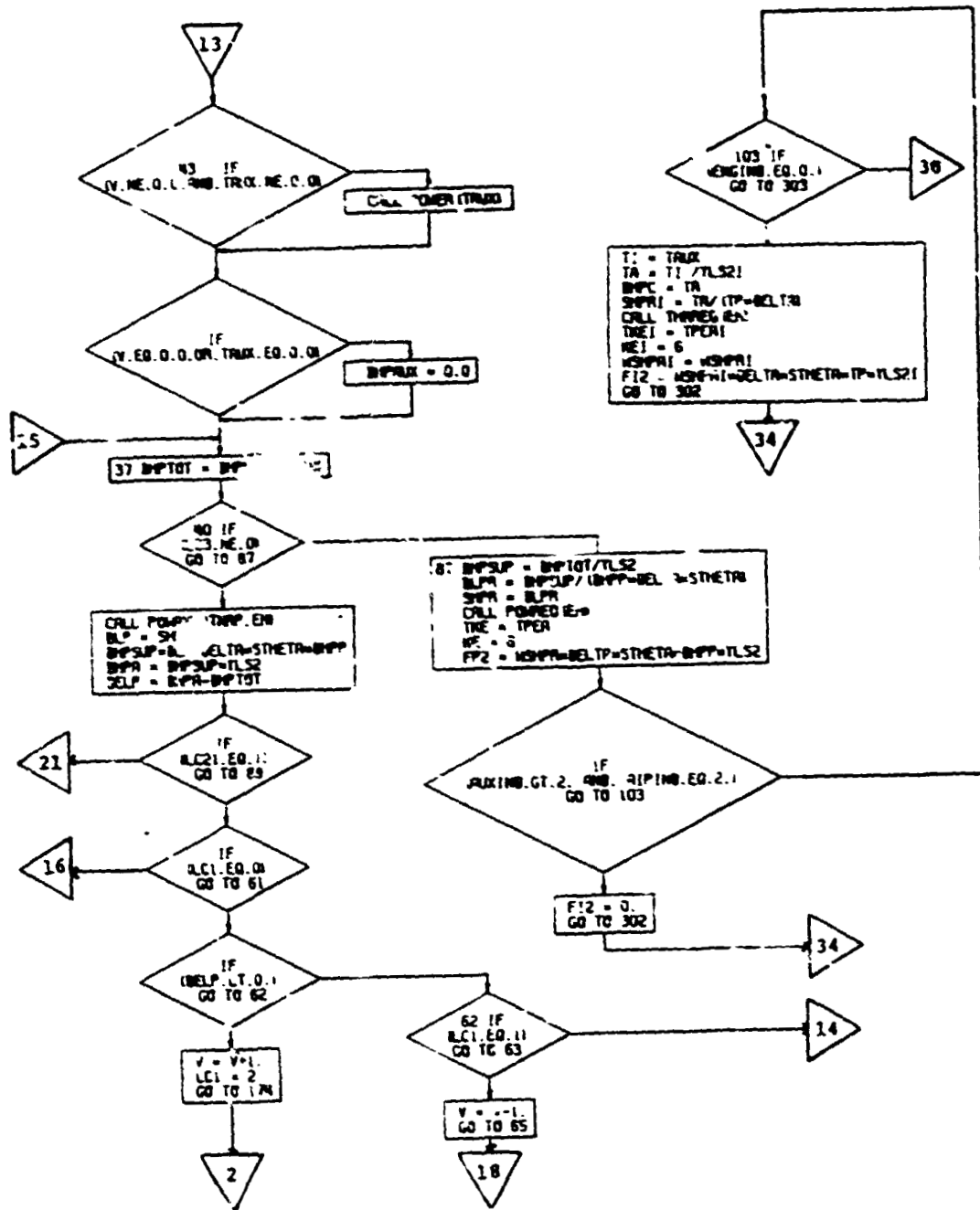


Figure 4-56. LOITER Subroutine, Flow Chart (Part 5 of 12)

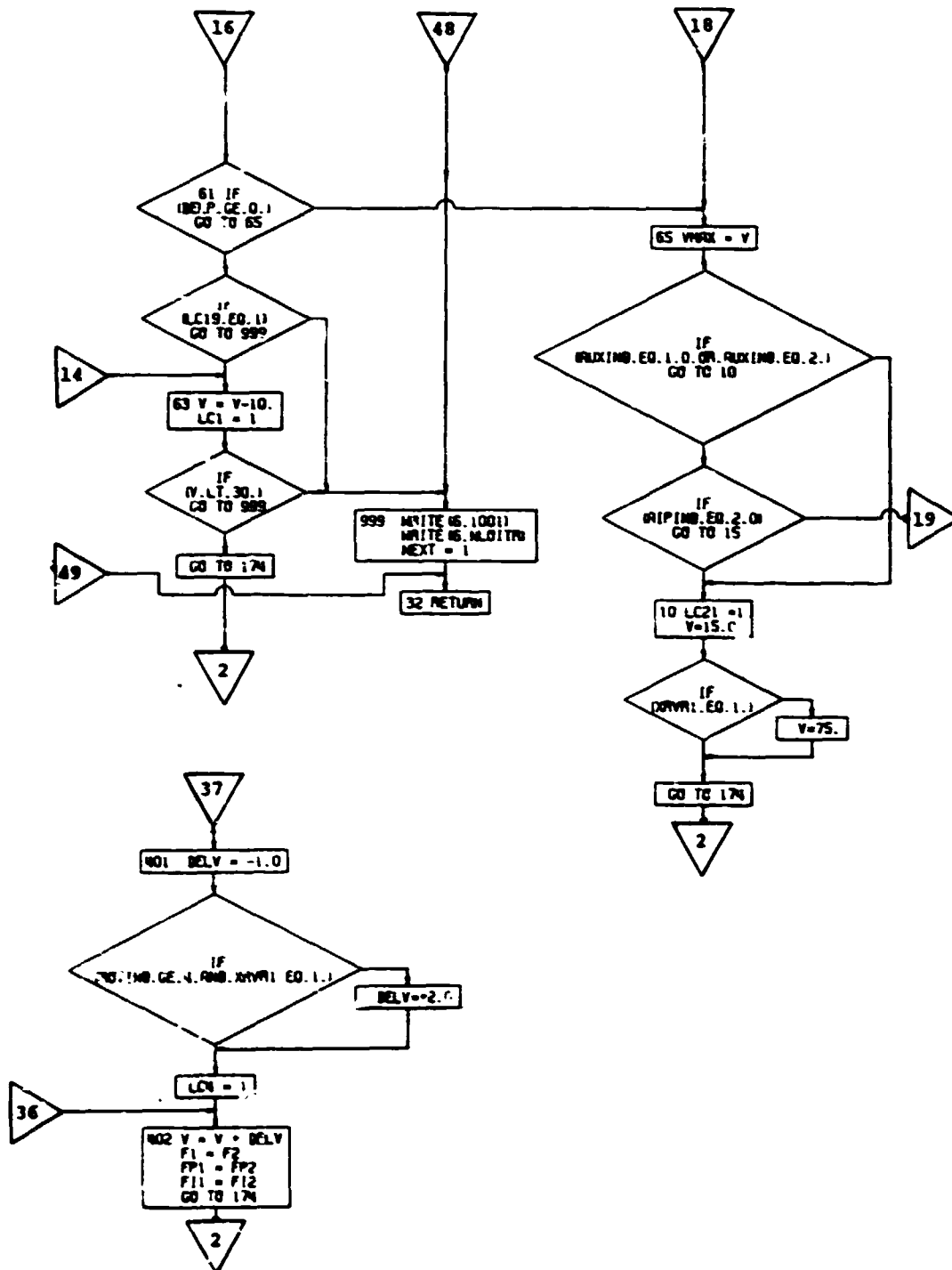


Figure 4-56 LCITR, Subroutine, Flow Chart (Part 6 of 12)

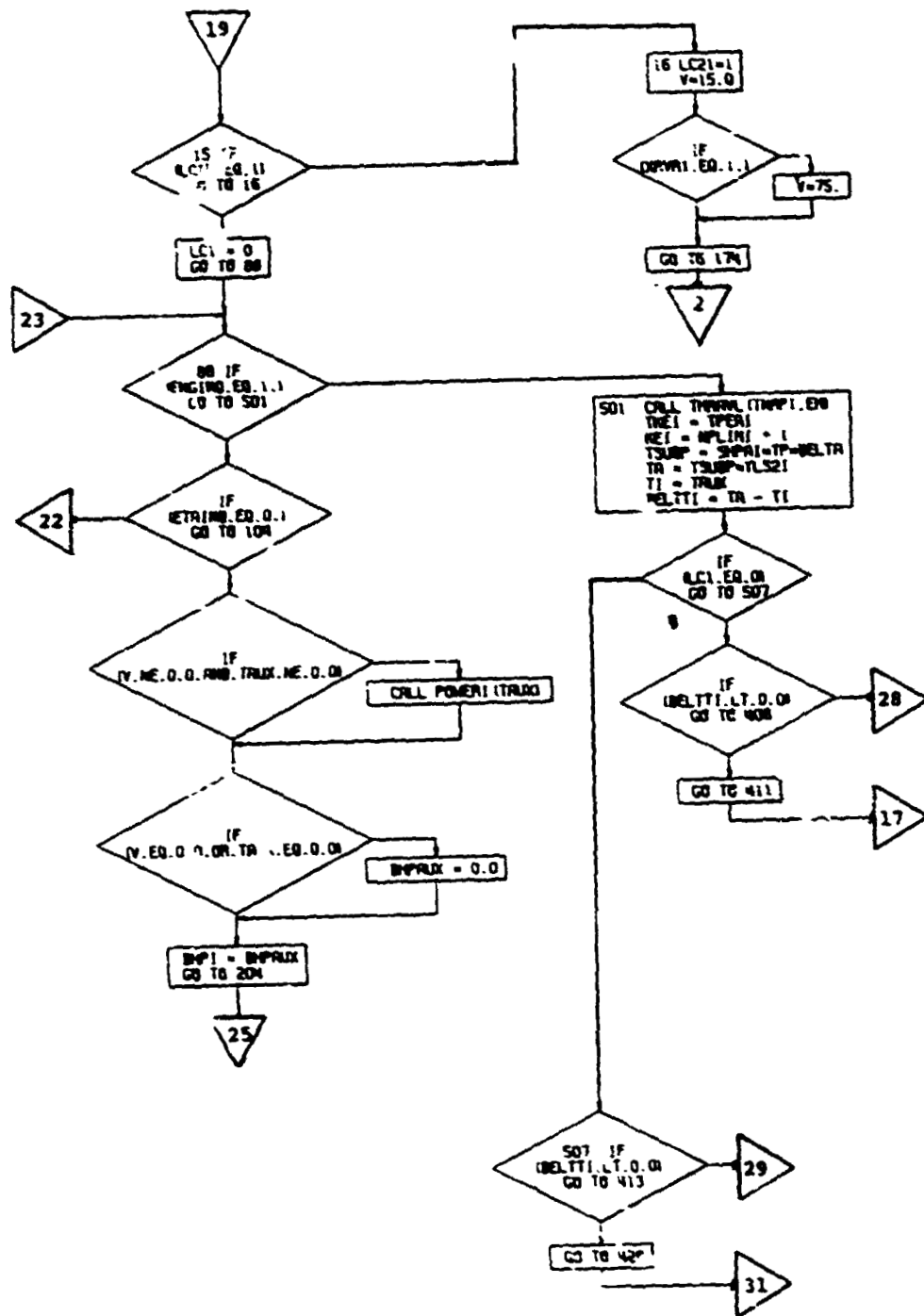


Figure 4-56. LOITR Subroutine, Flow Chart (Part 7 of 12)

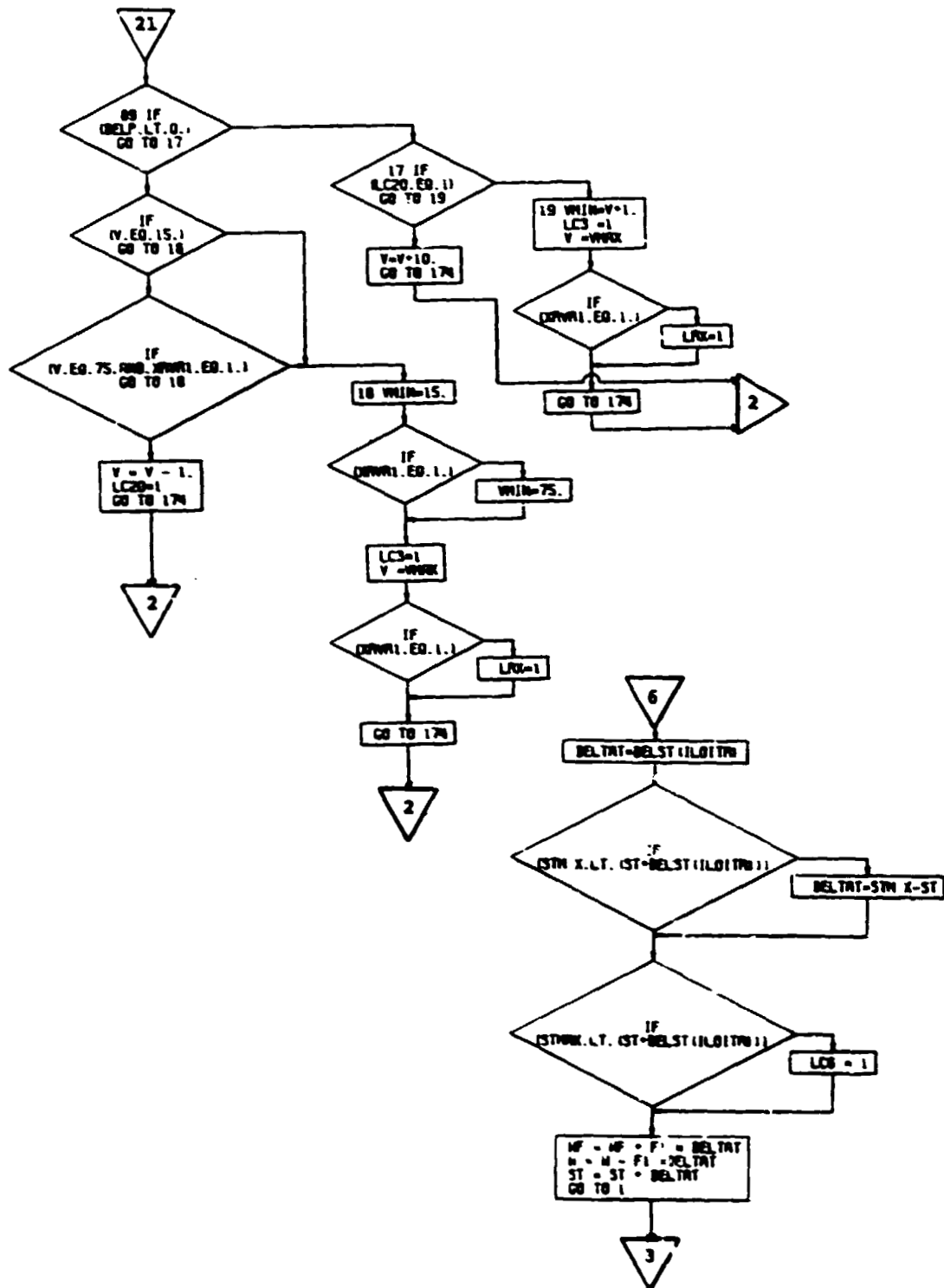


Figure 4-56. LOITR Subroutine, Flow Chart (Part d of 12)

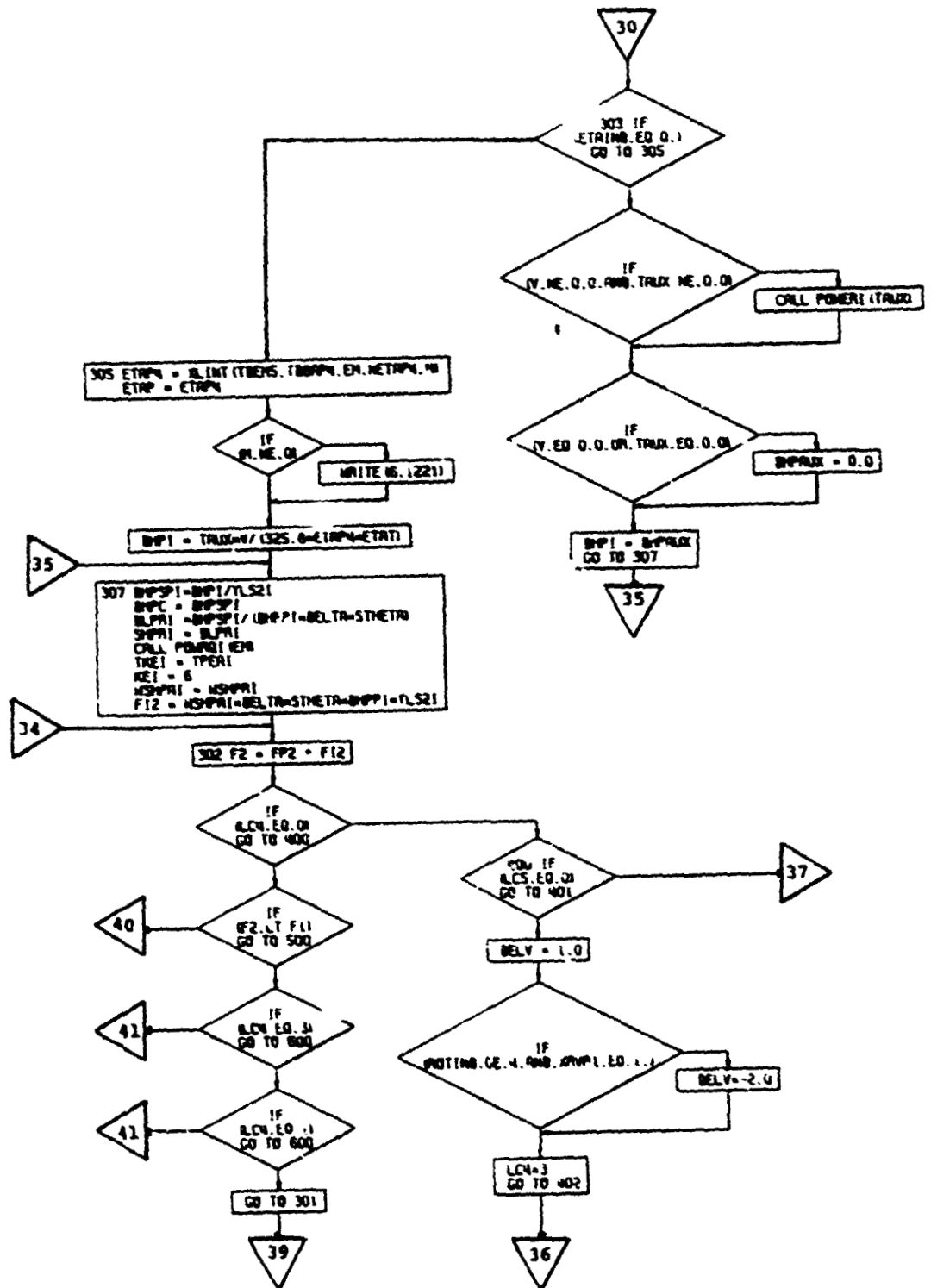


Figure 4-56. LOITR Subroutine, Flow Chart (Part 9 of 12)

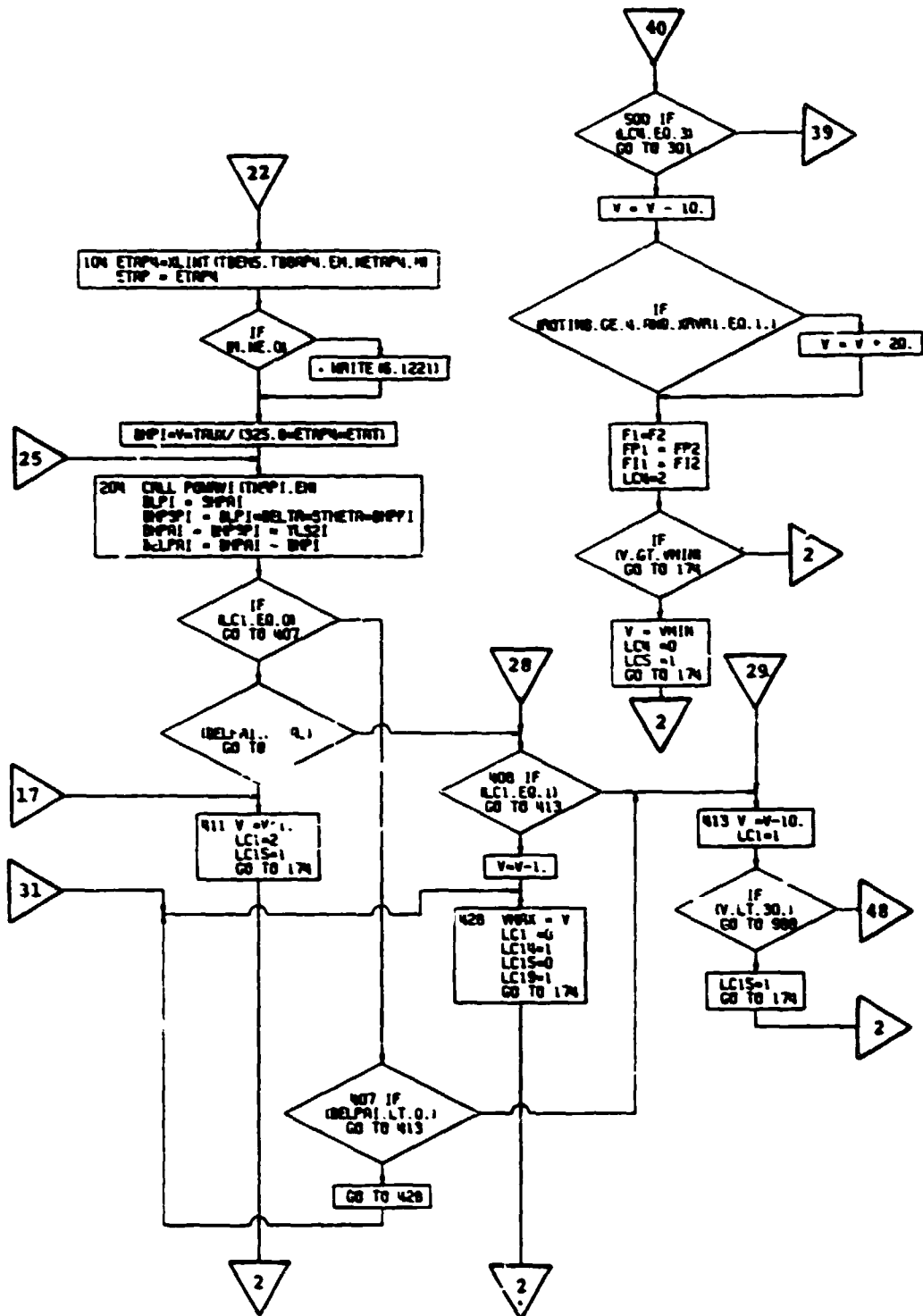


Figure 4-56. LOITER Subroutine, Flow Chart (Part 10 Of 12)

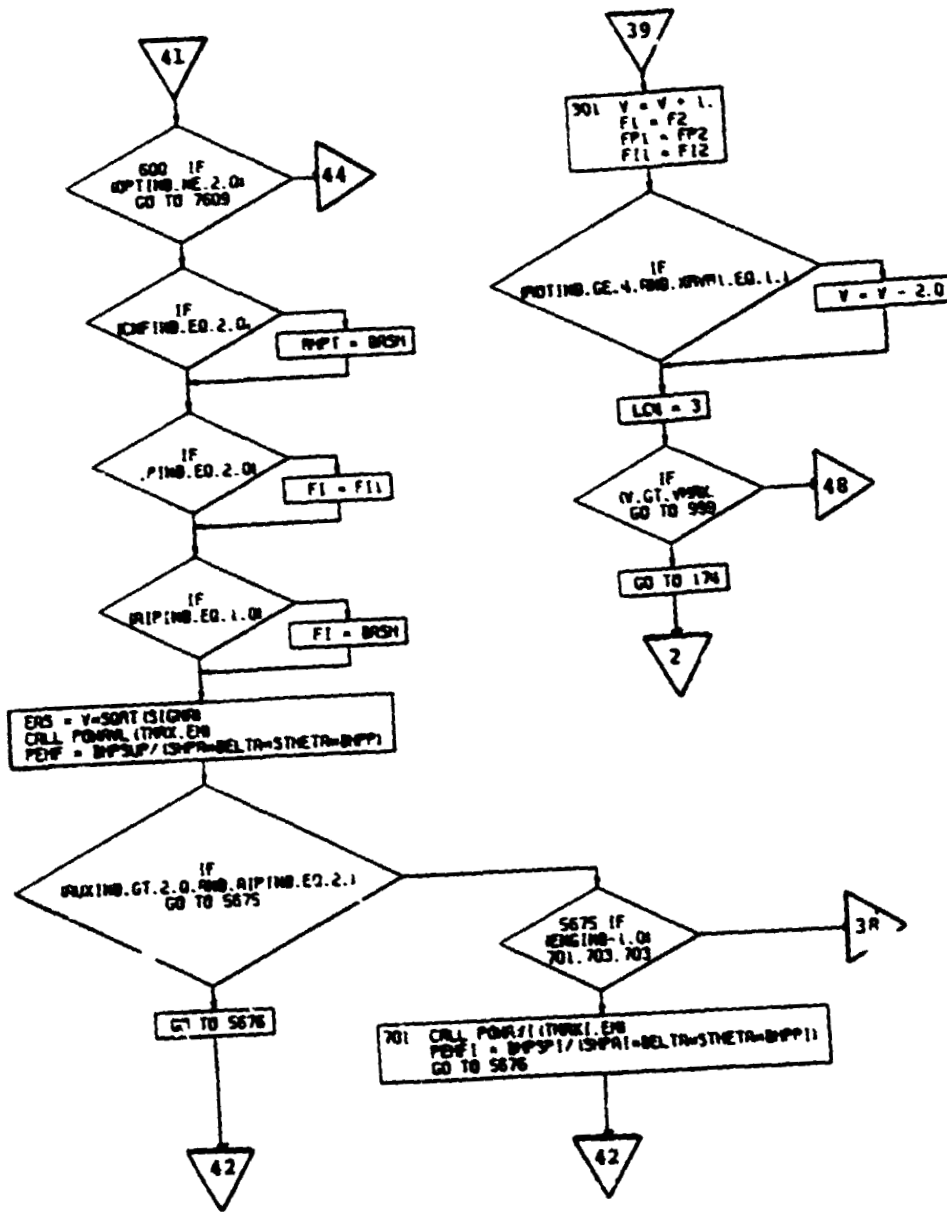


Figure 4-56. LOETR Subroutine, Flow Chart (Part 11 of 12)



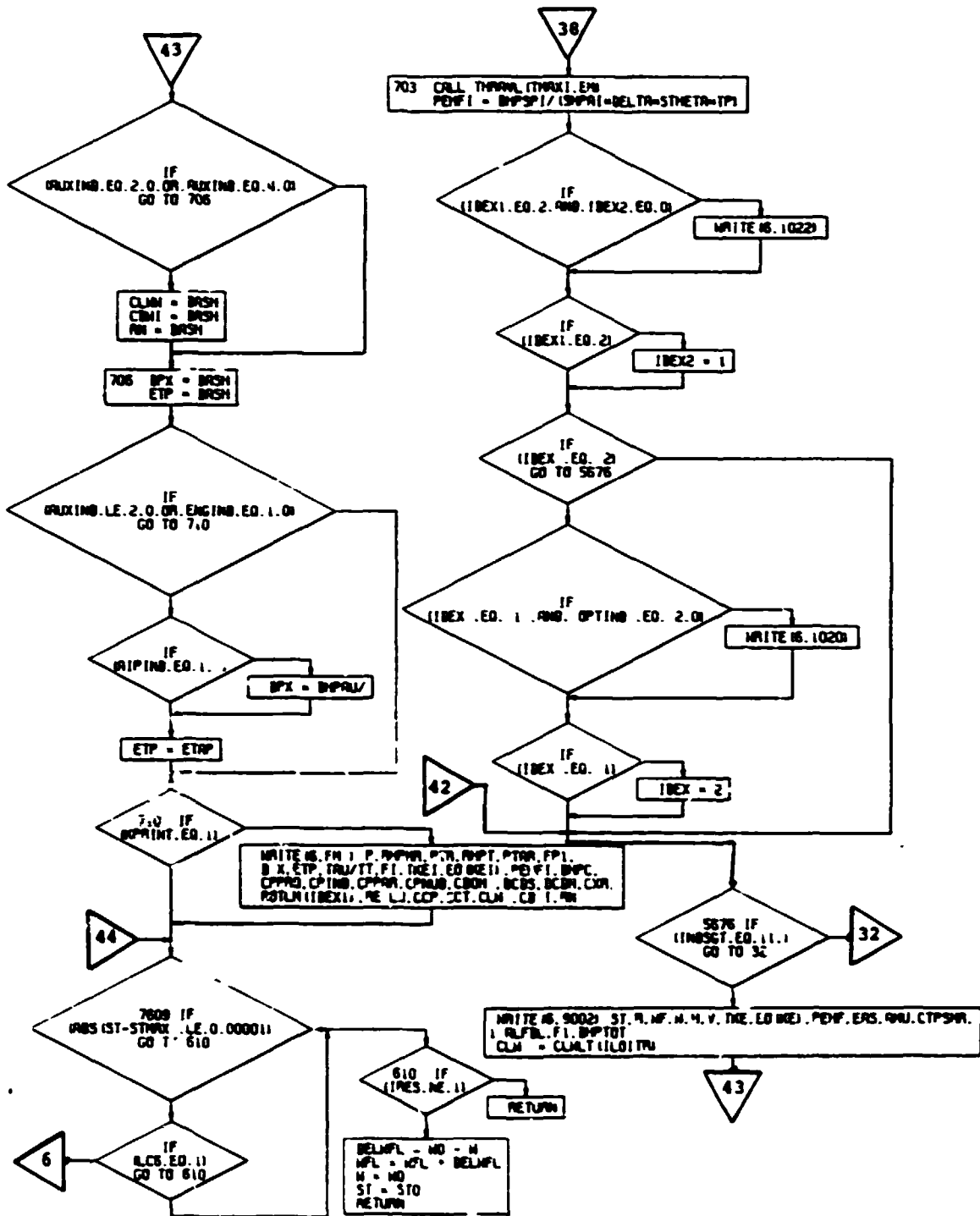


Figure 4-56. LOITR Subroutine, Flow Chart (Part 12 of 12)

#### 4.12.7 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 4-57 and 4-58 are flow charts of these subroutines.

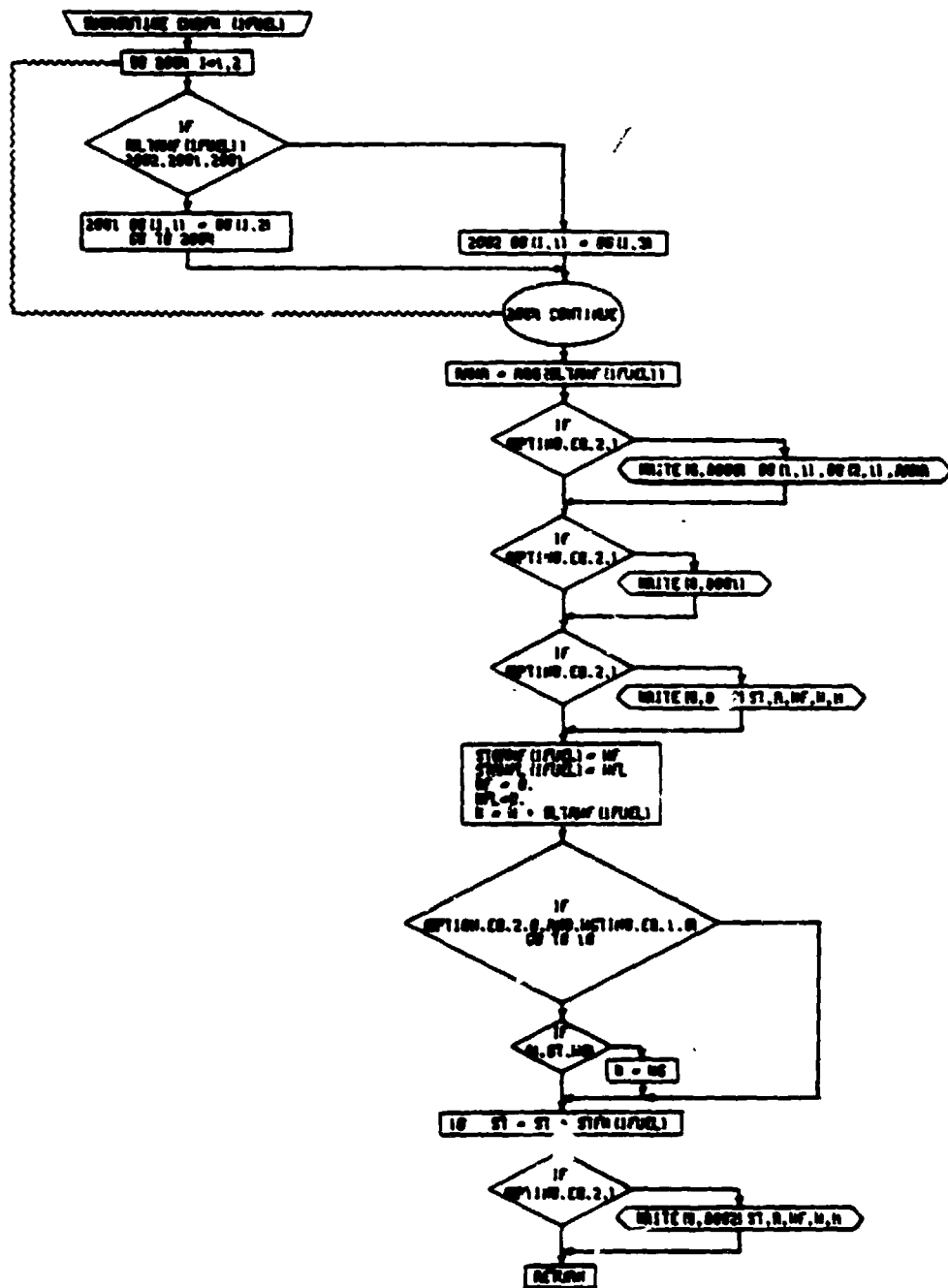


Figure 4-57. Change of Fuel Weight Subroutine, Flow Chart.

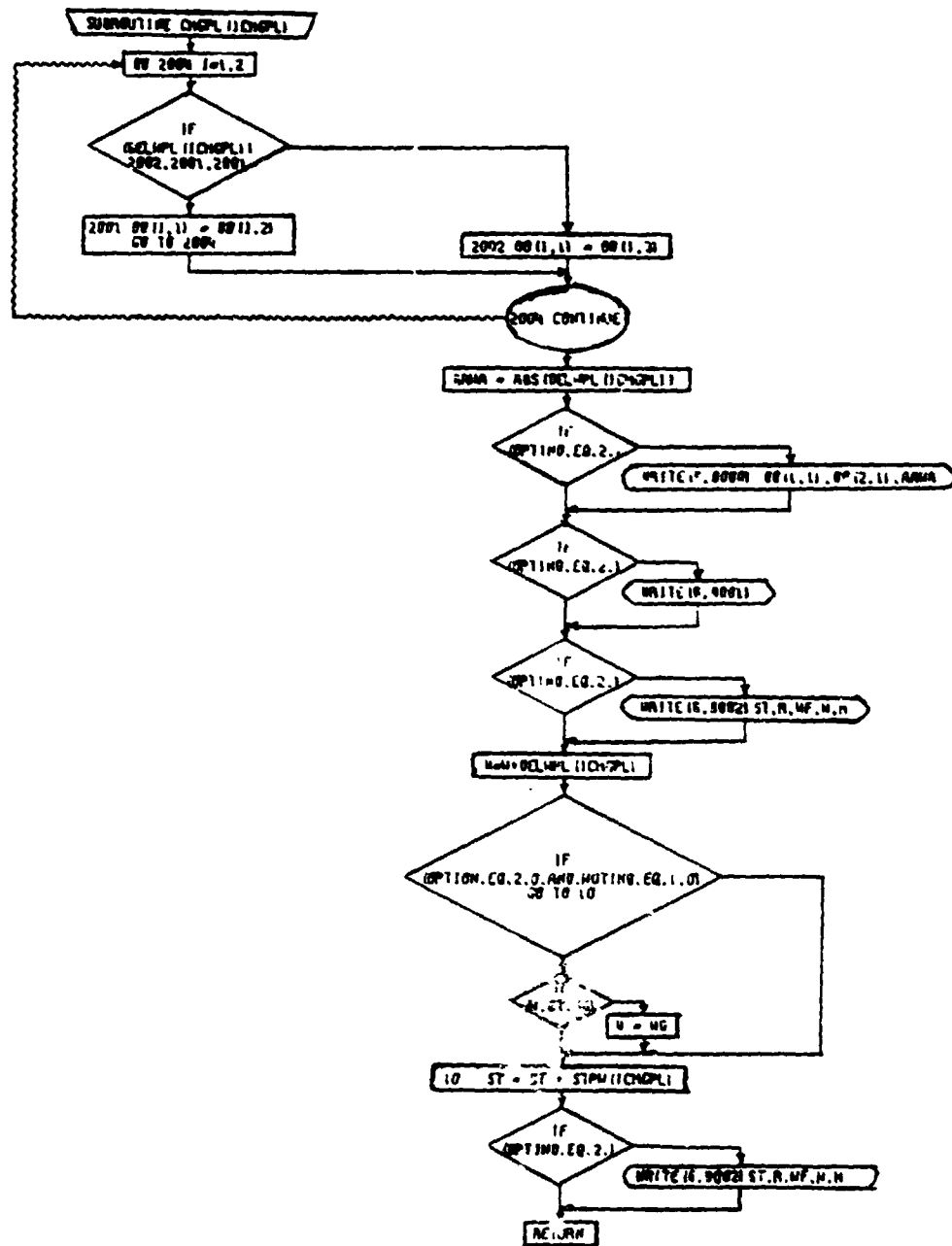


Figure 4-58. Change of Payload Weight routine, Flow Chart.

#### 4.12.8 Transfer Altitude

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

1. 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.
2. It may be required that no credit be taken for range, fuel, or distance during descent (for example, Reference 9).
3. 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 aircraft 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 4-59 is a flow chart of this subroutine.

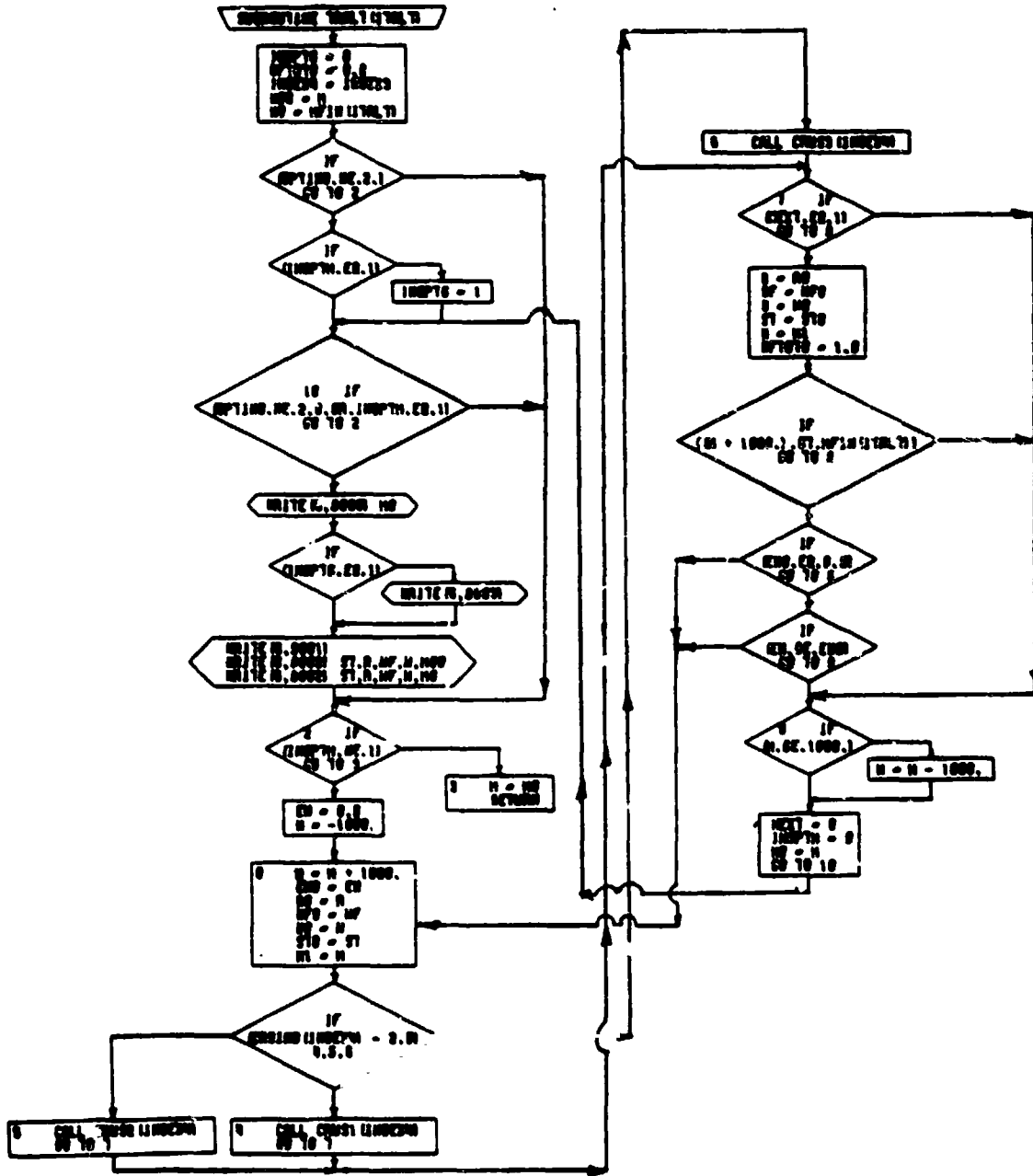


Figure 4-59. Transfer Altitude Subroutine, Flow Chart.

#### 4.12.9 General Performance

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

GWIND = 1. - User inputs the incremental change in gross weight into location 4150.

GWIND = 2. - User inputs the gross weight into location 4150.

The aircraft performance is calculated and printed out in velocity increments specified in LOC (4230) up to a maximum velocity input in LOC (4250). The program user specified the altitude, temperature, power turbine speed ratio, thrust to weight, wing lift coefficient, and incremental change in airplane equivalent flat plate area drag.

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 4-60.





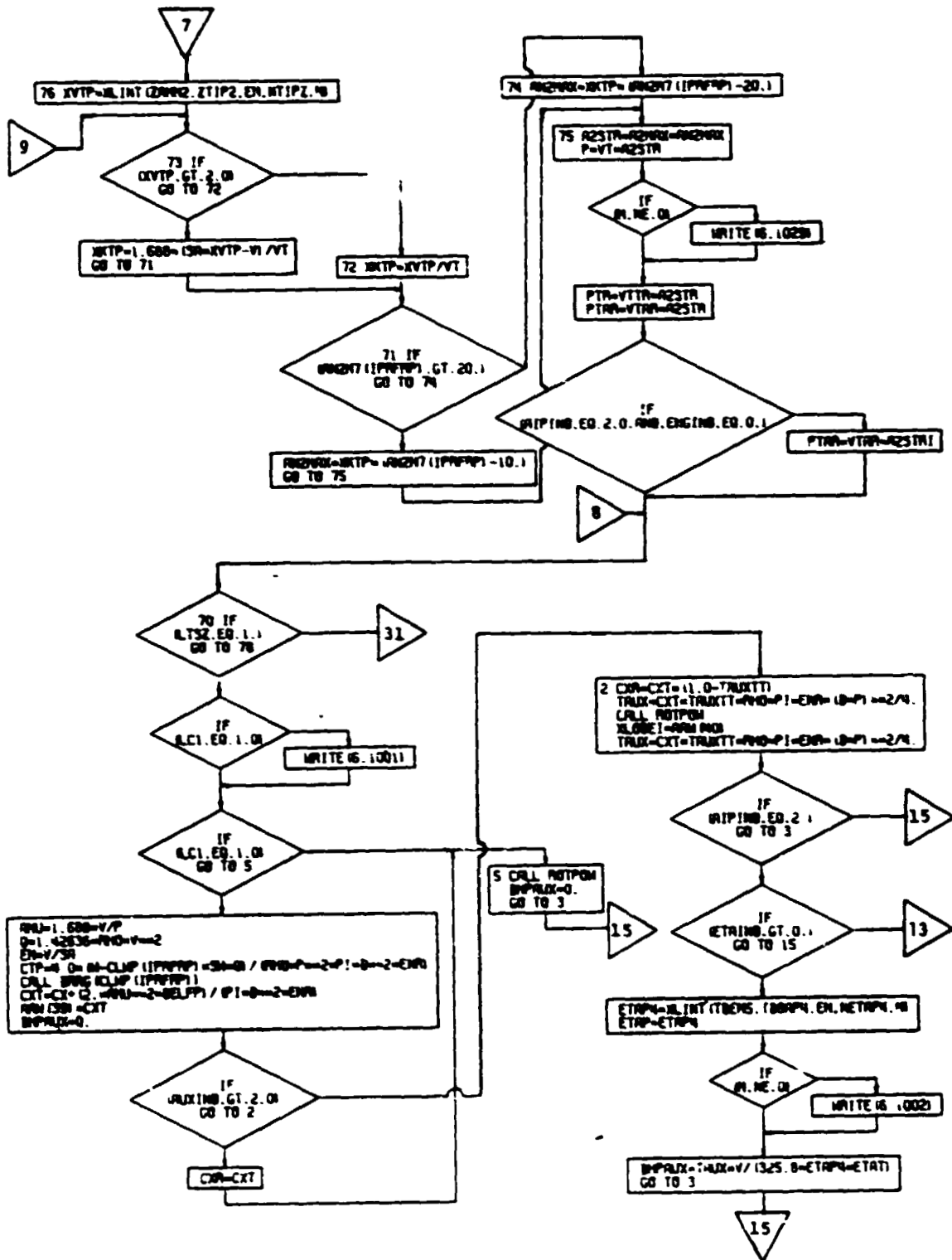


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 2 of 9)

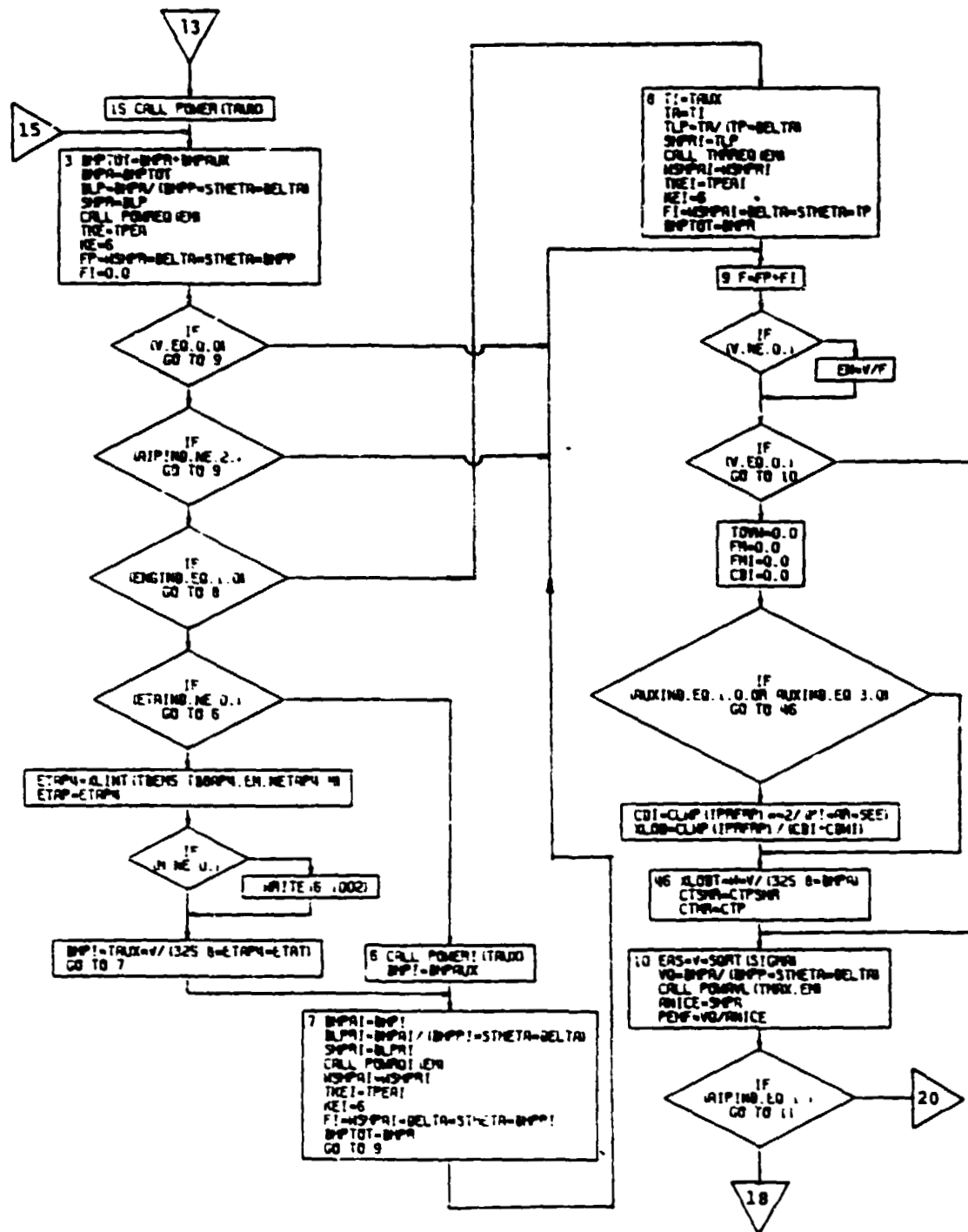


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 3 of 9)

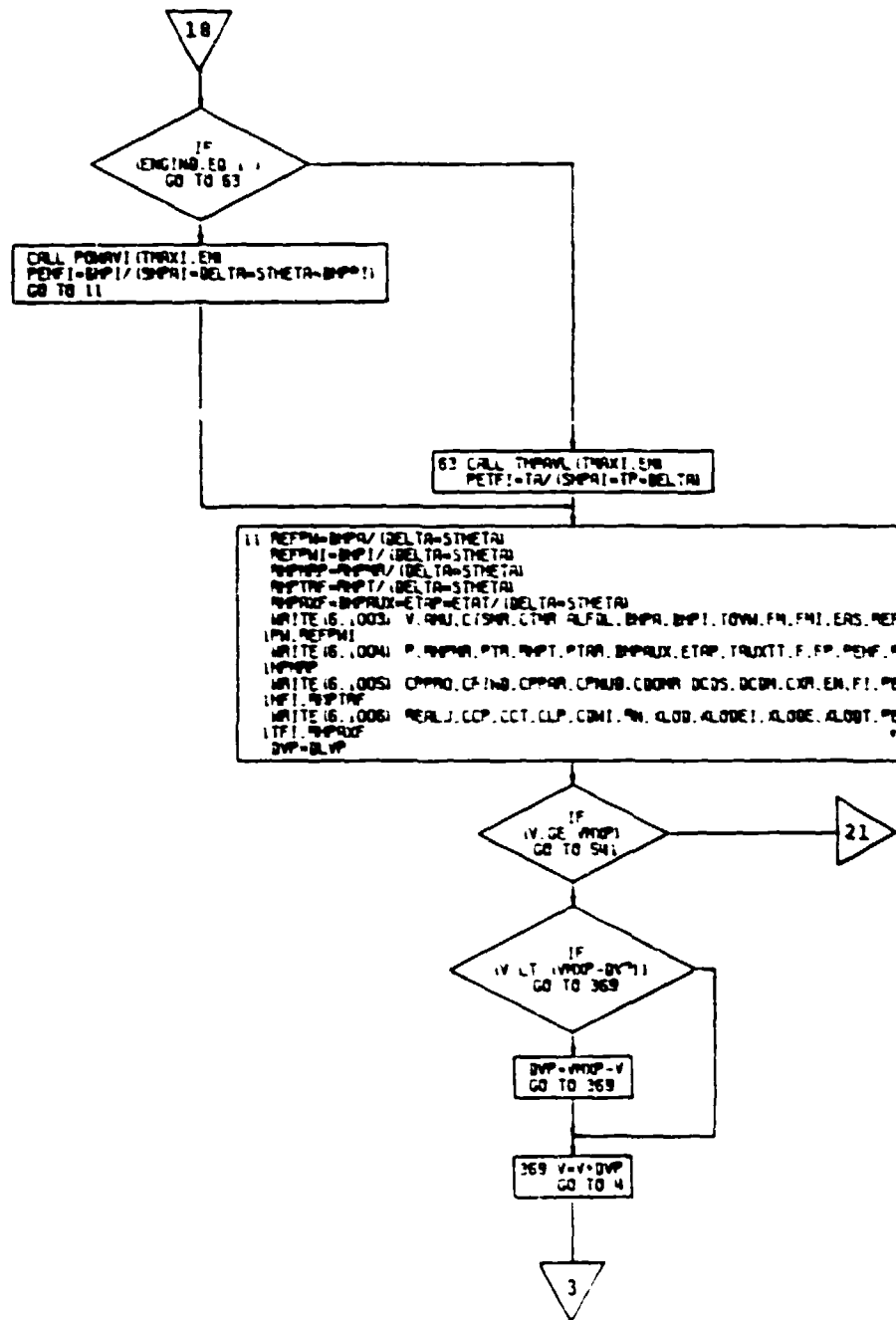


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 4 of 9)

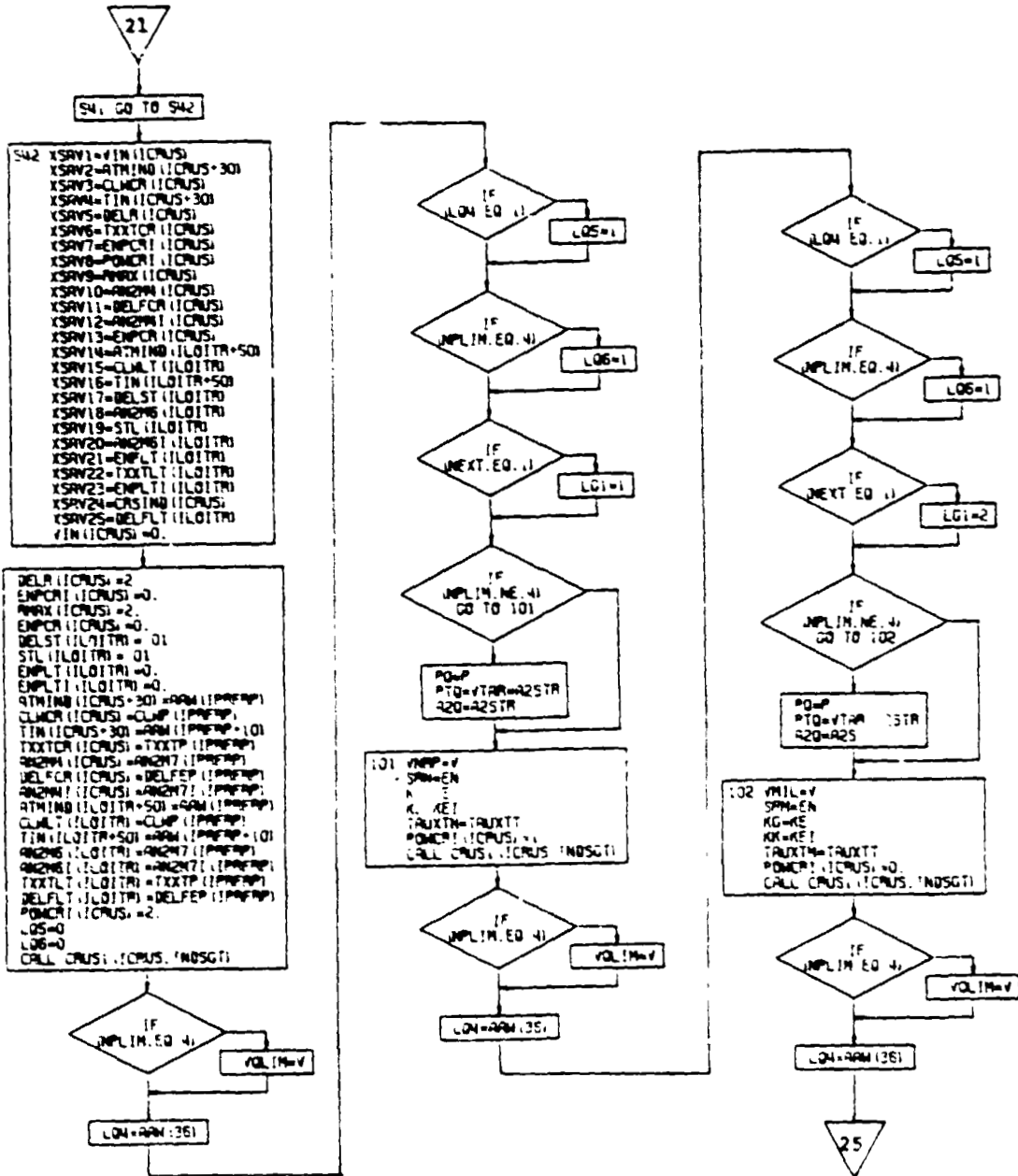


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 5 of 9)

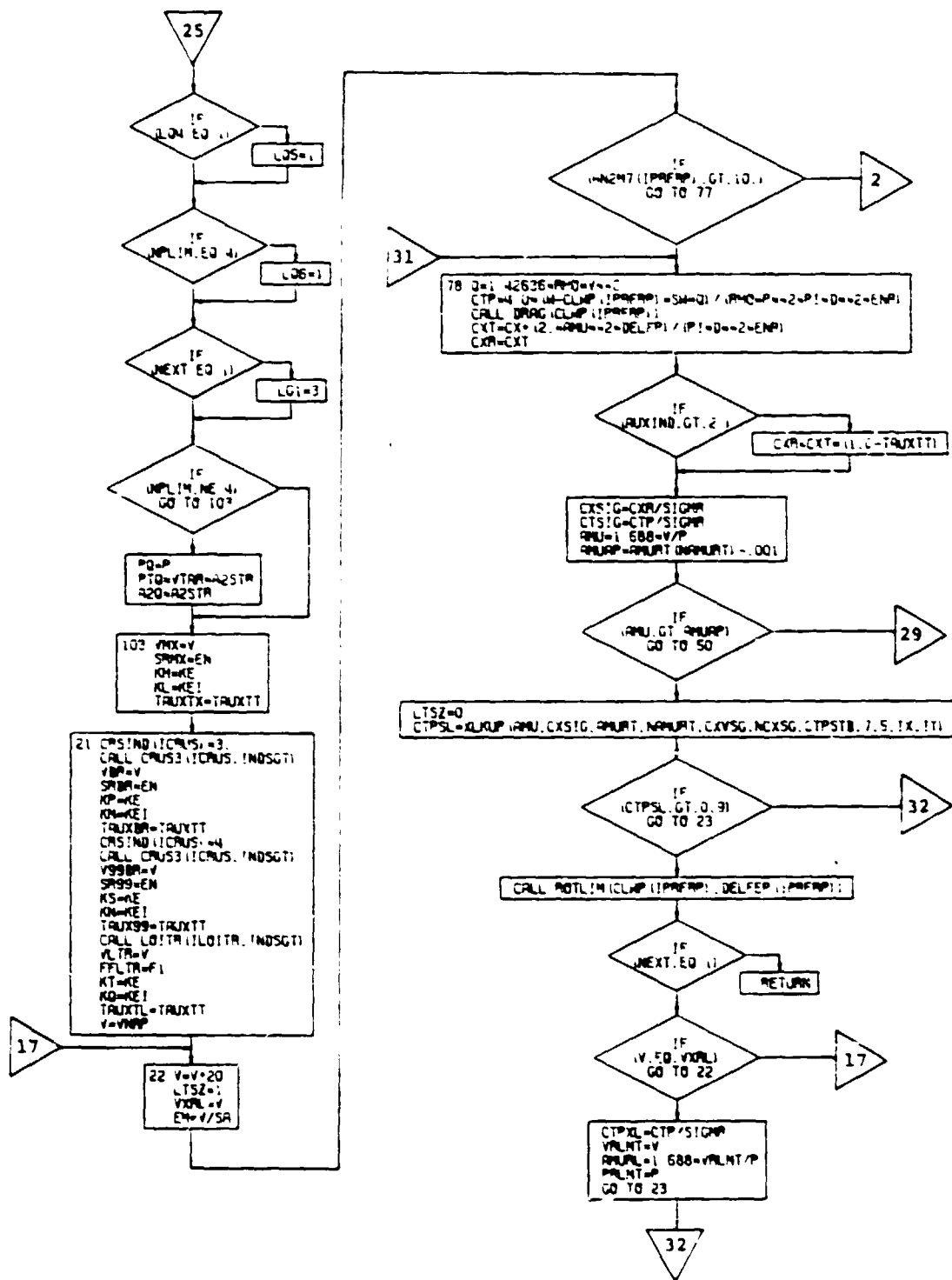


Figure 4-60 PRFRP Subroutine, Flow Chart (Part 6 of 9)

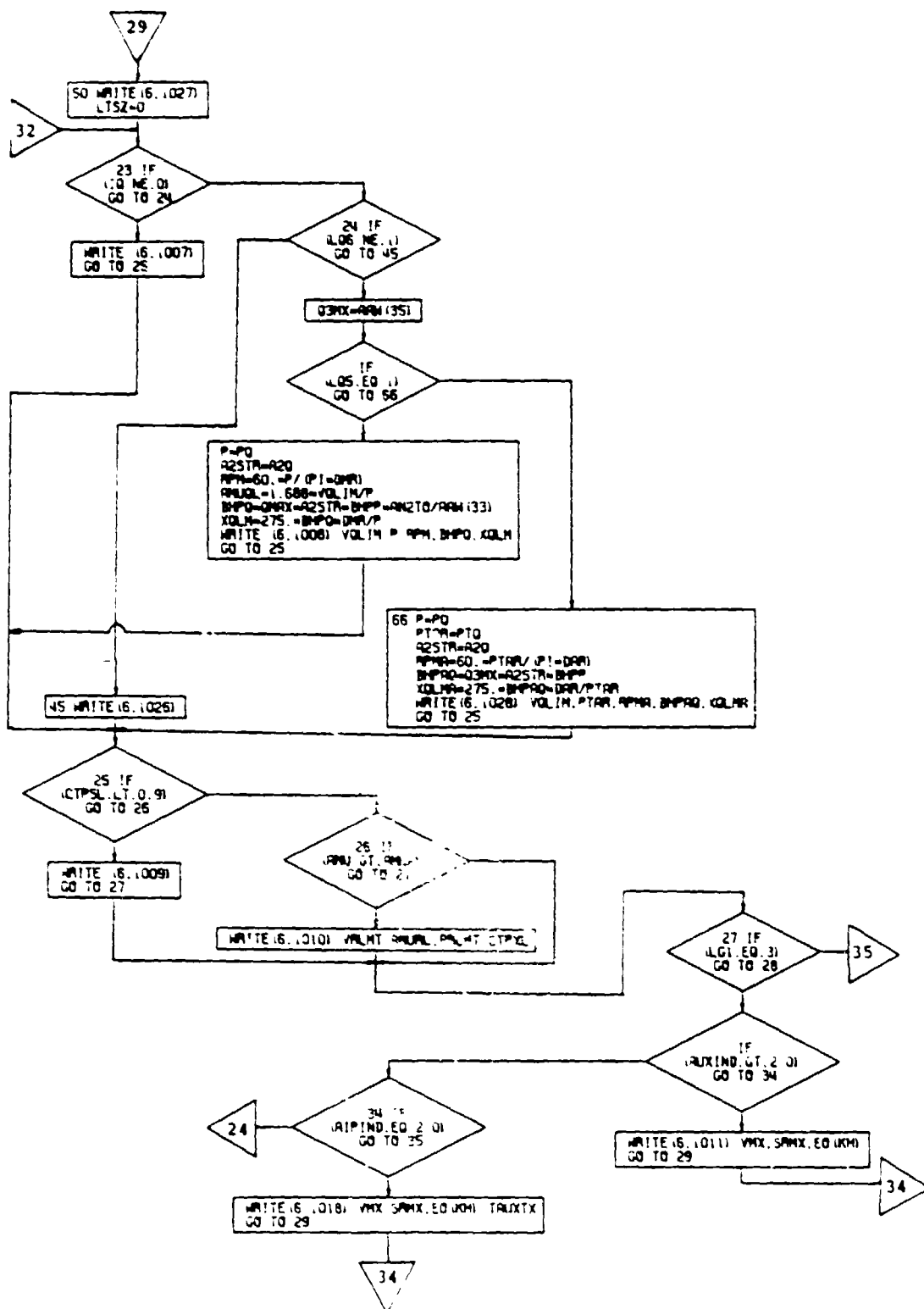


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 7 of 9)

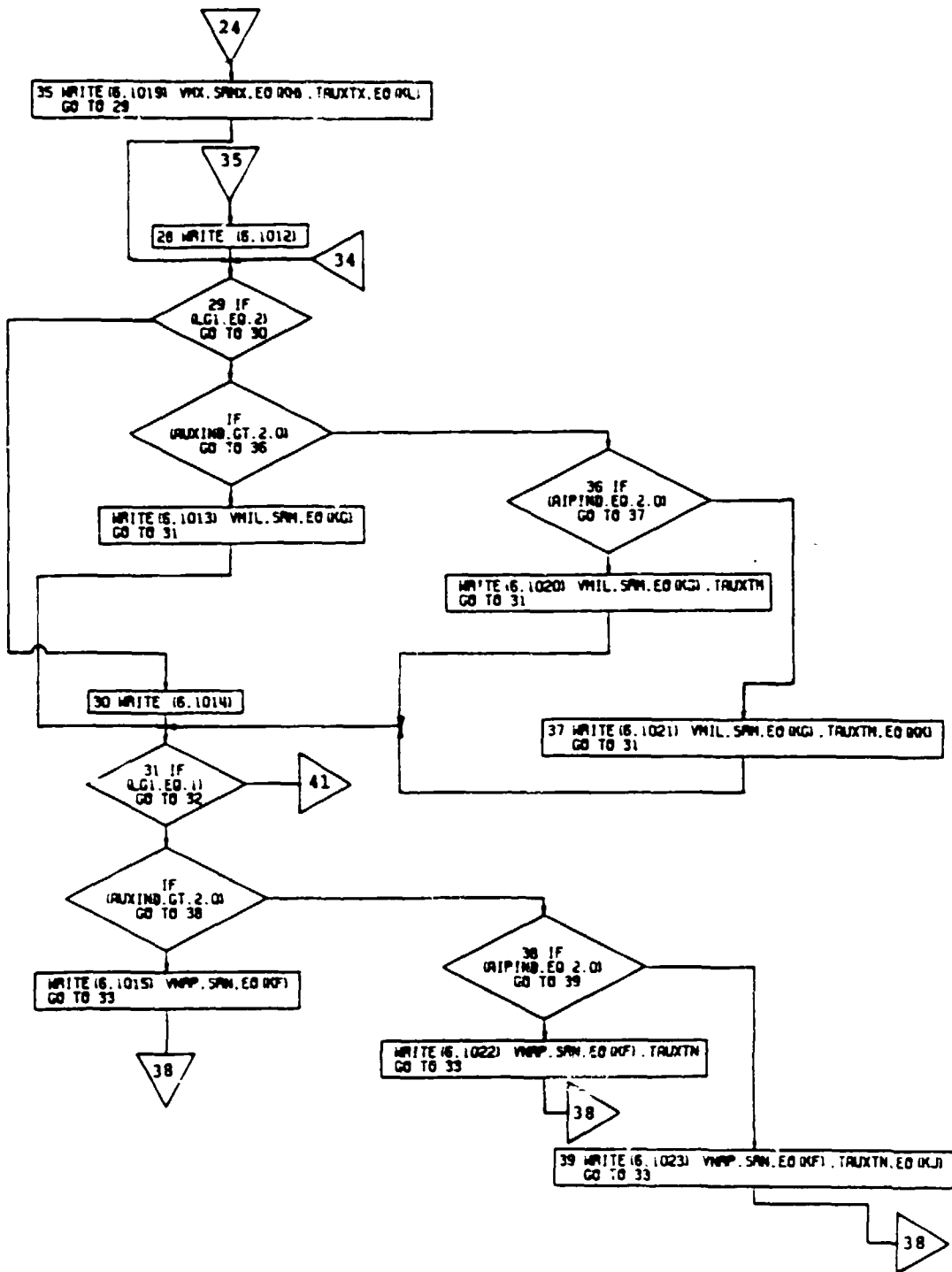


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 8 of 9)

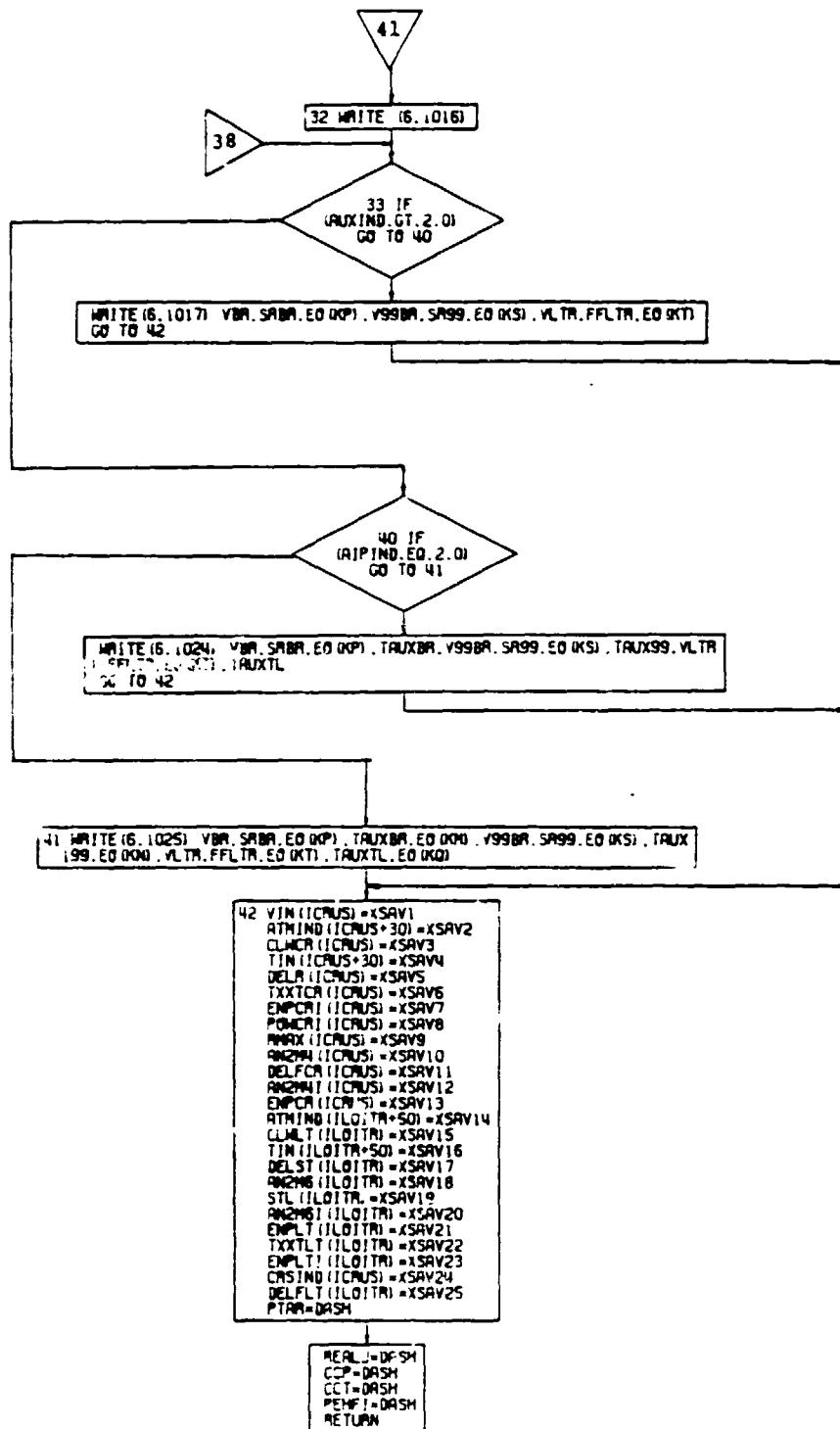


Figure 4-60. PRFRP Subroutine, Flow Chart (Part 9 of 9)



#### 4.12.10 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  $N_I$  and  $N_{II}$ . 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 4-61.

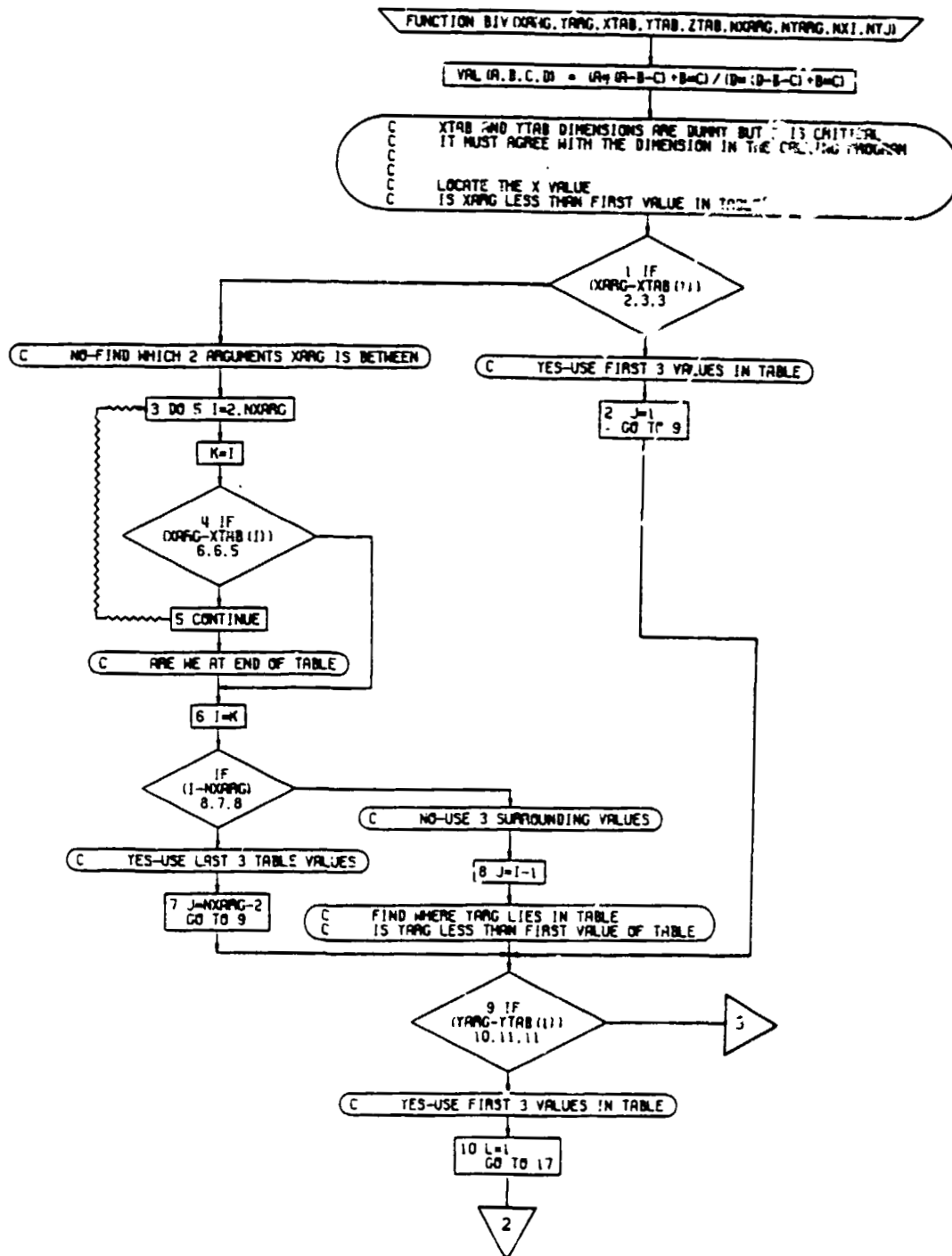


Figure 4-61. BIV Function, Flow Chart (Part 1 of 2)

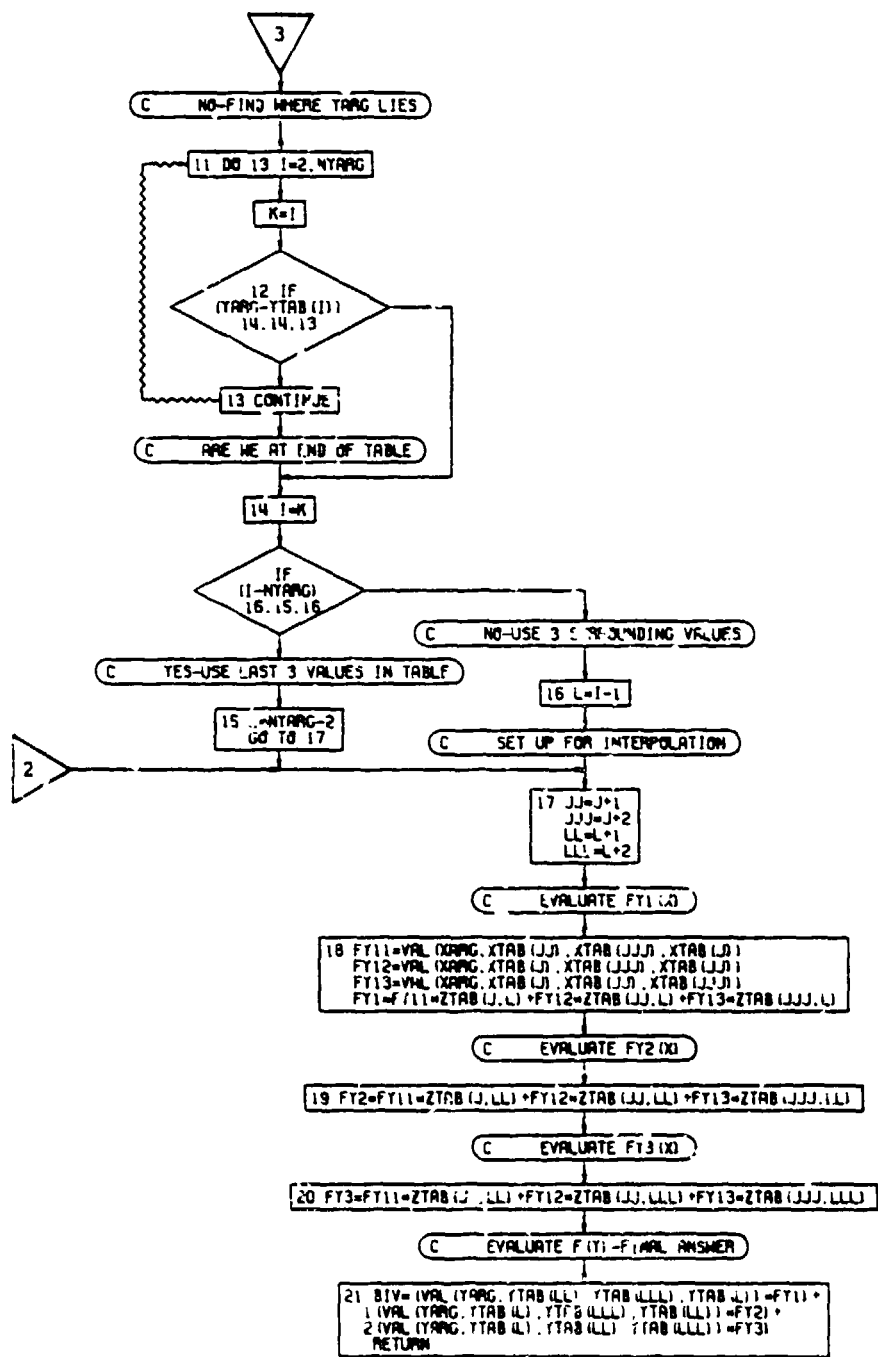


Figure 4-6i. BIV Function, Flow Chart (Part 2 of 2)

#### 4.12.11 Function PARA

PARA is a two-dimensional parabolic interpretation function used periodically throughout HESCOMP. A flow chart of the subroutine is shown in Figure 4-62.

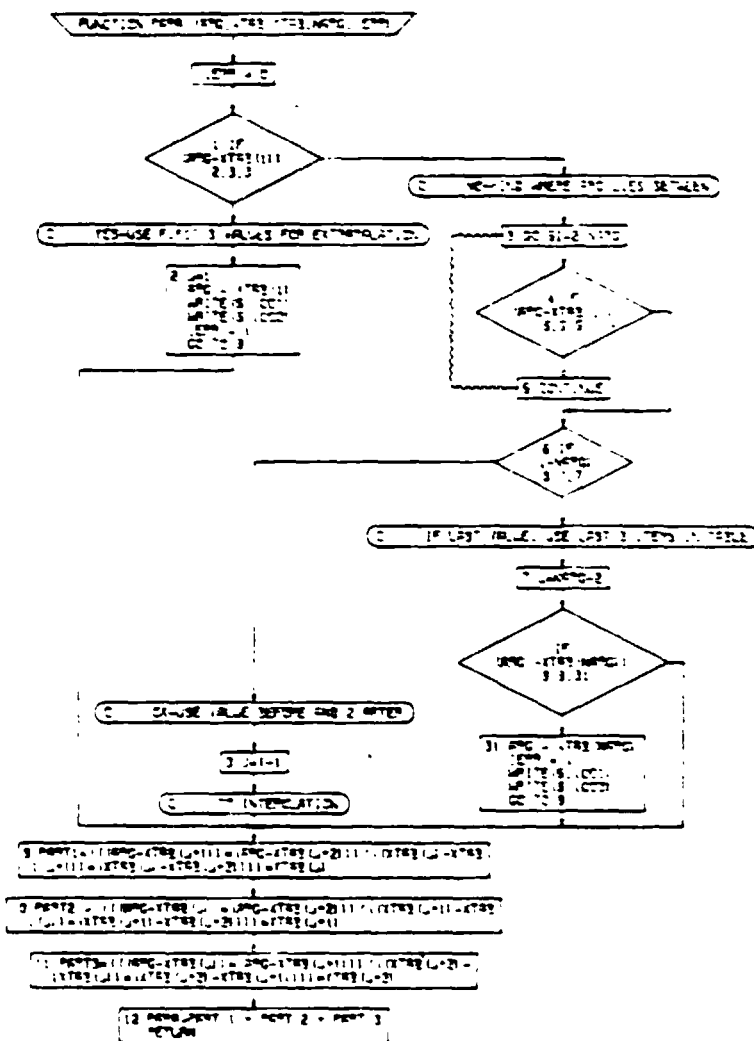


Figure 4-62. PARA Function, Flow Chart

4.12.12 Function Table

TABLE is a fourth-order Lagrangian interpolation function shown flowcharted in Figure 4-63.

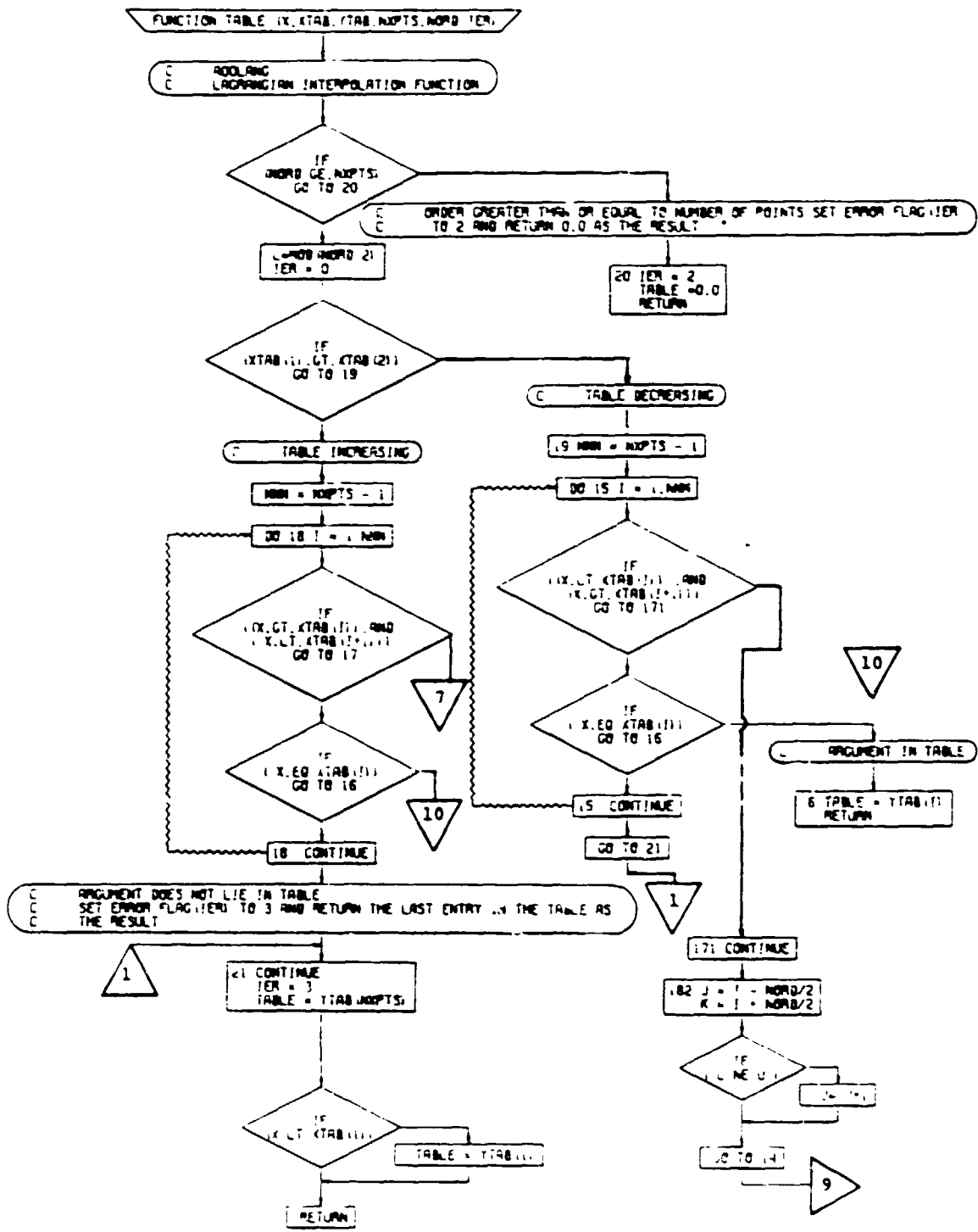


Figure 4-63. TABLE Function, Flow Chart (Part 1 of 2)

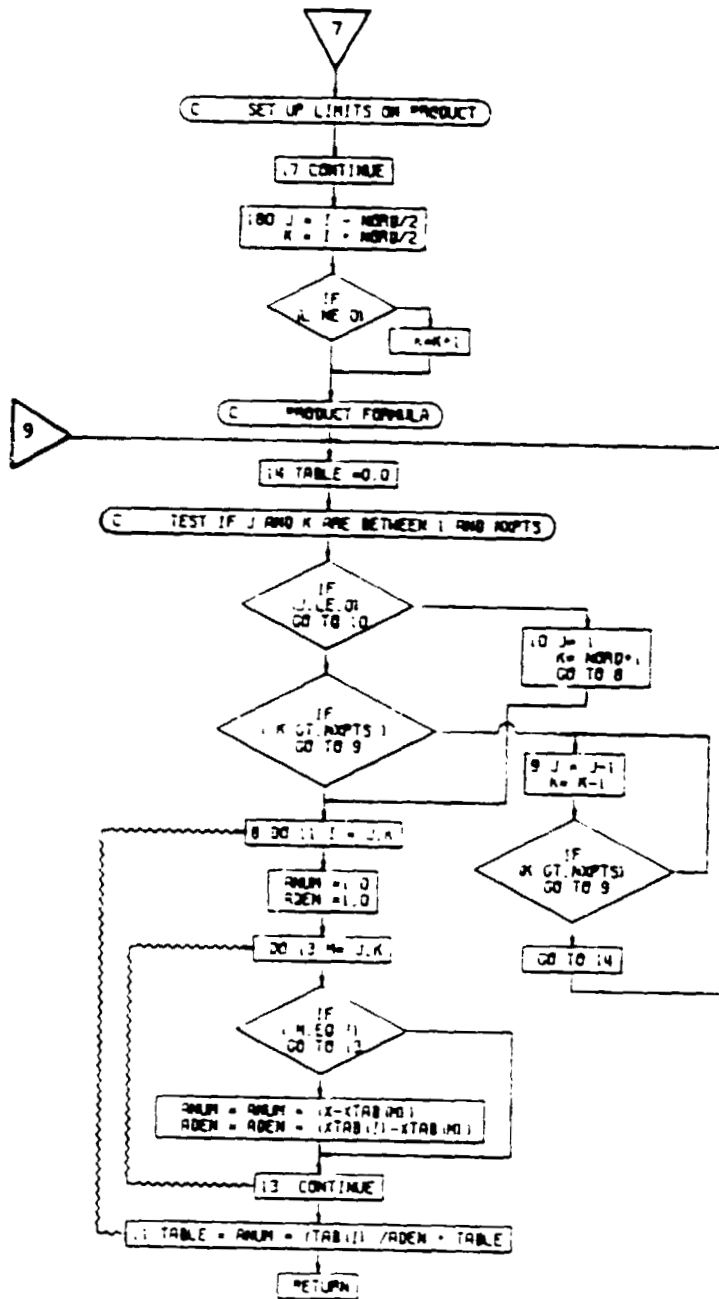


Figure 4-63. TABLE Function, Flow Chart (Part 2 of 2)



#### 4.12.13 Function TRIV

TRIV is a three-dimensional parabolic table look-up function. The subroutine flow chart is shown in Figure 4-64.

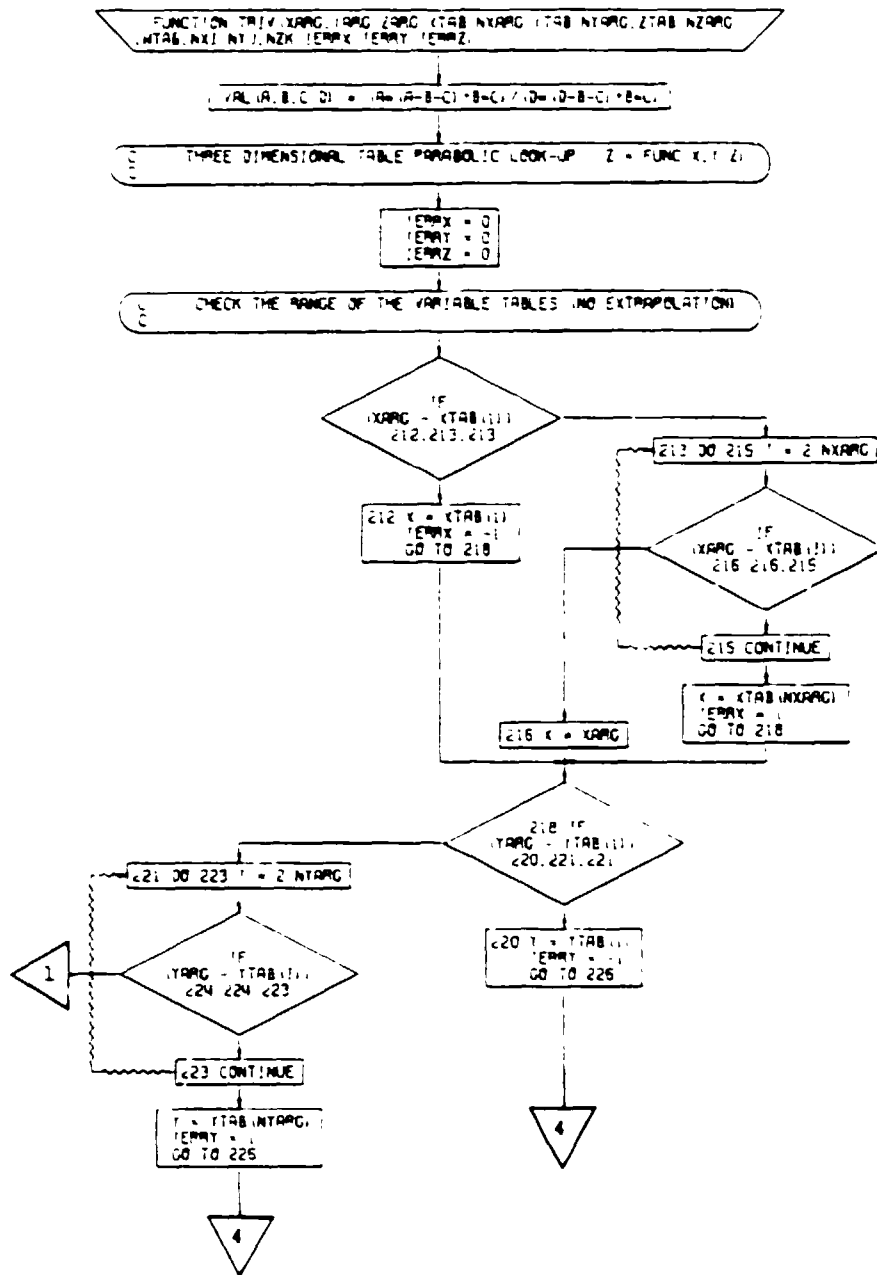


Figure 4-64. TRIV Function, Flow Chart (Part 1 of 5)

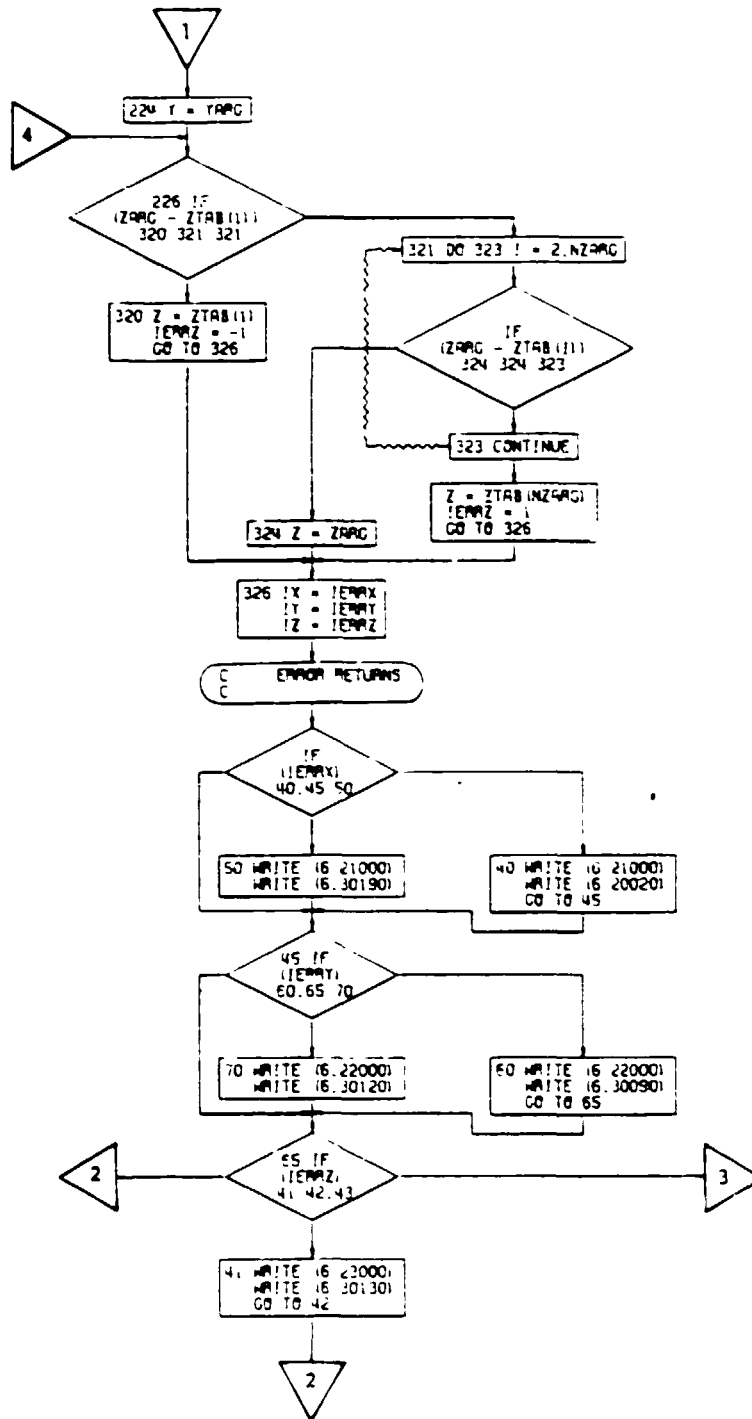


Figure 4-64. TRIV Function, Flow Chart (Part 2 of 5)

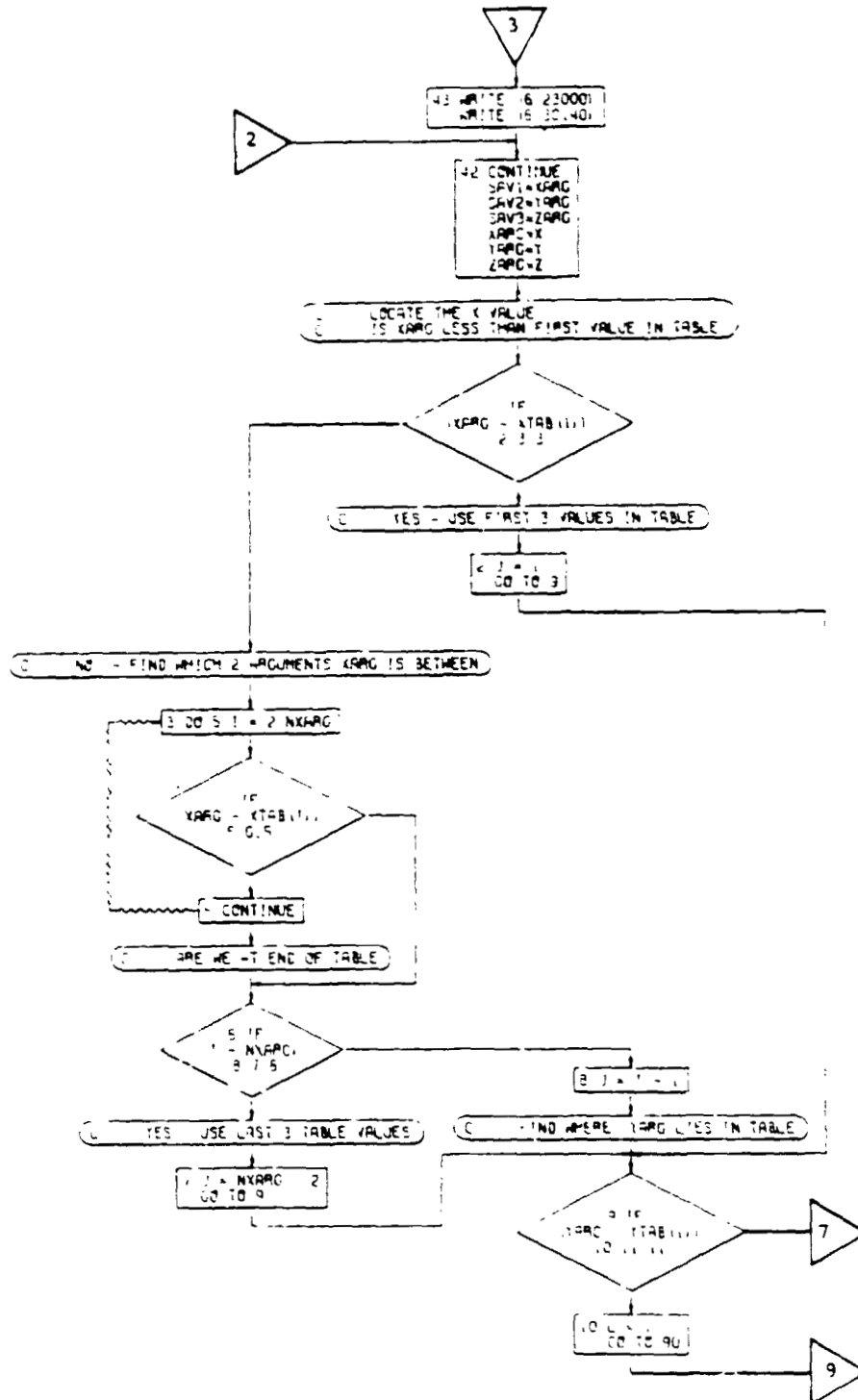


Figure 4-64. TRIV Function, Flow Chart (Part 3 of 5)

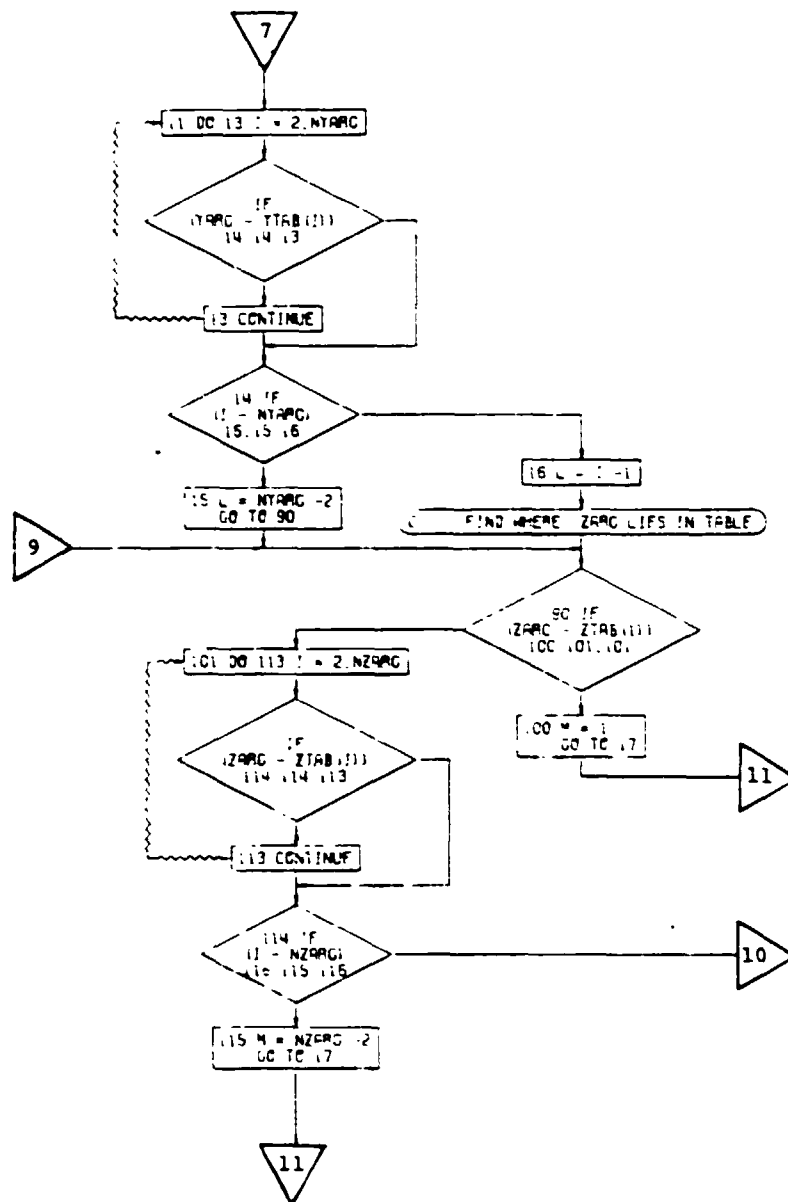


Figure 4-64. SPIV Function, Flow Chart (Part 4 of 5)

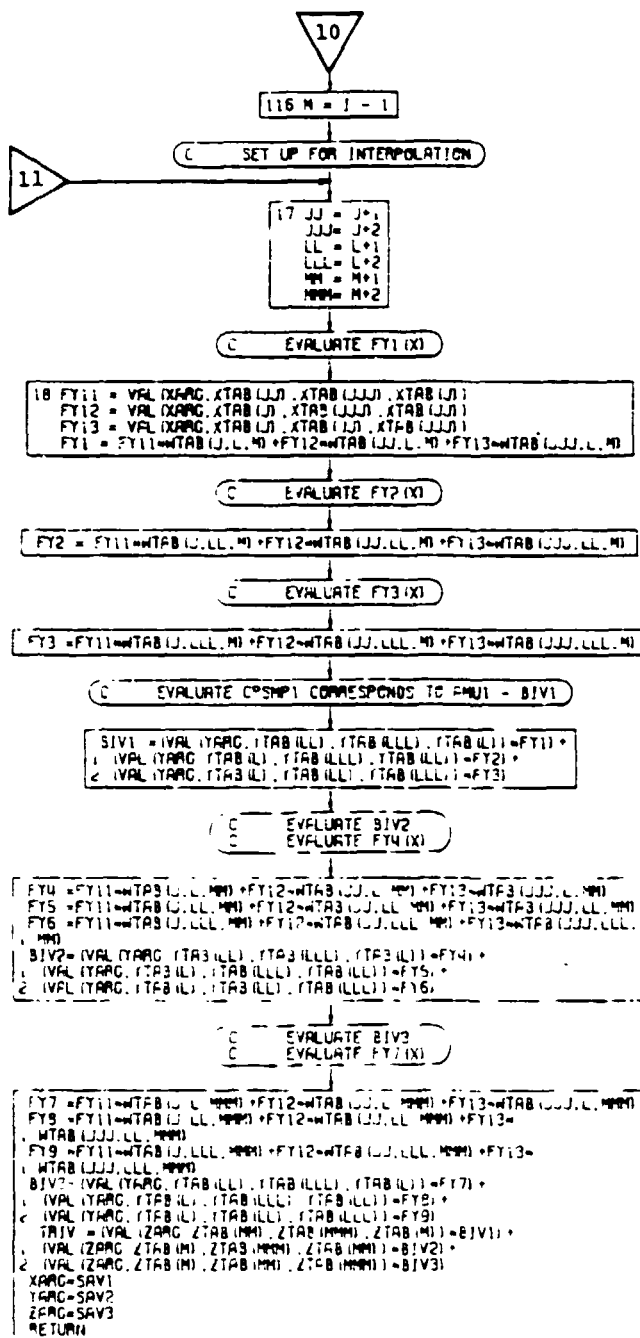


Figure 4-64. TRIV Function, Flow Chart (Part 5 of 5)

#### 4.12.14 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 4-65.

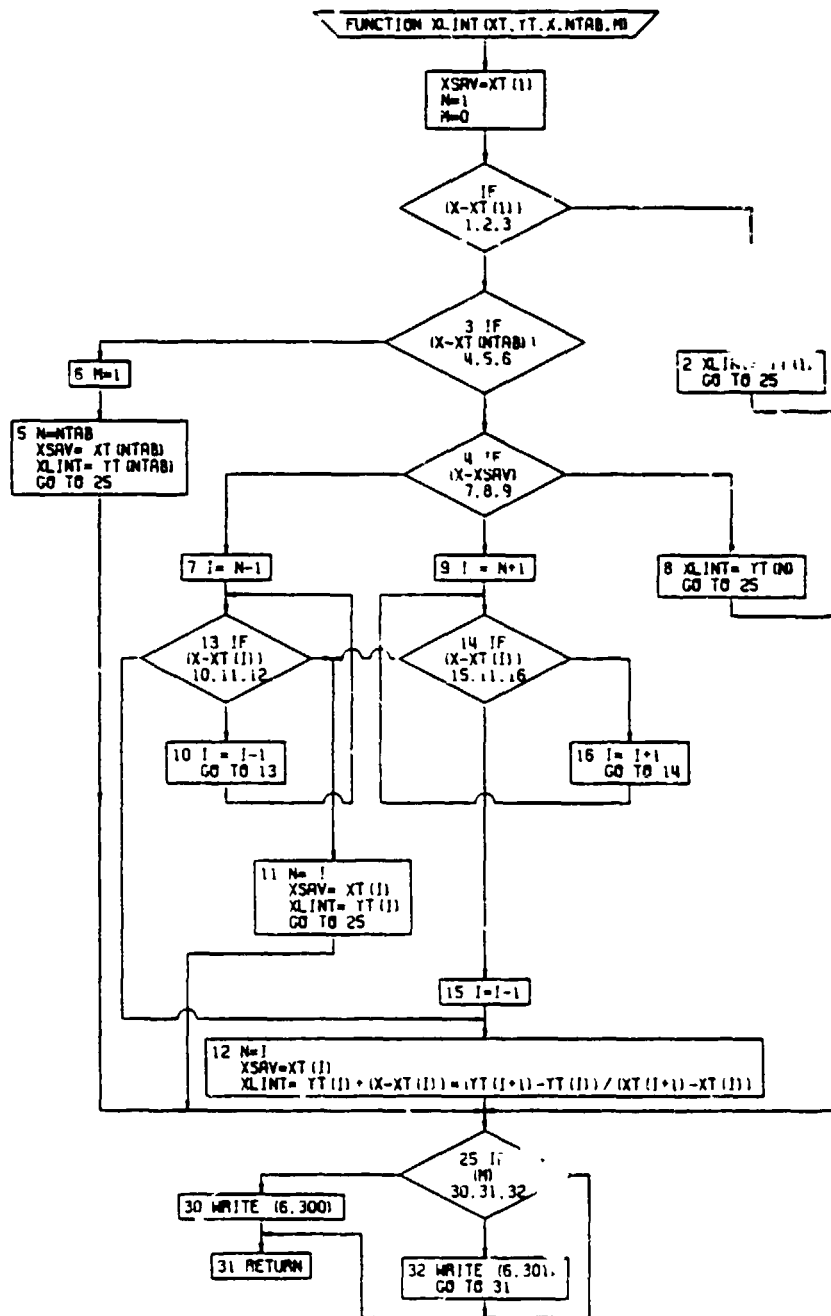


Figure 4-65. XLINT Function, Flow Chart



4.12.15 Function XLKUP

XLKUP is a double table parabolic look-up function. A flowchart of the subroutine is shown in Figure 4-66.

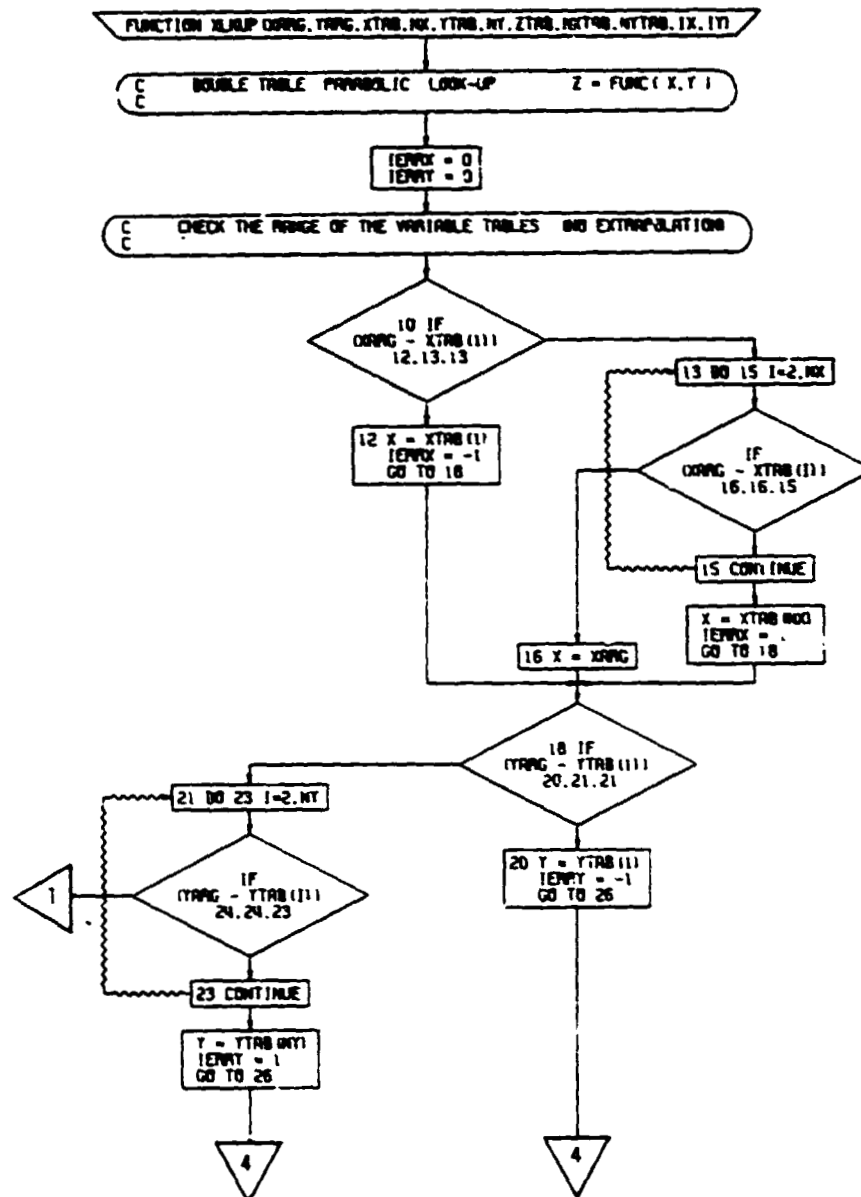


Figure 4-66. XLKUP Function, Flow-Chart (Part 1 of 2)

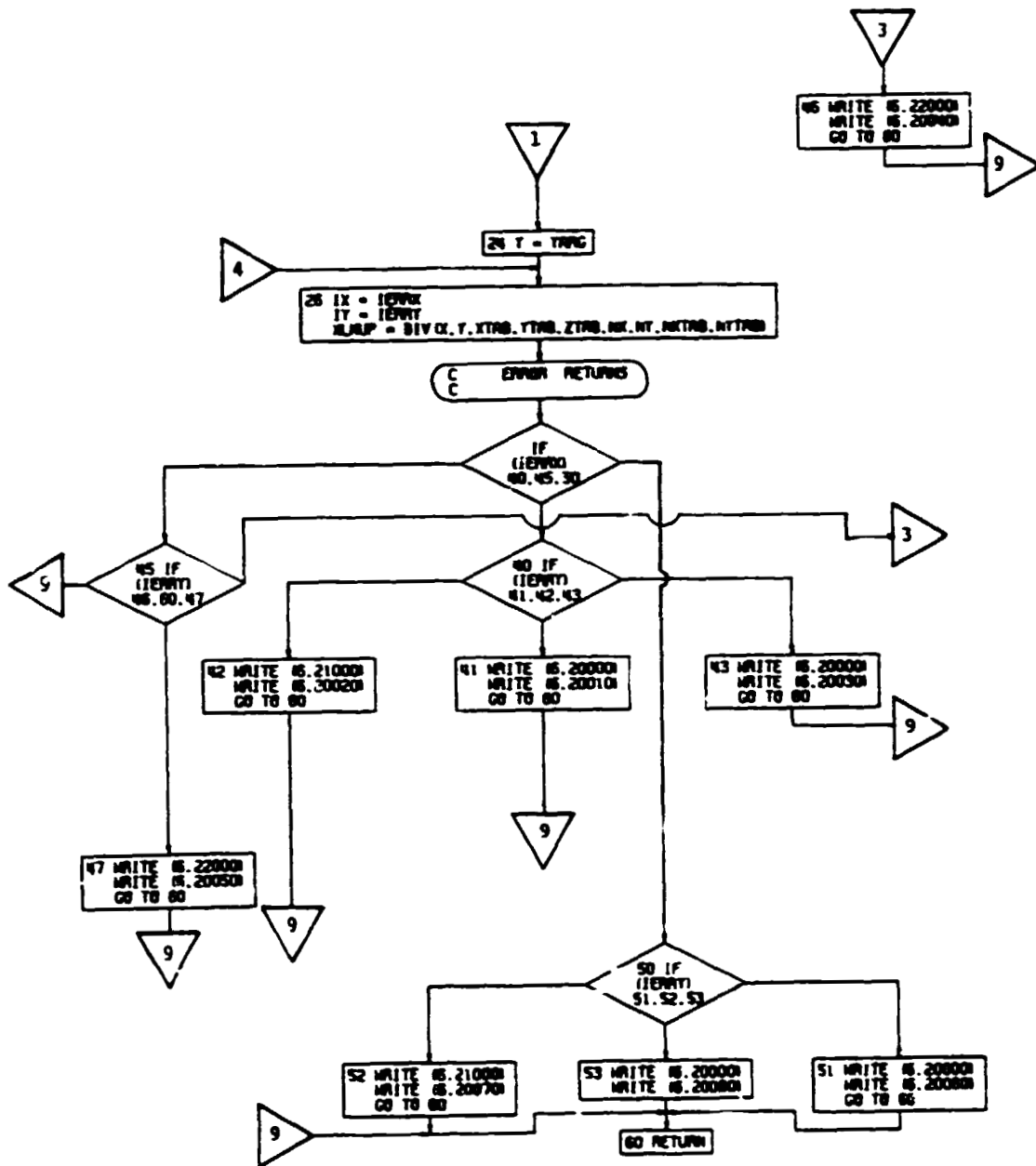


Figure 4-66. XLKUP Function, Flow Chart (Part 2 of 2)

4.12.16 Function XIBIV

XIBIV is an inverse double table parabolic look-up. A schematic of the flowchart is shown in Figure 4-67.

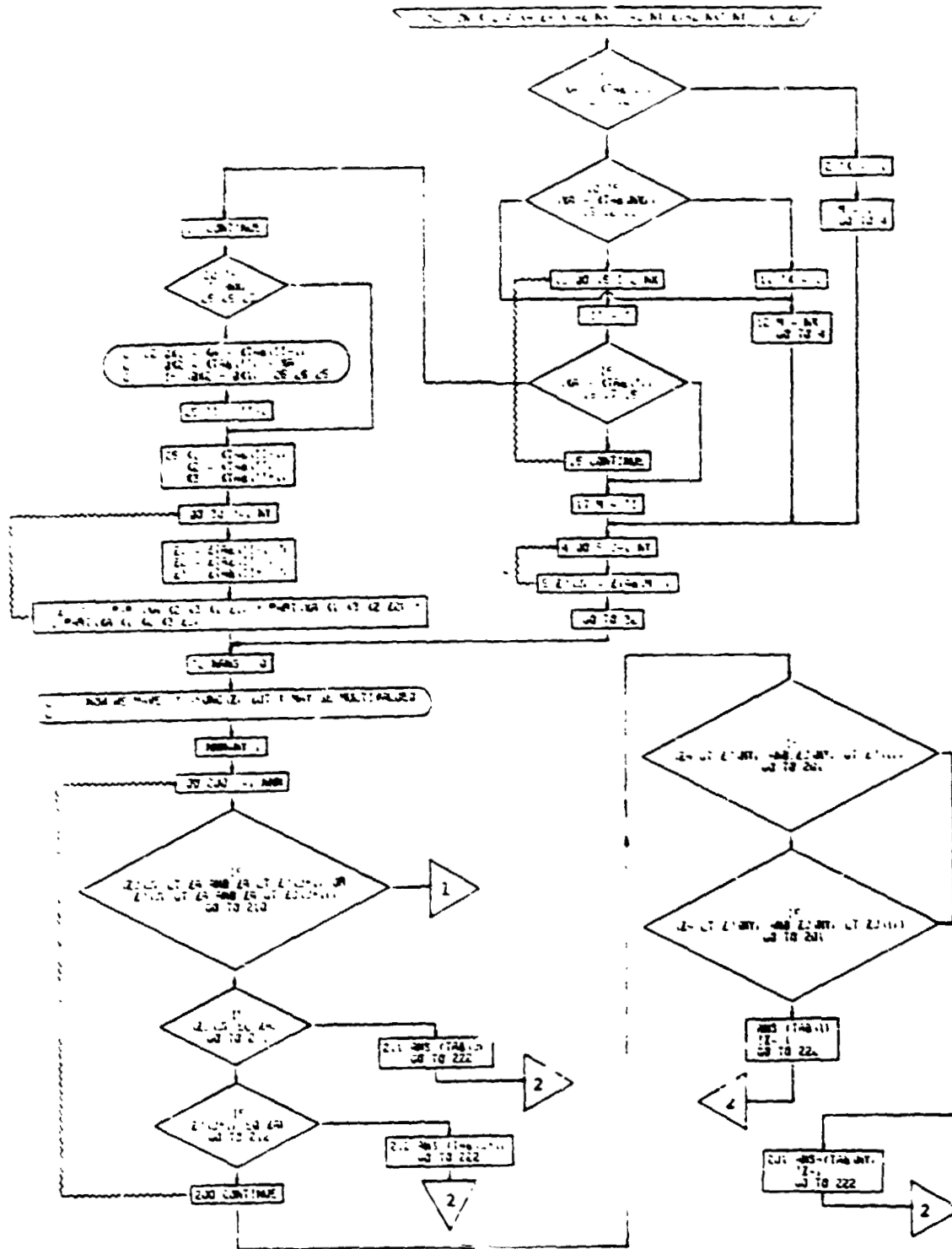


Figure 4-67. XIBIV Function, Flow Chart (Part 1 of 3)

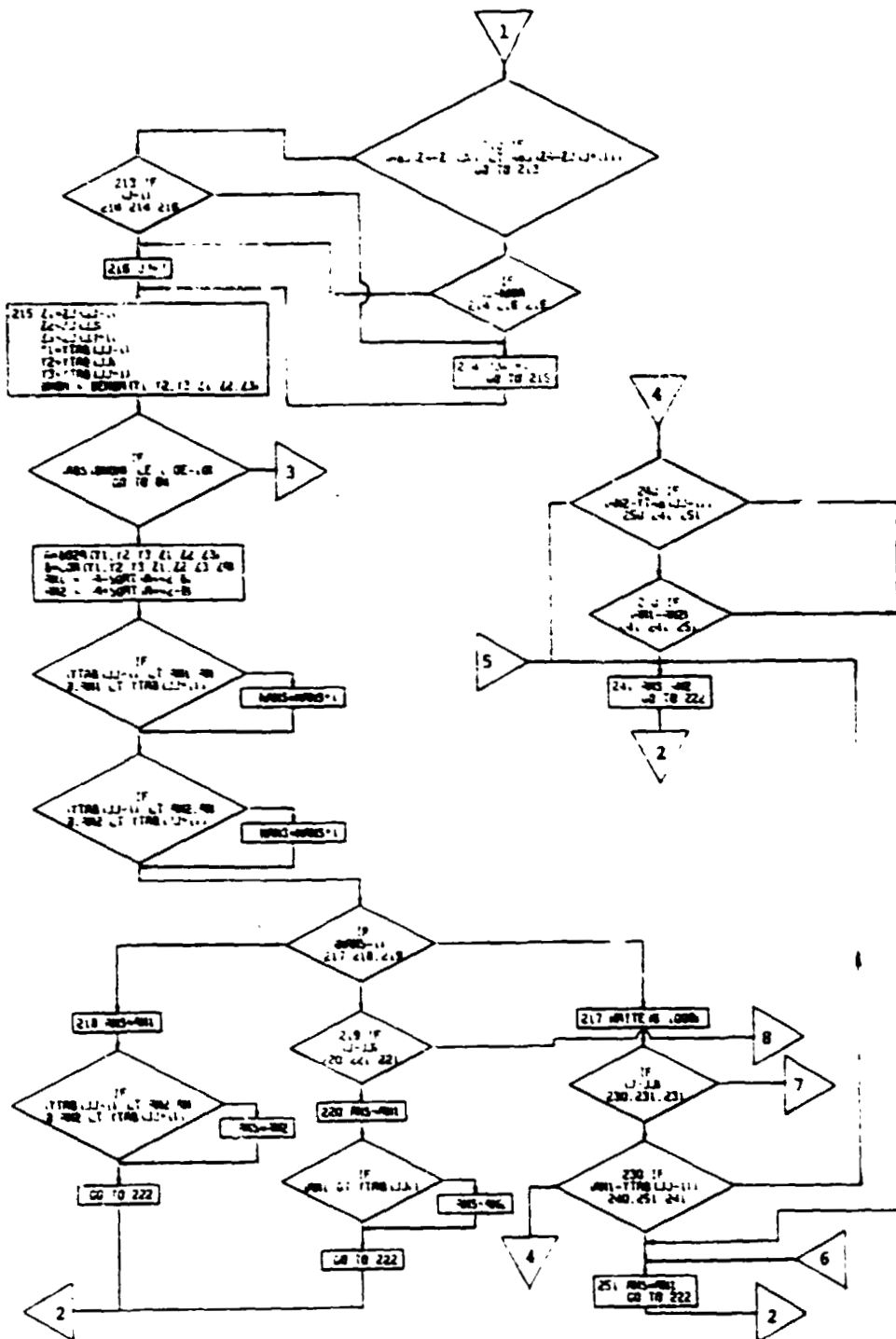


Figure 4-67. XIBIV Function, Flow Chart (Part 2 of 3)

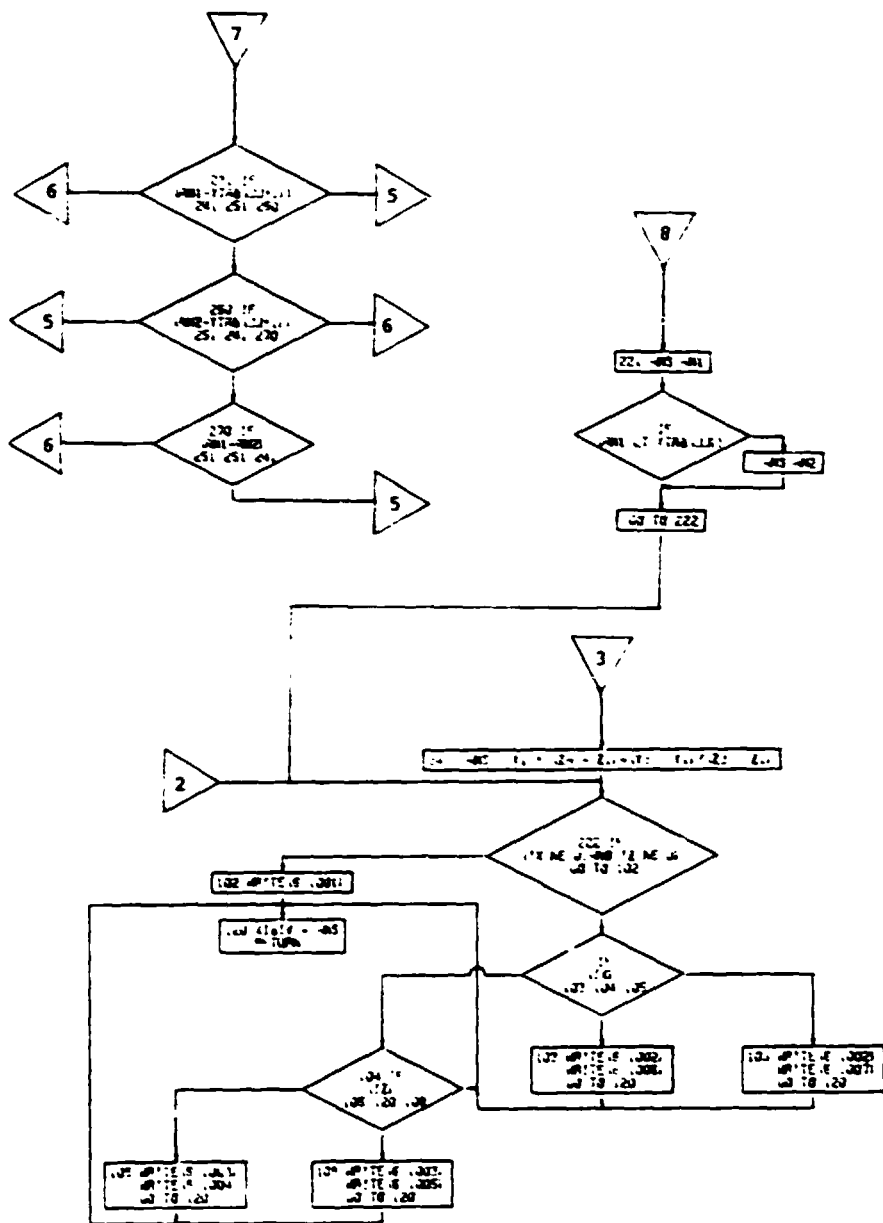


Figure 4-67. XIBIV Function, Flow Chart (Part 3 of 3)

## 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:

1. 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.
2. The input sheets have been color-coded to distinguish between the data required in the sizing options (OPTIND = 0 or 1) and the much smaller amount of data required for performance calculations (OPTIND = 2 or 3).
3. Footnotes on the input sheets call attention to input which is not required due to selection of one of the optional paths or computation.
4. 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.
5. All of the input sheets are generally not required for typical sizing and performance runs. For example, the rotor tip speed schedule, rotor incremental performance and auxiliary propulsion schedule are usually input only once and used in successive cases. In addition, the rotor cycles or maps, engine cycles and propeller performance maps (when required) are generally input and stored in libraries until called.

Altogether there are 43 different input sheets which can be loosely grouped into 10 categories: general information, aircraft descriptive information, mission profile information, rotor tip speed schedule, incremental rotor performance, auxiliary propulsion input schedule, engine cycle information, rotor performance information, propeller performance information, and supplementary input information. A specimen copy of each input sheet is included in this section. Descriptions of input variables, fortran names and program indicators are given in Section 5.3. For completeness, and to aid in trouble shooting, a subroutine cross reference is provided in Section 3.4. This section lists each subroutine and the subroutines it calls. The use of the various input sheets is discussed in subsequent paragraphs.



### 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. This sheet is always used.

### 5.1.2 Aircraft Description Information

5.1.2.1 Dimensional Information - Input characteristic geometric information for aircraft being studied. This includes information for sizing the airframe and the rotor (main and tail rotor if applicable). These sheets are used as appropriate.

5.1.2.2 Propulsion Information - Input data for numbers of primary and auxiliary independent propulsion engines, propellers, propeller cruise efficiencies, etc., and critical engine sizing conditions. There are three different input sheets for propulsion information: one for the primary engines (always used) and two for use with compound and auxiliary propulsion helicopter configurations. Of these two, one sheet is for propeller data and the other for auxiliary independent propulsion engine data.

5.1.2.3 Aerodynamics Information - Aircraft drag can be estimated two different ways. Either a detailed buildup or a trend can be used. For preliminary design, the trend is sufficiently accurate. In the case of a compound and winged helicopter, wing section lift/drag characteristics, two dimensional lift curve slope and Reynolds number/ft should be input. In addition, Kw (Loc 0327) should be input as 1.0.

5.1.2.4 Weights Information - Weights inputs are grouped according to the major aircraft groups. In addition, provisions are included to add incremental weights to each group as well as multiplicative factors which can be used to modify subsystem weights in each major group.

Operating weight empty (input only if OPTIND = 2 or 3), fixed equipment, fixed useful load and payload are input as lump sum numbers. Flight control inputs are broken down into the major groups of cockpit, rotor, system (upper controls), fixed wing SAS, and tilt mechanism controls. Inputs for auxiliary controls are also provided.

The inputs for structural weights include fuselage, landing gear, wings and tails. Crash load factors, nacelle and air induction system factors are also input. Provisions are included which account for concentrated loads on wing structure.

Propulsion group weights are subdivided into main rotor blades and hubs, tail and auxiliary rotors, main and auxiliary powerplant installation weights. Primary and auxiliary engine weights are input as part of the engine cycle data. The weights information sheet is always used when using OPTIND = 0, 1 and 3.0.

When MRPIND (LOC 0019) is set to either 1.0 or 2.0, the program will compute the main rotor position of a single rotor pure or compound helicopter based on a simple mass balance. If this option is used, the non-dimensional positions of the major subsystems must be input. If this option is not used, the main rotor non-dimensional position must be input. For most preliminary design studies, the rotor position is input.

5.1.2.5 Rotor Limits Information - Rotor limits information are always used. Limits are input in the form of rotor lift ( $C_T'/\sigma$ ) as a function of propulsive force ( $C_P/\sigma$ ) and rotor advance ratio  $\mu$ . All tables must be input in ascending order and be 3 x 3 or greater. This table must be consistent with the  $C_T'/\sigma$  values used in rotor sizing.

5.1.2.6 Non Standard Atmosphere Information - HESCOMP currently permits three atmosphere options. Standard atmosphere, standard atmosphere plus a constant change in temperature, and on arbitrary non standard atmosphere. This sheet is only used if a non standard atmosphere is used anywhere in the program.

### 5.1.3 Mission Profile Information

There are eight input sheets for mission profile information. These are not required when OPTIND = 0 (weights only). The sheets are:

1. Taxi Information
2. Takeoff, Hover, and Landing Information
3. Climb Information
4. Cruise Information
5. Descent Information
6. Loiter Information
7. Change of Weight and Transfer Altitude Information (incorporating change of fuel weight, change of payload weight, and transfer altitude)
8. 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 Rotor Tip Speed Schedule

Rotor tip speed or advancing tip Mach number can be input as a function of forward flight Mach number. This option is most useful in simulating rotor speed reduction required for a compound helicopter flying to high speeds. If  $N_{II}/N_{II_{max}}$  is input between 10 and 20, the program assumes the schedule is a mix of advancing tip Mach number and tip speeds. If  $N_{II}/N_{II_{max}}$  is input greater than 20, then the program assumes tip speeds only are input.

If a tip speed schedule is not desired, the tip speed in each segment can be changed by inputting the appropriate value of  $N_{II}/N_{II_{max}}$  in the segment. In this case,  $N_{II}/N_{II_{max}}$  is always input less than 10. This sheet will generally not be required for anything but a high speed helicopter. Additional explanation is found in Section 5.3, Program Input, and in the sample cases.

#### 5.1.5 Auxiliary Propulsion Schedule Input

When studying a propulsively unloaded compound helicopter, the propulsive unloading ratio ( $T_{aux}/T$ ) in segments 2, 3, 4, 5, 6 and 11 can be specified in three ways. If  $T_{aux}/T$  is input  $< 1000$  (typically between 0.0 and approximately 1.2) in the segments noted, the program uses them as input. If the  $T_{aux}/T$  inputs in the noted segments are input equal to 1000, the auxiliary propulsive schedule as a function of advance ratio  $\mu$  is used by the program. If the  $T_{aux}/T$  inputs in segments 2, 3, 4, 5, 6 and 11 are set equal to 2000, the input auxiliary propulsion schedule is used up to the transition advance ratio indicated by location 1692. Above that advance ratio, the  $T_{aux}/T$  corresponding to maximum rotor or configuration  $L/D$  is used. Additional explanation is included in Section 5.3, Program Input, and in the sample cases.

#### 5.1.6 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 three engine cycle sheets are divided into standard performance information and nonstandard performance information. The standard performance data, of which there are

two sheets, 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. It should be noted that auxiliary independent engine input data can be created from the HESCOMP engine cycle library data simply by the input of the applicable engine cycle IBM card deck, preceded and followed by a "66666" card. Nonstandard auxiliary independent engine performance is input using the sheet provided for that purpose. The engine non-dimensionalized weight and dimensions are input on these sheets. Engine cycle data are always required.

#### 5.1.7 Rotor Performance Data

Rotor performance is calculated either by the short form rotor performance method (ROTIND = 1) or using input maps of rotor performance as a function of lift and propulsive force (ROTIND = 2 to 6). The short form rotor performance methodology (ROTIND = 1.0) is a combination of momentum theory and empirically derived factors. The option is used when the performance of a conventional rotor is desired. In addition, the input coefficients can be modified to simulate more advanced rotor cycles.

Alternatively, rotor performance data may be input in "map" form (ROTIND = 2, 3 in the case of Type I "maps" and ROTIND = 4, 5, 6 for Type II "maps") using the ten input sheets (combined total of Types I and II) provided for this purpose. The first sheet is for hover performance data which is input as a table of  $C_P/\sigma$  as a function of  $C_T/\sigma$  and  $M_{TIP}$  in the case of Type I "map" and F.M. as a function of  $C_T/\sigma$  and  $M_{TIP}$  in the case of the Type II "map". The remaining four sheets are for cruise performance data which is input as a table of  $C_P/\sigma$  as a function of  $\mu$ ,  $C_T'/\sigma$ , and  $C_X/\sigma$  for the Type I "map" and  $L/D_E$  as a function of  $\mu$ ,  $C_T'/\sigma$ , and  $X/L$  for the Type II "map". When ROTIND = 5 and 6, rotor performance is optimized for either best rotor or best overall configuration  $L/D_E$ .

#### 5.1.8 Propeller Performance Data

Propeller performance computations are input to the program in three ways. In the first ( $\eta_p$  IND = 0), propeller efficiencies are input as a function of flight Mach number. This is generally the most convenient way of conducting parametric studies. In the second ( $\eta_p$  IND = 1), a complete map of a known propeller is used. Values of propeller power coefficient are input for combinations of propeller advance ratio and thrust coefficient. This option requires that a propeller has been defined and complete performance information is available from some other source.

The third method provided is to allow the program to calculate propeller performance using a short method when propeller geometry is either known or assumed. The user need only specify the number of blades (3 or 4), the activity factor per blade and the integrated lift coefficient,  $C_L$ . The method used is the short method originated at the Curtis-Wright Corporation (Reference 10) and involves the use of a set of equations which are developed from strip theory, and includes the effects of compressibility on performance. This option should be used primarily when a propeller has already been selected and performance is desired.

#### 5.1.9 Supplementary Information

The supplementary input sheet may be used for the second and subsequent cases of a parametric study. For example, in the case of a tandem rotor helicopter, if the user wishes to change both the rotor overlap/diameter ratio (location 0132 - see dimensional information sheet) and the disc loading (location 0173 - see dimensional information sheet), these locations and their new values may be filled in on the supplementary input sheet.

Five typical problems, from input to output, are discussed in Section 7.3 of this manual.

## 5.2 Specimen Input Sheets

**BOEING VERTOL COMPANY**  
A DIVISION OF THE BOEING COMPANY

**HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91**

SHEET NO.	CASE NO.
OF	

### GENERAL INFORMATION

TITLE CARD (72) (DIGITS)	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; border: 1px solid black;">7</td> <td style="width: 10%; border: 1px solid black;">10</td> <td style="width: 10%; border: 1px solid black;">13</td> <td style="width: 10%; border: 1px solid black;">16</td> <td style="width: 10%; border: 1px solid black;">19</td> <td style="width: 10%; border: 1px solid black;">22</td> <td style="width: 10%; border: 1px solid black;">25</td> <td style="width: 10%; border: 1px solid black;">28</td> <td style="width: 10%; border: 1px solid black;">31</td> <td style="width: 10%; border: 1px solid black;">34</td> <td style="width: 10%; border: 1px solid black;">37</td> <td style="width: 10%; border: 1px solid black;">40</td> <td style="width: 10%; border: 1px solid black;">42</td> </tr> <tr> <td style="border: 1px solid black;">43</td> <td style="border: 1px solid black;">46</td> <td style="border: 1px solid black;">49</td> <td style="border: 1px solid black;">52</td> <td style="border: 1px solid black;">55</td> <td style="border: 1px solid black;">58</td> <td style="border: 1px solid black;">61</td> <td style="border: 1px solid black;">64</td> <td style="border: 1px solid black;">67</td> <td style="border: 1px solid black;">70</td> <td style="border: 1px solid black;">73</td> <td style="border: 1px solid black;">76</td> <td style="border: 1px solid black;">78</td> </tr> </table>	7	10	13	16	19	22	25	28	31	34	37	40	42	43	46	49	52	55	58	61	64	67	70	73	76	78
7	10	13	16	19	22	25	28	31	34	37	40	42															
43	46	49	52	55	58	61	64	67	70	73	76	78															

OPTION INDICATOR	VARIABLE	UNIT	LOC.	VALUE
PRINT INDICATOR	OPTIND		0001	
	OPTIONAL PRINT		0002	

AERO-DYNAMICS INDICATORS	VARIABLE	UNIT	LOC.	VALUE
	DRGIND		0003	
	OSWIND		0004	

1ST ORDER SIZE TREND AND PRO-PULSION INDICATORS (ALWAYS INPUT)	VARIABLE	UNIT	LOC.	VALUE
	CNFIND		0005	
	AUXIND		0006	
	RDMIND		0007	
	FIXIND		0008	
	ROTIND		0009	

2ND ORDER SIZE TREND AND PRO-PULSION INDICATORS (OPTIONAL INPUT)	VARIABLE	UNIT	LOC.	VALUE
	S <sub>w</sub> IND	NOTE a	0010	
	b <sub>w</sub> IND	NOTE a	0011	
	AIPIND	NOTE b	0012	
	ENGIND	NOTE c	0013	
	FIXINDI	NOTE d	0014	
	TRDIND	NOTE d	0015	
	TRSIND	NOTE d	0016	
	VTFIND	NOTE d	0017	
	HTIND	NOTE d	0018	
	MRPIND	NOTE d	0019	
	FDMIND	NOTE e	0020	
	APHIND	NOTE e	0021	
	ESCIND	NOTE f	0022	

INITIAL CONDITIONS	VARIABLE	UNIT	LOC.	VALUE
	W <sub>G0</sub>	LBS	0023	
	h <sub>0</sub>	FT	0024	
	R <sub>0</sub>	NM	0025	
	t <sub>0</sub>	HR	0026	

FLIGHT PATH CONTROL INDICATOR	VARIABLE	UNIT	LOC.	VALUE
	hOPTIND		0027	

LIMITING SPEED	VARIABLE	UNIT	LOC.	VALUE
	M <sub>MO</sub>		0028	
	V <sub>MO</sub>	KTS EAS	0029	
	V <sub>DIVE</sub>	KTS EAS	0030	

MANEUVER LOAD FACTOR	VARIABLE	UNIT	LOC.	VALUE
	M <sub>LF</sub>		0031	

RESERVE FUEL FACTORS	VARIABLE	UNIT	LOC.	VALUE
	K <sub>I</sub>		0032	
	δ <sub>wF</sub>	LBS	0033	
	K <sub>FF</sub>		0034	

### MISSION PROFILE INFORMATION

MAXIMUM OF 50 CONSECUTIVE SEGMENTS

#### VALUES OF SGTIND

- |  |   |
|--|---|
| 0 = END OF MISSION<br>1 = TAXI<br>2 = T.O., HOVER, LAND<br>3 = CLIMB<br>4 = CRUISE | 5 = DESCENT<br>6 = LOITER<br>7 = CHANGE FUEL<br>8 = CHANGE PAYLOAD<br>9 = TRANSFER ALTITUDE<br>11 = GENERAL PERFORMANCE |
|--|---|

100 = END OF CASE

LOC.	VALUE	LOC.	VALUE
1st	0035	26th	0060
2nd	0036	27th	0061
3rd	0037	28th	0062
4th	0038	29th	006C
5th	0039	30th	0064
6th	0040	31st	0065
7th	0041	32nd	0066
8th	0042	33rd	0067
9th	0043	34th	0068
10th	0044	35th	0069
11th	0045	36th	0070
12th	0046	37th	0071
13th	0047	38th	0072
14th	0048	39th	0073
15th	0049	40th	0074
16th	0050	41st	0075
17th	0051	42nd	0076
18th	0052	43rd	0077
19th	0053	44th	0078
20th	0054	45th	0079
21st	0055	46th	0080
22nd	0056	47th	0081
23rd	0057	48th	0082
24th	0058	49th	0083
25th	0059	50th	0084

- NOTES: INPUT ONLY IF:
- |                 |               |
|-----------------|---------------|
| a. AUXIND = 2,4 | e. CNFIND = 2 |
| b. AUXIND = 3,4 | f. FIXIND = 1 |
| c. AIPIND = 2   |               |
| d. CNFIND = 1   |               |

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

HELICOPTER DIMENSIONAL INFORMATION

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

† ~ WHEN CNFIND = 1.0  
VTFIND = 1.0 } K<sub>2</sub> = VERTICAL TAIL  
TRDIND = 0.0 } SPAN (b<sub>VT</sub>)

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	S <sub>w</sub>	FT <sup>2</sup>	0101	
b	w/s	PSF	0102	
c	bw/D		0103	
d	AR		0104	
	(t/c) <sub>R</sub>		0105	
	(t/c) <sub>T</sub>		0106	
	ΔC/4	DEG	0107	
	λ		0108	
e	C <sub>F</sub> /C		0109	
	h'/h <sub>F</sub>		0110	
f	C <sub>L<sub>D</sub></sub>		0111	

WING

NOM = 1.0

	AR <sub>HT</sub>		0112	
	l <sub>TH</sub> '		0113	
	(t/c) <sub>HT</sub>		0114	
g	V <sub>H</sub>		0115	
	λ <sub>H</sub>		0116	
h	S <sub>HT</sub>	FT <sup>2</sup>	0117	

HOR. TAIL

i	Y <sub>CL</sub>	FT	0118	
i	ζ <sub>2</sub>		0119	

(IF LOCATED ON WING)

AUX. PROP.

	ΔS <sub>WET</sub> /S <sub>F</sub>		0120	
	ΔS <sub>WET</sub>	FT <sup>2</sup>	0121	

GEN.

NOTE	VARIABLE	UNIT	LOC.	VALUE
	h <sub>F</sub>	FT	0122	
	W <sub>F</sub>	FR	0123	
	(l/d) <sub>P</sub>		0124	
	(l/d) <sub>T</sub>		0125	
	l <sub>C</sub>	FT	0126	
	l <sub>RW</sub>	FR	0127	
j	(X <sub>M</sub> /l <sub>B</sub> )		0128	
k	(l <sub>TB</sub> /d <sub>TB</sub> )		0129	
k	(d <sub>TB</sub> /d <sub>TB</sub> )		0130	
k	k <sub>T</sub> STING		0131	
l	(t <sub>0</sub> /l)/D		0132	
m	(Δx <sub>1</sub> /l <sub>P</sub> )		0133	
m	(Δx <sub>2</sub> /l <sub>T</sub> )		0134	

BODY

VER. TAIL

PRIM. ENG. NAC.

AUX. IND. ENG. NAC.

n	AR <sub>VT</sub>		0135	
	λ <sub>VT</sub>		0136	
	(t/c) <sub>VT</sub>		0137	
p	ζ <sub>VT</sub>		0138	
†	Y <sub>2</sub> OR b <sub>VT</sub>		0139	
q	C <sub>LDES</sub>		0140	
q	V <sub>DES</sub>	KTS TAS	0141	

	γ <sub>1</sub>		0142	
	γ <sub>2</sub>		0143	
	γ <sub>3</sub>		0144	
	(l <sub>AIP</sub> /l <sub>C</sub> )		0145	

r	γ <sub>4</sub>		0146	
r	γ <sub>5</sub>		0147	
r	γ <sub>6</sub>		0148	
r	(l <sub>AIA</sub> /l <sub>OA</sub> )		0149	
r	ΔS/S <sub>STR</sub>		0150	
r	b <sub>NS</sub> /d <sub>NI</sub>		0151	

NOTES: INPUT NOT NECESSARY WHEN:

- |                             |                 |
|-----------------------------|-----------------|
| a. S <sub>w</sub> IND = 2,3 | j. MRPIND = 1,2 |
| b. S <sub>w</sub> IND = 1,3 | k. CNFIND = 2   |
| c. b <sub>w</sub> IND = 2,3 | l. FDMIND = 3   |
| d. b <sub>w</sub> IND = 1,3 | m. FDMIND = 2   |
| e. AUXIND = 1,3             | n. VTFIND = 2   |
| f. S <sub>w</sub> IND = 1,2 | p. VTFIND = 3   |
| g. HTIND = 1                | q. VTFIND = 1   |
| h. HTIND = 2                | r. AIPIND = 2   |
| i. b <sub>w</sub> IND = 1,  |                 |

**ROTOR DIMENSIONAL DATA FOR SIZING MAIN ROTOR(S)**

ROTOR MAP NO.	0170
ROTOR CYCLE NO.	0171

NOTE	VARIABLE	UNIT	LOC.	VALUE
↑	$N_R$		0172	
a	W/A	PSF	0173	
b	$D_{MR}$	FT	0174	
c	$\sigma_{MR}$		0175	
	$D_{MR}$		0176	
	$\theta_{TMR}$	DEG	0177	
	$X_{C_{MR}}$		0178	
	$X_{MR}$		0179	
	$h(c)_{26R}$		0180	
	V TIP REF	FT	0181	

ROTOR CHARACTERISTICS

d	$(C_T/\sigma)_H$		0182
d	T/W		0183

HOVER COND. FOR ROTOR SIZING

	$V_{KT(c)}$	KTS	0184
	$h(c)$	FT	0185
	$\Delta TINC$	°F	0186
1	$(C_T/\sigma)_{CR}$		0187
	$g_{REQM'T}$		0188
	$g$ (ROTOR)		0189
	$N$ (ROTOR LOADING)		0190

CRUISE COND FOR ROTOR AND WING SIZING

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

ROTOR VERTICAL R/C EFFICIENCY FACTORS	$V_{C/H1}$	0191
	$V_{C/H2}$	0192

INCREMENTAL ROTOR FIGURE OF MERIT INPUT	$\Delta T.M.$	0195
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1 IF NO. OF ROTORS = 1, MUST ADD TAIL ROTOR SIZING SHT.

ROTOR CLIMB & DESCENT EFFICIENCIES	$K_P$ CLIMB	0193
	$K_P$ DESCENT	0194

NOTES: INPUT NOT NECESSARY WHEN:  
 a. RDMIND = 1,3  
 b. RDMIND = 2,4  
 c. RDMIND = 3,4  
 d. RDMIND = 1,2



ROTOR DIMENSIONAL DATA FOR SIZING MAIN ROTOR(S)

ROTOR MAP NO.	0170
ROTOR CYCLE NO.	0171

NOTE	VARIABLE	UNIT	LOC.	VALUE
a	N <sub>R</sub>		0172	
b	W/A	PSF	0173	
c	D <sub>MR</sub>	FT	0174	
d	σ <sub>MR</sub>		0175	
e	ρ <sub>MR</sub>		0176	
f	θ <sub>T MR</sub>	DEG	0177	
g	X <sub>C MR</sub>		0178	
h	X <sub>MR</sub>		0179	
i	(1/c).25R		0180	
j	V <sub>TIP REF</sub>	PPS	0181	

ROTOR CHARACTERISTICS

d	(C <sub>T</sub> /σ) <sub>H</sub>		0182
d	T/W		0183

HOVER COND. FOR ROTOR SIZING

	V <sub>KT(c)</sub>	FTS	0184
	h <sub>C(c)</sub>	FT	0185
	ΔTINC	°F	0186
d	(C <sub>T</sub> /σ) <sub>CR</sub>		0187
	η <sub>REOMT</sub>		0188
	g (ROTOR)		0189
	N (ROTOR LOADING)		0190

CRUISE COND. FOR ROTOR AND WING SIZING

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

ROTOR VERTICAL R/C EFFICIENCY FACTORS	V <sub>CRH1</sub>	0181
	V <sub>CRH2</sub>	0182

INCREMENTAL ROTOR FIGURE OF MERIT INPUT	Λ F.M.	0195
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1 IF NO. OF ROTORS = 1, MUST ADD TAIL ROTOR SIZING SHT.

ROTOR CLIMB & DESCENT EFFICIENCIES	K <sub>P</sub> CLIMB	0183
	K <sub>P</sub> DESCENT	0184

NOTES INPUT NOT NECESSARY WHEN  
 a. RDMIND = 1,3  
 b. RDMIND = 2,4  
 c. RDMIND = 3,4  
 d. RDMIND = 1,2

**ROTOR DIMENSIONAL DATA FOR SIZING TAIL ROTOR (CNFIND = 1)**

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

NOTE	VARIABLE	UNIT	LOC	VALUE
a	(T/λ) NET	PSF	0200	
b	$D_{TR}$	FT	0201	
c	$C_{TR}$		0202	
	$b_{TR}$		0203	
	$\theta_{YTR}$	DEG	0204	
	$X_{CTR}$		0205	
	$X_{TR}$		0206	
	$V_{TTR REF}$	PPH	0207	

TAIL ROTOR CHARACTERISTICS

d	$(C_T/C_{TNET})_{DES}$ (H)		0208	
	YAW ACCEL ( $\ddot{\psi}$ )	RAD/SEC <sup>2</sup>	0209	
	YAW RATE ( $\dot{\psi}$ )	RAD/SEC	0210	
e	$(C_T/C_{TNET})$		0211	
e	$\bar{C}$		0212	
d	$K_{ZZZ}$		0213	
f	$\theta_{MR/TR}$	FT	0214	
d	$K_{TRS}$		0215	

TAIL ROTOR SIZING COND.

NOTE	VARIABLE	UNIT	LOC	VALUE
	$C_{LFIN}$		0216	

- NOTES:
- INPUT NOT NECESSARY WHEN TRIND = 1,2
  - INPUT NOT NECESSARY WHEN TRIND = 1,3
  - INPUT NOT NECESSARY WHEN TRIND = 2
  - INPUT NOT NECESSARY WHEN TRIND = 1
  - IF OPTIND = 1,  $(C_T/C_{TNET})$  MAY BE INPUT AS 1.00, AND A VALUE OF  $\bar{C}$  INPUT, PROGRAM WILL THEN CALCULATE A VALUE OF  $(C_T/C_{TNET})$ . IF VALUE OF  $(C_T/C_{TNET}) > 1.0$  INPUT, IT IS NOT NECESSARY TO INPUT  $\bar{C}$ .

- IF CNFIND = 1.0 AND TRIND = 0,  $\theta_{MR/TR}$  IS THE GAP FROM THE MAIN ROTOR TIP TO THE END OF THE FUSELAGE.

g	$D_{TR}/B_{PAN}$		0202	NOM. = 1.0
h	$FANOP_H$		0203	NOM. = 0.0
i	$FANOP_C$		0204	NOM. = 0.0

NOM. = 1.0

- NOTES:
- INPUT USED TO SIMULATE "FENESTRON" SHROUDED TAIL ROTOR.
  - IF  $FANOP_H$  INPUT AS 1.0, TAIL ROTOR/FAN SHUT DOWN IN HOVER.
  - IF  $FANOP_C$  INPUT AS 1.00, TAIL ROTOR/FAN SHUT DOWN IN CRUISE.

HELICOPTER PROPULSION INFORMATION REQUIRED FOR PRIMARY ENGINE SIZING

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

NOTE	PRIMARY ENGINE CYCLE NO.	UNIT	LOC	VALUE
	0217			

NOTE	VARIABLE	UNIT	LOC	VALUE
<b>b</b>	SHP*P	HP	0218	

PRIMARY ENGINE DATA

NOTE	VARIABLE	UNIT	LOC	VALUE
	$N_p$		0219	

MAIN XMSN & ACC DATA

NOTE	VARIABLE	UNIT	LOC	VALUE
	XMSNIND		0220	
	SHP <sub>MIX</sub> /SHP* MH		0221	
<b>b</b>	KALT PAYL		0222	
	$\eta_T$		0223	
	$\Delta$ SHP ACC	HP	0224	

T. ROTOR & AUX DRIVE SYS XMSN DATA

NOTE	VARIABLE	UNIT	LOC	VALUE
	SHP <sub>TIX</sub> /TRP*		0225	
	SHP <sub>AUX</sub> /SHP* AUX		0226	

- NOTES: a. INPUT NOT NECESSARY WHEN FIXIND = 1  
b. INPUT NOT NECESSARY WHEN XMSNIND = 1, 2  
c. INPUT NOT NECESSARY WHEN AUXIND = 1, 2  
d. INPUT NOT NECESSARY WHEN AUXIND = 1, 3

NOTE	VARIABLE	UNIT	LOC	VALUE
	$h_{TOHD}$	FT	0227	
	(T/W) <sup>0</sup>		0228	
	$\Delta T_{IN TO HD}$	°F	0229	
	$\left( \frac{N_{HLL}}{N_{HMAX}} \right)$ TO $N_{p, D}$		0230	
	SHP <sub>p</sub> SHP*		0231	
	(V <sub>H/C</sub> ) <sup>0</sup> D	FPM	0232	
			0233	

T/O LOAD FOR ENG SIZING

MAIN XMSN & ACC DATA

NOTE	VARIABLE	UNIT	LOC	VALUE
	POWIND		0234	
	$\eta_C$	FT	0235	
	V <sub>C</sub>	KTS TAS	0236	
	$\Delta T_{INCE}$	°F	0237	
	$\left( \frac{N_{HLL}}{N_{HMAX}} \right) C$		0238	
<b>c</b>	$\left( T_{AUX} / T_{TOT C} \right)$		0239	
<b>d</b>	$C_{LDP}$		0240	
	$\left( N_{PSD} \right) C$		0241	

CRUISE COND FOR PRIMARY ENGINE & AUXILIARY ENGINE SIZING

HELICOPTER PROPULSION INFORMATION REQUIRED FOR SEPARATE AUXILIARY CRUISE ENGINE SIZING (AIPIND = 2)

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

AUX PROPULSION ENGINE CYCLE NO.	0242
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NOTE	VARIABLE	UNIT	LOC	VALUE
1	SHP <sup>1</sup>	HP	0243	
2	FN <sup>2</sup>	LBS	0244	
	N <sub>p</sub>		0245	

AUX  
PROPULSION  
ENGINE  
DATA

CRUISE  
CONDITIONS  
FOR AUX.  
PROPULSION  
ENGINE  
SIZING

	POWIND		0246	
	(N <sub>1</sub> /N <sub>1</sub> ) <sub>MAX</sub> <sup>1</sup>		0247	

0 : MAX POWER  
1 : MIL POWER  
2 : NORMAL POWER

NOTES: 1. INPUT NOT NECESSARY WHEN FIXINDI = 1.

PROPELLER DATA REQUIRED FOR COMPOUND HELICOPTER AUXILIARY PROPULSION (T/SHAFT ENGINES)

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

$\eta_{p4}$  CRUISE & LOITER

NO. OF PAIRS IN $\eta_{p4}$ TABLE	0281
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VALUES OF EFFICIENCY

NOTE	VARIABLE	UNIT	LOC	VALUE
CLIMB	$\eta_{p3}$		0284	
DESCENT	$\eta_{p5}$		0286	

NOTE	VARIABLE	UNIT	LOC	VALUE
	NO. OF PROPS		0248	
	VTAR	FPS	0249	
	DIA	FT	0250	
	XAR		0251	
	$\eta_{T}$ AUX		0252	

$\eta_{p}$  IND = 0

NOTE	VARIABLE	UNIT	LOC	VALUE
	AF/BLADE		0257	
	NO. OF BLADES		0269	

0 - INPUT  $\eta_{p}$ 'S

1 - INPUT PROP TABLE

2 - PROG CALC PROP PERR.

$\eta_{p}$ IND	0253
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$\eta_{p6}$	0288
PROP TABLE NO.	0280

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

AF/BLADE	0267
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$\eta_{p}$  IND = 2

NO. OF BLADES	0286
$C_{L1}$	0289
$\eta_{p8}$	0285

LOC	VALUE	LOC	VALUE
0282		0272	
0283		0273	
0284		0274	
0285		0275	
0286		0276	
0287		0277	
0288		0278	
0289		0279	
0290		0280	
0291		0281	

V A L U E S OF  $\eta_{p4}$

V A L U E S OF M

HELICOPTER AERODYNAMICS INFORMATION

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

NOTE	VARIABLE	LOC.	VALUE
a	$C_{DVTI}$	0301	
a	$C_{DHTI}$	0302	
b	$C_{DAP}$	0303	
	$C_{DFP}$	0304	
	$C_{DCSMR}$	0305	
	$C_{DSHMR}$	0306	
a	$C_{DCSTR}$	0307	
a	$C_{DSHTR}$	0308	
	$C_{DN}$	0309	
	$C_{DNI}$	0310	
	$C_{DNS}$	0311	
c	$(G_w F_e)$	0312	
c	$K_{FED}$	0313	
d	e	0314	
a	TFEF	0315	
e	$\Delta Fe FT^2$	0316	

NOTE	VARIABLE	LOC.	VALUE
a	$K_{VT}$	0317	
a	$K_{HT}$	0318	
b	$K_{AP}$	0319	
	$K_{FP}$	0320	
	$K_{HPIM}$	0321	
a	$K_{HPIT}$	0322	
	$K_N$	0323	
	$K_{NI}$	0324	
	$K_{NS}$	0325	
	$K_F$	0326	
	$K_W$	0327	

f	$(Re/l)_i$	0328	
---	------------	------	--

f	$CL_{\alpha}^{RAD^{-1}}$	0329	
---	--------------------------	------	--

WING PROFILE DRAG AS FUNCTION OF  $C_L$

NO. OF PAIRS IN TABLE	0330	
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NOTE:  $C_{LW}$ ,  $C_{Dwi}$  INPUT NOT NECESSARY WHEN AUXIND = 1,3

$C_{LW(1)}$	0331	
$C_{LW(2)}$	0332	
$C_{LW(3)}$	0333	
$C_{LW(4)}$	0334	
$C_{LW(5)}$	0335	
$C_{LW(6)}$	0336	
$C_{LW(7)}$	0337	
$C_{LW(8)}$	0338	

$C_{Dwi(1)}$	0339	
$C_{Dwi(2)}$	0340	
$C_{Dwi(3)}$	0341	
$C_{Dwi(4)}$	0342	
$C_{Dwi(5)}$	0343	
$C_{Dwi(6)}$	0344	
$C_{Dwi(7)}$	0345	
$C_{Dwi(8)}$	0346	

NOTES: a. INPUT NOT NECESSARY WHEN CNFIND = 2  
 b. INPUT NOT NECESSARY WHEN CNFIND = 1  
 c. INPUT NOT NECESSARY WHEN DRGIND = 1  
 d. INPUT NOT NECESSARY WHEN OSWIND = 1  
 e. IF OPTIND = 2,3,  $F_e$  IS INPUT AS TOTAL DRAG  
 f. INPUT NOT NECESSARY WHEN AUXIND = 1,3  
 g. IF DRGIND = 1, ALL LOCATIONS MUST BE INPUT

HELICOPTER WEIGHT INFORMATION

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

VARIABLE	LOC.	VALUE
* OWE	2601	
W <sub>FE</sub>	2602	
W <sub>FUL</sub>	2603	
# W <sub>PL</sub>	2604	

INCREMENTAL GROUP WTS. NOM = 0

VARIABLE	LOC.	VALUE
ΔW <sub>FC</sub>	2605	
ΔW <sub>P</sub>	2606	
ΔW <sub>ST</sub>	2607	

VARIABLE	LOC.	VALUE
RM <sub>I</sub>	2608	
W <sub>I</sub>	2609	
W <sub>O</sub>	2610	
d <sub>I</sub>	2611	
d <sub>O</sub>	2612	

GROUP WEIGHT INFORMATION

FLIGHT CONTROLS

k <sub>CC</sub>	2613	
k <sub>RC</sub>	2614	
k <sub>SC</sub>	2615	
k <sub>FW</sub>	2616	
k <sub>TM</sub>	2617	
k <sub>SAS</sub>	2618	
k <sub>RCA</sub>	2619	
k <sub>SCA</sub>	2620	
k <sub>MC</sub>	2621	

STRUCTURAL

k <sub>B</sub>	2622	
ΔC.G.	2623	
k <sub>LG</sub>	2624	
k <sub>NG</sub>	2625	
k <sub>WW</sub>	2626	
LF	2627	
k <sub>WS</sub>	2628	
k <sub>WP</sub>	2629	
k <sub>HT</sub>	2630	
k <sub>CLF</sub>	2631	
k <sub>NAC</sub>	2632	
k <sub>AIP</sub>	2633	
k <sub>NACA</sub>	2634	
k <sub>AFA</sub>	2635	
k <sub>NS</sub>	2636	

PROPULSION

k <sub>PRB</sub>	2637	
k <sub>RBF</sub>	2638	
k <sub>PH</sub>	2639	
k <sub>amd</sub>	2640	
k <sub>BLFD</sub>	2641	
k <sub>TR</sub>	2642	
k <sub>AR</sub>	2643	
k <sub>PA</sub>	2644	
k <sub>VTAR</sub>	2645	
k <sub>PDS</sub>	2646	
k <sub>PDSZ</sub>	2647	
k <sub>TRDS</sub>	2648	
k <sub>ADS</sub>	2649	
k <sub>ADSZ</sub>	2650	
k <sub>FS</sub>	2651	
k <sub>PEI</sub>	2652	
k <sub>AEI</sub>	2653	

\* 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>1</sub>	2654	
K <sub>2</sub>	2655	
K <sub>3</sub>	2656	
K <sub>4</sub>	2657	
K <sub>5</sub>	2658	

K <sub>6</sub>	2659	
K <sub>7</sub>	2660	
K <sub>8</sub>	2661	
K <sub>9</sub>	2662	
K <sub>10</sub>	2663	
K <sub>11</sub>	2664	

K <sub>12</sub>	2665	
K <sub>13</sub>	2666	
K <sub>14</sub>	2667	
K <sub>15</sub>	2668	
K <sub>16</sub>	2669	
K <sub>17</sub>	2670	
K <sub>18</sub>	2671	
K <sub>19</sub>	2672	
K <sub>20</sub>	2673	

WEIGHT-BALANCE INFORMATION (REQUIRED ONLY WHEN MRPIND = 0)

NOTE	VARIABLE	LOC.	VALUE
	(X <sub>CGF</sub> ) <sub>B</sub>	2678	
	CC <sub>R</sub>	2679	
	(X <sub>NG</sub> ) <sub>B</sub>	2680	
	(X <sub>MG</sub> ) <sub>B</sub>	2681	
	(X <sub>PE</sub> ) <sub>B</sub>	2682	
	(X <sub>PDS</sub> ) <sub>B</sub>	2683	
	(X <sub>AV</sub> ) <sub>B</sub>	2684	

NOTE	VARIABLE	LOC.	VALUE
	(X <sub>FURN</sub> ) <sub>B</sub>	2685	
	(X <sub>APU</sub> ) <sub>B</sub>	2686	
b.	(X <sub>AE</sub> ) <sub>B</sub>	2687	
c.	(X <sub>ADS</sub> ) <sub>B</sub>	2688	
a.	(X <sub>AR</sub> ) <sub>B</sub>	2689	
	(X <sub>SC</sub> ) <sub>B</sub>	2690	
	(X <sub>ASC</sub> ) <sub>B</sub>	2691	

NOTE	VARIABLE	LOC.	VALUE
	W <sub>AV</sub>	2692	
	W <sub>FURN</sub>	2693	
	W <sub>APU</sub>	2694	
	K <sub>FULS</sub>	2695	
	K <sub>TBBS</sub>	2696	

NOTES: WHEN MRPIND EQUALS

1.0 ~ PROGRAM CALCULATES MAIN ROTOR POSITIONS  
BASED ON SIMPLE MASS BALANCE

2.0 ~ SAME AS 1, EXCEPT FOR COMPOUND HELICOPTER,  
THE AUX DRIVE SYSTEM, PROPELLER AND AUX  
INDEPENDENT ENGINES ARE ASSUMED TO BE  
LOCATED ON THE WING.

- a) INPUT ONLY IF AUXIND > 2.0
- b) INPUT ONLY IF AUXIND > 2, AIPIND = 2
- c) INPUT ONLY IF AUXIND > 2, AIPIND = 1



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

ROTOR LIMITS INFORMATION

NUMBER OF $C_X/\sigma$	LOC	VALUE
	0347	
NUMBER OF $\mu$	0348	

VALUES OF $C_X/\sigma$	
$(C_X/\sigma)_1$	0349
$(C_X/\sigma)_2$	0350
$(C_X/\sigma)_3$	0351
$(C_X/\sigma)_4$	0352
$(C_X/\sigma)_5$	0353

VALUES OF $\mu$	
$\mu_1$	0354
$\mu_2$	0355
$\mu_3$	0356
$\mu_4$	0357
$\mu_5$	0358
$\mu_6$	0359
$\mu_7$	0360

NOTE: ALL TABLES MUST BE AT LEAST 3 X 3 OR GREATER  
INPUT  $C_X/\sigma$  AND  $\mu$  IN ASCENDING ORDER

VALUES OF  $C_T/\sigma$

	$(C_X/\sigma)_1$		$(C_X/\sigma)_2$		$(C_X/\sigma)_3$		$(C_X/\sigma)_4$		$(C_X/\sigma)_5$	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
$\mu_1 =$	0361		0368		0375		0382		0389	
$\mu_2 =$	0362		0369		0376		0383		0390	
$\mu_3 =$	0363		0370		0377		0384		0391	
$\mu_4 =$	0364		0371		0378		0385		0392	
$\mu_5 =$	0365		0372		0379		0386		0393	
$\mu_6 =$	0366		0373		0380		0387		0394	
$\mu_7 =$	0367		0374		0381		0388		0395	

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HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91

SHEET NO 01	CAT. NO.
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NOTE: WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE  
ITEMS IN THE SHADED BLOCKS.

NONSTANDARD ATMOSPHERE INFORMATION

NO OF PAIRS	1650
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NOTE: THIS TABLE IS NOT  
NECESSARY IF ATMIND  
IS NEVER SET TO 2

$h_1$	1651	
$h_2$	1652	
$h_3$	1653	
$h_4$	1654	
$h_5$	1655	
$h_6$	1656	
$h_7$	1657	
$h_8$	1658	
$h_9$	1659	
$h_{10}$	1660	

$\theta_1$	1661	
$\theta_2$	1662	
$\theta_3$	1663	
$\theta_4$	1664	
$\theta_5$	1665	
$\theta_6$	1666	
$\theta_7$	1667	
$\theta_8$	1668	
$\theta_9$	1669	
$\theta_{10}$	1670	

TAXI INFORMATION

	ATMIND		SGTIND = i $\Delta T_{IN}^{(0)}$ (NOTE a)		$(N_{II}/N_{II MAX})$ (PRIM ENG)	
	LOC	VALUE	LOC	VALUE	LOC	VALUE
1 <sup>st</sup>	0401		0421		0441	
2 <sup>nd</sup>	0402		0422		0442	
3 <sup>rd</sup>	0403		0423		0443	
4 <sup>th</sup>	0404		0424		0444	
5 <sup>th</sup>	0405		0425		0445	
6 <sup>th</sup>	0406		0426		0446	
7 <sup>th</sup>	0407		0427		0447	
8 <sup>th</sup>	0408		0428		0448	
9 <sup>th</sup>	0409		0429		0449	
10 <sup>th</sup>	0410		0430		0450	

1. STD ATMOSPHERE  
2. STD  $\Delta T_{IN}$   
3. ARBITRARY (in)

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

	$K_{FI}$		$K_{FI}$ (NOTE b)	
	LOC	VALUE	LOC	VALUE
1 <sup>st</sup>	0411		0431	
2 <sup>nd</sup>	0412		0432	
3 <sup>rd</sup>	0413		0433	
4 <sup>th</sup>	0414		0434	
5 <sup>th</sup>	0415		0435	
6 <sup>th</sup>	0416		0436	
7 <sup>th</sup>	0417		0437	
8 <sup>th</sup>	0418		0438	
9 <sup>th</sup>	0419		0439	
10 <sup>th</sup>	0420		0440	

NOTE: a. INPUT NOT NECESSARY WHEN ATMIND = 0, 2  
b. INPUT NOT NECESSARY WHEN AIPIND = 1.

TAKEOFF, HEIGHT, AND LANDING INFORMATION (SGTIND = 2)

TOLIND	LOC	VALUE
1 <sup>st</sup>	0461	
2 <sup>nd</sup>	0462	
3 <sup>rd</sup>	0463	
4 <sup>th</sup>	0464	
5 <sup>th</sup>	0465	
6 <sup>th</sup>	0466	
7 <sup>th</sup>	0467	
8 <sup>th</sup>	0468	
9 <sup>th</sup>	0469	
10 <sup>th</sup>	0470	

- 1 - INPUT T/W, V<sub>R/C</sub>
- 2 - INPUT PEHF, V<sub>R/C</sub>
- 3 - INPUT T/W, V<sub>R/C</sub>, h<sub>BF/D</sub>
- 4 - INPUT PEHF, V<sub>R/C</sub>, h<sub>BF/D</sub>

ATMIND	LOC	VALUE
	0481	
	0482	
	0483	
	0484	
	0485	
	0486	
	0487	
	0488	
	0489	
	0490	

- 0 - STANDARD ATMOSPHERE
- 1 - STD + ΔT<sub>IN</sub>
- 2 - ARBITRARY θ (in)

ΔT <sub>IN</sub> (°F)	LOC	VALUE
(NOTE a)	0501	
	0502	
	0503	
	0504	
	0505	
	0506	
	0507	
	0508	
	0509	
	0510	

T/W	LOC	VALUE
(NOTE b)	0521	
	0522	
	0523	
	0524	
	0525	
	0526	
	0527	
	0528	
	0529	
	0530	

(N <sub>11</sub> /N <sub>11</sub> ) <sub>MAX</sub>	LOC	VALUE
(PRIMARY ENG)	0541	
	0542	
	0543	
	0544	
	0545	
	0546	
	0547	
	0548	
	0549	
	0550	

h <sub>BF/D</sub> (NOTE c)	LOC	VALUE
	0471	
	0472	
	0473	
	0474	
	0475	
	0476	
	0477	
	0478	
	0479	
	0480	

PEHF	LOC	VALUE
(NOTE d)	0491	
	0492	
	0493	
	0494	
	0495	
	0496	
	0497	
	0498	
	0499	
	0500	

- a. INPUT NOT NECESSARY WHEN ATMIND = 0, 2
- b. INPUT NOT NECESSARY WHEN TOLIND = 2, 4

V <sub>R/C</sub> (FPM)	LOC	VALUE
	0511	
	0512	
	0513	
	0514	
	0515	
	0516	
	0517	
	0518	
	0519	
	0520	

Δt <sub>H</sub> (HR)	LOC	VALUE
	0531	
	0532	
	0533	
	0534	
	0535	
	0536	
	0537	
	0538	
	0539	
	0540	

t <sub>H</sub> (HR)	LOC	VALUE
	0551	
	0552	
	0553	
	0554	
	0555	
	0556	
	0557	
	0558	
	0559	
	0560	

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

SHEET NO.	CASE NO.
OF	

**CLIMB INFORMATION (SGTIND = 3)**

	CLMIND	ATMIND	$\Delta T_{in}$ (°F) (NOTE a)	POWIND	$N_{11}/N_{11}$ MAX (PRIMARY ENG)	$N_{11}/N_{11}$ MAX (AUX ENG)	$T_{AUX}/T_{TOT}$ (NOTE b)
	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE
1 <sup>st</sup>	0671	0681	0611	0631	0651	0671	0691
2 <sup>nd</sup>	0672	0652	0612	0632	0652	0672	0692
3 <sup>rd</sup>	0673	0683	0613	0633	0653	0673	0693
4 <sup>th</sup>	0674	0694	0614	0634	0654	0674	0694
5 <sup>th</sup>	0675	0695	0615	0635	0655	0675	0695
6 <sup>th</sup>	0676	0696	0616	0636	0656	0676	0696
7 <sup>th</sup>	0677	0697	0617	0637	0657	0677	0697
8 <sup>th</sup>	0678	0698	0618	0638	0658	0678	0698
9 <sup>th</sup>	0679	0699	0619	0639	0659	0679	0699
10 <sup>th</sup>	0680	0601	0620	0640	0660	0680	0700

0 = STANDARD ATMOSPHERE  
1 = STD +  $\Delta T_{in}$   
2 = ARBITRARY  $\theta$  (h)

0 = MAX POWER  
1 = MIL POWER  
2 = NORMAL POWER

MACH OR  
EAS OR TAS  
(NOTE c)

$C_{LWING}$   
(NOTE d)

	VALUE	LOC VALUE	$\Delta h$ (FT)	$h_{MAX}$ (FT)	$\Delta F_{eCL}$ (FT <sup>2</sup> )	$N_{PSD_{CL}}$	$N_{PSD_{CL}}$ (NOTE e)
	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE	LOC VALUE
1 <sup>st</sup>	0681	0601	0621	0641	0661	0681	0701
2 <sup>nd</sup>	0682	0602	0622	0642	0662	0682	0702
3 <sup>rd</sup>	0683	0603	0623	0643	0663	0683	0703
4 <sup>th</sup>	0684	0604	0624	0644	0664	0684	0704
5 <sup>th</sup>	0685	0605	0625	0645	0665	0685	0705
6 <sup>th</sup>	0686	0606	0626	0646	0666	0686	0706
7 <sup>th</sup>	0687	0607	0627	0647	0667	0687	0707
8 <sup>th</sup>	0688	0608	0628	0648	0668	0688	0708
9 <sup>th</sup>	0689	0609	0629	0649	0669	0689	0709
10 <sup>th</sup>	0690	0610	0630	0650	0670	0690	0710

NOTES: a. INPUT NOT NECESSARY WHEN CLMIND = 0, 1, 2  
b. INPUT NOT NECESSARY WHEN ATMIND = 0, 1, 2  
c. INPUT NOT NECESSARY WHEN CLMIND = 1  
d. INPUT NOT NECESSARY WHEN AUXIND = 1, 3  
e. INPUT NOT REQUIRED WHEN AIRIND = 1.

REMARKS: ...

HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91

SHEET NO.	CASE NO.
OF	

CRUISE INFORMATION (SGTIND = 4)

	CRSIND	ATMIND	$\Delta T_{IN}$ (°F) (NOTE a)	POWIND (NOTE b)	$N_{11}/N_{11}$ MAX (PRIMARY ENG)	$N_{11}/N_{11}$ MAX (AUX. ENG) (NOTE c)	$T_{AUX}/T_{TOT}$ (NOTE c)	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
1 <sup>st</sup>	0721		0781		0801	0821	0841	
2 <sup>nd</sup>	0722		0782		0802	0822	0842	
3 <sup>rd</sup>	0723		0783		0803	0823	0843	
4 <sup>th</sup>	0724		0784		0804	0824	0844	
5 <sup>th</sup>	0725		0785		0805	0825	0845	
6 <sup>th</sup>	0726		0786		0806	0826	0846	
7 <sup>th</sup>	0727		0787		0807	0827	0847	
8 <sup>th</sup>	0728		0788		0808	0828	0848	
9 <sup>th</sup>	0729		0789		0809	0829	0849	
10 <sup>th</sup>	0730		0790		0810	0830	0850	

- 1 - SPECIFIED POWER  
2 - CONSTANT TAS  
3 - BEST NMPP  
4 - 99% BEST NMPP  
5 - BEST NMPP  
6 - 99% BEST NMPP, CONST. W/O CONST W/O

- 0 - MAX POWER  
1 - MIL POWER  
2 - NORMAL POWER

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

	$V_{IN}$ OR HEADWIND (K.T.S) (NOTE d)	$C_{LWING}$ (NOTE e)	$\Delta R$ (NM)	$R_{MAX}$ (NM)	$\Delta \theta_{GR}$ (FT <sup>2</sup> )	$N_{3DGR}$	$N_{PSD}$ (NOTE f)	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
1 <sup>st</sup>	0731		0771		0811	0831	0851	
2 <sup>nd</sup>	0732		0772		0812	0832	0852	
3 <sup>rd</sup>	0733		0773		0813	0833	0853	
4 <sup>th</sup>	0734		0774		0814	0834	0854	
5 <sup>th</sup>	0735		0775		0815	0835	0855	
6 <sup>th</sup>	0736		0776		0816	0836	0856	
7 <sup>th</sup>	0737		0777		0817	0837	0857	
8 <sup>th</sup>	0738		0778		0818	0838	0858	
9 <sup>th</sup>	0739		0779		0819	0839	0859	
10 <sup>th</sup>	0740		0780		0820	0840	0860	

- 0 - STANDARD ATMOSPHERE  
1 - STD +  $\Delta T_{IN}$   
2 - ARBITRARY  $\theta$  (h)

- d. NOT REQUIRED WHEN CRSIND = 1  
INPUT  $V_{IN}$  WHEN CRSIND = 2

- e. INPUT NOT NECESSARY WHEN AUXIND = 1, 3  
f. INPUT NOT NECESSARY WHEN AIPIND = 1

HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91

SHEET NO.	CASE NO.
OF	

DESCENT INFORMATION (SGTIND = 5)

	DESIND	HMAXIND	ATMIND	$\Delta T$ IN (°F) (NOTE a)	R/D (FPM)	$N_{11}/N_{11} \text{ MAX}$ (PRIMARY FNG)	$N_{11}/N_{11} \text{ MAX}$ (AUX ENGI)(NOTE d)	$T_{\text{AUX}}/T_{\text{TOT}}$ (NOTE b)
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
1 <sup>ST</sup>	0871		0811	080	0851	0871	0891	1011
2 <sup>ND</sup>	0872		0812	0832	0852	0872	0892	1012
3 <sup>RD</sup>	0873		0813	0833	0853	0873	0893	1013
4 <sup>TH</sup>	0874		0814	0834	0854	0874	0894	1014
5 <sup>TH</sup>	0875		0815	0835	0855	0875	0895	1015
6 <sup>TH</sup>	0876		0816	0836	0856	0876	0896	1016
7 <sup>TH</sup>	0877		0817	0837	0857	0877	0897	1017
8 <sup>TH</sup>	0878		0818	0838	0858	0878	0898	1018
9 <sup>TH</sup>	0879		0819	0839	0859	0879	0899	1019
10 <sup>TH</sup>	0880		0820	0840	0860	0880	1000	1020

1 - CONSTANT TAS  
2 - CONSTANT EAS  
3 - CONSTANT MACH NO.  
0 - TERMINAL RANGE SPECIFIED  
1 - TERM. RANGE CHKD, BUT NOT MATCHED  
2 - DESCENT TO SPECIFIED MIN ALT.  
3 - SPIRAL DESCENT PATH

	MACH OR EAS OR TAS (KTS)	$C_{LW}$ (NOTE c)	$h_{\text{MIN}}$ (FT)	$R_{\text{MAX}}$ (NM)	$\Delta F_{\text{DSC}}$ (FT <sup>2</sup> )	$N_{\text{PSD}}$ (DSC)	$N_{\text{PSD}}$ (NOTE d)	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
1 <sup>ST</sup>	0881		0821	0851	0861	1001		
2 <sup>ND</sup>	0882		0822	0852	0862	1002		
3 <sup>RD</sup>	0883		0823	0853	0863	1003		
4 <sup>TH</sup>	0884		0824	0854	0864	1004		
5 <sup>TH</sup>	0885		0825	0855	0865	1005		
6 <sup>TH</sup>	0886		0826	0856	0866	1006		
7 <sup>TH</sup>	0887		0827	0857	0867	1007		
8 <sup>TH</sup>	0888		0828	0858	0868	1008		
9 <sup>TH</sup>	0889		0829	0859	0869	1009		
10 <sup>TH</sup>	0890		0830	0860	0870	1010		

NOTES  
a - INPUT NOT NECESSARY WHEN ATMIND = 0, 2  
b - INPUT NOT NECESSARY WHEN AUXIND = 1, 2  
c - T - TNEC - ARY WHEN AUXIND = 1, 3

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

SHEET NO.	CASE NO.
OF	

LOITER INFORMATION (SGTIND = 6)

ATMIND	LOC	VALUE
1 <sup>st</sup>	1031	
2 <sup>nd</sup>	1032	
3 <sup>rd</sup>	1033	
4 <sup>th</sup>	1034	
5 <sup>th</sup>	1035	
6 <sup>th</sup>	1036	
7 <sup>th</sup>	1037	
8 <sup>th</sup>	1038	
9 <sup>th</sup>	1039	
10 <sup>th</sup>	1040	

0 - STANDARD ATMOSPHERE

1 - STD +  $\Delta T$  IN

2 - ARBITRARY  $\beta$  (h)

$C_{LW}$

(NOTE c)

LOC	VALUE
1041	
1042	
1043	
1044	
1045	
1046	
1047	
1048	
1049	
1050	

LOC	VALUE
1061	
1062	
1063	
1064	
1065	
1066	
1067	
1068	
1069	
1070	

LOC	VALUE
1081	
1082	
1083	
1084	
1085	
1086	
1087	
1088	
1089	
1090	

LOC	VALUE
1101	
1102	
1103	
1104	
1105	
1106	
1107	
1108	
1109	
1110	

LOC	VALUE
1071	
1072	
1073	
1074	
1075	
1076	
1077	
1078	
1079	
1080	

LOC	VALUE
1091	
1092	
1093	
1094	
1095	
1096	
1097	
1098	
1099	
1100	

LOC	VALUE
1121	
1122	
1123	
1124	
1125	
1126	
1127	
1128	
1129	
1130	

LOC	VALUE
1061	
1062	
1063	
1064	
1065	
1066	
1067	
1068	
1069	
1070	

LOC	VALUE
1071	
1072	
1073	
1074	
1075	
1076	
1077	
1078	
1079	
1080	

LOC	VALUE
1091	
1092	
1093	
1094	
1095	
1096	
1097	
1098	
1099	
1100	

LOC	VALUE
1111	
1112	
1113	
1114	
1115	
1116	
1117	
1118	
1119	
1120	

5  
1  
5

1<sup>st</sup>  
2<sup>nd</sup>  
3<sup>rd</sup>  
4<sup>th</sup>  
5<sup>th</sup>  
6<sup>th</sup>  
7<sup>th</sup>  
8<sup>th</sup>  
9<sup>th</sup>  
10<sup>th</sup>

NOTES a. INPUT NOT NECESSARY WHEN ATMIND = 0, 2  
b. INPUT NOT NECESSARY WHEN AUXIND = 1, 2  
c. INPUT NOT NECESSARY WHEN AUXIND = 1, 3  
d. INPUT NOT NECESSARY WHEN AIRIND = 1.

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



CHANGE IN FUEL WEIGHT (SGTIND = 7)

$\Delta W_F$  (LBS)

LOC	VALUE
1141	
1142	
1143	
1144	
1145	
1146	
1147	
1148	
1149	
1150	

$t_{FW}$  (HR)

LOC	VALUE
1151	
1152	
1153	
1154	
1155	
1156	
1157	
1158	
1159	
1160	

$\Delta W_{PL}$  (LBS)

LOC	VALUE
1161	
1162	
1163	
1164	
1165	
1166	
1167	
1168	
1169	
1170	

$t_{PW}$  (HR)

LOC	VALUE
1171	
1172	
1173	
1174	
1175	
1176	
1177	
1178	
1179	
1180	

1<sup>st</sup>  
2<sup>nd</sup>  
3<sup>rd</sup>  
4<sup>th</sup>  
5<sup>th</sup>  
6<sup>th</sup>  
7<sup>th</sup>  
8<sup>th</sup>  
9<sup>th</sup>  
10<sup>th</sup>

TRANSFER ALTITUDE (SGTIND = 9)

$h_{FINAL}$  (FT) ( $h_{OPTIND=0}$ )  
OR  $h_{MAX}$  (FT) ( $h_{OPTIND=1}$ )

LOC	VALUE
1181	
1182	
1183	
1184	
1185	
1186	
1187	
1188	
1189	
1190	

1<sup>st</sup>  
2<sup>nd</sup>  
3<sup>rd</sup>  
4<sup>th</sup>  
5<sup>th</sup>  
6<sup>th</sup>  
7<sup>th</sup>  
8<sup>th</sup>  
9<sup>th</sup>  
10<sup>th</sup>

CHANGE FUEL OR CHANGE PAYLOAD

WGTING

LOC	VALUE
1191	
1192	
1193	
1194	
1195	
1196	
1197	
1198	
1199	
1200	

OR SGTIND = 7  
SGTIND = 8

0 -  $W + \Delta W \leq W_G$   
1 - NO WEIGHT RESTRICTION

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

GENERAL PERFORMANCE INFORMATION (SGTIND = 11)

	GWIND		ATMIND		$\Delta T_{IN}$ (°F) (NOTE a)		ALTITUDE (FT)		$N_{II}/N_{II} \text{ MAX}$ (PRIMARY ENG)		$N_{II}/N_{II} \text{ MAX}$ (AUX ENG) (NOTE a)		TAUX/TTOT (NOTE b)	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
1st	4140		4160		4180		4200		4220		4240		4260	
2nd	4141		4161		4181		4201		4221		4241		4261	
3rd	4142		4162		4182		4202		4222		4242		4262	
4th	4143		4163		4183		4203		4223		4243		4263	
5th	4144		4164		4184		4204		4224		4244		4264	
6th	4145		4165		4185		4205		4225		4245		4265	
7th	4146		4166		4186		4206		4226		4246		4266	
8th	4147		4167		4187		4207		4227		4247		4267	
9th	4148		4168		4188		4208		4228		4248		4268	
10th	4149		4169		4189		4209		4229		4249		4269	

0 = STANDARD ATMOSPHERE  
1 = STD +  $\Delta T_{IN}$   
2 = ARBITRARY  $\rho(h)$

1 =  $\Delta GW$  INPUT  
2 = GW INPUT

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

	GW OR $\Delta GW$ (LB) (NOTE c)		$C_{LWING}$ (NOTE d)		$F_{CR}$ (FT <sup>2</sup> )		T/W		$\Delta V$ (KTS)		VMAX (KTS)	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
1st	4150		4170		4190		4210		4230		4250	
2nd	4151		4171		4191		4211		4231		4251	
3rd	4152		4172		4192		4212		4232		4252	
4th	4153		4173		4193		4213		4233		4253	
5th	4154		4174		4194		4214		4234		4254	
6th	4155		4175		4195		4215		4235		4255	
7th	4156		4176		4196		4216		4236		4256	
8th	4157		4177		4197		4217		4237		4257	
9th	4158		4178		4198		4218		4238		4258	
10th	4159		4179		4199		4219		4239		4259	

NOTES: a. INPUT NOT NECESSARY WHEN ATMIND = 0, 2 c. INPUT  $\Delta GW$  WHEN GWIND = 1  
b. INPUT NOT NECESSARY WHEN AUXIND = 1, 2 d. INPUT NOT NECESSARY WHEN AUXIND = 1, 3  
e. INPUT NOT NECESSARY WHEN AIPIND = 1

SHEET NO.	CASE NO.
OF	

ROTOR TIP SPEED OR MACH NUMBER SCHEDULE

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

	LOC	VALUE
NO. OF PAIRS IN $V_{TIP}/M_{T,90}$ TABLE	1258	

	LOC	VALUE		LOC	VALUE
V A L U E S  O F  M	1259		V A L U E S  O F  M	1269	
	1260			1270	
	1261			1271	
	1262			1272	
	1263			1273	
	1264			1274	
	1265			1275	
	1266			1276	
	1267			1277	
	1268			1278	

- NOTES: 1. IF  $N_{II}/N_{II\text{MAX}} < 10$ , PROGRAM USES ACTUAL VALUE OF  $N_{II}/N_{II\text{MAX}}$ .
2. IF  $10 < N_{II}/N_{II\text{MAX}} < 20$ , PROGRAM ASSUMES  $V_{TIP}$  SCHEDULE IS MIX OF  $M_{ADV\text{TIP}}$  AND  $V_{TIP}$ .
3. IF  $N_{II}/N_{II\text{MAX}} > 20$ , PROGRAM ASSUMES  $V_{TIP}$  SCHEDULE IS IN  $V_{TIP}$  ONLY.

SHEET NO.	CASE NO.
OF	

**AUXILIARY PROPULSION SCHEDULE ( $T_{AUX}/T$ )**

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

	LOC	VALUE
NO. OF PAIRS IN $T_{AUX}/T$ TABLE	1671	

V A L U E S  O F  $\mu$	LOC	VALUE	V A L U E S  O F  $T_{AUX}/T$	LOC	VALUE
	1672			1682	
	1673			1683	
	1674			1684	
	1675			1685	
	1676			1686	
	1677			1687	
	1678			1688	
	1679			1689	
	1680			1690	
1681		1691			

$T_{AUX}/T$ SCHEDULE $\mu$ LIMIT	1692	
----------------------------------	------	--

- NOTES: 1. IF  $T_{AUX}/T < 1000$ , INPUT  $T_{AUX}/T$  IS USED  
 2. IF  $T_{AUX}/T = 1000$ , INPUT SCHEDULE IS USED  
 3. IF  $T_{AUX}/T = 2000$ , INPUT SCHEDULE IS USED UP TO  
 TRANSITION  $\mu$  INDICATED BY LOC 1692. ABOVE  
 THAT  $\mu$  THE  $T_{AUX}/T$  CORRESPONDING TO MAX  
 ROTOR OR CONFIGURATION  $L/D_E$  IS USED. USE  
 THIS OPTION ONLY WITH ROTIND > 4, AUXIND > 2.

ENGINE CYCLE DATA; NON-STANDARD PERFORMANCE

SHEET NO.	CASE NO.
OF	

PRIMARY ENGINE DATA

VARIABLE	LOC	VALUE
WDTIND	1201	
N1IND	1202	
N1ΘIND	1203	
N2IND	1204	
QIND	1205	

VARIABLE	LOC	VALUE
$\dot{W}_{MAX}/\dot{W}^*$	1220	
$N1_{MAX}/N1^*$	1221	
$(N1/\dot{W}/N1^*)_{MAX}$	1222	
$N2_{MAX}/N2^*$	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 = 1,2

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 LIMIT  
 1 = TORQUE LIMIT IMPOSED ON MAIN AND TAIL ROTOR XMSN  
 2 = TORQUE LIMIT IMPOSED ON AUX PROPULSION XMSN

N1ΘIND: { 0 = NO REFERRED N1 CUTOFF  
 1 = REFERRED N1 CUTOFF

NOTE: QIND = 2 IS USED ONLY WITH  
 AUXIND > 2.0,  $\eta_{PI}$ IND = 0 AND AIPIND = 1

WHEN OPTIND = 2 OR 3, 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  $\frac{N1}{N1^*} \frac{D}{V1}$

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	

INPUT THIS TABLE IF RNOIND = 1

OUTPUT SHAFT SPEED CORRECTION

VALUES OF  $\frac{N1X}{N1IOPT}$

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 N2IND = 2 AND  
 NON-STANDARD CORRECTION IS DESIRED

ENGINE CYCLE DATA; NON-STANDARD PERFORMANCE

AUXILIARY INDEPENDENT ENGINE DATA

VARIABLE	LOC	VALUE
WDTINDI	2201	
N1INDI	2202	
N1θINDI	2203	
N2INDI	2204	
QINDI	2205	

VARIABLE	LOC	VALUE
$N_{MAX}/N^*$	2220	
$N_{MAX}/N_1^*$	2221	
$(N_1/\sqrt{\theta})/N_1^* MAX$	2222	
$N_{H1} MAX/N_{H1}^*$	2223	
$C_{X}/Q^*$	2224	

INPUT IF WDTINDI = 1

INPUT IF N1INDI = 1

INPUT IF N1θINDI = 1

INPUT IF N2INDI = 1, 2

INPUT IF QINDI = 1

WDTINDI: { 0 = NO FUEL FLOW CUTOFF  
          { 1 = FUEL FLOW CUTOFF

N1INDI: { 0 = NO N1 CUTOFF  
          { 1 = N1 CUTOFF

N2INDI: { 0 = NO N2 CUTOFF; OPTIMUM N2 VARIATION  
          { 1 = N2 CUTOFF; OPTIMUM N2 VARIATION  
          { 2 = N2 CUTOFF; NON-OPTIMUM N2 VARIATION

QINDI: { 0 = NO TORQUE CUTOFF  
          { 1 = TORQUE CUTOFF

N1θINDI: { 0 = NO REFERRED N1 CUTOFF  
          { 1 = REFERRED N1 CUTOFF

VARIABLE	LOC	VALUE
RNOINDI	2206	

0 = NO REYNOLDS NO. CORRECTIONS  
1 = REYNOLDS NO. CORRECTIONS

REYNOLDS NO. CORRECTION FACTOR

VALUES OF  $\frac{N_1}{N_1^*} \frac{D}{V_1}$

LOC	VALUE
2207	
2208	
2209	
2210	
2211	
2212	
2213	
2214	
2215	
2216	

VALUES OF  $K_{PR}$

LOC	VALUE
2225	
2226	
2227	
2228	
2229	
2230	
2231	
2232	
2233	
2234	

OUTPUT SHAFT SPEED CORRECTION

VALUES OF  $\frac{N_{H1}}{N_{H1} OPT}$

LOC	VALUE
2238	
2239	
2240	
2241	
2242	
2243	
2244	
2245	
2246	
2247	

VALUES OF  $K_{PN}$

LOC	VALUE
2248	
2249	
2250	
2251	
2252	
2253	
2254	
2255	
2256	
2257	

INPUT THIS TABLE IF RNOINDI = 1

INPUT THIS TABLE IF N2INDI = 2 AND NON-STANDARD CORRECTION IS DESIRED

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

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
$\zeta_4$	1304	
$T_{G1}$ ( $^{\circ}R$ )	1305	
$T_{F2}$ ( $^{\circ}R$ )	1306	

VARIABLE	LOC	VALUE
$T_{NP}$ ( $^{\circ}R$ )	1307	
$T_{MIL}$ ( $^{\circ}R$ )	1308	
$T_{MAX}$ ( $^{\circ}R$ )	1309	

NOTE a.

NOTE b.

NO. OF T/ $\theta$	LOC	VALUE
1	1311	
2	1312	
3	1313	
4	1314	
5	1315	
6	1316	
7	1317	
8	1318	

NO. OF M	LOC	VALUE
1	1320	
2	1321	
3	1322	
4	1323	
5	1324	
6	1325	

ALL TABLES MUST BE AT LEAST 3 x 3 IN SIZE

VALUES OF REFERRED THRUST OR HORSEPOWER ( $F_N / \delta F_N$  OR SHP /  $\delta W_{SHP}$ )

	$(T/\theta)_1$		$(T/\theta)_2$		$(T/\theta)_3$		$(T/\theta)_4$		$(T/\theta)_5$		$(T/\theta)_6$		$(T/\theta)_7$		$(T/\theta)_8$	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M1	1326		1332		1338		1344		1350		1356		1362		1368	
M2	1327		1333		1339		1345		1351		1357		1363		1369	
M3	1328		1334		1340		1346		1352		1358		1364		1370	
M4	1329		1335		1341		1347		1353		1359		1365		1371	
M5	1330		1336		1342		1348		1354		1360		1366		1372	
M6	1331		1337		1343		1349		1355		1361		1367		1373	

NOTE: WHEN USING AUXILIARY ENGINES, AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE.

NO. OF T/ $\theta$	LOC	VALUE
1	1375	
2	1376	
3	1377	
4	1378	
5	1379	
6	1380	
7	1381	
8	1 2	

NO. OF M	LOC	VALUE
1	1384	
2	1385	
3	1386	
4	1387	
5	1388	
6	1389	

VALUES OF REFERRED FUEL FLOW ( $\omega_1 / \delta \omega_1 F_N$  OR  $\omega_2 / \delta \omega_2 F_N$ )

	$(T/\theta)_1$		$(T/\theta)_2$		$(T/\theta)_3$		$(T/\theta)_4$		$(T/\theta)_5$		$(T/\theta)_6$		$(T/\theta)_7$		$(T/\theta)_8$	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M1	1390		1396		1402		1408		1414		1420		1426		1432	
M2	1391		1397		1403		1409		1415		1421		1427		1433	
M3	1392		1398		1404		1410		1416		1422		1428		1434	
M4	1393		1399		1405		1411		1417		1423		1429		1435	
M5	1394		1400		1406		1412		1418		1424		1430		1436	
M6	1395		1401		1407		1413		1419		1425		1431		1437	

NOTE a.  $k_4$  IN LBS; IF ENGINE = 0,  $k_3$  IS IN LB/HP; IF ENGINE = 1, 2,  $k_3$  IS IN LB/LB THRUST

b. IF ENGINE = 0,  $\zeta_4$  IS IN FT./SHP; IF ENGINE = 1, 2,  $\zeta_4$  IS IN FT/LB THRUST

HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91

SHEET NO.	CASE NO.
07	

PRIMARY ENGINE CYCLE INFORMATION (Sheet 2)

LOC	VALUE
1	1439
2	1440
3	1441
4	1442
5	1443
6	1444
7	1445
8	1446

LOC	VALUE
M <sub>1</sub>	1447

VALUES OF M	
LOC	VALUE
M <sub>1</sub>	1448
M <sub>2</sub>	1449
M <sub>3</sub>	1450
M <sub>4</sub>	1451
M <sub>5</sub>	1452
M <sub>6</sub>	1453

VALUES OF REFERRED N<sub>I</sub> (N<sub>I</sub>/√θ N<sub>I</sub>)

	(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	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M <sub>1</sub>	1454	1460	1466	1472	1478	1484	1490	1496								
M <sub>2</sub>	1455	1461	1467	1473	1479	1485	1491	1497								
M <sub>3</sub>	1456	1462	1468	1474	1480	1486	1492	1498								
M <sub>4</sub>	1457	1463	1469	1475	1481	1487	1493	1499								
M <sub>5</sub>	1458	1464	1470	1476	1482	1488	1494	1500								
M <sub>6</sub>	1459	1465	1471	1477	1483	1489	1495	1501								

LOC	VALUE
1	1502
2	1503
3	1504
4	1505
5	1506
6	1507
7	1508
8	1509

LOC	VALUE
M <sub>1</sub>	1510

VALUES OF M	
LOC	VALUE
M <sub>1</sub>	1511
M <sub>2</sub>	1512
M <sub>3</sub>	1513
M <sub>4</sub>	1514
M <sub>5</sub>	1515
M <sub>6</sub>	1516
M <sub>7</sub>	1517

VALUES OF REFERRED N<sub>II</sub> (N<sub>II</sub>/√θ N<sub>II</sub>)

	(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	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
M <sub>1</sub>	1518	1524	1530	1536	1542	1548	1554	1560								
M <sub>2</sub>	1519	1525	1531	1537	1543	1549	1555	1561								
M <sub>3</sub>	1520	1526	1532	1538	1544	1550	1556	1562								
M <sub>4</sub>	1521	1527	1533	1539	1545	1551	1557	1563								
M <sub>5</sub>	1522	1528	1534	1540	1546	1552	1558	1564								
M <sub>6</sub>	1523	1529	1535	1541	1547	1553	1559	1565								

NOTE: WHEN USING AUXILIARY ENGINES, AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE.



**BOEING VERTOL COMPANY**  
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**HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91**

SHEET NO.	CASE NO.
OF	

**SHORT FORM AERO (MAIN) ROTOR CYCLE INFORMATION**

VARIABLE	LOC	VALUE

VARIABLE	LOC	VALUE

HOVER  
(STATIC  
THRUST  
DATA)

CRUISE  
DATA

VARIABLE	LOC	VALUE

NOTES: INPUT ONLY WHEN ROTIND = 1

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

NO. OF CT	VALUES OF CT		VALUES OF K <sub>HOVA</sub>	
	LOC	VALUE	LOC	VALUE
	1616			

HOVER  
(STATIC  
THRUST  
DATA)

1637

0 = USES SCHEDULED ROTOR  
PROPULSIVE EFFICIENCY  
1 = USES 100% ROTOR  
PROPULSIVE EFFICIENCY

THIS INFORMATION IS FOR REFERENCE PURPOSES ONLY

REFERENCE BLADE NO.	
BLADE PLANFORM TAPER RATIO	$\lambda = C_{Tip}/C_c$ LINE ROT.
BLADE AIRFOIL DISTRIBUTION	
RADIAL STA (r/R)	AIRFOIL DESIGNATION
REMARKS	

ROTOR PERFORMANCE MAP  
(ROTIND = 2,3)

	LOC	VALUE
ROTOR MAP NO.	2700	

	LOC	VALUE
$b_{REF}$	2701	
$Q_{REF}$	2702	
$\theta_{TREF}$	2703	

HOVER PERFORMANCE

	LOC	VALUE
NO. OF $C_T/\sigma$ 'S	2704	

	LOC	VALUE
NO. OF $M_{TIP}$ 'S	2715	

VALUES OF  $C_T/\sigma$

	LOC	VALUE
$(C_T/\sigma)_1$	2705	
$(C_T/\sigma)_2$	2706	
$(C_T/\sigma)_3$	2707	
$(C_T/\sigma)_4$	2708	
$(C_T/\sigma)_5$	2709	
$(C_T/\sigma)_6$	2710	
$(C_T/\sigma)_7$	2711	
$(C_T/\sigma)_8$	2712	
$(C_T/\sigma)_9$	2713	
$(C_T/\sigma)_{10}$	2714	

VALUES OF  $M_{TIP}$

	LOC	VALUE
$M_{T1}$	2716	
$M_{T2}$	2717	
$M_{T3}$	2718	
$M_{T4}$	2719	
$M_{T5}$	2720	
$M_{T6}$	2721	

$$C_T/\sigma = 4T/\rho \pi D^2 V_T^2 N_R \sigma$$

$$C_{PH}/\sigma = 2200 \text{ RHP}/\rho \pi D^2 V_T^3 N_R \sigma$$

INPUT VALUES OF  $C_{PH}/\sigma$  FOR COMBINATIONS  
OF  $C_T/\sigma$  AND  $M_{TIP}$

	$M_{TIP1} =$		$M_{TIP2} =$		$M_{TIP3} =$		$M_{TIP4} =$		$M_{TIP5} =$		$M_{TIP6} =$	
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE
$(C_T/\sigma)_1 =$	2722		2732		2742		2752		2762		2772	
$(C_T/\sigma)_2 =$	2723		2733		2743		2753		2763		2773	
$(C_T/\sigma)_3 =$	2724		2734		2744		2754		2764		2774	
$(C_T/\sigma)_4 =$	2725		2735		2745		2755		2765		2775	
$(C_T/\sigma)_5 =$	2726		2736		2746		2756		2766		2776	
$(C_T/\sigma)_6 =$	2727		2737		2747		2757		2767		2777	
$(C_T/\sigma)_7 =$	2728		2738		2748		2758		2768		2778	
$(C_T/\sigma)_8 =$	2729		2739		2749		2759		2769		2779	
$(C_T/\sigma)_9 =$	2730		2740		2750		2760		2770		2780	
$(C_T/\sigma)_{10} =$	2731		2741		2751		2761		2771		2781	

- NOTES: a.  $C_T$  &  $C_P$  ARE IN "ROTOR" NOTATION  
 b. WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS  
 c. ALL TABLES MUST BE COMPLETELY FILLED.

**BOEING VERTOL COMPANY**  
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**HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91**

SHEET NO 2 OF 5 CASE NO

**ROTOR PERFORMANCE "MAP"  
(ROTIND = 2,3)**

**CRUISE PERFORMANCE**

NO. OF ADVANCE RATIOS ( $\mu$ )	LOC	VALUE
	2782	

NO. OF ROTOR LIFT COEFFICIENTS ( $C_T'/\sigma$ )	LOC	VALUE
	2789	

NO. OF ROTOR PROPULSIVE THRUST COEFFICIENTS ( $C_X'/\sigma$ )	LOC	VALUE
	2800	

VALUES OF  $\mu$

LOC	VALUE
2783	
2784	
2785	
2786	
2787	
2788	

$$\mu = \frac{1.688 V_{KT}}{V_{TIP}}$$

$$C_T'/\sigma = \frac{LIFT}{\rho \pi D^2 V_T^2 \sigma_{MR} NR}$$

$$C_X'/\sigma = \frac{PROPULSIVE FORCE}{\rho \pi D^2 V_T^2 \sigma_{MR} NR}$$

$$C_P'/\sigma = \frac{200 \times \text{ROTOR POWER (BHP)}}{\rho \pi D^2 V_T^3 \sigma_{MR} NR}$$

VALUES OF  $(C_T'/\sigma)$

LOC	VALUE
2790	
2791	
2792	
2793	
2794	
2795	
2796	
2797	
2798	
2799	

VALUES OF  $C_X'/\sigma$

LOC	VALUE
2801	
2802	
2803	
2804	
2805	
2806	
2807	
2808	
2809	
2810	

NOTES: a. WHEN OPTIND = 2 OR 3 CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS  
b. ALL TABLES MUST BE COMPLETELY FILLED.

**BOEING HELICOPTER COMPANY**  
 HELICOPTER ENGINEERING AND PERFORMANCE  
 COMPUTER PROGRAM R 91

BOEING HELICOPTER COMPANY  
 HELICOPTER ENGINEERING AND PERFORMANCE  
 COMPUTER PROGRAM R 91

CRUISE PERFORMANCE INPUT VALUES OF TORQUE COEFFICIENT ( $C_T$ ) FOR COMBINATIONS OF  $P$ ,  $C_1$ ,  $R$ ,  $C_X$

NOTE: ALL TABLES ARE IN SI UNITS.

BEFORE PROPORTIONAL FORCE COEFFICIENT

ADVERSE BALLS	$C_T$ (0.1)	$C_T$ (0.2)	$C_T$ (0.3)	$C_T$ (0.4)	$C_T$ (0.5)	$C_T$ (0.6)	$C_T$ (0.7)	$C_T$ (0.8)	$C_T$ (0.9)	$C_T$ (1.0)	$C_T$ (1.1)	$C_T$ (1.2)	$C_T$ (1.3)	$C_T$ (1.4)	$C_T$ (1.5)	$C_T$ (1.6)	$C_T$ (1.7)	$C_T$ (1.8)	$C_T$ (1.9)	$C_T$ (2.0)
0.1	2811	2821	2831	2841	2851	2861	2871	2881	2891	2901	2911	2921	2931	2941	2951	2961	2971	2981	2991	3001
0.2	2812	2822	2832	2842	2852	2862	2872	2882	2892	2902	2912	2922	2932	2942	2952	2962	2972	2982	2992	3002
0.3	2813	2823	2833	2843	2853	2863	2873	2883	2893	2903	2913	2923	2933	2943	2953	2963	2973	2983	2993	3003
0.4	2814	2824	2834	2844	2854	2864	2874	2884	2894	2904	2914	2924	2934	2944	2954	2964	2974	2984	2994	3004
0.5	2815	2825	2835	2845	2855	2865	2875	2885	2895	2905	2915	2925	2935	2945	2955	2965	2975	2985	2995	3005
0.6	2816	2826	2836	2846	2856	2866	2876	2886	2896	2906	2916	2926	2936	2946	2956	2966	2976	2986	2996	3006
0.7	2817	2827	2837	2847	2857	2867	2877	2887	2897	2907	2917	2927	2937	2947	2957	2967	2977	2987	2997	3007
0.8	2818	2828	2838	2848	2858	2868	2878	2888	2898	2908	2918	2928	2938	2948	2958	2968	2978	2988	2998	3008
0.9	2819	2829	2839	2849	2859	2869	2879	2889	2899	2909	2919	2929	2939	2949	2959	2969	2979	2989	2999	3009
1.0	2820	2830	2840	2850	2860	2870	2880	2890	2900	2910	2920	2930	2940	2950	2960	2970	2980	2990	3000	3010

BOEING VERTOL COMPANY  
A DIVISION OF THE BOEING COMPANY

HELI-COMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91

ROTOR PERFORMANCE "MAP"  
(ROTIND = 2,3)

CRUISE PERFORMANCE INPUT VALUES OF ROTOR POWER COEFFICIENT ( $C_p$ ) FOR COMBINATIONS OF  $\mu$ ,  $C_T$  &  $C_X$

NOTE: ALL VALUES MUST BE COMPLETELY FILLED.

ADVANCE RATIO $\mu$	$(C_X^{(n)})_1$		$(C_X^{(n)})_2$		$(C_X^{(n)})_3$		$(C_X^{(n)})_4$		$(C_X^{(n)})_5$		$(C_X^{(n)})_6$		$(C_X^{(n)})_7$		$(C_X^{(n)})_8$		$(C_X^{(n)})_9$		$(C_X^{(n)})_{10}$		
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	
$(C_T^{(n)})_1$	3011		3021		3031		3041		3051		3061		3071		3081		3091		3101		3110
$(C_T^{(n)})_2$	3012		3022		3032		3042		3052		3062		3072		3082		3092		3102		3110
$(C_T^{(n)})_3$	3013		3023		3033		3043		3053		3063		3073		3083		3093		3103		3110
$(C_T^{(n)})_4$	3014		3024		3034		3044		3054		3064		3074		3084		3094		3104		3110
$(C_T^{(n)})_5$	3015		3025		3035		3045		3055		3065		3075		3085		3095		3105		3110
$(C_T^{(n)})_6$	3016		3026		3036		3046		3056		3066		3076		3086		3096		3106		3110
$(C_T^{(n)})_7$	3017		3027		3037		3047		3057		3067		3077		3087		3097		3107		3110
$(C_T^{(n)})_8$	3018		3028		3038		3048		3058		3068		3078		3088		3098		3108		3110
$(C_T^{(n)})_9$	3019		3029		3039		3049		3059		3069		3079		3089		3099		3109		3110
$(C_T^{(n)})_{10}$	3020		3030		3040		3050		3060		3070		3080		3090		3100		3110		3110
ADVANCE RATIO $\mu$	$(C_X^{(n)})_1$	$(C_X^{(n)})_2$	$(C_X^{(n)})_3$	$(C_X^{(n)})_4$	$(C_X^{(n)})_5$	$(C_X^{(n)})_6$	$(C_X^{(n)})_7$	$(C_X^{(n)})_8$	$(C_X^{(n)})_9$	$(C_X^{(n)})_{10}$	$(C_X^{(n)})_1$	$(C_X^{(n)})_2$	$(C_X^{(n)})_3$	$(C_X^{(n)})_4$	$(C_X^{(n)})_5$	$(C_X^{(n)})_6$	$(C_X^{(n)})_7$	$(C_X^{(n)})_8$	$(C_X^{(n)})_9$	$(C_X^{(n)})_{10}$	
$(C_T^{(n)})_1$	3111	3121	3131	3141	3151	3161	3171	3181	3191	3201	3111	3121	3131	3141	3151	3161	3171	3181	3191	3201	
$(C_T^{(n)})_2$	3112	3122	3132	3142	3152	3162	3172	3182	3192	3202	3112	3122	3132	3142	3152	3162	3172	3182	3192	3202	
$(C_T^{(n)})_3$	3113	3123	3133	3143	3153	3163	3173	3183	3193	3203	3113	3123	3133	3143	3153	3163	3173	3183	3193	3203	
$(C_T^{(n)})_4$	3114	3124	3134	3144	3154	3164	3174	3184	3194	3204	3114	3124	3134	3144	3154	3164	3174	3184	3194	3204	
$(C_T^{(n)})_5$	3115	3125	3135	3145	3155	3165	3175	3185	3195	3205	3115	3125	3135	3145	3155	3165	3175	3185	3195	3205	
$(C_T^{(n)})_6$	3116	3126	3136	3146	3156	3166	3176	3186	3196	3206	3116	3126	3136	3146	3156	3166	3176	3186	3196	3206	
$(C_T^{(n)})_7$	3117	3127	3137	3147	3157	3167	3177	3187	3197	3207	3117	3127	3137	3147	3157	3167	3177	3187	3197	3207	
$(C_T^{(n)})_8$	3118	3128	3138	3148	3158	3168	3178	3188	3198	3208	3118	3128	3138	3148	3158	3168	3178	3188	3198	3208	
$(C_T^{(n)})_9$	3119	3129	3139	3149	3159	3169	3179	3189	3199	3209	3119	3129	3139	3149	3159	3169	3179	3189	3199	3209	
$(C_T^{(n)})_{10}$	3120	3130	3140	3150	3160	3170	3180	3190	3200	3210	3120	3130	3140	3150	3160	3170	3180	3190	3200	3210	

CRUISE PERFORMANCE INPUT VALUES OF ROTOR POWER COEFFICIENT ( $C_p$ ) FOR COMBINATIONS OF  $\mu, C_T, B, C_X$   
 (ROTIND = 2,3) ROTOR PROPULSIVE FORCE COEFFICIENT

NOTE: ALL TABLES MUST BE COMPLETELY FILLED.

ADVANCE RATIO $\mu_5$	$(C_X/\sigma)_1$		$(C_X/\sigma)_2$		$(C_X/\sigma)_3$		$(C_X/\sigma)_4$		$(C_X/\sigma)_5$		$(C_X/\sigma)_6$		$(C_X/\sigma)_7$		$(C_X/\sigma)_8$		$(C_X/\sigma)_9$		$(C_X/\sigma)_{10}$		
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	
$(C_T/\sigma)_1$	3211		3221		3231		3241		3251		3261		3271		3281		3291		3301		3310
$(C_T/\sigma)_2$	3212		3222		3232		3242		3252		3262		3272		3282		3292		3302		3310
$(C_T/\sigma)_3$	3213		3223		3233		3243		3253		3263		3273		3283		3293		3303		3310
$(C_T/\sigma)_4$	3214		3224		3234		3244		3254		3264		3274		3284		3294		3304		3310
$(C_T/\sigma)_5$	3215		3225		3235		3245		3255		3265		3275		3285		3295		3305		3310
$(C_T/\sigma)_6$	3216		3226		3236		3246		3256		3266		3276		3286		3296		3306		3310
$(C_T/\sigma)_7$	3217		3227		3237		3247		3257		3267		3277		3287		3297		3307		3310
$(C_T/\sigma)_8$	3218		3228		3238		3248		3258		3268		3278		3288		3298		3308		3310
$(C_T/\sigma)_9$	3219		3229		3239		3249		3259		3269		3279		3289		3299		3309		3310
$(C_T/\sigma)_{10}$	3220		3230		3240		3250		3260		3270		3280		3290		3300		3310		3310
ADVANCE RATIO $\mu_6$	$(C_X/\sigma)_1$		$(C_X/\sigma)_2$		$(C_X/\sigma)_3$		$(C_X/\sigma)_4$		$(C_X/\sigma)_5$		$(C_X/\sigma)_6$		$(C_X/\sigma)_7$		$(C_X/\sigma)_8$		$(C_X/\sigma)_9$		$(C_X/\sigma)_{10}$		
$(C_T/\sigma)_1$	3311		3321		3331		3341		3351		3361		3371		3381		3391		3401		3410
$(C_T/\sigma)_2$	3312		3322		3332		3342		3352		3362		3372		3382		3392		3402		3410
$(C_T/\sigma)_3$	3313		3323		3333		3343		3353		3363		3373		3383		3393		3403		3410
$(C_T/\sigma)_4$	3314		3324		3334		3344		3354		3364		3374		3384		3394		3404		3410
$(C_T/\sigma)_5$	3315		3325		3335		3345		3355		3365		3375		3385		3395		3405		3410
$(C_T/\sigma)_6$	3316		3326		3336		3346		3356		3366		3376		3386		3396		3406		3410
$(C_T/\sigma)_7$	3317		3327		3337		3347		3357		3367		3377		3387		3397		3407		3410
$(C_T/\sigma)_8$	3318		3328		3338		3348		3358		3368		3378		3388		3398		3408		3410
$(C_T/\sigma)_9$	3319		3329		3339		3349		3359		3369		3379		3389		3399		3409		3410
$(C_T/\sigma)_{10}$	3320		3330		3340		3350		3360		3370		3380		3390		3400		3410		3410

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

ROTOR PERFORMANCE MAP  
(ROTIND = 4,5,6)

	LOC	VALUE
ROTOR MAP NO.	3420	

	LOC	VALUE
b <sub>REF</sub>	3421	
σ <sub>REF</sub>	3422	
ρ <sub>T REF</sub>	3423	

HOVER PERFORMANCE

	LOC	VALUE
NO. OF C <sub>T</sub> /σ'S	3424	

	LOC	VALUE
NO. OF MTIP'S	3435	

VALUES OF C<sub>T</sub>/σ

	LOC	VALUE
(C <sub>T</sub> /σ) <sub>1</sub>	3425	
(C <sub>T</sub> /σ) <sub>2</sub>	3426	
(C <sub>T</sub> /σ) <sub>3</sub>	3427	
(C <sub>T</sub> /σ) <sub>4</sub>	3428	
(C <sub>T</sub> /σ) <sub>5</sub>	3429	
(C <sub>T</sub> /σ) <sub>6</sub>	3430	
(C <sub>T</sub> /σ) <sub>7</sub>	3431	
(C <sub>T</sub> /σ) <sub>8</sub>	3432	
(C <sub>T</sub> /σ) <sub>9</sub>	3433	
(C <sub>T</sub> /σ) <sub>10</sub>	3434	

VALUES OF MTIP

	LOC	VALUE
MT <sub>1</sub>	3436	
MT <sub>2</sub>	3437	
MT <sub>3</sub>	3438	
MT <sub>4</sub>	3439	
MT <sub>5</sub>	3440	
MT <sub>6</sub>	3441	

$$C_T/\sigma = 4T/\rho D^2 V_T^2 N_{REF}$$

INPUT VALUES OF F.M. FOR COMBINATIONS  
OF C<sub>T</sub>/σ 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 <sub>T</sub> /σ) <sub>1</sub> =	3442		3452		3462		3472		3482		3492	
(C <sub>T</sub> /σ) <sub>2</sub> =	3443		3453		3463		3473		3483		3493	
(C <sub>T</sub> /σ) <sub>3</sub> =	3444		3454		3464		3474		3484		3494	
(C <sub>T</sub> /σ) <sub>4</sub> =	3445		3455		3465		3475		3485		3495	
(C <sub>T</sub> /σ) <sub>5</sub> =	3446		3456		3466		3476		3486		3496	
(C <sub>T</sub> /σ) <sub>6</sub> =	3447		3457		3467		3477		3487		3497	
(C <sub>T</sub> /σ) <sub>7</sub> =	3448		3458		3468		3478		3488		3498	
(C <sub>T</sub> /σ) <sub>8</sub> =	3449		3459		3469		3479		3489		3499	
(C <sub>T</sub> /σ) <sub>9</sub> =	3450		3460		3470		3480		3490		3500	
(C <sub>T</sub> /σ) <sub>10</sub> =	3451		3461		3471		3481		3491		3501	

NOTES: a) C<sub>T</sub>/σ IS IN "ROTOR" NOTATION  
b) ALL TABLES MUST BE COMPLETELY FILLED

ROTOR PERFORMANCE "MAP"  
(ROTIND = 4,5,6)

CRUISE PERFORMANCE

NO. OF PROPULSIVE FORCE / LIFT RATIOS (X/L)	LOC	VALUE
	3502	

NO. OF ROTOR LIFT COEFFICIENTS (CT'/σ)	LOC	VALUE
	3509	

NO. OF ADVANCE RATIOS (μ)	LOC	VALUE
	3520	

VALUES OF X/L

LOC	VALUE
3503	
3504	
3505	
3506	
3507	
3508	

$$\mu = \frac{1.688VKT}{VTIP}$$

$$CT'/\sigma = \frac{LIFT}{\rho \pi D^2 V T^2 C_{MR} NR}$$

$$X/L = \frac{ROTOR PROPULSIVE FORCE}{ROTOR LIFT}$$

VALUES OF CT'/σ

LOC	VALUE
3510	
3511	
3512	
3513	
3514	
3515	
3516	
3517	
3518	
3519	

VALUES OF μ

LOC	VALUE
3521	
3522	
3523	
3524	
3525	
3526	
3527	
3528	
3529	
3530	

- NOTES: a) AT LEAST 3 VALUES OF X/L, CT'/σ, AND μ MUST BE INPUT  
b) WHEN OPTIND = 2 OR 3, CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS  
ALL TABLES MUST BE COMPLETELY FILLED.



ROTOR PERFORMANCE "MAP"  
(ROTIND = 4,5,6)

CRUISE PERFORMANCE

INPUT VALUES OF ROTOR L/D<sub>E</sub> FOR COMBINATIONS OF  $\mu$ ,  $C_T$  & X/L

ROTOR ADVANCE RATIO

NOTE: ALL TABLES MUST BE COMPLETELY FILLED

PROPULSIVE FORCE /LIFT RATIO	$\mu_1$		$\mu_2$		$\mu_3$		$\mu_4$		$\mu_5$		$\mu_6$		$\mu_7$		$\mu_8$		$\mu_9$		$\mu_{10}$		
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	
(X/L) <sub>1</sub>	3531	3541	3551	3561	3571	3581	3591	3601	3610	3620	3630	3640	3650	3660	3670	3680	3690	3700	3710	3720	3730
(C <sub>T</sub> '/σ) <sub>1</sub>	3532	3542	3552	3562	3572	3582	3592	3602	3611	3621	3631	3641	3651	3661	3671	3681	3691	3701	3711	3721	3731
(C <sub>T</sub> '/σ) <sub>2</sub>	3533	3543	3553	3563	3573	3583	3593	3603	3612	3622	3632	3642	3652	3662	3672	3682	3692	3702	3712	3722	3732
(C <sub>T</sub> '/σ) <sub>3</sub>	3534	3544	3554	3564	3574	3584	3594	3604	3613	3623	3633	3643	3653	3663	3673	3683	3693	3703	3713	3723	3733
(C <sub>T</sub> '/σ) <sub>4</sub>	3535	3545	3555	3565	3575	3585	3595	3605	3614	3624	3634	3644	3654	3664	3674	3684	3694	3704	3714	3724	3734
(C <sub>T</sub> '/σ) <sub>5</sub>	3536	3546	3556	3566	3576	3586	3596	3606	3615	3625	3635	3645	3655	3665	3675	3685	3695	3705	3715	3725	3735
(C <sub>T</sub> '/σ) <sub>6</sub>	3537	3547	3557	3567	3577	3587	3597	3607	3616	3626	3636	3646	3656	3666	3676	3686	3696	3706	3716	3726	3736
(C <sub>T</sub> '/σ) <sub>7</sub>	3538	3548	3558	3568	3578	3588	3598	3608	3617	3627	3637	3647	3657	3667	3677	3687	3697	3707	3717	3727	3737
(C <sub>T</sub> '/σ) <sub>8</sub>	3539	3549	3559	3569	3579	3589	3599	3609	3618	3628	3638	3648	3658	3668	3678	3688	3698	3708	3718	3728	3738
(C <sub>T</sub> '/σ) <sub>9</sub>	3540	3550	3560	3570	3580	3590	3600	3610	3619	3629	3639	3649	3659	3669	3679	3689	3699	3709	3719	3729	3739
(C <sub>T</sub> '/σ) <sub>10</sub>									3620	3630	3640	3650	3660	3670	3680	3690	3700	3710	3720	3730	

ROTOR PERFORMANCE "MAP"  
(ROTIND = 4,5,6)

CRUISE PERFORMANCE

INPUT VALUES OF ROTOR L/D FOR COMBINATIONS OF  $\mu$ , C<sub>T</sub>' & X L

NOTE: ALL TABLES MUST BE COMPLETELY FILLED

ROTOR ADVANCE RATIO

	μ = 1		μ = 2		μ = 3		μ = 4		μ = 5		μ = 6		μ = 7		μ = 8		μ = 9		μ = 10			
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE		
PROPULSIVE FORCE 'LIFT RATIO																						
(X'L) <sub>3</sub>	3731	3741	3751	3761	3771	3781	3791	3801	3811	3821	3831	3841	3851	3861	3871	3881	3891	3901	3911	3921	3931	
(C <sub>T</sub> ' <sub>1</sub> ) <sub>1</sub>	3732	3742	3752	3762	3772	3782	3792	3802	3812	3822	3832	3842	3852	3862	3872	3882	3892	3902	3912	3922	3932	
(C <sub>T</sub> ' <sub>2</sub> ) <sub>1</sub>	3733	3743	3753	3763	3773	3783	3793	3803	3813	3823	3833	3843	3853	3863	3873	3883	3893	3903	3913	3923	3933	
(C <sub>T</sub> ' <sub>3</sub> ) <sub>1</sub>	3734	3744	3754	3764	3774	3784	3794	3804	3814	3824	3834	3844	3854	3864	3874	3884	3894	3904	3914	3924	3934	
(C <sub>T</sub> ' <sub>4</sub> ) <sub>1</sub>	3735	3745	3755	3765	3775	3785	3795	3805	3815	3825	3835	3845	3855	3865	3875	3885	3895	3905	3915	3925	3935	
(C <sub>T</sub> ' <sub>5</sub> ) <sub>1</sub>	3736	3746	3756	3766	3776	3786	3796	3806	3816	3826	3836	3846	3856	3866	3876	3886	3896	3906	3916	3926	3936	
(C <sub>T</sub> ' <sub>6</sub> ) <sub>1</sub>	3737	3747	3757	3767	3777	3787	3797	3807	3817	3827	3837	3847	3857	3867	3877	3887	3897	3907	3917	3927	3937	
(C <sub>T</sub> ' <sub>7</sub> ) <sub>1</sub>	3738	3748	3758	3768	3778	3788	3798	3808	3818	3828	3838	3848	3858	3868	3878	3888	3898	3908	3918	3928	3938	
(C <sub>T</sub> ' <sub>8</sub> ) <sub>1</sub>	3739	3749	3759	3769	3779	3789	3799	3809	3819	3829	3839	3849	3859	3869	3879	3889	3899	3909	3919	3929	3939	
(C <sub>T</sub> ' <sub>9</sub> ) <sub>1</sub>	3740	3750	3760	3770	3780	3790	3800	3810	3820	3830	3840	3850	3860	3870	3880	3890	3900	3910	3920	3930	3940	
PROPULSIVE FORCE 'LIFT RATIO																						
(X'L) <sub>4</sub>	3831	3841	3851	3861	3871	3881	3891	3901	3911	3921	3931	3941	3951	3961	3971	3981	3991	4001	4011	4021	4031	
(C <sub>T</sub> ' <sub>1</sub> ) <sub>2</sub>	3832	3842	3852	3862	3872	3882	3892	3902	3912	3922	3932	3942	3952	3962	3972	3982	3992	4002	4012	4022	4032	
(C <sub>T</sub> ' <sub>2</sub> ) <sub>2</sub>	3833	3843	3853	3863	3873	3883	3893	3903	3913	3923	3933	3943	3953	3963	3973	3983	3993	4003	4013	4023	4033	
(C <sub>T</sub> ' <sub>3</sub> ) <sub>2</sub>	3834	3844	3854	3864	3874	3884	3894	3904	3914	3924	3934	3944	3954	3964	3974	3984	3994	4004	4014	4024	4034	
(C <sub>T</sub> ' <sub>4</sub> ) <sub>2</sub>	3835	3845	3855	3865	3875	3885	3895	3905	3915	3925	3935	3945	3955	3965	3975	3985	3995	4005	4015	4025	4035	
(C <sub>T</sub> ' <sub>5</sub> ) <sub>2</sub>	3836	3846	3856	3866	3876	3886	3896	3906	3916	3926	3936	3946	3956	3966	3976	3986	3996	4006	4016	4026	4036	
(C <sub>T</sub> ' <sub>6</sub> ) <sub>2</sub>	3837	3847	3857	3867	3877	3887	3897	3907	3917	3927	3937	3947	3957	3967	3977	3987	3997	4007	4017	4027	4037	
(C <sub>T</sub> ' <sub>7</sub> ) <sub>2</sub>	3838	3848	3858	3868	3878	3888	3898	3908	3918	3928	3938	3948	3958	3968	3978	3988	3998	4008	4018	4028	4038	
(C <sub>T</sub> ' <sub>8</sub> ) <sub>2</sub>	3839	3849	3859	3869	3879	3889	3899	3909	3919	3929	3939	3949	3959	3969	3979	3989	3999	4009	4019	4029	4039	
(C <sub>T</sub> ' <sub>9</sub> ) <sub>2</sub>	3840	3850	3860	3870	3880	3890	3900	3910	3920	3930	3940	3950	3960	3970	3980	3990	4000	4010	4020	4030	4040	

ROTOR PERFORMANCE "MAP"  
(ROTIND = 4.5,6)

INPUT VALUES OF ROTOR L/D<sub>E</sub> FOR COMBINATIONS OF  $\mu$ , CT<sub>R</sub> & X/L

CRUISE PERFORMANCE

ROTOR ADVANCE RATIO

NOTE: ALL TABLES MUST BE COMPLETELY FILLED

PROPULSIVE FORCE LIFT RATIO	$\mu_1 =$		$\mu_2 =$		$\mu_3 =$		$\mu_4 =$		$\mu_5 =$		$\mu_6 =$		$\mu_7 =$		$\mu_8 =$		$\mu_9 =$		$\mu_{10} =$		
	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	LOC	VALUE	
(X/L) <sub>5</sub>																					
(CT <sub>R</sub> /σ) <sub>1</sub>	3931	3941	3951	3961	3971	3981	3991	4001	4011	4021	4031	4041	4051	4061	4071	4081	4091	4101	4111	4121	4131
(CT <sub>R</sub> /σ) <sub>2</sub>	3932	3942	3952	3962	3972	3982	3992	4002	4012	4022	4032	4042	4052	4062	4072	4082	4092	4102	4112	4122	4132
(CT <sub>R</sub> /σ) <sub>3</sub>	3933	3943	3953	3963	3973	3983	3993	4003	4013	4023	4033	4043	4053	4063	4073	4083	4093	4103	4113	4123	4133
(CT <sub>R</sub> /σ) <sub>4</sub>	3934	3944	3954	3964	3974	3984	3994	4004	4014	4024	4034	4044	4054	4064	4074	4084	4094	4104	4114	4124	4134
(CT <sub>R</sub> /σ) <sub>5</sub>	3935	3945	3955	3965	3975	3985	3995	4005	4015	4025	4035	4045	4055	4065	4075	4085	4095	4105	4115	4125	4135
(CT <sub>R</sub> /σ) <sub>6</sub>	3936	3946	3956	3966	3976	3986	3996	4006	4016	4026	4036	4046	4056	4066	4076	4086	4096	4106	4116	4126	4136
(CT <sub>R</sub> /σ) <sub>7</sub>	3937	3947	3957	3967	3977	3987	3997	4007	4017	4027	4037	4047	4057	4067	4077	4087	4097	4107	4117	4127	4137
(CT <sub>R</sub> /σ) <sub>8</sub>	3938	3948	3958	3968	3978	3988	3998	4008	4018	4028	4038	4048	4058	4068	4078	4088	4098	4108	4118	4128	4138
(CT <sub>R</sub> /σ) <sub>9</sub>	3939	3949	3959	3969	3979	3989	3999	4009	4019	4029	4039	4049	4059	4069	4079	4089	4099	4109	4119	4129	4139
(CT <sub>R</sub> /σ) <sub>10</sub>	3940	3950	3960	3970	3980	3990	4000	4010	4020	4030	4040	4050	4060	4070	4080	4090	4100	4110	4120	4130	4140
PROPULSIVE FORCE LIFT RATIO	$\mu_1 =$		$\mu_2 =$		$\mu_3 =$		$\mu_4 =$		$\mu_5 =$		$\mu_6 =$		$\mu_7 =$		$\mu_8 =$		$\mu_9 =$		$\mu_{10} =$		
(X/L) <sub>6</sub>																					
(CT <sub>R</sub> /σ) <sub>1</sub>	4031	4041	4051	4061	4071	4081	4091	4101	4111	4121	4131	4141	4151	4161	4171	4181	4191	4201	4211	4221	4231
(CT <sub>R</sub> /σ) <sub>2</sub>	4032	4042	4052	4062	4072	4082	4092	4102	4112	4122	4132	4142	4152	4162	4172	4182	4192	4202	4212	4222	4232
(CT <sub>R</sub> /σ) <sub>3</sub>	4033	4043	4053	4063	4073	4083	4093	4103	4113	4123	4133	4143	4153	4163	4173	4183	4193	4203	4213	4223	4233
(CT <sub>R</sub> /σ) <sub>4</sub>	4034	4044	4054	4064	4074	4084	4094	4104	4114	4124	4134	4144	4154	4164	4174	4184	4194	4204	4214	4224	4234
(CT <sub>R</sub> /σ) <sub>5</sub>	4035	4045	4055	4065	4075	4085	4095	4105	4115	4125	4135	4145	4155	4165	4175	4185	4195	4205	4215	4225	4235
(CT <sub>R</sub> /σ) <sub>6</sub>	4036	4046	4056	4066	4076	4086	4096	4106	4116	4126	4136	4146	4156	4166	4176	4186	4196	4206	4216	4226	4236
(CT <sub>R</sub> /σ) <sub>7</sub>	4037	4047	4057	4067	4077	4087	4097	4107	4117	4127	4137	4147	4157	4167	4177	4187	4197	4207	4217	4227	4237
(CT <sub>R</sub> /σ) <sub>8</sub>	4038	4048	4058	4068	4078	4088	4098	4108	4118	4128	4138	4148	4158	4168	4178	4188	4198	4208	4218	4228	4238
(CT <sub>R</sub> /σ) <sub>9</sub>	4039	4049	4059	4069	4079	4089	4099	4109	4119	4129	4139	4149	4159	4169	4179	4189	4199	4209	4219	4229	4239
(CT <sub>R</sub> /σ) <sub>10</sub>	4040	4050	4060	4070	4080	4090	4100	4110	4120	4130	4140	4150	4160	4170	4180	4190	4200	4210	4220	4230	4240

SHEET NO.	CASE NO.
OF	

**INCREMENTAL ROTOR PERFORMANCE INPUT**  
(USE WHEN ROTIND = 4,5,6)

HOVER PERFORMANCE

INCREMENTAL  
ROTOR FIGURE  
OF MERIT INPUT

$\Delta$ F.M.	0195
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CRUISE PERFORMANCE

	LOC	VALUE
NO. OF PAIRS IN $\mu$ - $\Delta$ L/D <sub>E</sub> TABLE	1279	

INCREMENTAL  
ROTOR L/D<sub>E</sub>

V A L U E S  O F  $\mu$	LOC	VALUE	V A L U E S  O F  $\Delta$ L/D <sub>E</sub>	LOC	VALUE
	1280			1290	
1281		1291			
1282		1292			
1283		1293			
1284		1294			
1285		1295			
1286		1296			
1287		1297			
1288		1298			
1289		1299			

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

SHEET NO.	CASE NO.
OF	

PROPELLER PERFORMANCE DATA (Sheet 1 of 3)

THIS SHEET IS REQUIRED WHEN  $\tau_p \text{IND} = 1$

NOTES: AT LEAST 3 VALUES OF J AND 3 VALUES OF  $C_T$  MUST BE USED  
WHEN OPTIND = 2,3, CONSIDER ONLY THOSE ITEMS IN THE SHADED BLOCKS

	LOC.	VALUE
PROP. TABLE NO.	1700	

	LOC.	VALUE
NO. OF ADVANCE RATIOS (J)	1701	

	LOC.	VALUE
NO. OF PROP THRUST COEFFICIENTS ( $C_T$ )	1722	

VALUES OF J

	LOC.	VALUE
J <sub>1</sub>	1702	
J <sub>2</sub>	1703	
J <sub>3</sub>	1704	
J <sub>4</sub>	1705	
J <sub>5</sub>	1706	
J <sub>6</sub>	1707	
J <sub>7</sub>	1708	
J <sub>8</sub>	1709	
J <sub>9</sub>	1710	
J <sub>10</sub>	1711	
J <sub>11</sub>	1712	
J <sub>12</sub>	1713	
J <sub>13</sub>	1714	
J <sub>14</sub>	1715	
J <sub>15</sub>	1716	
J <sub>16</sub>	1717	
J <sub>17</sub>	1718	
J <sub>18</sub>	1719	
J <sub>19</sub>	1720	
J <sub>20</sub>	1721	

VALUES OF  $C_T$

	LOC.	VALUE
$C_{T1}$	1723	
$C_{T2}$	1724	
$C_{T3}$	1725	
$C_{T4}$	1726	
$C_{T5}$	1727	
$C_{T6}$	1728	
$C_{T7}$	1729	
$C_{T8}$	1730	
$C_{T9}$	1731	
$C_{T10}$	1732	
$C_{T11}$	1733	
$C_{T12}$	1734	
$C_{T13}$	1735	
$C_{T14}$	1736	
$C_{T15}$	1737	
$C_{T16}$	1738	
$C_{T17}$	1739	
$C_{T18}$	1740	
$C_{T19}$	1741	
$C_{T20}$	1742	

HESCOMP HELICOPTER SIZING AND PERFORMANCE  
COMPUTER PROGRAM B-91

SHEET NO.	CASE NO.
OF	

PROPELLER PERFORMANCE DATA (Sheet 2 of 3)

THIS SHEET IS REQUIRED WHEN  $\gamma_p$  IND = 1

INPUT VALUES OF PROPELLER POWER COEFFICIENT FOR COMBINATIONS OF J & CT

PROPELLER THRUST COEFFICIENT

ADVANCE RATIO	CT <sub>1</sub> =		CT <sub>2</sub> =		CT <sub>3</sub> =		CT <sub>4</sub> =		CT <sub>5</sub> =		CT <sub>6</sub> =		CT <sub>7</sub> =		CT <sub>8</sub> =		CT <sub>9</sub> =		CT <sub>10</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	LOC. VALUE	LOC. VALUE
J <sub>1</sub> =	1743	1763	1783	1803	1823	1843	1863	1883	1903	1923										
J <sub>2</sub> =	1744	1764	1784	1804	1824	1844	1864	1884	1904	1924										
J <sub>3</sub> =	1745	1765	1785	1805	1825	1845	1865	1885	1905	1925										
J <sub>4</sub> =	1746	1766	1786	1806	1826	1846	1866	1886	1906	1926										
J <sub>5</sub> =	1747	1767	1787	1807	1827	1847	1867	1887	1907	1927										
J <sub>6</sub> =	1748	1768	1788	1808	1828	1848	1868	1888	1908	1928										
J <sub>7</sub> =	1749	1769	1789	1809	1829	1849	1869	1889	1909	1929										
J <sub>8</sub> =	1750	1770	1790	1810	1830	1850	1870	1890	1910	1930										
J <sub>9</sub> =	1751	1771	1791	1811	1831	1851	1871	1891	1911	1931										
J <sub>10</sub> =	1752	1772	1792	1812	1832	1852	1872	1892	1912	1932										
J <sub>11</sub> =	1753	1773	1793	1813	1833	1853	1873	1893	1913	1933										
J <sub>12</sub> =	1754	1774	1794	1814	1834	1854	1874	1894	1914	1934										
J <sub>13</sub> =	1755	1775	1795	1815	1835	1855	1875	1895	1915	1935										
J <sub>14</sub> =	1756	1776	1796	1816	1836	1856	1876	1896	1916	1936										
J <sub>15</sub> =	1757	1777	1797	1817	1837	1857	1877	1897	1917	1937										
J <sub>16</sub> =	1758	1778	1798	1818	1838	1858	1878	1898	1918	1938										
J <sub>17</sub> =	1759	1779	1799	1819	1839	1859	1879	1899	1919	1939										
J <sub>18</sub> =	1760	1780	1800	1820	1840	1860	1880	1900	1920	1940										
J <sub>19</sub> =	1761	1781	1801	1821	1841	1861	1881	1901	1921	1941										
J <sub>20</sub> =	1762	1782	1802	1822	1842	1862	1882	1902	1922	1942										

NOTES: 1. IF MORE THAN 10 VALUES OF CT ARE REQUIRED, USE SHEET 3 FOR CONTINUATION OF TABLE.  
2. WHEN OPTIND = 2,3, CONSIDER ONLY THOSE ITEMS IN SHADED BLOCKS

PROPELLER PERFORMANCE DATA (Sheet 3 of 3)

THIS SHEET IS REQUIRED WHEN OPTIND = 1  
INPUT VALUES OF PROPELLER POWER COEFFICIENT FOR COMBINATIONS OF J & CT

PROPELLER THRUST COEFFICIENT

ADVANCE RATIO	C <sub>T11</sub> =		C <sub>T12</sub> =		C <sub>T13</sub> =		C <sub>T14</sub> =		C <sub>T15</sub> =		C <sub>T16</sub> =		C <sub>T17</sub> =		C <sub>T18</sub> =		C <sub>T19</sub> =		C <sub>T20</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	LOC. VALUE	LOC. VALUE	
J <sub>1</sub> =	1943	1963	1983	2003	2023	2043	2063	2083	2103	2123											
J <sub>2</sub> =	1944	1964	1984	2004	2024	2044	2064	2084	2104	2124											
J <sub>3</sub> =	1945	1965	1985	2005	2025	2045	2065	2085	2105	2125											
J <sub>4</sub> =	1946	1966	1986	2006	2026	2046	2066	2086	2106	2126											
J <sub>5</sub> =	1947	1967	1987	2007	2027	2047	2067	2087	2107	2127											
J <sub>6</sub> =	1948	1968	1988	2008	2028	2048	2068	2088	2108	2128											
J <sub>7</sub> =	1949	1969	1989	2009	2029	2049	2069	2089	2109	2129											
J <sub>8</sub> =	1950	1970	1990	2010	2030	2050	2070	2090	2110	2130											
J <sub>9</sub> =	1951	1971	1991	2011	2031	2051	2071	2091	2111	2131											
J <sub>10</sub> =	1952	1972	1992	2012	2032	2052	2072	2092	2112	2132											
J <sub>11</sub> =	1953	1973	1993	2013	2033	2053	2073	2093	2113	2133											
J <sub>12</sub> =	1954	1974	1994	2014	2034	2054	2074	2094	2114	2134											
J <sub>13</sub> =	1955	1975	1995	2015	2035	2055	2075	2095	2115	2135											
J <sub>14</sub> =	1956	1976	1996	2016	2036	2056	2076	2096	2116	2136											
J <sub>15</sub> =	1957	1977	1997	2017	2037	2057	2077	2097	2117	2137											
J <sub>16</sub> =	1958	1978	1998	2018	2038	2058	2078	2098	2118	2138											
J <sub>17</sub> =	1959	1979	1999	2019	2039	2059	2079	2099	2119	2139											
J <sub>18</sub> =	1960	1980	2000	2020	2040	2060	2080	2100	2120	2140											
J <sub>19</sub> =	1961	1981	2001	2021	2041	2061	2081	2101	2121	2141											
J <sub>20</sub> =	1962	1982	2002	2022	2042	2062	2082	2102	2122	2142											

NOTE: WHEN OPTIND = 2,3, CONSIDER ONLY THOSE ITEMS IN SHADED BLOCKS





### 5.3 PROGRAM INPUT VARIABLES

#### 5.3.1 Program Variables

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
AF	0257	AF	Activity factor (per blade) of propeller
AR	0104	DAM 2	Wing aspect ratio
AR <sub>AP</sub>	0159	ARAP	Aft rotor pylon aspect ratio (tandem rotor helicopter)
AR <sub>FP</sub>	0154	ARFP	Forward rotor pylon aspect ratio (tandem rotor helicopter)
AR <sub>HT</sub>	0112	ARHT	Horizontal tail aspect ratio
AR <sub>VT</sub>	0135	DAM 11	Vertical tail aspect ratio
BHP			Brake horsepower primary engine including transmission and power accessory losses. BHP is synonymous with shaft horsepower (ShP)
BHPI			Brake horsepower of independent engine including transmission and power accessory losses. BHPI is synonymous with SHPI.
BMR	0176		Blade number per main rotor or propeller
$b_{NS}/d_{NI}$	0151	BNSDN1	Ratio of auxiliary independent engine nacelle strut span to nacelle diameter
$b_{REF}$	2701	BREF	Reference number of blade. Used when ROTIND > 1
$b_{REF}$	3421	BREFL	
$b_{TR}$	0203	BTR	Blade number of tail rotor
$b_{VT}$	0139	DAM 12	Vertical tail span; only when CNFIND = VTFIND = and VTDIND = 0
$b_W/D$	0103	BWD	Ratio of wing span to main rotor diameter

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$\bar{C}$	0212	SUPRSZ	Tail rotor/fin blockage factor
$C_{DB}$	1609	CDBB	Baseline rotor cruise profile drag coefficient (input in rotor "cycle")
$C_{DB0}$	1603	CDBO	Baseline rotor hover profile drag coefficient (input in rotor "cycle")
$C_{DAP}$	0303	CDAP	Aft rotor pylon profile drag coefficient at $R_e=10^7$ (based on aft pylon planform area)
$C_{DFP}$	0304	CDFP	Forward rotor pylon profile drag coefficient at $R_e=10^7$ (based on forward pylon max frontal area)
$C_{DC}$	0305	CDCSMR	Main rotor hub center section profile drag coefficient (based on center section frontal area)
$C_{D0}$			Total rotor profile drag coefficient
$C_{DCSTR}$	0307	CDCSTR	Tail rotor hub center section profile drag coefficient (based on center section frontal area)
$C_{LHT_i}$	0302	CDHT	Profile drag coefficient of horizontal tail at $R_e=10^7$ (based on horizontal tail planform area)
$C_{DN}$	0309	CDN	Profile drag coefficient of primary engine nacelles at $R_e=10^7$ (based on wetted area of all nacelles)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$C_{DNI}$	0310	CDNI	Profile drag coefficient of auxiliary independent engine nacelle at $R_e=10^7$ (based on wetted area of all nacelles)
$C_{DNS}$	0311	CDNS	Profile drag coefficient of auxiliary independent engine nacelle strut at $R_e=10^7$ (based on wetted area of strut(s))
$C_{D_{SHMR}}$	0306	CDSHMR	Main rotor hub shank profile drag coefficient (based on shank frontal area)
$C_{D_{SHTR}}$	0308	CDSHTR	Tail rotor hub shank profile drag coefficient (based on shank frontal area)
$C_{DVT_i}$	0301	CDVT	Profile drag coefficient of vertical tail at $R_e=10^7$ (based on vertical tail planform area)
$C_{DWI}$	0339	TBCDWI	Profile drag coefficient of wing at $R_e=10^7$ (based on wing planform area)
$C_{\delta}/C$	0109	CFC	Ratio of download alleviating flap chord to wing chord
AC.G.	2623	DFLCC	Helicopter cg travel (ft)
AC.G. <sub>R</sub>	2679	DCGR	Location of main rotor in the longitudinal direction relative to the aircraft operating empty (OME) cg position (ft)
$C_{LW}$	0331	TBCI1(8)	Wing lift coefficient
$C_{LD}$	0111	CLD	Wing design lift coefficient
$C_{LDP}$	0240	CLDP	Wing operating lift coefficient at cruise condition for engine sizing

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$C_{L_{DES}}$	0140	CLDES	Tail fin design lift coefficient
$C_{L_{FIN}}$	0216	CLFIN	Tail fin cruise lift coefficient
$C_{Li}$	0259	CLEYE	Propeller integrated design lift coefficient
$C_{La}$	0329	CLALPH	Two-dimensional wing lift coefficient slope (Rad. $^{-1}$ )
$C_P$			Propeller power coefficient ( $550 \text{ HP} / \rho \pi^3 D^5$ )
$C_P / \sigma$			Ratio of rotor power coefficient to rotor solidity ( $C_P / \sigma = \text{RHP} / \rho \pi^3 D^5 \sigma$ )
$C_{P_{IND}}$			Induced power coefficient of main rotor $C_{P_{IND}}^{\text{HOVER}} = .707 K_{HOV}^{3/2} K_{CL}^{3/2}$ $C_{P_{IND}}^{\text{CRUISE}} = K_{IND} K_{EXT} C_T'^2$
$C_{P_{PAR}}$			Parasite power coefficient of main rotor in cruise condition $C_{P_{PAR}} = C_{PER} (K_{PER})$
$C_{P_{PRO}}$			Profile power coefficient of main rotor $C_{P_{PRO}}^{\text{HOVER}} = C_{D_0} \frac{\sigma}{8} (1 - X_c^4)$ $C_{P_{PRO}}^{\text{CRUISE}} = C_{D_0} \frac{\sigma}{8} (1 + 4.65 \mu^2) (1 - X_c^4)$
$C_T$	1723	CPROC(20)	Propeller thrust coefficient ( $\text{Thrust} / \rho n^2 D^4$ )
$C_{T_E}$			Rotor thrust coefficient ( $\text{Thrust} / \rho A_{TIP}^2$ )

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$(C_T/\sigma)$	0182	CTSIGH	Ratio of thrust coefficient to rotor solidity (helicopter $C_T = \text{Thrust}/\rho A N_R V_{TIP}^2 \sigma$ ), includes $C_T/\sigma$ , $(C_T/\sigma)_H$ , $(C_T/\sigma)_{CR}$
$(C_{TG}/C_{T_{NET}})$	0211	DAM 20	Ratio of tail rotor total thrust coefficient to net thrust coefficient, where $C_{T_{NET}} = C_{TG} - \text{Fin blocking losses}$
$C_{XR}$			Rotor propulsive force coefficient
$C_X/\sigma$	0349	CXVSG	Rotor propulsive thrust coefficient divided by main rotor solidity. Used in defining rotor limits $C_X/\sigma = \frac{\text{Thrust required}}{\rho \pi \frac{D_{MR}^2 N_R V_{TIP}^2 \sigma_{MR}}{4}}$
$D_{MR}$	0174	DAM 15	Main rotor diameter (feet)
$D_{TR}$	0201	DAM 18	Tail rotor diameter (feet)
$D_{TBE}/D_{FAN}$	0282	DTRDFF	Equivalent tail rotor diameter/shrouded tail rotor/fan diameter used to simulate effect of shrouded tail rotor/fan
DIA	0280	DAM 25	Propeller diameter (feet)
$d_i$	2611	DI	Position of inboard underwing store (fraction of wing semi-span)
$d_o$	2612	DZ	Position of outboard underwing store (fraction of wing semi-span)
$d_{TIB}/d_{TB}$	0130	DTRDTE	Ratio of average tail boom tip diameter to average tail boom diameter

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
EAS	0581/0881	ENACH(10)/ EAS5	Equivalent airspeed required during climb and/or descent
e	0314	DAM26	Span loading efficiency factor
FM			Main rotor overall hover figure of merit (for a tandem rotor configuration this includes rotor/rotor interference)
FMI			Isolated main rotor hover figure of merit.
$\Delta F_e$	0315	DLTAFE	Increment in equivalent flat plate area parasite drag of fuselage (ft <sup>2</sup> )
AF.M.	0195	AKP	Incremental figure of merit added to results obtained when using "short form method". Input only if POTIND = 1
$t_N^*$	0244	DAM24	Auxiliary Independent engine maximum static thrust at sea level, standard conditions (total thrust for all engines)
$\Delta F_{eCL}$	0661	DELFCCL	Increment in equivalent flat plate area parasite drag (climb performance segment) - ft <sup>2</sup>
$\Delta F_{eCR}$	0811	DELFCR(10)	Increment in equivalent flat plate area parasite (cruise performance segment) - ft <sup>2</sup>
$\Delta F_{eNSC}$	0981	DELFD(10)	Increment in equivalent flat plate area parasite drag (descent performance segment) - ft <sup>2</sup>
$\Delta F_{eLOITER}$	1131	DELFLT(10)	Increment in equivalent flat plate area parasite drag (loiter performance segment) - ft <sup>2</sup>
$F_N / F_N^*$			Referred thrust for turbojet/fan engine cycles

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$g_{ROMT}$	0188	GREQSZ	Total maneuver g requirement helicopter must satisfy (wing + rotor) - g
$g_{ROT}$	0189	GROTSZ	Maneuver g's which rotor must carry. In the case of a pure helicopter, $g_{ROMT} = g_{ROT}$
g/S	0162	GS	Tandem rotor gap/stagger ratio
$G_{MR/TR}$	0214	G	Gap between tail rotor disc and main rotor disc (ft)
$(GW/F_e)$	0312	GWFE	Ratio of configuration design gross weight to equivalent flat plate area parasitic drag $(lb/ft)^2$
GW	415C	GWP(10)	User inputs GW or $\Delta GW$ depending on GWIND (LOC. 4140)
$h'/h_F$	0110	HPHF	Ratio of wing height on fuselage (relative to the bottom of the fuselage), $h'$ , to the total fuselage height, $h_F$ .
HEADWIND	0731	VIN(10)	Headwind during cruise (knots)
$h_C$	0024	HOC	Initial altitude at start of mission (ft)
$h_{C(C)}$	0135	HCRSZ	Cruise altitude for sizing main rotor solidity (ft)
$h_C$	0235	HC	Cruise altitude for sizing primary engines (ft)
$h_{BF/D}$	0471	EBFD2(10)	Ratio of fuselage bottom height above ground to main rotor diameter
$h_{FINAL}$	1181	HFIN	Final altitude for transfer altitude segment (SGFIND=9)
$h_{P_2}$	0161	DAM 13	Aft rotor pylon height (ft)
$h_{P_1}$	0153	HP1	Forward rotor pylon height (ft)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$h_{TO}$	0227	HES	Takeoff altitude for starting engines (ft)
$H_{MAX}$	0641/1181	HMAX	Maximum altitude during climb (ft) or during transfer altitude (ft)
$h_{min}$	0941	HMIN	Minimum altitude during descent (ft)
$\Delta h$	0621/0921	DELH3	Step size for climb or descent (ft)
$h_F$	0122	HF	Height of fuselage (ft)
J	1702	XPJ(20)	Propeller advance ratio, $J = V/nD$
$k_3$	1302	SK3	Primary engine weight multiplicative factor
$k_4$	1303	SK4	Primary engine weight additional factor
$k_{amd}$	2640	SKAMD	Main rotor weight factor
$k_{AEI}$	2653	SKAEI	Auxiliary engine installation weight factor
$k_B$	2622	SKB	Body group weight factor
$k_{CC}$	2613	SKCC	Cockpit controls weight factor
$k_{FS}$	2651	SKFS	Fuel system weight factor
$k_{FW}$	2616	SKFW	Fixed wing controls weight factor
$k_{LG}$	2624	SKLG	Landing gear weight factor
$k_{MC}$	2621	SKMC	Miscellaneous controls weight factor
$k_{MG}$	2625	SKMG	Main landing gear weight factor
$k_{PEI}$	2652	SKPEI	Primary engine installation weight factor



<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$k_{RC}$	2614	SKRC	Main rotor controls weight factor
$k_{RCA}$	2619	SKRCA	Auxiliary rotor controls weight factor
$k_{SAS}$	2618	SKSAS	Stability Augmentation System (SAS) weight factor
$k_{SC}$	2615	SKSC	Main rotor system controls weight factor
$k_{SCA}$	2620	SKSCA	Auxiliary rotor system controls weight factor
$k_{TM}$	2617	SKTM	Tilt mechanism weight factor
$k_{T.STING}$	0131	SKTING	Tail boom (on single rotor helicopter) length extending aft of tail rotor center as a fraction of tail rotor radius
$k_{VTAR}$	2645	SKVTAR	Auxiliary tail rotor multiplicative tip speed factor. Expressed as a fractional part of input tip speed.
$k_{WW}$	2626	SKWW	Detailed wing weight factor
$k_{ZZZ}$	0213	SKZZZ	Single rotor helicopter yaw moment of inertia adjustment factor
$k_1$	2654	SK1	Main rotor controls weight factor
$k_2$	2655	SK2	Main rotor system controls weight multiplicative factor
$k_3$	2656	DK3	Fixed wing controls weight multiplicative factor
$k_4$	2657	DK4	Auxiliary rotor controls weight multiplicative factor
$k_5$	2658	SK5	Auxiliary rotor system controls weight multiplicative factor

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$k_6$	2659	SK6	Body weight multiplicative factor
$k_7$	2660	SK7	Landing gear weight multiplicative factor
$k_8$	2661	SK8	Wing weight multiplicative factor
$k_9$	2662	SK9	Horizontal tail weight multiplicative factor
$k_{10}$	2663	SK10	Primary nacelle weight multiplicative factor
$k_{11}$	2664	SK11	Auxiliary nacelle weight multiplicative factor
$k_{12}$	2665	SK12	Primary rotor blade weight multiplicative factor
$k_{13}$	2666	SK13	Primary rotor hub weight multiplicative factor
$k_{14}$	2667	SK14	Tail rotor weight multiplicative factor
$k_{15}$	2668	SK15	Auxiliary rotor weight multiplicative factor
$k_{16}$	2669	SK16	Primary drive system weight multiplicative factor
$k_{17}$	2670	SK17	Auxiliary drive system weight multiplicative factor
$k_{18}$	2671	SK18	Primary engine weight multiplicative factor
$k_{19}$	2672	SK19	Auxiliary engine weight multiplicative factor
$k_{20}$	2673	SK20	Tail rotor drive system weight multiplicative factor
$k_{AIR}$	2635	SKAIA	Auxiliary air induction system weight factor
$k_{AIP}$	2633	SKAIP	Primary air induction system weight factor

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$k_{ADS}$	2649	SKADS	Auxiliary drive system weight factor
$k_{ALDSZ}$	2650	SKADSZ	Auxiliary drive system weight factor (number of gears in system)
$k_{ALT. PAYL.}$	0222	SKLTPY	Ratio of alternate payload increment to design payload (used in XMSN sizing)
$k_{A-}$	0319	CKAP	Aft rotor pylon multiplicative drag factor
$k_{AR}$	2643	SKAR	Auxiliary rotor weight factor
$k_{BLFD}$	2641	SKBLFD	Blade fold weight factor
$k_{CLF}$	2631	SKCLF	Crash load factor
$k_{FP}$	0320	CKFP	Forward rotor pylon multiplicative drag factor
$k_{C_1}$	1610	CKC1	Rotor retreating blade stall profile drag parameters (input in rotor "cycle")
$k_{C_2}$	1611	CKC2	Rotor retreating blade stall profile drag parameters (input in rotor "cycle")
$k_{C_3}$	1612	CK3	Rotor advancing tip mach number compressibility drag parameters (input in rotor "cycle")
$k_{C_3}$	1612	CK3	} Rotor advancing tip mach number compressibility drag parameters (input in rotor "cycle")
$k_{C_4}$	1613	CK4	
$k_{C_5}$	1614	CK5	
$k_F$	0326	CKF	Fuselage multiplicative drag factor

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$K_{FED}$	0313	AKFED	Trend constant input with GW/Fe when DRGIND = 2
$K_{FI}$	0431	SKFL(10)	Auxiliary independent engines fuel flow multiplicative factor (used in TAXI)
$K_{FF}$	0034	CKFF	Fuel flow multiplicative factor
$K_{FULS}$	2695	SKFLS	Fraction of fixed useful load located in cockpit area
$K_{H1}$	1604	CKH1	Rotor (hover) blade profile drag parameter (input in rotor "cycle")
$K_{H2}$	1605	CKH2	Rotor blade (hover) compressibility drag parameter (input in rotor "cycle")
$K_{H3}$	1606	CKH3	Rotor blade (hover) compressibility drag parameter (input in rotor "cycle")
$K_{H4}$	1607	CKH4	Rotor blade (hover) drag divergence Mach number parameter (input in rotor "cycle")
$K_{HOVA}$			Rotor hover induced power factor (input in rotor "cycle")
$K_{HOVB}$			Rotor hover induced power factor. Found in block data and used to correct rotor maps.
$K_{HT}$	0318	CKHT	Horizontal tail multiplicative drag factor
$K_N$	0323	CKN	Primary nacelle multiplicative drag factor
$K_{NS}$	0325	SKNS	Auxiliary nacelle engine nacelle strut multiplicative drag factor

<u>Variable</u>	<u>Location</u>	<u>For cran Name</u>	<u>Description</u>
$k_{PCLIMB}$	0193	XKPD	Helicopter forward flight climb efficiency
$k_{HT}$	2630	SKHT	Horizontal tail unit weight in pounds per square foot
$k_{NAC}$	2632	SKNAC	Primary cowling weight factor (psf)
$k_{NACA}$	2634	SKNACA	Auxiliary cowling weight factor (psf)
$k_{NI}$	6324	CYNI	Auxiliary independent engine nacelle multiplicative drag factor
$k_{NS}$	2636	SKNS	Nacelle strut weight factor
$k_{PA}$	2644	SKPA	Auxiliary rotor multiplicative input power factor. Expressed as a fractional part of the input power.
$k_{PER}$		CKPER	Rotor efficiency as a function of advance ratio
$k_{PDESCENT}$	0194	DELFM	Main rotor descent efficiency
$k_{PDS}$	2646	SKPDS	Primary drive system weight factor
$k_{PDSZ}$	2647	SKPDSZ	Primary drive system weight factor (number of gears in system)
$k_{PH}$	2639	SKPH	Primary hub weight factor
$k_{PN}$	1248	PNZ(10)	Ratio of power available at specified $N_{II}$ to power available at optimum $N_{II}$ defined as $K_{pn} = \frac{(1 - (1 - \frac{N_{II}}{N_{IIOPT}})^2)}{N_{IIOPT}}$
$k_{PR}$	1225	RNE(10)	Correction factor for engine power to account for Reynolds number effects

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$K_{PRB}$	2637	SKPRB	Primary rotor blade weight factor
$K_{HPHM}$	0321	CKHPHM	Main rotor hub/shank multiplicative drag factor
$K_{HPIT}$	0322	CKHPIT	Tail rotor hub/shank multiplicative drag factor
$K_{RBF}$	2638	SKRBF	Rotor type factor; 1.0 articulated, 2.2 hingeless or teetering
$K_{TBBS}$	2696	DSKTBB	Weight of tail boom as a fraction of total fuselage weight
$K_{TR}$	2642	SKTR	Tail rotor weight factor
$K_{TRDS}$	2648	SKTRDS	Tail rotor drive system weight factor
$K_{TRS}$	0215	CKTRS	Tail rotor solidity multiplicative factor (used to determine tail rotor solidity)
$K_{VT}$	0317	CKVT	Vertical tail multiplicative drag factor
$K_w$	0327	CKW	Wing multiplicative drag factor
$K_{WF}$	2629	SKWF	Wing weight/area factor (psf)
$K_{WS}$	2628	SKWS	Wing stores only weight trend factor
$K_z$	0139	DAM 12	Vertical tail fin height factor
$L/D_E$			Rotor lift/effective drag ratio
$\Delta L/D_E$	1290	XDLDS(10)	Incremental rotor lift/effective drag ratio input in the incremental rotor performance input sheet
LF	2627	ELF	Wing unload factor
$\rho AIA/le_A$	0149	ELLEA	Ratio of air induction system length to engine length (auxiliary independent engines)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$\ell_{AIP}/\ell_C$	0145	ELLEP	Ratio of air induction system length to engine length (primary engines)
$\ell_{CONST}$ DIA( $\ell_C$ )	0126	DAM 6	Constant diameter section (cabin) length (ft)
$\ell_{RW}$	0127	ELRW	Length of ramp wall (ft)
$\ell_{TH}$	0113	ELTHP	Horizontal tail moment arm (ft) - measured from rotor $\xi$ to tail C/4
$\ell_{TB}$	0113	ELTBP	Ratio of horizontal tail moment arm to main rotor radius
$(\ell/d)_P$	0124	ELDP	Fineness ratio of aircraft nose section
$(\ell/d)_T$	0125	ELDT	Fineness ratio of aircraft tail section
$(\ell_{TB}/d_{TB})$	0129	ELTDB	Fineness ratio of tail boom (single rotor helicopter)
MACH	0262	TBEM5(10)	Mach number required during climb and/or descent
$M_{LF}$	0031	EMLF	Maneuver load factor (g's)
$M_{MO}$	0028	EMMO	Maximum operating Mach number
$M_{DO}$	1615	EMDO	Baseline rotor advancing tip compressibility drag rise Mach number (input in rotor "cycle")
$M_{DBO}$	1608	EMDBO	Baseline rotor hover compressibility drag rise (lift=0) Mach No. (input in rotor "cycle")
$M_{TIP}$	3436	EMTIP(6)	Rotor hover tip Mach No.
N	0190	EMRTSZ	Rotor loading (rotor lift/TW)
$N_P$	0219	ENP	Number of primary engines
$N_{PI}$	0245	ENPI	Number of auxiliary independent engines

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$N_{PSD}$	0231	ENPSD	Number of primary engines inoperative (for engine sizing)
$N_{PSD}(\ )$			Number of primary engines shut down during cruise, loiter, climb or descent
$(N_{PSD})_C$	0241	ENPSDC	Number of primary engines shut down during cruise (for engine sizing)
$N_{PSD}_i(\ )$			Number of auxiliary independent engines shut down during cruise loiter, climb or descent
$N_{PROP}$	0248	ENRI	Number of propellers
$N_R$	0172	ENR	Number of rotors
$N_{INAX}/N_i^*$	1221	AINAX	Gas generator RPM limit - ratio of max gas generator RPM to RPM at maximum static power, sea level, standard
$(N_i/\sqrt{\theta})_{1^*}^{MAX}$	1222	A3MAX	Gas generator referred RPM limit ( $\theta$ = temperature ratio @ compression face), this input simulates a restriction on compression speed
$N_{II}/N_{II_{OPT}}$	1238	AZNO(10)	Ratio of operating power turbine speed to optimum power turbine speed (input when #2IND = 2). $N_{II}/N_{II_{OPT}}$ is set = 1.0, $N_{II}/N_{II_{MAX}}$ is determined from $\frac{N_{II}}{N_{II_{OPT}}} = \frac{N_{II}}{N_{II_{MAX}}} \left( \frac{N_{II_{MAX}}}{N_{II}^*} \right)$ If $N_{II}/N_{II_{MAX}}$ is much greater than 1.0, then set $N_{II}/N_{II_{MAX}} = 1$ and calculate $N_{II}/N_{II_{OPT}}$ .



<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$(N_{II}/N_{IIMAX})$	0541	AN2M2(10)	Ratio of operating power turbine speed to maximum power turbine speed (input for both primary and auxiliary independent engines in performance segments 1-6, and 11).

This value can be altered to obtain the desired operating tip velocity through the correlation

$$V_{T\text{OPERATING}} = \left( \frac{N_{II}}{N_{IIMAX}} \right) \left( \frac{N_{IIMAX}}{N_{II}^*} \right) V_{T\text{REP}}$$

where  $\left( \frac{N_{IIMAX}}{N_{II}^*} \right)$  is input in LOC (1223) and  $V_T$  is input in LOC (0181).

There are three options to choose from when using  $\frac{N_{II}}{N_{IIMAX}}$ .

If

- $\frac{N_{II}}{N_{IIMAX}} < 10$ . the program uses

the actual input value of  $\frac{N_{II}}{N_{IIMAX}}$

- $10 < \frac{N_{II}}{N_{IIMAX}} < 20$ . the program

assumes  $V_{TIP}$  schedule is a mixture of  $M_{ADV_{TIP}}$  and  $V_{TIP}$

input in locations 1258-1278. This should be input as

$$\left( 10 + \frac{N_{II}}{N_{IIMAX}} \right)$$

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			<ul style="list-style-type: none"> <li>• <math>\frac{N_{II}}{N_{II\_MAX}} &gt; 20</math>. the program</li> </ul>
			$\left( 20 + \frac{N_{II}}{N_{II\_MAX}} \right)$
			<p>assumes <math>V_{TIP}</math> schedule is in <math>V_{TIP}</math> only, input in locations 1258-1278. This should be input as</p>
			<p>The rotor tip speed or Mach number schedule is a plot of Tip Speed (FPS) versus True Airspeed (kts) for lines of constant <math>\mu</math>. This schedule enables the user to input a constant tip velocity, a constant tip Mach number, or a combination of the two. To obtain a mixture of <math>M_{ADV\_TIP}</math> and <math>V_{TIP}</math> the forward flight Mach number from 0 to a transition Mach number must have a corresponding value of referred <math>V_{TIP}</math>, where</p>
			$V_{TIP\_REF} = \frac{V_T}{\left( \frac{N_{II}}{N_{II\_MAX}} \right) \left( \frac{N_{II\_MAX}}{N_{II}^*} \right)}$
			<p><math>\frac{N_{II}}{N_{II\_MAX}}</math> is input LOC (0230), and</p>
			<p><math>\frac{N_{II\_MAX}}{N_{II}^*}</math> is input LOC (1223).</p>
			<p>From the forward flight transition Mach number to maximum Mach number specified by LOC (0028) corresponding values of advancing tip Mach number, <math>M_{T90REF}</math>, must be input.</p>
$(N_{II\_MAX} / N_{II}^*)$ 1223		A2MAX	Power turbine speed limit ratio of maximum power turbine speed to power turbine speed at maximum static power, sea level, standard.

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$(N_{II}/\sqrt{\theta}N_{II}^*)$	1518-1565	ATWO (6,8)	Values of referred power turbine speed limit ratio, input as a function of referred temperature and Mach number.
$(N_{II}/N_{II\_MAX})_C$	0238	AN2CR	<p>Ratio of operating power turbine speed to maximum power turbine speed (input when sizing primary engines for cruise)</p> <p>If in cruise the rotor is slowed to a known velocity, <math>\left(\frac{N_{II}}{N_{II\_MAX}}\right)_C</math> can be determined from</p> $\left(\frac{N_{II}}{N_{II\_MAX}}\right)_C = \frac{V_{T\_OPERATING}}{\left(\frac{N_{II\_MAX}}{N_{II}^*}\right) V_T}$ <p>where <math>V_T</math> is input in LOC (0181), <math>\left(\frac{N_{II\_MAX}}{N_{II}^*}\right)</math> is in LOC (1223).</p> <p>Both tip speed schedule options should be used in this location if applicable.</p>
$(N_{II}/N_{II\_MAX})_i$	0247	AN2CR1	Ratio of operating power turbine speed to maximum power turbine speed (input when sizing auxiliary independent engines for cruise).
$(N_{II}/N_{II\_MAX})_{TO}$	0230	AN2TO	<p>Ratio of operating power turbine speed to maximum power turbine speed (input when sizing primary engines for takeoff).</p> <p>This value is set to obtain the desired operating tip velocity at takeoff from the equation</p> $\left(\frac{N_{II}}{N_{II\_MAX}}\right)_{TO} = \frac{V_{T\_OPERATING}}{\left(\frac{N_{II\_MAX}}{N_{II}^*}\right) V_T}$ <p>Specific range in nautical miles per pound.</p>

NMPP

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
((O/L)/D)	0132	DAM 8	Tandem rotor overlap/main rotor diameter ratio
OWE	2601	DAM 28	Operating weight empty (pounds)
PEHF	0491	PFET2(10)	Primary engine power fraction. Required when TOLIND = 2 and 4
$Q_{MAX}/Q^*$	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.
RHP			Rotor horsepower, does not include transmission or accessory power losses. $RHP = \frac{PAV_T^3 C_D}{550}$
$R_0$	0025	ROO	Initial range at start of mission (nautical miles)
$R_{MAX}$	0791-0961	RMAX	Range at end of cruise and/or descent
$R_{M_T}$	2608	RMI	Wing relief as percentage of GW
$R_N$			Fraction of total lift carried by rotor
AR	0771	DELR	Step size for cruise (nautical miles)
R/D	J951	RSREQ	Rate of descent (fpm)
$(Re/l)_1$	0328	DAM 27	Mean Reynolds number per foot for mission
$S_{HT}$	0117	DAM 3	Area of horizontal tail. Used when HTIND = 1
$S_W$	0101	DAM 1	Wing planform area (ft <sup>2</sup> )
$\frac{SHP_{MRX}}{SHP^*}$	0221	XMSMET	Ratio of main rotor drive system XMSN rating to maximum static sea level power

<u>Variable</u>	<u>Location</u>	<u>Fortra- Name</u>	<u>Description</u>
$\frac{SHP_{TRX}}{SHP^*}$	0225	TRXMSN	Ratio of tail rotor drive system XMSN rating maximum static sea level power
$SHP/\sqrt{SHP^*}$	1326- 1373	SHPAV	Referred power for turboshaft engine cycles
$\frac{SHP_{AUX}}{SHP^*_{AUX}}$	0226	TRXSNI	Ratio of auxiliary propulsion drive system XMSN rating to auxiliary propeller design power
$SHP^*_i$	0243	DAM 23	Auxiliary independent engine installed power (total for all engines)
$SHP^*_p$	0218	DAM 22	Primary engine installed power (total for all engines)
$SHP_{ACC}$	0224	DSHPAC	Accessory power losses (SHP)
$SHP_E/SHP^*$	0232	SHPTO	Ratio of design engine rating to maximum S.L. static (STD DAY) engine power
$\Delta S/S_{STR}$	0150	DSSTR	Ratio of incremental auxiliary independent engine nacelle strut planform area to auxiliary independent engine nacelle strut planform area
$\Delta S_{WET}$	0121	DSWET	Incremental wetted area of aircraft (ft <sup>2</sup> )
$\Delta S_{WET}/S_F$	0120	DLSWSW	Incremental wetted area of airplane ratioed to fuselage wetted area
$(T/A)_{NET}$	0700	DAM 17	Net tail rotor disc loading (psf)
TAS	0581	EMACH	True airspeed (knots)
$T_{AUX}/T_{TOT}$	0691	TXXTCL	Ratio of thrust produced by auxiliary propulsive device to total helicopter thrust required
TPEF	0315	TPEF	Tail fan aspect ratio effectiveness factor
TFI	1306	TFI	Turbine inlet temperature (flight idle power setting), or input on engine cycle sheets
TGI	1305	TGI	Turbine inlet temperature (ground idle power setting), or input on engine cycle sheets

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
TMAX	1309	MAX	Turbine inlet temperature (maximum power setting), or input on engine cycle sheets
TMIL	1308	TMIL	Turbine inlet temperature (military power setting), or input on engine cycle sheets
TNF	1307	TNRP	Turbine inlet temperature (normal power setting) or input on engine cycle sheets
T/W	0183	TVW	Configuration thrust/weight ratio (hover)
(T/W) <sub>D</sub>	0228	TVWD	Configuration design thrust/weight ratio (hover)
(T <sub>AUX</sub> /T <sub>TOT</sub> ) <sub>C</sub>	0239	TAUXCR	Ratio of thrust produced by auxiliary propulsive device to total helicopter thrust required. This value input as design point for sizing primary or auxiliary independent engines in cruise.
(T <sub>AUX</sub> /T <sub>TOT</sub> )		TAUXTT	Ratio of thrust produced by auxiliary propulsive device to total helicopter thrust required. This value is input when AUXIND LOC (0006) = 3,4 and SGIND = 3,4,5,6,11. If: <ul style="list-style-type: none"> <li>• T<sub>AUX</sub>/T &lt; 1000. input T<sub>AUX</sub>/T for each individual segment is used.</li> <li>• T<sub>AUX</sub>/T = 1000. input T<sub>AUX</sub>/T schedule, locations 1671-1692 are used.</li> <li>• T<sub>AUX</sub>/T = 2000. input T<sub>AUX</sub>/T schedule is used up to transition <math>\mu</math> indicated by LOC (1692). Above that <math>\mu</math> the T<sub>AUX</sub>/T corresponding to max rotor configuration L/D<sub>E</sub> is used. This option is used only when ROTIND &gt; 4, AUXIND &gt; 2.</li> </ul>

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			<p>In the preliminary design of the aircraft the user inputs the maximum velocity before auxiliary propulsion is supplemented (i.e.):</p> $\mu = \frac{V_{FWD}}{V_{T_{90}}} = \frac{\text{forward flight velocity}}{\text{tip velocity}}$ <p>where <math>V_{T_{90}} = a M_{T_{90}} - V_{FWD}</math></p> <p>and <math>a</math> = speed of sound at given atmospheric condition</p> <p><math>M_{T_{90}}</math> = constant tip Mach number at given atmospheric conditions.</p> <p>In a similar manner as above, <math>M_{MAX}</math> can be calculated using the maximum forward flight velocity in LOC (0029). At this point it is usually desired to have <math>T_{AUX}/T \geq 1.0</math> which would be input in the corresponding <math>T_{AUX}/T</math> location. Intermediate points of <math>\mu</math> are now calculated for various airspeeds, and corresponding values of <math>T_{AUX}/T</math> are proportionately input, or input as desired.</p>
$\Delta T_{in_{CE}}$	0237	ATMIY	Increment in ambient temperature for primary engine sizing at cruise condition ( $^{\circ}R$ )
$\Delta T_{in_{TO}}$	0229	TIN/	Increment in ambient temperature for engine sizing at takeoff conditions ( $^{\circ}R$ )
T/3	1300		Referred turbine temperature ( $^{\circ}R$ )
$t_0$	0026	STOO	Initial time at start of mission (hours)
$t_T$	0411	DELTT(10)	Incremental time for taxi (hours)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$t_H$	0551	STH(10)	Incremental time for hover (hours)
$t_L$	1081	STL	Incremental time for loiter (hours)
$t_{FW}$	1151	STFW	Incremental time for change of fuel weight (hours)
$t_{PW}$	1171	STPW	Incremental time for change of payload weight (hours)
$\Delta t_H$	0531	DELTH(10)	Step size for hover (hours)
$\Delta t_L$	1061	DELST	Step size for loiter (hours)
$(t/C)_R$	0105	TCR	Wing root thickness to chord ratio
$(t/C)_T$	0106	TCT	Wing tip thickness to chord ratio
$(t/C)_{HT}$	0114	TCHT	Horizontal tail mean thickness to chord ratio
$(t/C)_{VT}$	0137	TCVT	Vertical tail mean thickness to chord ratio
$(t/C)_{R_A}$	0157	TCRA	Aft rotor pylon root thickness to chord ratio
$(t/C)_{R_F}$	0152	TCRF	Forward rotor pylon root thickness to chord ratio
$(t/C)_{T_A}$	0158	TCTA	Aft rotor pylon tip thickness to chord ratio
$(t/C)_{T_F}$	0153	TCTF	Forward rotor pylon tip thickness to chord ratio
$(t/C)_{.25R}$	0180	TVCMR	Main rotor blade thickness to chord ratio @ .25 rotor radius
$V_C$	0236	VC	Design cruise speed for engine sizing (kts)
$V_{CEH1}$	0191	VCE1	Main rotor vertical R/C efficiency factors
$V_{CEH2}$	0192	VCE2	
$V_{DES}$	0141	VDES	Flight speed at which single rotor helicopter vertical tail is sized to provide complete directional stability in the event of the loss of the tail rotor (kt)



<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
V <sub>DIVE</sub>	0030	VDIVE	Dive speed (knots <del>RAS</del> )
V <sub>in</sub>	0731	VIN	True airspeed for during cruise segment CRSIND = 2 (kt)
V <sub>MAX</sub>	4250	VMAXP(10)	User inputs maximum velocity for general performance
V <sub>MO</sub>	0029	VMO	Maximum operating equivalent airspeed (kt)
(V <sub>R/C</sub> ) <sub>D</sub>	0233	VRCRC	Design vertical rate of climb (ft/min) used in sizing primary engines in hover
V <sub>R/C</sub>	0511	VRVC2(10)	Vertical rate of climb (ft/min)
V <sub>TIP REF</sub>			Main rotor design tip speed (pfs). Note: This is the tip speed corresponding to $N_{II} = N^*_{II}$
V <sub>TTR</sub>	0207	VTTR	Tail rotor design tip speed (hover) - (fps)
V <sub>TIP P</sub>			Propeller design tip speed (fps)
$\bar{V}_H$	0115	VBARH	Horizontal tail volume coefficient
$\Delta V$	4230	DELVP(10)	User inputs velocity increment for calculation and print out during general performance segment.
W <sub>APU</sub>	2694	WAPU	Auxiliary power unit weight (lb)
W <sub>AV</sub>			Avionics weight (lb)
W <sub>FE</sub>	2602	WFE	Weight of field equipment (lb)
W <sub>FUL</sub>	2603	WFUL	Weight of fixed useful load (lb)
W <sub>FURN</sub>	2693	WFURN	Furnishings and equipment weight (lb)
W <sub>GO</sub>	0023	WGOO	Initial gross weight at start of mission (lb)
W <sub>I</sub>	109	WI	Weight of inboard stores

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$W_O$	2610	WZ	Weight of outboard store
$W_{PL}$	2604	WPL	Weight of payload (lb)
$W/A$	0173	DAM 14	Disc loading (g.f)
$W/S$	0102	WS	Wing loading (psf)
$W_{MAX}/W^*$	1220	WMAX	Engine flow limit - ratio of maximum fuel flow to fuel flow at maximum static power, sea level, standard
$\Delta W_{FC}$	2605	DELWFC	Flight controls group incremental weights (lb)
$\Delta W_P$	2606	DELWP	Propulsion group incremental weight (lb)
$\Delta W_{ST}$	2607	DELWST	Structures group incremental weight (lb)
$\Delta W_f$	1141	DLTAWF	Increment in weight during change of fuel weight subroutine (lb)
$\Delta W_{PL}$	1161	DELWPL	Increment in payload weight during change of payload weight subroutine (lb)
$\delta W_f$	0033	DELWF	Fuel required additive reserve f
$W_F$	0123	WFL	Width of fuselage (ft)
$\dot{W}_f/\delta\sqrt{\theta}F_N^*$	1390	WDOT	Referred fuel flow for turbojet/fan engine cycles
$\dot{W}_f/\delta\sqrt{\theta}SHP^*$	1437		Referred fuel flow rate for primary engines (turboshaft engine cycles, lb/hr/SHP*)
$X_{ADS}/\Delta X_{ADS}$	2658	XADSX	Auxiliary independent drive system C.G. position aft of nose as a fraction of the distance between the auxiliary independent engine and the propeller

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$X_{AE}/l_B$	2687	XAELB	Auxiliary independent engine C.G. position aft of nose as a fraction of body length
$X_{APU}/l_B$	2686	XAPUB	Auxiliary power unit C.G. position aft of nose as a fraction of body length
$X_{AR}$	0251	XAR	Propeller blade attachment point as a fraction of propeller radius
$X_{AR}/l_{TB}$	2689	XARLB	Propeller position aft of a body/tail boom junction as a fraction of tail boom length
$X_{ASC}$	2691	XASCB	Auxiliary rotor (propeller) systems controls C.G. position aft of nose as a fraction of body length
$X_{AV}/l_B$	2684	XAVLB	Avionics C.G. position aft of nose as a fraction of body length
$X_{CG}/l_B$	2678	XCGLB	Single rotor fuselage (minus tail boom) C.G. position aft of nose as a fraction of body length
$X_{CMR}$	0178	XC	Main rotor blade cutout (end of blade shank, beginning of rotor airfoil sections) position as a fraction of rotor radius
$X_{CTR}$	0205	XCTR	Tail rotor blade cutout (end of blade shank, beginning of rotor airfoil sections) position as a fraction of rotor radius
$X_{FURN}/l_B$	2685	XFURNB	Furnishings and equipment C.G. position aft of nose as a fraction of body length
$X/L$	3503	YOLL(	Propulsive force/lift ratio input in rotor performance $m_e$ (ROTINT = 4.5)
$X_M/l_B$	0128	DAM 7	Ratio of distance from tip of nose to rotor shaft, $X_M$ main fuselage length (B) (single rotor helicopter)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$X_{MG}/L_B$	2681	XMGLB	Main landing gear position aft of nose as a fraction of body length
$X_{MP}$	0179	XMR	Main rotor blade attachment point as a fraction of rotor radius
$X_{NG}/L_B$	2680	XNGLB	Nose landing gear position aft of nose as a fraction of body length
$X_{PE}/L_B$	2682	XPELB	Primary engine C.G. position aft of nose as a fraction of body length
$X_{PDS}/L_{X_P}$	2683	XPDSX	Primary drive system C.G. position aft of nose as a fraction of the distance between main and tail rotor centers
$X_{SC}/L_B$	2690	XSCLB	Rotor system controls C.G. position aft of nose as a fraction of body length
$X_{TR}$	0206	XI	Tail rotor blade attachment point as a fraction of rotor radius
$X_{L_1}$	0133	DAM 9	Distance of forward rotor center from aircraft nose as a fraction of aircraft nose section length
$X_2/L_T$	0134	DAM 10	Distance from aft rotor center from aircraft tail cone as a fraction of aircraft tail
$Y_{CL}$	0119	YCL	Clearance from inboard propeller tip to inboard propeller tip across fuselage (ft)
$z_1$	0142	AZETA1	Primary engine nacelle dimensional factors
$z_2$	0143	AZETA2	
$z_3$	0144	AZETA3	

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$z_4$	0146	AZETA4	} Auxiliary independent engine nacelle dimensional factors
$z_5$	0147	AZETA5	
$z_6$	0148	AZETA6	
$\alpha D/L$			Angle of total rotor thrust (lift plus propulsive force) vector with respect to a line perpendicular to the A/C flight path (printed out in climb, cruise, descent, loiter)
$\alpha LO$			Wing airfoil section angle of zero lift
$\delta$		DELTA	Ambient pressure ratio, tabular function of altitude
$\Delta C/4$	0107	DMLC4	Sweep angle of wing quarter chord (degrees)
$\lambda$	0108	CFC	Taper ratio of wing
$\lambda_{AP}$	0160	SLMAP	Taper ratio of aft rotor pylon
$\lambda_{FP}$	0155	SLMFP	Taper ratio of forward rotor pylon
$\lambda_H$	0116	SLMH	Taper ratio of horizontal tail
$\lambda_{VT}$	0136	SLMVT	Taper ratio of vertical tail
$\sigma_{PEF}$	3422	SREFL	Reference rotor solidity ratio
$\eta_{P3}$	0254	ETAP 3	Propeller propulsive efficiency for SGTIND = 3
$\eta_{P5}$	0255	ETAP 5	Propeller propulsive efficiency for SGTIND = 5
$\eta_{P4}$	0272	TB8AP4(10)	Propeller propulsive efficiency for SGTIND = 4, 6 tabular function of Mach number
$\eta_T$	0223	ETAT	Transmission efficiency
$\eta_{T_{AUX}}$	0252	ETATI	Transmission efficiency (auxiliary drive system)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
$\zeta_{VT}$	1138	DAM 5	Vertical tail span overlap distance/tail rotor radius ratio - input as a function of tail rotor radius
$\zeta_2$	0116	ZETA 1	Propeller over wing tip overlap fraction of radius
$\theta$	1901	TBTBE(10)	Ambient temperature ratio, tabular function of altitude
$\theta_{TMR}$	0177	THSTMP	Main rotor blade twist (degrees)
$\theta_{TREF}$	3423	TREFL	Reference rotor twist
$\theta_{TTR}$	0204	THETTR	Tail rotor blade twist (degrees)
$\xi_4$	1304	XI4	Primary engine dimensional factor
$\dot{\psi}$	0210	YAWDSZ	Helicopter yaw rate, rad/sec
$\ddot{\psi}$	0209	YAWSZ	Helicopter yaw acceleration, rad/sec <sup>2</sup>
$\sigma_{MR}$	0175	DAM 16	Main rotor solidity ( $\sigma = bc/\pi R$ )
$\sigma_{TR}$	0202	DAM 19	Tail rotor solidity ( $\sigma = bc/\pi R$ )
$\mu$	0354	AMURT(7)	Rotor forward flight advance ratio ( $\mu = V_{FPS}/V_{TIP}$ )

### 5.3.2 Program Indicators

#### Option Indicators

OPTIND	0001	OPTIND	0 = Calculate aircraft weight empty for a given gross weight and geometry
			1 = size aircraft
			2 = calculate performance (specify initial gross weight)
			3 = calculate performance (specify operating weight empty)

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
OPTIONAL PRINT	0002	TNIRPK	0 = standard print 1 = detailed print
<u>Propulsion Indicators</u>			
AIPIND	0012	AIPIND	1 = single gas generator connected to main rotor and auxiliary propulsion 2 = independent gas generators
ENGIND	0013	ENGIND	0 = turboshaft (power producing) cycle 1 = turbofan or turbojet (thrust producing) cycle
ESCIND	0022	ESCIND	1 = program will size engines for takeoff only 2 = program will size engines for more critical choice of takeoff or cruise
<u>NOTE:</u> ESCIND is applicable only if FIXIND = 1.0			
FANOP <sub>C</sub>	0284	FANOPC	0 = all rotor/fan operating in cruise (nominal value) 1 = tail rotor/fan shut down in cruise
FANOP <sub>H</sub>	0283	FANOPH	0 = tail rotor/fan operating in hover (nominal value) 1 = tail rotor/fan shut down in hover.
FIXIND	0008	FIXIND	0 = fixed size engines, user inputs maximum power 1 = rubberized engines, program will calculate max power
FIXINDI	0014	FXINDI	0 = user inputs fixed size auxiliary independent

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			engines
			1 = program sizes auxiliary independent engines to meet cruise requirements
N1IND, N1INDI	1202 2202	AN1IND AN1NDI	0 = no $N_I$ limit 1 = $N_I$ limit
N1θIND, N1θINDI	1203 2203	AN3IND AN3NDI	0 = no $N_I/\sqrt{\theta_1}$ limit 1 = $N_I/\sqrt{\theta_1}$ limit
N2IND N2INDI	1204 2204	AN2IND AN2NDI	0 = no $N_{II}$ limit, engine operating at optimum $N_{II}$ 1 = $N_{II}$ limit, engine operating at known value of $N_{II}$ (in general, nonoptimum) 2 = $N_{II}$ cutoff, nonoptimum $N_{II}$ variation
POWIND			0 = maximum engine rating 1 = military engine rating 2 = normal engine rating
QIND QINDI	1205 2205	QIND	0 = no torque limit 1 = torque limit 2 = torque limit imposed on auxiliary propulsion XMSN
RNOIND RNOINDI	1206 2206	RNOIND RNONDI	0 = no Reynold's number corrections 1 = Reynold's number corrections
WDTIND WDTINDI	1201 2201	WDTIND WDTNDI	0 = no fuel flow cutoff 1 = fuel flow limit
ROTIND	0009	ROTIND	1 = performance calculated by short method



<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			2 = rotor map input, corrections applied
			3 = rotor map input, no corrections applied
			4 = rotor map (L/D <sub>g</sub> ) input, corrections applied
			5 = rotor map input, rotor operated at maximum rotor L/D <sub>g</sub> with TAUX/T as output
			6 = rotor map input, rotor operated at maximum configuration L/D <sub>g</sub> with TAUX/T as output
npIND	0253	ETAIND	0 = user specifies "point" propeller efficiencies for climb, cruise, and descent
			1 = user inputs propeller performance map
			2 = propeller performance automatically calculated within program
<u>Aerodynamic Indicators</u>			
DRGIND	0003	DRGIND	1 = drag build up by component, Reynold's number scaling
			2 = drag trend by input GW/P <sub>e</sub> versus GW
OSWIND	0004	OSWIND	0 = user inputs Oswald's efficiency, (e)
			1 = program calculates Oswald's efficiency
<u>Sizing Indicators</u>			
APHIND	0021	APHIND	1 =input aft pylon height

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			2 = input gap/stagger ratio
NOTE: Input APHIND only if CNFIND = 2.0			
AUXIND	0006	AUXIND	1 = pure helicopter 2 = including wings (only) 3 = including auxiliary propulsion (only) 4 = compound helicopter (wings and auxiliary propulsion)
b <sub>w</sub> IND	0011	BWIND	1 = input span/diameter ratio 2 = input wing aspect ratio 3 = determined for propeller clearance
CNFIND	0005	CNFIND	1 = single rotor 2 = tandem rotor
FDMIND	0020	FDMIND	1 = input overlap and rotor positions 2 = input overlap and cabin length 3 = input cabin length and rotor positions
HTIND	0018	HTIND	0 = no horizontal tail 1 = input fixed size tail 2 = input tail volume coefficient
MRPIND	0019	EMRPND	0 = user inputs main rotor placement (single rotor) 1 = program calculates main rotor positions based on simple mass balance 2 = same as 1, except that in the case of a compound helicopter, the auxiliary

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			drive system, propeller and auxiliary independent engines (if any) are assumed to be located on the wing
RDMIND	0007	RDMIND	1 = input main rotor diameter 2 = input $W/A, \sigma$ 3 = input diameter, $C_T/\sigma$ 4 = input $W/A, C_T/\sigma$
S <sub>W</sub> IND	0010	SWIND	1 = input wing area 2 = input wing loading 3 = size for maneuver
TRDIND	0015	TRDIND	0 = no tail rotor 1 = use trend of diameter main/diameter tail = $f_n(W/A)_{MAIN}$ 2 = input diameter 3 = input T/A
TRSIND	0016	TRSIND	1 = input $\sigma$ 2 = input $C_T/\sigma$
VTFIND	0017	VTFIND	1 = input aspect ratio and tail fin overlap 2 = input directional stability required and tail fin overlap 3 = input directional stability required and aspect ratio
XMSNIND	0220	XMSND	0 = main, tail, and auxiliary drive system ratings specified as fraction of primary engine installed power (in the case of a compound helicopter with auxiliary independent propulsion, the auxiliary independent drive system rating is specified as a fraction of the auxiliary

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			independent engine installed power)
			1 = the drive system ratings calculated are equal to the product of the applicable multiplicative factors ( $SHP_{MRX}/SHP_{MR}^*$ , $SHP_{TRX}/SHP_{TRP}^*$ , $SHP_{AUX}/SHP_{AUX}^*$ ) and the component (main, tail, and auxiliary) power obtained from the proportional split (based on the power required) of the total sea level standard maximum (installed) engine power.
			2 = Main, tail, and auxiliary drive system ratings specified at fraction of power required to hover or cruise at design conditions (more critical of the two conditions is selected)
			3 = Same as 2, except the most critical of the two design conditions is compared to the drive system rating required at an alternate payload/gross weight hover at the design point condition. The most critical of these three conditions is selected.
			4 = Same as 2, except that tail rotor drive system rating is selected independently of the main rotor drive system to match a specified fraction of the power required to hover or cruise at design conditions (more critical of the two conditions is selected)
			5 = Same as 3, except that the tail rotor drive system rating is selected independ-

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			ently of the main rotor drive system as in 4, and the most critical of the two design conditions is compared to the tail rotor drive system rating required at an alternate payload/gross weight: hover at the design point conditions. The most critical of these three conditions is selected.

Flight Path Control Indicators

$h_{OPT}^{IND}$	0027	HOPTIN	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
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Mission Performance Indicators

CLMIND	0571	CLMIND	1 = climb at maximum R/C 2 = climb at constant EAS 3 = climb at constant Mach No. 4 = climb at constant TAS
CRSIND	0721	CRSIND	1 = cruise at cruise power 2 = cruise at constant TAS 3 = cruise at speed for best specific range 4 = cruise at speed for 99% of best specific range 5 = cruise - climb (constant W/S) at speed for best specific range 6 = cruise - climb (constant W/S) at speed for 99% of best specific range

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
DESIND	0873	DESIND	1 = descend at constant TAS 2 = descend at constant EAS 3 = descend at constant Mach No.
GWIND	4140	GWIND	1 = user inputs difference in gross weight 2 = user inputs gross weight
RMAXND	0891	RMAXND	0 = descent flight path ends at specified terminal range (cruise segment must be input previous to descent) 1 = checks specified terminal range, if predicted flight path will end beyond specified terminal range value, spiral descent path assumed at that point, if predicted flight path ends before reaching specified terminal range point, program prints SHALLOWER DESCENT REQUIRED 2 = descent ends at specified minimum altitude, terminal range requirement not considered 3 = fuel used and time required for descent calculated, but no range credit given (i.e., spiral descent path)
SGTIND	0035 to 0084	SGTIND	0 = end of mission 1 = taxi 2 = takeoff, hover and landing 3 = climb 4 = cruise 5 = descent 6 = loiter

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
			7 = change of fuel weight
			8 = change of payload weight
			9 = transfer altitude
			11 = general performance
			100 = end of case
NOTE: Segments 1 through 6 can be used for reserve fuel calculations (gross weight reset following segment) by inputting 10X SGTIND; i.e., SGTIND = 10, 20, 30, 40, 50, or 60.			
TOLIND	0461	TOLIND	1 = user inputs required thrust/weight ratio and $V_{R/C}$
			2 = user inputs required fractions of maximum power and $V_{R/C}$
			3 = same as 1, but analysis includes hover-in-ground effect
			4 = same as 2, but analysis includes hover-in-ground effect
WGTIND	1191	WGTIND	0 = restriction on maximum aircraft weight, weight cannot exceed gross weight
			1 = no restriction on aircraft weight (will only apply when running performance)

#### Atmosphere Indicator

<u>Variable</u>	<u>Location</u>	<u>Fortran Name</u>	<u>Description</u>
ATMIND		ATMIND	0 = standard atmosphere
			1 = non-standard atmosphere, user inputs single point value for increment in ambient temperature above standard day value
			2 = non-standard atmosphere, user inputs table of temperature ratio as a function of altitude

#### NOTE:

This indicator can be found in the input sheets for SGTIND = 1, 2, 3, 4, 5, 6, and 11

### 5.3.3 FORTRAN VARIABLES

<u>FORTRAN VARIABLE</u>	<u>PROGRAM VARIABLE</u>	<u>LOCATION</u>
AF	AF/BLADE	0257
AIPIND	AIPIND	0012
AKFPO	KFED	0313
AKP	Δ F.M.	0195
AM1(6)	VALUES OF	1448 - 1453
AM2(6)	VALUES OF	1512 - 1517
ALMAX	$N_{I \text{ MAX}} / \sqrt{N_I}$	1221
A2MAX	$N_{II \text{ MAX}} / \sqrt{N_{II}^*}$	1223
A3MAX	$(N_I / \sqrt{\theta} / \sqrt{N_I^*}) \text{ MAX}$	1222
ALMAXI	$N_{\text{MAX}} / \sqrt{N_{I^*}}$	2221
A2MAXI	$N_{II \text{ MAX}} / \sqrt{N_{II}}$	2223
A3MAXI	$(N_I / \sqrt{\theta} / \sqrt{N_I^*}) \text{ MAX}$	2222
AMSMP(6)	VALUES OF M	1320 - 1325
AMULD(10)	VALUES OF M'	1280 - 1289
AMURT(7)	$\mu(7)$	0354 - 0360
AMURTN	NO. OF	0348
AMUTZ(10)	VALUES OF $\mu(10)$	1672 - 1681
AMVZ(6)	VALUES OF $\mu$	2781 - 2788
AMWD(6)	VALUES OF $\mu$	1384 - 1389
AN2CR	$(N_{II} / \sqrt{N_{II \text{ MAX}}})^C$	0238
AN2CKI	$(N_{II} / \sqrt{N_{II \text{ MAX}}})^I$	0247



ANCT1	NO. OF C <sub>T</sub> /s	2704
ANCT2	NO. OF C <sub>2</sub> /s	2789
ANCT1L	NO. OF C <sub>1</sub> /s	3424
ANCTT	NO. OF C <sub>T</sub>	1614
ANOLDE	NO. OF PAIRS IN u - L/D <sub>E</sub> TABLE	1279
AN1IND	N1IND	1202
AN2IND	N2IND	1204
AN3IND	N16IND	1203
AN2M1(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> )	0441 - 0449
AN2M2(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (PRI. ENG.)	0541 - 0550
AN2M3(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (PRI. ENG.)	0651 - 0660
AN2M4(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (PRI. ENG.)	0801 - 0810
AN2M5(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (PRI. ENG.)	0971 - 0980
AN2M6(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (PRI. ENG.)	1071 - 1080
AN2M7(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (PRI. ENG.)	4220 - 4229
AN2M3I(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (AUX. ENG.)	0671 - 0680
AN2M4I(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (AUX. ENG.)	0821 - 0830
AN2M5I(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (AUX. ENG.)	0991 - 1000
AN2M6I(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (AUX. ENG.)	1091 - 1100
AN2M7I(10)	(N <sub>II</sub> /N <sub>II</sub> <sup>MAX</sup> ) (AUX. ENG.)	4240 - 4249

ANNU2I	NO. OF ADVANCE RATIOS	3520
AN1NDI	N1INDI	2202
AN2NDI	N2INDI	2204
AN3NDI	N1 INDI	2203
A2NO(10)	VALUES OF $(N_{II}/N_{II_{OPT}})$	1238 - 1247
A2NOI(10)	VALUES OF $(N_{II}/N_{II_{OPT}})$	2238 - 2247
AN2TO	$(N_{II}/N_{II_{OPT}})$ TO	0230
ANXOLL	NO. OF PROPULSIVE FORCE/LIFT RATIOS	3502
AONE(6.8)		1454 - 1501
ARAP	$AR_{AP}$	0159
ARFP	$AR_{FP}$	0154
AHT	$AR_{HT}$	0112
ATCRSE	$\Delta T_{INC}$	0186
ATMIN1(10)	ATMIN1	0401 - 0410
ATMIN2(10)	ATMIN2	0481 - 0490
ATMIN3(10)	ATMIN3	0591 - 0600
ATMIN4(10)	ATMIN4	0741 - 0750
ATMIN5(10)	ATMIN5	0911 - 0920
ATMIN6(10)	ATMIN6	1031 - 1040
ATMIN7(10)	ATMIN7	4160 - 4169
ATMIY	ATMIY	0237

ATWO(6,8)	$(N_{II}/N_{II}^* \sqrt{\theta})$	1516 - 1565
AUXIND	AUXIND	0006
AZETA1	$n_1$	0147
AZETA2	$n_2$	0143
AZETA3	$n_3$	0144
AZETA4	$n_4$	0146
AZETA5	$n_5$	0147
AZETA6	$n_6$	0148
BLDN	NO. OF BLADES	0258
BMR	$b_{MR}$	0176
BNSDNI	$b_{NS/dNI}$	0151
BREF	$b_{REF}$	2701
BREFL	$b_{REF}$	3421
BTR	$b_{TR}$	0203
BWD	$b_{W/D}$	0103
BWIND	BWIND	0011
CDAP	$C_{DAP}$	0303
CDBB	$C_{DB}$	1609
CDBO	$C_{DBB}$	1603
CDCSMR	$C_{DCSMR}$	0305
CDCSTR	$C_{DCSTR}$	0307
CDFF	$C_{DFF}$	0304
CDHT	$C_{D_{Tii}}$	0302
CDN	$C_{DN}$	0309
CDNI	$C_{DNI}$	0310
CDNS	$C_{DNS}$	0311

CDSEMR	$C_{DSEMR}$	0308
CDSETR	$C_{DSETR}$	0308
CDVT	$C_{DVTi}$	0391
CFC	$C_{F/C}$	0109
CKAP	$K_{AP}$	0219
CKC1	$K_{C1}$	1610
CKC2	$K_{C2}$	1611
CKC3	$K_{C3}$	1612
CKC4	$K_{C4}$	1613
CKC5	$K_{C5}$	1614
CKF	$K_F$	0326
CKFF	$K_{FF}$	0054
CKFP	$K_{FP}$	0320
CKH1	$K_{H1}$	1604
CKH2	$K_{H2}$	1605
CKH3	$K_{H3}$	1606
CKH4	$K_{H4}$	1607
CKBCVT(10)	VALUES OF $K_{BOV_A}$	1627 - 1636
CKHPIM	$K_{HPIM}$	0321
CKHPIT	$K_{HPIT}$	0322
CKHT	$K_{HT}$	0318
CKI	$K_I$	0032
CKN	$K_N$	0323
CKNI	$K_{NI}$	0324
CKNS	$K_{NS}$	0325
CKTRS	$K_{TRS}$	0215

CKVT	$K_{VT}$	0317
CKW	$K_W$	0327
CLAPH	$C_{La}$	0329
CLD	$C_{LD}$	0111
CLDES	$C_{LDES}$	0140
CLDP	$C_{LDP}$	0240
CLEYE	$C_{Li}$	0251
CLFIN	$C_{LFIN}$	0216
CLMIND(10)	$C_{LMIND}$	0571 - 0580
CLWCL(10)	$C_{LWING}$	3601 - 0610
CLWCR(10)	$C_{LWING}$	0751 - 0760
CLWDS(10)	$C_{LW}$	0901 - 0910
CLWLT(10)	$C_{LW}$	1011 - 1020
CLWP(10)	$C_{LWING}$	4170 - 4179
CNFIND	$C_{NFIND}$	0006
CPPNO	NO. OF PROP THRUST COEFFICIENTS(CT)	1722
CPPROP(20)	VALUES OF CT	1723 - 1742
CRSIND(10)	CRSIND	0721 - 0730
CSX2(10)	VALUES OF $C_{X/\sigma}$	2801 - 2810
CT1(10)	VALUES OF $C_{T/\sigma}$	2705 - 2714
CT2(10)	VALUES OF $C_{T/\sigma}$	2790 - 2799
CTB(10, )	$C_{PB/\sigma}$ FOR COMBINATIONS OF $C_{T/\sigma}$ & MIP	2722 - 2791
CT1L(10)	VALUES OF $C_{T/\sigma}$	3425 - 3434
CT2L(10)	VALUES OF $C_{T/\sigma}$	3510 - 3519
CTPROP(20,20)	PROPELLER THRUST COEFFICIENT	1743 - 2142

CIPS(10,10,6)	ROTOR PROPULSIVE COEFFICIENT	3211 - 3410
CIPS2(10,10,6)	ROTOR PROPULSIVE FORCE	2011 - 2910
CIPS2(10,10,6)	ROTOR PROPULSIVE COEFFICIENT	3011 - 3110
CIPSTB(7.5)	VALUE OF $C_T / \sigma$	0361 - 0395
CTSIGB	$(C_{m/\sigma})_B$	0182
CTSRSZ	$(C_{T/\sigma})_{SR}$	0187
CTT(10)	VALUES OF $C_T$	1626
CTTLSZ	$(C_{T/\sigma})_{DES}$	0208
CYCAUX	AUX. PROPULSION ENGINE CYCLE NO.	0242
CYCPRL	CYCLE NO.	1301
CYCPRP	PRI. ENGINE CYCLE NO.	0217
CYPROP	PROP TABLE NO.	0260
CYSGM	NO. OF $C_{x/\sigma}$	0347
CEVSG(5)	VALUES OF $C_{x/\sigma}$	0349 - 0353
DAM1	$S_{x_1}$	0101
DAM2	AR	0104
DAM3	$S_{HT}$	0117
DAM5	$S_{VT}$	0138
DAM6	$Z_C$	0126
DAM7	$(X_H/l_B)$	0128
DAM8	$((O/L)/D)$	0132
DAM9	$(\Delta X_1/l_P)$	0133
DAM10	$(\Delta X_2/l_T)$	0134

DAM11	$\Delta R_{VT}$	0135
DAM12	$K_z$ or $D_{VT}$	0139
DAM13	$h_{PZ}$	0161
DAM14	W/A	0173
DAM15	$D_{MR}$	0174
DAM16	$T_{MR}$	0175
DAM17	(T/A) NET	0200
DAM18	$D_{TR}$	0201
DAM19	$\sigma_{TR}$	0202
DAM20	$(C_{TG}/C_{TNET})$	0211
DAM22	$SHP^*_p$	0218
DAM23	$SHP^*_i$	0243
DAM24	$F^*_N$	0244
DAM25	DIA.	0250
DAM26	e	0314
DAM27	(Re/l)i	0328
DAM28	OWE	2601
DCGR	$\Delta CG_R$	2679
D 2FDS(10)	$\Delta F_{e_{DSC}}$	0981 - 0990
DELCC	$\Delta C.G.$	2623
DELFCCL(10)	$\Delta F_{e_{CL}}(FT^2)$	0661 - 0670
DELFCR(10)	$\Delta F_{e_{CR}}$	0811 - 0820
DELPEP(10)	$\Delta F_{e_{CR}}$	4190 - 4199
DELFLT	$\Delta F_{e_h}$	1131 - 1140
DELFM	$K_D$ DESCENT	0194
DELM3(10)	$\Delta h$	0621 - 0630

DELM5(10)	$\Delta h$	0921 - 0930
DELR(10)	$\Delta R(\text{MM})$	0771 - 0780
DELST(10)	$\Delta t_L(\text{HR})$	1061 - 1070
DELTH(10)	$\Delta t_H(\text{HR})$	0531 - 0540
DELT(10)	$\Delta t_T(\text{HR})$	0411 - 0420
DELWF	$\Delta W_F$	0033
DELWFC	$\Delta W_{FC}$	2605
DELWP	$\Delta W_P$	2606
DELWPL(10)	$\Delta W_{PL}$	1161 - 1170
DELWST	$\Delta W_{ST}$	2607
DELVP(10)	$\Delta V$	4230 - 4239
DESIND(10)	DESIND	0871 - 0880
DI	$d_i$	2611
DK3	$K_3$	2656
DK4	$K_4$	2657
DLSWSW	SWET/SF	0120
DLTAFE	$\Delta F_o(\text{FT}^2)$	0316
DLTAWF(10)	$\Delta W_F$	1141 - 1150
DMLC4	$\Delta C/4$	0107
DRGIND	DRGIND	0003
DSHPAC	$\Delta \text{SHP}_{\text{ACC}}$	0224
DSKTBB	$K_{\text{TBBS}}$	2696
DSSTR	$\Delta S/S_{\text{STR}}$	0150
DTBCDTB	$d_{\text{TIB}}/d_{\text{TB}}$	0130
DTRODF	$D_{\text{TRE}}^L \text{FAN}$	0282
DZ	$d_o$	2612



EAS5(10)	MACH	0251 - 0890
ELDP	(1/d) p	0789
ELDT	(1/d) T	0815
ELF	LF	2627
ELLEA	<sup>1</sup> AIA/ <sup>1</sup> CA	0149
ELLEP	<sup>2</sup> AIP/ <sup>1</sup> C	0145
ELRW	<sup>2</sup> RW	0127
ELTDS	<sup>1</sup> TB/ <sup>d</sup> TS	0124
ELTHP	<sup>2</sup> TH	0113
EMACH(10)	MACH	0581 - 0590
EMDC	M <sub>DO</sub>	1615
EMDBO	M <sub>BO</sub>	1608
EMLF	M <sub>LF</sub>	0031
EMNO	M <sub>NO</sub>	0029
EMRPND	MRPND	0019
EMTIP(6)	VALUES OF M <sub>TIP</sub>	2716 - 2771
EMTIPL(6)	VALUES OF M <sub>TIP</sub>	3436 - 3441
EMCTZL	NO. OF ROTOR LIFT COEFFICIENTS	3509
ENGIND	ENGIND	0013
EMMCXS	NO. OF ROTOR PROPULSIVE THRUST COEFFICIENTS	2800
EMMTPL	NO. OF MTIP'S	3435
EMMTPS	NO. OF MTIP'S	2715
EMMUS	NO. OF ADVANCE RATIO'S	2782
ENP	N <sub>p</sub>	0219

ENPCL	$N_{PSD_{CL}}$	0681 - 0590
ENPCLI	$N_{PSDI_{CL}}$	0701 - 0710
ENPCR(10)	$N_{PSD_{CR}}$	0831 - 0840
ENPCRI(10)	$N_{PSDI_{CR}}$	0851 - 0860
ENPDS(10)	$N_{PSD_{DSC}}$	1001 - 1010
ENPDSI(10)	$N_{PSDI_{DSC}}$	1021 - 1030
ENPI	$N_P$	0245
ENPLT(10)	$N_{PSD_{LOITER}}$	1101 - 1170
ENPLTI(10)	$N_{PSDI_{LOITER}}$	1121 - 1130
ENPSD	$N_{PSD}$	0231
ENPSD	$(N_{PSD})^C$	0241
ENR	$N_R$	0172
ENRI	NO. OF PROPS	0248
ENRTSZ	$N$	0190
ETAIND	$n_{IND}$ $P$	0253
ETAP3	$n_{P3}$	0254
ETAP5	$n_{P5}$	0255
ETAP4N	NO. OF PAIRS IN $n_{P4}$ TABLE	0261
ETAT	$n_T$	0223
ETATI	$n_{AUX}$ $P$	0252
FANOPC	FANOP <sub>C</sub>	0284
FANOPH	FANOP <sub>H</sub>	0283
FIXIND	FIXIND	0068
FXINDI	FXINDI	0014
FML(10,6)	INPUT VALUES OF F.M. FOR COMBINATIONS OF CT/G AND MTIP	3442 - 3501

C	$g_{MR/TR}$	0214
GREQSZ	$g_{REQM'T}$	0188
GROTSZ	$g(\text{ROTOR})$	0189
GS	$g/S$	0162
GWFE	$G^W/FE$	0312
GWIND(10)	GWIND	4140 - 4149
GWP(10)	GW	4150 - 4159
HBFDZ(10)	$h_{BF/D}$	0471 - 0480
HC	$h_C$	0235
HCRSZ	$h_{C(C)}$	0185
HFIN(10)	TRANSFER ALTITUDE	1181 - 1190
HMAX(10)	$h_{MAX}$	0641 - 0650
HMIN(10)	$h_{MIN}$	0941 - 0950
HOP(10)	ALTITUDE	4200 - 4209
HOPTIN	$h_{OPT IND}$	0027
HP1	$h_{P_1}$	0156
HPHF	$h/h_f$	0110
KAIP	$K_{AIF}$	2633
NDTIND	WDTIND	0201
OPTIND	OPTIND	0001
OSWIND	OSWIND	0004
PFETZ(10)	PEHF	0491 - 0500
PN2(10)	VALUES OF $K_{PN}$	1248 - 1257
PNZI(10)	VALUES OF $K_{PN}$	2248 - 2257
POWCLI	POWIND	0631 - 0640

POWCRI	POWIND	0781 - 0790
POWES	POWIND	0234
POWESI	POWIND	0146
PRN(10)	VALUES OF $\frac{N_I}{N_I^*} \frac{D}{v_1}$	1207 - 1216
PRNI(10)	VALUES OF $\frac{N_I}{N_I^*} \frac{D}{v_1}$	2207 - 2216
PROPCY	PROP. TABLE NO.	1700
QIND	QIND	1205
QMAX	QMAX/Q*	1224
QMAXI	QMAX/Q*	2224
QNDI	QINDI	2205
RCYCNO	ROTOR CYCLE NO.	0171
KDMIND	KDMIND	0007
RMAPNL	ROTOR MAP NO.	3420
RMAPNO	ROTOR MAP NO.	2700
RMAX(10)	R <sub>MAX</sub>	0791 - 0800
RMAX5(10)	R <sub>MAX</sub>	0961 - 0970
RMAXND(10)	R <sub>MAX</sub> IND	0891 - 0900
RMT	RM <sub>I</sub>	2608
RNE(10)	VALUES OF K <sub>PR</sub>	1225 - 1234
RNEI(10)	VALUES OF K <sub>PR</sub>	2225 - 2234
RNOIND	RNOIND	1206
RNONDI	RNOINDI	2206
ROTCYC	ROTOR CYCLE NO.	1601
ROTIND	ROTIND	0009
ROTMNO	ROTOR MAP NO.	0170

ROTPRE	ROTOR PROPULSIVE EFFICIENCY INDICATOR	1637
RSREQ(10)	R/D	0951 - 0960
SHPAV (6, 8)	$F_N / F_N^{*6}$	1326 - 1373
SHPTO	SHPE/SHP	0232
SK1	$K_1$	2654
SK2	$K_2$	2655
SK3	$K_3$	1302
SK4	$K_4$	1303
SK5	$K_5$	2658
SK6	$K_6$	2659
SK7	$K_7$	2660
SK8	$K_8$	2661
SK9	$K_9$	2662
SK10	$K_{10}$	2663
SK11	$K_{11}$	2664
SK12	$K_{12}$	2665
SK13	$K_{13}$	2666
SK14	$K_{14}$	2667
SK15	$K_{15}$	2668
SK16	$K_{16}$	2669
SK17	$K_{17}$	2670
SK18	$K_{18}$	2671
SK19	$K_{19}$	2672
SK20	$K_{20}$	2673
SKADS	$K_{ADS}$	2649

SKADZ	K ADSZ	2650
SKAIE	K AEI	2653
SKAIA	K AIA	2635
SKAMD	K AMD	2640
SKAR	K AR	2643
SKB	K B	2622
SKBLEFD	K BLEFD	2641
SKCC	K CC	2613
SKCLF	K CLF	2631
SKFLS	K FLS	2695
SKFS	K FS	2651
SKFW	K FW	2616
SKHT	K HT	2630
SKLG	K LG	2624
SKLTPY	K ALT PAYL	0222
SKMC	K MC	2621
SKNG	K NG	2625
SKNAC	K NAC	2632
SKNS	K NS	2636
SKPA	K PA	2644
SKPDS	K PDS	2646
SKPDSZ	K PDSZ	2647
SKPEI	K PEI	2652
SKPH	K PH	2639
SKPRB	K PRB	2637
SKRBF	K RBF	2638

SKRC	K <sub>RC</sub>	2614
SKSAS	K <sub>SAS</sub>	2618
SKSC	K <sub>SC</sub>	2615
SKSCA	K <sub>SCA</sub>	2520
SKTING	K <sub>T</sub> STING	0121
SKTM	K <sub>TM</sub>	2617
SKTR	K <sub>TR</sub>	2542
SKTRDS	K <sub>TRDS</sub>	2648
SKVTAR	K <sub>VTAR</sub>	2645
WP	K <sub>WP</sub>	2629
SKWS	K <sub>WS</sub>	2528
SKWW	K <sub>WW</sub>	2626
SKZZ	K <sub>ZZZ</sub>	0213
SLM	$\lambda$	0108
SLMAP	$\lambda$ AP	0160
SLMFP	$\lambda$ FP	0155
SLMH	$\lambda$ H	0116
SLMVT	$\lambda$ VT	0136
SREF	$\sigma$ REF.	2702
SREFL	$\sigma$ REF.	3422
STFW (10)	T <sub>FW</sub>	1151 - 1160
STGIND	MISSION PROFILE SEGMENT INDICATOR	0035 - 0084
STH (10)	t <sub>H</sub> (HR)	0551 - 0560
STL (10)	t <sub>L</sub>	1081 - 1090
STOO	t <sub>O</sub>	0026

STPW (10)	$t_{PW}$	1171 - 1180
SUPRSZ	$\bar{c}$	0212
SWIND	$C_{WIND}$	0029
TAUXCR	TAUX/TTOTC	0259
TBSAP4 (10)	VALUES OF $\epsilon_{p4}$	0272 - 0281
TBCDWI (8)	$C_{DWI}$	0339 - 0346
TBCL (8)	$C_{LW}$	0331 - 0338
TBEM (10)	VALUES OF M	0262 - 0271
TBE (10)	h	1651 - 1660
TBTHE (10)	e	1661 - 1670
TCHT	$(t/c)_{HT}$	0114
TCLN	NO OF CL-CD PAIRS LN TABLE	0330
TCR	$(t/c)_R$	0105
TCRA	$(t/c)_{RA}$	0157
TCEV	$(t/c)_{RF}$	0152
TCT	$(t/c)_T$	0106
TCTA	$(t/c)_{TA}$	0158
TCTF	$(t/c)_{TF}$	053
TCVT	$(t/c)_{VT}$	0137
TFEF	TFEF	0315
TFI	$T_{FI} (^{\circ}R)$	1306
TFN1 (10)	$\Delta T_{IN} (^{\circ}F)$	0421 - 0430
TGI	$T_{GI} (^{\circ}R)$	1305
THEMR	$\theta T_{MR}$	0177
THTRF	$\theta TWIST REF.$	1602



THEPTR	BTTR	0204
THN	NO. OF h-8 PAIRS	1650
TIN2 (10)	$\Delta T_{IN}$ ( $^{\circ}F$ )	0501 - 0510
TIN3 (10)	$\Delta T_{IN}$ ( $^{\circ}F$ )	0611 - 0620
TIN4 (10)	$\Delta T_{IN}$ ( $^{\circ}F$ )	0761 - 0770
TIN5 (10)	$\Delta T_{IN}$ ( $^{\circ}F$ )	0931 - 0940
TIN6 (10)	$\Delta T_{IN}$ ( $^{\circ}F$ )	1051 - 1060
TIN7 (10)	$\Delta T_{IN}$ ( $^{\circ}F$ )	4180 - 4189
TINY	$\Delta T_{INTO}$ (H)	0229
TIPEZ	NO. OF PAIRS IN $V_{TIP}/M_{T90}$ TABLE	1259
TMAX	$T_{MAX}$ ( $^{\circ}R$ )	1309
TMIL	$T_{MIL}$ ( $^{\circ}R$ )	1308
TN1 (8)	VALUES OF T/O	1439 - 1446
TN2 (8)	VALUES OF T/O	1503 - 1510
TNIRPK	OPTIONAL PRINT	0002
TNRP	$T_{NP}$ ( $^{\circ}R$ )	1307
TOLIND (10)	TOLIND	0461 - 0470
TOWP (10)	T/W	4210 - 4216
TRDIND	TRDIND	0015
TREF	0 TREF	2703
TREFL	0 TREF	3423
TRSIND	TRSIND	0016
TRMSH	SEPTRA/TREF	0225
TRXNI	SEPAUX/SEP $^{\circ}$ RUX	0226
TSEP (6)	VALUES OF T/	1311 - 1318

TVCNR	( $\bar{v}/c$ ).25R	0180
TVW	T/W	0183
TVWD	(T/W)D	0223
TWD (8)	VALUES OF T/0	1375 - 1382
TWTW (10)	T/W	0521 - 0530
TXTZ1 (10)	VALUES OF TAUX/T	1682 - 1691
TXTZZ	NO. OF PAIRS IN TAUX/T TABLE	1671
TXXILL	TAUX/T <sub>TOT</sub>	0691 - 0700
TXXTCR (10)	TAUX/T <sub>TOT</sub>	0841 - 0850
TXXILT (10)	TAUX/T <sub>TOT</sub>	1111 - 1120
TXXTOS (10)	TAUX/T <sub>TOT</sub>	1011 - 1020
TXXTIP (10)	TAUX/T <sub>TOT</sub>	4260 - 4269
UMS	NO. OF M	3319
UMW	NO. OF M	1383
UMM1	NO. OF M	2447
UMM2	NO. OF M	1511
UNT1	NO. OF T/0	1438
UNT2	NO. OF T/0	1502
UNTS	NO. OF T/0	1510
UNTW	NO. OF T/0	1374
VBARH	$\bar{v}_H$	0115
VC	$v_C$	0236
VCEH1	$v_{CEH1}$	0191
VCEH2	$v_{CEH2}$	0192
VDES	$v_{DES}$	0141

V DIVE	V <sub>DIVE</sub>	0030
VIN (10)	V <sub>IN</sub> /HEADWIND	0731 - 0740
VKTSZ	V <sub>KT</sub> (C)	0184
VMAXP	V <sub>MAX</sub>	4250 - 4259
VNO	V <sub>NO</sub>	0029
VRCRC	(V <sub>R</sub> /C)D	0232
VRVCZ (10)	(F <sub>R</sub> /C) (FPM)	0511 - 0520
VT	V <sub>TIP</sub>	0181
VTAR	V <sub>TAR</sub>	0249
VTTR	V <sub>TTR</sub>	0207
WDOT (6, 8)	W <sub>F</sub> /8 SHP*	1390 - 1399
WTINDI	W <sub>TINDI</sub>	2201
WF	W <sub>F</sub>	0123
WFE	W <sub>FE</sub>	2602
WFUL	W <sub>FUL</sub>	2603
WGOO	W <sub>GO</sub>	0023
WGTIND	W <sub>GTIND</sub>	1191
WMAX	W <sub>MAX</sub> /W*	1220
WMAXI	W*MAX/W*	2220
WPL	W <sub>PL</sub>	2604
WZ	W <sub>O</sub>	2610
XADSK	X <sub>ADS</sub> /Δ X <sub>ADS</sub>	2688
XAELB	X <sub>AE</sub> /L <sub>B</sub>	2687
XAPUB	X <sub>APU</sub> /L <sub>B</sub>	2686
XAR	X <sub>AR</sub>	0249
SARLB	X <sub>AR</sub> /L <sub>TB</sub>	2689

XASCB	$X_{ASC} / l_B$	2691
XAVLB	$X_{AV} / l_B$	
XC	$X_{CMR}$	0178
XCGLB	$X_{CGF} / l_B$	2678
XCTR	$X_{CTR}$	0205
XDLDE (10)	VALUES OF L/DE	1290 - 1299
XFRNB	$X_{FURN} / l_B$	2685
XI4	$\epsilon_4$	1304
XKPD	$K_P$ CLING	0193
XKGLB	$X_{KG} / l_B$	2681
XMR	$X_{MR}$	0179
XMSNRT	$SHP_{MAX} / SHP_{*MR}$	0221
XMSND	XMSNIND	0220
XNUZL (10)	VALUES OF N	3521 - 3530
XNGLB	$X_{NG} / l_B$	2680
XOLL (6)	VALUES OF X/L	3503 - 3508
XOLNL (10, 10, 6)	ROTOR ADVANCE RATIO	3531 - 3630
XOLNL (10, 10, 6)	ROTOR ADVANCE RATIO	3731 - 3830
XOLNL (10, 10, 6)	ROTOR ADVANCE RATIO	3931 - 4030
XPDSX	$X_{PDS} / \Delta X_{PDS}$	2683
XPELB	$X_{PE} / l_B$	2682
XPJ (20)	VALUES OF J	1702 - 1721
XPJHO	NO. OF ADVANCE RATIOS (J)	1701
XSCLB	$X_{SC} / l_B$	2690
XTR	$X_{TR}$	0206

YAWDSZ	YAW RATE ( $\dot{\psi}$ )	0210
YAWSZ	YAW ACCEL ( $\ddot{\psi}$ )	0209
YCL	$Y_{CL}$	0118
ZANN 2 (10)	VALUES OF M	1259 - 1268
ZANUZ	$T_{AUX}/T$	1692
	SCHEDULE      UNIT	
ZETA1	$b_2$	0119
ZTIPZ (10)	VALUES OF VTIP	1269 - 1278

## 6.0 PROGRAM OUTPUT

A reproduction of the program output for three sample cases is included in Section 7.0. 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 HESCOMP consists of four types of information:

- a. General
- b. Input Data
- c. Sizing Data (program output)
- d. Mission Performance Data (for the "sized" helicopter)

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:

HESCOMP

HELICOPTER SIZING AND PERFORMANCE COMPUTER PROGRAM

Depending on the configuration options (CNFIND, AUXIND, AIPIND, ENGIND) chosen, one of the following statements will be printed out.

SINGLE ROTOR PURE HELICOPTER

SINGLE ROTOR WINGED HELICOPTER

SINGLE ROTOR COMPOUND HELICOPTER

SINGLE ROTOR COMPOUND HELICOPTER AUXILIARY INDEPENDENT  
T/SHAFT CRUISE PROPULSION

SINGLE ROTOR COMPOUND HELICOPTER AUXILIARY INDEPENDENT T/FAN  
OR T/JET CRUISE PROPULSION

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER AUXILIARY  
INDEPENDENT T/SHAFT CRUISE PROPULSION

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER AUXILIARY  
INDEPENDENT T/FAN OR T/JET CRUISE PROPULSION

The printout for the tandem rotor configurations will be identical except for the substitution of TANDEM ROTOR for SINGLE ROTOR

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.

6.1.3 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 units. For example:

WG/A                      DISC LOADING                      10.0 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

Single Rotor Helicopter

Fuselage:

$l_F, l_C, l_B, l_{TB}, X_M, W_F, S_F$

Wing:

If AUXIND = 2 or 4 print AR,  $S_W, b_W, C_W, \lambda_{C/4}, \lambda, (t/c)_T,$

$W_G/S_W, G_{RW}, C_F/C$

If AUXIND = 1 or 3 print NO WING USED

Horizontal Tail:

If HTIND = 1 or 2 print  $AR_{HT}$ ,  $S_{HT}$ ,  $b_{HT}$ ,  $C_{HT}$ ,  $\lambda_{HT}$ ,  $L_{TH}$

If HTIND = 0 print NO HORIZONTAL TAIL USED

Vertical Tail:

$AR_{VT}$ ,  $S_{VT}$ ,  $b_{VT}$ ,  $C_{VT}$ ,  $\lambda_{VT}$ ,  $Z_{TR}$ ,  $\zeta_{VT}$ ,  $(T/C)_{VT}$

Main Rotor Pylon:

$AR$ ,  $S_{FP}$ ,  $FA_{FP}$ ,  $H_{P1}$ ,  $C_{FP}$ ,  $\lambda_{FP}$ ,  $(T/C)_R$ ,  $(T/C)_T$

Primary Engine Nacelle:

$L_N$ ,  $D_N$ ,  $S_N$

Auxiliary Independent Engine Nacelle:

If AIPIND = 2 print  $L_{NI}$ ,  $D_{NI}$ ,  $S_{NI}$

Auxiliary Independent Engine Nacelle Strut:

If AIPIND = 2 print  $S_{STR}$ ,  $b_{NS}$ ,  $C_{NS}$

Auxiliary Independent Propulsion:

If AIPIND = 2 and ENGIN = 1, print AUXILIARY INDEPENDENT  
PROPULSION - TURBOFAN (OR TURBOJET) ENGINE

If AIPIND = 1 print NO AUXILIARY INDEPENDENT ENGINE USED

Propeller (Auxiliary Propulsion):

If AUXIND = 3 or 4 and ENGIN = 0 print  $D_{AR}$ ,  $AF$ ,  $\sigma_{AR}$ ,  $N_{RA}$ ,  
NO. BLADES,  $V_{TIP}$

If AUXIND = 1 or 2 print NO PROPELLER USED

Main Rotor:

$D_{MR}$ ,  $\sigma_{MR}$ ,  $W_G/A$ ,  $C_T/\sigma$ ,  $N_R$ , NO BLADES,  $\theta_{MR}$ ,  $X_C$ ,  $V_{TIP}$

Tail Rotor:

$D_{TR}$ ,  $\sigma_{TR}$ ,  $(T/A)_{NET}$ ,  $C_T/\sigma$ , NO BLADES,  $\theta_{TR}$ ,  $X_{CTR}$ ,  $G$ ,  $V_{TIP}$



### Tandem Rotor Helicopter

#### Fuselage:

$l_F, l_C, \Delta X_1, \Delta X_2, w_F, \epsilon's, (O/L/D), S_F$

#### Wing:

Same printout as single rotor helicopter

#### Forward Rotor Pylon:

$AR, S_{FP}, FA_{FP}, HP_1, C_{FP}, \lambda_{FP}, (T/C)_R, (T/C)_T$

#### Aft Rotor Pylon:

$AR, S_{AP}, HP_2, C_{AP}, \lambda_{AP}, (T/C)_R, (T/C)_T$

#### Primary Engine Nacelle:

$l_N, D_N, S_v$

#### Auxiliary Independent Engine Nacelle:

Same printout as single rotor helicopter

#### Auxiliary Independent Engine Nacelle Strut:

Same printout as single rotor helicopter

#### Auxiliary Independent Propulsion:

Same printout as single rotor helicopter

#### Propeller (Auxiliary Propulsion):

Same printout as single rotor helicopter

#### Main Rotor:

Same printout as single rotor helicopter

### 6.1.3.2 Weights Data

#### Single and Tandem Rotor Helicopters

First print  $M_{LF}, G_{LF}, U_{LF}$ , then print,

Propulsion Group:

$W_{PRG}$ ,  $K_{12}W_{PRB}$ ,  $K_{13}W_{PH}$ ,  $W_{BF}$ ,  $K_{15}W_{AR}$ ,  $W_{DS}$ ,  $K_{16}W_{PDS}$ ,  
 $K_{20}W_{TRDS}$ ,  $K_{17}W_{ADS}$ ,  $K_{18}W_{EP}$ ,  $K_{19}W_{EA}$ ,  $W_{PEI}$ ,  $W_{AEI}$ ,  $W_{FS}$ ,  $\Delta W_P$ ,  
 $W_P$

Structures Group:

$K_8W_W$ ,  $W_{TG}$ ,  $K_9W_{HT}$ ,  $K_{14}W_{TR}$ ,  $K_6W_B$ ,  $K_7W_{LG}$ ,  $W_{NG}$ ,  $W_{MG}$ ,  $W_{TES}$ ,  
 $W_{PES}$ ,  $W_{AES}$ ,  $\Delta W_{ST}$ ,  $W_{ST}$

Flight Controls Group:

$W_{PFC}$ ,  $W_{CC}$ ,  $K_1W_{RC}$ ,  $K_2W_{SC}$ ,  $K_3W_{FW}$ ,  $W_{TM}$ ,  $W_{SAS}$ ,  $W_{AFC}$ ,  $K_4W_{RCA}$ ,  
 $K_5W_{SCA}$ ,  $W_{MC}$ ,  $\Delta W_{FC}$ ,  $W_{FC}$

Weight of Fixed Equipment:

$W_{FE}$

Weight Empty

$W_E$

Fixed Useful Load

$W_{FUL}$

Operating Weight Empty

$OWE$

Payload

$W_{PL}$

Fuel

$(W_F)_A$

Gross Weight

$WG$

6.1.3.3 Rotor Data

Single Rotor Helicopter

ROTOR CYCLE NO. \_\_\_\_\_  
(printed if ROTIND = 1)

ROTOR MAP NO. \_\_\_\_\_  
(printed if ROTIND = 2)

FIXED MAIN ROTOR SOLIDITY INPUT  
(printed if RDMIND = 1 or 2)

If RDMIND = 3 or 4, and depending on which solidity sizing requirement is most critical, one of the following statements will be printed out:

MAIN ROTOR SOLIDITY SIZED BY MANEUVER CONDITIONS  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG., V = \_\_\_\_\_ KT.  
ROTOR MANEUVER G'S = \_\_\_\_\_,  $C_T/\sigma$  = \_\_\_\_\_

MAIN ROTOR SOLIDITY SIZED BY HOVER CONDITIONS  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG., T/W = \_\_\_\_\_  
 $C_T/\sigma$  = \_\_\_\_\_

MAIN ROTOR SOLIDITY SIZED BY CRUISE CONDITIONS  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG., V = \_\_\_\_\_ KT.  
ROTOR LIFT/GW FRACTION = \_\_\_\_\_  $C_T/\sigma$  = \_\_\_\_\_

Which is followed by:

FIXED TAIL ROTOR SOLIDITY  
(printed if TRSIND = 1)

TAIL ROTOR SIZED AT \_\_\_\_\_ TIMES THE SOLIDITY REQUIRED TO SATISFY HOVER ANTI-TORQUE REQUIREMENTS AT  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.,  $C_{TG}/C_{TNET}$  = \_\_\_\_\_  
(printed if TRSIND = 2 and  $\psi = 0$ ,  $\dot{\psi} = 0$ )

TAIL ROTOR SIZED AT \_\_\_\_\_ TIMES THE SOLIDITY REQUIRED TO SATISFY HOVERING TURN REQUIREMENTS AT

H	=	_____	FT.
TEMP	=	_____	F.
$C_{TG}/C_{TNET}$	=	_____	DEG.
YAW RATE	=	_____	RAD/SEC
YAW ACCELERATION	=	_____	RAD/SEC <sup>2</sup>
TAIL ROTOR POLAR MOM. OF INERTIA	=	_____	SLUG/FT <sup>2</sup>
HELICOPTER YAW MOM. OF INERTIA	=	_____	SLUG/FT <sup>2</sup>

(printed if TRSIND = 2 and  $\dot{\psi}$  or  $\ddot{\psi} \neq 0$ .)

Tandem Rotor Helicopter

Main rotor data printout same as for single rotor helicopter.

6.1.3.4 Propulsion Data

Single Rotor Helicopter

PRIMARY PROPULSION CYCLE NO. \_\_\_\_\_  
TURBOSHAFT ENGINE

\_\_\_\_\_ ENGINES

BHP\*P MAX. STANDARD S.L. STATIC H.P. = \_\_\_\_\_ H.P.

ENGINE SIZE WAS FIXED BY INPUT  
(printed if FIXIND = 0)

IF ESCIND = 1 print;

ENGINE SIZED FOR TAKEOFF AT T/W = \_\_\_\_\_,  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
AND \_\_\_\_\_ ENGINES INOPERATIVE

If ESCIND = 2 either of the following statements are printed depending on which engine sizing requirement (hover or cruise) is critical.

ENGINE SIZED FOR TAKEOFF AT T/W = \_\_\_\_\_,  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
AND \_\_\_\_\_ ENGINES INOPERATIVE

ENGINE SIZED FOR CRUISE AT V<sub>C</sub> = \_\_\_\_\_ KNOTS  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
AND \_\_\_\_\_ ENGINES INOPERATIVE

Which is followed by:

NO AUX. INDEPENDENT ENGINE CYCLE SELECTED  
(printed if AUXIND = 3 or 4 and AIPIND = 1)

AUX. INDEPENDENT PROPULSION CYCLE NO. \_\_\_\_\_  
(printed if AUXIND = 3 or 4 and AIPIND = 2)

IF ENGININD = 0.0, TURBOSHAFT ENGINE is printed

IF ENGININD = 1.0, either TURBOFAN or TURBOJET ENGINE is printed

\_\_\_\_\_ ENGINES

BHP\*P MAX. STANDARD S.L. STATIC H.P. \_\_\_\_\_ H.P.  
(printed if ENGININD = 0.0)

T\*P MAX. STANDARD S.L. STATIC THRUST \_\_\_\_\_ LBS.  
(printed if ENGININD = 1.0)

ENGINE SIZE WAS FIXED BY INPUT  
(printed if FIXINDI = 0.0)

ENGINE SIZED FOR CRUISE AT  $V_C$  \_\_\_\_\_ KNOTS  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if FIXINDI = 1.0)

MAIN DRIVE SYSTEM RATING \_\_\_\_\_ H.P.  
MAIN ROTOR DRIVE SYSTEM RATING \_\_\_\_\_ H.P.

Depending on the transmission sizing option chosen (XMSNIND), and the results of the sizing, one of the following four statements will be printed:

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TOTAL PRIMARY  
ENGINE INSTALLED POWER  
MAX. STANDARD S.L. STATIC H.P.  
(printed if XMSNIND = 1.0)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF MAIN ROTOR HOVER  
POWER REQUIRED AT  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if XMSNIND = 2 or if XMSNIND = 3 and the  
alternate payload hover is not critical)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF MAIN ROTOR HOVER  
POWER REQUIRED AT ALTERNATE  
PAYLOAD = \_\_\_\_\_ LBS., ALTERNATE GROSS WEIGHT = \_\_\_\_\_ LBS.  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if XMSNIND = 3 and the alternate payload hover  
is critical)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF MAIN ROTOR CRUISE  
POWER REQUIRED AT  $V_C$  = \_\_\_\_\_ KT.,  
H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if XMSNIND = 2 or if XMSNIND = 3 and the  
alternate payload hover is not critical)

Which is followed by:

TAIL ROTOR DRIVE SYSTEM RATING \_\_\_\_\_ H.P.  
(printed if CNFIND = 1)

Depending on the transmission sizing option chosen (XMSNIND) and the results of the sizing, one of the following four statements will be printed:

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TOTAL PRIMARY ENGINE  
INSTALLED POWER

MAX. STANDARD S.L. STATIC H.P.

(printed if XMSNIND = 1.0)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TAIL ROTOR HOVER  
POWER REQUIRED

AT H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.

(printed if XMSNIND = 2 or if XMSNIND = 3 and the  
alternate payload hover is not critical)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TAIL ROTOR HOVER  
POWER REQUIRED AT ALTERNATE

PAYLOAD = \_\_\_\_\_ LBS., ALTERNATE GROSS WEIGHT = \_\_\_\_\_ LBS.

H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.

(printed if XMSNIND = 3 and the alternate payload  
hover is critical)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TAIL ROTOR CRUISE  
POWER REQUIRED AT  $V_C$  = \_\_\_\_\_ KT.

H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.

(printed if XMSNIND = 2 or if XMSNIND = 3 and the  
alternate payload hover is not critical)

Which is followed by:

AUXILIARY PROPULSION DRIVE SYSTEM RATING \_\_\_\_\_ H.P.

(printed if AUXIND = 3 or 4 and AIPIND = 1)

Depending on the transmission sizing option chosen (XMSNIND)  
and the results of the sizing one of the following three  
statements will be printed:

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TOTAL CONFIGURATION  
POWER REQUIRED TO HOVER

AT H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.

(printed if ESCIND = 1.0 and XMSNIND = 2 or 3)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TOTAL PRIMARY ENGINE  
INSTALLED POWER

MAX. STANDARD S.L. STATIC H.P.

(printed if XMSNIND = 1.0)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF AUX. PROPULSION  
CRUISE POWER REQUIRED AT  $V_C$  = \_\_\_\_\_ KT.

$H_C$  = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.

(printed if ESCIND = 2.0 and XMSNIND = 2 or 3)

AUXILIARY INDEPENDENT PROPULSION DRIVE SYSTEM RATING

(printed if AUXIND = 3 or 4, AIPIND = 2, ENGIND = 0)

Depending on the transmission sizing option chosen (XMSNIND) and the results of the sizing one of the following four statements will be printed:

XMSN SIZED AT \_\_\_\_\_ PERCENT OF TOTAL AUXILIARY  
INDEPENDENT ENGINE INSTALLED POWER  
MAX. STANDARD S.L. STATIC H.P.  
(printed if AIPIND = 2, ENGININD = 0, and XMSNIND = 1.0)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF MAX. AUXILIARY  
INDEPENDENT ENGINE POWER AVAILABLE  
AT H = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if AIPIND = 2, ENGININD = 0, ESCIND = 1 and  
XMSNIND = 2 or 3)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF MAX. AUXILIARY  
INDEPENDENT ENGINE POWER AVAILABLE IN CRUISE  
AT  $V_C$  = \_\_\_\_\_ KT.,  $H_C$  = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if AIPIND = 2, ENGININD = 0, XMSNIND = 2 or 3  
and FIXIND = 0.0)

XMSN SIZED AT \_\_\_\_\_ PERCENT OF AUXILIARY PROPULSION  
CRUISE POWER REQUIRED AT  $V_C$  = \_\_\_\_\_ KT.  
 $H_C$  = \_\_\_\_\_ FT., TEMP. = \_\_\_\_\_ DEG.F.  
(printed if AIPIND = 2, ENGININD = 0, XMSNIND = 2 or 3  
and FIXIND = 1.0)

### 6.1.3.5 Aerodynamics Data

#### Single and Tandem Rotor Helicopter

TOTAL EFFECTIVE FLAT PLATE AREA  
TOTAL WETTED AREA  
MEAN SKIN FRICTION COEFF.

#### DRAC BREAKDOWN

WING FE  
FUSELAGE FE  
FORWARD (MAIN) ROTOR PYLON FE  
AFT ROTOR PYLON FE  
MAIN ROTOR HUB(s) FE  
TAIL ROTOR HUB FE  
VERTICAL TAIL FE  
HORIZONTAL TAIL FE  
PRIMARY ENGINE NACELLE FE  
AUXILIARY INDEPENDENT CRUISE ENGINE NACELLE FE  
AUXILIARY INDEPENDENT CRUISE ENGINE NACELLE STRUT FE  
INCREMENTAL FE

## AERODYNAMIC COEFFICIENTS

A5  
A6  
A7  
A8  
A9  
WING LIFT EFFICIENCY FACTOR  
VERTICAL TAIL LIFT EFFICIENCY

### 6.1.4 Mission Performance Data

Two types of output are possible. If the OPTIONAL PRINT INDICATOR = 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 15 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<sub>1</sub>: weight of fuel used in pounds  
W: aircraft weight in pounds  
h: altitude in feet  
TAS: the true airspeed in knots

Primary Turb. Temp: the primary engine turbine temperature

PRIMARY 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 rmp limit



C = compressor ( $N_1/\theta_1$ ) limit

N2 = output shaft RPM limit

Q = torque limit

PRIMARY ENG. PEHF: The primary engine horsepower fraction. This is the ratio of power being used at any altitude, Mach number condition to the maximum power available at that condition.

In addition, the following data is printed out in different segments:

AUX. TURB. TEMP: The auxiliary independent engine turbine temperature.

AUX. ENG. CODE: A code letter which designates the condition governing the auxiliary independent engine performance: (code is same as for primary engines).

AUX. ENG. PEHF: The auxiliary independent engine thrust 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.

AUX. ENG. FUEL FLOW: Auxiliary independent engine time rate of fuel consumption in pounds per hour.

TEMP DEG. (F) Ambient temperature °F, printed out in Taxi, and Takeoff, Hover, Landing only.

TOTAL FUEL FLOW: Total time rate of fuel consumption (primary plus auxiliary independent engines) in pounds per hour.

T/W: The thrust-to-weight ratio (printed out in takeoff, hover, and landing).

FM: Main rotor overall hover figure of merit (for a tandem rotor configuration, this includes rotor/rotor interference) (printed out in takeoff, hover and landing).

BHP: Total power required (printed out in takeoff, hover, and landing, climb, cruise, descent, and loiter)

CT: Main rotor thrust coefficient (printed out in takeoff, hover, and landing, climb, cruise, descent, and loiter).

CT/SIGMA: CT/main rotor solidity (printed out in takeoff, hover, and landing).

EAS: The equivalent airspeed in knots (printed out in climb, cruise, descent, and loiter).

MU: Main rotor advance ratio (printed out in climb, cruise, descent, and loiter).

CT PRIME/SIGMA: Main rotor cruise lift coefficient/main rotor solidity (printed out in climb, cruise, descent, and loiter).

ALPHA D/L: Angle of total rotor thrust (lift plus propulsive force) vector with respect to a line perpendicular to the A/C flight path (printed out in climb, cruise, descent and loiter).

NMPP: The specific range in nautical miles per pound (printed out in cruise).

GAMMA: The flight path angle in degrees (printed out in climb and descent).

R/C: Rate of climb in feet per minute (printed out in climb).

R/S: Rate of descent in feet per minute (printed out in descent).

#### 6.1.4.2 Detailed Printout

In addition to the data printed above, the following data (unless noted otherwise) will be printed in takeoff, hover, and landing, climb, cruise, descent, and loiter segments if the OPTIONAL PRINT INDICATOR = 1:

VRC RHP: Vertical rate of climb rotor horsepower (printed out only in takeoff, hover and landing).

FMI: Isolated main rotor hover figure of merit (printed out only in takeoff, hover, and landing).

TOTAL FUEL FLOW: Total fuel consumption (primary + auxiliary independent engines) - lb/hr (printed out only, in loiter).

M. ROTOR VTIP: Main rotor tip speed - feet per second

M. ROTOR RHP: Main rotor horsepower (no losses)

T. ROTOR VTIP: Tail rotor tip speed - feet per second

T. ROTOR RHP: Tail rotor horsepower (no losses)

PRIM. ENG. FUEL FLOW: Primary engine fuel consumption - lb/hr

AUX. ENG. FUEL FLOW: Auxiliary independent engine fuel consumption - lb/hr

ROTLIM CODE: A code letter which designates whether main rotor has exceeded the rotor limits input to the program.

A = Within input rotor limits

E = Rotor limits exceeded

DELCDM: Compressibility drag coefficient increment to rotor profile power. In hover, it is a function of rotor  $C_T/\sigma$  and  $V_{Tip}$ . In cruise it is a function of rotor  $C_T/\sigma$  and advancing blade tip Mach number (only printed out when a rotor "cycle" is input).

CPPRO: Rotor profile power coefficient (only printed out when a rotor "cycle" is input).

CPIND: Rotor induced power coefficient (only printed out when a rotor "cycle" is input).

CDO: Rotor profile drag (total) coefficient (only printed out when a rotor "cycle" is input).

PROP VTIP: Propeller tip speed - ft/sec.

BHP AUX: Auxiliary propulsion power required (not printed out in takeoff, hover, and landing).

ETAP PROP: Propeller cruise efficiency

TAUX/T:	Ratio of auxiliary propulsion thrust to total configuration thrust required.
AUX. ENG. FUEL FLOW:	} Same as noted earlier
AUX. TURB. TEMP:	
AUX. ENG. CODE:	
AUX. ENG. PEHF:	
AUX. ENG. BHP OR THRUST:	Auxiliary independent engine power (if ENGIN = 0, horsepower required printed out. If ENGIN = 1, thrust required printed out).
CPPAR:	Rotor parasite power coefficient (only printed out when a rotor "cycle" is input).
CPNUD:	Rotor nonuniform downwash power coefficient (only printed out when a rotor "cycle" is input).
DELCDSD:	Retreating blade stall coefficient increment to rotor profile power (only printed out when a rotor "cycle" is input).
CXR:	Rotor propulsive force coefficient
J	Propeller advance ratio
CP	Propeller power coefficient
CT	Propeller thrust coefficient
CLW	Wing lift coefficient
CDW	Wing profile drag coefficient
RN	Fraction of total lift carried by rotor

#### 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 PEHF = \_\_\_\_\_, 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 RATING  
 CRUISE AT BEST RANGE SPEED WITH HEADWIND OF \_\_\_\_\_ KNOTS  
 CRUISE AT SPEED FOR 99 PERCENT BEST RANGE WITH HEADWIND OF \_\_\_\_\_ KNOTS  
 CRUISE AT BEST RANGE SPEED WITH HEADWIND OF \_\_\_\_\_ KNOTS, CONSTANT W/DELTA = \_\_\_\_\_
- e. DESCEND TO H = \_\_\_\_\_ FT AT CONSTANT EAS  
 DESCEND TO H = \_\_\_\_\_ FT AT CONSTANT TAS  
 DESCEND TO H = \_\_\_\_\_ FT AT CONSTANT TAS (SPIRAL DESCENT PATH)  
 DESCEND TO H = \_\_\_\_\_ FT AT CONSTANT EAS (SPIRAL DESCENT PATH)  
 DESCEND TO H \_\_\_\_\_ FT AT CONSTANT MACH NO.  
 DESCEND TO H = \_\_\_\_\_ FT AT CONSTANT MACH NO. (SPIRAL DESCENT PATH)

DESCEND TO H = \_\_\_\_\_ FT., R = \_\_\_\_\_ NM AT CONSTANT EAS

DESCEND TO H = \_\_\_\_\_ FT., R = \_\_\_\_\_ NM AT CONSTANT MACH NO.

DESCEND TO H = \_\_\_\_\_ FT., R = \_\_\_\_\_ NM AT CONSTANT TAS

f. LOITER FOR \_\_\_\_\_ HRS.

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 =

NOTE: If segments 1 through 6 are used for reserve fuel calculations, headings a. through f. will be followed by the statement FOR RESERVE FUEL.

#### 6.1.4.4 General Performance Data

If the General Performance Mission (SGTIND = 11) is issued, a fixed heading consisting of 7 constant parameters, followed by a 49 variable list will be printed.

The fixed constants are:

GROSS WEIGHT = _____	W/Delta = _____
ALTITUDE = _____	DELTRTH = _____
TEMPERATURE = _____	DELTA = _____
	THETA = _____

where  $\Delta = P/P_0$

$\theta = T/T_0$

$\Delta \sqrt{\theta} = \frac{P}{P_0} \frac{T}{T_0}$

The 49 variables will be printed out according to the input velocity increment  $\Delta V$  - (LOC 4230). These variables consist of:

SHP/DELRTH = RATIO OF SHAFT HORSEPOWER TO PRESSURE RATIO MULTIPLIED BY SQUARE ROOT TEMPERATURE RATIO.

SHPI/DELRTA = RATIO OF AUXILIARY INDEPENDENT ENGINE SHAFT HORSEPOWER TO PRESSURE RATIO MULTIPLIED BY SQUARE ROOT TEMPERATURE RATIO.

M. ROTOR RHP/DELRTH = RATIO OF MAIN ROTOR HORSEPOWER TO PRESSURE RATIO MULTIPLIED BY SQUARE ROOT TEMPERATURE RATIO.

T. ROTOR RHP/DELRTH = RATIO OF TAIL ROTOR HORSEPOWER TO PRESSURE RATIO MULTIPLIED BY SQUARE ROOT TEMPERATURE RATIO.

AUX. PROP RHP/DELRTH = RATIO OF AUXILIARY PROPULSION ROTOR HORSEPOWER TO PRESSURE RATIO MULTIPLIED BY SQUARE ROOT TEMPERATURE RATIO.

CONFIG L/DE = RATIO OF LIFT TO EFFECTIVE DRAG FOR THE ENTIRE CONFIGURATION OF AIRCRAFT.

ROTOR L/DE = RATIO OF ROTOR LIFT TO EFFECTIVE DRAG FOR THE ROTOR ONLY.

ROTOR (L/DE)I = RATIO OF ROTOR LIFT TO EFFECTIVE DRAG FOR THE INDEPENDENT (TANDEM) ROTOR ONLY.

WING L/DE = RATIO OF WING LIFT TO EFFECTIVE DRAG

$R_N$  = FRACTION OF TOTAL LIFT CARRIED BY ROTOR.

The remaining variables are printed out in the General Performance segment regardless of the value of the optional print indicator (LOC 0002).

TAS	M. ROTOR VTIP	CPPRO	J
MU	M. ROTOR RHP	CPIND	CP
CT/SIGMA	T. ROTOR VTIP	CPPAR	CT
CT	T. ROTOR RHP	RPNUD	CLW
ALPHA D/L	PROP VTIP	EDO	CDW
BHP	BHP AUX	DELCDS	AUX ENG PETF
BHPI	ETAP PROP	DELCOM	
T/W	TAUX/T	CXR	
FM	TOTAL FUEL FLOW	SPEC RANGE (NMPP)	
FMI	PRIM ENG FF	AUX ENG FF	
EAS	PRIM ENG PEHF	AUX ENG PEHF	

## 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 0217)

REMEDY: Use correct engine cycle

- 6.2.1.2 \*\*\* ERROR THE USER REQUESTED ROTOR MAP NO. XXX BUT THE INPUT DECK WAS SET UP TO USE NO. YYY

The operator used a rotor map whose identification number differed from that requested by the user (LOC. 0170)

REMEDY: Use correct rotor map

- 6.2.1.3 \*\*\* ERROR THE USER REQUESTED ROTOR CYCLE NO. XXX BUT THE INPUT DECK WAS SET UP TO USE NO. YYY

The operator used a rotor cycle whose identification number differed from that requested by the user (LOC. 0171)

REMEDY: Use correct rotor cycle

- 6.2.1.4 \*\*\* ERROR THE USER REQUESTED AUXILIARY ENGINE NO. XXX BUT THE INPUT DECK WAS SET UP TO USE NO. YYY

The operator used a auxiliary engine whose identification number differed from that requested by the user (LOC. 0242)

REMEDY: Use correct auxiliary engine

- 6.2.1.5 \*\*\* 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. 0260)

REMEDY: Use correct propeller table

- 6.2.1.6 ERROR \*\*\* THE FIRST SEGMENT INDICATOR OF A MISSION CANNOT BE 0., 100., or 5. (RMAXND = 0) 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 (RMAXND = 0) must be preceded by a cruise segment.

REMEDY: Rewrite segment indicator list (Starts at (LOC 0035))

- 6.2.1.7 ERROR \*\*\* DESCENT (RMAXND = 0) MUST BE PRECEDED BY A CRUISE

See 6.2.1.6 (b)

REMEDY: Redefine the mission with a different sequence of segment indicators

- 6.2.1.8 \*\*\* 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 helicopter sized by HESCOMP. It may require some novel design considerations.

- 6.2.1.9 \*\*\* 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 0032, 33, 34)

REMEDY: Correct reserve fuel factors

- 6.2.1.10 \*\*\*\*\* THIS AIRCRAFT HAS NOT CONVERGED AFTER 25 ATTEMPTS. THE WEIGHT OF FULL 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.

- 6.2.1.11 \*\*\* ERROR - NO TITLE CARD / AFTER SEVEN CARD, COLUMNS 1 THROUGH 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.

- 6.2.1.12 J DOES NOT CONVERGE IN 25 ITERATIONS - SUBROUTINE POWER

This message is printed if a match cannot be found between propeller thrust and available power. The message is printed in forward flight calculations.

REMEDY: Increase engine power, reduce drag or modify propeller related inputs.

- 6.2.1.13 WARNING: THIS CASE HAS BEEN TERMINATED BECAUSE THE CALCULATED FUSELAGE CONSTANT DIAMETER SECTION (CABIN LENGTH) IS LESS THAN ZERO. CHECK ALL FUSELAGE AND ROTOR SIZING INPUTS.

This message will be printed if in the process of sizing a tandem rotor helicopter (FDMIND = 1) fuselage,  $t_c$  is calculated as a negative number.

REMEDY: Review input data that specifies tandem rotor helicopter fuselage size requirements.

- 6.2.1.14 WARNING: THIS CASE HAS BEEN TERMINATED BECAUSE THE CALCULATED TANDEM ROTOR OVERLAP RATIO EXCEEDS \_\_\_\_\_ CHECK ALL FUSELAGE AND ROTOR SIZING INPUTS

This message will be printed if in the process of sizing a tandem rotor helicopter (FDMIND = 3) fuselage, the overlap/diameter ratio exceeds the value printed in the error message.

REMEDY: Review input data that specifies tandem rotor helicopter fuselage size requirements.

- 6.2.1.15 AFTER 20 ITERATIONS, DTR DID NOT CONVERGE (SUBROUTINE SIZTR)

This message will be printed if the tail rotor diameter sizing iterative option (TRDIND = 3) does not converge.

REMEDY: Check all tail rotor sizing input data  
( $(T/A)_{NET}$ ,  $h_{TR}$ ,  $\theta_{TR}$ ,  $X_{CTR}$ , etc.)

6.2.1.16 AFTER 20 ITERATIONS,  $X_M/l_B$  DOES NOT CONVERGE

This message will be printed if  $X_M/l_B$  calculated by the main rotor position sizing option (MRPIND = 1 or 2) does not converge.

REMEDY: Check all input values required for this option (LOC 2678 - LOC 2696)

6.2.1.17 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.

REMEDY: Review input data that specifies propeller requirements.

6.2.2 Errors Related to Tabulated Inputs

6.2.2.1 Two Dimensional Tables

\* \* ERPOR\*\*\*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 VARIABLE</u>	<u>DEPENDENT VARIABLE</u>	<u>XXXX</u>
M	$C_{D0}$	M, ETAP4
$C_L$	$C_{Dwi}$	CL, CDM1
h		H-THETA
$C_T$	$K_{HOVA}$	CT, KHOVA TABLE (SUBR. ROTPOW) ††
$C_T$	$K_{HOVB}$	CT KHOVB TABLE (SUBR. ROTPOW) ††
EPSILON	$K_{INTO}$	EPSILON-KINTO TABLE (SUBR. ROTPOW) ††
	$K_{NUD}$	MU-KNUD TABLE (SUBR. ROTPOW) ††
	TAUX/T	M-TAUX/T SCHEDULE (TABLE (SUBROUTINE) ROTPOW
$C_A$	$K_{HOVA_{ATR}}$	CT, KHOVATR TABLE (SUBR. ROTPOW) ††
(O, L)/D	$K_{2W}$	SIZTR SUBR.
$N_{II}/N_{IIOPT}$	$K_{PN}$	NSUB2 CORRECTION FACTOR
$(N_I/N_I^*)(D/ \bar{L})$	$D_{PR}$	REYNOLDS NUMBER
$\omega/\Omega^*$	T/ $\theta$	TORQUE LIMIT LOOK UP
$(SHP/\delta \sqrt{\theta} SHP^*)_{REQ}$	T/ $\theta$	POWER REQUIRED LOOK UP
$C_L$		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. 0259). The control 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.

This table is not input. It is stored as BLOCK DATA

### 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
$\dot{W} / \delta \sqrt{\theta SHP^*}$	$T/\theta (T), M$	REFERRED FUEL FLOW
OR		
$\dot{W} / \delta \sqrt{\theta F_N^*}$		
$N_I / \sqrt{\theta N_I^*}$	$T/\theta (T), M$	REFERRED NSUB1
$N_{II} / \sqrt{\theta N_{II}^*}$	$T/\theta (T), M$	REFERRED NSUB2
$C_T$	$C_p (CP), H$	PROPELLER POWER COEFFICIENT
$C_T' / \sigma$	$\mu, C_X / \sigma$	CT'/SIGMA TABLE (SUBR. BOTLIM)

<u>DEPENDENT VARIABLE</u>	<u>INDEPENDENT VARIABLES (XXXX)</u>	<u>NAME OF TABLE (YYYYY)</u>
$\Delta K_{HOV} \theta_T$	$C_T, \theta_{TMR}$ or $C_T, \theta_{TTR}$ or $C_T, \theta_{TREF}$	DELTA KHOVER - THETA T TABLE (SUBR ROTPOW) †
$\sigma_{IF}$	$S, Z_W$	PRANDTL DRAG INTER- FERENCE TABLE (AERO SUBR) †
$C_P/\sigma$	$\mu, C_T'/\sigma, C_X/\sigma$	CTP/SIGMA ROTOR MAP (Type I Rotor map)
$C_{PH}/\sigma$	$C_T, M_{TIP}$	HOVER PORTION OF THE ROTOR MAP (Type I Rotor map)
F.M.	$C_T, M_{TIP}$	HOVER PORTION OF THE FM ROTOR MAP (Type II Rotor map)
$L/D_E$	$\mu, C_T'/\sigma, X/L$	L/D <sub>E</sub> ROTOR MAP (Type II Rotor map)

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.

†This table is not input. It is stored as BLOCK DATA.

### 6.2.3 Errors Occuring in Performance Calculations

6.2.3.1 WARNING: ROTOR LIMIT HAS BEEN EXCEEDED. FORWARD FLIGHT SPEED HAS BEEN REDUCED ACCORDINGLY. CHECK ALL VALUES OF TAS, MU, CT'/SIGMA AND CXR IN THIS PERFORMANCE LEG.

This message will be printed in segments climb, cruise, descent and loiter if a rotor limit has been exceeded.

REMEDY: Check rotor limits tabular input values (LOC 0347 - 0395) and segment input values.

- 6.2.3.2 WARNING: ROTOR LIMIT HAS BEEN EXCEEDED. EITHER REDUCE MAIN ROTOR THRUST REQUIREMENTS AT THESE OPERATING CONDITIONS OR INCREASE MAIN ROTOR TIP SPEED, CHECK ALL VALUES OF CT/SIGMA IN THIS PERFORMANCE LEG.

This message will be printed in the takeoff hover, and landing segment if a rotor limit has been exceeded.

REMEDY: Check rotor limits tabular input values (LOC -347 - 0395) and segment input values.

- 6.2.3.3 CAUTION: TAIL ROTOR ANTI-TORQUE THRUST REQUIRED AT THIS OPERATING CONDITION IS NEGATIVE. CHECK ALL VALUES OF CLFIN.

This message is printed in forward flight (climb, cruise, descent, and loiter segments) when single rotor helicopter vertical tail fin lift exceeds the total anti-torque thrust required at a given operating condition (resulting in a negative anti-torque thrust required for this tail rotor). This condition can be the result of:

- a) too much vertical tail fin area
- b) tail fin operating at too large a fin  $C_L$

REMEDY: Check sizing requirements for vertical tail and input value for fin operating  $C_L$  (LOC 0216)

- 6.2.3.4 CAUTION: TAIL ROTOR CT EXCEEDS .030. TAIL ROTOR TIP SPEED RESET - CHECK ALL VALUES IN PERFORMANCE LEG.

This message is printed when the tail rotor  $C_T$  exceeds .03. This condition can be the result of

- a) too small a tail rotor diameter
- b) operating the tail rotor at too low a tip speed

REMEDY: Check the sizing requirements for the tail rotor diameter, or increase the tail rotor tip speed.

6.2.3.5 INSUFFICIENT POWER AVAILABLE TO HOVER. (T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN/DOWNLOAD.

This message will be printed during the take-off, hover and landing segments if the value of T/W calculated from the input (TOLIND = 2 or 4) is less than that required to provide sufficient thrust to overcome hover load (based on the design (T/W)<sub>D</sub> LOC 0228). NOTE: (T/W)<sub>D</sub> is always input.

REMEDY: Increase the input value of PEHF

6.2.3.6 CAUTION \*\* PEHF IS GREATER THAN 1

This message indicates a condition for which greater than 100 percent of maximum power or thrust was required during take-off, hover or landing.

REMEDY: Increase engine power available or decrease required thrust-weight for hover

6.2.3.7 WARNING: THIS CASE HAS BEEN TERMINATED BECAUSE OF INSUFFICIENT POWER AVAILABLE FOR CLIMB AT THIS FLIGHT CONDITION. CHECK ALL INPUTS

This 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 drag and adjust them if they appear to give a grossly over-rated value of drag.

6.2.3.8 WARNING: THIS CASE HAS BEEN TERMINATED BECAUSE THE CLIMB ANGLE IS TOO LARGE DUE TO EXCESSIVE POWER AVAILABLE AT THIS FLIGHT CONDITION. CHECK ALL INPUTS

This message is printed if the engine thrust or power input by the user is excessive (resulting in climb angles greater than 45°) for the flight condition desired.

REMEDY: a) Decrease the engine power or thrust or  
b) Increase the value of the drag input to this segment



6.2.3.9 INSUFFICIENT POWER AVAILABLE FOR CRUISE AT INPUT  
TAUXTT

This message will be printed during cruise, if in the case of a compound or auxiliary propulsion helicopter, the input value of  $T_{AUX}/T_{TOT}$  does not permit a power or thrust available-required match at a given cruise speed.

REMEDY: Check  $T_{AUX}/T_{TOT}$  inputs in the cruise segment.

6.2.3.10 ERROR \*\*\*\*\* INSUFFICIENT POWER AVAILABLE FOR CRUISE  
AT DESIRED SPEED

This message will be printed during cruise  $CRSIND = 2$  (cruise at specified  $T_{AUX}/T_{TOT}$  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.

6.2.3.11 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 0721 through 0730)

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 CLQS IS TOO LARGE FOR DESCENT AT REQUIRED SPEED

This message is printed out when, in the case of a winged helicopter, the wing contribution to the total aircraft lift is too high to permit this aircraft to descend.

REMEDY: Reduce wing operating  $C_L$

6.2.3.14 INSUFFICIENT POWER TO DESCEND AT THE REQUIRED SPEED

This message is printed out when the aircraft has insufficient power to descend at the required speed.

REMEDY: Reduce value of drag input in this segment.

6.2.3.15 TERMINAL RANGE EXCEEDED, SPIRAL DESCENT REQUIRED

This message is printed when the predicted flight path ends beyond the specified terminal range (RMAXND = 1)

REMEDY: Reevaluate terminal range requirement or increase value of drag input in this segment.

6.2.3.16 TERMINAL RANGE NOT ATTAINED, USE MORE CRUISE OR A SHALLOWER DESCENT

This message is printed out when the predicted flight path ends before the specified terminal range (RMAXND = 1).

REMEDY: Reevaluate the terminal range requirement or reduce the drag input to this segment.

6.2.3.17 \*\*ERROR\*\* THE RANGE NECESSARY TO DESCENT 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 RMAXND = 0. This error message is printed if the stored values do not cover a sufficient range back from  $R_{max}$ . Either R is too small or the angle of descent is very small.

REMEDY: Check R (LOC. 0771 through 0780).

ERRORS OCCURING IN PERFORMANCE CALCULATIONS

6.2.3.18 THIS ERROR IS IN THE M-VTIP SCHEDULE TABLE - SUBROUTINE PRFRP

This message is printed out when the Rotor Tip Speed or Mach Number Schedule is not properly input in accordance with the  $N_{II}$  option.

REMEDY: Check all inputs of  $N_{II}$  to see which  
 $N_{II\_MAX}$

option is being exercised, then alter locations 1258 - 1278 accordingly.

6.2.3.19 INSUFFICIENT POWER AVAILABLE FOR CRUISE AT \_\_\_\_\_  
ENGINE RATING

Input options are MAXIMUM, MILITARY, OR  
NORMAL ENGINE RATING.

This message is printed out during the General  
Performance Mission (SGTIND = 11.) when there  
is insufficient power available to maintain  
steady level flight.

REMEDY: Increase engine power, decrease drag  
level, or decrease gross weight.

6.2.3.20 CAUTION: X/L BEING USED IN MAX L/DE SEARCH HAS  
EXCEEDED MINIMUM VALUE OF X/L IN ROTOR MAP -  
SUBROUTINE ROTPOW.

This message is printed out when the maximum  
L/DE operating point lies beyond the minimum  
value of X/L. The program interpolates the  
input rotor map at the particular opera-  
ting point of  $\mu$  and  $(C_H/\sigma)$  and generates a  
data array of rotor L/DE versus X/L.

REMEDY: Expand the range of the minimum value of  
X/L. This value is usually input in  
location 3503.

## 7.1 COMMENTS ON PROGRAM USAGE

Following are a list of rules and suggestions for using the program:

### 7.1.1 Rules

1. Do not use descent option  $RMAXND = 0$  unless preceded by a cruise.
2. Do not input a turbofan or turbojet engine cycle for the primary engines.

$(T/W)_D$  (LOC 0228) must always be input. This is the basic configuration design thrust-to-weight ratio. It is used to establish the basic configurations download for calculation of both hover and low forward speed performance.

4. If  $FIXIND = 0$  and  $FIXINDI = 0.1$ , locations 0234 - 0241 must be input to allow sizing of the auxiliary independent engines.
5. If  $FIXIND = 1$  and  $ESCIND = 1$  only fixed size auxiliary independent engines ( $FIXINDI = 0.0$ ) may be input.
6. If  $OPTIND = 2$ , the helicopter parasite drag should be input as two terms. The wing (if there is one) profile drag coefficient is input to the table of  $C_{Dwi}$  versus  $C_L$ , and all other component contributions are input by means of the term  $F_e$  (LOC 0316). The terms  $C_{DAP}$ ,  $C_{DFP}$ ,  $C_{DCSMR}$ ,  $C_{D SHMR}$ ,  $C_{DCSTR}$ ,  $C_{D SHTR}$ ,  $C_{DN}$ ,  $C_{DNI}$ ,  $C_{DNS}$ ,  $C_{DVT}$ , and  $C_{DHT}$ .  $K_{HPIM}$ ,  $K_{HPIT}$ ,  $K_{VT}$ ,  $K_{NS}$ ,  $K_E$ ,  $K_{VT}$ , and  $K_{KT}$  are not used in  $OPTIND = 2$ . If the option indicator is 1, all terms and factors may be used.
7. If  $OPTIND = 2$ , all necessary green colored locations on the input sheets should be filled in, regardless of any footnote messages.
8. If cruise is followed by descent with  $RMAXND = 0$ , the cruise step size (LOC. 0771 - 0780) 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:

\*\*\* 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.

9. At present do not use SGTIND = 7 with OPTIND = 1 unless a sufficiently large  $S_f$  is input to completely refuel the aircraft. 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.
10. The value for payload which is input (LOC. 2604) should be the payload at initial takeoff.
11. If KPRINT (LOC. 0002) = 0, ambient temperature will only be printed out in TAXI (SGTIND = 1.), and General Performance (SGTIND = 11.)

#### 7.1.2 Suggestions

1. Input locations 0005 - 0022 are arranged in a sequential order (1st and 2nd order size trend and propulsion indicators) which allows configuration types to be input in a logical "building block" manner. Use of this arrangement facilitates the input of data. For example if the user wishes to input a single rotor auxiliary independent engine compound helicopter, the following input sequence follows:
  - a) Input CNFIND = 1 (single rotor helicopter)
  - b) Input AUXIND = 4 (compound helicopter)
  - c) Since a compound helicopter has wings, input desired wing sizing options ( $S_w$ IND and  $b_w$ IND).
  - d) Input AIPIND = 2 (auxiliary independent engines)
  - e) Input desired type of auxiliary independent engine (ENGIND)
  - f) Input those options pertaining only to single rotor helicopters (TRDIND, TRSIND, VTFIND, HTIND, and MRPIND)
2. 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.
3. If it is desired to run OPTIND = 2 for a helicopter which has previously been sized in a separate case, the drag

## 7.2 DISCUSSION OF PROGRAM TOLERANCES

The tolerances tabulated in Table 7-1 represent the accuracy required of iterated values calculated at certain points in the program. Whenever the values of the quantities named in Table 7-1 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	0.01	WG, Gross Weight	Main Control Loop	When the quantity $ 1 - (W_F)_A / (W_F)_R  < \text{TOL}$ , the fuel required and available are considered to be sufficiently close and the sizing calculation is terminated.
$\Delta\gamma$	0.1°	$\gamma$ , Flight Path Angle	Climb & Descent Sub routines	Determines flight path angle to within 0.1°
$\frac{\Delta\text{BHP}}{\text{BHP}_A}$	0.01	$\frac{\text{BHP}_A - \text{BHP}_R}{\text{BHP}_A}$	Cruise	The cruise speed is set when $\text{BHP}_R$ is within 0.01 $\text{BHP}_A$
$\Delta B$	0.01	$\frac{B_1 - B_2}{B_2}$	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 $\Delta B$ , $\text{BHP}_R$ always exceeds $\text{BHP}_A$
$\frac{\Delta(X_M/\lambda_B)}{(X_M/\lambda_B)_c}$	0.01	$\frac{(X_M/\lambda_B) - (X_M/\lambda_B)_c}{(X_M/\lambda_B)_c}$	Main control loop	The main rotor position is determined when $X_M/\lambda_B$ is within 0.01 $(X_M/\lambda_B)_c$
$\frac{\Delta\text{DTR}}{\text{DTR}_I}$	0.01	$\frac{\text{DTR} - \text{DTR}_I}{\text{DTR}_I}$	Size trends subroutine	The tail rotor diameter is determined when $\text{DTR}$ is within 0.01 $\text{DTR}_I$ .
$\frac{\Delta\sigma_{TR1}}{\sigma_{TR}}$	0.01	$\frac{\sigma_{TR1} - \sigma_{TR}}{\sigma_{TR}}$	Main control loop	The tail rotor solidity is determined when $\sigma_{TR1}$ is within 0.01 $\sigma_{TR}$ .
$R_{\text{TOL}}$	5 nm R, Range		Descent Sub routine	If the range at the end of descent is within $R_{\text{TOL}}$ nm of $R_{\text{max}}$ the calculation terminates.

### 7.3 SAMPLE CASES

To illustrate the use of the program, five sample cases have been run and the output included here.

The first case, first run, is for a single-rotor compound helicopter with auxiliary independent cruise propulsion (T/Shaft - Propeller). This case illustrates main rotor (diameter and solidity) sizing, wing sizing for maneuver conditions, auxiliary independent engine sizing, tail rotor solidity sizing to meet hovering turn requirements, vertical tail area sizing based on tail rotor loss (in cruise) criteria, and the use of a drag trend. The primary engines and drive system are sized to meet specified takeoff and cruise requirements. The second run of Case No. 1 is identical to Run 1, except the helicopter is sized for weights only.

The second case, run 1, is for a tandem rotor winged helicopter. It illustrates the use of the component drag buildup option, fuselage sizing based on specified rotor overlap and cabin dimensions, aft rotor pylon sizing based on an input gap/stagger ratio, wing sizing for maneuver conditions, and main rotor (diameter and solidity) sizing. The primary engines and drive systems are sized to meet specified takeoff and cruise requirements. The second run of Case 2 is identical to Run 1, except the print option is for standard print, eliminating specific details.

The third sample case, run 1, is for a helicopter which has two contra-rotating, coaxial, three-bladed rigid rotors. Lift offset is employed on each rotor disc to increase lift and maintain roll trim. The need for a conventional tail antitorque rotor is eliminated by the coaxial arrangement. Two auxiliary fuselage mounted fans driven from the primary engines are used to provide propulsive force at high speeds. This case illustrates the use of the rotor L/D (Type II) rotor map input (ROTIND = 4) and the sizing of a helicopter without a tail anti-torque rotor (TRDIND = 0). Rotor solidity and disc loading are specified to size the rotor. The engines are sized to meet either the takeoff or cruise speed requirements, whichever are critical. The main rotor transmissions were sized for full installed torque and the auxiliary transmission used to drive the auxiliary fuselage mounted fans were sized for a high speed cruise torque requirements. Run 2 is identical to Run 1, except a torque limit was imposed on the auxiliary propulsion transmission instead of on the main and tail rotor transmission as in Run 1. Run 3 is identical to Run 2 except the drive system was rated for cruise. The drive system component (main, tail and auxiliary) power was obtained from the proportional split of the total sea level standard power.



The fourth sample case, Run 1, is for a helicopter which has two contra-rotating, coaxial, four-bladed rigid rotors. The need for a conventional tail anti-torque rotor is eliminated by the coaxial arrangement. Two auxiliary fuselage mounted propellers driven from the primary engines are used to provide propulsive force at high speeds. Run 1 illustrates the use of the rotor  $L/D_E$  rotor map input (ROTIND = 5). The rotor is operated at maximum rotor  $L/D_E$  with  $T_{AUX}/T$  as output. The program accepts a tip velocity schedule which consists of a mix between the advancing blade tip Mach number and the tip velocity. The helicopter is sized without a tail anti-torque rotor (TRDIND = 0). Rotor solidity and disc loading are specified to size the rotor (RDMIND = 2). The engines are sized to meet the takeoff requirements (ESCIND = 1). The main, tail and auxiliary drive system ratings are specified at a fraction of the power required to hover or cruise at design conditions. The more critical of the two conditions is selected.

In Run 1 when  $T_{AUX}/T = 1000$ , the auxiliary propulsion schedule (locations 1671 - 1692) is followed direct as input. Run 2 is identical to Run 1 except for the  $L/D_E$  rotor map input (ROTIND = 6.) In Run 2 the rotor is operated at maximum configuration  $L/D_E$  with  $T_{AUX}/T$  as output. Run 3 is similar to Run 2 with changes only in  $N_{II}$  and  $T_{X}/T$ . The program

$\frac{N_{II}}{N_{IIMAX}}$

assumes the  $V_{TIP}$  schedule is in  $V_{TIP}$  only (locations 1269 - 1278). Also, the propulsive thrust provided by auxiliary propulsion at the specified condition for engine sizing follows the Auxiliary Propulsion Schedule in locations 1671 - 1692. Above that  $\mu$  the maximum  $L/D_E$  is used.

The fifth sample case is for a single-rotor helicopter including wings only. This case illustrates wing sizing for maneuver conditions, main rotor disc loading sizing, tail rotor solidity sizing to meet hovering turn requirements, and the use of the General Performance Segment (SGTIND = 11). The primary engines are sized to meet takeoff requirements only.

7.3.1 Single Rotor Compound Helicopter (Auxiliary Independent Engines)

The design mission profile is illustrated in Figure 7-1. All the inputs are discussed for this case. The engine and rotor cycles are discussed only in sample case No. 1. A complete copy of the program printout follows the description of the input.

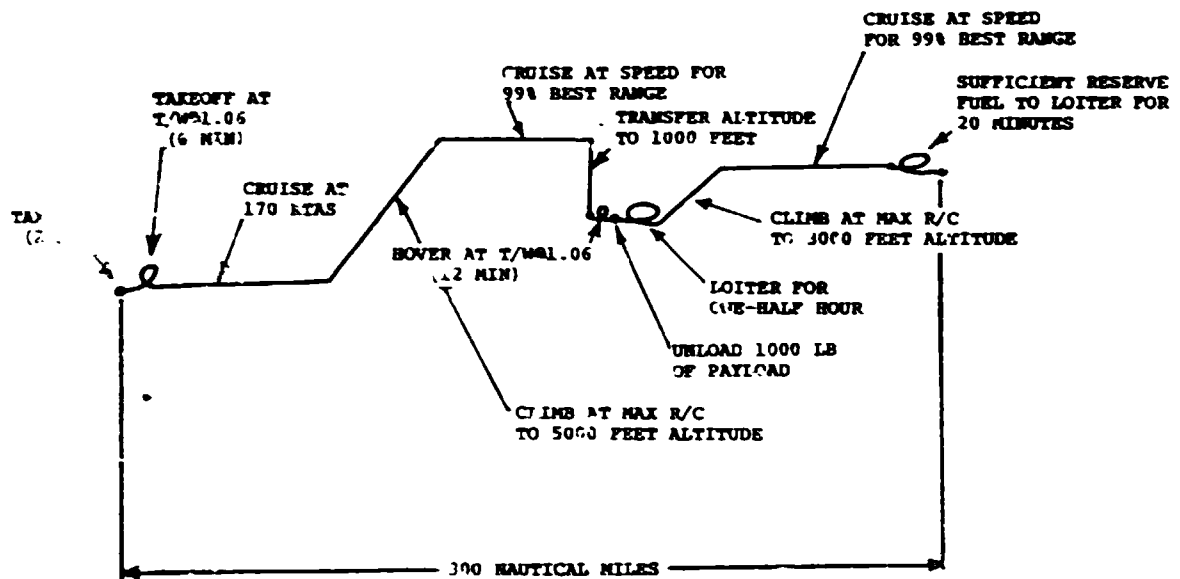


Figure 7-1. Design Mission - Sample Case No. 1

SAMPLE CASE NO. 1

GENERAL INFORMATION SHEET

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
OPTIND	0001	1.0	Sizing run
OPTIONAL PRINT	0002	1.0	Detailed printout de- sired
DRGIND	0003	2.0	GW/Fe Drag trend uti- lized
OSWIND	0004	0	User inputs Oswald efficiency factor
CNFIND	0005	1.0	Single-rotor helicopter
AUXIND	0006	4.0	Compound helicopter
RDMIND	0007	4.0	Main rotor diameter sized based on input d <sub>sc</sub> loading; solidity sized based on input C <sub>T</sub> /σ
FIXIND	0008	1.0	Program sizes primary engines
ROTIND	0009	1.0	Short form rotor per- formance not used
S <sub>w</sub> IND	0010	3.0	Wing area sized by ma- neuver conditions
b <sub>w</sub> IND	0011	1.0	Wing span sized based on input wing span/rotor diameter ratio
AIPIND	0012	2.0	Independent auxiliary engines
ENGIND	0013	0	Turboshaft auxiliary in- dependent engines
FIXINDI	0014	1.0	Program sizes auxiliary independent engines

VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS
TRDIND	0015	1.0	Tail rotor diameter sized based on tail rotor/main rotor diameter trend
TSSIND	0016	2.0	Tail rotor solidity sized based on input $C_T/\sigma$
VTFIND	0017	2.0	Vertical Fin area sized to meet configuration anti-torque requirements upon loss of tail rotor
HTIND	0018	2.0	Horizontal tail volume coefficient input
MRPIND	0019	0	Main rotor position (on fuselage) input by user
ESCIND	0022	2.0	Primary engines sized for either takeoff or cruise
WG <sub>c</sub>	0023	25000	First guess at design gross weight
h <sub>o</sub>	0024	0	Start altitude } Starting range } Starting time } Normally 0 except for partial mission analysis
R <sub>o</sub>	0025	0	
t <sub>o</sub>	0026	0	
h <sub>OPT</sub> IND	0027	0	Cruise at specified altitudes
M <sub>MO</sub>	0028	0.33	Maximum operating Mach number
V <sub>MO</sub>	0029	220	Maximum operating EAS knots
V <sub>DIVE</sub>	0030	220	Design dive speed, knots EAS

VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS
M <sub>LF</sub>	0031	3.5	Maneuver load factor
K <sub>1</sub>	0032	1.0	Factor on mission fuel burned to give reserve fuel, i.e., 1.1 would give 10 percent reserves
δW <sub>F</sub>	0033	0	Fixed fuel increment for reserves or other use
K <sub>FF</sub>	0034	1.05	Increase basic engine SFC by 5 percent
SGTIND	0035	1.0	Taxi
	0036	2.0	Takeoff
	0037	4.0	Cruise
	0038	3.0	Climb
	0039	4.0	Cruise
	0040	9.0	Transfer altitude
	0041	2.0	Takeoff
	0042	8.0	Change payload
	0043	6.0	Loiter
	0044	3.0	Climb
	0045	4.0	Cruise
	0046	60.0	Loiter (reserve fuel)
	0047	100.0	End of case

Sequence  
of  
Design  
Mission

HELICOPTER DIMENSIONAL INFORMATION SHEET

VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS
$b_w/D$	0103	0.5	Wing span/main rotor diameter ratio
$(t/c)_R$	0105	0.20	Wing root thickness/chord ratio
$(t/c)_T$	0106	0.12	Wing tip thickness/chord ratio
$\Delta_c/4$	0107	0	Quarter-chord mean sweep angle, degrees
$\lambda$	0108	0.5	Wing taper ratio (tip chord/root chord)
$C_F/C$	0109	1.0	Ratio of download alleviating flap chord to wing chord (1.0 signifies a fully tilting wing)
$h'/h_F$	0110	0.20	Ratio of vertical wing position on fuselage as a fraction of fuselage height
$CL_D$	0111	0.8	Wing design lift coefficient
$AR_{HT}$	0112	4.0	Horizontal tail aspect ratio
$l'_{TH}$	0113	1.15	Ratio of horizontal tail moment arm to main rotor radius
$(t/c)_{HT}$	0114	0.12	Horizontal tail thickness/chord ratio
$\bar{V}_H$	0115	0.0162	Horizontal tail volume coefficient
$\lambda_H$	0116	0.5	Horizontal tail taper ratio
$\Delta S_{wet}/S_F$	0120	0	Fuselage wetted area ratio

VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS
$\Delta S_{wet}$	0121	0	Incremental fuselage wetted area
$h_F$	0122	7.0	Fuselage height
$W_F$	0123	6.5	Fuselage width
$(l/d)_P$	0124	1.3	Fineness ratio of nose
$(l/d)_T$	0125	1.0	Fineness ratio of tail
$l_C$	0126	12.	Constant diameter section length
$l_{RW}$	0127	0	Length of ramp well
$X_M/l_B$	0128	0.55	Main rotor position aft of the nose as a fraction of main fuselage length
$l_{TB}/d_{TB}$	0129	5.0	Fineness ratio of tail boom
$d_{TTB}/d_{TB}$	0130	0.3	Ratio of average tail boom tip diameter to average tail boom diameter
$k_{T. STING}$	0131	1.1	tail boom extends aft of the tail rotor disc by 10 percent of the tail rotor radius
$\lambda_{VT}$	0136	0.45	Vertical tail taper ratio
$(t/c)_{VT}$	0137	0.15	Vertical tail thickness/chord ratio
$\zeta_{VT}$	0138	0.80	Vertical tail fin/tail rotor overlap ratio
$z_z$	0139	0.85	Vertical position of the tail rotor center (relative to the vertical fin root chord) as a fraction of tail rotor radius

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$C_{L_{DES}}$	0140	0.5	Vertical tail fin design lift coefficient
$V_{DES}$	0141	180	Vertical tail fin sized to provide aircraft directional stability at 180 kts in event of tail rotor loss
$Z_1$	0142	0.035	} Primary engine nacelle constants
$Z_2$	0143	2.0	
$Z_3$	0144	0.078	
$l_{AIP}/l_C$	0145	.1	Ratio of air induction system length to engine length (primary engines)
$Z_4$	0146	0.035	} Auxiliary independent engine nacelle constants
$Z_5$	0147	2.0	
$Z_6$	0148	0.078	
$l_{AIA}/l_{EA}$	0149	.0	Ratio of air induction system length to engine length (auxiliary engines)
$\Delta S/S_{STR}$	0150	.0	Ratio of incremental auxiliary independent engine nacelle strut planform area to auxiliary independent engine nacelle strut planform area
$b_{NS}/d_{NI}$	0151	.1	Ratio of auxiliary independent engine nacelle strut span to nacelle diameter
$(t/c)_{RF}$	0152	0.40	Forward rotor pylon root thickness/chord ratio
$(t/c)_{TF}$	0153	0.20	Forward rotor pylon tip thickness/chord ratio



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$AR_{FP}$	0154	0.5	Forward rotor pylon aspect ratio
$\lambda_{FP}$	0155	0.4	Forward rotor pylon taper ratio
$h_{p1}$	0156	3.0	Forward rotor pylon height
<b>MAIN ROTOR DIMENSIONAL DATA SHEET</b>			
ROTOR CYCLE NO.	0171	3	Rotor blade section aerodynamic characteristics selection
$N_R$	0172	1.0	Number of rotors
W/A	0173	11.0	Disc loading
$b_{MR}$	0176	4.0	Number of blades/main rotor
$\theta_{TMR}$	0177	-9.0	Main rotor twist (deg)
$X_{CMR}$	0178	0.25	Main rotor blade cutout as a fraction of radius
$X_{MR}$	0179	0.075	Main rotor blade attachment point as a fraction of radius
$(t/c)_{.25R}$	0180	0.10	Rotor blade thickness/chord at 25 percent radius
$v$	0181	725	Main rotor tip speed
$(C_T/c)_H$	0182	0.12	$R_c$ - "lift coefficient" for hover sizing solidity
T/W	0183	1.06	Rotor design thrust/weight ratio
$V_{KT}(c)$	0184	165	Cruise flight conditions for sizing rotor solidity
$h_c(c)$	0185	3000	
$\Delta T_{I.I}$	0186	43.2	

C

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$(C_T/\sigma)_{CR}$	0187	0.110	Rotor "lift coefficient" for sizing rotor solidity in cruise flight
$g_{REQM'T}$	0188	1.75	Total g requirement, helicopter must satisfy
$g$ (ROTOR)	0189	1.35	Maneuver g's carried by main rotor
$N$ (ROTOR LOADING)	0190	1.00	Rotor lift/GW for 1g cruise flight rotor solidity sizing
$V_{CEH}^1$	0191	1.53	Main rotor vertical rate-of-climb efficiency factors
$V_{CEH}^2$	0192	0	
$K_{P_{CLIMB}}$	0193	0.85	Helicopter forward flight climb efficiency
TAIL ROTOR DIMENSIONAL DATA SHEET			
$b_{TR}$	0203	5.0	No. of blades/tail rotor
$\theta_{TR}^T$	0204	-4.0	Tail rotor twist (deg)
$X_{CTR}$	0205	0.3	Tail rotor blade cutout as a fraction of radius
$X_{TR}$	0206	0.075	Tail rotor blade attachment point as a fraction of radius
$V_{TTR}$	0207	690	Tail rotor tip speed
$(C_T/\sigma)_{DES}^{(H)}$	0208	0.17	Tail rotor limiting design rotor "lift coefficient"
$\dot{\psi}$	0209	0.30	Helicopter yaw acceleration, rad/sec <sup>2</sup>
$\ddot{\psi}$	0210	0.75	Helicopter yaw rate, rad/sec
$C_T / C_T$ G NET	0211	1.00	Vertical tail fin/tail rotor sideload ratio (when input as 1.00, program calculates a value of $C_T / C_T$ based on tail fin/rotor geometry)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\bar{c}$	0212	0.72	Tail rotor induced velocity ratio for a pusher type tail rotor (see fig. 4-21, sect. 4.8)
$K_{ZZZ}$	0213	1.00	Single rotor helicopter yaw moment of inertia trend adjustment factor (nominally = 1.00)
$g_{MR/TR}$	0214	1.0	Gap between main and tail rotor disc (ft)
$K_{TRS}$	0215	1.05	Tail rotor solidity increased 5 percent over that dictated by hovering turn requirements
$C_{L_{FIN}}$	0216	0	Vertical tail fin operating cruise lift coefficient

PRIMARY ENGINE SIZING INFORMATION SHEET

PRIMARY ENGINE SIZING INFORMATION SHEET			
PRIMARY ENGINE CYCLE NO.	0217	1.761	Primary engine selection
$N_p$	0219	2.0	No. of primary engines
XMSNIND	0220	2.0	Drive system rated at power required to hover or cruise (more critical of the two conditions selected by program)
$SHP_{MRX}/SHP_{MR}^*$	0221	1.0	Main rotor drive system is rated at 100 percent of main rotor design power
$K_{ALTPAYL}$	0222	1.	Ratio of alternate payload increment to design payload (used in XMSN sizing)
$\eta_T$	0223	0.97	Transmission efficiency
$\Delta SHF_{CC}$	0224	100	Accessory power losses
$SHP_{TRX}/TRP^*$	0225	1.0	Tail rotor drive system is rated at 100 percent of tail rotor design power

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$SHP_{AUX}/SHP^*_{AUX}$	0226	1.0	Aux propulsion drive system is rated at 100 percent of aux propulsion design power
$h_{TO}(H)$	0227	4000	Design point hover altitude (engine sizing)
$(T/W)_D$	0228	1.06	Configuration design point hover thrust/weight ratio
$\Delta T_{INTO}(H)$	0229	50.3	Increment in ambient temperature for engine sizing at takeoff conditions ( $^{\circ}F$ )
$(N_{II}/N_{IIMAX})_{TO}$	0230	1.105	Main rotor operating at 100 percent of hover tip speed (725 rps); as input in location 0181, i.e. $\left(\frac{N_{II}}{N_{II\ MAX}}\right)_{TO} \left(\frac{N_{IIMAX}}{N_{II*}}\right)_{VT}$ $(LOC\ 0230) \times (LOC\ 1223) \times (LOC\ 0181)$ $= (1.105) (.905) (725)$ $= 725 = V_{T\ OPERATING}$
$N_{PSD}$	0231	0	No. of engines inoperative at hover design point conditions
$SHP_E/SHP^*$	0232	0.95	Engines sized to permit operation in hover (OGE) at 95 percent of the maximum rated power
$(VR/C)_D$	0233	.0	Design vertical rate of climb (ft/min) used in sizing primary engines in hover
POWIND	0234	2.	Normal engine rating
$h_C$	0235	3000	Design point (cruise) altitude (engine sizing)
$v_C$	0236	170	Design point cruise speed (engine sizing)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta T_{INCE}$	0237	43.2	Increment in ambient temperature for primary engine sizing at cruise condition ( $^{\circ}F$ )
$(N_{II}/N_{IIMAX})_c$	0238	1.105	Ratio of operating power turbine speed to maximum power turbine speed (input when sizing primary engines for cruise)
$(T_{AUX}/T_{TOT})_c$	0239	0.75	75 percent of propulsive thrust provided by aux. propulsion at cruise conditions for engine sizing
$C_{LDP}$	0240	0.3	Wing operating lift coefficient at cruise conditions for engine sizing
$(N_{PSD})_c$	0241	0	No. of primary engines shut down during cruise (for engine sizing)

AUXILIARY INDEPENDENT ENGINE SIZING INFORMATION SHEET

AUX PROPULSION ENGINE CYCLE NO.	0242	1.761	Auxiliary independent engine selection
$N_P$	0245	1.0	Helicopter has one aux. independent engine
POWIND	0246	2	Aux. independent engine sized to provide 75 percent of configuration propulsive thrust at NRP
$(N_{II}/N_{IIMAX})_i$	0247	1.105	Ratio of operating power turbine speed to maximum power, turbine speed (input when sizing primary engines for cruise)
No. of PROPS	0248	1	Number of propellers

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
<b>PROPELLER DATA REQUIRED FOR COMPOUND HELICOPTER AUX PROPULSION INFORMATION SHEET</b>			
$V_{TAR}$	0249	900	Propeller tip speed
DIA	0250	10	Propeller diameter
$X_{AR}$	0251	0.075	Propeller blade attachment point as fraction of radius
$\eta_{T_{AUX}}$	0252	0.97	Auxiliary drive system transmission efficiency
$\eta_{P_{IND}}$	0253	0	"Point" propeller efficiencies specified for climb and cruise
$\eta_{p^c}$	0254	0.82	Propeller efficiency in climb
$\eta_{p^5}$	0255	.8	Propeller propulsive efficiency for $SG_{IND}=5$
AF/Blade	0257	140	3-way propeller, 140 activity factor/blade
No. of Blades	0258	3	
No. of pairs in $\eta_{p4}$ Table	0261	4	Number of pairs in prop/fan efficiency table, locations 0262-0271
Values of MACH	0262	.0	} Mach number required during climb and/or descent
	0263	.2	
	0264	.4	
	0265	.8	
$\eta_{p4}$	0272	.85	} Propeller propulsive efficiency for $SG_{IND} = 4, 6$ tabular function of Mach number
	0273	.83	
	0274	.8	
	0275	.78	

**HELICOPTER AERODYNAMICS INFORMATION SHEET**

(GW/Fe)	0312	1130	Drag trend constants derived from data such as illustrated by fig. 4-30, section 4-9
$K_{FED}$	0313	.555	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
e	0314	0.75	Wing "span loading" efficiency factor
TFEF	0315	1.0	Tail fin aspect ratio effectiveness factor (nominally = 1.0)
$K_N$	0323	.0	Primary nacelle multiplicative drag factor
$K_W$	0327	1.02	Wing multiplicative drag factor
$(Re/1)_i$	0328	$1.464(10^6)$	Mean Reynolds No./ft based on primary engine cruise sizing flight conditions
$Cl_\alpha$	0329	6.28	Wing 2-D lift curve slope
No. of pairs in CL-Cd Table	0330	7.	Number of pairs input in locations 0331-0346
Clw(1)	0331	.0	Wing lift coefficient
Clw(2)	0332	.2	
Clw(3)	0333	.4	
Clw(4)	0334	.6	
Clw(5)	0335	.8	
Clw(6)	0336	1.	
Clw(7)	0337	1.4	
Cdwi(1)	0339	.006	Profile drag coefficient of wing at $Re=10^6$ (based on wing planform area)
Cdwi(2)	0340	.0062	
Cdwi(3)	0341	.007	
Cdwi(4)	0342	.008	
Cdwi(5)	0343	.0095	
Cdwi(6)	0344	.012	
Cdwi(7)	0345	.02	
No. of $C_X/\sigma$	0347	3.	Specifies number of $C_X/\sigma$ values in table locations 0349-0353
No. of $\mu$	0348	3.	Specifies number of values in table locations 0354-0360
Values of $C_X/\sigma$	0349	.0	Rotor propulsive thrust coefficient divided by main rotor solidity. Used in defining rotor limits
	0350	.5	
	351	1.	

$$C_X/\sigma = \frac{\text{THRUST REQUIRED}}{\rho AN_R V_{TIP}^2 \sigma_{MR}}$$

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
	0354	.0	Rotor forward flight advance ratio $\mu = \frac{V_{FPS}}{\overline{V}_{TIP}}$
	0355	.5	
	0356	1.	
Values of $C_T/\sigma$	0361	1.	Values of $C_T/\sigma$ corresponding to $(C_X/\sigma)$ , location 0349 and $\mu_1, \mu_2,$ and $\mu_3$ .
	0362	1.	
	0363	1.	
	0368	1.	Values of $C_T/\sigma$ corresponding to $(C_X/\sigma)_2$ location 0350 and $\mu_1, \mu_2,$ and $\mu_3$ .
	0369	1.	
	0370	1.	
	0375	1.	Values of $C_T/\sigma$ corresponding to $(C_X/\sigma)_3$ location 0351 and $\mu_1, \mu_2,$ and $\mu_3$ .
	0376	1.	
	0377	1.	

#### HELICOPTER WEIGHT INFORMATION SHEET

$W_{FE}$	2602	2200	Weight of fixed equipment in lbs.
$W_{FUL}$	2603	450	Weight of fixed useful load in lbs.
$W_{PL}$	2604	2000	Weight of payload in lbs.
$\Delta W_{FC}$	2605	100	Flight controls group incremental weights in lbs.
$\Delta W_P$	2606	.0	Propulsion group incremental weight in lbs.
$\Delta W_{ST}$	2607	.0	Structures group incremental weight in lbs.
$RM_1$	2608	.0	Wing relief as percentage of GW
$W_I$	2609	.0	Weight of inboard store
$W_O$	2610	.0	Weight of outboard store
$d_i$	2611	.0	Position of inboard underwing store (fraction of wing semi-span)



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$d_o$	2612	.0	Positon of outboard underwing store (fraction of wing semi-span).
$k_{CC}$	2613	25.	Cockpit controls weight factor.
$k_{RL}$	2614	25.	Main rotor controls weight factor.
$k_{SC}$	2615	25.	Main rotor system controls weight factor.
$k_{FW}$	2616	.0	Fixed wing controls.
$k_{TM}$	2617	.0	Tilt mechanism weight factor.
$k_{SAS}$	2618	30.	Stability Augmentation System (SAS) weight factor. Usually in the range of 20-100 pounds.
$k_{RCA}$	2619	.18	Auxiliary rotor controls weight factor.
$k_{SCA}$	2620	25.	Auxiliary rotor system controls weight factor.
$k_{MG}$	2621	.0	Miscellaneous controls weight factor in CBS.
$k_B$	2622	125.	Body group weights factor.
$\Delta C.G.$	2623	2.08	Helicopter cg travel (FT).
$k_{LG}$	2624	.04	Landing gear weight factor. Percentage of gross weight.
$k_{MG}$	2625	.8	Main landing gear weight factor.
$k_{WW}$	2626	.0	Detailed wing weight factor. This adjusts the constant 220 in $W_N = 220(k)^{.582}$ up or down depending on the complexity of the control surfaces.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_F$	2627	1.	Wing unload factor. Entered as a fraction of design gross weight.
$k_{WS}$	2628	.0	Wing stores only weight trend factor.
$k_{WP}$	2629	2.06	Wing weight/area factor (psf).
$k_{HT}$	2630	2.	Horizontal tail unit weight in PSF.
$k_{CLF}$	2631	24.1	Crash load factor.
$k_{NAC}$	2632	1.	Primary cowling weight factor (PSF).
$k_{AIP}$	2633	.75	Primary air induction system weight factor.
$k_{NACA}$	2634	1.	Auxiliary cowling weight factor (PSF).
$k_{AIA}$	2635	.75	Auxiliary air induction system weight factor.
$k_{NS}$	2626	.0	Nacelle strut weight factor.
$k_{PRB}$	2637	44.	Primary rotor blade weight factor.
$k_{RBF}$	2638	2.2	Rotor type factor; hingeless for this example.
$k_{PH}$	2639	61.	Primary hub weight factor.
$k_{amd}$	2640	.286	Main rotor weight factor.
$k_{BLFD}$	2641	1.15	Blade fold weight factor. Input as a fractional part of the total rotor weight.
$k_{TR}$	2642	14.2	Tail rotor weight factor.
$k_{AR}$	2643	14.2	Auxiliary rotor weight factor. This is the average value for the rotor or propeller weight (LB), $W_R = 14.2 a (k)^{.67}$ .

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{PA}$	2644	1.	Auxiliary rotor multiplicative input power, expressed here as 100% input power.
$k_{VTAR}$	2645	1.	Auxiliary tail rotor multiplicative top speed factor here as 100% input speed.
$k_{PDS}$	2646	25.0	Primary drive system weight factor.
$k_{PDSZ}$	2647	3.	Primary drive system weight factor. Number of gears in system.
$k_{TRDS}$	2648	250.	Tail rotor drive system weight factor.
$k_{ADS}$	2649	250.	Auxiliary drive system weight factor.
$k_{ADSZ}$	2650	1.	Auxiliary drive system weight factor (number of gears in system).
$k_{FS}$	2651	.11	Fuel system weight factor.
$k_{PEI}$	2652	.17	Primary engine installation weight factor.
$k_{AEI}$	2653	.17	Auxiliary engine installation weight factor.
$K_1$	2654	1.	Main rotor controls weight factor.
$K_2$	2655	1.	Main rotor system controls weight multiplicative factor.
$K_3$	2656	1.	Fixed wing controls weight multiplicative factor.
$K_4$	2657	1.	Auxiliary rotor controls weight multiplicative factor.
$K_5$	2658	1.	Auxiliary rotor system controls weight multiplicative factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
K <sub>6</sub>	2659	1.	Body weight multiplicative factor.
K <sub>7</sub>	2660	1.	Landing gear weight multiplicative factor.
K <sub>8</sub>	2661	1.	Wing weight multiplicative factor.
K <sub>9</sub>	2662	1.	Horizontal tail weight multiplicative factor.
K <sub>10</sub>	2663	1.	Primary nacelle weight multiplicative factor.
K <sub>11</sub>	2664	1.	Auxiliary nacelle weight multiplicative factor.
K <sub>12</sub>	2665	1.	Primary rotor blade weight multiplicative factor.
K <sub>13</sub>	2666	1.	Primary rotor kit weight multiplicative factor.
K <sub>14</sub>	2667	1.	Tail rotor weight multiplicative factor.
K <sub>15</sub>	2668	1.	Auxiliary rotor weight multiplicative factor.
K <sub>16</sub>	2669	1.	Primary drive system weight multiplicative factor.
K <sub>17</sub>	2670	1.	Auxiliary drive system weight multiplicative factor.
K <sub>18</sub>	2671	1.	Primary engine weight multiplicative factor.
K <sub>19</sub>	2672	1.	Auxiliary engine weight multiplicative factor.
K <sub>20</sub>	2673	1.	Tail rotor drive system weight multiplicative factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
<u>TAXI INFORMATION</u>			
ATMIND	0401	.0	Standard atmosphere.
$t_T$	0411	.0333	Taxi for 2 minutes.
$\Delta T_{IN}$ (°F)	0421	.0	Increment in ambient temperature for primary engine sizing at takeoff conditions.
$K_{FI}$	0431	1.0	Auxiliary engine fuel flow multiplicative factor.

**TAKEOFF, HOVER, AND LANDING INFORMATION**

$N_{II,MAX}$  (PRIM ENG) 0441 1.105 Operating point for engine power turbine during taxi

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

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
TOLIND	0461	1.0	Specify required T/W for hover out-of-ground of effect.
	0462	1.0	
ATMIND	0481	.0	Standard atmosphere.
	0482	.0	
$\Delta T_{IN}$ (°F)	0501	.0	Increment in ambient temperature for primary engine sizing at takeoff conditions.
	0502	.0	
$V_{R/C}$ (FPM)	0511	.0	Vertical rate of climb.
	0512	.0	
T/W	0521	1.06	Configuration thrust/weight ratio (hover).
	0522	1.06	
$\Delta T_M$ (HR)	0531	.02	Step size for hover.
	32	.02	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
N <sub>II</sub> /N <sub>II</sub> MAX (PRIM MAX)	0541		Operating point for engine power turbine during takeoff, hover or landing
	0542		
			$\left( \frac{N_{II}}{N_{II \text{ MAX}}} \right)_{\text{TOHL}} = \frac{V_{\text{OPERATING}}}{V_T \left( \frac{N_{II \text{ MAX}}}{N_{II}} \right)}$
t <sub>H</sub>	0551	0.1	Hover for 16 minutes.
	0552	0.2	Hover for 12 minutes.
CLIMB INFORMATION			
CLMIND	0571	1.0	Climb at maximum rate of climb limited by NRP available.
	0572	1.0	
ATMIND	0591	.0	Standard atmosphere.
	0592	.0	
C <sub>L</sub>	0601	0.3	Wing operating C <sub>L</sub> in climb.
	0602	0.4	
ΔT <sub>IN</sub> (°F)	0611	.0	Incremental temperature above standard, in degrees.
	0612	.0	
Δh (FT)	0621	500.	Step size for climb.
	0622	500.	
POWIND	0631	2.	Normal engine rating.
	0632	2.	
h MAX	0641	5000.	Maximum altitude during climb.
	0642	3000.	
N <sub>II</sub> /N <sub>II</sub> MAX (PRIM ENG)	0651	1.105	Specifies operating point for engine power turbine at design climb conditions.
	0652	1.105	
ΔFe <sub>CL</sub> (FT <sup>2</sup> )	0661	6.	Increment in equivalent flat plate area parasite drag (climb performance segment).
	0662	6.	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$N_{II}/N_{II\ MAX}$ (AUX ENG)	0671	1.105	Specifies operating point for engine power turbine.
	0672	1.105	
$N_{PSD_{CL}}$	0681	1.0	One primary engine shut down during climb.
	0682	1.0	
$T_{AUX}/T_{TOT}$	0691	0	All propulsive thrust provided by main rotor
	0692	0	
$N_{PSDi_{CL}}$	0701	1.0	Auxiliary independent engine shut down during climb.
	0702	1.0	
CRUISE INFORMATION			
CRSIND	0721	2.0	Cruise at specified TAS
	0722	4.0	Cruise at 99 percent best range speed.
	0723	4.0	
$V_{IN}$	0731	170.	True airspeed for cruise during cruise segment with CRSIND=2 (Kt)
ATMIND	0741	.0	Standard Atmosphere.
	0742	.0	
	0743	.0	
$C_{L_{WING}}$	0751	0.5	Wing operating $C_L$ in cruise.
	0752	0.5	
	0753	0.5	
$\Delta T_{IN} (^{\circ}F)$	0761	.0	Incremental temperature above standard, in degrees.
	0762	.0	
	0763	.0	
$\Delta R(NM)$	0771	15.	Step size for cruise (nautical miles).
	0772	15.	
	0773	15.	
POWIND	0781	2.	Normal engine rating.
	0782	2.	
$R_{MAX}$	0791	60	Values of range at end of each cruise.
	0792	150	
	0793	300	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$N_{II}/N_{II\text{MAX}}$	0801	1.105	} Operating point of primary engine power turbine during cruise.
	0802	1.105	
	0803	1.105	

$$\left( \frac{N_{II}}{N_{II\text{MAX}}} \right)_{\text{PRI CR}} = \frac{V_{T\text{OPERATING}}}{V_T \left( \frac{N_{II\text{MAX}}}{N_{II}^*} \right)_{\text{PRI CR}}}$$

$\Delta Fe_{CR} (FT^2)$	0811	.0	} Increment in equivalent flat plate area parasite (cruise performance segment).
	0812	.0	
	0813	.0	

$N_{II}/N_{II\text{MAX}}$ (AUX ENG)	0821	1.105	} Operating point for auxiliary engine power turbine cruise.
	0822	1.105	
	0823	1.105	

$$\left( \frac{N_{II}}{N_{II\text{MAX}}} \right)_{\text{AUX CR}} = \frac{V_{T\text{OPERATING}}}{V_T \left( \frac{N_{II\text{MAX}}}{N_{II}^*} \right)_{\text{AUX}}}$$

$N_{\text{PSD CR}}$	0831	.0	} Number of primary engines shut down during cruise.
	0832	.0	
	0833	.0	

$T_{\text{AUX}}/T_{\text{TOT}}$	0841	0.55	} Propeller/main rotor propulsive thrust split during cruise segments.
	0842	0.60	
	0843	0.70	

$N_{\text{PSD i CR}}$	0851	.0	} Number of auxiliary independent engines shut down during cruise.
	0852	.0	
	0853	.0	

LOITER INFORMATION STGIND=6

ATMIND	1031	.0	Standard atmosphere.
	1032	.0	

$C_{LW}$	1041	0.4	Wing operating $C_L$ in loiter.
	1042	0.4	

$\Delta T_{IN} (^{\circ}F)$	1051	.0	Incremental temperature above standard, in degrees.
	1052	.0	



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
TRANSFER ALTITUDE SHEET			
$\Delta W_{PL}$	1161	-1000.	Unload 100% of payload after 12 minutes of hovering.
$t_{PW}$ (HR)	1171	.01	Incremental time for change of payload weight.
$h_{FINAL}$ (ft)	1181	1000.	Final altitude for transfer altitude segment (SGT IND=9).
WGTIND	1191	1.	No restriction on aircraft weight (will only apply when running performance).
PRIMARY ENGINE DATA			
WDTIND	1201	0.	No fuel flow cutoff.
N1IND	1202	0.	No gas generator RPM limit.
N10IND	1203	0.	No referred gas generator RPM limit.
N2IND	1204	2.	Power turbine cutoff Non optimum $N_{II}$ variation.
QUND	1205	0.	No torque limit imposed.
RNOIND	1206	0.	No Reynolds Number correction.
$N_{II}^{MAX}/N_{II}^*$	1223	.905	Power turbine speed limit ratio of maximum power turbine speed to power turbine speed at maximum static power, sea level, Standard.
PRIMARY ENGINE CYCLE INFORMATION			
CYCLE NO.	1301	1.761	Engine Cycle Number.
$k_3$	1302	0.159	Primary engine weights multiplicative factor.
$k_4$	1303	0.	Primary engine weights additional factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta T_L$ (HR)	1061	.05	Step size for loiter.
	1062	.05	
$N_{II}/N_{II,MAX}$ (PRIM ENG)	1071	1.105	Operating point for primary engine power turbine during loiter.
	1072	1.105	
		$\left( \frac{N_{II}}{N_{II,MAX}} \right)_{LOITER} = \frac{V_T^{OPERATING}}{V_T \left( \frac{N_{II,MAX}}{N_{II}^*} \right)} = 1.105$	
$t_L$	1081	0.5	Loiter for 30 minutes.
	1082	0.25	
$N_{II}/N_{II,MAX}$ (AUX ENG)	1091	1.105	Operating point for auxiliary power turbine during loiter.
	1092	1.105	
		$\left( \frac{N_{II}}{N_{II,MAX}} \right)_{AUX LOITER} = \frac{V_T^{OPERATING}}{V_T \left( \frac{N_{II,MAX}}{N_{II}^*} \right)_{AUX}} = 1.105$	
$N_{PSD LOITER}$	1101	.0	Number of primary engines shut down during loiter.
	1102	.0	
$T_{AUX}/T_{TOT}$	1111	0.35	Propeller/main rc. propulsive thrust split in loiter.
	1112	0.35	
$N_{PSD i LOITER}$	1121	.0	Number of auxiliary independent engines shut down during loiter.
	1122	.0	
$\Delta Fe_L$	1131	.0	Increment in equivalent flat plate area parasite drag (loiter performance segment).
	1132	.0	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\xi_4$	1304	.032	Primary engine dimensional factor.
$T_{GI} (^{\circ}R)$	1305	950.	Turbine inlet temperature ground idle power setting in degrees Rankine.
$T_{FI} (^{\circ}R)$	1306	1100.	Turbine inlet temperature, flight idle power setting, in degrees Rankine.
$T_{NP} (^{\circ}R)$	1307	1856.	Turbine inlet temperature normal power setting. When this power setting is desired the input temperature is referred for the given altitude. The referred temperature, $T/\theta$ , is used in the table look-up for referred power fuel flow, gas generator RPM limit, and power turbine speed.
$T_{MIL} (^{\circ}R)$	1308	2000.	Turbine inlet temperature, military power setting. When this power setting is desired the input temperature is referred for the given altitude. The referred temperature, $T/\theta$ , is used in the beforementioned table look-ups.
$T_{MAX} (^{\circ}R)$	1309	2000.	Turbine inlet temperature, maximum power setting. When this power setting is desired the input temperature is referred for the given altitude. The referred temperature, $T/\theta$ , is used in the beforementioned table look-up.
No. of $T/\theta$	1310	8.	Number of referred temperatures in locations 1311-1318.
Values of $T/\theta$	1311	950.	Values of referred temperatures for the referred thrust or horsepower tables.
	1312	1200.	
	1313	1400.	
	1314	1600.	
	1315	1800.	
	1316	2000.	
	1317	2200.	
	1318	2600.	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
No. of M	1319	5.	Number of Mach. Numbers in location 1320-1325.
Values of M	1320	0.	Values of Mach. Number for the referred thrust or horsepower table.
	1321	.2	
	1322	.4	
	1323	.6	
	1324	.8	
Referred thrust or horsepower table.			
	1326	.025	Values of referred thrust or horsepower corresponding to T/θ location 1311 and mach numbers found in locations 1320-1324.
	1327	.0257	
	1328	.0278	
	1329	.0313	
	1330	.0362	
	1332	.163	Values of referred thrust or horsepower corresponding to T/θ location 1312 and mach numbers found in locations 1320-1324.
	1333	.1676	
	1334	.1813	
	1335	.2041	
	1336	.236	
	1338	.535	Values of referred thrust or horsepower corresponding to T/θ location 1313 and mach numbers found in locations 1320-1324.
	1339	.3444	
	1340	.3725	
	1341	.4194	
	1342	.4851	
	1344	.544	Values of referred thrust or horsepower corresponding to T/θ location 1314 and mach number locations 1320-1324.
	1345	.5597	
	1346	.6049	
	1347	.6811	
	1348	.7877	
	1350	.77	Values of referred thrust or horsepower corresponding to T/θ location 1315 and mach number locations 1320-1324.
	1351	.7916	
	1352	.8562	
	1353	.9640	
	1354	1.115	
	1356	1.0	Values of referred thrust or horsepower corresponding to T/θ location 1316 and mach number locations 1320-1324.
	1357	1.028	
	1358	1.112	
	1359	1.252	
	1360	1.448	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
	1362	1.2	} Values of referred thrust or horsepower corresponding to T/θ location 1317 and mach number locations 1320-1324.
	1363	1.2336	
	1364	1.3344	
	1365	1.5024	
	1366	1.7376	
	1368	1.55	} Values of referred thrust or horsepower corresponding to T/θ location 1318 and mach number locations 1320-1324.
	1369	1.5934	
	1370	1.7236	
	1371	1.9406	
	1372	1.2444	
No of T/θ	1374	8.	Number of referred temperatures in locations 1375-1382.
Values of T/θ	1375	950.	} Values of referred temperature for the referred fuel flow table.
	1376	1200.	
	1377	1400.	
	1378	1600.	
	1379	1800.	
	1380	2000.	
	1381	2200.	
1382	2600.		
No. of M	1383	5.	Number of mach numbers in locations 1384-1389.
Values of M	1384	0.	} Values of mach numbers for the referred fuel flow table.
	1385	.2	
	1386	.4	
	1387	.6	
	1388	.8	
Referred Fuel Flow Table	1390	.065	} Values of referred fuel flow corresponding to the T/θ location 1375 and mach numbers found in locations 1384-1388.
	1391	.0651	
	1392	.0653	
	1393	.067	
	1394	.071	
	1396	.115	} Values of referred fuel flow corresponding to T/θ location 1376 and mach numbers found in locations 1384-1388.
	1397	.116	
	1398	.118	
	1399	.128	
	1400	.14	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
	1402	.18	} Value of referred fuel flow corresponding to T/θ location 1377 and mach numbers found in locations 1384-1388.
	1403	.181	
	1404	.19	
	1405	.208	
	1406	.227	
	1408	.26	} Values of referred fuel flow corresponding to T/θ location 1378 and mach number found in locations 1384-1388.
	1409	.261	
	1410	.273	
	1411	.295	
	1412	.325	
	1414	.342	} Values of referred fuel flow corresponding to T/θ location 1379 and mach numbers found in locations 1384-1388.
	1415	.347	
	1416	.362	
	1417	.389	
	1418	.425	
	1420	.425	} Values of referred fuel flow corresponding to T/θ location 1380 and mach numbers found in locations 1384-1388.
	1421	.435	
	1422	.451	
	1423	.486	
	1424	.517	
	1426	.5	} Values of referred fuel flow corresponding to T/θ location 1381 and mach numbers found in locations 1384-1388
	1427	.511	
	1428	.53	
	1429	.56	
	1430	.61	
	1432	.626	} Values of referred fuel flow corresponding to T/θ location 1382 and mach numbers found in locations 1384-1388.
	1433	.631	
	1434	.66	
	1435	.718	
	1436	.78	
No. of T/θ	1438	3.	Number of referred temperature found in locations 1439-1446
Values of T/θ	1439	950.	} Values of referred temperature for the referred gas generator RPM.
	1440	1600.	
	1441	2600.	
No. of M	1447	3.	Number of mach numbers in location 144-1453.
Values of M	1448	0.	} Values of mach number for the referred gas generator RPM.
	1449	.4	
	1450	.8	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>	
Referred Gas Generator RPM table	1454	.26	} Values of referred gas generator RPM limit corresponding to T/θ location 1439 and mach numbers found in locations 1448-1453.	
	1455	.271		
	1456	.29		
		1460	.82	} Values of referred gas generator RPM limit corre- sponding to T/θ location 1440 and mach numbers in locations 1448-1453.
		1461	.84	
		1462	.9	
		1466	1.09	} Values of referred gas generator RPM limit corre- sponding to T/θ location 1441 and mach numbers found in locations 1448-1453.
		1467	1.118	
	No. of T/θ	1502	8.	Number of referred tempera- tures in locations 1510.
	Values of T/θ	1503	950.	} Values of referred tempera- ture for the referred power turbine speed limit ratio.
1504		1200.		
1505		1400.		
1506		1600.		
1507		1800.		
1508		2000.		
1509		2200.		
	1510	2600.		
No. of M	1511	5.	Number of mach numbers in locations 1512-1517.	
Values of M	1512	0.	} Values of mach number for the referred power turbine speed limit ratio.	
	1513	.2		
	1514	.4		
Referred Power Turbine Limit Table	1518	.26	} Values of referred power turbine speed limit corre- sponding to T/θ location 1503 and mach numbers found in locations 1512-1517.	
	1519	.256		
	1520	.271		
	1521	.28		
	1522	.29		
		1524	.52	} Values of referred power tur- bine speed limit corresponding to location 1504 and mach numbers found in locations 1512-1517.
		1525	.527	
		1526	.54	
		1527	.56	
		1528	.59	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
	1530	.68	} Values of referred turbine speed limit corresponding to T/θ location 1505 and mach numbers found in locations 1512-1517.
	1531	.69	
	1532	.705	
	1533	.73	
	1534	.76	
	1536	.82	} Values of referred power turbine speed limit corresponding to T/θ location 1506 and mach numbers found in locations 1512-1517.
	1537	.824	
	1538	.84	
	1539	.868	
	1540	.9	
	1542	.92	} Values of referred power turbine speed limit corresponding to T/θ location 1507 and mach numbers found in locations 1512-1517.
	1543	.93	
	1544	.95	
	1545	.98	
	1546	1.02	
	1548	1.0	} Values of referred power turbine speed limit corresponding to T/θ location 1508 and mach numbers found in locations 1512-1517.
	1549	1.002	
	1550	1.02	
	1551	1.05	
	1552	1.09	
	1554	1.052	} Values of referred power turbine speed limit corresponding to T/θ location 1509 and mach numbers found in locations 1512-1517.
	1555	1.055	
	1556	1.07	
	1557	1.1	
	1558	1.131	
	1560	1.09	} Values of referred power turbine speed limit corresponding to T/θ location 1510 and mach numbers found in locations 1512-1517.
	1561	1.1	
	1562	1.118	
	1563	1.135	
	1564	1.165	

Since this example utilized an auxiliary engine, the auxiliary engine cycle input locations were created by placing a 66666 card in front and behind a standard engine cycle. The 66666 cards added an additional 1000 on the standard engine cycle input locations. This is shown in the output as locations 2201 to 1564. The auxiliary engine inputs are identical to the primary engine inputs for this example. The auxiliary engine cycle input locations are not listed in order to avoid redundancy.



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
SHORT FORM AERO (MAIN) ROTOR CYCLE INFORMATION			
Rotor Cycle No.	1601	3.	Input rotor cycle number.
$\theta$ TWIST REF	1602	-9.	
$C_{DB0}$	1603	.00995	Baseline rotor hover profile drag coefficient.
$K_H$	1604	-.028	Rotor blade hover profile drag parameter.
$K_{H2}$	1605	.262	Rotor blade hover compressibility drag parameter.
$K_{H3}$	1606	.276	Rotor blade hover compressibility drag parameter.
$K_{H4}$	1607	2.54	Rotor blade hover drag divergence mach number parameter.
$M_{DB0}$	1608	.865	Baseline rotor hover compressibility drag rise, left=0, mach number.
$C_{DB}$	1609	.0105	Baseline rotor cruise profile drag coefficient.
$K_{C1}$	1610	2.82	Rotor retreating blade stall profile drag parameter.
$K_{C2}$	1611	.09	Rotor retreating blade stall profile drag parameter.
$K_{C3}$	1612	1.17	Rotor advancing tip mach number compressibility drag parameter.
$K_{C4}$	1613	.00124	
$K_{C5}$	1614	.758	
$M_{D0}$	1615	.743	Baseline rotor advancing tip compressibility drag rise mach number.
No. of $C_T$	1616	10.	Number of $C_T$ 's input in locations 1617-1626.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
Values of $C_T$	1617	0.	Values of propeller thrust coefficient.
	1618	.004	
	1619	.007	
	1620	.009	
	1621	.01	
	1622	.011	
	1623	.0115	
	1624	.012	
	1625	.0155	
	1626	.022	
Values of $K_{HOV_A}$	1627	1.018	Values of rotor hover induced power factor.
	1628	1.085	
	1629	1.154	
	1630	1.233	
	1631	1.279	
	1632	1.314	
	1633	1.327	
	1634	1.337	
	1635	1.364	
	1636	1.397	

SAMPLE CASE NO 1. RUN 2.

OPTIND	0001	0	Size for weights only, no performance mission.
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HELICOPTER ENGINE PERFORMANCE COMPUTER PROGRAM R-01

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.  
 VAL2 VALUE CORRESPONDING TO LOC.  
 VAL3 VALUE CORRESPONDING TO LOC.  
 VAL4 VALUE CORRESPONDING TO LOC.  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
1201	5	0.0	0.0	0.0	0.0	0.0
1202	1	0.0	0.0	0.0	0.0	0.0
1203	1	0.0500	0.0500	0.0500	0.0500	0.0500
1204	5	1.7710	1.7710	1.7710	1.7710	1.7710
1205	5	1.1010	1.1010	1.1010	1.1010	1.1010
1206	5	4.7000	4.7000	4.7000	4.7000	4.7000
1207	5	2.1000	2.1000	2.1000	2.1000	2.1000
1208	5	2.0000	2.0000	2.0000	2.0000	2.0000
1209	5	0.1630	0.1630	0.1630	0.1630	0.1630
1210	5	0.1550	0.1550	0.1550	0.1550	0.1550
1211	5	0.5440	0.5440	0.5440	0.5440	0.5440
1212	5	0.7700	0.7700	0.7700	0.7700	0.7700
1213	5	1.0000	1.0000	1.0000	1.0000	1.0000
1214	5	1.2000	1.2000	1.2000	1.2000	1.2000
1215	5	1.4500	1.4500	1.4500	1.4500	1.4500
1216	5	4.0000	4.0000	4.0000	4.0000	4.0000
1217	5	1.0000	1.0000	1.0000	1.0000	1.0000
1218	5	0.0000	0.0000	0.0000	0.0000	0.0000
1219	5	0.0000	0.0000	0.0000	0.0000	0.0000
1220	5	0.0000	0.0000	0.0000	0.0000	0.0000
1221	5	0.0000	0.0000	0.0000	0.0000	0.0000
1222	5	0.0000	0.0000	0.0000	0.0000	0.0000
1223	5	0.0000	0.0000	0.0000	0.0000	0.0000
1224	5	0.0000	0.0000	0.0000	0.0000	0.0000
1225	5	0.0000	0.0000	0.0000	0.0000	0.0000
1226	5	0.0000	0.0000	0.0000	0.0000	0.0000
1227	5	0.0000	0.0000	0.0000	0.0000	0.0000
1228	5	0.0000	0.0000	0.0000	0.0000	0.0000
1229	5	0.0000	0.0000	0.0000	0.0000	0.0000
1230	5	0.0000	0.0000	0.0000	0.0000	0.0000
1231	5	0.0000	0.0000	0.0000	0.0000	0.0000
1232	5	0.0000	0.0000	0.0000	0.0000	0.0000
1233	5	0.0000	0.0000	0.0000	0.0000	0.0000
1234	5	0.0000	0.0000	0.0000	0.0000	0.0000
1235	5	0.0000	0.0000	0.0000	0.0000	0.0000
1236	5	0.0000	0.0000	0.0000	0.0000	0.0000
1237	5	0.0000	0.0000	0.0000	0.0000	0.0000
1238	5	0.0000	0.0000	0.0000	0.0000	0.0000
1239	5	0.0000	0.0000	0.0000	0.0000	0.0000
1240	5	0.0000	0.0000	0.0000	0.0000	0.0000
1241	5	0.0000	0.0000	0.0000	0.0000	0.0000
1242	5	0.0000	0.0000	0.0000	0.0000	0.0000
1243	5	0.0000	0.0000	0.0000	0.0000	0.0000
1244	5	0.0000	0.0000	0.0000	0.0000	0.0000
1245	5	0.0000	0.0000	0.0000	0.0000	0.0000
1246	5	0.0000	0.0000	0.0000	0.0000	0.0000
1247	5	0.0000	0.0000	0.0000	0.0000	0.0000
1248	5	0.0000	0.0000	0.0000	0.0000	0.0000
1249	5	0.0000	0.0000	0.0000	0.0000	0.0000
1250	5	0.0000	0.0000	0.0000	0.0000	0.0000
1251	5	0.0000	0.0000	0.0000	0.0000	0.0000
1252	5	0.0000	0.0000	0.0000	0.0000	0.0000
1253	5	0.0000	0.0000	0.0000	0.0000	0.0000
1254	5	0.0000	0.0000	0.0000	0.0000	0.0000
1255	5	0.0000	0.0000	0.0000	0.0000	0.0000
1256	5	0.0000	0.0000	0.0000	0.0000	0.0000
1257	5	0.0000	0.0000	0.0000	0.0000	0.0000
1258	5	0.0000	0.0000	0.0000	0.0000	0.0000
1259	5	0.0000	0.0000	0.0000	0.0000	0.0000
1260	5	0.0000	0.0000	0.0000	0.0000	0.0000
1261	5	0.0000	0.0000	0.0000	0.0000	0.0000
1262	5	0.0000	0.0000	0.0000	0.0000	0.0000
1263	5	0.0000	0.0000	0.0000	0.0000	0.0000
1264	5	0.0000	0.0000	0.0000	0.0000	0.0000
1265	5	0.0000	0.0000	0.0000	0.0000	0.0000
1266	5	0.0000	0.0000	0.0000	0.0000	0.0000
1267	5	0.0000	0.0000	0.0000	0.0000	0.0000
1268	5	0.0000	0.0000	0.0000	0.0000	0.0000
1269	5	0.0000	0.0000	0.0000	0.0000	0.0000
1270	5	0.0000	0.0000	0.0000	0.0000	0.0000
1271	5	0.0000	0.0000	0.0000	0.0000	0.0000
1272	5	0.0000	0.0000	0.0000	0.0000	0.0000
1273	5	0.0000	0.0000	0.0000	0.0000	0.0000
1274	5	0.0000	0.0000	0.0000	0.0000	0.0000
1275	5	0.0000	0.0000	0.0000	0.0000	0.0000
1276	5	0.0000	0.0000	0.0000	0.0000	0.0000
1277	5	0.0000	0.0000	0.0000	0.0000	0.0000
1278	5	0.0000	0.0000	0.0000	0.0000	0.0000
1279	5	0.0000	0.0000	0.0000	0.0000	0.0000
1280	5	0.0000	0.0000	0.0000	0.0000	0.0000
1281	5	0.0000	0.0000	0.0000	0.0000	0.0000
1282	5	0.0000	0.0000	0.0000	0.0000	0.0000
1283	5	0.0000	0.0000	0.0000	0.0000	0.0000
1284	5	0.0000	0.0000	0.0000	0.0000	0.0000
1285	5	0.0000	0.0000	0.0000	0.0000	0.0000
1286	5	0.0000	0.0000	0.0000	0.0000	0.0000
1287	5	0.0000	0.0000	0.0000	0.0000	0.0000
1288	5	0.0000	0.0000	0.0000	0.0000	0.0000
1289	5	0.0000	0.0000	0.0000	0.0000	0.0000
1290	5	0.0000	0.0000	0.0000	0.0000	0.0000
1291	5	0.0000	0.0000	0.0000	0.0000	0.0000
1292	5	0.0000	0.0000	0.0000	0.0000	0.0000
1293	5	0.0000	0.0000	0.0000	0.0000	0.0000
1294	5	0.0000	0.0000	0.0000	0.0000	0.0000
1295	5	0.0000	0.0000	0.0000	0.0000	0.0000
1296	5	0.0000	0.0000	0.0000	0.0000	0.0000
1297	5	0.0000	0.0000	0.0000	0.0000	0.0000
1298	5	0.0000	0.0000	0.0000	0.0000	0.0000
1299	5	0.0000	0.0000	0.0000	0.0000	0.0000
1300	5	0.0000	0.0000	0.0000	0.0000	0.0000

NOTE: IN USING AUXILIARY ENGINES, AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 6666 CARD IN FRONT AND REWIND A STANDARD ENGINE CYCLE



11	10000	20000	10000	10000	10000	10000
12	20000	20000	20000	20000	20000	20000
13	25000	25000	25000	25000	25000	25000
14	30000	30000	30000	30000	30000	30000
15	35000	35000	35000	35000	35000	35000
16	40000	40000	40000	40000	40000	40000
17	45000	45000	45000	45000	45000	45000
18	50000	50000	50000	50000	50000	50000
19	55000	55000	55000	55000	55000	55000
20	60000	60000	60000	60000	60000	60000
21	65000	65000	65000	65000	65000	65000
22	70000	70000	70000	70000	70000	70000
23	75000	75000	75000	75000	75000	75000
24	80000	80000	80000	80000	80000	80000
25	85000	85000	85000	85000	85000	85000
26	90000	90000	90000	90000	90000	90000
27	95000	95000	95000	95000	95000	95000
28	100000	100000	100000	100000	100000	100000
29	105000	105000	105000	105000	105000	105000
30	110000	110000	110000	110000	110000	110000
31	115000	115000	115000	115000	115000	115000
32	120000	120000	120000	120000	120000	120000
33	125000	125000	125000	125000	125000	125000
34	130000	130000	130000	130000	130000	130000
35	135000	135000	135000	135000	135000	135000
36	140000	140000	140000	140000	140000	140000
37	145000	145000	145000	145000	145000	145000
38	150000	150000	150000	150000	150000	150000
39	155000	155000	155000	155000	155000	155000
40	160000	160000	160000	160000	160000	160000
41	165000	165000	165000	165000	165000	165000
42	170000	170000	170000	170000	170000	170000
43	175000	175000	175000	175000	175000	175000
44	180000	180000	180000	180000	180000	180000
45	185000	185000	185000	185000	185000	185000
46	190000	190000	190000	190000	190000	190000
47	195000	195000	195000	195000	195000	195000
48	200000	200000	200000	200000	200000	200000
49	205000	205000	205000	205000	205000	205000
50	210000	210000	210000	210000	210000	210000
51	215000	215000	215000	215000	215000	215000
52	220000	220000	220000	220000	220000	220000
53	225000	225000	225000	225000	225000	225000
54	230000	230000	230000	230000	230000	230000
55	235000	235000	235000	235000	235000	235000
56	240000	240000	240000	240000	240000	240000
57	245000	245000	245000	245000	245000	245000
58	250000	250000	250000	250000	250000	250000
59	255000	255000	255000	255000	255000	255000
60	260000	260000	260000	260000	260000	260000
61	265000	265000	265000	265000	265000	265000
62	270000	270000	270000	270000	270000	270000
63	275000	275000	275000	275000	275000	275000
64	280000	280000	280000	280000	280000	280000
65	285000	285000	285000	285000	285000	285000
66	290000	290000	290000	290000	290000	290000
67	295000	295000	295000	295000	295000	295000
68	300000	300000	300000	300000	300000	300000
69	305000	305000	305000	305000	305000	305000
70	310000	310000	310000	310000	310000	310000
71	315000	315000	315000	315000	315000	315000
72	320000	320000	320000	320000	320000	320000
73	325000	325000	325000	325000	325000	325000
74	330000	330000	330000	330000	330000	330000
75	335000	335000	335000	335000	335000	335000
76	340000	340000	340000	340000	340000	340000
77	345000	345000	345000	345000	345000	345000
78	350000	350000	350000	350000	350000	350000
79	355000	355000	355000	355000	355000	355000
80	360000	360000	360000	360000	360000	360000
81	365000	365000	365000	365000	365000	365000
82	370000	370000	370000	370000	370000	370000
83	375000	375000	375000	375000	375000	375000
84	380000	380000	380000	380000	380000	380000
85	385000	385000	385000	385000	385000	385000
86	390000	390000	390000	390000	390000	390000
87	395000	395000	395000	395000	395000	395000
88	400000	400000	400000	400000	400000	400000
89	405000	405000	405000	405000	405000	405000
90	410000	410000	410000	410000	410000	410000
91	415000	415000	415000	415000	415000	415000
92	420000	420000	420000	420000	420000	420000
93	425000	425000	425000	425000	425000	425000
94	430000	430000	430000	430000	430000	430000
95	435000	435000	435000	435000	435000	435000
96	440000	440000	440000	440000	440000	440000
97	445000	445000	445000	445000	445000	445000
98	450000	450000	450000	450000	450000	450000
99	455000	455000	455000	455000	455000	455000
100	460000	460000	460000	460000	460000	460000

2627	1.0000	0.0000	2.0000	24.11
2632	1.0000	75.00	1.0000	0.0000
2637	44.070	2.2500	75.00	1.1500
2642	14.200	14.200	2746.00	250.00
2647	3.0000	25.000	1.0000	0.1100
2652	17000	17000	1.0000	1.0000
2659	1.0000	1.0000	1.0000	1.0000
2664	1.0000	1.0000	1.0000	1.0000
2669	1.0000	1.0000	1.0000	1.0000
307	2.0000	3.0000	0.0000	1.0000
354	0.0000	7.000	1.0000	1.0000
363	1.0000	1.0000	1.0000	1.0000
368	1.0000	1.0000	1.0000	1.0000
375	1.0000	1.0000	1.0000	1.0000
4 1	1.0000	1.0000	1.0000	1.0000
411	0.3300F-01			
421	0.0000			
431	1.0000			
441	1.0000			
451	1.0000			
461	1.0000			
471	1.0000			
481	1.0000			
491	1.0000			
501	1.0000			
511	1.0000			
521	1.0000			
531	1.0000			
541	1.0000			
551	1.0000			
561	1.0000			
571	1.0000			
581	1.0000			
591	1.0000			
6 1	1.0000			
611	1.0000			
621	1.0000			
631	1.0000			
641	1.0000			
651	1.0000			
661	1.0000			
671	1.0000			
681	1.0000			
691	1.0000			
701	1.0000			
711	1.0000			
721	1.0000			
731	1.0000			
741	1.0000			
751	1.0000			
761	1.0000			
771	1.0000			
781	1.0000			
791	1.0000			
8 1	1.0000			
811	1.0000			
821	1.0000			
831	1.0000			
841	1.0000			
851	1.0000			
861	1.0000			
871	1.0000			
881	1.0000			
891	1.0000			
901	1.0000			
911	1.0000			
921	1.0000			
931	1.0000			
941	1.0000			
951	1.0000			
961	1.0000			
971	1.0000			
981	1.0000			
991	1.0000			

1081	2	.5000	.2500
1091	2	1.1000	1.1000
1101	2	.0	.0
1111	1	.3500	.0
1121	2	.0	.0
1131	2	.0	.0
1141	1	-1000.0	.0
1171	1	.1000E-11	.0
1181	1	1000.0	.0
1191	1	1.0000	.0

WG = 0.250000E+15 MFA = 0.0 MFR = 1.0  
 WR = 1.250000E+15 MFA = 0.75663 E+04 MFR = 0.512243E+04  
 WC = 0.215093E+05 MFA = 0.557073E+14 MFR = 0.448605E+04  
 WU = 0.181972E+05 MFA = 0.43652E+14 MFR = 0.357657E+04

HELICOPTER SIZING & PERFORMANCE COMPUTE PROGRAM R-01

SINGLE ROTOR COMPOUND HELICOPTER AUX. THEFFPENT T/SHAFT CRUISE PROPULSION

SIZE OPT THIS RUN COMPLETED IN 4 ITERATIONS

GROSS WEIGHT = 17600. LB

FUSELAGE

LF LENGTH BODY+TAIL (MOON)  
 LC LENGTH CAPTIVE  
 LE LENGTH (BODY)  
 LPT LENGTH TAIL (MOON)  
 FM ROTOR LOCATION  
 WM WIDTH  
 WF WETTED AREA

5.1 FT.  
 12.0 FT.  
 27.7 FT.  
 22.6 FT.  
 19.1 FT.  
 6.5 FT.  
 736.2 SQ. FT.

WING

AR ASPECT RATIO  
 AREA  
 SPAN  
 MEAN CHORD  
 QUARTER CHORD CHORD  
 TAPER RATIO  
 ROOT THICKNESS/CHORD  
 TIP THICKNESS/CHORD  
 WING LOADING  
 ROTOR/TIP GAP  
 FLAP CHORD/SPAN CHORD RATIO

4.51  
 113.6 SQ. FT.  
 22.6 FT.  
 5.0 FT.  
 0.66  
 0.22  
 0.12  
 126.7 LB/FT. FT.  
 1.04 FT.  
 1.00

PROP. TAIL

ASPT ASPECT RATIO  
 AREA  
 SPAN  
 MEAN CHORD  
 TAPER RATIO  
 WING/PROP  
 WING/TIP GAP  
 WING/TAIL AREA RATIO

0.22  
 1.04 SQ. FT.  
 1.04 FT.  
 0.22  
 0.12  
 0.12  
 0.12

WEPT. TAIL

ASPT ASPECT RATIO  
 AREA  
 SPAN  
 MEAN CHORD  
 TAPER RATIO  
 WING/WEPT. TAIL  
 WING/TIP GAP  
 WING/TAIL AREA RATIO

1.507  
 21.2 SQ. FT.  
 3.7 FT.  
 3.7 FT.  
 0.48  
 4.06 FT.  
 1.66



0.150

THICKNESS/CHORD

CT/CVNT

MAIN ROTOR PYLON

ASPECT RATIO 9.00  
WETTED AREA 39.1 SQ. FT.  
FRONTAL AREA 5.2 SQ. FT.  
HEIGHT 3.8 FT.  
MEAN CHORD 6.0 FT.  
TAPER RATIO 3.400  
ROOT THICKNESS/CHORD 0.400  
TIP THICKNESS/CHORD 0.200

PRIMARY ENGINE NACELLE

LN 5.8 FT.  
DN 2.0 FT.  
SN 60.9 SQ. FT.

WETTED AREA(TOTAL FOR ALL ENGINES)

AUXILIARY INDEPENDENT ENGINE NACELLE

LN 4.8 FT.  
DN 1.0 FT.  
SN 19.0 SQ. FT.

WETTED AREA(TOTAL FOR ALL ENGINES)

AUXILIARY INDEPENDENT ENGINE NACELLE STRUT

SSTR 3.0 SQ. FT.  
RNS 0.1 FT.  
CNS 2.8 FT.

WETTED AREA(TOTAL)

SPAN

MEAN CHORD

PROPELLER(AUXILIARY PROPULSION)

DAR 39.0 FT.  
AF 100.0  
SIGR 0.171  
NRA 1.  
NO. BLADES 3.  
VTIP 900. FT./SEC

DIAMETER

ACTIVITY FACTOR PER BLADE

SOLIDITY

NO. OF PROPELLERS

NO. (BLADES/PROP)

TIP SPEED

MAIN ROTOR

CMR 45.2 FT.  
SIFMR 2.125  
WR/A 11.0 LP/SQ. FT.  
CT/SIGMA 0.114  
MP 1.  
NO. BLADES 0.  
THYA 0.005 NEG.  
YC 0.005  
VTIP 1000. FT./SEC.

DIAMETER

SOLIDITY

W/C LOADING

THRUST COEFF./SQ. IDITY

NO. OF ROTORS

NO. OF PLAYS/PROP

PLANE THIRST

PLANE CUTOUT/RADIUS RATIO

TIP SPEED

TAIL ROTOR

CTR 3.5 FT.  
STGR 0.257  
CT/SIGMA 37.6 LP/SQ. FT.  
NO. BLADES 0.  
THYA 0.005 NEG.

DIAMETER

SOLIDITY

REV. DISC LOADING

THRUST COEFF./SOLIDITY

NO. BLADES

PLANE THIRST

HELICOPTER SYSTEM & PERFORMANCE COMPUTER PROGRAM P-91

H T S O M P

P R O P U L S I O N D A T A  
PRIMARY PROPELLER CYCLE NO. 1.761  
TURBOCHAFT ENGINE

2. ENGINES

PROP MAX. STANDARD S.O.L. STATIC H.P. 4630 H.P.

ENGINE SIZED FOR TAKEOFF AT 10000 FT.  
50% PERCENT MILITARY POWER SETTING  
H = 4000 FT. TEMPERATURE = 45.14 DEGS. F.  
ENGINE INOPERATIVE. AND 0% PLUM VERTICAL RATE OF CLIPP.

AV. INDEPENDENT PROPELLER CYCLE NO. 1.0761  
TURBOCHAFT ENGINE

1. ENGINES

PROPEL MAX. STANDARD S.O.L. STATIC H.P. 1882 H.P.

ENGINE SIZED FOR CRUISE AT VC = 17% MINUTE  
NORMAL POWER SETTING  
H = 3000 FT. TEMPERATURE = 41.54 DEGS. F.  
AND 0% ENGINE INOPERATIVE.

PROPEL AND TAIL ROTOR DRIVE SYSTEM RATING 3257 H.P.

MAIN ROTOR DRIVE SYSTEM RATING 2021 H.P.

ENGINE SIZED AT 10% PERCENT OF TAIL ROTOR POWER SOURCE PROVIDED  
AT H = 4000 FT. TEMPERATURE = 45.14 DEGS. F. ENGINE INOPERATIVE

TAIL ROTOR DRIVE SYSTEM RATING 477 H.P.

ENGINE SIZED AT 10% PERCENT OF TAIL ROTOR POWER SOURCE PROVIDED  
AT H = 4000 FT. TEMPERATURE = 45.14 DEGS. F. ENGINE INOPERATIVE

AVG. INDEPENDENT PROPELLER DRIVE SYSTEM RATING 477 H.P.

ENGINE SIZED AT 10% PERCENT OF AV. PROPELLER DRIVE POWER PROVIDED AT VC 17%  
H = 3000 FT. TEMPERATURE = 41.54 DEGS. F.

VTIC  
C  
VTIC

PLANE CUTOUT/RADIUS RATIO  
MAX TAIL ROTOR GAS  
TER SPED

VTIC  
C  
VTIC

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-93

M E S C O M P

WEIGHTS DATA IN LBS

MLF	MANUEVER LOAD FACTOR	3.500
GLF	GUST LOAD FACTOR	3.500
ULF	ULTIMATE LOAD FACTOR	6.250
PROPULSION GROUP		
UPPS	TOTAL MAIN ROTOR GROUP	1765.
UPRR	MAIN ROTOR BLADE (PER ROTOR)	1.26.
UPRH	MAIN ROTOR HUB (PER ROTOR)	512.
UPR	BLADE TOLLING/SCIPER ROTORS	231.
UPR	AUXILIARY PROPULSION ROTOR GROUP	122.
UPR	DRIVE SYSTEM	1686.
UPR	MAIN ROTOR DRIVE SYSTEM	1362.
UPR	TAIL ROTOR DRIVE SYSTEM	139.
UPR	AUXILIARY PROPULSION DRIVE SYSTEM	275.
UPR	PRIMARY ENGINE	737.
UPR	AUXILIARY ENGINE	2.0.
UPR	PRIMARY ENGINE INSTALLATION	185.
UPR	AUXILIARY ENGINE INSTALLATION	75.
UPR	FUEL SYSTEM	416.
UPR	PROPULSION GROUP WEIGHT INCREMENT	0.
UPR	TOTAL PROPULSION GROUP WEIGHT	9103.
STRUCTURES GROUP		
USR	WING	234.
USR	TAIL GROUP	144.
USR	HOR. TAIL	71.
USR	TAIL ROTOP	124.
USR	FUSELAGE	1946.
USR	LANDING GEAR	707.
USR	NOSE GEAR	141.
USR	MAIN GEAR	766.
USR	TOTAL ENGINE SECTION	146.
USR	PRIMARY ENGINE SECTION	140.
USR	AUXILIARY ENGINE SECTION	61.
USR	STRUCTURE WEIGHT INCREMENT	0.
USR	TOTAL STRUCTURE WEIGHT	3277.
FLIGHT CONTROLS GROUP		
UPPC	PRIMARY FLIGHT CONTROLS	716.
UPC	COCKPIT CONTROLS	11.
UPC	MAIN ROTOR CONTROLS	347.
UPC	MAIN ROTOR SYSTEMS CONTROLS	0.
UPC	FIXED WING CONTROLS	0.
UPC	TILT MECHANISM	0.
UPC	SW	3.
UPC	AUXILIARY FLIGHT CONTROLS	55.
UPC	SUB. PROPULSION ROTOR CONTROLS	24.

WFC	WFC	AVG. PROPELLSION ROTOR SVR. CONTROLS	31.
WFC	WFC	MISCELLANEOUS CONTROLS	0.
WFC	WFC	CONTROL WEIGHT INCREMENT	190.
		TOTAL CONTROL WEIGHT	471.
WFC		WEIGHT OF FIXED EQUIPMENT	2817.
WFC		WEIGHT EMPTY	31452.
WFC		FIXED USEFUL LOAD	451.
WFC		OPERATING WEIGHT EMPTY	31902.
WFC		PAYLOAD	2660.
WFC		FUEL	2781.
WFC		GROSS WEIGHT	17683.

SAMPLE CASE NO. 1 RUN 1

PAGE 4

7-50

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

ROTOR DATA

ROTOR CYCLE NO. 3.0030  
 MAIN ROTOR SOLIDITY SIZED BY MANUEVER CONDITIONS  
 M = 3000.0 FT. \* 12MP = 51.5 DEG. \* V = 167.0 KT.  
 100.0 PERCENT MOTOR RPM  
 ROTOR MANUEVER G'S = 1.350 \* CT/SIGMA = 0.130

TAIL ROTOR SIZED AT 1.00 TIMES THE SOLIDITY  
 REQUIRED TO SATISFY HOVER/TURN REQUIREMENTS AT 1  
 M  
 12MP = 4100.0 FT.  
 CT/CTHET = 99.235 DEG. \* V = 3.023  
 YAW RATE = 0.790 RAD/SEC.  
 YAW ACCELERATION = 0.130 RAD/SEC.  
 TAIL ROTOR DUEAR  
 MOM. OF INERTIA PER BLADE = 0.192 SLUG/FT.<sup>2</sup>  
 HELICOPTER YAW  
 MOM. OF INERTIA = 36506.9 SLUG/FT.<sup>2</sup>

END OF SUCCESSIVE CASE

SAMPLE CASE NO. 1 RUN 1

PAGE 6

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 0-91

A E R O D Y N A M I C S O A T A			
SOFT	TOTAL EFFECTIVE FLATPLATE AREA	19.916	SOFT
CBHP	TOTAL WETTED AREA	2293.	SOFT
	MEAN SKIN FRICTION COEFF.	0.01638	
O R A S P R E A P D O W N			
PCU	WING FC	0.731	
FEF	FUSELAGE FF	18.288	
FEAP	FORWARD MAIN ROTOR PYLON FF	0.0	
FPYON	AFT ROTOR PYLON FF	0.0	
FEVH	MAIN ROTOR HUB FF	0.0	
FEV	TAIL ROTOR HUB FF	0.0	
FEM	VERTICAL TAIL FE	0.0	
FEM	HORIZONTAL TAIL FE	0.0	
FEM	PRIMARY ENGINE MACCELL FF	0.0	
FEM	AUX. INDEPENDENT CHUSP ENG. MAC. FE	0.0	
FEM	AUX. INDEPENDENT CHUSP ENG. STRUT FE	0.0	
DELTA FE	INCREMENTAL FE	0.0	
A E R O D Y N A M I C C O E F F .			
A6		18.288	
A7		0.0	
A8		0.0	
A9		0.0	
E	WING LIFT EFFICIENCY FACTOR	0.7802	
FV	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.00108	

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-00

MISSION PERFORMANCE DATA

TASK FOR 0.033 HR. AT GROUND IDLE ENGINE RATING

TIME (HRS)	RANGE (M.P.)	FUEL USED (LBS)	WEIGHT (LBS)	PRESS. ALT. (FT)	TAS (KTS)	PRIP. TURN. TEMP. (C)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/HR)	AUX. TURB. TEMP. (C)	AUX. ENG. CODE	AUX. ENG. PEMP	AUX. FUEL FLOW (LBS/HR)	AUX. TEMP. (C)
0.0	0.0	0.0	17473	0	0.0	92.0	Y	0.0	0.0	92.0	Y	0.0	0.0	92.0
0.033	0.0	14.6	17469	0	0.0	92.0	Y	0.0	0.0	92.0	Y	0.0	0.0	92.0

TAKOFF, POWER, OR LAND AT TAN = 1.06 FOR 0.100 HRS.

TIME (HRS)	RANGE (M.P.)	FUEL USED (LBS)	WEIGHT (LBS)	PRESS. ALT. (FT)	TAS (KTS)	PRIP. TURN. TEMP. (C)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/HR)	AUX. TURB. TEMP. (C)	AUX. ENG. CODE	AUX. ENG. PEMP	AUX. FUEL FLOW (LBS/HR)	AUX. TEMP. (C)
0.033	0.0	14.6	17468	0	0.0	165.7	F	0.608	133.0	1.6	0.75	200.0	0.0	0.75
725.0	2702	601.0	319	0	1420	142.0	A	0.608	59.1	0.0	0.75	200.0	0.0	0.75
0.033	0.0	14.6	17470	0	0.0	164.0	F	0.621	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2326	601.0	314	0	1420	142.0	A	0.621	59.1	0.0	0.75	200.0	0.0	0.75
0.033	0.0	14.6	17470	0	0.0	162.0	F	0.619	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2375	600.6	314	0	1420	142.0	A	0.619	59.1	0.0	0.75	200.0	0.0	0.75
0.033	0.0	14.6	17476	0	0.0	161.0	F	0.618	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2328	600.6	314	0	1420	142.0	A	0.618	59.1	0.0	0.75	200.0	0.0	0.75
0.033	0.0	14.6	17506	0	0.0	167.0	F	0.618	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2765	600.6	314	0	1420	142.0	A	0.618	59.1	0.0	0.75	200.0	0.0	0.75
0.033	0.0	14.6	17516	0	0.0	167.0	F	0.616	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2389	600.6	314	0	1420	142.0	A	0.616	59.1	0.0	0.75	200.0	0.0	0.75
0.033	0.0	14.6	17516	0	0.0	167.0	F	0.616	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2769	600.6	314	0	1420	142.0	A	0.616	59.1	0.0	0.75	200.0	0.0	0.75

CRUISE AT 17% MOTOR TAS. LIMITED BY NORMAL ENGINE RATING

TIME (HRS)	RANGE (M.P.)	FUEL USED (LBS)	WEIGHT (LBS)	PRESS. ALT. (FT)	TAS (KTS)	PRIP. TURN. TEMP. (C)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/HR)	AUX. TURB. TEMP. (C)	AUX. ENG. CODE	AUX. ENG. PEMP	AUX. FUEL FLOW (LBS/HR)	AUX. TEMP. (C)
0.033	0.0	14.6	17516	0	0.0	167.0	F	0.616	132.0	1.6	0.75	200.0	0.0	0.75
725.0	2769	600.6	314	0	1420	142.0	A	0.616	59.1	0.0	0.75	200.0	0.0	0.75







TIME (HRS)	W-ROTOR RPM	W-ROTOR VTY (FT)	FUEL USED (LBS)	TORQUE (LBS-FT)	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)
0.788	97.85	1100.0	16570	5000	149.1	1812.5	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370
725.0	1600	600.0	170	170	980	1812.5	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370	0.00370
3.000400	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.889	112.26	1237.6	16450	9100	149.1	1811.5	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369
725.0	1550	630.4	170	170	986	1811.5	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369	0.00369
0.889406	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.989	127.65	1360.2	16320	5000	149.1	1810.7	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	1420	690.0	186	186	982	1810.7	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
0.889405	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.090	142.24	1467.5	16195	5000	149.1	1807.7	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	1470	700.0	176	176	979	1807.7	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
0.889403	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.437	150.20	1547.2	16135	5000	149.1	1806.4	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	1560	700.0	176	176	978	1806.4	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
0.889402	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

TRANSFER ALTITUDE TO 100 FT.

FILES

WEIGHT ALT. WTS

VAROFF. MOVE. OP. LAMP AT 1/6 = 10.6 FOR 1.200 MBS.

TIME (HRS)	W-ROTOR RPM	W-ROTOR VTY (FT)	FUEL USED (LBS)	TORQUE (LBS-FT)	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)	W-ROTOR RPM	W-ROTOR VTY (FT)
1.137	150.00	1547.3	16135	1000	149.1	1833.1	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2100	600.0	271	271	1301	1833.1	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
1.137	150.00	1775.1	16135	1000	149.1	1631.0	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2100	600.0	271	271	1290	1631.0	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
1.177	150.00	1602.9	16040	1000	149.1	1637.6	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2050	600.0	263	263	1206	1637.6	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
1.197	150.00	1620.7	16032	1000	149.1	1629.0	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2000	600.0	260	260	1200	1629.0	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
1.217	150.00	1650.0	16020	1000	149.1	1620.2	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2050	600.0	267	267	1201	1620.2	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
1.237	150.00	1686.1	15997	1000	149.1	1627.1	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2000	600.0	266	266	1200	1627.1	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
1.257	150.00	1733.7	15969	1000	149.1	1625.0	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368
725.0	2070	600.0	260	260	1207	1625.0	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368	0.00368

TRANSFER ALTITUDE TO 100 FT.



TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PREP. ALT. (FT)	TAS (KTS)	DELCS	DELCOM	CRP	RTLIM CODE	J	CP	CT	ALPHA D/L (DEG)	GAMMA B/P (DEG)	R/C (FFM)
0.000150	0.000157	0.000033	0.000009	0.00021	0.0	0.00038	0.000183	A					0.006	0.007	0.046
1.597	150.00	2065.5	14617.	1000.	75.6	1372.0	P	0.237		74.5	0.176	0.055	-1.5	964.	1079.
725.0	890.	690.0	57.		809.		0.039	0.350		155.	1207.5	P	0.443	964.	95.
0.000150	0.000156	0.000032	0.000009	0.00021	0.0	0.00038	0.000182	A					0.400	0.007	0.042
1.647	150.00	2133.7	14569.	1100.	75.6	1371.4	P	0.236		74.5	0.176	0.055	-1.5	963.	1176.
725.0	890.	690.0	57.		809.		0.039	0.350		155.	1207.4	P	0.443	963.	95.
0.000150	0.000155	0.000032	0.000009	0.00021	0.0	0.00037	0.000182	A					0.400	0.007	0.041
1.697	150.00	2161.9	14521.	1000.	75.6	1370.8	P	0.235		74.5	0.176	0.055	-1.5	962.	1373.
725.0	887.	690.0	57.		807.		0.039	0.350		155.	1207.4	P	0.443	962.	95.
0.000150	0.000154	0.000032	0.000009	0.00021	0.0	0.00037	0.000182	A					0.400	0.007	0.041
1.747	150.00	2210.0	14473.	1000.	75.6	1370.2	P	0.235		74.5	0.176	0.055	-1.5	961.	1069.
725.0	884.	690.0	57.		807.		0.039	0.350		155.	1207.4	F	0.443	961.	95.
0.000150	0.000153	0.000032	0.000009	0.00021	0.0	0.00037	0.000182	A					0.400	0.007	0.041
1.797	150.00	2258.1	14425.	1000.	75.6	1369.6	P	0.234		74.5	0.176	0.055	-1.5	960.	1066.
725.0	881.	690.0	56.		806.		0.039	0.350		155.	1207.5	P	0.443	960.	95.
0.000150	0.000152	0.000032	0.000009	0.00021	0.0	0.00037	0.000182	A					0.400	0.007	0.041
1.847	150.00	2306.1	14376.	1000.	74.6	1369.3	P	0.233		73.5	0.174	0.054	-1.5	959.	1064.
725.0	878.	690.0	56.		805.		0.039	0.350		154.	1206.2	P	0.442	959.	95.
0.000149	0.000151	0.000031	0.000009	0.00021	0.0	0.00034	0.000178	A					0.400	0.007	0.042

CLIMB TO 3000 FT. WITH MAXIMUM R/C AT NORMAL ENGINE RATING  
 50 TAS AND EAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PREP. ALT. (FT)	TAS (KTS)	DELCS	DELCOM	CRP	RTLIM CODE	J	CP	CT	ALPHA D/L (DEG)	GAMMA B/P (DEG)	R/C (FFM)
1.847	150.00	2306.1	14376.	1000.	71.5	1356.0	T	0.243		70.5	0.169	0.055	-2.6	11.3	1919. 1460.
725.0	945.	690.0	58.		876.		0.020	0.0		0.	1856.	T	0.438		
0.000147	0.000157	0.000054	0.000036	0.00023	0.0	0.00037	0.000317	A					0.411	0.007	0.045
1.853	150.01	2311.1	14372.	1500.	71.5	1356.0	T	0.240		70.0	0.169	0.055	-2.6	11.0	1900. 1424.
725.0	945.	690.0	57.		865.		0.020	0.0		0.	1856.0	T	0.440		
0.000147	0.000156	0.000054	0.000036	0.00023	0.0	0.00033	0.000318	A					0.410	0.007	0.046
1.859	150.04	2316.1	14366.	2600.	72.5	1356.0	T	0.241		70.4	0.171	0.056	-2.6	11.6	1868. 1390.
725.0	947.	690.0	57.		854.		0.020	0.0		0.	1856.0	T	0.441		
0.000149	0.000166	0.000056	0.000039	0.00020	0.0	0.00038	0.000326	A					0.400	0.007	0.045
1.867	151.20	2321.2	14361.	2500.	72.5	1356.0	T	0.243		69.9	0.171	0.057	-2.6	11.5	1870. 1390.
725.0	949.	690.0	57.		844.		0.020	0.0		0.	1856.	T	0.443		
0.000149	0.000171	0.000057	0.000039	0.00023	0.0	0.00041	0.000327	A					0.400	0.007	0.046

1.871 151.73 2326.4 14356. 3070. 72.5 1856.0 69.4 0.171 0.083 2.5 1.0 1827. 13.4.  
 725.0 949. 670.0 56. 833. 833. 0.820 0.0 0. 0.244 0.440 0.997  
 0.000150 0.000176 0.000057 0.000009 0.0.026 0. 0.00044 0.000328 A

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 0.0 KNOTS

TIME (HRS)	PANGE (N.M.P.)	FUEL USED (LBS)	T. MOTOR RMP	W. MOTOR RMP	WEIGHT (LBS.)	VTIP (FPS)	PRF. ALT. (FT)	TAS (KTS)	DELCS	CDN	DELCM	CHX	ROTLIM CODE	J	CP	CT	CLN	CDU	RM
M. MOTOR VTIP (FPS)	M. MOTOR RMP	T. MOTOR VTIP (FPS)	T. MOTOR RMP	PRP VTIP (FPS)	PRIM. FNG. PTHF	TAUXAT (LBS/MR)	PROP	FTAP	AUX. FNG. TAU (LBS/MR)	AUX. FNG. TURR. (RPM)	AUX. FNG. CODE	AUX. FNG. CODE	AUX. FNG. CODE	FAS. (KTS)	MU	CT PRIM. OVER SIGMA	ALPHA D/L (DEG)	SPFC. RANGE (NMP)	PMP
CPPRO	CPIND	CPPAR	CFNUM	CDN	DELCM	CHX	ROTLIM CODE	J	CP	CT	CLN	CDU	RM						
1.871	151.73	2326.4	14356.	3070.	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.						
725.0	1376.	690.0	130.	939.	939.	0.820	0.0	0. 0.244	0.440	0.997									
0.000361	0.000058	0.000114	0.000041	0.0143	0.0001	0.00652	0.00273	A											
1.971	166.73	2452.6	14229.	310.	150.1	1458.6	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1363.	690.0	130.	939.	939.	0.820	0.0	0. 0.244	0.440	0.997									
0.000360	0.000099	0.000113	0.000040	0.0134	0.0001	0.00643	0.00272	A											
2.071	181.73	2640.5	14102.	3000.	150.1	1457.3	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1356.	690.0	130.	934.	934.	0.826	0.0	0. 0.244	0.440	0.997									
0.000359	0.000098	0.000113	0.000040	0.0134	0.0001	0.00643	0.00272	A											
2.171	176.73	2707.2	13975.	3100.	150.1	1455.8	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1345.	690.0	130.	931.	931.	0.826	0.0	0. 0.244	0.440	0.997									
0.000357	0.000097	0.000113	0.000039	0.0129	0.0000	0.00639	0.00272	A											
2.271	211.73	2833.5	13849.	3000.	150.1	1454.6	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1327.	690.0	99.	929.	929.	0.826	0.0	0. 0.244	0.440	0.997									
0.000356	0.000095	0.000113	0.000039	0.0125	0.0000	0.00634	0.00272	A											
2.371	226.73	2959.7	13723.	3100.	150.1	1453.2	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1315.	690.0	99.	927.	927.	0.826	0.0	0. 0.244	0.440	0.997									
0.000355	0.000094	0.000113	0.000038	0.0121	0.0000	0.00630	0.00271	A											
2.471	241.73	3045.1	13597.	3000.	150.1	1451.0	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1297.	690.0	99.	924.	924.	0.826	0.0	0. 0.244	0.440	0.997									
0.000354	0.000094	0.000113	0.000038	0.0116	0.0000	0.00626	0.00271	A											
2.571	256.73	3211.1	13471.	3000.	150.1	1450.1	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1321.	690.0	99.	922.	922.	0.826	0.0	0. 0.244	0.440	0.997									
0.000353	0.000092	0.000113	0.000037	0.0112	0.0000	0.00622	0.00271	A											
2.671	271.73	3336.5	13346.	3000.	150.1	1449.3	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				
725.0	1314.	690.0	99.	920.	920.	0.826	0.0	0. 0.244	0.440	0.997									
0.000352	0.000091	0.000112	0.000037	0.0108	0.0000	0.00617	0.0027	A											
2.771	286.73	3461.5	13221.	3000.	150.1	1448.0	72.5	1856.0	69.4	0.171	0.083	2.5	1.0	1827.	13.4.				

C

725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667
0.000581	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2.659	310.00	382.00	310	180.0	0.00000	0.00000	145.0	0.300	0.30	0.12	150.0
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667
0.000150	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

LOITER FOR 0.250 HRS. FOR RESERVE FUEL

TIME (HRS)	RANGE (NM)	FUEL USED (LBS)	T.ENTR (HRS)	WIGHT (LBS)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TEMP. (R)	FUEL CODE	FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	PRIME OVER SIGMA	ALPHA R/L (DEG)	YCTAL FUEL FLOW (LBS/HR)	PMF
M. POTUP (FPS)	W. PMP (FPS)	T. ENT (FPS)	W. PMP (FPS)	PRIM. FUE (FPS)	ALT. (FT)	TAS (KTS)	PRIM. TEMP. (R)	FUEL CODE	FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	PRIME OVER SIGMA	ALPHA R/L (DEG)	YCTAL FUEL FLOW (LBS/HR)	PMF
CPRO	CFIM	CPAR	CPUN	COO	COO	DELCO	DELCO	EXP	RYLTM CODE	J	CP	CLL	FMU	FM
2.659	310.00	382.00	310	310	310	73.0	136.0	P	0.277	79.9	0.17	-2.0	0.17	1.20
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667			
0.000148	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2.900	310.00	382.00	310	310	310	73.0	136.0	P	0.277	79.9	0.17	-2.0	0.17	1.20
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667			
0.000148	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2.959	310.00	382.00	310	310	310	73.0	136.0	P	0.277	79.9	0.17	-2.0	0.17	1.20
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667			
0.000148	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3.000	310.00	382.00	310	310	310	73.0	136.0	P	0.277	79.9	0.17	-2.0	0.17	1.20
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667			
0.000148	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3.059	310.00	382.00	310	310	310	73.0	136.0	P	0.277	79.9	0.17	-2.0	0.17	1.20
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667			
0.000148	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3.109	310.00	382.00	310	310	310	73.0	136.0	P	0.277	79.9	0.17	-2.0	0.17	1.20
725.0	1304	650.0	310	510	6.626	0.750	333	14049	P	0.07	667			
0.000147	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

MISSIOM FUEL REQUIRED = 371.14  
 RESERVE FUEL REQUIRED = 510.00  
 TOTAL FUEL REQUIRED = 371.14

H F S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 0-51

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. (MAY. =5)  
VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
VAL1 VALUE CORRESPONDING TO LOC.+00.1  
VAL2 VALUE CORRESPONDING TO LOC.+00.2  
ETC.

LOC. . . . . NUM VAL VAL1 VAL2 VAL3 VAL4

NOTE: IN USING AUXILIARY ENGINES & AUXILIARY ENGINE CYCLE INPUT LOCATIONS CARD, BE CREATED BY PLACING A 6666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE

1  
MG = 0.254000E+05 MFA = 0.372059E+04 MFF = 0.372059E+04

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

SINGLE ROTOR COMPOUND HELICOPTER AUX. INDEPENDENT 1/3 SHAFT CRUISE PROPULSION

S I Z E D A T A THIS RUN CONVERGED IN 0 ITERATIONS

GROSS WEIGHT = 25700. LB

FUSELAGE

LFNGTH(ROO) / (TAILROO)	54.8 FT.
LFNGTH(CABIN)	12.0 FT.
LFNGTH(BODY)	27.5 FT.
LFNGTH(TAILROO)	29.0 FT.
FWD. ROTOR LOCATION	18.1 FT.
WING	6.5 FT.
WETTED AREA	422.9 SQ. FT.

WING

ASPECT RATIO	4.81
AREA	168.4 SQ. FT.
SPAN	26.9 FT.
MEAN CHORD	6.0 FT.
QUARTER CHORD SWEEP	0.0 DEG.
TAPER RATIO	0.802
ROTY THICKNESS/CHORD	0.230
TIP THICKNESS/CHORD	0.120
WING LOADING	175.7 LBS/SQ. FT.
ROTOR/WING GAP	2.6 FT.
FLAP CHORD/MEAN CHORD RATIO	1.000

HOR. TAIL

ASPECT RATIO	4.200
AREA	27.3 SQ. FT.
SPAN	14.2 FT.
MEAN CHORD	3.5 FT.
TAPER RATIO	0.802
THICKNESS/CHORD	0.120
HOR. TAIL ARM	70.0 FT.

VERT. TAIL

ASPECT RATIO	1.460
AREA	24.1 SQ. FT.
SPAN	6.8 FT.
MEAN CHORD	4.0 FT.
TAPER RATIO	0.487
TAIL ROTOR WET. LOCATION	5.5 FT.
TAIL ROTOR WET. TAIL OVERLAP RATIO	0.886



BY CIVY

THICKNESS/CHORD

MAIN MOTOR PULLEY  
 SP. 20.1 IN. FT.  
 WETTED AREA 60.7 IN. FT.  
 PAINTAL AREA 30.7 FT.  
 MFRM 6.1 FT.  
 CHARGE HEAD CHORD 2.0  
 LAMINA FT. 2.2  
 CY/DA TIP THICKNESS/CHORD

PRIMARY FACINE NACELLE  
 L4 6.0 FT.  
 P4 2.5 FT.  
 P5 1.0 50. FT.

AUXILIARY INDEPENDENT FACINE NACELLE  
 L4 6.1 FT.  
 P4 1.0 FT.  
 P5 2.0 50. FT.

AUXILIARY INTERDEPENDENT FACINE NACELLE STAFF  
 L4 6.0 FT.  
 P4 2.5 FT.  
 P5 1.0 50. FT.

EXPELLER/AUXILIARY PROPELLERS  
 L4 1.0 FT.  
 P4 1.0 FT.  
 P5 1.0 FT.  
 L4 1.0 FT.  
 P4 1.0 FT.  
 P5 1.0 FT.

WPM MOTOR  
 L4 1.0 FT.  
 P4 1.0 FT.  
 P5 1.0 FT.  
 L4 1.0 FT.  
 P4 1.0 FT.  
 P5 1.0 FT.

TAIL MOTOR  
 L4 1.0 FT.  
 P4 1.0 FT.  
 P5 1.0 FT.  
 L4 1.0 FT.  
 P4 1.0 FT.  
 P5 1.0 FT.

HCTR 0.300  
 0  
 VTIP 3.0 FT.  
 690. FT./SEC.

BLADE CUTOUT/RADIUS RATIO  
 MAIN/TAIL ROTOR GAP  
 TIP SPEED

SAMPLE CASE NO. 1 RUN 2 PART 3

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 0-01

M I A C O W O

WEIGHTS DATA IN LBS

WT	DESCRIPTION	WT
PLI	MAXIMUM LOAD FACTOR	1.000
OP	BURST LOAD FACTOR	1.000
ULV	ULTIMATE LOAD FACTOR	1.000
PROPULSION GROUP		
W00A	TOTAL MAIN ROTOR GROUP	2642
W00B	MAIN ROTOR HUB (PER ROTOR)	1430
W00C	MAIN ROTOR HUB (PER ROTOR)	1430
W00D	PLANE FOLDING/RETR. MOTOR	3500
W00E	AUXILIARY PROPULSION MOTOR GROUP	0
W00F	DRIVE SYSTEM	2320
W00G	MAIN ROTOR DRIVE SYSTEM	1110
W00H	TAIL ROTOR DRIVE SYSTEM	1110
W00I	AUXILIARY PROPULSION DRIVE SYSTEM	2340
W00J	AUXILIARY ENGINE	140
W00K	PRIMARY ENGINE INSTALLATION	170
W00L	AUXILIARY ENGINE INSTALLATION	420
W00M	FUEL SYSTEM	210
W00N	PROPULSION GROUP WEIGHT FACTOR	1.0
W00O	TOTAL PROPULSION GROUP WEIGHT	7906
STRUCTURE GROUP		
W01A	VIEW GROUP	231
W01B	TAIL GROUP	240
W01C	HOR. TAIL	130
W01D	TAIL ROTOR	142
W01E	FUZZLAGE	200
W01F	LANDING GEAR	110
W01G	WOP GROUP	110
W01H	MAIN GEAR	110
W01I	TOTAL CHAIR GROUP	210
W01J	PRIMARY ENGINE SECTION	170
W01K	AUXILIARY ENGINE SECTION	170
W01L	STRUCTURE WEIGHT FACTOR	1.0
W01M	TOTAL STRUCTURE WEIGHT	1240
FLIGHT CONTROLS GROUP		
W02A	PRIMARY FLIGHT CONTROLS	100
W02B	COCKPIT CONTROLS	100
W02C	MAIN ROTOR CONTROLS	100
W02D	TAIL ROTOR CONTROLS	100
W02E	SYSTEMS CONTROLS	100
W02F	WEIGHT FACTOR	1.0

WV	WVCF	AVG. DISCRETE ROTOR SYS. CONTROL	0.
WV	WVCC	WING/BLADES CONTROL	1.00
WV	WVCT	CONTROL WEIGHT INCREMENT	111.4.
WV	WVTC	TOTAL CONTROL WEIGHT	12.00
WV	WVTD	WEIGHT OF FIXED EQUIPMENT	1498.0.
WV	WVTE	WEIGHT EMPTY	47.0.
WV	WVTF	FIXED USEFUL LOAD	1043.0.
WV	WVTH	OPERATING WEIGHT EMPTY	1.000.
WV	WVTI	PAYLOAD	716.6.
WV	WVTL	FUEL	2.000.
WV	WVTR	CRUIS WEIGHT	2.000.

SAMPLE CASE NO. 1 NUM 2 PART 4

7-64

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

ROTOR DATA

ROTOR CYCLE NO. 3.0000  
 MAIN ROTOR SOLIDITY SIZED BY MANUEVER CONDITIONS 169.0 MT.  
 W = 3.0000 FT. \* TEMP = 41.0 DEG. F \* V =  
 100.0 PERCENT HOVER RPM  
 ROTOR MANUEVER G'S = 1.100 \* CT/STOMA = 0.310

TAIL ROTOR SIZED AT 1.000 TIMES THE SOLIDITY  
 REQUIRED TO SAVE 10% HOVER/TURN PERFORMANCE AT  
 W = 3.0000 FT. \* TEMP = 41.0 DEG. F \* V =  
 100.0 PERCENT HOVER RPM  
 ROTOR MANUEVER G'S = 1.100 \* CT/STOMA = 0.310

TEMP	81.000 DEG. F
CT/STOM	95.036 DEG. OF
YAW RATE	1.843
YAW ACCELERATION	1.740 RAD/SEC.
TAIL ROTOR SOLIDITY	0.350 RAD/SEC.
MON. OF INSTRUMENTER BLADES	6.678 SLUG/FT <sup>2</sup>
HELICOPTER YAW	61390.0 SLUG/FT <sup>2</sup>
MON. OF INERTIA	

SAMPLE CASE NO. 1 RUN 2

PAGE 6

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 8-93

M F S C O M P

PROPELLION DATA

PRIMARY PROPELLSION CYCLE NO. 1.761  
TURBOSHAFT ENGINE

2. ENGINES

MPHP MAX. STANDARD S.L. STATIC H.P. 5533.0 H.P.

ENGINE SIZED FOR TAKEOFF AT 100% MILITARY POWER SETTING.

MC = 4088. FT. TEMPERATURE = 95.00 DEG.F.

6.0 ENGINES IMOPERATIVE, AND 9.1 FT/MIN VERTICAL RATE OF CLIMB.

AUX. INDEPENDENT PROPELLSION CYCLE NO. 1.761  
TURBOSHAFT ENGINE

1. ENGINES

MPHP MAX. STANDARD S.L. STATIC H.P. 1560.0 H.P.

ENGINE SIZED FOR CRUISE AT VC = 170. KNOTS.

NORMAL POWER SETTING.

MC = 3200. FT. TEMPERATURE = 91.00 DEG.F.

AND 6.0 ENGINES IMOPERATIVE.

MAIN AND TAIL ROTOR DRIVE SYSTEM RATING 4713.0 H.P.

MAIN ROTOR DRIVE SYSTEM RATING 4778.0 H.P.

ENGINE SIZED AT 100% PERCENT OF MAIN ROTOR DRIVE POWER REQUIRED  
AT MC = 4700. FT. TEMP = 95.00 DEG.F. 100.0 PERCENT HOVER RPM

TAIL ROTOR DRIVE SYSTEM RATING 623.0 H.P.

ENGINE SIZED AT 110% PERCENT OF TAIL ROTOR DRIVE POWER REQUIRED  
AT MC = 4800. FT. TEMP = 95.00 DEG.F. 100.0 PERCENT HOVER RPM

AUXILIARY INDEPENDENT PROPELLSION DRIVE SYSTEM RATING

ENGINE SIZED AT 100% PERCENT OF AUX. PROPELLSION CRUISE POWER REQUIRED AT VC 171. KNOTS.  
MC = 3200. FT. TEMP = 91.00 DEG.F. H.P.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91  
M F S C O M P

A F R O D Y N A M I C S D A T A			
FF	TOTAL EFFECTIVE PLATPLATE AREA	23.128	SOFT
SVFT	TOTAL WETTED AREA	3440.	SOFT
CBARF	MEAN SKIN FRICTION COEFF.	0.016265	
D R A G	B R E A K D O W N		
FCU	WING FE	1.004	
FFF	FURCLAGE FE	22.124	
FFFP	FORWARDMAIN ROTOR PYLON FE	2.6	
FFAP	APT ROTOR PYLON FE	0.6	
FFRH	MAIN ROTOR HUB FE	0.1	
FFTRM	TAIL ROTOR HUB FE	0.0	
FFVY	VERTICAL TAIL FE	3.3	
FFMT	HORIZONTAL TAIL FE	2.7	
FFM	PRIMARY ENGINE WAGLE FE	3.6	
FFM1	AUX. INDEPENDENT CRUISE ENG. WAG. FE	0.0	
FFM2	AUX. INDEPENDENT CRUISE ENG. STRUT FE	0.0	
FFM3	INCREMENTAL FE	0.0	
DELTA FE			
A F R O D Y N A M I C C O E F F .			
AP		22.1289	
Ah		1.04280	
A7		0.09423	
AP		0.00007	
AP		0.23004	
EVT	WING LIFT EFFICIENCY FACTOR	0.75701	
	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.87487	

### 7.3.2 Tandem Rotor Winged Helicopter

The design mission profile is illustrated in Figure 7-2. The engine and rotor cycles are not discussed in this case. A complete copy of the program printout follows the description of the input.

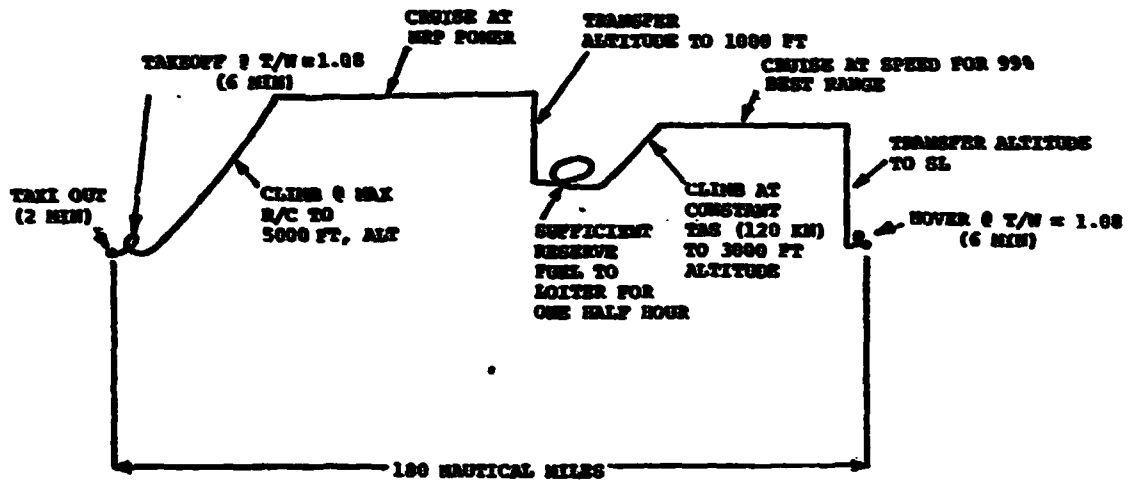


Figure 7-2. Design Mission - Sample Case No. 2

SAMPLE CASE NO. 2

GENERAL INFORMATION SHEET

VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS
OPTIND	0001	1.0	Sizing run
OPTIONAL PRINT	0002	1.0	Detailed printout de- sired
DRGIND	0003	1.0	Component drag build-up desired
OSWIND	0004	0	User inputs Oswald ef- ficiency factor
CNFIND	0005	2.0	Tandem rotor helicopter
AUXIND	0006	2.0	Winged helicopter
RDMIND	0007	4.0	Main rotor diameter sized based on input disc loading; solidity sized based on input $C_T/\sigma$
FIXIND	0008	1.0	Program sizes primary engines
ROTIND	0009	1.0	Short form rotor per- formance method used
$S_W$ IND	0010	3.0	Wing area sized by ma- neuver conditions
$b_W$ IND	0011	2.0	Wing span sized by in- put aspect ratio
AIPIND	0012	1.0	No independent aux. engines
FDMIND	0020	2.0	Tandem rotor fuselage sized by input of $l_c$ and $((O/L)/D)$
APHIND	0021	2.0	Aft rotor pylon geom- etry calculated based on input rotor gap/ stagger ratio

VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS	
ESCIND	0022	2.0	Primary engines sized for either takeoff or cruise	
WG <sub>0</sub>	0023	30000	First guess at design gross weight	
h <sub>0</sub>	0024	0	Start altitude } Normally 0 except for partial mission analysis	
R <sub>0</sub>	0025	0		Starting range
t <sub>0</sub>	0026	0		Starting time
h <sub>OPT</sub> IND	0027	0	Cruise at specified altitudes	
M <sub>MO</sub>	0028	0.32	Maximum operating Mach number	
V <sub>MO</sub>	0029	200	Maximum operating EAS knots	
V <sub>DIVE</sub>	0030	200	Design dive speed, knots EAS	
M <sub>LF</sub>	0031	3.0	Maneuver load factor	
K <sub>1</sub>	0032	1.0	Factor on mission fuel burned to give reserve fuel; i.e., 1.1 would give 10 percent reserves	
δW <sub>f</sub>	0033	0.0	Fixed fuel increment for reserves or other use	
K <sub>FF</sub>	0034	1.05	Increase basic engine SFC by 5 percent	



VARIABLE	LOCATION	VALUE ASSIGNED	REMARKS
SGTIND	0035	1.0	Taxi
	0036	2.0	Takeoff
	0037	3.0	Climb
	0038	4.0	Cruise
	0039	9.0	Transfer altitude
	0040	60.0	Loiter (reserve fuel)
	0041	.0	Climb
	0042	4.0	Cruise
	0043	9.0	Transfer altitude
	0044	2.0	Hover and land
0045	100	End of case	

} Sequence of Design Mission

#### HELICOPTER DIMENSIONAL INFORMATION SHEET

AR	0104	6.0	Wing aspect ratio (input because $b_{WIND} = 2.0$ )
$(t/c)_R$	0105	0.20	Wing root thickness/chord ratio
$(t/c)_T$	0106	0.12	Wing tip thickness/chord ratio
$\Lambda c/4$	0107	0	Quarter-chord mean sweep angle, degrees
$\lambda$	0108	0.5	Wing taper ratio
$C_F/C$	0109	1.0	Ratio of download alleviating flap chord to wing chord (1.0 signifies a fully tilting wing)

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$h'/h_F$	0110	1.0	Wing located at top of fuselage
$C_{L_D}$	0111	1.2	Wing design lift coefficient
$\Delta S_{WET}/S_F$	0120	.0	Incremental wetted area of airplane ratioed to fuselage wetted area.
$\Delta S_{WET}$	0121	.0	Incremental wetted area of aircraft (ft <sup>2</sup> )
$h_F$	0122	7.0	Fuselage height
$W_F$	0123	6.5	Fuselage width
$(l/d)_P$	0124	0.70	Fineness ratio of nose
$(l/d)_T$	0125	1.2	Fineness ratio of tail
$l_C$	0126	35.0	Constant diameter section length
$l_{RW}$	0127	5.0	Length of ramp well
$((O/L)/D)$	0132	0.22	Tandem rotor overlap/diameter ratio
$Z_1$	0142	0.035	Primary engine nacelle constants
$Z_2$	0143	2.0	
$Z_3$	0144	0.078	
$l_{AIP}/l_C$	0145	.0	Ratio of air induction system length to engine length (primary engines)
$(t/c)_{R_F}$	0152	0.45	Forward rotor pylon root thickness/chord ratio
$(t/c)_{T_F}$	0153	0.25	Forward rotor pylon tip thickness/chord ratio
$AR_{FP}$	0154	0.4	Forward rotor pylon aspect ratio
$\lambda_{FP}$	0155	0.7	Forward rotor pylon taper ratio

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$h_{P_1}$	0156	3.0	Forward rotor pylon height
$(t/c)_{R_A}$	0157	0.50	Aft rotor pylon root thickness/chord ratio
$(t/c)_{T_A}$	0158	0.30	Aft rotor pylon tip thickness/chord ratio
$AR_{AP}$	0159	0.7	Aft rotor pylon aspect ratio
$\lambda_{AP}$	0160	0.75	Aft rotor pylon taper ratio
g/s	0162	0.16	Tandem rotor gap/stagger ratio (input because APHIND = 2.0)

#### MAIN ROTOR DIMENSIONAL DATA SHEET

ROTOR CYCLE NO.	0171	3.0	Rotor blade section aerodynamic characteristics selection
$N_R$	0172	2.0	No. of rotors
W/A	0173	8.0	Disc loading
$b_{MR}$	0176	4.0	No. of blades/main rotor
$\theta_{T_{MR}}$	0177	-9.0	Main rotor twist (deg)
$x_{C_{MR}}$	0178	0.2	Main rotor blade cutout as a fraction of radius
$x_{MR}$	0179	0.075	Main rotor blade attachment point as a fraction of radius
$(t/c)_{.25R}$	0180	0.12	Rotor blade thickness/chord at 25 percent radius

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$V_{TIP}$	0181	700	Main rotor tip speed
$(C_T/\sigma)_H$	0182	0.12	Rotor "lift coefficient" for hover sizing rotor solidity
T/W	0183	1.08	Rotor design thrust/weight ratio
$V_{KT}(c)$	0184	160	Cruise flight conditions for sizing rotor solidity
$h_c(c)$	0185	4000	
$\Delta T_{IN_c}$	0186	0	
$(C_T/\sigma)_{CR}$	0187	0.095	Rotor "lift coefficient" for sizing rotor solidity in cruise flight
g REQM'T	0188	2.0	Total g requirement helicopter must satisfy at $V_{KT}(c)$
g(ROTOR)	0189	1.5	Maneuver g's carried by main rotor at $V_{KT}(c)$
N (ROTOR LOADING)	0190	1.0	Rotor lift/GW for 1g cruise flight rotor solidity sizing
$V_{CEH1}$	0191	1.53	Main rotor vertical rate-of-climb efficiency factors
$V_{CEH2}$	0192	0.0	
$K_{P_{CLIMB}}$	0193	0.85	Helicopter forward flight climb efficiency
ΔF.M.	0195	.0	Incremental figure of merit added to results obtained when using "short form method". Input only if ROTIND = 1

PRIMARY ENGINE SIZING INFORMATION SHEET

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
PRIMARY ENGINE CYCLE NO.	0217	1.761	Engine selection
$N_P$	0219	4.0	No. of primary engines
XMSNIND	0220	2.0	Drive system rated at power required to hover or cruise (more critical of the two conditions selected by program)
$\frac{SBP_{MRX}}{SHP^*_{MR}}$	0221	1.00	Main rotor drive system is rated at 100 percent of main rotor design power
$\eta_T$	0223	0.97	Transmission efficiency
$\Delta SHP_{ACC}$	0224	100	Accessory power losses
$h_{TO}(H)$	0227	4000	Design point hover altitude (engine sizing)
$(T/W)_D$	0228	1.08	Configuration design point hover thrust/weight ratio
$\Delta T_{INTO}(H)$	0229	50.3	Increment in ambient temperature for engine sizing at takeoff conditions.
$(\frac{N_{II}}{N_{II_{MAX TO}}})$	0230	1.105	Main rotor operating at 100 percent of hover tip speed (700 fps); i.e.

$$\left[ \frac{N_{II}}{N_{II_{MAX TO}}} \right] \left[ \frac{N_{II_{MAX}}}{N_{II^*}} \right] V_T$$

(LOC 0230) (LOC 1223) (LOC 0181)

$$= 1.105 \underbrace{(.905)}_{1.0} (700)$$

$$= 700$$

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$N_{P_{SD}}$	0231	1.0	One engine inoperative at hover design point conditions
$SHP_E/SHP^*$	0232	0.95	Engines sized for hover (OGE) with 1 engine out and the remaining engines operating at 95% MRP
$(V_{R, D})$	0233	.0	Design vertical rate of climb used in sizing primary engines.
POWIND	0234	2.0	Maximum engine rating for cruise engine sizing. For this example, normal rated power is the maximum rating to be used
$h_C$	0235	3000	Design point (cruise) altitude (engine sizing)
$V_C$	0236	155	Design point cruise speed (kts) (engine sizing)
$C_{LDP}$	0240	0.45	Wing operating lift coefficient at cruise condition for engine sizing
$(N_{P_{SD} C})$	0241	0.0	No. of primary engines shut down during cruise (for engine sizing)

**HELICOPTER AERODYNAMICS INFORMATION SHEET**

$C_{DAP}$	0303	.006	AFT rotor pylon profile drag coefficient at $Re = 10^7$ (based on aft pylon planform area)
$C_{DFP}$	0305	.15	Forward rotor pylon profile drag coefficient at $Re = 10^7$ (based on forward pylon max frontal area)
$C_{DCSMR}$	0305	.75	Main rotor hub center section profile drag coefficient (based on center section frontal area)
$CD_{SHMR}$	0306	1.4	Main rotor hub shank profile drag coefficient (based on shank frontal area)

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$C_{D_N}$	0309	.0032	Profile drag coefficient of primary engine nacelles at $Re = 10^7$ (based on wetted area of all nacelles)
e	0314	.75	Span loading efficiency factor
$\Delta F_e \text{ FT}^2$	0316	5.5	Increment in equivalent flat plate area parasite drag of fuselage (ft <sup>2</sup> )
$K_{AP}$	0319	1.045	Aft rotor pylon multiplicative drag factor
$K_{FP}$	0320	1.25	Forward rotor pylon multiplicative drag factor
$K_{HPIM}$	0321	1.3	Main rotor hub/shank multiplicative drag factor
$K_N$	0323	2.86	Primary nacelle multiplicative drag factor
$K_F$	0326	1.25	Fuselage multiplicative drag factor
$K_W$	0327	1.54	Wing multiplicative drag factor
$(Re/l)i$	0328	.1544( $10^7$ )	Mean Reynolds number per foot for mission
$C_{L\alpha} \text{ RAD}^{-1}$	0329	6.28	Two-dimensional wing lift coefficient slope
NO. OF PAIRS IN TABLE $C_{LW}$	0330	6.0	Number of $C_{LW}$ pairs input in locations 0331 - 0346
$C_{LW}(1)$	0331	.0	} Wing lift coefficients
	0332	.2	
	0333	.4	
	0334	.6	
	0335	.8	
$C_{LW}(6)$	0336	.10	

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
C <sub>Dwi</sub> (1) ↓	0339	.59E-02	Profile drag coefficient of wing at Re = 10' (based on wing planform area)
	0340	.006	
	0341	.0068	
	0342	.008	
	0343	.0095	
C <sub>Dwi</sub> (6)	0344	.0116	

**ROTOR LIMITS INFORMATION SHEET**

NO. OF CX/σ	0347	3.	Specifies number of CX/σ values in table locations 0349 - 0353
NO. OF μ	0348	3.	Specifies number of μ values in table locations 0354 - 0360
VALUES OF CX/σ	0349	0	Rotor propulsive thrust coefficient divided by main rotor solidity. Used in defining rotor limits.
	0350	.5	
	0351	1.0	

$$CX/\sigma = \frac{\text{THRUST REQUIRED}}{4 \rho R^2 N^2 V_{TIP}^2 \sigma}$$

VALUES OF μ	0354	.0	Rotor forward flight advance ratio
	0355	.5	
	0356	1.	
$\mu = \frac{V_{FPS}}{V_{TIP}}$			
VALUES OF CT'/σ	0361	1.	Values of CT'/σ corresponding to (CX/σ) <sub>1</sub> location 0349 and μ <sub>1</sub> , μ <sub>2</sub> , and μ <sub>3</sub> .
	0362	1.	
	0363	1.	



<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
	0368	1.	Values of $CT'/\sigma$ corresponding to $(CX/\sigma)_2$ location 0350 and $\mu_1, \mu_2,$ and $\mu_3$ .
	0369	1.	
	0370	1.	
	0375	1.	Values of $CT'/\sigma$ corresponding to $(CX/\sigma)_3$ location 0351 and $\mu_1, \mu_2,$ and $\mu_3$ .
	0376	1.	
	0377	1.	

**HELICOPTER WEIGHT INFORMATION SHEET**

$W_{FE}$	2602	3000	Weight of fixed equipment in LBS
$W_{FUL}$	2603	600	Weight of fixed useful load in LBS
$W_{PL}$	2604	5000	Weight of payload in LBS
$\Delta W_{FC}$	2605	.0	Flight controls group incremental weights in LBS.
$\Delta W_P$	2606	.0	Propulsion group incremental weight in LBS
$\Delta W_{ST}$	2607	.0	Structures group incremental weight in LBS
$RM_1$	2608	.0	Wing relief as percentage of GW
$W_i$	2609	.0	Weight of inboard store
$W_o$	2610	.0	Weight of outboard store
$d_i$	2611	.0	Position of inboard underwing store (fraction of wing semi-span)
$d_o$	2612	.0	Position of outboard underwing store (fraction of wing semi-span)
$K_{CC}$	2613	26.	Cockpit controls weight factor
$K_{RC}$	2614	18.	Main rotor controls weight factor

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
K <sub>SC</sub>	2615	42.	Main rotor system controls weight factor
K <sub>FW</sub>	2616	.0	Fixed wing controls
K <sub>TM</sub>	2617	.0	Tilt mechanism weight factor
K <sub>SAS</sub>	2618	100.	Stability Augmentation System (SAS) weight factor. Usually in the range of 20-100 pounds.
K <sub>RCA</sub>	2619	.0	Auxiliary rotor controls weight factor
K <sub>SCA</sub>	2620	.0	Auxiliary rotor systems controls weight factor
K <sub>MC</sub>	2621	.0	Miscellaneous controls weight factor in LBS
K <sub>B</sub>	2622	125.	Body group weights factor
ΔCG	2623	3.	Helicopter cg travel (FT)
K <sub>LG</sub>	2624	.04	Landing gear weight factor input as percentage of gross weight
K <sub>MG</sub>	2625	.8	Main landing gear weight factor
K <sub>WW</sub>	2626	.0	Detailed wing weight factor. This adjusts the constant 220 in $W_w = 220(k)^{0.585}$ up or down depending on the complexity of the control surfaces
LF	2627	1.	Wing unload factor. Entered as a fraction of design gross weight
K <sub>WS</sub>	2628	.0	Wing stores only weight trend factor
K <sub>WP</sub>	2629	2.06	Wing weight/area factor (psf)
K <sub>HT</sub>	2630	.0	Horizontal tail unit weight in psf
K <sub>CLF</sub>	2631	.0	Crash load factor

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$K_{WAC}$	2632	.0	Primary cowling weight factor (psf)
$K_{AIP}$	2633	120.	Primary air induction system weight factor
$K_{NACA}$	2634	.0	Auxiliary cowling weight factor (psf)
$K_{AIA}$	2635	.0	Auxiliary air induction system weight factor
$K_{NS}$	2636	.0	Nacelle strut weight factor
$K_{PRB}$	2637	44.	Primary rotor blade weight factor
$K_{RBF}$	2638	1.	Rotor type factor; hingeless for this example
$K_{PH}$	2639	61.	Primary hub weight factor
$K_{AMD}$	2640	1.	Main rotor weight factor
$K_{BLFD}$	2641	1.25	Blade fold weight factor. Input as a fractional part of the total rotor weight
$K_{TR}$	2642	.0	Tail rotor weight factor
$K_{AR}$	2643	.0	Auxiliary rotor weight factor. This is the average value for the rotor or propeller weight  (LB). $W_R = 14.2a(k)^{.67}$
$K_{PA}$	2644	.0	Auxiliary rotor multiplicative input power, expressed here as 0% input power
$K_{VTAR}$	2645	.0	Auxiliary tail rotor multiplicative tip speed factor expressed here as 0% input speed
$K_{PDS}$	2646	.19	Primary drive system weight factor
$K_{PDSZ}$	2647	4.	Primary drive system weight factor. Number of gears in system
$K_{TRDS}$	2648	.0	Tail rotor drive system weight factor

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$K_{ADS}$	2649	.0	Auxiliary drive system weight factor
$K_{ADSZ}$	2650	.0	Auxiliary drive system weight factor (number of gears in system)
$K_{FS}$	2651	.19	Fuel system weight factor
$K_{PEI}$	2652	200.	Primary engine installation weight factor
$K_{AEI}$	2653	.0	Auxiliary engine installation weight factor
$K_1$	2654	1.	Main rotor controls weight factor
$K_2$	2655	1.	Main rotor system controls weight multiplicative factor
$K_3$	2656	1.	Fixed wings controls weight multiplicative factor
$K_4$	2657	1.	Auxiliary rotor controls weight multiplicative factor
$K_5$	2658	1.	Auxiliary rotor system controls weight multiplicative factor
$K_6$	2659	1.	Body weight multiplicative factor
$K_7$	2660	1.	Landing gear weight multiplicative factor
$K_8$	2661	1.	Wing weight multiplicative factor
$K_9$	2662	1.	Horizontal tail weight multiplicative factor
$K_{10}$	2663	1.	Primary nacelle weight multiplicative factor
$K_{11}$	2664	1.	Auxiliary nacelle weight multiplicative factor
$K_{12}$	2665	1.	Primary rotor blade weight multiplicative factor

$K_{13}$	2666	1.	Primary rotor hub weight multiplicative factor
$K_{14}$	2667	1.	Tail rotor weight multiplicative factor
$K_{15}$	2668	1.	Auxiliary rotor weight multiplicative factor
$K_{16}$	2669	1.	Primary drive system weight multiplicative factor
$K_{17}$	2670	1.	Auxiliary drive system weight multiplicative factor
$K_{18}$	2671	1.	Primary engine weight multiplicative factor
$K_{19}$	2672	1.	Auxiliary engine weight multiplicative factor
$K_{20}$	2673	1.	Tail rotor drive system weight multiplicative factor

**TAXI INFORMATION SHEET**

ATMIND	0401	.0	Standard atmosphere selected
$t_T$	0411	0.0333	Taxi for 2 minutes
$\Delta T_{INTO} (^{\circ}F)$	0421	.0	Increment in ambient temperature for primary engine sizing at takeoff conditions
$K_{FI}$	0431	.0	Auxiliary independent engines fuel flow multiplicative factor (used in TAXI)
$(\frac{N_{II}}{N_{II,MAX}})$ (PRIM ENG)	0441	1.105	Operating point for engine power turbine during TAXI

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

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
<b>TAKEOFF, HOVER, AND LANDING INFORMATION SHEET</b>			
TOLIND	0461	1.0	Specify required T/W for hover out of ground effect
	0462	1.0	
ATMIND	0481	.0	Standard atmosphere
ATMIND	0482	.0	
$\Delta T_{IN}$ ( $^{\circ}F$ )	0501	.0	Incremental temperature above standard, in degrees
$\Delta T_{IN}$ ( $^{\circ}F$ )	0502	.0	
$V_{R/C}$	0511	.0	0 ft/min vertical rate of climb capability desired
$V_{R/C}$	0512	.0	
T/W	0521	1.08	Hover thrust/weight ratio specified
T/W	0522	1.08	
$\Delta t_H$ (HR)	0531	.01	Time increments for takeoff, hover or landing computations in hours
$\Delta t_H$ (HR)	0532	.01	
$N_{II}/N_{II\text{MAX}}$ PRIMARY ENGINE	0541	1.105	Operating point for engine power turbine during takeoff, hover or landing
$N_{II}/N_{II\text{MAX}}$ SECONDARY ENGINE	0542	1.105	
$\left( \frac{N_{II}}{N_{II\text{MAX}}} \right)_{\text{TOHL}} = \frac{V_T \text{ OPERATING}}{V_T \left( \frac{N_{II\text{MAX}}}{N_{II}^*} \right)}$			
$t_H$	0551	0.1	Hover for 6 minutes
	0552	0.1	

**CLIMB INFORMATION SHEET**

CLMIND	0571	1.0	Climb at maximum rate of climb
	0572	4.0	Climb at constant TAS

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
MACH <sub>2nd</sub>	0582	120.0	Mach number required during climb
ATMIND	0591	.0	Standard atmosphere
ATMIND	0592	.0	
C <sub>L</sub> WING	0601	0.4	Wing operating C <sub>L</sub> in climb
	0602	0.5	
ΔT <sub>IN</sub> (°F)	0611	.0	Incremental temperature above standard, in degrees
ΔT <sub>IN</sub> (°F)	0612	.0	
Δh (FT)	0621	500.	Altitude increments for climb calculations
	0622	500.	
POWIND	0631	2.0	Climb at normal engine power
POWIND	0632	2.0	
h <sub>MAX</sub> (FT)	0641	5000.	Final altitudes for climb
h <sub>MAX</sub> (FT)	0642	3000.	
N <sub>II</sub> /N <sub>II</sub> MAX PRIMARY ENG	0651	1.015	This location specifies the operating point for engine power turbine at design climb conditions
	0652	1.015	
ΔF <sub>e</sub> CL (FT <sup>2</sup> )	0661	.0	Increment in equivalent flat plate area parasite drag (climb performance segment)
	0662	.0	
N <sub>P</sub> SD CL	0681	2.0	Shut down two of the primary engines in climb
	0682	2.0	
NPSD i <sub>CL</sub>	0701	.0	Number of auxiliary independent engines shut down during climb
NPSD i <sub>CL</sub>	0702	.0	

**CRUISE INFORMATION SHEET**

CRSIND	0721	1.0	Cruise at specified power setting
	0722	4.0	Cruise at 99 percent best range speed

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$V_{IN_{2nd}}$	0732	25.0	True air speed for cruise during cruise segment with $CRSIN^{\circ} = 2$ (kts)
ATMIND	0741	.0	} Standard atmosphere
ATMIND	0742	.0	
$C_{L_{WING}}$	0751	0.4	} Wing operating $C_L$ in cruise
	0752	0.45	
$\Delta T_{IN}$ ( $^{\circ}F$ )	0761	.0	} Incremental temperature above standard in degrees
$\Delta T_{IN}$ ( $^{\circ}F$ )	0762	.0	
$\Delta R$ (NM)	0771	20.0	} Step size for cruise (nautical miles)
	0772	20.0	
POWIND	0781	2.0	Cruise at NRP for first cruise segment
$R_{MAX}$	0791	80	} Values of range at end of each cruise
	0792	180	
$N_{II}/N_{II_{MAX}}$ (PRIMARY ENG)	0801	1.105	} Specifies the operating point for engine power turbine at design cruise conditions
	0802	1.105	
$\Delta Fe_{CR}$ ( $FT^2$ )	0811	.0	} Increment in equivalent flat plate area parasite (cruise performance segment)
	0812	.0	
$N_{PSD_{CR}}$	0831	.0	} Number of primary engines shut down during cruise
	0832	.0	

**LOITER INFORMATION SHEET**

ATMIND	1031	.0	Standard atmosphere
$C_{LW}$	1041	.4	Wing operating $C_L$ in loiter
$\Delta T_{IN}$ ( $^{\circ}F$ )	1051	.0	Incremental temperature above standard, in degrees
$\Delta T_L$ (HR)	1061	.05	Step size for loiter



<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
$N_{II}/N_{II\_MAX}$ (PRIMARY ENG)	1071	1.105	Specifies the operating point for engine power turbine at design loiter conditons
$t_L$	1081	.5	Incremental time for loiter
$N_{PSD\_LOITER}$	1101	.0	Number of primary engines shut down during loiter
$\Delta Fe_L$	1131	.0	Increment in equivalent flat plate area parasite drag (loiter performance sector)
TRANSFER ALTITUDE	1181	1000.	Transfer altitude

ENGINE CYCLE DATA; NON-STANDARD PERFORMANCE

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
WDTIND	1201	.0	No fuel flow cutoffs
N1IND	1202	.0	No $N_I$ cutoffs
N10ND	1203	.0	No referred $N_I$ cutoff
N2IND	1204	2.	Free turbine engine to be simulated
$Q_{IND}$	1205	.0	No torque limit.
RNOIND	1206	.0	No Reynolds No. corrections
$(N_{II\_MAX}/N_{II}^*)$	1223	.905	Value for $N_{II}$ cutoff referred to $N_{II}^*$

SAMPLE CASE NO 2. RUN 2.

<u>VARIABLE</u>	<u>LOC</u>	<u>VALUE</u>	<u>REMARKS</u>
OPTIONAL PRINT	2	.0	Standard print, no details

H E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91

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	.0
1206	1	.0	.0	.0	.0	.0
1223	1	.90500	.0	.0	.32000E-01	950.00
1301	5	1.7610	.05900	.0	2000.0	8.0000
1306	5	1.100.0	1056.0	2000.0	1600.0	1000.0
1311	5	950.00	1200.0	1400.0	5.0000	.0
1316	5	2.000.0	2200.0	2600.0	.6000	.0
1321	4	.2000	.0	.0	.31500E-01	.36200E-01
1326	5	.25000E-01	.25000E-01	.27000E-01	.2000	.23600
1332	5	.16300	.36760	.18130	.41900	.68510
1336	5	.33500	.3440	.37250	.64110	.78770
1344	5	.54000	.55920	.60490	.96450	1.1150
1350	5	.77000	.79160	.85620	1.2520	1.4480
1356	5	1.0000	1.0280	1.1120	1.5024	1.7376
1362	5	1.2300	1.2336	1.3344	1.9406	2.2440
1368	5	1.5500	1.5934	1.7236	2.6000	3.0000
1374	5	8.0000	950.00	1200.0	.60000	.80000
1379	5	1600.0	2100.0	2200.0	.67000E-01	.71000E-01
1384	5	.0	.20000	.40000	.12000	.14000
1390	5	.65000E-01	.65100E-01	.65300E-01	.20000	.22000
1396	5	.11500	.11600	.11800	.20000	.22000
1402	5	.18000	.18100	.19000	.20000	.20000
1408	5	.26000	.26100	.27300	.29500	.30000
1414	5	.34200	.34700	.36200	.38700	.40000
1420	5	.42500	.43500	.45100	.48600	.50000
1426	5	.50000	.51100	.53000	.56000	.58000
1432	5	.62500	.63300	.66000	.71000	.72000
1438	5	3.0000	950.00	1600.0	.80000	.80000
1444	4	5.0000	.0	.40000	.60000	.80000
1454	3	.27100	.27100	.29000	.30000	.30000
1460	3	.84000	.84000	.90000	.90000	.90000
1466	3	1.05000	1.11800	1.16500	1.16500	1.16500
1502	5	8.0000	950.00	1200.0	2200.0	1600.0
1507	5	1600.0	2100.0	2200.0	2600.0	3000.0
1512	5	.0	.20000	.40000	.60000	.80000
1518	5	.26000	.26500	.27100	.28000	.28000
1524	5	.52000	.52700	.54000	.56000	.58000
1530	5	.87000	.89000	.92500	.95000	.97000

NOTE: IN USING AUXILIARY ENGINES & AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE





1001	1	.50000	
1101	1	.0	
121	1	.0	
131	1	1/00.0	
141	2	1/00.0	
UC = 0.30000E+05		VFA = 0.0	VFR = 0.0
UC = 0.30000E+05		VFA = 0.50260E+04	VFR = 0.39740E+04
UC = 0.27355E+05		VFA = 0.48490E+04	VFR = 0.36500E+04

HELICOPTER SIZING & PERFORMANCE CALCULATION PROGRAM 8-91

YANZER ROTOR VINGED HELICOPTER

SIZE DATA THIS RUN CONVERGED IN 3 ITERATIONS  
GROSS WEIGHT = 24854. LB

FUSELAGE

LP	LENGTH	47.8 FT.
LC	CASIN LENGTH	38.8 FT.
DELTA1	FWD. ROTOR LOCATION	9.8 FT.
DELTA2	AFT ROTOR LOCATION	4.8 FT.
W	WIDTH	6.8 FT.
G/S	ROTOR GAP/STAGGER RATIO	8.160
(O/L/D)	ROTOR OVERLAP/DIAMETER RATIO	0.228
SP	WETTED AREA	936.4 SQ. FT.

WING

AR	ASPECT RATIO*	6.00
SU	AREA	134.4 SQ. FT.
SU	SPAN	38.4 FT.
CBARV	MEAN CHORD	4.7 FT.
LAMBDA C/4	QUARTER CHORD SWEEP	8.18 DEG.
LAMBDA	TAPER RATIO	4.500
(T/C)R	ROOT THICKNESS/CHORD	0.200
(T/C)T	TIP THICKNESS/CHORD	0.120
W/SU	WING LOADING	189.0 LBS/SQ. FT.
ORV	ROTOR/VEG. GAP	3.8 FT.
CF/C	FLAP CHORD/MEAN CHORD RATIO	1.000

FORWARD ROTOR PYLON

AR	ASPECT RATIO	0.400
SPP	WETTED AREA	59.8 SQ. FT.
FAPP	FRONTAL AREA	8.3 SQ. FT.
HP1	HEIGHT	3.8 FT.
CBARFP	MEAN CHORD	7.8 FT.
LAMBDA FP	TAPER RATIO	0.700
(T/C)R	ROOT THICKNESS/CHORD	0.400
(T/C)T	TIP THICKNESS/CHORD	0.200

AFT ROTOR PYLON

AR	ASPECT RATIO	0.700
SAP	WETTED AREA	834.3 SQ. FT.
HP2	HEIGHT	8.8 FT.
CBARAP	MEAN CHORD	32.1 FT.
LAMBDA AP	TAPER RATIO	0.700

CT/CIP	ROOT THICKNESS/CHORD	0.500
CT/CST	TIP THICKNESS/CHORD	0.500
PRIMARY ENGINE NACELLE		
LN	LENGTH	9.8 FT.
DN	MEAN DIAMETER	1. FT.
SN	WETTED AREA(TOTAL FOR ALL ENGINES)	94.1 SQ. FT.
AUXILIARY INDEPENDENT ENGINE NACELLE -NO AUXILIARY INDEPENDENT		
PROPELLER/AUXILIARY PROPULSION) - NO PROPELLER USED		
MAIN ROTOR		
CMR	DIAMETER	49.8 FT.
ZIGR	SOLIDITY	0.122
WG/A	DISC LOADING	9.8 LB/SQ. FT.
CT/SIGMA	THRUST COEFF./SOLIDITY	0.096
NR	NO. OF ROTORS	2.
NO. BLADES	NO. OF BLADES/ROTOR	4.
THETA	BLADE TWIST	-9.880 DEG.
EC	BLADE CUTOUT/RADIUS RATIO	0.280
VTIP	TIP SPEED	700. FT./SEC.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91  
M E S C O M P

W E I G H T S D A T A IN LBS

MLF	MANEUVER LOAD FACTOR	3.080
SLF	GUST LOAD FACTOR	1.438
ULF	ULTIMATE LOAD FACTOR	4.800
PROPULSION GROUP		
MPA6	TOTAL MAIN ROTOR GROUP	2946.
K12 WPAR	MAIN ROTOR BLADE (PER ROTOR)	999.
K13 WPH	MAIN ROTOR HUB (PER ROTOR)	579.
WV	BLADE FOLDING (PER ROTOR)	290.
K16 WAB	AUXILIARY PROPULSION ROTOR GROUP	0.
WDS	DRIVE SYSTEM	2271.
K16 WPD8	MAIN ROTOR DRIVE SYSTEM	2271.
K20 WTR08	TAIL ROTOR DRIVE SYSTEM	0.
K17 WAD5	AUXILIARY PROPULSION DRIVE SYSTEM	0.
K18 WEP	PRIMARY ENGINES	1074.
K19 WEA	AUXILIARY ENGINES	0.
WPE1	PRIMARY ENGINE INSTALLATION	200.
WAE1	AUXILIARY ENGINE INSTALLATION	0.
WFS	FUEL SYSTEM	635.
DELTA UP	PROPULSION GROUP WEIGHT INCREMENT	0.
UP	TOTAL PROPULSION GROUP WEIGHT	7126.
STRUCTURES GROUP		
K6 WU	WING GROUP	277.
WT6	TAIL	0.
K9 WMY	HOR. TAIL	0.
K14 WTR	TAIL ROTOR	0.
K5 WB	FUSELAGE	3251.
K7 WLG	LANDING GEAR	994.
WNG	NOSE GEAR	199.
WRS	MAIN GEAR	795.
WTS	TOTAL ENGINE SECTION	120.
WPS	PRIMARY ENGINE SECTION	120.
WAS	AUXILIARY ENGINE SECTION	0.
DELTA WST	STRUCTURE WEIGHT INCREMENT	0.
WST	TOTAL STRUCTURE WEIGHT	4642.
FLIGHT CONTROLS GROUP		
WPPC	PRIMARY FLIGHT CONTROLS	1145.
WCC	COCKPIT CONTROLS	97.
K1 WRC	MAIN ROTOR CONTROLS	351.
K2 WPC	MAIN ROTOR SYSTEMS CONTROLS	597.
K3 WFN	FIXED WING CONTROLS	0.
WTH	TILT MECHANISM	0.
WAS	SAS	100.
WAPC	AUXILIARY FLIGHT CONTROLS	0.
WACA	AUX. PROPULSION ROTOR CONTROLS	0.



K5	USCA	AUX. PROPULSION ROTOR SYS. CONTROLS	0.
	UMC	MISCELLANEOUS CONTROLS	0.
	DELTA WFC	CONTROL WEIGHT INCREMENT	0.
	WFC	TOTAL CONTROL WEIGHT	1145.
WFE		WEIGHT OF FIXED EQUIPMENT	3086.
WE		WEIGHT EMPTY	1971.
WFUL		FIXED USEFUL LOAD	688.
OME		OPERATING WEIGHT EMPTY	16514.
MPL		PAYLOAD	5088.
(WFA)		FUEL	3341.
WG		GROSS WEIGHT	24854.

SAMPLE CASE NO. 2 RUN 1

PAGE 4

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91

R O T O R D A T A

ROTOR CYCLE NO. 3.0000

MAIN ROTOR SOLIDITY SIZED BY MANUEVER CUNDITONS  
H = 0000.0 FT. \* TEMP = 00.7 DEG. \* V =  
100.0 PERCENT HOVER RPM  
ROTOR MANUEVER G'S = 1.000 \* CT/SIGMA = 0.095

100.0 KT.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91  
M E S C O M P

F R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE NO. 1.761  
TURBOSHAFT ENGINE

4. ENGINES

BHP@P MAX. STANDARD S.L. STATIC H.P. 6756. H.P.

ENGINE SIZED FOR TAKEOFF AT 1/4 21.08  
98.0 PERCENT MILITARY POWER SETTING.  
H = 4000. FT, TEMPERATURE = 98.04 DEG.F.,  
1.000 ENGINES INOPERATIVE, AND 0.0 FT/MIN VERTICAL RATE OF CL:

MAIN ROTOR DRIVE SYSTEM RATING 3671. H.P.

XRMSN SIZED AT 100. PERCENT OF MAIN ROTOR HOVER POWER REQUIRED  
AT H = 4000. FT, TEMP = 96.04 DEG.F., 100.0 PERCENT HOVER RPM

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-1  
 H E S C O M P

A E R O D Y N A M I C S D A T A			
FE	TOTAL EFFECTIVE FLATPLATE AREA	23.662	SQFT
SMCT	TOTAL WETTED AREA	1529.	SQFT
CBARF	MEAN SKIN FRICTION COEFF.	0.015080	
D R A G B R E A K D O U N	IN SQFT		
FEM	WING FE	1.285	
FEFF	FUSELAGE FE	2.479	
FEFP	FORWARD(MAIN) ROTOR PYLON FE	1.551	
FEAP	AFT ROTOR PYLON FE	1.350	
FENRH	MAIN ROTOR HUB(S) FE	12.067	
FETRN	TAIL ROTOR HUB FE	0.0	
FEVT	VERTICAL TAIL FE	0.0	
FEN7	HORIZONTAL TAIL FE	0.0	
FEN	PRIMARY ENGINE NACELLE FE	0.892	
FEN5	AUX. INDEPENDENT CRUISE ENG. NAC. FE	0.0	
FEN3	AUX. INDEPENDENT CRUISE ENG. STRUT FE	0.0	
FEN1	INCREMENTAL FE	4.058	
DELTA FE			
A E R O D Y N A M I C C O E F F .			
A5		22.37697	
A6		1.62076	
A7		0.07374	
AR		0.00010	
A9		0.0	
E	WING LIFT EFFICIENCY FACTOR	0.75800	
EVT	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.0	

H E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91

MISSION PERFORMANCE DATA

TAXI FOR 3.033 HRS. AT GROUND IDLE ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRESS. ALT. (FT)	IAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PENF	TOTAL FUEL FLOW (LBS/HR)	AUX. TURB. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. PENF	AUX. FUEL FLOW (LBS/HR)	TEMP. DEG. (F)
0.0	0.0	0.0	24854.	0.	0.0	950.0	T	0.0	461.	-----	-----	-----	-----	59.0
0.033	0.0	15.4	24839.	0.	0.0	956.0	T	0.0	461.	-----	-----	-----	-----	59.0

TAKEOFF, HOVER, OR LAND AT T/W = 1.080 FOR 0.100 HRS.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PALS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PENF	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	GHP	CT	CT/SIGMA
0.033	0.0	15.4	24839.	0.	0.0	1574.7	P	0.086	1772.	1.080	0.673	3282.	0.0074	0.061
700.0	3.077.	-----	-----	-----	1772.	59.0	A	0.085	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.043	0.0	33.1	24821.	0.	0.0	1574.3	P	0.085	1771.	1.080	0.673	3279.	0.0074	0.061
700.0	3.094.	-----	-----	-----	1771.	59.0	A	0.085	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.053	0.0	50.8	24803.	0.	0.0	1573.9	P	0.085	1769.	1.080	0.673	3276.	0.0074	0.061
700.0	3.080.	-----	-----	-----	1769.	59.0	A	0.084	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.063	0.0	68.5	24786.	0.	0.0	1573.5	P	0.084	1768.	1.080	0.673	3272.	0.0074	0.061
700.0	3.077.	-----	-----	-----	1768.	59.0	A	0.084	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.073	0.0	86.2	24768.	0.	0.0	1573.1	P	0.084	1767.	1.080	0.673	3269.	0.0074	0.061
700.0	3.074.	-----	-----	-----	1767.	59.0	A	0.083	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.083	0.0	103.8	24751.	0.	0.0	1572.7	P	0.083	1766.	1.080	0.673	3266.	0.0074	0.060
700.0	3.071.	-----	-----	-----	1766.	59.0	A	0.083	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.093	0.0	121.5	24733.	0.	0.0	1572.3	P	0.083	1765.	1.080	0.673	3262.	0.0074	0.060
700.0	3.068.	-----	-----	-----	1765.	59.0	A	0.082	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.103	0.0	139.2	24715.	0.	0.0	1571.9	P	0.082	1764.	1.080	0.673	3259.	0.0074	0.060
700.0	3.064.	-----	-----	-----	1764.	59.0	A	0.082	59.0	1.0	0.707	0.00011	0.00056	0.0072
0.113	0.0	156.8	24697.	0.	0.0	1571.6	P	0.082	1763.	1.080	0.673	3256.	0.0074	0.060
700.0	3.061.	-----	-----	-----	1763.	59.0	A	0.082	59.0	1.0	0.707	0.00011	0.00056	0.0072

TIME (MRS)	RANGE (N-M)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. PENF	P	0.461	1762	1.080	0.673	3253	0.0074	0.060
0-123 700.0	0.0 3056.	174.4 ----	24667.0 ----	0. 0.	0.0 1762.	1571.2	A	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-133 700.0	0.0 3055.	192.0 ----	24662.0 ----	0. 0.	0.0 1761.	1570.8	F	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-133 700.0	0.0 3055.	192.0 ----	24662.0 ----	0. 0.	0.0 1761.	1570.8	P	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072

CLIMB TO 3000. FT. WITH MAXIMUM R/C AT NORMAL ENGINE RATINGS  
 .. TAS(AND EAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (MRS)	RANGE (N-M)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. PENF	P	0.461	1762	1.080	0.673	3253	0.0074	0.060
0-133 700.0	0.0 1669.	192.0 0.00051	24662.0 0.00012	0. 0.00061	0.0 1311.	1556.0 0.00023	T A	0.035 3.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-142 700.0	0.74 1872.	204.0 0.00052	24650.0 0.00012	500. 0.00065	85.5 1295.	1556.0 0.00027	T A	0.037 3.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-152 700.0	1.60 1874.	216.3 0.00053	24636.0 0.00012	1040. 0.00067	85.5 1279.	1556.0 0.00030	T A	0.038 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-162 700.0	2.46 1676.	229.0 0.00053	24625.0 0.00013	1500. 0.00070	85.5 1264.	1556.0 0.00032	T A	0.040 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-172 700.0	3.36 1681.	242.0 0.00055	24612.0 0.00013	2000. 0.00075	86.5 1248.	1556.0 0.00037	T A	0.041 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-183 700.0	4.31 1684.	255.6 0.00055	24599.0 0.00013	2500. 0.00078	86.5 1233.	1556.0 0.00040	T A	0.043 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-194 700.0	5.31 1689.	269.6 0.00057	24585.0 0.00014	3000. 0.00084	87.5 1217.	1556.0 0.00046	T A	0.044 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-206 700.0	6.37 1693.	284.3 0.00057	24570.0 0.00014	3500. 0.00087	87.5 1202.	1556.0 0.00050	T A	0.046 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072

TIME (MRS)	RANGE (N-M)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. PENF	P	0.461	1762	1.080	0.673	3253	0.0074	0.060
0-133 700.0	0.0 3056.	174.4 ----	24667.0 ----	0. 0.	0.0 1762.	1571.2	A	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-133 700.0	0.0 3055.	192.0 ----	24662.0 ----	0. 0.	0.0 1761.	1570.8	F	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-133 700.0	0.0 3055.	192.0 ----	24662.0 ----	0. 0.	0.0 1761.	1570.8	P	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072

TIME (MRS)	RANGE (N-M)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. PENF	P	0.461	1762	1.080	0.673	3253	0.0074	0.060
0-133 700.0	0.0 1669.	192.0 0.00051	24662.0 0.00012	0. 0.00061	0.0 1311.	1556.0 0.00023	T A	0.035 3.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-142 700.0	0.74 1872.	204.0 0.00052	24650.0 0.00012	500. 0.00065	85.5 1295.	1556.0 0.00027	T A	0.037 3.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-152 700.0	1.60 1874.	216.3 0.00053	24636.0 0.00012	1040. 0.00067	85.5 1279.	1556.0 0.00030	T A	0.038 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-162 700.0	2.46 1676.	229.0 0.00053	24625.0 0.00013	1500. 0.00070	85.5 1264.	1556.0 0.00032	T A	0.040 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-172 700.0	3.36 1681.	242.0 0.00055	24612.0 0.00013	2000. 0.00075	86.5 1248.	1556.0 0.00037	T A	0.041 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-183 700.0	4.31 1684.	255.6 0.00055	24599.0 0.00013	2500. 0.00078	86.5 1233.	1556.0 0.00040	T A	0.043 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-194 700.0	5.31 1689.	269.6 0.00057	24585.0 0.00014	3000. 0.00084	87.5 1217.	1556.0 0.00046	T A	0.044 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-206 700.0	6.37 1693.	284.3 0.00057	24570.0 0.00014	3500. 0.00087	87.5 1202.	1556.0 0.00050	T A	0.046 0.0	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072

TIME (MRS)	RANGE (N-M)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. PENF	P	0.461	1762	1.080	0.673	3253	0.0074	0.060
0-133 700.0	0.0 3056.	174.4 ----	24667.0 ----	0. 0.	0.0 1762.	1571.2	A	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-133 700.0	0.0 3055.	192.0 ----	24662.0 ----	0. 0.	0.0 1761.	1570.8	F	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072
0-133 700.0	0.0 3055.	192.0 ----	24662.0 ----	0. 0.	0.0 1761.	1570.8	P	A	0.00011	59.0	0.0	0.707	0.00011	0.00055	0.0072

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	T. ROTOR RMP	T. ROTOR VTIP (FPS)	T. ROTOR RHP	PROP VTIP (FPS)	PROP ALT. (FT)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	ETAP PROP	PRIM. ENG. CODE	Y	0.847	82.6	0.213	0.059	-2.1	3.9	2612.	617.
0-219	7.50	299.5	24556.	4200.	87.5	1856.0	Y	0.847	0.213	0.059	-2.1	3.9	2612.	617.							
700.0	1097.	0.000165	0.000220	0.000015	0.00491	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							
0-233	9.70	315.6	24539.	4500.	88.9	1856.0	Y	0.849	0.216	0.068	-2.1	3.6	2583.	578.							
700.0	1503.	0.000167	0.000232	0.000015	0.00899	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							
0-247	9.99	332.5	24522.	5000.	88.5	1856.0	Y	0.850	0.216	0.061	-2.0	3.4	2553.	538.							
700.0	1909.	0.000167	0.000239	0.000016	0.00903	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							

CRUISE AT NORMAL ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	T. ROTOR RMP	T. ROTOR VTIP (FPS)	T. ROTOR RHP	PROP VTIP (FPS)	PROP ALT. (FT)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	ETAP PROP	PRIM. ENG. CODE	Y	0.851	169.6	0.440	0.051	-7.5	-0.7753	5323.
0-247	9.99	332.5	24522.	5000.	182.7	1856.0	Y	0.851	0.440	0.051	-7.5	-0.7753	5323.							
700.0	5066.	0.000605	0.000881	0.000559	0.000032	0.02807	0.00074	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							
0-357	29.99	590.5	24264.	5000.	183.5	1856.0	Y	0.851	0.443	0.050	-8.1	-0.7789	5374.							
700.0	5116.	0.000610	0.000879	0.000569	0.000031	0.02896	0.00071	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							
0-466	49.99	847.2	24007.	5000.	183.8	1856.0	Y	0.851	0.443	0.049	-8.2	-0.7800	5373.							
700.0	5114.	0.000616	0.000876	0.000572	0.000031	0.02891	0.00066	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							
0-574	69.99	1103.6	23751.	5000.	184.1	1856.0	Y	0.851	0.4	0.048	-8.3	-0.7812	5371.							
700.0	5113.	0.000609	0.000874	0.000576	0.000030	0.02885	0.00062	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							
0-629	89.00	1231.8	23622.	5000.	184.3	1856.0	Y	0.851	0.444	0.046	-6.4	-0.7818	5376.							
700.0	5112.	0.000609	0.000873	0.000577	0.000030	0.02882	0.00060	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							

TRANSFER ALTITUDE TO 1000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRES. ALT. (FT)
0-629	89.00	1231.8	23622.	5000.	5000.
0-629	89.00	1231.8	23622.	1000.	1000.

LOITER FOR 0.500 HRS. FOR RESERVE FUEL

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	DELCD	DELCD	CMR	ROTLIM CODE	J	CP	CT	ALPHA D/L (DEG)	TOTAL FUEL FLOW (LBS/HR)	BMP
K-ROTOR VTIIP (FPS)	M-ROTOR RMP	T-ROTOR VTIIP (FPS)	T-ROTOR RMP	PROP VTIIP (FPS)	PRIM-ENG FUEL FLOW (LBS/HR)	BHP AUX	DELCD	ETA/PROP	TAUX/T	AUX-ENG FUEL FLOW (LBS/HR)	AUX-ENG TURB. TEMP.	AUX-ENG CODE	AUX-ENG PENF		
CPRO	CPIND	CPPAR	CPMUD	SDO	DELCD	DELCD	DELCD	CMR	ROTLIM CODE	J	CP	CT	ALPHA D/L (DEG)	CDM	RM
0.629	80.00	1231.0	23622.	1000.	85.0	1415.9	0.0025	P	0.292	83.7	0.205	0.052	-2.1	1293.	1946.
700.0	1796.	0.000182	0.000050	0.00063	0.0	0.00025	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946
0.679	80.00	1296.4	23550.	1000.	85.0	1415.3	0.0025	P	0.291	83.7	0.205	0.052	-2.1	1291.	1940.
700.0	1785.	0.000181	0.000050	0.00063	0.0	0.00025	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946
0.729	80.00	1361.0	23493.	1000.	84.0	1414.6	0.0023	P	0.290	82.7	0.202	0.052	-2.1	1290.	1934.
700.0	1779.	0.000183	0.000046	0.00061	0.0	0.00023	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.947
0.829	80.00	1425.5	23429.	1000.	84.0	1414.0	0.0023	P	0.290	82.7	0.202	0.052	-2.1	1288.	1929.
700.0	1774.	0.000182	0.000048	0.00061	0.0	0.00023	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.947
0.929	80.00	1489.9	23364.	1000.	84.0	1413.4	0.0023	P	0.289	82.7	0.202	0.052	-2.1	1286.	1924.
700.0	1769.	0.000181	0.000048	0.00060	0.0	0.00023	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.947
1.029	80.00	1554.2	23300.	1000.	84.0	1412.8	0.0022	P	0.288	82.7	0.202	0.052	-2.1	1285.	1918.
700.0	1764.	0.000180	0.000046	0.00060	0.0	0.00022	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946
1.129	80.00	1618.4	23236.	1000.	84.0	1412.2	0.0022	F	0.287	82.7	0.202	0.051	-2.1	1283.	1913.
700.0	1759.	0.000179	0.000048	0.00060	0.0	0.00022	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.001	0.946
1.229	80.00	1682.6	23172.	1000.	84.0	1411.6	0.0022	P	0.286	82.7	0.202	0.051	-2.1	1281.	1908.
700.0	1754.	0.000178	0.000048	0.00060	0.0	0.00022	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946
1.329	80.00	1746.7	23108.	1000.	84.0	1410.9	0.0022	P	0.286	82.7	0.202	0.051	-2.1	1280.	1903.
700.0	1749.	0.000177	0.000048	0.00060	0.0	0.00022	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946
1.429	80.00	1810.7	23044.	1000.	84.0	1410.3	0.0022	P	0.285	82.7	0.202	0.051	-2.1	1278.	1898.
700.0	1744.	0.000176	0.000048	0.00060	0.0	0.00022	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946
1.529	80.00	1874.6	22980.	1000.	84.0	1409.7	0.0022	P	0.284	82.7	0.202	0.051	-2.1	1276.	1892.
700.0	1739.	0.000175	0.000048	0.00060	0.0	0.00022	0.0023	A	0.0	0.0	0.0	0.0	0.400	0.007	0.946



CLIMB TO 3000 FT. WITH CONSTANT TAS AT NORMAL ENGINE RATINGS  
 .. TAS(AND EAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (MRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TURP. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERF	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	GAMMA (DEG)	BHP (FPM)	R/C (FPM)
M.ROTOR W/TIP (FPS)	M.ROTOR RMP	T.ROTOR W/TIP (FPS)	T.ROTOR RMP	PROP W/TIP (FPS)	PRIM.ENG FUEL FLOW (LBS/NR)	RHP AUX	ETAP PROP	AUX. ENG. FUEL FLOW (LBS/NR)	J	CP	CT	CLV	CDV	BHP	R/C
CPPRO	CPIND	CPPAR	CPNUD	CCG	DELCD5	DELCDM	EXR	ROTLM CODE	J	CP	CT	CLV	CDV	BHP	R/C
3.529	60.60	1870.6	23622	1070.	120.0	1856.0	T	0.838	118.3	0.289	0.048	-4.2	2.6	2825.	589.
700.8	2147.	---	---	---	1287.	---	---	0.0	---	---	---	---	---	---	---
0.000268	0.000109	0.000136	0.00027	0.00084	0.00000	0.00143	0.000430	A	---	---	---	0.500	0.007	0.865	---
0.643	61.70	1892.8	23634.	1500.	120.0	1856.0	T	0.640	117.4	0.289	0.048	-4.2	2.6	2794.	559.
700.8	2143.	---	---	---	1272.	---	---	0.0	---	---	---	---	---	---	---
0.000210	0.000113	0.000136	0.00028	0.00092	0.00016	0.00151	0.000431	A	---	---	---	0.500	0.007	0.867	---
0.654	63.49	1911.7	23585.	2000.	120.0	1856.0	T	0.642	116.5	0.289	0.049	-4.1	2.5	2764.	529.
700.8	2139.	---	---	---	1266.	---	---	0.0	---	---	---	---	---	---	---
0.000212	0.000116	0.000136	0.00028	0.01000	0.00010	0.00160	0.000432	A	---	---	---	0.500	0.007	0.869	---
0.674	65.36	1931.5	23565.	2500.	120.0	1856.0	T	0.843	115.7	0.289	0.050	-4.1	2.3	2733.	499.
700.8	2135.	---	---	---	1241.	---	---	0.0	---	---	---	---	---	---	---
0.000214	0.000120	0.000137	0.00028	0.01009	0.00011	0.00168	0.000434	A	---	---	---	0.500	0.007	0.871	---
0.698	67.36	1952.2	23545.	3000.	120.0	1856.0	T	0.844	114.8	0.289	0.051	-4.0	2.2	2702.	464.
700.8	2132.	---	---	---	1225.	---	---	0.0	---	---	---	---	---	---	---
0.000216	0.000124	0.000137	0.00029	0.01018	0.00011	0.00177	0.000435	A	---	---	---	0.500	0.007	0.873	---

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 25.0 KNOTS

TIME (MRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TURP. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERF	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	SFLC RANGE (NMPP)	BHP
M.ROTOR W/TIP (FPS)	M.ROTOR RMP	T.ROTOR W/TIP (FPS)	T.ROTOR RMP	PROP W/TIP (FPS)	PRIM.ENG FUEL FLOW (LBS/NR)	RHP AUX	ETAP PROP	AUX. ENG. FUEL FLOW (LBS/NR)	J	CP	CT	CLV	CDV	BHP
CPPRO	CPIND	CPPAR	CPNUD	CCG	DELCD5	DELCDM	EXR	ROTLM CODE	J	CP	CT	CLV	CDV	BHP
0.698	67.36	1952.2	23545.	3000.	156.6	1660.5	P	0.843	149.8	0.378	0.047	-6.6	0.07489	3532.
700.8	3529.	---	---	---	1756.	---	---	0.0	---	---	---	---	---	---



1.199	180.00	3277.0	2222.0	00	1621.0	1521.0	P	0.018	1620.0	1.100	0.066	0.00006	0.0072
700.0	2603.0	---	---	00	1621.0	---	A	---	59.0	0.0	0.00006	0.00006	0.0072
1.469	100.00	3093.2	2223.0	00	1619.0	1621.0	P	0.018	1619.0	1.000	0.066	0.00006	0.0072
700.0	2400.0	---	---	00	1619.0	---	A	---	59.0	0.0	0.00006	0.00006	0.0072
1.479	100.00	3104.4	2218.0	00	1618.0	1620.7	P	0.017	1618.0	1.000	0.066	0.00006	0.0072
700.0	1620.0	---	---	00	1618.0	---	A	---	59.0	0.0	0.00006	0.00006	0.0072
1.489	100.00	3125.6	2213.0	00	1617.0	1620.0	P	0.017	1617.0	1.000	0.066	0.00006	0.0072
700.0	2400.0	---	---	00	1617.0	---	A	---	59.0	0.0	0.00006	0.00006	0.0072
1.499	100.00	3100.0	2215.0	00	1616.0	1620.1	P	0.017	1616.0	1.000	0.066	0.00006	0.0072
700.0	1620.0	---	---	00	1616.0	---	A	---	59.0	0.0	0.00006	0.00006	0.0072
1.509	100.00	3100.0	2215.0	00	1616.0	1620.1	P	0.017	1616.0	1.000	0.066	0.00006	0.0072
700.0	1620.0	---	---	00	1616.0	---	A	---	59.0	0.0	0.00006	0.00006	0.0072

A LOW FUEL REQUIRED = 2698.94  
 AT FUEL REQUIRED = 448.74  
 FUEL REQUIRED = 3147.77

END OF SUCCESSFUL CABL

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPONDS TO LOCATION NUM. R GIVEN ON INPUT SHEET  
NUM STANDS FOR THE NUMBER OF SEQUENTIAL INPUT VALUES STARTING WITH LOC. (MAX. 99)  
VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
VAL1 VALUE FOR VARIABLE CORRESPONDING TO LOC. 0001  
VAL2 VALUE FOR VARIABLE CORRESPONDING TO LOC. 0002  
ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
2	1	0.30000E+05	0.33000E+04	0.33000E+04	0.33000E+04	0.33000E+04
2	1	0.30000E+05	0.33000E+04	0.33000E+04	0.33000E+04	0.33000E+04
2	1	0.30000E+05	0.33000E+04	0.33000E+04	0.33000E+04	0.33000E+04
2	1	0.30000E+05	0.33000E+04	0.33000E+04	0.33000E+04	0.33000E+04

NOTE: IN USING AUXILIARY ENGINES 3, AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91

TANDEM ROTOR WINGED HELICOPTER

S I Z E D A T A THIS RUN CONVERGED IN 3 ITERATIONS  
GROSS WEIGHT = 24850. LP

FUSELAGE

LF	LENGTH	47.8 FT.
LC	CABIN LENGTH	38.3 FT.
DELTA1	FWD. ROTOR LOCATION	9.0 FT.
DELTA2	AFT ROTOR LOCATION	4.5 FT.
WF	WIDTH	6.0 FT.
G/S	ROTOR GAP/STAGGER RATIO	0.160
(O/L/D)	ROTOR OVERLAP/DIAMETER RATIO	0.280
SF	WETTED AREA	936.4 SQ. FT.

WING

AR	ASPLCT RATIO	6.00
SA	AREA	136.4 SQ. FT.
SW	SPAN	26.4 FT.
BW	MEAN CHORD	4.7 FT.
CBARV	QUARTER CHORD SUEEP	0.0 DEG.
LAMBDA C/A	TAPER RATIO	0.500
CT/CSR	ROOT THICKNESS/CHORD	0.200
(T/CBT)	TIP THICKNESS/CHORD	0.120
WG/SU	WING LOADING	185.0 LBS/SQ. FT.
GRU	ROTS/MIN GAP	3.0 FT.
CF/C	FLAP CHORD/MEAN CHORD RATIO	1.000

FORWARD ROTOR PYLON

AR	ASPECT RATIO	0.400
SFP	WETTED AREA	50.3 SQ. FT.
PAF1	FRONTAL AREA	0.3 SQ. FT.
MP1	HEIGHT	3.0 FT.
CBARF	MEAN CHORD	7.6 FT.
LAMBDA FP	TAPER RATIO	0.700
(T/CFR)	ROOT THICKNESS/CHORD	0.480
(T/CFT)	TIP THICKNESS/CHORD	0.250

AFT ROTOR PYLON

AR	ASPECT RATIO	3.700
SAP	WETTED AREA	234.3 SQ. FT.
MP2	HEIGHT	6.6 FT.
CBARAP	MEAN CHORD	12.2 FT.
LAMBDA AP	TAPER RATIO	0.750

CT/C18                      ROOT THICKNESS/CHORD                      0.500  
 CT/CT7                      TIP THICKNESS/CHORD                      0.300

PRIMARY ENGINE MACELLE

LN                              LENGTH                              5.2 FT.  
 CM                              MEAN DIAMETER                      1. FT.  
 SM                              NETTED AREA TOTAL FOR ALL ENGINES)                      94.1 SQ. FT.

AUXILIARY INDEPENDENT ENGINE MACELLE -NO AUXILIARY INDEPENDENT ENGINE USED  
 PROPELLER(AUXILIARY PROPULSION) - NO PROPELLER USED

MAIN ROTOR

DMR                              DIAMETER                              1.6 FT.  
 S10PR                              SOLIDITY                              0.122  
 MS/A                              DISC LOADING                              8.8 LB/SQ. FT.  
 CT/SIGMA                              THRUST COEFF./SOLIDITY                              0.695  
 MR                              NO. OF ROTORS                              2  
 NO. BLADES                              NO. OF BLADES/ROTOR                              4  
 THETA                              BLADE TWIST                              -3.889 DEG.  
 XC                              BLADE CUTOUT/RADIUS RATIO                              0.200  
 Y/TIP                              TIP SPEED                              700. FT./SEC.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM b-91

M E S C O M P

W E I G H T S D A T A IN LBS

CLF	MANUEVER LOAD FACTOR	3.040
GLF	GUST LOAD FACTOR	1.436
.17	ULTIMATE LOAD FACTOR	4.850
PROPULSION GROUP		
UPRG	TOTAL MAIN ROTOR GROUP	2946.
K12 WPRB	MAIN ROTOR BLADE (PER ROTOR)	599.
K13 WPM	MAIN ROTOR HUB (PER ROTOR)	579.
WBY	BLADE FOLDING (PER ROTOR)	295.
K18 WAR	AUXILIARY PROPULSION ROTOR GROUP	0.
K19 WDS	DRIVE SYSTEM	2271.
K16 WPOS	MAIN ROTOR DRIVE SYSTEM	2271.
K20 WTRDS	TAIL ROTOR DRIVE SYSTEM	0.
K17 WADS	AUXILIARY PROPULSION DRIVE SYSTEM	0.
K19 WEA	PRIMARY ENGINES	1074.
K19 WPEI	AUXILIARY ENGINES	0.
WAEI	PRIMARY ENGINE INSTALLATION	280.
WAEI	AUXILIARY ENGINE INSTALLATION	0.
WFS	FUEL SYSTEM	636.
DELTA WP	PROPULSION GROUP WEIGHT INCREMENT	0.
UP	TOTAL PROPULSION GROUP WEI	7126.
STRUCTURES GROUP		
WB	WING	277.
WU	TAIL GROUP	0.
WYO	HOR. TAIL	0.
WMT	TAIL ROTOR	0.
WTR	FUSelage	3251.
WB	LANDING GEAR	994.
WLO	NOSE GEAR	199.
WLG	MAIN GEAR	795.
WMS	TOTAL ENGINE SECTION	120.
WES	PRIMARY ENGINE SECTION	128.
WPEB	AUXILIARY ENGINE SECTION	0.
WAEI	STRUCTURE WEIGHT INCREMENT	0.
DELTA WST	TOTAL STRUCTURE WEIGHT	4642.
WST		
FLIGHT CONTROLS GROUP		
WPFC	PRIMARY FLIGHT CONTROLS	1145.
WCC	COCKPIT CONTROLS	97.
WRC	MAIN ROTOR CONTROLS	351.
WMC	MAIN ROTOR SYSTEMS CONTROLS	597.
WFC	FIXED WING CONTROLS	0.
WTH	TILT MECHANISM	0.
WAS	SAS	106.
WATC	AUXILIARY FLIGHT CONTROLS	0.
WACA	AUX. PROPULSION ROTOR CONTROLS	0.

MS	USCA	AUX. PROPULSION ROTOR SYS. CONTROLS	0:
	UMC	MISCELLANEOUS CONTROLS	0:
DELTA	UFC	CONTROL WEIGHT INCREMENT	6:
	UFC	TOTAL CONTROL WEIGHT	1145.
WFE		WEIGHT OF FIXED EQUIPMENT	3000.
WE		WEIGHT EMPTY	15914.
WFUL		FIXED USEFUL LOAD	600.
OWE		OPERATING WEIGHT EMPTY	16514.
WPL		PAYLOAD	5000.
WUPFA		FUEL	3341.
WG		GROSS WEIGHT	24854.



SAMPLE CASE NO. 2 RUN 2

PAGE 4

H E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 4-91

R O T O R D A T A

ROTOR CYCLE NO. 3.0000

MAIN ROTOR SOLIDITY SIZED BY MANUEVER CONDITIONS  
H = 4000.0 FT. , TEMP = 44.7 DEG. , V =  
100.0 PERCENT HOVER RPM  
ROTOR MANUEVER G'S = 1.500 , CT/SIGMA = 0.095

160.0 KT.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91  
H E S C O M P

P R O P U L S I O N   D A T A  
PRIMARY PROPULSION CYCLE NO.    1.761  
TURBOSHIFT ENGINE

4. ENGINES

2HP-4    MAN. STANDARD S.L. STATIC H.P.    6756.    H.P.

ENGINE SIZED FOR TAKEOFF AT 174 23.08  
95.0 PERCENT MILITARY POWER SETTING.  
H = 4000. FT. TEMPERATURE = 95.04 DEG.F.  
1.000 ENGINES IMPERATIVE, AND    0.0 FT/MIN VERTICAL RATE OF CLIMB.

MAIN ROTOR DRIVE SYSTEM RATING    3671.    H.P.

MSM SIZED AT 100. PERCENT OF MAIN ROTOR HOVER POWER REQUIRED  
AT H = 4000. FT. TEMP = 95.04 DEG.F. 100.0 PERCENT HOVER RPM

H E L I C O P T E R  
 HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 6-91

A E R O D Y N A M I C S D A T A			
FE	TOTAL EFFECTIVE FLATPLATE AREA	23.662	SOFT
SWET	TOTAL WETTED AREA	1529.	SOFT
CBARF	MEAN SKIN FRICTION COEFF.	0.015480	
D R A G C O E F F I C I E N T I N S O F T			
FEN	WING FE	1.285	
PEP	FUSELAGE FE	2.479	
FEPP	FORWARD(MAIN) ROTOR PYLON FE	1.951	
FEAP	AFT ROTOR PYLON FE	1.330	
PEMRH	MAIN ROTOR HUB(S) FE	12.867	
FEYRH	TAIL ROTOR HUB FE	0.0	
FEVT	VERTICAL TAIL FE	0.0	
FEHT	HORIZONTAL TAIL FE	0.0	
FEN	PRIMARY ENGINE NACELLE FE	0.892	
FENI	AUX. INDEPENDENT CRUISE ENG. NAC. FE	0.0	
FENS	AUX. INDEPENDENT CRUISE ENG. STRUT FE	0.0	
DELTA FE	INCREMENTAL FE	4.058	
A E R O D Y N A M I C C O E F F .			
A5		22.37697	
A6		1.62676	
A7		0.07074	
A8		0.00010	
A9		0.0	
E	WING LIFT EFFICIENCY FACTOR	0.75000	
EVT	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.8	

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 8-91

MISSION PERFORMANCE DATA

TAXI FOR 9.033 MRS. AT GROUND IDLE ENGINE RATING

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRESS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/HR)	AUX. TURB. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. PEMP	AUX. FUEL FLOW (LBS/HR)	TEMP. DEG. (F)
0.0	0.0	6.3	24854.	0.	0.0	950.0	T	0.0	461.	----	----	----	59.0	
9.033	0.0	15.4	24839.	0.	0.0	950.0	T	0.0	461.	----	----	----	59.0	

TAKEOFF, HOVER, OR LAND AT T/W = 1.000 FOR 0.100 MRS.

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	BHP	CT	CT/SIGMA
0.033	0.0	15.4	24839.	0.	0.0	1574.7	P	0.486	1772.	1.000	0.673	3282.	0.0074	0.061
0.043	0.0	33.1	24821.	0.	0.0	1574.5	P	0.485	1771.	1.000	0.673	3279.	0.0074	0.061
0.053	0.0	50.8	24803.	0.	0.0	1573.9	P	0.485	1769.	1.000	0.673	3276.	0.0074	0.061
0.063	0.0	68.5	24786.	0.	0.0	1573.5	P	0.484	1768.	1.000	0.673	3272.	0.0074	0.061
0.073	0.0	86.2	24767.	0.	0.0	1573.1	P	0.484	1767.	1.000	0.673	3269.	0.0074	0.061
0.083	0.0	103.8	24748.	0.	0.0	1572.7	P	0.483	1766.	1.000	0.673	3266.	0.0074	0.060
0.093	0.0	121.5	24733.	0.	0.0	1572.3	P	0.483	1765.	1.000	0.673	3262.	0.0074	0.060
0.103	0.0	139.1	24715.	0.	0.0	1571.9	P	0.482	1764.	1.000	0.673	3259.	0.0074	0.060
0.113	0.0	156.8	24697.	0.	0.0	1571.6	P	0.482	1763.	1.000	0.673	3256.	0.0074	0.060
0.123	0.0	174.4	24680.	0.	0.0	1571.2	P	0.481	1762.	1.000	0.673	3253.	0.0074	0.060
0.133	0.0	192.0	24662.	0.	0.0	1570.8	P	0.481	1761.	1.000	0.673	3249.	0.0074	0.060
0.133	0.0	192.0	24662.	0.	0.0	1570.8	P	0.481	1761.	1.000	0.673	3249.	0.0074	0.060

CLIMB TO 5000. FT. WITH MAXIMUM R/C AT NORMAL ENGINE RATING  
D/D (TAS&W/EAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	RAMMA (DEG)	BHP	R/C (FPM)
0.133	0.0	192.0	24662.	0.	84.5	1856.0	T	0.835	84.3	0.206	0.053	-2.1	6.0	2853.	913.
0.142	0.0	204.0	24650.	500.	85.5	1856.0	T	0.837	84.9	0.209	0.054	-2.1	5.7	2824.	877.
0.152	0.0	216.3	24638.	1000.	86.5	1856.0	T	0.838	84.3	0.209	0.054	-2.1	5.5	2794.	841.
0.162	0.0	229.0	24625.	1500.	87.5	1856.0	T	0.840	83.6	0.209	0.055	-2.1	5.2	2763.	805.
0.172	0.0	242.0	24612.	2000.	88.5	1856.0	T	0.841	84.0	0.211	0.056	-2.1	4.9	2733.	768.
0.183	0.0	255.6	24599.	2500.	89.5	1856.0	T	0.843	83.4	0.213	0.057	-2.1	4.7	2703.	731.
0.194	0.0	269.6	24585.	3000.	90.5	1856.0	T	0.844	83.7	0.213	0.058	-2.1	4.4	2673.	693.
0.205	0.0	284.3	24570.	3500.	91.5	1856.0	T	0.846	83.1	0.213	0.059	-2.1	4.2	2643.	655.
0.219	0.0	299.5	24555.	4000.	92.5	1856.0	T	0.847	82.5	0.213	0.059	-2.1	3.9	2612.	617.
0.233	0.0	315.5	24539.	4500.	93.5	1856.0	T	0.849	81.8	0.216	0.060	-2.1	3.6	2583.	578.
0.247	0.0	332.5	24522.	5000.	94.5	1856.0	T	0.850	81.2	0.216	0.061	-2.0	3.4	2553.	538.

CRUISE AT NORMAL ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (°R)	PRIM. ENG. CODE	PRIM. ENG. PERF	EAS (KTS)	HL	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (NMPP)	BHP
0-247	9-99	332.5	24522.	5000.	142.7	1856.0	T	0.851	169.6	0.440	0.051	-7.5	0.0753	5323.
0-357	29-99	590.5	24264.	5000.	143.5	1856.0	T	0.851	170.4	0.443	0.053	-8.1	0.07749	5374.
0-466	49-99	847.2	24007.	5000.	143.8	1856.0	T	0.851	171.6	0.443	0.049	-8.2	0.0780	5373.
0-574	69-99	1103.6	23751.	5000.	144.1	1856.0	T	0.851	170.9	0.444	0.044	-8.3	0.07612	5371.
0-629	80-00	1231.8	23622.	5000.	144.3	1856.0	T	0.851	171.0	0.444	0.048	-8.4	0.07818	5370.

TRANSFER ALTITUDE TO 1000 FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)
0-629	80-00	1231.8	23622.	5000.
0-629	80-00	1231.8	23622.	1000.

LCITER FOR 0.500 MRS. FOR RESERVE FUEL

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (°R)	PRIM. ENG. CODE	PRIM. ENG. PERF	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	TOTAL FUEL FLOW (LBS/HR)	BHP
0-629	80-00	1231.8	23622.	1000.	145.0	1815.9	T	0.292	83.7	0.205	0.052	-2.1	1293.	1946.
0-679	80-00	1296.4	23558.	1000.	145.0	1815.7	P	0.291	83.7	0.205	0.052	-2.1	1293.	1946.
0-729	80-00	1361.0	23493.	1000.	145.0	1814.6	P	0.290	82.7	0.202	0.052	-2.1	1290.	1934.
0-779	80-00	1425.5	23429.	1000.	145.0	1814.0	P	0.290	82.7	0.202	0.052	-2.1	1288.	1929.
0-829	80-00	1490.0	23364.	1000.	145.0	1813.4	P	0.289	82.7	0.202	0.052	-2.1	1286.	1924.
0-879	80-00	1554.2	23300.	1000.	145.0	1812.8	P	0.288	82.7	0.202	0.052	-2.1	1285.	1918.
0-929	80-00	1618.4	23236.	1000.	145.0	1812.2	P	0.287	82.7	0.202	0.051	-2.1	1283.	1913.
0-979	80-00	1682.6	23172.	1000.	145.0	1811.6	P	0.286	82.7	0.202	0.051	-2.1	1281.	1908.
1-029	80-00	1746.7	23108.	1000.	145.0	1810.9	P	0.285	82.7	0.202	0.051	-2.1	1280.	1903.
1-079	80-00	1810.7	23044.	1000.	145.0	1810.3	P	0.285	82.7	0.202	0.051	-2.1	1278.	1898.
1-129	80-00	1874.6	22980.	1000.	145.0	1809.7	P	0.284	82.7	0.202	0.051	-2.1	1276.	1892.

CLIMB TO 3000 FT. WITH CONSTANT TAS AT NORMAL ENGINE RATING  
 \*\* TAS AND CAS IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (°R)	PRIM. ENG. CODE	PRIM. ENG. PERF	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	GAMMA (DEG)	BHP	R/C (PPH)
0-629	80-00	1674.6	23622.	1000.	121.0	1856.0	T	0.838	114.3	0.289	0.048	-4.2	2.6	2625.	5.0
0-643	81-70	1892.8	23604.	1500.	120.0	1856.0	T	0.840	117.4	0.289	0.046	-4.2	2.6	2794.	5.0
0-651	83-49	1911.7	23545.	2000.	120.0	1856.0	T	0.842	116.9	0.289	0.049	-4.1	2.5	2764.	5.0
0-674	85-38	1931.5	23565.	2500.	120.0	1856.0	T	0.843	115.7	0.289	0.044	-4.1	2.5	2733.	4.99
0-690	87-38	1952.2	23545.	3000.	120.0	1856.0	T	0.844	114.6	0.289	0.041	-4.0	2.2	2702.	4.67

CRUISE AT SPEED FOR 99 PER CENT BEST RANGE WITH HEADWIND OF 25.0 KNOTS

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (°R)	PRIM. ENG. CODE	PRIM. ENG. PERF	EAS (KTS)	HL	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (NMPP)	BHP
0-690	107-38	1952.2	23545.	3000.	156.6	1600.5	P	0.543	149.6	0.378	0.047	-6.6	0.07489	3532.
0-842	107-38	2219.3	23276.	3000.	156.6	1602.9	P	0.544	149.6	0.378	0.046	-6.7	0.07521	3511.

TIME (HRS)	RANGE (M.M.)	FUEL USED (LBS.)	WEIGHT (LBS.)	PRES. ALT. (FT)	156.6	1680.4	P	0.537	149.8	0.378	0.046	-6.7	0.07581	3491.
1.146	147.38	2750.1	3000.	3000.	156.6	1697.9	P	0.534	149.8	0.378	0.045	-6.8	0.07581	3471.
1.290	167.38	3013.9	22483.	3000.	156.6	1695.4	P	0.531	149.8	0.378	0.044	-6.9	0.07611	3451.
1.394	180.00	3179.7	22317.	3000.	156.6	1693.9	P	0.529	149.8	0.378	0.044	-7.0	0.07629	3439.

TRANSFER ALTITUDE TO 0. FT.

TAKEOFF, HOVER, OR LAND AT T/W = 1.080 FOR 0.100 HRS.

TIME (HRS)	RANGE (M.M.)	FUEL USED (LBS.)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS./HR)	THRUST TO WEIGHT	FM	BHP	CT	CT/SIGMA
1.394	180.00	3179.7	22317.	0.	0.0	1523.2	P	0.420	1625.	1.080	0.666	2848.	0.0867	0.055
1.484	180.00	3195.9	22301.	0.	0.0	1522.9	P	0.420	1624.	1.080	0.666	2838.	0.0867	0.055
1.414	180.00	3212.2	22283.	0.	0.0	1522.6	P	0.419	1623.	1.080	0.666	2835.	0.0867	0.054
1.424	180.00	3226.4	22269.	0.	0.0	1522.3	P	0.419	1622.	1.080	0.666	2832.	0.0866	0.054
1.434	180.00	3244.6	22252.	0.	0.0	1522.0	P	0.419	1621.	1.080	0.666	2830.	0.0866	0.054
1.444	180.00	3260.8	22236.	0.	0.0	1521.7	P	0.418	1620.	1.080	0.665	2827.	0.0866	0.054
1.454	180.00	3277.0	22224.	0.	0.0	1521.4	P	0.418	1620.	1.080	0.665	2825.	0.0866	0.054
1.464	180.00	3293.2	22204.	0.	0.0	1521.1	P	0.418	1619.	1.080	0.665	2822.	0.0866	0.054
1.474	180.00	3309.4	22188.	0.	0.0	1520.7	P	0.417	1618.	1.080	0.665	2819.	0.0866	0.054
1.484	180.00	3325.6	22171.	0.	0.0	1520.4	P	0.417	1617.	1.080	0.665	2817.	0.0866	0.054
1.494	180.00	3341.8	22155.	0.	0.0	1520.1	P	0.417	1616.	1.080	0.665	2814.	0.0866	0.054
1.494	180.00	3341.8	22155.	0.	0.0	1520.1	P	0.417	1616.	1.080	0.665	2814.	0.0866	0.054

MISS ON FUEL REQUIRED = 2698.99  
 RESERVE FUEL REQUIRED = 642.79  
 TOTAL FUEL REQUIRED = 3341.77

END OF SUCCESSFUL CASE

### 7.3.3 Coaxial Rotor Helicopter with Auxiliary Propulsion

The design mission profile is illustrated in Figure 7-3. The engine and rotor cycles are not discussed in this case. A complete copy of the program printout follows the description of the input.

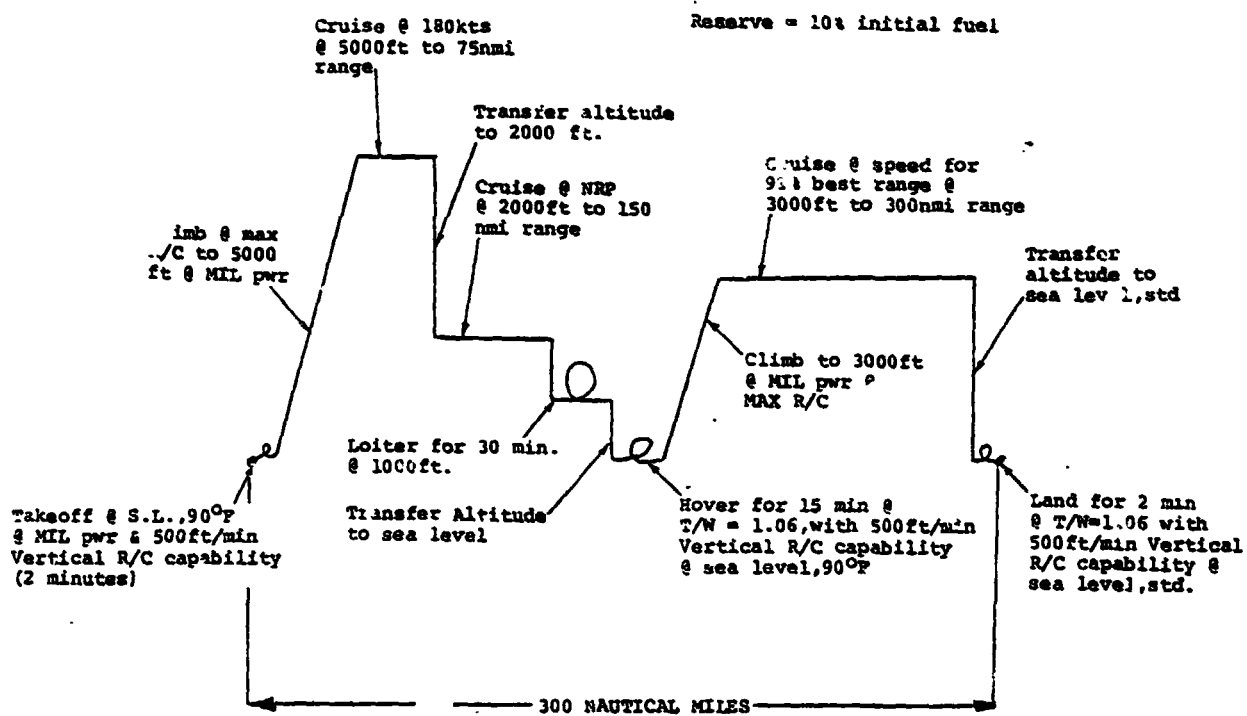


Figure 7-3. Design Mission - Sample Case No. 3

SAMPLE CASE NO. 3

GENERAL INFORMATION SHEET

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
OPTIND	0001	1.0	Sizing run
OPTIONAL PRINT	0002	1.0	Detailed printout desired
DRGIND	0003	2.0	GW/Fe drag trend utilized
CNFIND	0005	1.0	Single rotor helicopter desired
AUXIND	0006	3.0	Compound helicopter with auxiliary propulsion only
RDMIND	0007	2.0	Main rotor diameter based on input disc loading. Solidity fixed by input.
FIXIND	0008	1.0	Program sizes primary engines
ROTIND	0009	4.0	Rotor figure of merit and cruise L/De maps are input
AIPIND	0012	1.0	No independent auxiliary engines. Auxiliary fans are driven through gear boxes by primary engines.
TRDIND	0015	0.0	No antitorque tail rotor on this design
HTIND	0018	2.0	Horizontal tail volume coefficient input
MRPIND	0019	0.0	Main rotor position on fuselage input by user
ESCIND	0022	2.0	Primary engines are sized for either takeoff or cruise
WG <sub>0</sub>	0023	30000	First guess at design gross weight



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$h_0$	0024	0.0	Initial altitude
$R_0$	0025	0.0	Initial range
$t_0$	0026	0.0	Starting time
$h_{OPT\_IND}$	0027	0.0	Cruise at specified altitude
$M_{MO}$	0028	.443	Maximum operating Mach number
$V_{MO}$	0029	260	Maximum operating equivalent airspeed knots
$V_{DIVE}$	0030	312	Dive speed - approximately equal to $1.2 \times V_{MO}$ in knots
$M_{LF}$	0031	3.0	Maneuver load factor
$K_1$	0032	1.111	Factor on mission fuel burned to give reserve fuel. 1.111 results in 10% of initial fuel for reserve
$\delta W_f$	0033	0.0	Fixed fuel increment for reserves or other use.
$K_{FF}$	0034	1.05	Increase basic engine SFC by 5 percent
SGTIND	0035	2.0	Takeoff
	0036	3.0	Climb
	0037	4.0	Cruise
	0038	9.0	Transfer altitude
	0039	4.0	Cruise
	0040	9.0	Transfer altitude
	0041	6.0	Loiter
	0042	9.0	Transfer altitude

Normally  
0.0  
except  
for  
mission  
analysis

Sequence  
of  
design  
mission

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
SGTIND	0043	2.0	Hover
	0044	3.0	Climb
	0045	4.0	Cruise
	0046	9.0	Transfer altitude
	0047	2.0	Land
	0048	100.0	End of Case

} Sequence  
of  
design  
mission

#### Helicopter Dimensional Information Sheet

$AR_{HT}$	0112	5.50	Horizontal tail aspect ratio
$l'_{TH}$	0113	.775	Ratio of horizontal tail moment arm to main rotor radius
$(t/c)_{HT}$	0114	.150	Horizontal tail thickness/chord ratio
$\bar{V}_H$	0115	.020	Horizontal tail volume coefficient referred to main rotor diameter and tail arm.
$\lambda_H$	0116	.660	Horizontal tail taper ratio
$\Delta S_{WET}/S_P$	0120	0.0	Fuselage wetted area ratio
$\Delta S_{WT}$	0121	0.0	Incremental fuselage wetted area
$h_F$	0122	8.17	Fuselage height
$W_F$	0123	8.33	Fuselage width
$(l/d)_P$	0124	1.12	Fineness ratio of nose
$(l/d)_T$	0125	0.688	Fineness ratio of tail
$l_C$	0126	20.3	Constant diameter section length

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$l_{RW}$	0127	0.0	Length of ramp well
$(X_H/l_B)$	0128	.40	Main rotor position aft of the nose as a fraction of main fuselage length
$(l_{TB}/d_{TB}^m)$	0129	2.28	Fineness ratio of tail boom
$(d_{TTB}^m/d_{TB}^m)$	0130	0.205	Ratio of average tail boom tip diameter to average tail boom diameter
$AR_{VT}$	0135	1.5	Vertical tail aspect ratio
$\lambda_{VT}$	0136	0.50	Vertical tail taper ratio
$(t/c)_{VT}$	0137	.15	Thickness/chord ratio of vertical tail
$K_z$	0139	6.7	Vertical position of the tail rotor center (relative to the vertical fin root chord) as a fraction of tail rotor radius. When TRDIND=0, (as in this example), vertical tail span is input into this location.
$n_1$	0142	0.	Primary engine nacelle constants
$n_2$	0143	0.	
$n_3$	0144	0.	
$(l_{aip}/l_c)$	0145	0.	Ratio of air induction system length to primary engine length

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$n_4$	0146	0.	Auxiliary independent engine nacelle constants
$n_5$	0147	0.	
$n_6$	0148	0.	
$(l_{aia}/l_{ea})$	0149	0.	Ratio of air induction system length to auxiliary engine length
$\Delta s/s_{str}$	0150	0.	Ratio of incremental auxiliary independent engine nacelle strut planform area to auxiliary independent engine nacelle strut planform area
$b_{NS}/d_{NI}$	0151	0.	Ratio of auxiliary independent engine nacelle strut span to nacelle diameter
$(t/c)_{RF}$	0152	.800	Main rotor pylon root thickness/chord ratio
$(t/c)_{TF}$	0153	.600	Main rotor pylon tip thickness/chord ratio
$AR_{FP}$	0154	.210	Main rotor pylon aspect ratio
$\lambda_{FP}$	0155	.75	Forward rotor pylon taper ratio
$h_{Pl}$	0156	3.58	Main rotor pylon height.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
<b>Rotor Dimensional Data for Sizing Main Rotor</b>			
Rotor Map No.	0170	123	Coaxial rotor helicopter figure of merit and cruise $L/D_E$ rotor map
$N_R$	0172	1.0	Number of rotors
W/A	0173	15.0	Main rotor disc loading
$\sigma_{MR}$	0175	0.111	Main rotor solidity
$b_{MR}$	0176	6.0	Number of main rotor blades
$\theta_{TMR}$	0177	-10.0	Main rotor twist (degrees)
$X_{C_{MR}}$	0178	.10	Main rotor blade cutout as a fraction of radius
$X_{MR}$	0179	.05	Main rotor blade attachment point as a fraction of radius
(t/c) .25R	0180	.32	Rotor blade thickness/chord at 25 percent radius
$V_T$	0181	650	Main rotor tip speed
$V_{CEH1}$	0191	1.00	Main rotor vertical rate of climb efficiency factors
$V_{CEH2}$	0192	0	
$K_{P_{CLIM}}$	0193	.85	Helicopter forward flight climb efficiency
$K_{P_{DESCENT}}$	0194	.85	Main rotor descent efficiency

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
<b>Rotor Dimensional Data for Sizing Tail Rotor</b>			
$S_{MR/TR}$	0214	- .5	Gap between main and tail rotor disc (FT). When TRDIND=0, represents gap between main rotor disc and end of tail boom (FT). Negative number implies tail boom ends under the main rotor disc.
$C_{L_{FIN}}$	0216	0.0	Vertical tail fin operating cruise lift coefficient
<b>Primary Engine Sizing Information Sheet</b>			
Primary Engine Cycle No.	0217	2.41	Primary engine selection
$N_p$	0219	2.0	Number of primary engines
$XMSNIND$	0220	0.0	Drive system ratings specified as fraction of primary engine installed power
$SHP_{MRX}/SHP_{MR}$	0221	1.02	Main rotor drive system is rated at 102% of main rotor design power
$\eta_T$	0223	0.98	Transmission efficiency
$\Delta SHP_{ACC}$	0224	30.	Accessory power losses

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\text{SHP}_{\text{AUX}}/\text{SHP}_{\text{AUX}}^*$	0226	.46	Auxiliary propulsion drive system rating as a fraction of auxiliary propulsion system installed power. When no auxiliary engines are specified, this input specifies the auxiliary drive system is rated to 46% of main rotor design power
$H_{\text{To(H)}}$	0227	0.0	Design point hover altitude for engine sizing
$(T/W)_D$	0228	1.06	Configuration design point hover thrust/weight ratio
$\Delta T_{\text{IN TO}}(\text{H})$	0229	31.0	Temperature increment in degrees above standard at altitude for engine sizing
$(N_{\text{II}}/N_{\text{IIMAX}})_{\text{T.O.}}$	0230	0.8237	Operating point for engine power turbine. Operating tip speed is computed from

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

To operate at  $V_T = 625$  ft/sec requires that  $N_{\text{II}}/N_{\text{IIMAX}}$  be the reciprocal of  $\frac{N_{\text{II}}^*}{N_{\text{IIMAX}}}$

$N_{\text{PSD}}$	0231	0.0	Number of engines inoperative at hover design point conditions
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<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$SHP_E/SHP^*$	0232	1.00	Engines sized to permit operation at 100% of maximum rated power
$(V_{R/C})_D$	0233	500.	500 ft/min vertical rate of climb capability required at hover design point.
POWIND	0234	2.0	Maximum engine rating for cruise engine sizing. For this example, normal rated power is the maximum rating to be used.
$h_c$	0235	0.0	Design point cruise altitude for engine sizing.
$V_c$	0236	250.	Design point cruise speed for engine sizing.
$\Delta T_{IN_{CE}}$	0237	0.	Temperature increment above standard for cruise engine sizing.
$(N_{II}/N_{II_{MAX}})_C$	0238	.7389	Operating point of engine turbine at design cruise conditions. Operating tip speed is computed from

$$V_{T_{OPERATING}} = V_T \left[ \frac{N_{II}}{N_{II_{MAX}}} \right] \left[ \frac{N_{II}}{N_{II}^*} \right]$$

The rotor is slowed to 583 ft/sec for this example.  $(N_{II}/N_{II_{MAX}})$  is computed from the above equation e.g.

$$\frac{N_{II}}{N_{II_{MAX}}} = \frac{V_{T_{OPERATING}}}{V_T \left( \frac{N_{II_{MAX}}}{N_{II}^*} \right)}$$

$$= \frac{583}{650(1.214)} = .7389$$



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$(T_{AUX}/T_{TOT})_C$	0239	1.00	100% propulsive thrust provided by auxiliary propulsion at cruise condition for engine sizing.
$(N_{PSD})_C$	0241	0.0	No. of primary engines shut down during cruise (for engine sizing)

**Propeller Data Required for Compound Helicopter Auxiliary Propulsion Information Sheet**

No. of Props.	0248	2.0	Two auxiliary propellers/fans are use on this configuration
$V_{TAR}$	0249	900	Auxiliary propeller tip speed
DIA	0250	4.0	Diameter of auxiliary prop/fan is 4 ft.
$X_{AR}$	0251	.10	Prop/fan blade attachment point as a fraction of radius
$\eta_{TAUX}$	0252	.96	Transmission efficiency of auxiliary drive system
$\eta_{PIND}$	0253	0.0	Table of prop/fan efficiencies are input
$\eta_{P3}$	0254	0.85	Prop/fan climb efficiency
$\eta_{P5}$	0255	0.60	Prop/fan descent efficiency

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
AF/Blade	0257	169.0	Prop/fan activity factor per blade. For this example a 13 bladed 2200 total activity prop/fan was selected.
No. of Blades	0258	13.0	Number of prop/fan blades
No. of Pairs in $\eta_{p4}$ Table	0261	3.0	Number of pairs in prop/fan efficiency table
Values of Mach No.	0262	0.0	Values of Mach Number in cruise efficiency table
	0263	0.5	
	0264	1.0	
Values of $\eta_{p4}$	0272	.60	Values of cruise efficiency
	0273	.75	
	0274	.60	
<b>Helicopter Aerodynamics Information Sheet</b>			
GW/Fe	0312	2020	Dr $\mu$ and constants $d$ from data as illustrated by Figure 4-30, Section 4.9.
$K_{FED}$	0313	0.561	
No. of $C_{x/\sigma}$	0347	3.	Specifies number of $C_{x/\sigma}$ values in table locations 0349-0353
No. of $\mu$	0348	3.	Specified number of $\mu$ values in table locations 0354-0360

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
Values of $C_{x/\sigma}$	0349	-1.	Rotor propulsive thrust coefficient divided by main rotor solidity. Used in defining rotor limits $C_{x/\sigma} = \frac{\text{Thrust Required}}{\rho \Pi \frac{b^2}{4} n^2 R V_{tip}^2 \sigma_{MR}}$
	0350	0.	
	0351	1.	
Values of $\mu$	0354	0.	Rotor forward flight advance ratio $\mu = \frac{V_{fps}}{V_{tip}}$
	0355	.5	
	0356	1.	
Values of $C_T'/\sigma$	0361	1.	Values of $C_T'/\sigma$ corresponding to $(C_{x/\sigma})_1$ , location 0349 <sup>x</sup> and $\mu_1, \mu_2,$ and $\mu_3$ .
	0362	1.	
	0363	1.	
	0368	1.	Values of $C_T'/\sigma$ corresponding to $(C_{x/\sigma})_2$ location 0350 <sup>x</sup> and $\mu_1, \mu_2,$ and $\mu_3$
	0369	1.	
	0370	1.	
	0375	1.	Values of $C_T'/\sigma$ corresponding to $(C_{x/\sigma})_3$ location 0351 <sup>x</sup> and $\mu_1, \mu_2$ and $\mu_3$
	0376	1.	
	0377	1.	

Helicopter Weight Information Sheet

WFE	2602	2475.	Weight of fixed equipment in lbs.
WFUL	2603	864.	Weight of fixed useful load in lbs.
WPL	2604	6328.	Weight of payload in lbs.
$\Delta$ WFC	2605	0.	Flight controls group incremental weights in lbs.
$\Delta$ WP	2606	0.	Propulsion group incremental weights in lbs.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta W_{ST}$	2607	200.	Structures group incremental weight in lbs.
$RM_1$	2608	1.	Wing relief as percentage of GW.
$W_i$	2609	1.	Weight in inboard store.
$W_o$	2610	1.	Weight of outboard store.
$d_i$	2611	1.	Position of inboard underwing store (fraction of wing semi-span).
$d_o$	2612	1.	Position of outboard underwing store (fraction of wing semi-span).
$k_{CC}$	2613	17.5	Cockpit controls weight factor.
$k_{RL}$	2614	30.	Main rotor controls weight factor.
$k_{RC}$	2615	22.2	Main rotor system control weight factor.
$k_W$	2616	.005	Fixed wing controls.
$k_{TM}$	2617	0.	Tilt mechanism weight factor.
$k_{SAS}$	2618	75.	Stability Augmentation System (SAS) weight factor. Usually in the range of 20-100 pounds.
$k_{RCA}$	2619	.1	Auxiliary rotor controls weight factor.
$k_{SCA}$	2620	25.	Auxiliary rotor systems control weight factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{MC}$	2621	60.	Miscellaneous controls weight factor in LBS.
$k_B$	2622	125.	Body group weights factor
$\Delta C.G.$	2623	2.	Helicopter cg travel (FT)
$k_{LG}$	2624	.04	Landing gear weight factor. Percentage of gross weight.
$k_{MG}$	2625	.8	Main landing gear weight factor.
$k_{WW}$	2626	0.	Detailed wing weight factor. This adjusts the constant 220 in $W_N=220 (k)0.585$ up or down depending on the complexity of the control surfaces.
LF	2627	1.	Wing unload factor. Entered as a fraction of design gross weight.
$k_{WS}$	2628	0.	Wing stores only weight trend factor.
$k_{WP}$	2629	0.	Wing weight/area factor (psf).
$k_{HT}$	2630	2.	Horizontal tail unit weight in PSF.
$k_{CLF}$	2631	0.	Crash load factor.
$k_{NAC}$	2632	0.	Primary cowling weight factor (PSF).
$k_{AIP}$	2633	276.	Primary air induction system weight factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{NACA}$	2634	0.	Auxiliary cowling weight factor/PSF.
$k_{AIA}$	2635	0.	Auxiliary air induction system weight factor.
$k_{NS}$	2636	0.	Nacelles strut weight factor.
$k_{PRB}$	2637	52.8	Primary rotor blade weight factor.
$k_{RBF}$	2638	2.2	Rotor type factor; hingeless for this example.
$k_{PH}$	2639	73.2	Primary hub weight factor.
$k_{AND}$	2640	.177	Main rotor weight factor.
$k_{BLFD}$	2641	1.	Blade fold weight factor. Input as a fractional part of the total rotor weight.
$k_{TR}$	2642	0.	Tail rotor weight factor
$k_{AR}$	2643	14.2	Auxiliary rotor weight factor. This is the average value for the rotor or propeller weight (LB). $W_r = 14.2a(\kappa)^{.67}$
$k_{PA}$	2644	1.	Auxiliary rotor multiplicative input power, expressed here as 100% input power.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{VTAR}$	2645	1.	Auxiliary tail rotor multiplicative tip speed factor expressed here as 100% input speed.
$k_{PDS}$	2646	250.	Primary drive system weight factor.
$k_{PDSZ}$	2647	3.	Primary drive system weight factor. Number of gears in system.
$k_{TRDS}$	2648	0.	Tail rotor drive system weight factor.
$k_{ADS}$	2649	250.	Auxiliary drive system weight factor.
$k_{ADSZ}$	2650	3.	Auxiliary drive system weight factor (number of gears in system).
$k_{FS}$	2651	.08	Fuel system weight factor.
$k_{PEI}$	2652	.17	Primary engine installation weight factor.
$k_{AEI}$	2653	0.	Auxiliary engine installation weight factor.
$K_1$	2654	1.	Main rotor controls weight factor.
$K_2$	2655	.8	Main rotor system controls weight multiplicative factor.
$K_3$	2656	1.	Fixed wings controls weight multiplicative factor.
$K_4$	2657	1.	Auxiliary rotor controls weight multiplicative factor.
$K_5$	2658	1.	Auxiliary rotor system controls weight multiplicative factor.
$K_6$	2659	1.	Body weight multiplicative factor.
$K_7$	2660	1.	Landing gear weight multiplicative factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
K <sub>8</sub>	2661	1.	Wing weight multiplicative factor.
K <sub>9</sub>	2662	1.	Horizontal tail weight multiplicative factor.
K <sub>10</sub>	2663	1.	Primary nacelle weight multiplicative factor.
K <sub>11</sub>	2664	1.	Auxiliary nacelle weight multiplicative factor.
K <sub>12</sub>	2665	1.22	Primary rotor blade weight multiplicative factor.
K <sub>13</sub>	2666	4.16	Primary rotor kit weight multiplicative factor.
K <sub>14</sub>	2667	1.	Tail rotor weight multiplicative factor.
K <sub>15</sub>	2668	1.	Auxiliary rotor weight multiplicative factor.
K <sub>16</sub>	2669	1.	Primary drive system weight multiplicative factor.
K <sub>17</sub>	2670	1.	Auxiliary drive system weight multiplicative factor.
K <sub>18</sub>	2671	1.	Primary engine weight multiplicative factor.
K <sub>19</sub>	2672	1.	Auxiliary engine weight multiplicative factor.

**Takeoff, Hover, and Landing Information**

TOLIND	0461	2.0	Specify power fraction and vertical rate of climb Specify required T/W for hover out of ground effect.
	0462	1.0	
	0463	1.0	
ATMIND	0481	1.00	Standard atmosphere plus an incremental temperature
	0482	1.00	
	0483	0.0	Standard atmosphere
PEHF	0491	1.00	Power fraction - 100 percent of power available at these ambient conditions is being used.



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
POWIND	0781	2.0	} Cruise speed by normal rated primary engine power
	0782	2.0	
	0783	2.0	
R <sub>MAX</sub> (N.M.)	0791	75.0	} Values of range at end of each cruise segment
	0792	150.0	
	0793	300.0	
(N <sub>II</sub> /N <sub>II MAX</sub> ) (Primary Engine)	0801	.8237	} Operating point for engine power turbine during cruise. $\frac{N_{II}}{N_{II MAX}} = \frac{V_T OPERATING}{V_T \left( \frac{N_{II MAX}}{N_{II}^*} \right)}$
	0802	.7389	
	0803	.8237	
Δfe <sub>CR</sub> (FT <sup>2</sup> )	0811	1.0	} Increment in cruise equivalent flat plate area (FT <sup>2</sup> )
	0812	0.0	
	0813	1.0	
N <sub>PSD CR</sub>	0831	0.0	} Number of primary engines shut down in cruise
	0832	0.0	
	0833	0.0	
T <sub>AUX</sub> /T <sub>TOT</sub>	0841	1.0	} 100% of required propulsive force is provided by auxiliary prop/fans
	0842	1.0	
	0843	1.0	

Loiter Information Sheet

ATMIND	1031	0.0	Standard atmosphere specified
Δt <sub>L</sub> (HR)	1061	.100	Time increments for loiter calculations

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta T_{IN} (^{\circ}F)$	0401	31.0	} Incremental temperature above standard, in degrees.
	0502	31.0	
$V_{R/C} (FPM)$	0511	500.	} 500 ft/min vertical rate of climb capability desired
	0512	500.	
	0513	500.	
T/W	0522	1.06	} Hover thrust/weight ratio specified.
	0523	1.06	
$\Delta T_H (HR)$	0531	.0111	} Time increments for takeoff, hover or landing computation in hours.
	0532	.050	
	0533	0111	
$(N_{II}/N_{II_{MAX}})$ (Primary Engine)	0541	.8237	} Operating point for engine power turbine during takeoff, hover or landing.
	0542	.8237	
	0543	.8237	
			$\frac{N_{II}}{N_{II_{MAX}}} = \frac{V_T^{OPERATING}}{V_T \left( \frac{N_{II_{MAX}}}{N_{II}^*} \right)}$ $\frac{650}{650(1.214)} = .8237$
$t_H (HR)$	0551	.0333	} Takeoff, hover, or landing total time in hours.
	0552	.250	
	0553	.0333	

Climb Information Sheet

CLMIND	0571	1.0	} Maximum rate of climb desired
	0572	1.0	
ATMIND	0571	0.0	} Atmosphere indicator. Standard atmosphere specified.
	0592	0.0	
$\Delta h (FT)$	0621	500.	} Altitude increments for climb calculations.
	0622	300.	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
POWIND	0631	1.0	} Climb at maximum rate of climb, limited by military power available.
	0632	1.0	
h <sub>MAX</sub> (FT)	0641	5000.	} Final altitudes for climb.
	0642	3000.	
(N <sub>II</sub> /N <sub>II</sub> <sub>MAX</sub> ) (Primary Engine)	0651	.8237	} Operating point for engine turbine during climb.
	0652	.8237	
			$\frac{N_{II}}{N_{II_{MAX}}} = \frac{V_T}{V_T} \frac{N_{II_{OPERATING}}}{N_{II_{MAX}}} = .8237$
Δf <sub>e</sub> <sub>CL</sub> (FT <sup>2</sup> )	0661	.500	} Incremental drag area in climb
	0662	.500	
N <sub>PSD</sub> <sub>CL</sub>	0681	0.0	} Number of primary engines shut down during climb
	0682	0.0	
T <sub>AUX</sub> /T <sub>TOT</sub>	0691	.300	} 30% of required propulsive force provided by auxiliary fans.
	0692	.300	

Cruise Information Sheet

CRSIND	0721	2.0	Cruise at constant true airspeed	
	0722	1.0	Cruise at specified power setting	
	0723	4.0	Cruise at 79% best range speed	
	0731	180.	Cruise at 280 knots T.A.S.	
ATMIND	0741	0.0	} Atmosphere indicator	
	0742	0.0		} Standard atmosphere
	0743	0.0		
ΔR(N.M)	0771	15.0	} Calculation increments during cruise in nautical miles	
	0772	15.0		
	0773	15.0		

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$(N_{II}/N_{II\text{MAX}})$ (Primary Engines)	1071	.8237	Operating point for primary engine power turbine during loiter.  $\frac{N_{II}}{N_{II\text{MAX}}} = \frac{V_{T\text{OPERATING}}}{V_T} \frac{N_{II\text{MAX}}}{N_{II}^*} = .8237$
$t_L$ (RH)	1081	.500	30 minutes of loiter specified
$N_{\text{PSD LOITER}}$	1101	0.0	Number of primary engines shut down during loiter
$T_{\text{AUX}}/T_{\text{TOT}}$	1111	.30	30% of required propulsive force is provided by auxiliary prop/fans.
$\Delta f e_L$ (FT <sup>2</sup> )	1131	.500	Increment in loiter equivalent flat plate drag area (FT <sup>2</sup> )

Transfer Altitude Sheet

$h_{\text{FINAL}}$ (FT)	1181	2000.	} Transfer altitude to these final values with no time, fuel or distance credits
	1182	1000.	
	1183	0.0	
	1184	0.0	

Primary Engine Cycle Data; Non-Standard Performance

WDTIND	1201	0.0	No fuel flow cutoffs
N1IND	1202	0.0	No $N_1$ cutoffs
N10IND	1203	1.0	Referred $N_1$ cutoff
N2IND	1204	2.0	Free turbine engine to be simulated
QIND	1205	1.0	Torque cutoff
RNOIND	1206	0.0	No Reynolds No. corrections
$(N_1/\sqrt{\sigma_1}/N_1^*)_{\text{MAX}}$	1222	1.115	Value for referred $N_1$ limit
$(N_{II\text{MAX}}/N_{II}^*)$	1223	1.214	Value for $N_{II}$ cutoff referred to $N_{II}^*$

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$Q_{MAX}/Q^*$	1224	1.00	Value of torque cutoff referred to value at sea level standard static condition
SAMPLE CASE NO. 3 Run 2			
QIND	1205	2.	Torque limit imposed on auxiliary propulsion transmission.
SAMPLE CASE NO. 3 Run 3			
XMSNIND	0220	1.	When XMSNIND = 0. or 1. the transmission can be rated either takeoff or cruise. In this example ESCIND (LOC 0022)=2. This internally sets the maximum power to the cruise power in location 0238. XMSNIND = 1 indicates that the drive system component (main tail, and auxiliary) power is obtained from the proportional split of the total sea level standard power.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

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. =4)  
 VAL EQUALS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL1 VALUE CORRESPONDING TO LOC.+10.1  
 VAL2 VALUE CORRESPONDING TO LOC.+10.2  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
1261	5	.1	.1	1.0000	2. 3.	1.0000
1262	1	.1	.1	1.0000		
1222	3	1.1151	1.214	1.0000		
1301	3	2.4100	15750	.0		
1305	2	1725.0	1725.0	266.00		
1317	3	25.000	25.000			
1318	1	0.0000				
1331	4	1625.0	1625.0	2100.0	24.000	265.00
1316	3	2000.0	3150.0	2400.0		
1319	1	5.0000				
1320	4	.0	2.0000	40000	6.1000	70.00
1326	5	.0	.0	.0	.0	.0
1332	5	1.0000	1.0000	170.0	2.200	2140.0
1339	4	4.6	4300	46100	4.200	5.100
1344	5	74000	77500	81600	8.800	9.900
1345	4	94800	104500	1.00600	1.2450	1.3140
1356	5	1.2300	1.3140	1.3880	1.5440	1.6230
1362	5	1.4500	1.5700	1.6400	1.8200	1.9100
1369	4	1.6300	1.7700	1.8700	2.0700	2.2100
1374	1	0.0000				
1375	4	1625.0	1625.0	2100.0	24.000	265.00
1380	3	2400.0	3150.0	3400.0		
1383	1	5.0000				
1384	4	.0	2.0000	40000	6.1000	70.00
1390	5	40000E-01	40000E-01	40000E-01	40000E-01	40000E-01
1391	5	1.0000	1.0000	1.0000	1.0000	1.0000
1402	5	2.5	2100	2140	2.200	2.100
1410	4	32400	33400	34300	3.500	3.600
1414	4	42100	43400	44800	4.700	4.800
1420	5	50300	52000	53800	5.600	5.800
1426	5	67400	69300	71400	7.500	7.800
1432	5	84500	86700	89100	9.400	9.800
1438	1	0.0000				
1439	4	1625.0	1625.0	2100.0	24.000	265.00
1444	3	2400.0	3150.0	3400.0		
1447	1	5.0000				
1448	5	.0	2.0000	40000	6.1000	70.00
1450	5	650	65400	65400	6.500	6.500

NOTE: IN USING AUXILIARY ENGINES & AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 6666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE



3591	5	0	1,900	3,400	4,600	5,450
3596	5	6,000	6,200	6,350	6,250	6,250
3601	5	0	1,200	2,300	3,250	4,050
3606	5	4,700	5,150	5,500	5,500	5,150
3611	5	0	1,000	1,400	2,750	3,300
3616	5	0	4,900	4,500	4,400	4,400
3621	5	0	4,700	1,600	2,300	2,900
3626	5	3,450	3,250	4,050	4,100	3,900
3631	5	0	5,100	4,500	4,100	4,050
3636	5	6,000	3,000	2,200	1,100	6,000
3641	5	0	1,500	2,650	2,600	2,100
3646	5	1,700	1,300	1,050	7,800	5,200
3651	5	0	2,650	4,200	4,550	4,000
3656	5	3,300	2,400	2,450	1,900	1,220
3661	5	0	3,250	5,300	6,200	5,700
3666	5	0	4,200	3,700	3,400	2,100
3671	5	0	3,500	6,000	7,350	7,400
3676	5	6,950	5,300	5,500	4,500	3,500
3681	5	0	3,200	6,100	8,200	9,700
3686	5	9,900	9,150	6,100	7,100	6,100
3691	5	0	3,050	5,750	6,000	9,800
3696	5	10,500	1,200	9,450	4,450	7,500
3701	5	0	2,000	3,600	4,800	4,900
3706	5	6,600	7,050	4,900	4,800	4,900
3711	5	0	1,500	2,400	3,600	6,300
3716	5	4,900	5,300	5,500	4,350	4,350
3721	5	0	1,000	2,800	5,400	5,350
3726	5	4,100	4,600	4,800	4,750	4,800
3731	5	0	3,800	4,900	6,000	4,900
3736	5	4,000	2,100	2,100	2,000	1,000
3741	5	0	1,400	2,500	2,500	2,000
3746	5	1,700	1,450	1,200	4,100	5,600
3751	5	0	2,400	4,050	4,050	3,900
3756	5	3,400	2,900	2,450	1,400	1,200
3761	5	0	3,100	5,250	5,900	5,900
3766	5	4,050	3,500	3,500	2,800	2,450
3771	5	0	5,000	6,000	7,100	7,100
3776	5	6,550	5,650	5,950	4,10	3,150
3781	5	0	8,350	6,100	6,200	6,200
3786	5	8,600	3,050	7,100	6,10	6,200
3791	5	9,200	3,050	5,750	6,10	6,10
3796	5	7,000	7,900	7,900	7,900	6,000
3801	5	2,100	4,000	4,000	5,600	6,000
3806	5	7,600	2,100	7,750	6,950	5,950
3811	5	0	3,600	3,600	4,500	5,400
3816	5	6,300	6,800	7,000	6,800	6,800
3821	5	0	1,300	2,500	3,600	4,400
3826	5	5,500	5,400	5,500	5,350	5,000
3831	5	3,800	4,000	5,600	4,500	4,500
3836	5	0	2,600	1,000	1,100	1,000
3841	5	1,400	1,400	2,060	2,000	1,700
3846	5	1,400	1,300	9,100	7,500	5,200
3851	5	0	2,300	4,500	3,700	3,360
3856	5	2,700	2,000	1,600	1,600	1,600
3861	5	0	3,100	4,700	4,900	4,900
3866	5	4,300	3,100	2,500	2,500	1,600
3871	5	0	5,000	5,000	6,700	6,500
3876	5	5,050	4,550	3,000	3,000	2,700
3881	5	0	3,500	4,220	7,500	8,600
3886	5	8,200	6,000	6,720	5,700	4,500



3891	60	7.6500	5.7500	8.8800	7.5500	8.8800
3896	60	8.2100	7.4000	6.5000	6.5000	5.5000
3901	7	7.4500	4.0000	6.8000	6.8000	6.8000
3906	00	7.4500	6.9000	5.6000	6.0000	5.6000
3911	00	1.6500	3.1100	4.4000	4.4000	5.4500
3916	00	6.6200	6.6500	5.9800	5.9800	4.9500
3921	00	1.3000	2.5000	3.6000	3.6000	4.4000
3926	00	5.2000	4.2500	5.0000	5.0000	4.6000
3931	00	4.9000	6.6100	5.5000	5.5000	4.8000
3936	00	2.5000	1.3000	1.0000	1.0000	1.9000
3941	00	1.4100	1.9800	1.9800	1.9800	1.6500
3946	00	1.1000	3.9000	3.9000	3.9000	4.9000
3951	00	2.3000	1.9000	1.4200	1.4200	3.1000
3956	00	2.3000	4.5000	4.7000	4.7000	4.5000
3961	00	3.1000	2.4500	1.5100	1.5100	4.5000
3966	00	4.0300	5.6500	6.3000	6.3000	6.1000
3971	00	5.5000	4.1500	3.3000	3.3000	2.3500
3976	00	7.3000	6.8000	7.4200	7.4200	7.4200
3981	00	6.9500	5.9200	4.9000	4.9000	3.7500
3986	00	7.8000	5.7500	7.3000	7.3000	8.1000
3991	00	7.8000	4.3500	5.4000	5.4000	4.4500
3996	00	7.8000	4.0000	6.7000	6.7000	4.4500
4001	00	6.9500	5.7000	4.7500	4.7500	3.7000
4006	00	1.7000	3.2500	4.5000	4.5000	5.5000
4011	00	2.1500	4.0000	4.9000	4.9000	4.1800
4016	00	5.9100	5.4600	4.2500	4.2500	4.2500
4021	00	4.4500	2.5000	3.6000	3.6000	4.2500
4026	00	6.5000	4.5000	4.5000	4.5000	3.6500
4031	00	1.4000	1.0000	5.1000	5.1000	3.2000
4036	00	2.1000	1.0000	8.7000	8.7000	5.1000
4041	00	1.2000	2.3000	2.0000	2.0000	1.4000
4046	00	1.2000	3.6300	6.3000	6.3000	5.4000
4051	00	2.4000	1.6000	3.5900	3.5900	2.9400
4056	00	3.3000	1.6000	1.4000	1.4000	4.9000
4061	00	3.3000	4.6100	4.7200	4.7200	4.1700
4066	00	3.5000	2.6500	2.1400	2.1400	1.4300
4071	00	3.5000	5.4000	5.8000	5.8000	5.5000
4076	00	5.1500	3.7500	2.9800	2.9800	2.9800
4081	00	3.3200	5.6000	6.5000	6.5000	6.5000
4086	00	5.4000	4.7000	3.2500	3.2500	2.9000
4091	00	3.7000	5.4500	6.1000	6.1000	6.7000
4096	00	6.2500	4.8000	4.0000	4.0000	3.1500
4101	00	1.7000	2.0000	4.0000	4.0000	3.1500
4106	00	3.0000	1.0000	1.0000	1.0000	1.0000
4111	00	1.0000	1.0000	1.0000	1.0000	1.0000
4116	00	2.0000	3.0000	3.0000	3.0000	3.0000
4121	00	2.0000	4.0000	4.0000	4.0000	4.0000
4126	00	3.0000	2.0000	9.0000	9.0000	4.0000
4131	00	1.1111	1.0000	2.0000	2.0000	3.0000
4136	00	2.0000	6.0000	1.0000	1.0000	3.0000
4141	00	4.0000	4.0000	1.0000	1.0000	1.0000
4146	00	5.5000	7.7000	2.0000	2.0000	1.0000
4151	00	6.8000	6.0000	4.0000	4.0000	2.0000
4156	00	2.5000	5.0000	4.0000	4.0000	2.0000
4161	00	1.0000	1.0000	2.0000	2.0000	1.0000
4166	00	6.7000	6.0000	4.0000	4.0000	2.0000
4171	00	1.0000	1.0000	1.0000	1.0000	1.0000
4176	00	2.0000	3.0000	3.0000	3.0000	3.0000
4181	00	2.0000	4.0000	4.0000	4.0000	4.0000
4186	00	3.0000	5.0000	5.0000	5.0000	5.0000
4191	00	4.0000	6.0000	6.0000	6.0000	6.0000
4196	00	5.0000	7.0000	7.0000	7.0000	7.0000
4201	00	6.0000	8.0000	8.0000	8.0000	8.0000
4206	00	7.0000	9.0000	9.0000	9.0000	9.0000
4211	00	8.0000	10.0000	10.0000	10.0000	10.0000
4216	00	9.0000	11.0000	11.0000	11.0000	11.0000
4221	00	10.0000	12.0000	12.0000	12.0000	12.0000
4226	00	11.0000	13.0000	13.0000	13.0000	13.0000
4231	00	12.0000	14.0000	14.0000	14.0000	14.0000
4236	00	13.0000	15.0000	15.0000	15.0000	15.0000
4241	00	14.0000	16.0000	16.0000	16.0000	16.0000
4246	00	15.0000	17.0000	17.0000	17.0000	17.0000
4251	00	16.0000	18.0000	18.0000	18.0000	18.0000
4256	00	17.0000	19.0000	19.0000	19.0000	19.0000
4261	00	18.0000	20.0000	20.0000	20.0000	20.0000
4266	00	19.0000	21.0000	21.0000	21.0000	21.0000
4271	00	20.0000	22.0000	22.0000	22.0000	22.0000
4276	00	21.0000	23.0000	23.0000	23.0000	23.0000
4281	00	22.0000	24.0000	24.0000	24.0000	24.0000
4286	00	23.0000	25.0000	25.0000	25.0000	25.0000
4291	00	24.0000	26.0000	26.0000	26.0000	26.0000
4296	00	25.0000	27.0000	27.0000	27.0000	27.0000
4301	00	26.0000	28.0000	28.0000	28.0000	28.0000
4306	00	27.0000	29.0000	29.0000	29.0000	29.0000
4311	00	28.0000	30.0000	30.0000	30.0000	30.0000
4316	00	29.0000	31.0000	31.0000	31.0000	31.0000
4321	00	30.0000	32.0000	32.0000	32.0000	32.0000
4326	00	31.0000	33.0000	33.0000	33.0000	33.0000
4331	00	32.0000	34.0000	34.0000	34.0000	34.0000
4336	00	33.0000	35.0000	35.0000	35.0000	35.0000
4341	00	34.0000	36.0000	36.0000	36.0000	36.0000
4346	00	35.0000	37.0000	37.0000	37.0000	37.0000
4351	00	36.0000	38.0000	38.0000	38.0000	38.0000
4356	00	37.0000	39.0000	39.0000	39.0000	39.0000
4361	00	38.0000	40.0000	40.0000	40.0000	40.0000
4366	00	39.0000	41.0000	41.0000	41.0000	41.0000
4371	00	40.0000	42.0000	42.0000	42.0000	42.0000
4376	00	41.0000	43.0000	43.0000	43.0000	43.0000
4381	00	42.0000	44.0000	44.0000	44.0000	44.0000
4386	00	43.0000	45.0000	45.0000	45.0000	45.0000
4391	00	44.0000	46.0000	46.0000	46.0000	46.0000
4396	00	45.0000	47.0000	47.0000	47.0000	47.0000
4401	00	46.0000	48.0000	48.0000	48.0000	48.0000
4406	00	47.0000	49.0000	49.0000	49.0000	49.0000
4411	00	48.0000	50.0000	50.0000	50.0000	50.0000
4416	00	49.0000	51.0000	51.0000	51.0000	51.0000
4421	00	50.0000	52.0000	52.0000	52.0000	52.0000
4426	00	51.0000	53.0000	53.0000	53.0000	53.0000
4431	00	52.0000	54.0000	54.0000	54.0000	54.0000
4436	00	53.0000	55.0000	55.0000	55.0000	55.0000
4441	00	54.0000	56.0000	56.0000	56.0000	56.0000
4446	00	55.0000	57.0000	57.0000	57.0000	57.0000
4451	00	56.0000	58.0000	58.0000	58.0000	58.0000
4456	00	57.0000	59.0000	59.0000	59.0000	59.0000
4461	00	58.0000	60.0000	60.0000	60.0000	60.0000
4466	00	59.0000	61.0000	61.0000	61.0000	61.0000
4471	00	60.0000	62.0000	62.0000	62.0000	62.0000
4476	00	61.0000	63.0000	63.0000	63.0000	63.0000
4481	00	62.0000	64.0000	64.0000	64.0000	64.0000
4486	00	63.0000	65.0000	65.0000	65.0000	65.0000
4491	00	64.0000	66.0000	66.0000	66.0000	66.0000
4496	00	65.0000	67.0000	67.0000	67.0000	67.0000
4501	00	66.0000	68.0000	68.0000	68.0000	68.0000
4506	00	67.0000	69.0000	69.0000	69.0000	69.0000
4511	00	68.0000	70.0000	70.0000	70.0000	70.0000
4516	00	69.0000	71.0000	71.0000	71.0000	71.0000
4521	00	70.0000	72.0000	72.0000	72.0000	72.0000
4526	00	71.0000	73.0000	73.0000	73.0000	73.0000
4531	00	72.0000	74.0000	74.0000	74.0000	74.0000
4536	00	73.0000	75.0000	75.0000	75.0000	75.0000
4541	00	74.0000	76.0000	76.0000	76.0000	76.0000
4546	00	75.0000	77.0000	77.0000	77.0000	77.0000
4551	00	76.0000	78.0000	78.0000	78.0000	78.0000
4556	00	77.0000	79.0000	79.0000	79.0000	79.0000
4561	00	78.0000	80.0000	80.0000	80.0000	80.0000
4566	00	79.0000	81.0000	81.0000	81.0000	81.0000
4571	00	80.0000	82.0000	82.0000	82.0000	82.0000
4576	00	81.0000	83.0000	83.0000	83.0000	83.0000
4581	00	82.0000	84.0000	84.0000	84.0000	84.0000
4586	00	83.0000	85.0000	85.0000	85.0000	85.0000
4591	00	84.0000	86.0000	86.0000	86.0000	86.0000
4596	00	85.0000	87.0000	87.0000	87.0000	87.0000
4601	00	86.0000	88.0000	88.0000	88.0000	88.0000
4606	00	87.0000	89.0000	89.0000	89.0000	89.0000
4611	00	88.0000	90.0000	90.0000	90.0000	90.0000
4616	00	89.0000	91.0000	91.0000	91.0000	91.0000
4621	00	90.0000	92.0000	92.0000	92.0000	92.0000
4626	00	91.0000	93.0000	93.0000	93.0000	93.0000
4631	00	92.0000	94.0000	94.0000	94.0000	94.0000
4636	00	93.0000	95.0000	95.0000	95.0000	95.0000
4641	00	94.0000	96.0000	96.0000	96.0000	96.0000
4646	00	95.0000	97.0000	97.0000	97.0000	97.0000
4651	00	96.0000	98.0000	98.0000	98.0000	98.0000
4656	00	97.0000	99.0000	99.0000	99.0000	99.0000
4661	00	98.0000	100.0000	100.0000	100.0000	100.0000



631	2	1.0000	1.0000	
641	2	5000.0	5000.0	
651	2	.02370	.02370	
661	2	.50000	.50000	
671	2	.0	.0	
691	2	.30000	.30000	
721	3	2.00000	1.00000	4.00000
731	1	100.00		
741	3	.0	.0	.0
771	3	15.000	15.000	15.000
781	3	2.0000	2.0000	2.0000
791	3	75.000	150.00	300.00
811	3	.02370	.73000	.02370
831	3	1.0000	.0	1.0000
841	3	1.0000	1.0000	.0
851	1	.0		1.0000
1061	1	.10000		
1071	1	.02370		
1081	1	.50000		
1101	1	.0		
1111	1	.30000		
1131	1	.50000		
1141	4	2000.0		
1159	1	2500.0	1000.0	.0
U0	0.300000E+05	MFA = 0.0		
U1	0.300000E+05	MFA = 0.312492E+04		
U2	0.337622E+05	MFA = 0.465469E+04		
U3	0.300000E+05	MFA = 0.527023E+04		
U4	0.337622E+05	MFA = 0.573333E+04		

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM M-91

SINGLE MOTOR AUXILIARY PROPULSION HELICOPTER

9 1 2 F D A T A THIS RUN CONVERGED IN 7 ITERATIONS

GROSS WEIGHT 7 56144. LP

FUJPLAGE

LFNGTH/ROD(Y+TAILROD) 41.3 FT.  
 LFNGTH/CAPITM) 27.3 FT.  
 LFNGTH/BODY) 30.2 FT.  
 LFNGTH/TAILOD) 5.1 FT.  
 PWD. MOTOR LOCATION 14.3 FT.  
 WIDTH 0.8 FT.  
 WCTED AREA 41.3 SQ. FT.

WING - NO WING USED

WING AREA 5.400  
 WING SPAN 27.7 SQ. FT.  
 WING MEAN CYCRO 23.2 FT.  
 WING TAPER RATIO 0.67  
 WING THICKNESS/CHORD 0.150  
 WING MONO TAIL ARM 21.5 FT.

WEPT. TAIL

WEPT. TAIL ASPECT RATIO 0  
 WEPT. TAIL AREA 1.011  
 WEPT. TAIL SPAN 29.8 SQ. FT.  
 WEPT. TAIL MEAN CHORD 6.7 FT.  
 WEPT. TAIL TAPER RATIO 0.8 FT.  
 WEPT. TAIL TAIL MOTOR(VERT.) LOCATION 0.0 FT.  
 WEPT. TAIL TAIL MOTOR(VERT.) TAIL OVERLAP PATIC 0.0  
 WEPT. TAIL THICKNESS/CHORD 0.17

WATM MOTOR Pylon

WATM MOTOR Pylon ASPECT RATIO  
 WATM MOTOR Pylon WETTED AREA 21  
 WATM MOTOR Pylon FRONTAL AREA 17.0 SQ. FT.  
 WATM MOTOR Pylon HEIGHT 43.6 SQ. FT.  
 WATM MOTOR Pylon MEAN CHORD 3.0 FT.  
 WATM MOTOR Pylon TAPER RATIO 17.0 FT.  
 WATM MOTOR Pylon FOOT THICKNESS/CHORD 0.07  
 WATM MOTOR Pylon TIP THICKNESS/CHORD 0.4

PRIMARY ENGINE MACELLE

LN 0.0 FT.  
 OM 0. FT.  
 SM 0.0 SQ. FT.  
 WPM DIAMETER  
 WETTED AREA/TOTAL FOR ALL PROJMERS

AUXILIARY INDEPENDENT ENGINE MACELLE -NO AUXILIARY INDEPENDENT ENGINE USED

PROPELLER/AUXILIARY PROPELLER

DAP 4.0 FT.  
 AF 169.0  
 SGR 0.847  
 MRA 2.  
 NO. OF PROPELLERS  
 NO. OF PLANS/PROP 13.  
 VTIP 400. FT./SEC

MAIN ROTOP

OMR 55.4 FT.  
 SIGR 0.113  
 W/A 15.0 LB/SQ. FT.  
 CT/SIGMA 0.0  
 MR 1.  
 NO. OF ROTORS 5.  
 NO. OF BLADES/ROTOP 10.  
 THETA 0.100 DEG.  
 XT 450. FT./SEC.  
 VTIP

- NO TAIL ROTOR USED

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM P-01  
M R C O P

V I S I T A D A T A IN LBS

PLF	MANUEVER LOAD FACTOR	9.270
ULF	ULTIMATE LOAD FACTOR	4.0850
<b>PROPULSION GROUP</b>		
WPPC	TOTAL MAIN MOTOR GROUP	6582
M12 WPP	MAIN MOTOR CLAY (SEE NOTES)	2604
M13 WPP	MAIN MOTOR MUP (SEE NOTES)	3778
M14 WPP	BLADE FOLDING MOTOR GROUP	0
M15 WPP	AUXILIARY PROPULSION MOTOR GROUP	943
M16 WPP	DRIVE SYSTEM	4015
M17 WPP	MAIN MOTOR DRIVE SYSTEM	4177
M18 WPP	TAIL MOTOR DRIVE SYSTEM	0
M19 WPP	AUXILIARY PROPULSION DRIVE SYSTEM	1320
M20 WPP	PP ARY ENGINE	2970
M21 WPP	AUXILIARY ENGINE	0
M22 WPP	PRIMARY ENGINE INSTALLATION	2870
M23 WPP	AUXILIARY ENGINE INSTALLATION	0
M24 WPP	PULL SYSTEM	4450
M25 WPP	PROPULSION GROUP WEIGHT INCREMENT	0
M26 WPP	TOTAL PROPULSION GROUP WEIGHT	13870
<b>STRUCTURE GROUP</b>		
WV	WING GROUP	0
WY	HOB. TAIL	1700
WZ	TAIL MOTOR	1450
W1	FUSLAGE	3240
W2	LAMPING AREA	1407
W3	HOLE GRAB	0
W4	WAIN GRAB	1170
W5	TOTAL TAIL SECTION	2700
W6	PRIMARY ENGINE SECTION	0
W7	AUXILIARY ENGINE SECTION	0
W8	STRUCTURE WEIGHT INCREMENT	0
W9	TOTAL STRUCTURE WEIGHT	6160
<b>FLIGHT CONTROLS GROUP</b>		
W10	PRIMARY FLIGHT CONTROLS	1130
W11	COCKPIT CONTROLS	70
W12	MAIN MOTOR CONTROLS	400
W13	MAIN MOTOR SYSTEM CONTROLS	110
W14	TIRES WING CONTROLS	110
W15	TILT MECHANISM	0
W16	SAP	70
W17	AUXILIARY FLIGHT CONTROLS	270
W18	AUX. PROPULSION MOTOR CONTROLS	0
W19	AUX. PROPULSION MOTOR WING CONTROLS	170

	MISC DATA VPC VPP	MISCELLANEOUS CHARGES CONTROL WEIGHT INCREMENT TOTAL CONTROL WEIGHT	1. 400
WFI		WEIGHT OF CIVIL EQUIPMENT	1400.
WR		WEIGHT EMPTY	2470.
WHL		FUEL WEIGHT LOAD	22740.
WR		OPERATING WEIGHT EMPTY	400.
WR		OVERALL	6320.
WR		EMPTY	1300.
WR		OPER. WEIGHT	70364.

SAMPLE CASE NO. 3 (PUB. 3)

PAGE 4

MI ... TPA SIZING P PERFORMANCE SECURITY REPORT (A-9)

M. R. O. P.

R. P. C. A. T. A.

TISED WITH ANTON SOLICITY INPUT



HELICOPTER SETTING & PERFORMANCE COMPUTE PROGRAM 4-03

M F 9 C 0 M P

P R O C E S S I N G C A T A  
PRIMARY PRODUCTION CYCLE 0.0 2.031  
TURBOCHARGED ENGINE

2. ENGINES

IMP. P. MAX. STANDARD C.L. STATIC M.P. 9973. M.P.

ENGINE SIZED FOR CRUISE AT VC 1 20% WHITE,  
NORMAL FUEL SYSTEM, 100% EXHAUST POWER RPM,  
TAKEOFF = 1.000 M.P. 10.0% TEMPERATURE = 15.00 070.00  
AND 1. ENGINE, IMPROVED.

NO AIR. IMPROVED ENGINE CYCLE SELECT

MAIN ROTOR DRIVE SYSTEM RATIO 1 17.0 M.P.

ENGINE SIZED AT 10% PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
GEN. STANDARD C.L. STATIC M.P. 10.0% PERCENT POWER RPM

AUXILIARY PRODUCTION DRIVE SYSTEM RATIO 0007. M.P.

ENGINE SIZED AT 40% PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
GEN. STANDARD C.L. STATIC M.P. 10.0% PERCENT POWER RPM



HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91

H F S C O M P

MISSION PERFORMANCE DATA

TAKOFF, HOVER, OR LAND AT PTF = 1.000 FOR 0.033 HRS.

TIME (HRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRFS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. COEF	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	EMF	CT	CT/SIGMA
0-0	0-0	0-0	36164	0	3646	2500-1	T	1-070	3646	1-262	0-730	7911	0-0	0-180
650-0	7381	0-0	0	342	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0
0-011	0-0	40-5	36123	0	3646	2500-1	T	1-000	3646	1-262	0-730	7997	0-0	0-180
650-0	7367	0-0	0	342	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0
0-022	0-0	80-9	36083	0	3646	2500-1	T	1-070	3646	1-262	0-730	7993	0-0	0-180
650-0	7354	0-0	0	342	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0
0-033	0-0	121-4	36042	0	3646	2500-1	T	1-070	3646	1-262	0-730	7969	0-0	0-179
650-0	7340	0-0	0	341	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0

CLIMB TO 5000 FT. WITH MAXIMUM R/C AT MILITARY ENGINE RATING  
 .. TANDARD GAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRFS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. COEF	PRIM. ENG. PEMP	FAS (KTS)	MU	SIGMA	ALPHA D/L (DEG)	GAMMA R/P (DEG)	R/C (FT/M)
0-0	0-0	0-0	36164	0	3646	2500-1	T	1-070	3646	1-262	0-730	7911	0-0	0-180
650-0	7381	0-0	0	342	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0
0-011	0-0	40-5	36123	0	3646	2500-1	T	1-000	3646	1-262	0-730	7997	0-0	0-180
650-0	7367	0-0	0	342	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0
0-022	0-0	80-9	36083	0	3646	2500-1	T	1-070	3646	1-262	0-730	7993	0-0	0-180
650-0	7354	0-0	0	342	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0
0-033	0-0	121-4	36042	0	3646	2500-1	T	1-070	3646	1-262	0-730	7969	0-0	0-179
650-0	7340	0-0	0	341	3646	0	A	0-0	0-0	0-0	0-730	0-0	0-0	0-0

TIME (HRS)	RANGE (M.M.)	FUEL USED (LRS)	WEIGHT (LRS.)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TURP. TEMP. (R)	PRIM. ENG. CRMF	FAS (KTS)	MU	CT PRIM OVER SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (NMPP)	9346. 55.9.
0.036	0.28	133.0	36030.	1.000.	96.1	2580.0	T 1.000	94.7	0.252	0.159	-0.6	20.2	9346. 55.9.
650.0	1959.	0.0	0.0	0.0	4135.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000157 A						
0.036	0.43	140.1	36024.	1.500.	97.1	2580.0	T 1.000	95.0	0.255	0.141	-0.6	20.6	9253. 5415.
650.0	2030.	0.0	0.0	0.0	4049.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000160 A						
0.039	0.58	146.4	36017.	2.000.	97.1	2580.0	T 1.000	94.3	0.255	0.143	-0.6	20.1	9161. 5320.
650.0	2761.	0.0	0.0	0.0	4041.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000160 A						
0.041	0.74	152.7	36011.	2.500.	98.1	2580.0	T 1.000	94.6	0.257	0.145	-0.6	21.5	9170. 5223.
650.0	2097.	0.0	0.0	0.0	3995.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000163 A						
0.042	0.80	159.1	36005.	3.000.	98.1	2580.0	T 1.000	93.9	0.257	0.147	-0.6	21.0	8976. 5120.
650.0	2133.	0.0	0.0	0.0	3948.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000163 A						
0.044	1.06	165.5	35998.	3.500.	99.1	2580.0	T 1.000	94.1	0.260	0.149	-0.6	21.3	8885. 5024.
650.0	2175.	0.0	0.0	0.0	3911.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000167 A						
0.046	1.22	172.0	35992.	4.000.	100.1	2580.0	T 1.000	94.4	0.263	0.151	-0.6	21.7	8796. 4922.
650.0	2219.	0.0	0.0	0.0	3855.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000170 A						
0.047	1.39	176.5	35985.	4.500.	101.1	2580.0	T 1.000	94.6	0.265	0.154	-0.6	21.0	8711. 4820.
650.0	2266.	0.0	0.0	0.0	3800.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000174 A						
0.049	1.57	185.1	35979.	5.000.	102.1	2580.0	T 1.000	94.8	0.268	0.156	-0.6	21.3	8624. 4715.
650.0	2317.	0.0	0.0	0.0	3743.	51.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000177 A						

CRUISE AT 140.0 KNOTS TAS. LIMITED BY NORMAL ENGINE RATING

TIME (HRS)	RANGE (M.M.)	FUEL USED (LRS)	WEIGHT (LRS.)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TURP. TEMP. (R)	PRIM. ENG. CRMF	FAS (KTS)	MU	CT PRIM OVER SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (NMPP)	9346. 55.9.
0.049	1.57	185.1	35979.	5.000.	102.1	2580.0	T 1.000	94.8	0.268	0.156	-0.6	21.3	8624. 4715.
650.0	3196.	0.0	0.0	0.0	2206.	1475.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000177 A						
0.133	16.57	376.4	35767.	5.000.	101.1	2154.1	F 0.925	167.1	0.467	0.155	-0.6	21.6	8110.
650.0	3196.	0.0	0.0	0.0	2206.	1475.	(.85) 0.300						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000177 A						

TIME (MPS)	RANGE (NM)	FUEL USED (LBS)	WEIGHT (LBS)	HEIGHT (FT)	PRPS ALT (FT)	PRIM. TEMP (R)	EMG. CODE	PRIM. ENG. CODE	PPRM. ENG. PERH	EAS (KTS)	MU	CT OVRP SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (MPP)	PHF
650.0	3159.0	566.7	35597.0	5100.0	2271.0	1365.0	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
0.216	3124.0	566.7	35597.0	5100.0	2271.0	1365.0	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
650.0	3124.0	566.7	35597.0	5100.0	2271.0	1365.0	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
0.299	3089.0	755.6	35074.0	5100.0	2256.0	2147.5	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
650.0	3089.0	755.6	35074.0	5100.0	2256.0	2147.5	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
0.482	3054.0	949.1	34529.0	5100.0	2247.0	2144.2	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
650.0	3054.0	949.1	34529.0	5100.0	2247.0	2144.2	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
0.657	3024.0	1111.7	33952.0	5100.0	2230.0	2141.0	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0
650.0	3024.0	1111.7	33952.0	5100.0	2230.0	2141.0	0.6683	1.000	A	167.1	0.467	0.152	6.0	0.64512	4511.0

TRANSFER ALTITUDE TO 2000. FT.

CRUISE AT NORMAL ENGINE RATING

TIME (MPS)	RANGE (NM)	FUEL USED (LBS)	WEIGHT (LBS)	HEIGHT (FT)	PRPS ALT (FT)	PRIM. TEMP (R)	EMG. CODE	PRIM. ENG. CODE	PPRM. ENG. PERH	EAS (KTS)	MU	CT OVRP SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (MPP)	PHF
0.957	2999.0	1342.8	34401.0	2100.0	2228.0	2512.0	0.714	1.000	A	243.0	0.721	0.172	0.0	0.640	4744.0
583.1	2999.0	1342.8	34401.0	2100.0	2228.0	2512.0	0.714	1.000	A	243.0	0.721	0.172	0.0	0.640	4744.0
0.517	2970.0	1572.8	34401.0	2100.0	2228.0	2512.0	0.714	1.000	A	243.0	0.721	0.172	0.0	0.640	4744.0
583.1	2970.0	1572.8	34401.0	2100.0	2228.0	2512.0	0.714	1.000	A	243.0	0.721	0.172	0.0	0.640	4744.0
0.637	2941.0	1811.7	34392.0	2100.0	2228.0	2512.0	0.714	1.000	A	243.0	0.721	0.172	0.0	0.640	4744.0
583.1	2941.0	1811.7	34392.0	2100.0	2228.0	2512.0	0.714	1.000	A	243.0	0.721	0.172	0.0	0.640	4744.0

TIME (HRS)	RANGE (M.P.H.)	FUEL USED (LBS)	T-ROTOP RPM	VTIP (RPM)	T-ROTOP RPM	VTIP (RPM)	PROF (FT)	ALT. (FT)	PRF. YRNG. (R)	PRIM. ENG. CODE	PRIM. ENG. CODE	PROP. TAILX/T (R)	AUX. ENG. TAILX/T (R)	FAS (KTS)	MU	CT PRIMF OVER SIGMA	AUX. ENG. PFMF	TOTAL FUEL FLW (LBS/HR)	FIP	
0.696	135.0	2129.6	34134	2000	2540.0	2540.0	2540.0	2540.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
583.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.755	150.00	2257.5	31907	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
583.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TRANSFER ALTITUDE TO 1 00 FT.

FUEL USED (LBS) 34134  
 WEIGHT (LBS) 2000  
 ALT. (FT) 2540.0  
 PRF. YRNG. (R) 0.0  
 T-ROTOP RPM 31907  
 VTIP (RPM) 2000  
 PROF (FT) 2550.2  
 ALT. (FT) 2550.2  
 PRF. YRNG. (R) 0.0

LOTTER FOR 0.50 HRS.

TIME (HRS)	RANGE (M.P.H.)	FUEL USED (LBS)	T-ROTOP RPM	VTIP (RPM)	T-ROTOP RPM	VTIP (RPM)	PROF (FT)	ALT. (FT)	PRF. YRNG. (R)	PRIM. ENG. CODE	PRIM. ENG. CODE	PROP. TAILX/T (R)	AUX. ENG. TAILX/T (R)	FAS (KTS)	MU	CT PRIMF OVER SIGMA	AUX. ENG. PFMF	TOTAL FUEL FLW (LBS/HR)	FIP	
0.755	150.00	2257.5	31907	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.855	150.00	2411.1	32753	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.955	150.00	2565.2	33607	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.055	150.00	2719.8	33440	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.155	150.00	2871.6	33242	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.255	150.00	3024.4	33146	2000	2550.2	2550.2	2550.2	2550.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TRANSFER ALTITUDE TO 0. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. ENG. FUEL FLOW (LBS/HR)	AUX. ENG. FUEL FLOW (LBS/HR)	ROT LIM CODE	PRIM. ENG. PMPF	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	CPRO	CPIND	CT	CT/STGMA
1.255	150.00	3224.4	33139.	314.	2654.	2345.6	---	P	0.673	2698.	1.160	0.746	5320.	0.0	0.0	0.139
1.255	150.00	3224.4	33139.	314.	2654.	2345.6	---	A	0.669	2687.	1.160	0.746	5297.	0.0	0.0	0.139
1.355	150.00	3270.	32870.	311.	2476.	2342.0	---	P	0.665	2676.	1.61	0.746	5265.	0.0	0.0	0.137
1.355	150.00	3270.	32870.	311.	2476.	2342.0	---	A	0.661	2655.	1.61	0.746	5233.	0.0	0.0	0.137
1.455	150.00	3260.7	32603.	309.	2655.	2335.1	---	P	0.657	2655.	1.61	0.746	5210.	0.0	0.0	0.136
1.455	150.00	3260.7	32603.	309.	2655.	2335.1	---	A	0.653	2644.	1.61	0.746	5170.	0.0	0.0	0.136
1.505	150.00	32470.	32470.	307.	2644.	2332.5	---	P	0.652	2644.	1.61	0.746	5170.	0.0	0.0	0.136
1.505	150.00	32470.	32470.	307.	2644.	2332.5	---	A	0.652	2644.	1.61	0.746	5170.	0.0	0.0	0.136

TAKEOFF, HOVER, OR LAND AT 1/4 = 10660 FOR 0.250 MRS.

TIME (HRS)	M. ROTOR RHP	W. ROTOR RHP	VRC RHP	PRIM. ENG. FUEL FLOW (LBS/HR)	AUX. ENG. FUEL FLOW (LBS/HR)	ROT LIM CODE	PRIM. ENG. CODE	PRIM. ENG. PMPF	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	DELOCM	FMI	CPRO	CPIND	CT	CT/STGMA
1.255	4879.	33139.	314.	2345.6	---	P	0.673	2698.	1.160	0.746	5320.	0.0	0.0	0.0	0.0	0.139
1.305	4849.	33034.	312.	2342.0	---	P	0.669	2687.	1.160	0.746	5297.	0.0	0.0	0.0	0.0	0.139
1.355	4819.	32870.	311.	2342.0	---	P	0.665	2676.	1.61	0.746	5265.	0.0	0.0	0.0	0.0	0.137
1.405	4789.	32736.	310.	2337.7	---	P	0.661	2655.	1.61	0.746	5233.	0.0	0.0	0.0	0.0	0.137
1.455	4759.	32603.	309.	2335.1	---	P	0.657	2655.	1.61	0.746	5210.	0.0	0.0	0.0	0.0	0.136
1.505	4730.	32470.	307.	2332.5	---	P	0.653	2644.	1.61	0.746	5170.	0.0	0.0	0.0	0.0	0.136
1.505	4730.	32470.	307.	2332.5	---	P	0.652	2644.	1.61	0.746	5170.	0.0	0.0	0.0	0.0	0.136

CLIMB TO 3' DEL. WITH MAXIMUM R/C AT MILITARY ENGINE FATIGING  
 AS TANGENT EAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	M. ROTOR RHP	W. ROTOR RHP	VRC RHP	PRIM. ENG. FUEL FLOW (LBS/HR)	AUX. ENG. FUEL FLOW (LBS/HR)	ROT LIM CODE	PRIM. ENG. CODE	PRIM. ENG. PMPF	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	DELOCM	FMI	CPRO	CPIND	CT	CT/STGMA
1.255	4879.	33139.	314.	2345.6	---	P	0.673	2698.	1.160	0.746	5320.	0.0	0.0	0.0	0.0	0.139
1.305	4849.	33034.	312.	2342.0	---	P	0.669	2687.	1.160	0.746	5297.	0.0	0.0	0.0	0.0	0.139
1.355	4819.	32870.	311.	2342.0	---	P	0.665	2676.	1.61	0.746	5265.	0.0	0.0	0.0	0.0	0.137
1.405	4789.	32736.	310.	2337.7	---	P	0.661	2655.	1.61	0.746	5233.	0.0	0.0	0.0	0.0	0.137
1.455	4759.	32603.	309.	2335.1	---	P	0.657	2655.	1.61	0.746	5210.	0.0	0.0	0.0	0.0	0.136
1.505	4730.	32470.	307.	2332.5	---	P	0.653	2644.	1.61	0.746	5170.	0.0	0.0	0.0	0.0	0.136
1.505	4730.	32470.	307.	2332.5	---	P	0.652	2644.	1.61	0.746	5170.	0.0	0.0	0.0	0.0	0.136

1.595 1:0.00 3603.4 32470. 0. 41.0 2560.0 1 1.00 91.0 241 0.121 0.6 35.0 519. 62 1.





TIME	1-517	1-592	1-672	1-751	1-831	1-910	1-987	2-060	2-145	2-225	2-305
0.0	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74
1.0	3725.7	3905.2	4164.3	4262.5	4447.2	4617.2	4793.5	4970.5	5145.2	5320.2	5495.1
2.0	3243.0	3270.0	3275.0	314.0	3172.0	3134.0	3170.0	3114.0	3118.0	3143.0	3161.0
3.0	3009.0	3000.0	3010.0	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0
4.0	2131.7	2125.5	2122.2	2129.0	2125.1	2134.2	2132.0	2130.0	2133.0	2131.0	2131.0
5.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0
6.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0
7.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0
8.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0
9.0	650.0	650.0	650.0	650.0	650.0	650.0	650.0	650.0	650.0	650.0	650.0
10.0	401.0	401.0	401.0	401.0	401.0	401.0	401.0	401.0	401.0	401.0	401.0
11.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0

TARGETS ALTIMETER TO ...  
 TIME RANGE FUEL USED WEIGHT OFF ...  
 1-517 16.74 3725.7 3243.0 3009.0 2131.7 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-592 16.74 3905.2 3270.0 3010.0 2125.5 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-672 16.74 4164.3 3275.0 3010.0 2122.2 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-751 16.74 4262.5 314.0 3000.0 2129.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-831 16.74 4447.2 3172.0 3000.0 2125.1 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-910 16.74 4617.2 3134.2 3000.0 2134.2 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-987 16.74 4793.5 3170.0 3000.0 2132.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-060 16.74 4970.5 3114.0 3000.0 2130.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-145 16.74 5145.2 3118.0 3000.0 2133.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-225 16.74 5320.2 3143.0 3000.0 2131.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-305 16.74 5495.1 3161.0 3000.0 2131.0 1677.0 1411.0 1152.0 902.0 650.0 401.0

TIME	1-517	1-592	1-672	1-751	1-831	1-910	1-987	2-060	2-145	2-225	2-305
TIME	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74	16.74
RANGE	3725.7	3905.2	4164.3	4262.5	4447.2	4617.2	4793.5	4970.5	5145.2	5320.2	5495.1
FUEL	3243.0	3270.0	3275.0	314.0	3172.0	3134.0	3170.0	3114.0	3118.0	3143.0	3161.0
USED	3009.0	3000.0	3010.0	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0
WEIGHT	2131.7	2125.5	2122.2	2129.0	2125.1	2134.2	2132.0	2130.0	2133.0	2131.0	2131.0
OFF	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0	1677.0
ALTS	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0	1411.0
FTS	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0	1152.0
OFFTS	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0	902.0

TARGETS RANGE OF LIGHT AT 1/2 EIGHT ...  
 TIME RANGE FUEL USED WEIGHT OFF ...  
 1-517 16.74 3725.7 3243.0 3009.0 2131.7 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-592 16.74 3905.2 3270.0 3010.0 2125.5 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-672 16.74 4164.3 3275.0 3010.0 2122.2 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-751 16.74 4262.5 314.0 3000.0 2129.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-831 16.74 4447.2 3172.0 3000.0 2125.1 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-910 16.74 4617.2 3134.2 3000.0 2134.2 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 1-987 16.74 4793.5 3170.0 3000.0 2132.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-060 16.74 4970.5 3114.0 3000.0 2130.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-145 16.74 5145.2 3118.0 3000.0 2133.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-225 16.74 5320.2 3143.0 3000.0 2131.0 1677.0 1411.0 1152.0 902.0 650.0 401.0  
 2-305 16.74 5495.1 3161.0 3000.0 2131.0 1677.0 1411.0 1152.0 902.0 650.0 401.0

WROTOR VTIP	MOTOR RMP	T-RATIO VTIP (FPS)	T-RATIO RMP	VRC RMP	PRIMEFT FUEL FLOW (LBS/MR)	AUX FLOW FUEL FLOW (LBS/MR)	POTLIM CODE	TRF PPH (%)	FEIDCH	FMI	CPPRD	CPINN	CO
2-305 657.7	300.00 421.5	546.0 0.0000	3067.0 0.	293. 0.	247. 247.	2175.5 ----	F F	247. 247.	1.6 1.6	0.747 0.747	4621. 0.	0.134 0.	0.121 0.
2-316 650.0	300.00 421.5	551.4 0.0000	3067.0 0.	290. 0.	245. 245.	2175.0 ----	F A	245. 245.	1.6 1.6	0.747 0.747	4727. 0.	0.134 0.	0.121 0.
2-327 650.0	300.00 421.5	556.0 0.0000	3062.5 0.	290. 0.	243. 243.	2175.6 ----	F F	243. 243.	1.6 0.0	0.747 0.747	4616. 0.0	0.134 0.0	0.121 0.0
2-33P 650.0	300.00 419.0	542.1 0.0000	3066.5 0.	293. 0.	241. 241.	2175.1 ----	P A	241. 241.	1.6 1.6	0.747 0.747	4611. 0.	0.134 0.	0.121 0.

MISSION FUEL REQUIRED = 5462.8  
 RESERVE FUEL REQUIRED = 418.62  
 TOTAL FUEL REQUIRED = 6126.72

.....  
 END OF SUCCESSFUL CASE  
 .....

MELTCOUNTER SIZING A PERFORMANCE COMPUTER PROGRAM M-91

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC. CORRESPOND TO LOCATION NUMBER (INPUT ON INPUT TAPE)  
 MIN. STOPS FOR THE NUMBER OF SUCCESSFUL INPUT VALUES STARTING WITH INC. (MAX. 99)  
 VAL. EQUAL VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL1 VALUE CORRESPONDING TO LOC.0001  
 VAL2 VALUE CORRESPONDING TO LOC.0002  
 ETC.

LOC.	MIN	VAL	VAL1	VAL2	VAL3	VAL4
------	-----	-----	------	------	------	------

NOTE: IN USING AUXILIARY ENTRIES 1 AUXILIARY ENTRY CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 16616 CARD IN FRONT AND BEHIND A STANDARD ENTRY CYCLE

12.0	1	2.00				
01	0.0000000000	000	0.0000000000	000	0.0000000000	000
02	0.0000000000	000	0.0000000000	000	0.0000000000	000
03	0.0000000000	000	0.0000000000	000	0.0000000000	000

H T S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 8-91

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER

SIZE DATA THIS RUN CONVERGED IN 3 ITERATIONS  
GROSS WEIGHT = 36164.10

FUSELAGE		
LF	LENGTH(FWD+TAILBOOM)	41.3 FT.
LC	LENGTH(CABIN)	28.3 FT.
LR	LENGTH(ROOFT)	35.2 FT.
LTB	LENGTH(TAILBOOM)	6.1 FT.
XM	FWD. ROTOR LOCATION	14.1 FT.
WP	WIDTH	8.3 FT.
SF	WETTED AREA	661.3 SQ. FT.

WING - NO WING USED

HOR. TAIL		
ARMY	ASPECT RATIO	1.500
SMY	AREA	97.7 SQ. FT.
PMY	SPAN	93.2 FT.
CRASHY	MEAN CHORD	4.2 FT.
LAMBDA H	TAPER RATIO	0.660
IT/PMY	THICKNESS/CHORD	0.150
LTH	HOP. TAIL ARM	21.5 FT.

VERT. TAIL

ARMY	ASPECT RATIO	3.500
SMY	AREA	29.9 SQ. FT.
PMY	SPAN	6.7 FT.
CRASHY	MEAN CHORD	4.4 FT.
LAMBDA VY	TAPER RATIO	0.800
ZTAV	TAIL ROTOR(VERT.) LOCATION	0.0 FT.
IT/PMY	TAIL ROTOR/AVPT. TAIL OVERLAP RATIO	1.1
	THICKNESS/CHORD	0.150

MAIN ROTOR PYLON

ARMY	ASPECT RATIO	1.231
SMY	WETTED AREA	34.4 SQ. FT.
PMY	FRONTAL AREA	43.6 SQ. FT.
MPY	HEIGHT	3.6 FT.
CRASHY	MEAN CHORD	17.7 FT.
LAMBDA PY	TAPER RATIO	0.751
IT/PMY	ROTT THICKNESS/CHORD	0.150
IT/PMY	TIP THICKNESS/CHORD	0.601

PRIMARY ENGINE NACELLE

LN                    LENGTH                    0.0 FT.  
 OW                    MEAN DIAMETER            0. FT.  
 SW                    WETTED AREA/TOTAL FOR ALL ENGINES    0.0 SQ. FT.

AUXILIARY INDEPENDENT ENGINE NACELLE - NO AUXILIARY INDEPENDENT ENGINE USED

PROPELLER/AUXILIARY PROPELLER

DAP                    DIAMETER                    9.9 FT.  
 AP                    ACTIVITY FACTOR/PROP BLADE            169.4  
 SIBAR                    SOLIDITY                    0.897  
 MPA                    NO. OF PROPELLERS            2.  
 MP                    NO. OF BLADES/PROP            13.  
 VTIP                    TIP SPEED                    400. FT./SEC

MAIN ROTOR

DMP                    DIAMETER                    58.4 FT.  
 SIGMA                    SOLIDITY                    0.111  
 W/A                    DISC LOADING                15.0 LB/SQ. FT.  
 CT/SIGMA                    THRUST COEFF./SOLIDITY            1.0  
 MR                    NO. OF ROTORS                1.  
 MP                    NO. OF BLADES/ROTOR            6.  
 THETA                    BLADE TWTY                    -10.000 DEG.  
 VC                    PLANE CUTOUT/RADIUS RATIO            0.120  
 VTIP                    TIP SPEED                    450. FT./SEC.

- NO TAIL ROTOR USED

M F S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-01

M F S C H T S D A Y A IN LBS

PLF	WANEUVER LOAD FACTOR	3.000
HLF	ULTIMATE LOAD FACTOR	4.0500
<b>PROPULSION GROUP</b>		
	TOTAL MAIN ROTOR GROUP	6302.
W12	MAIN ROTOR PLATF (PER ROTOR)	2674.
W13	MAIN ROTOR HUB (PER ROTOR)	3728.
W14	BLADE FOLDING/PER ROTOR	0.
W15	AUXILIARY PROPULSION ROTOR GROUP	342.
W16	DRIVE SYSTEM	6503.
W17	MAIN ROTOR DRIVE SYSTEM	4145.
W18	TAIL ROTOR DRIVE SYSTEM	7.
W19	AUXILIARY PROPULSION DRIVE SYSTEM	334.
W20	PRIMARY ENGINE	0.
W21	AUXILIARY ENGINE	0.
W22	PRIMARY ENGINE INSTALLATION	247.
W23	AUXILIARY ENGINE INSTALLATION	2.
W24	FUEL SYSTEM	402.
W25	PROPULSION GROUP WEIGHT INCREMENT	0.
W26	TOTAL PROPULSION GROUP WEIGHT	11577.
<b>STRUCTURE GROUP</b>		
W27	WING	0.
W28	TAIL GROUP	143.
W29	HOB, TAIL	106.
W30	TAIL ROTOR	0.
W31	FUSFLANK	3260.
W32	LANDING GEAR	1007.
W33	HOSE GRAB	219.
W34	MAIN GRAB	1177.
W35	TOTAL FRAME SECTION	274.
W36	PRIMARY ENGINE SECTION	0.
W37	AUXILIARY ENGINE SECTION	276.
W38	STRUCTURE WEIGHT INCREMENT	0.
W39	TOTAL STRUCTURE WEIGHT	7000.
<b>FLIGHT CONTROLS GROUP</b>		
W40	PRIMARY FLIGHT CONTROLS	1125.
W41	COCKPIT CONTROLS	76.
W42	MAIN ROTOR CONTROL	400.
W43	AUXILIARY SYSTEM CONTROL	312.
W44	FLY BY WIRE CONTROLS	1810.
W45	TELE OPERATOR	0.
W46	SEE	75.
W47	AUXILIARY FLIGHT CONTROLS	280.
W48	AUX. PROPULSION ROTOR CONTROLS	0.
W49	AUX. PROPULSION ROTOR SYS. CONTROLS	326.

VMC DELTA WFC	MISCELLANEOUS CONTROLS CONTROL WEIGHT INCREMENT	60.
WFC	TOTAL CONTROL WEIGHT	0.
WFF	WEIGHT OF FIXED EQUIPMENT	1396.
WF	WEIGHT EMPTY	2475.
WFHL	FIXED USEFUL LOAD	22722.
WV	OPERATING WEIGHT EMPTY	869.
WPL	PAYLOAD	23646.
WFD	FUEL	6320.
WS	GROSS WEIGHT	4196.
		34144.

SAMPLE CASE NO. 3 RUN 2

PAGE 4

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-9J  
M F S C O M P

R O T O R   C A T A

FIXED MAIN ROTOR SOLIDITY INPUT



HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM P-91

M F S L O V P

PL O F U L S I O N D A T A  
PRIMARY PROPELLSION CYCLE NO. 2-410  
TURBO-SHAFT ENGINE

2. ENGINES

PRCOP MAX. STANDARD S.O.L. STATIC H.P. 9971. H.P.

FACTORY SIZED FOR CRUISE AT VC = 2100 KNOTS  
ROTOR POWER SETTING, 90.7 PERCENT MAXIMUM RPM  
TAU/RT = 1.000, HP = 0.000, VTY, VELOCITY = 0.000, 0.000  
AUX OF ENGINE INOPERATIVE.

AS AUX. INEFFICIENT ENGINE CYCLE SELECTED

MAIN ROTOR DRIVE SYSTEM RATING 10174. H.P.

FACTORY SIZED AT 100 PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.O.L. STATIC H.P.) 19.7 PERCENT MAXIMUM RPM

AUXILIARY PROPELLSION DRIVE SYSTEM RATING 4567. H.P.

FACTORY SIZED AT 99 PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.O.L. STATIC H.P.) 19.7 PERCENT MAXIMUM RPM

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91  
M F S C O M P

A E R O D Y N A M I C S D A T A			
FE	TOTAL EFFECTIVE FLATPLATE AREA	16.493	SOFT
SMET	TOTAL WETTED AREA	1292.	SOFT
CRARF	MEAN SKIN FRICTION COEFF.	0.012766	
D R A G C O E F F I C I E N T	IN SOFT		
FFV	WING	0.1	
FFF	FUSELAGE FE	16.493	
FFFP	FORWARD(MAIN) ROTOR PYLON FF	3.0	
FEAP	AFT ROTOR PYLON FE	0.0	
FFMRH	MAIN ROTOR HUB FE	0.0	
FFVRH	TAIL ROTOR HUB FE	3.0	
FFVT	VERTICAL TAIL FF	0.0	
FFHT	HORIZONTAL TAIL FE	3.0	
FFM	PRIMARY ENGINE NACELLE FF	0.0	
FFMJ	AUX. INDEPENDENT CRUISE ENG. NAC. FE	3.0	
FFMS	AUX. INDEPENDENT CRUISE ENG. STRUT FE	3.0	
FFLTA FE	INCREMENTAL FF	3.0	
A E R O D Y N A M I C C O E F F			
A6		16.49284	
A7		0.5	
A8		0.1	
A9		0.1	
F	WING LIFT EFFICIENCY FACTOR	0.24666	
CVT	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.06071	

H F S C O W P  
 HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 8-91

MISSION PERFORMANCE DATA

TAKEOFF, HOVER, OR LAND AT WTEF = 1.00000E 00, 73 WPS.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRESS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PPHF	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	CPRO	CT	CT/SIGMA
0-0	0.0	0.0	36164	0	0	25500	Y	1.000	3646	0.0	0.730	7011	0.020	0.11
650.0	7361	0.0000	36164	342	3646	25500	A	1.000	3646	0.0	0.730	7011	0.020	0.11
0-011	0.0	40.5	36123	0	0	25500	Y	1.000	3646	0.0	0.730	7011	0.020	0.11
650.0	7367	0.0000	36123	342	3646	25500	A	1.000	3646	0.0	0.730	7011	0.020	0.11
0-022	0.0	80.0	36083	0	0	25500	Y	1.000	3646	0.0	0.730	7011	0.020	0.11
650.0	7354	0.0000	36083	342	3646	25500	A	1.000	3646	0.0	0.730	7011	0.020	0.11
0-033	0.0	121.4	36042	0	0	25500	Y	1.000	3646	0.0	0.730	7011	0.020	0.11
650.0	7340	0.0000	36042	341	3646	25500	A	1.000	3646	0.0	0.730	7011	0.020	0.11

CLIMB TO 500. FT. WITH MAXIMUM R/C AT MILITARY CONFIGURATION  
 TO TASCARD EAST TO THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRESS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PPHF	AUX. ENG. CODE	AUX. ENG. PPHF	TAUX/T FUEL FLOW (LBS/HR)	ROTLM	ROTLM CODE	CT	CT/SIGMA	R/C (FT/M)
0-033	0.0	121.4	36042	0	0	25500	Y	1.000	0	0	0	0	0	0.0	0.0	0.0
650.0	1443	0.0000	36042	4230	4230	25500	Y	1.000	0	0	0	0	0	0.0	0.0	0.0
0-035	0.0	127.0	36042	0	0	25500	Y	1.000	0	0	0	0	0	0.0	0.0	0.0
650.0	1445	0.0000	36042	4120	4120	25500	Y	1.000	0	0	0	0	0	0.0	0.0	0.0
0-0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0

TIME (HRS)	PANF (LBS)	FUEL USED (LBS)	WTGHT (LBS)	ALT. (FT)	PRPS. (FT)	TAS (KTS)	TRIP TURB. TEMP. (R)	PRIP TURB. TEMP. (R)	PHD PUMP FUEL FLOW (LBS/HR)	PHD AUX FUEL FLOW (LBS/HR)	STAB CORR	TAUST FUEL FLOW (LBS/HR)	FAS (KTS)	PU	TY CRIM (CY)	ALPPL D/L (LBS)	SPEC RANGE (LBS)	ETA
00016 65000 000	0.24 1999. 0.0	333.4 0.0	36030. 0.0	1400. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.252	0.130	0.06	20.2	0346. 55.0
00038 65000 000	0.43 2030. 0.0	141.1 0.0	36020. 0.0	1500. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.255	0.141	0.06	20.6	0255. 54.1
00030 65000 000	0.56 2101. 0.0	146.4 0.0	36017. 0.0	2100. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.255	0.143	0.06	20.1	0161. 53.0
00041 65000 000	0.74 2257. 0.0	152.7 0.0	36011. 0.0	2500. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.257	0.145	0.06	20.5	0170. 52.0
00042 65000 000	0.83 2333. 0.0	159.1 0.0	36005. 0.0	3000. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.257	0.147	0.06	20.0	0076. 51.0
00044 65000 000	1.06 2479. 0.0	165.5 0.0	35990. 0.0	3500. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.261	0.140	0.06	20.3	0035. 50.0
00046 65000 000	1.22 2610. 0.0	172.0 0.0	35980. 0.0	4000. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.262	0.141	0.06	21.7	0196. 49.0
00047 65000 000	1.39 2766. 0.0	177.6 0.0	35970. 0.0	4500. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.265	0.139	0.06	21.0	0171. 48.0
00049 65000 000	1.57 2917. 0.0	185.8 0.0	35970. 0.0	5000. 0.0	0.0	0.0	2540.0 57.	0.0	0.0	0.0	1.000 0.300	0.0	0.0	0.265	0.139	0.06	20.3	0124. 47.0

CRUISE AT 14000 FT. 145. LIMITED BY NORMAL ENGINE RATING

MONITOR VIF (FPS)	MONITOR FMD (FPS)	YACHTOR VIF (FPS)	YACHTOR FMD (FPS)	COMD	COMD	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	CELOP	
00045 55000 300	1.57 2196. 0.0	180.0 0.0	35570. 0.0	5000. 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
00133	16.57	276.4	35727.	2100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TIME (MRS)	ALT (FT)	WIND (KTS)	WIND DIR	WIND SFC	WIND 1000	WIND 2000	WIND 3000	WIND 4000	WIND 5000	WIND 6000	WIND 7000	WIND 8000	WIND 9000	WIND 10000	WIND 11000	WIND 12000	WIND 13000	WIND 14000	WIND 15000	WIND 16000	WIND 17000	WIND 18000	WIND 19000	WIND 20000	
530.0	0.0	3150	0.0	0.0	2283	0.0	1365	0.0	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.216	5120	566.7	35507	5.00	3180	2150.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	5120	0.0	0.0	0.0	2271	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.299	4657	755.9	35000	5.00	1800	2147.5	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	4657	0.0	0.0	0.0	2258	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.284	6157	544.1	35228	5.00	1800	2144.3	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	6157	0.0	0.0	0.0	2247	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.457	7500	1111.7	35052	5000	1800	2141.4	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.0	7500	0.0	0.0	0.0	2236	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TRANSFER ALTITUDE TO 2000 FT.

TIME (MRS)	FUEL USED (LBS)	WEIGHT (LBS)	ALT (FT)	FUEL USED (LBS)	WEIGHT (LBS)	ALT (FT)
0.457	7500	1111.7	35052	5000	1800	2141.4
0.457	7500	1111.7	35052	5000	1800	2141.4

CRUISE AT NORMAL ENGINE RATING

TIME (MRS)	ALT (FT)	WIND (KTS)	WIND DIR	WIND SFC	WIND 1000	WIND 2000	WIND 3000	WIND 4000	WIND 5000	WIND 6000	WIND 7000	WIND 8000	WIND 9000	WIND 10000	WIND 11000	WIND 12000	WIND 13000	WIND 14000	WIND 15000	WIND 16000	WIND 17000	WIND 18000	WIND 19000	WIND 20000	
0.517	5120	566.7	35507	5.00	3180	2150.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
583.0	5120	0.0	0.0	0.0	2271	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.577	4657	755.9	35000	5.00	1800	2147.5	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
583.0	4657	0.0	0.0	0.0	2258	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.637	6157	544.1	35228	5.00	1800	2144.3	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
583.0	6157	0.0	0.0	0.0	2247	0.0	1365	0.683	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

0.696	135.00	2029.6	34134.	2000.	254.0	2500.0	Y	0.910	246.6	0.735	0.167	0.0	0.66612	PR02.
583.1	4896.	0.0000	0.0	0.0	3842.	3770.	0.716	1.000	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	A	---	---	---	---	---	---
0.755	150.00	2256.5	33907.	2000.	255.2	2500.0	T	0.910	247.0	0.739	0.166	0.0	0.66639	AR04.
583.1	4853.	0.0000	0.0	0.0	3843.	3824.	0.716	1.000	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	A	---	---	---	---	---	---

TRANSFER ALTITUDE TO 1000. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	WEIGHT (LBS.)	PRFS. ALT. (FT)
0.755	150.00	2256.5	33907.	33907.	2000.
0.755	150.00	2256.5	33907.	33907.	1000.

LOTTER FOR 0.500 HRS.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENB. CODF	PRIM. ENR. PPMF	FAS (KTS)	MU	CT PRIM OVER SIGMA	ALPHA D/L (DEG)	TOTAL FUEL FLOW (LBS/HR)	RMP
M-ROTOR VTIIP (FPS)	M-ROTOR RMP	T-ROTOR VTIIP (FPS)	T-ROTOR RMP	PROP VTIIP (FPS)	PROP FUEL FLOW (LBS/HR)	RMP AUX	FTAP PROP	AUX. ENR. PPMF	AUX. ENR. PPMF	AUX. TURB. TEMP.	ENG. CODE	AUX. ENR. PPMF	ENG. CODE	ENG. OR THRUST
CPRO	CPIND	CPPAR	CPNUD	CDN	DELCD8	DELCDM	CRX	ROTLIM CODE	J	CP	CT	CLV	CDU	RM
0.755	150.00	2256.5	33907.	1000.	75.0	1974.7	P	0.204	74.7	0.197	0.131	-0.4	1546.	1092.
650.0	1796.	0.0	0.0	0.0	1546.	36.	0.635	0.300	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00096	A	---	---	---	---	---	---
0.855	150.00	2411.1	33753.	1000.	75.8	1933.2	P	0.202	74.7	0.197	0.130	-0.4	1541.	1076.
650.0	1773.	0.0	0.0	0.0	1541.	36.	0.635	0.300	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00096	A	---	---	---	---	---	---
0.955	150.00	2565.2	33599.	1000.	75.0	1931.7	P	0.201	74.7	0.197	0.130	-0.4	1536.	1059.
650.0	1757.	0.0	0.0	0.0	1536.	36.	0.635	0.300	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00096	A	---	---	---	---	---	---
1.055	150.00	2718.0	33405.	1000.	76.4	1930.2	P	0.199	75.7	0.200	0.129	-0.4	1531.	1044.
650.0	1741.	0.0	0.0	0.0	1531.	39.	0.635	0.300	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00096	A	---	---	---	---	---	---
1.155	150.00	2871.0	33292.	1000.	76.8	1928.8	P	0.197	75.7	0.200	0.129	-0.4	1526.	1029.
650.0	1726.	0.0	0.0	0.0	1526.	39.	0.635	0.300	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00096	A	---	---	---	---	---	---
1.255	150.00	3024.0	33119.	1000.	76.0	1927.3	P	0.196	75.7	0.200	0.129	-0.4	1521.	1012.
650.0	1710.	0.0	0.0	0.0	1521.	39.	0.635	0.300	---	---	---	---	---	---
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00096	A	---	---	---	---	---	---

TRANSFER ALTITUDE TO 0. FT.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LPS)	WEIGHT (LBS.)	PRES. ALT. (FT)	PRIM. ENR. CODE	ROTLM CODE	PRIM. ENR. CODE	TAS (KTS)	AUX. ENG. FUEL FLOW (LBS/HR)	ROTLM CODE	PRIM. ENR. P/MPH	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	BTW	CT	CT/SIGMA
1-255 658.6	150.00 4879.	5024.4 0.0000	33139. 0.	0. 314.	0. 2640.	P A	0.673 A	2945.6 2640.	2498. 90.0	P A	0.673 A	2498. 90.0	1.060 0.0	0.746 0.746	5320. 0.0	0.0154 0.0	0.130 0.0
1-305 658.8	150.00 4889.	3159.3 0.0000	33004. 0.	0. 313.	0. 2647.	P A	0.669 A	2342.9 2647.	2687. 90.0	P A	0.669 A	2687. 90.0	1.060 0.0	0.746 0.746	5297. 0.0	0.1153 0.0	0.119 0.0
1-355 658.8	150.00 4819.	3293.6 0.0000	32870. 0.	0. 311.	0. 2676.	P A	0.665 A	2340.3 2676.	2878. 90.0	P A	0.665 A	2878. 90.0	1.060 0.0	0.746 0.746	5265. 0.0	0.0153 0.0	0.137 0.0
1-405 658.8	150.00 4789.	3427.4 0.0000	32736. 0.	0. 310.	0. 2665.	P A	0.661 A	2337.7 2665.	2645. 90.0	P A	0.661 A	2645. 90.0	1.060 0.0	0.746 0.746	5233. 0.0	0.1152 0.0	0.137 0.0
1-455 658.8	150.00 4759.	3560.7 0.0000	32603. 0.	0. 309.	0. 2655.	P A	0.657 A	2335.1 2655.	2655. 90.0	P A	0.657 A	2655. 90.0	1.060 0.0	0.746 0.746	5201. 0.0	0.0151 0.0	0.136 0.0
1-505 658.8	150.00 4730.	3693.4 0.0000	32470. 0.	0. 307.	0. 2644.	P A	0.653 A	2332.5 2644.	2644. 90.0	P A	0.653 A	2644. 90.0	1.060 0.0	0.746 0.746	5170. 0.0	0.1151 0.0	0.136 0.0
1-555 658.8	150.00 4730.	3693.4 0.0000	32470. 0.	0. 307.	0. 2644.	P A	0.655 A	2332.5 2644.	2644. 90.0	P A	0.655 A	2644. 90.0	1.060 0.0	0.746 0.746	5170. 0.0	0.0151 0.0	0.136 0.0

CLIMB TO 3000. FT. WITH MAXIMUM R/C AT MILITARY FLIGHT RATING  
 \*\* TAS(AND FAR) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	RANGE (N.M.)	FUEL USED (LPS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. ENR. CODE	ROTLM CODE	PRIM. ENR. P/MPH	AUX. ENG. FUEL FLOW (LBS/HR)	ROTLM CODE	PRIM. ENR. P/MPH	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	BTW	CT	CT/SIGMA
1-585 658.8	150.00 4730.	3693.4 0.0000	32470. 0.	0. 307.	0. 2644.	P A	0.655 A	2332.5 2644.	2644. 90.0	P A	0.655 A	2644. 90.0	1.060 0.0	0.746 0.746	5170. 0.0	0.0151 0.0	0.136 0.0





1-513	1-0-74	3725.7	32074	3-0-0	180.7	2131.7	P	0.001	151.1	0.482	0.132	0.0	0.017	44.0
650-0	2659	0.0000	0.0	0.0	2266	1677	0.0	0.687	0.000	0.000	0.000	0.000	0.000	0.000
1-512	1-0-74	3014.2	32254	3-0-0	160.3	2120.0	P	0.078	151.1	0.482	0.131	0.0	0.017	44.0
650-0	2653	0.0000	0.0	0.0	2250	1677	0.0	0.687	0.000	0.000	0.000	0.000	0.000	0.000
1-512	1-0-74	4064.1	32074	3-0-0	179.2	2125.2	P	0.078	151.1	0.482	0.131	0.0	0.017	44.0
650-0	2612	0.0000	0.0	0.0	2252	1677	0.0	0.687	0.000	0.000	0.000	0.000	0.000	0.000
1-511	1-0-74	4222.7	31911	3-0-0	180.8	2120.0	P	0.078	150.6	0.477	0.129	0.0	0.017	43.0
650-0	2653	0.0000	0.0	0.0	2240	1664	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-510	1-0-74	4446.2	31757	3-0-0	185.1	2123.1	P	0.078	151.6	0.487	0.129	0.0	0.017	43.0
650-0	2653	0.0000	0.0	0.0	2231	1664	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-510	1-0-74	4617.3	31546	3-0-0	188.2	2115.0	P	0.078	151.6	0.487	0.129	0.0	0.017	43.0
650-0	2634	0.0000	0.0	0.0	2217	1650	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-509	1-0-74	4722.0	31370	3-0-0	186.2	2111.7	P	0.078	151.6	0.487	0.129	0.0	0.017	43.0
650-0	2618	0.0000	0.0	0.0	2211	1650	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-509	1-0-74	4944.0	31194	3-0-0	187.1	2110.0	P	0.078	170.6	0.486	0.127	0.0	0.017	43.0
650-0	2609	0.0000	0.0	0.0	2197	1640	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-508	1-0-74	5142.3	31018	3-0-0	187.1	2111.4	P	0.078	170.6	0.486	0.127	0.0	0.017	43.0
650-0	2619	0.0000	0.0	0.0	2191	1630	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-508	1-0-74	5320.2	30843	3-0-0	187.4	2111.0	P	0.078	170.6	0.486	0.125	0.0	0.017	43.0
650-0	2610	0.0000	0.0	0.0	2180	1630	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000
1-505	1-0-74	5486.0	30674	3-0-0	187.1	2109.0	P	0.078	170.2	0.486	0.125	0.0	0.017	43.0
650-0	2621	0.0000	0.0	0.0	2172	1626	0.0	0.686	0.000	0.000	0.000	0.000	0.000	0.000

TRANSFER ALTIITUDE TO 1. FT.

TIME RANGE FULL USED WEIGHT WFTMT  
 (MRS) (M.P.) (MRS) (MRS) (MRS)  
 2-300 300.00 500.00 300.00  
 2-300 300.00 500.00 300.00

TARGET, POWER OR LAND AT 1/4 IN 1.16 FOR 0.33 HRS.

TIME (MRS)	RANGE (M.P.)	TIME USED (MRS)	WEIGHT (MRS)	WFTMT (MRS)	PRCS (MRS)	ALTY (MRS)	YAF (MRS)	PAIM TURP YAF (MRS)	COIL RAC. COIL (MRS)	FRIM. CHG. COIL (MRS)	TOTAL SUFF. SUFF. (MRS)	WEIGHT TO (MRS)	FR (MRS)	CF (MRS)	CF (MRS)
1-513	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-512	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-512	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-512	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-511	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-510	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-510	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-509	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-509	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-509	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

W. ROTOR VTIP	M. ROTOR AMP	T. ROTOR VTIP (FPS)	T. ROTOR PMP	VAC AMP	PRIM. FMS FUEL FLOW (LBS/MR)	AUX. FMS FUEL FLOW (LBS/MR)	ROT LIM CODE	TFMP NEG. (F)	NELOCP	FMI	CPPRO	CPI'N	CD
2.305 650.0	300.00 4215.	5425.0 0000.	30470. 0.	0. 291.	0. 2467.	2176.5 ----	P A	2467. 59.0	1.061 0.0	0.747 0.747	4624. 0.0	0.134 0.	0.121 0.
2.316 650.0	300.00 4210.	5513.4 0000.	30650. 0.	0. 290.	0.0 2464.	2176.0 ----	P A	2465. 59.0	1.060 0.0	0.747 0.747	4622. 0.	0.134 0.	0.121 0.6
2.327 650.0	301.00 4214.	5500.4 0000.	30623. 0.	0. 290.	0.0 2463.	2175.6 ----	P A	2463. 59.0	1.060 0.0	0.747 0.747	4614. 0.0	0.134 0.	0.121 0.
2.338 650.0	300.00 4190.	5560.1 0000.	30592. 0.	0. 290.	0.0 2471.	2175.1 ----	P A	2461. 59.0	1.060 0.0	0.747 0.747	4616. 0.0	0.6 0.0	0.121 0.

MISSION FUEL REQUIRED = 5848.74  
 RESERVE FUEL REQUIRED = 418.42  
 TOTAL FUEL REQUIRED = 6267.16

.....

END OF SUCCESSFUL CASE

.....

RECEIVED SYSTEM PERFORMANCE COMPUTER (RCP) (R-01)

THE FOLLOWING IS A CARD BY CARD REPRODUCTION OF THE INPUT DECK FOR THIS CASE

LOC CORRESPONDS TO LOCATION NUMBER WITH AN INPUT SHEET  
 NUM STAGE FOR THE NUMBER OF STAGES THAT INPUT VALUE STARTING WITH LOC. (MAX. 99)  
 VAL INPUTS VALUE FOR VARIABLE CORRESPONDING TO LOC.  
 VAL1 VALUE CORRESPONDING TO LOC. 001  
 VAL2 VALUE CORRESPONDING TO LOC. 002  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3
001	001	001	001	001	001

ACTS IN USING AUXILIARY LOCATIONS. AUXILIARY LOCATIONS INPUT LOCATIONS CAN BE CREATED BY SELECTING A CARRY CARD IN FRONT OF A NUMBER & STANDARD PUNCH CYCLE

LOC	NUM	VAL	VAL1	VAL2	VAL3
002	001	001	001	001	001
003	001	001	001	001	001
004	001	001	001	001	001
005	001	001	001	001	001

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-01

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER

R T F O A T A THIS RUN CONVERGED IN 7 ITERATIONS  
 GROSS WEIGHT = 30820.10

FUSELAGE  
 LF 37.0 FT.  
 LC 29.3 FT.  
 LP 35.2 FT.  
 KM 3.0 FT.  
 WF 14.1 FT.  
 EF 9.2 FT.  
 WTTED AREA 226.4 SQ. FT.

WING - NO WING USED  
 POP. TAIL  
 ARWT 2.5 FT.  
 RWT 22.2 SQ. FT.  
 PWT 21.3 FT.  
 CBARWT 3.0 FT.  
 LAPRDA W 3.0 FT.  
 T/T/DHT 1.6 FT.  
 LTM 1.1 FT.  
 ASPECT RATIO 10.7 FT.  
 SPAN 21.3 FT.  
 MEAN CHORD 3.0 FT.  
 TAPER RATIO 1.6 FT.  
 THICKNESS/CHORD 1.1 FT.  
 HOP. TAIL ARM 10.7 FT.

VERT. TAIL  
 ARVT 1.5 FT.  
 RVT 25.0 SQ. FT.  
 PVT 6.7 FT.  
 CBARVT 4.0 FT.  
 LAPRDA VT 6.50 FT.  
 ZTA 1.0 FT.  
 ZTAVT 1.0 FT.  
 T/T/DVT 1.0 FT.  
 ASPECT RATIO 1.5 FT.  
 AREA 25.0 SQ. FT.  
 SPAN 6.7 FT.  
 MEAN CHORD 4.0 FT.  
 TAPER RATIO 6.50 FT.  
 TAIL ROTOR/VERT. LOCATION 1.0 FT.  
 TAIL ROTOR/VERT. TAIL OVERLAP RATIO 1.0 FT.  
 THICKNESS/HOPD 1.0 FT.

MAIN ROTOR PYLON  
 AR 1.21 FT.  
 RAR 1.0 FT.  
 PAPP 4.4 SQ. FT.  
 MP 3.0 FT.  
 CRARFP 17.0 FT.  
 LAPRDA FP 1.7 FT.  
 T/T/CP 1.0 FT.  
 T/T/CT 1.0 FT.  
 ASPECT RATIO 1.21 FT.  
 WTTED AREA 1.0 FT.  
 FRONTAL AREA 4.4 SQ. FT.  
 WFLIGHT 3.0 FT.  
 WFLM CHORD 17.0 FT.  
 TAPER RATIO 1.7 FT.  
 ROOT THICKNESS/CHORD 1.0 FT.  
 TIP THICKNESS/CHORD 1.0 FT.

PRIMARY ENGINE PELLETS

LN LENGTH 1.0 FT.  
 DN MEAN DIAMETER 1.0 FT.  
 SN VITTED AREA TOTAL FOR ALL PELLETS 0.0 SQ. FT.

AUXILIARY INDEPENDENT ENGINE PELLETS -NO AUXILIARY INDEPENDENT ENGINE USED

PROPELLER/AUXILIARY PROPELLER

DIE DIAMETER 0.0 FT.  
 AT ACTIVITY FACTOR FOR HEAD 1.00  
 SICAF SOLIDITY 1.00  
 PRA NO. OF PROPELLERS 2  
 NO. BLADES NO. OF BLADES/PROP 13  
 VTIP TIP SPEED 0.00 FT./SEC

MAIN ROTOR

RPR DIAMETER 0.0 FT.  
 SICAF SOLIDITY 1.00  
 WCA/A DISC LOADING 15.0 LB/SQ. FT.  
 CY/SICAF THRUST COEFF./SOLIDITY 0.0  
 RP NO. OF ROTORS 1  
 NO. BLADES NO. OF BLADES/PROP 6  
 THETA CLANG TWIST -13.00 DEG.  
 XC CLANG CUTOUT/RADIUS RATIO 0.1  
 VTIP TIP SPEED 0.00 FT./SEC.

- NO TOTAL ROTOR USED

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-91

V F I R M T S D A T A IN LBS

HLF	MANEUVER LOAD FACTOR	3.000
ULF	ULTIMATE LOAD FACTOR	4.500
PROPULSION GROUP		
MPBR	TOTAL MAIN ROTOR GROUP	4694.
K12	MAIN ROTOR PLATE (PER ROTOR)	2.75.
K13	MAIN ROTOR HUB (PER ROTOR)	2620.
UMF	BLADE FOLDING/DRIVE ROTOR	0.
UMR	AUXILIARY PROPULSION ROTOR GROUP	25.
UMS	DRIVE SYSTEM	264.
UMT	MAIN ROTOR DRIVE SYSTEM	24.7.
UMU	TAIL ROTOR DRIVE SYSTEM	0.
UMV	AUXILIARY PROPULSION DRIVE SYSTEM	170.
UMW	PRIMARY ENGINES	1367.
UMX	AUXILIARY ENGINES	0.
UMY	PRIMARY ENGINE INSTALLATION	252.
UMZ	AUXILIARY ENGINE INSTALLATION	0.
UMAA	FUEL SYSTEM	418.
UMAB	PROPULSION GROUP WEIGHT INCREMENT	5.
UMAC	TOTAL PROPULSION GROUP WEIGHT	4547.
STRUCTURES GROUP		
USC	TAIL GROUP	0.
USD	HUB, TAIL	144.
USE	TAIL ROTOR	164.
USF	FUSelage	3.17.
USG	LANDING GEAR	1217.
USH	NOSE GEAR	243.
USI	MAIN GEAR	473.
USJ	TOTAL ENGINE SECTION	276.
USK	PRIMARY ENGINE SECTION	276.
USL	AUXILIARY ENGINE SECTION	0.
USM	STRUCTURE WEIGHT INCREMENT	2.
USN	TOTAL STRUCTURE WEIGHT	4575.
FLIGHT CONTROLS GROUP		
UOP	PRIMARY FLIGHT CONTROLS	22.
UOQ	COCKPIT CONTROLS	71.
UOR	MAIN ROTOR CONTROLS	274.
UOS	MAIN ROTOR SYSTEMS CONTROLS	210.
UOT	FIXED WING CONTROLS	182.
UOU	TIPT MECHANISM	0.
UOV	SAS	75.
UOW	AUXILIARY FLIGHT CONTROLS	182.
UOX	AUX. PROPULSION ROTOR CONTROLS	25.
UOY	AUX. PROPULSION ROTOR SYS. CONTROLS	97.

WPC	MISCELLANEOUS CONTROLS	
DELTA WFC	CONTROL WEIGHT INCREMENT	0. 6.3
WFC	TOTAL CONTROL WEIGHT	1104.
WFE	WEIGHT OF FIXED EQUIPMENT	2475.
WE	WEIGHT EMPTY	38001.
WFUL	FIXED USEFUL LOAD	864.
OWE	OPERATING WEIGHT EMPTY	11667.
WPI	PAYLOAD	6327.
WUFA	FUEL	1227.
WC	GROSS WEIGHT	3420.

SAMPLE CASE NO. 3 PUN 3

PAGE 4

M - S C O ' P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-43

R O T O R D A T A

FIXED MAIN ROTOR SOLIDITY INPUT



HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91  
M E S C D M P

P R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE NO. 2.410  
TURBOSHAFT ENGINE

2. ENGINES

PHP\*P      MAX. STANDARD S.L. STATIC M\*P      8676.      H\*P.

ENGINE SIZED FOR CRUISE AT VC = 210. KNOTS.  
NORMAL POWER SETTING, 49.7 PERCENT HOVER RPM,  
TAUH/T = 1.000, MC = 0. FT, TEMPERATURE = 59.00 DEG.F.,  
AND C.A. ENGINES IMPERATIVE.

NO AUX. INDEPENDENT ENGINE CYCLE SELECTED

MAIN ROTOR DRIVE SYSTEM RATING      4891.      H\*P.

XMSN SIZED AT 56. PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.L. STATIC H\*P.), 49.7 PERCENT HOVER RPM

AUXILIARY PROPULSION DRIVE SYSTEM RATING      1785.      H\*P.

XMSN SIZED AT 21. PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.L. STATIC H\*P.), 49.7 PERCENT HOVER RPM

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-03

A E R O D Y N A M I C S D A T A			
FF	TOTAL EFFECTIVE FLATPLATE AREA	14.968	SGFT
SUET	TOTAL WETTED AREA	1295.	SGFT
CRNF	MEAN SKIN FRICTION COEFF.	0.1211A	
D R A G P R F A K D O W N	IN. SOFT		
FFW	WING FE	3.0	
FFP	FUSELAGE FF	14.968	
FFFP	FORWARD(MAIN) ROTOR PYLON FF	0.0	
FEAP	AFT ROTOR PYLON FF	0.0	
FERPM	MAIN ROTOR HUB FF	0.0	
FFTRH	TAIL ROTOR HUB FF	0.0	
FFVT	VERTICAL TAIL FE	0.0	
FFHT	HORIZONTAL TAIL FE	0.0	
FFN	PRIMARY ENGINE MACILL FF	0.0	
FFNI	AUX. INDEPENDENT CRUISE ENG. MAC. FE	0.0	
FENS	AUX. INDEPENDENT CRUISE ENG. STRUT FE	0.0	
DELTA FE	INCREMENTAL FF	0.0	
A E R O D Y N A M I C C O E F F .			
AP		14.16764	
AG		0.0	
AT		0.0	
AC		0.0	
AP		0.2409F	
F	WING LIFT EFFICIENCY FACTOR	0.0	
LV	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.64171	

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91

MISSION PERFORMANCE DATA

TAKEOFF, HOVER, OR LAND AT PETF = 1.000 FOR 0.033 HRS.

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	VTIP (FPS)	T-ROTOR RMP	TAS (KTS)	PRIM. TURP. TEMP. (R)	FRIM. ENG. CODE	PRIM. ENG. PERF	TOTAL FUEL FLOW (LBS/HR)	THRUST TO WEIGHT	FM	BHP	CT	CT/SIGMA
0.0	0.0	0.0	0.0	30420	0.0	2586.3	T	1.000	3173	1.289	0.726	6685	0.0204	0.184
650.0	6438	0.0	288	0.0	3173	0.0	A	0.0	90.0	0.0	0.728	0.0	0.0	0.0
0.011	0.0	35.2	0.0	30385	0.0	2586.3	C	1.070	3049	1.258	0.730	6617	0.0199	0.179
650.0	6168	0.0	288	0.0	3149	0.0	A	0.0	90.0	0.0	0.730	0.0	0.0	0.0
0.022	1.0	69.1	0.0	30351	0.0	2551.5	G	1.000	3066	1.258	0.731	6615	0.0199	0.179
650.0	6156	0.0	287	0.0	3168	0.0	A	0.0	90.0	0.0	0.731	0.0	0.0	0.0
0.033	0.0	103.1	0.0	30317	0.0	2551.7	Q	1.000	3069	1.258	0.731	6594	0.0199	0.179
650.0	6145	0.0	287	0.0	3169	0.0	A	0.0	90.0	0.0	0.731	0.0	0.0	0.0

CLIMB TO 500. FT. WITH MAXIMUM R/C AT MILITARY ENGINE RATING  
 \*\* TAS (AND FAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	VTIP (FPS)	T-ROTOR RMP	TAS (KTS)	PRIM. TURP. TEMP. (R)	FRIM. ENG. CODE	PRIM. ENG. PERF	DELCDM	DELCDL	DELCDR	DELCDM	DELCDL	DELCDR	DELCDM	DELCDL	DELCDR	DELCDM	DELCDL	DELCDR
0.0	0.0	1.3.1	30317	0.0	0.0	2306.2	0	1.000	98.7	0.259	0.130	0.7	10.0	5622	3487					
650.0	1656	0.0	0.0	0.0	2675	57	(.85)	0.3												
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000179	A												
0.036	0.24	109.5	30311	500	98.7	2308.6	0	1.000	98.0	0.259	0.137	0.7	10.9	5619	3466					
650.0	1676	0.0	0.0	0.0	2661	57	(.85)	0.3												
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000179	A												

0.038	0.00	115.0	30204.	1000.	96.7	2311.6	0	1.000	97.5	0.269	0.139	-0.7	14.0	5616.	3444.
0.00	1690.	0.0	0.0	0.0	2647.	56.	0.000179	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.041	0.72	122.5	30290.	1500.	99.7	2310.0	0	1.000	97.5	0.262	0.141	-0.7	14.5	5617.	3421.
0.00	1720.	0.0	0.0	0.0	2630.	57.	0.000183	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.043	0.97	124.7	30291.	2000.	99.7	2310.0	0	1.000	96.0	0.262	0.143	-0.7	14.4	5614.	3305.
0.00	1750.	0.0	0.0	0.0	2622.	56.	0.000186	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.045	1.21	130.2	30285.	2500.	100.7	2321.7	0	1.000	97.1	0.264	0.145	-0.7	14.1	5611.	3364.
0.00	1770.	0.0	0.0	0.0	2611.	57.	0.000186	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.048	1.41	141.6	30279.	3000.	100.7	2320.4	0	1.000	96.5	0.264	0.147	-0.7	17.0	5611.	3330.
0.00	1810.	0.0	0.0	0.0	2590.	56.	0.000186	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.050	1.72	148.1	30272.	3500.	101.7	2329.6	0	1.000	96.6	0.267	0.149	-0.7	17.6	5612.	3370.
0.00	1840.	0.0	0.0	0.0	2587.	57.	0.000190	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.053	1.90	154.6	30266.	4000.	101.7	2333.0	0	1.000	95.9	0.267	0.151	-0.7	17.5	5608.	3273.
0.00	1880.	0.0	0.0	0.0	2577.	56.	0.000190	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.055	2.24	161.2	30259.	4500.	102.7	2330.0	0	1.000	96.1	0.269	0.154	-0.7	17.1	5607.	3236.
0.00	1920.	0.0	0.0	0.0	2567.	57.	0.000194	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000
0.058	2.51	167.0	30252.	5000.	103.7	2344.1	0	1.000	96.5	0.272	0.156	-0.7	14.0	5606.	3100.
0.00	1960.	0.0	0.0	0.0	2560.	57.	0.000197	0.850	0.300	0.000	0.000	0.000	0.000	0.000	0.000

CRUISE AT 140.0 KNOTS TAS, LIMITED BY NORMAL ENGINE RATING

TIME (HRS)	RANGE (N.M.I)	FUEL USED (LBS)	WEIGHT (LBS)	PRFS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CONF	PRIM. ENG. PLMF	LAS (KTS)	MU	CT PRIMF OVER SIGMA	ALPHA D/L (DEG)	SCC. RANGE (NMPP)	FHP
M-ROTOR V/TTP (FPS)	M-ROTOR RPM	T-ROTOR V/TTP (FPS)	T-ROTOR RPM	PROP V/TTP (FPS)	PRIM-ENG FUEL FLOW (LBS/HR)	RHP AUX	PROP	TAXI/T FUEL FLOW (LBS/HR)	J	CP	CT	CLV	CDU	RH
0.058	2.51	167.0	30252.	5000.	103.0	2340.0	P	1.026	147.1	1.467	0.155	0.0	0.0	0.170
0.00	2000.	0.0	0.0	0.0	1940.	1940.	1.063	1.000	0.000	0.000	0.000	0.000	0.000	0.000
0.141	17.51	333.3	30067.	5700.	160.1	2140.5	P	0.626	117.1	0.467	0.145	0.0	0.0	0.114
0.00	17.51	333.3	30067.	5700.	160.1	2140.5	P	0.626	117.1	0.467	0.145	0.0	0.0	0.114





TRANSFER ALTITUDE TO 0. FT.

TYPE (MRS)	RANGE (M.P.)	FUEL USED (LBS.)	WEIGHT (LBS.)	PRCS. ALT. (FT)
1.131	150.00	2575.0	27914.	110.
1.331	150.00	2505.0	27914.	0.

TAKOFF, HOVER, OR LAND AT T/W = 1.06 FOR 0.857 MRS.

TIME (MRS)	RANGE (M.P.)	FUEL USED (LBS.)	WEIGHT (LBS.)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (C)	PRIM. ENCL. CORR	PRIM. ENCL. CORR	PRIM. ENCL. CORR	AUX. FUEL FLW (LBS/MIN)	AUX. FUEL FLW (LBS/MIN)	ROTLEM CODE	TEMP. (F)	TOTAL FUEL FLOW (LBS/HR)	THAUFY %	W/FIGHT	FM	HPM	CT	CT/ALPHA
1.031 650.0	150.00 0.133	2407.9 0.000	27914. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	291.0 99.0	291.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014
1.031 650.0	150.00 0.133	2420.0 0.000	27799. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	289.0 99.0	289.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014
1.031 650.0	150.00 0.133	2735.5 0.000	27685. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	287.0 99.0	287.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014
1.041 650.0	150.00 0.133	2649.6 0.000	27571. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	285.0 99.0	285.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014
1.051 650.0	150.00 0.133	2463.2 0.000	27457. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	283.0 99.0	283.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014
1.051 650.0	150.00 0.133	2760.4 0.000	27340. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	281.0 99.0	281.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014
1.051 650.0	150.00 0.133	3176.4 0.000	27300. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	279.0 99.0	279.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014

CLIMB TO 310. FT. WITH MAXIMUM R/C AT MILITARY FLIGHT RATING  
AS TASKARD FAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SEEN

TIME (MRS)	RANGE (M.P.)	FUEL USED (LBS.)	WEIGHT (LBS.)	PRCS. ALT. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (C)	PRIM. ENCL. CORR	PRIM. ENCL. CORR	PRIM. ENCL. CORR	AUX. FUEL FLW (LBS/MIN)	AUX. FUEL FLW (LBS/MIN)	ROTLEM CODE	TEMP. (F)	TOTAL FUEL FLOW (LBS/HR)	THAUFY %	W/FIGHT	FM	HPM	CT	CT/ALPHA
1.051 650.0	150.00 0.133	3076.4 0.000	27300. 0.	110. 249.	270. 270.	232.2 J---	1	0.014	0.014	277.0 99.0	277.0 99.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014

CPROD	CPTRD	CPPAR	CPNUD	CDON	DETRD	UCLCON	CHK	ROTLEM	CHK	ROTLEM	CHK	ROTLEM	CHK	ROTLEM	CHK	ROTLEM	CHK	ROTLEM	CHK	ROTLEM	CHK	ROTLEM
1.051	150.00	3076.4	27300.	0.	0.014	232.2	0	1.066	0.014	277.0	277.0	1.066	1.066	999.0	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014





TIME (HRS)	RANGE (H.M.)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)	TIME (HRS)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)	TIME (HRS)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)
1:59	151.2	3174.6	27412	3000	177.3	2:00	3174.6	27412	3000	177.3	2:00	3174.6	27412	3000	177.3
6:58.0	22:57	0.0	0.0	0.0	1947	0.0	0.0	0.0	0.0	1947	0.0	0.0	0.0	0.0	1947
3.0															
1:674	176.2	3564.3	27186	3000	177.3	1:23.0	3564.3	27186	3000	177.3	1:23.0	3564.3	27186	3000	177.3
6:59.0	21:56	0.0	0.0	0.0	1941	0.0	0.0	0.0	0.0	1941	0.0	0.0	0.0	0.0	1941
0.0															
1:754	171.2	3415.7	27100	3000	176.8	1:10.0	3415.7	27100	3000	176.8	1:10.0	3415.7	27100	3000	176.8
6:59.0	21:54	0.0	0.0	0.0	1928	0.0	0.0	0.0	0.0	1928	0.0	0.0	0.0	0.0	1928
3.0															
1:834	180.2	3724.6	26800	3000	176.8	1:00.0	3724.6	26800	3000	176.8	1:00.0	3724.6	26800	3000	176.8
6:59.0	21:50	0.0	0.0	0.0	1923	0.0	0.0	0.0	0.0	1923	0.0	0.0	0.0	0.0	1923
0.0															
1:914	211.2	4134.6	26510	3000	176.8	0:50.0	4134.6	26510	3000	176.8	0:50.0	4134.6	26510	3000	176.8
6:59.0	21:31	0.0	0.0	0.0	1911	0:00.0	0.0	0.0	0.0	1911	0:00.0	0.0	0.0	0.0	1911
0.0															
1:994	230.2	4722.7	26210	3000	176.8	0:40.0	4722.7	26210	3000	176.8	0:40.0	4722.7	26210	3000	176.8
6:59.0	21:10	0.0	0.0	0.0	1900	0:00.0	0.0	0.0	0.0	1900	0:00.0	0.0	0.0	0.0	1900
0.0															
2:075	241.2	4934.6	26100	3000	176.8	0:30.0	4934.6	26100	3000	176.8	0:30.0	4934.6	26100	3000	176.8
6:59.0	20:57	0.0	0.0	0.0	1895	0:00.0	0.0	0.0	0.0	1895	0:00.0	0.0	0.0	0.0	1895
0.0															
2:156	256.2	4934.6	26231	3000	176.8	0:20.0	4934.6	26231	3000	176.8	0:20.0	4934.6	26231	3000	176.8
6:59.0	20:33	0.0	0.0	0.0	1884	0:00.0	0.0	0.0	0.0	1884	0:00.0	0.0	0.0	0.0	1884
0.0															
2:237	271.2	4934.6	26779	3000	176.8	0:10.0	4934.6	26779	3000	176.8	0:10.0	4934.6	26779	3000	176.8
6:59.0	20:10	0.0	0.0	0.0	1872	0:00.0	0.0	0.0	0.0	1872	0:00.0	0.0	0.0	0.0	1872
0.0															
2:317	286.2	4934.6	26827	3000	176.8	0:00.0	4934.6	26827	3000	176.8	0:00.0	4934.6	26827	3000	176.8
6:59.0	20:00	0.0	0.0	0.0	1871	0:00.0	0.0	0.0	0.0	1871	0:00.0	0.0	0.0	0.0	1871
0.0															
2:392	300.2	4934.6	26769	3000	176.8	0:00.0	4934.6	26769	3000	176.8	0:00.0	4934.6	26769	3000	176.8
6:59.0	20:00	0.0	0.0	0.0	1866	0:00.0	0.0	0.0	0.0	1866	0:00.0	0.0	0.0	0.0	1866
0.0															

TRANSFER ALTITUDE TO 0. FT.

TIME (HRS)	RANGE (H.M.)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)	TIME (HRS)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)
2:342	370.0	4632.3	26784	3000	1871					
2:392	366.0	4632.3	26769	3000	1871					

TAKOFF POWER ON LAND AT 174 & 1.0 G FOR 1.025 HRS.

TIME (HRS)	RANGE (H.M.)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)	TIME (HRS)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)	TIME (HRS)	FUEL USED (LBS)	WEIGHT (LBS)	ALT. (FT)	TAS (KTS)
1:59	151.2	3174.6	27412	3000	177.3	2:00	3174.6	27412	3000	177.3	2:00	3174.6	27412	3000	177.3
1:674	176.2	3564.3	27186	3000	177.3	1:23.0	3564.3	27186	3000	177.3	1:23.0	3564.3	27186	3000	177.3
1:754	171.2	3415.7	27100	3000	176.8	1:10.0	3415.7	27100	3000	176.8	1:10.0	3415.7	27100	3000	176.8
1:834	180.2	3724.6	26800	3000	176.8	1:00.0	3724.6	26800	3000	176.8	1:00.0	3724.6	26800	3000	176.8
1:914	211.2	4134.6	26510	3000	176.8	0:50.0	4134.6	26510	3000	176.8	0:50.0	4134.6	26510	3000	176.8
1:994	230.2	4722.7	26210	3000	176.8	0:40.0	4722.7	26210	3000	176.8	0:40.0	4722.7	26210	3000	176.8
2:075	241.2	4934.6	26100	3000	176.8	0:30.0	4934.6	26100	3000	176.8	0:30.0	4934.6	26100	3000	176.8
2:156	256.2	4934.6	26231	3000	176.8	0:20.0	4934.6	26231	3000	176.8	0:20.0	4934.6	26231	3000	176.8
2:237	271.2	4934.6	26779	3000	176.8	0:10.0	4934.6	26779	3000	176.8	0:10.0	4934.6	26779	3000	176.8
2:317	286.2	4934.6	26827	3000	176.8	0:00.0	4934.6	26827	3000	176.8	0:00.0	4934.6	26827	3000	176.8
2:392	300.2	4934.6	26769	3000	176.8	0:00.0	4934.6	26769	3000	176.8	0:00.0	4934.6	26769	3000	176.8

N.ROTOR VTIP	M.ROTOR RMP	T.ROTOR VTIP (FPS)	T.ROTOR RMP	VRC AMP	PRIM.ENG FUEL FLOW (LBS/MR)	AUX.ENG FUEL FLOW (LBS/MR)	ROTLM CODE	TFMP DEG. (F)	DELCCH	CPPRO	CPIND	CD^
2.392 680.0	300.00 3542.	4632.3 0.0000	25780. 0.	0. 244.	0. 2184.	2164.7 ----	P A	2104. 59.0	1.160 0.0	0.747 0.0	1.0134 0.0	1.121 0.0
2.483 680.0	300.00 3537.	4655.7 0.0000	25764. 0.	0. 244.	0. 2102.	2164.3 ----	P A	2102. 59.0	1.160 0.0	0.747 0.0	1.0134 0.0	1.121 0.0
2.414 680.0	300.00 3533.	4679.0 0.0000	25741. 0.	0. 244.	0. 2100.	2163.8 ----	P A	2100. 59.0	1.160 0.0	0.747 0.0	1.0134 0.0	1.121 0.0
2.425 680.0	300.00 3528.	4702.3 0.0000	25710. 0.	0. 244.	0. 2159.	2163.4 ----	P A	2099. 59.0	1.160 0.0	0.747 0.0	1.0134 0.0	1.121 0.0

MISSION FUEL REQUIRED = 4702.31  
 RESERVE FUEL REQUIRED = 522.43  
 TOTAL FUEL REQUIRED = 5224.74

.....

END OF SUCCESSFUL CASE

.....

### 7.3.4 Coxial Rotor Helicopter With Auxiliary Propulsion

The design mission profile is illustrated in Figure 7-4. The engine and rotor cycles are not discussed in this case. A complete copy of the program printout follows the description of the input.

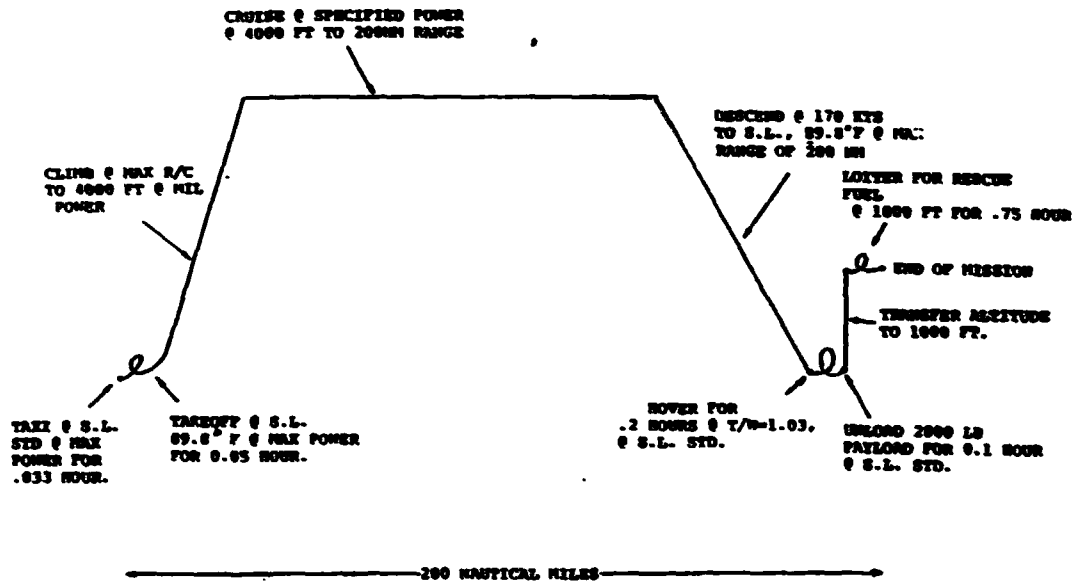


Figure 7-4. Design Mission - Sample Case No. 4

SAMPLE CASE NO, 4 RUN 1

GENERAL INFORMATION SHEET

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
OPTIND	0001	1.	Sizing run
OPTIONAL PRINT	0002	1.	Detailed printout desired
DGRIND	0003	2.	GW/Fe drag trend utilized. Locations 0312 and 0313 must be input.
OSWIND	0004	1.	Program calculates e.
CNFIND	0005	1.	This case is an ABC heli- copter run as a single rotor.
AUXIND	0006	3.	Compound helicopter with auxiliary propulsion only. Location 0012 must be input.
RDMIND	0007	2.	Input disc loading and solidity.
FIXIND	0008	1.	Program sizes primary engines.
ROTIND	0009	5.	L/D <sub>e</sub> rotor map input. Rotor is operated at max. rotor L/D <sub>e</sub> with TAUX/T as output. Program accepts VTIP schedule. Location 0006 must be greater than 2, and Location 0253 must equal 0.
AIPIND	0012	1.	No independent auxiliary engines.
TRDIND	0015	2.	No anti-torque tail rotor on this design.
VTFIND	0017	1.	Input locations 0135 and 0138, ARVT and VVT, respectively.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
HTIND	0018	2.	Horizontal tail volume coefficient input.
MRPIND	0019	0.	Main rotor position on fuselage input by user.
ESCIND	0022	1.	Primary engines are sized for either takeoff or cruise.
WGo	0023	40000.	First guess at design gross weight.
Ho	0024	0.	Initial altitude.
Ro	0025	0.	Initial range.
To	0026	0.	Initial starting time.
H <sub>OPTIND</sub>	0027	0.	Cruise at specified altitude.
M <sub>MD</sub>	0028	.456	Maximum operating Mach number.
V <sub>MO</sub>	0029	250.	Maximum operating equivalent airspeed in knots.
V <sub>DIVE</sub>	0030	300.	Dive speed - approximately equal 1.2 x V <sub>MO</sub> in knots.
M <sub>LF</sub>	0031	3.	Maneuver load factor.
K <sub>1</sub>	0032	1.0562	Factor on mission fuel burned to give reserve fuel. 1.0562 results in 5% of initial fuel for reserve.
ΔW <sub>F</sub>	0033	0.	Fixed fuel increment for reserves or other use.
K <sub>FF</sub>	0034	1.05	Increase basic engine SFC by 5%.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
SGTIND	0035	1.0	Taxi
	0036	2.0	Takeoff
	0037	3.0	Climb
	0038	4.0	Cruise
	0039	5.0	Descent
	0040	2.0	Hover
	0041	8.0	Transfer payload
	0042	9.0	Transfer altitude
	0043	60.0	Loiter for reserve fuel
	0044	100.0	End of case

#### HELICOPTER DIMENSIONAL INFORMATION SHEET

$AR_{HT}$	0112	4.178	Horizontal tail aspect ratio.
$l_{TH}'$	0113	.7866	Ratio of horizontal tail moment arm to main rotor radius.
$(t/c)_{HT}$	0114	.15	Horizontal tail thickness/chord ratio.
$\bar{V}_H$	0115	.0192	Horizontal tail volume coefficient referred to main rotor diameter and tail arm.
$\lambda_H$	0116	.555	Horizontal tail taper ratio.
$\Delta S_{WET}/S_F$	0120	0.	Fuselage wetted area ratio.
$\Delta S_{WET}$	0121	0.	Incremental fuselage wetted area.
$h_F$	0122	8.276	Fuselage height.
$W_F$	0123	8.276	Fuselage width.
$(l/d)_P$	0124	1.007	Fineness ratio of nose.
$(l/d)_T$	0125	1.329	Fineness ratio of tail.
$l_C$	0126	23.5	Constant diameter section length

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$l_{RW}$	0127	15.	Length of ramp well.
$(X_M/l_B)$	0128	.4825	Main rotor position aft of the nose as a fraction of main fuselage length.
$(l_{TB}/d_{TB})$	0129	2.133	Fineness ratio of tail boom.
$(d_{TTB}/d_{TB})$	0130	.2	Ratio of average tail boom tip diameter to average tail boom diameter.
$AR_{VT}$	0135	1.5	Vertical tail aspect ratio.
$\lambda_{VT}$	0136	.5	Vertical tail taper ratio.
$(t/c)_{VT}$	0137	.15	Thickness/chord ratio of vertical tail.
$K_z$ or $b_{VT}$	0139	9.274	Variable is $b_{VT}$ for this case of an ABC helicopter. Locations 0005 and 0017 must equal 1.0, and location 0015 must equal 0.0.
$\eta_1$	0142	0.	} Primary engine nacelle dimensional factors.
$\eta_2$	0143	0.	
$\eta_3$	0144	0.	
$(l_{AIP}/l_c)$	0145	0.	Ratio of air induction system length to primary engine length.
$\eta_4$	0146	0.	} Auxiliary independent engine nacelle dimensional factors.
$\eta_5$	0147	0.	
$\eta_6$	0148	0.	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$(l_{aia}/l_{ea})$	0149	0.	Ratio of air induction system length to auxiliary engine length.
$\Delta S/S_{STR}$	0150	0.	Ratio of incremental auxiliary engine nacelle strut planform area to auxiliary engine nacelle strut planform area.
$b_{NS}/d_{NI}$	0151	0.	Ratio of auxiliary independent engine nacelle strut span to nacelle diameter.
$(t/c)_{RF}$	0152	.21190	Main rotor pylon root thickness/chord ratio.
$(t/c)_{TF}$	0153	.2164	Main rotor pylon tip thickness/chord ratio.
ARFP	0154	.1928	Main rotor pylon aspect ratio.
$\lambda_{FP}$	0155	.6381	Forward rotor pylon taper ratio.
$h_{p1}$	0156	2.	Main rotor pylon height.

ROTOR DIMENSIONAL DATA FOR SIZING MAIN ROTOR

Rotor Map No.	0170	125.	Coaxial rotor helicopter figure of merit and cruise L/D <sub>g</sub> rotor map.
$N_R$	0172	1.	Number of rotors.
W/A	0173	15.	Main rotor disc loading.
$\sigma_{MR}$	0175	.1397	Main rotor solidity
BMR	0176	8.	Number of main rotor blades.
$\theta_{TMR}$	0177	-10.	Main rotor twist (degrees)



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
X <sub>CMR</sub>	0178	.1	Main rotor blade cutout as a fraction of radius.
X <sub>MR</sub>	0179	.07	Main rotor blade attachment point as a fraction of radius.
(t/c) <sub>.25R</sub>	0180	.32	Rotor blade thickness/chord at 25 percent radius.
V <sub>TIPREF</sub>	0181	723.51	Main rotor tip speed.
V <sub>CEH1</sub>	0191	1.53	} Main rotor vertical rate of climb efficiency factors.
V <sub>CEH2</sub>	0192	0.	
K <sub>PCLIMB</sub>	0193	.87	Helicopter forward flight climb efficiency.
K <sub>PDESCENT</sub>	0194	.87	Helicopter forward flight descent efficiency.

ROTOR DIMENSIONAL DATA FOR SIZING TAIL ROTOR

GMR/TR	0214	0.	Gap between main and tail rotor disc (FT). When location 0015=0 (TRDIND), represents gap between main rotor disc and end of tail boom (FT). Negative number would imply tail boom ends under the main rotor disc.
CLFIN	0216	0.	Vertical tail fin operating cruise lift coefficient.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
PRIMARY ENGINE SIZING INFORMATION SHEET			
Primary Engine Cycle No.	0217	1.82	Primary engine selection.
$N_p$	0219	4.	Number of primary engines.
XMSNIND	0220	2.	Drive system ratings specified as fraction of primary engine installed power required to hover or cruise at design conditions. The more critical of the two conditions is selected.
$SHP_{MRX}/SHP_{MR}^*$	0221	.9363	Main rotor drive system is rated at 93.63% of main rotor design power.
KALF PAYL	0222	0.	Ratio of main rotor drive system XMSN rating to main rotor design power.
$\eta_T$	0223	.97	Transmission efficiency.
$\Delta SHP_{ACC}$	0224	0.	Accessory power losses.
$SHP_{PAUX}/SHP_{PAUX}^*$	0226	.9364	Auxiliary propulsion drive system rating as a fraction of auxiliary propulsion system installed power. When no auxiliary engines are specified, this input specifies the auxiliary drive system is rated to 93.64% of main rotor design power.
$h_{TO(7)}$	0227	0.	Design point hover attitude for engine sizing.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$(T/W)_D$	0228	1.13	Configuration design point hover thrust/weight ratio.
$\Delta T_{INTO}(H)$	0229	30.8	Temperature increment in degrees above standard at altitude for engine sizing.
$\left(\frac{N_{II}}{N_{II\text{MAX}}}\right)_{TO}$	0230	.943	Operating point for engine power turbine. Operating tip speed is computed from
			$V_{T\text{Operating}} = V_T \left[ \frac{N_{II}}{N_{II\text{MAX}}} \right] \left[ \frac{N_{II\text{MAX}}}{N_{II^*}} \right]$
$N_{PSD}$	0231	0.	Number of engines in-operative at hover design point conditions.
$SHP_E/SHP^*$	0232	1.	Engines sized to permit operation at 100% of maximum rated power.
$(V_{R/C})_D$	0233	0.	0 ft/min vertical rate of climb capability required at hover design point.
$POW_{IND}$	0234	2.	Maximum engine rating for cruise engine sizing. For this example, normal rated power is the maximum to be used.
$h_c$	0235	0.	Design point cruise altitude for engine sizing.
$V_c$	0236	250.	Design point cruise speed for engine sizing.
$\Delta T_{INCE}$	0237	0.	Temperature increment above standard for cruise engine sizing.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\left(\frac{N_{II}}{N_{II\text{MAX}}}\right)_C$	0238	10.943	This location specifies the operating point for engine power turbine at design cruise conditions. However, in this example, since $N_{II}$ is $\frac{N_{II}}{N_{II\text{MAX}}}$ between 10. and 20., the program assumes a $V_{TIP}$ schedule mix of $MADV_{TIP}$ and $V_{TIP}$ as designated by locations 1259 to 1278.
$\left(\frac{T_{AUX}}{T_{TOT}}\right)_C$	0239	00.	This value signifies that the propulsive thrust provided by auxiliary propulsion at cruise condition for engine sizing follows the input schedule in locations 1571-1692.
$\left(N_{PSD}\right)_C$	0241	0.	Number of primary engines shut down during cruise (for engine sizing).

PROPELLER DATA REQUIRED FOR COMPOUND HELICOPTER  
AUXILIARY PROPULSION INFORMATION SHEET

No. of Props	0248	2.	Two auxiliary propellers are used on this configuration.
$V_{TAR}$	0249	927.	Auxiliary propeller tip speed.
DIA	0250	6.	Diameter of auxiliary prop fan is 6 ft.
$X_{AR}$	0251	.15	Prop fan blade attachment point as a fraction of radius.
$\eta_{TAUX}$	0252	.97	Transmission efficiency of auxiliary drive system

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\eta_{PIND}$	0253	0.	Table of prop/fan efficiencies are input.
$\eta_{P3}$	0254	.7	Prop/fan climb efficiency.
$\eta_{P4}$	0255	.5	Prop/fan descent efficiency.
AF/Blade	0257	100.	Prop/fan activity factor per blade. For this example, a 4 bladed 400 total activity prop/fan was selected.
No. of blades	0258	4.	Number of prop/fan blades.
No. of pairs in $\eta_{P4}$ Table	0261	2.	Number of pairs in prop/fan efficiency table, locations 0262-0281.
Values of Mach No.	0262 0263	0 .6	Values of Mach number in cruise efficiency table.
Values of $\eta_{P4}$	0272 0273	.8 .8	Values of cruise efficiency at corresponding Mach number.

#### HELICOPTER AERODYNAMICS INFORMATION SHEET

GW/Fe	0312	1762	} Drag trend constants derived from data such as illustrated by Figure 4-30, Section 4.9.
KFED	0313	0.561	
TFEF	0315	1.	Tail fin aspect ratio effectiveness factor.
$K_w$	0327	1.	Wing multiplicative drag factor.
No. of $C_x/\sigma$	0347	3.	Specifies number of $C_x/\sigma$ values in table locations 0349-0354.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
No. of $\mu$	0348	3.	Specifies number of $\mu$ values in table locations 0354-0360.
Values of $C_X/\sigma$	0349	-1	} Rotor propulsive thrust coefficient divided by main rotor solidity. Used in defining rotor limits.
	0350	0	
	0351	1	
$C_X/\sigma = \frac{\text{THRUST REQUIRED}}{4 \sigma \text{DMR}^2 \text{NR} \text{VTIP}^2 \text{OMR}}$			
Values of $\mu$	0354	0	} Rotor forward flight advance ratio $\mu = \frac{V_{FPS}}{V_{TIP}}$
	0355	.5	
	0356	1.	
Values of $C_T'/\sigma$	0361	1.	} Values of $C_T'/\sigma$ corresponding to $(C_X/\sigma)_1$ location 0349 and $\mu_1, \mu_2,$ and $\mu_3.$
	0362	1.	
	0363	1.	
	0368	1.	} Values of $C_T'/\sigma$ corresponding to $(C_X/\sigma)_2$ location 0350 and $\mu_1, \mu_2,$ and $\mu_3.$
	0369	1.	
	0370	1.	
	0375	1.	} Values of $C_T'/\sigma$ corresponding to $(C_X/\sigma)_3$ location 0351 and $\mu_1, \mu_2$ and $\mu_3.$
	0376	1.	
	0377	1.	

**HELICOPTER WEIGHT INFORMATION SHEET**

$W_{FE}$	2602	5622.	Weight of fixed equipment in LBS.
$W_{FUL}$	2603	1550.	Weight of fixed useful load in LBS.
$W_{PL}$	2604	5630.	Weight of payload in LBS.
$\Delta W_{FC}$	2605	0.	Flight controls group incremental weights in LBS.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta w_p$	2606	0.	Propulsion group incremental weight in LBS.
$\Delta w_{ST}$	2607	700.	Structures group incremental weight in LBS.
$RM_1$	2608	0.	Wing relief as percentage of GW.
$w_i$	2609	0.	Weight of inboard store.
$w_o$	2610	0.	Weight of outboard store.
$d_i$	2611	0.	Position of inboard underwing store (fraction of wing semi-span).
$d_o$	2612	0.	Position of outboard underwing store (fraction of wing semi-span).
$k_{CC}$	2613	26.	Cockpit controls weight factor.
$k_{RC}$	2614	30.	Main rotor controls weight factor.
$k_{SC}$	2615	30.	Main rotor system controls weight factor.
$k_{FW}$	2616	.005	Fixed wing controls.
$k_{TM}$	2617	0.	Tilt mechanism weight factor.
$k_{SAS}$	2618	75.	Stability Augmentation System (SAS) weight factor. Usually in the range of 20-100 pounds.
$k_{RCA}$	2619	18.	Auxiliary rotor controls weight factor.
$k_{SCA}$	2620	25.	Auxiliary rotor system controls weight factor.
$k_{MC}$	2621	0.	Miscellaneous controls weight factor in LBS.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
k <sub>B</sub>	2622	125.	Body group weight factor.
ΔC.G.	2623	2.08	Helicopter cg travel (FT).
k <sub>LG</sub>	2624	.04	Landing gear weight factor. Percentage of gross weight.
k <sub>MG</sub>	2625	.8	Main landing gear weight factor.
k <sub>WW</sub>	2626	0.	Detailed wing weight factor. This adjusts the constant 220 in $W_w = 220(k)0.585$ up or down depending on the complexity of the control surfaces.
LF	2627	1.	Wing unload factor. Entered as a fraction of design gross weight.
k <sub>WS</sub>	2628	0.	Wing stores only weight trend factor.
k <sub>WP</sub>	2629	0.	Wing weight/area factor (psf).
k <sub>HT</sub>	2630	2.5	Horizontal tail unit weight in PSF.
k <sub>CLF</sub>	2631	0.	Crash load factor.
k <sub>NAC</sub>	2632	0.	Primary cowling weight factor (PSF).
k <sub>AIP</sub>	2633	0.	Primary air induction system weight factor.
k <sub>NACA</sub>	2634	0.	Auxiliary cowling weight factor (PSF).
k <sub>AIA</sub>	2635	0.	Auxiliary air induction system weight factor.
k <sub>NS</sub>	2636	0.	Nacelle strut weight factor.



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
KPRB	2637	44.	Primary rotor blade weight factor.
KRBF	2638	2.2	Rotor type factor; hingeless for this example.
KPH	2639	61.	Primary hub weight factor.
kamd	2640	.286	Main rotor weight factor.
kBLFD	2641	1.1948	Blade fold weight factor. Input as a fractional part of the total rotor weight.
KTR	2642	0.	Tail rotor weight factor.
KAR	2643	14.2	Auxiliary rotor weight factor. This is the average value for the rotor or propeller weight (LB). WR = 14.2 a(k) .67
kPA	2644	1.	Auxiliary rotor multiplicative input power, expressed here as 100% input power.
KVTAR	2645	1.	Auxiliary tail rotor multiplicative tip speed factor expressed here as 100% input speed.
KPDS	2646	265.	Primary drive system weight factor.
KPDSZ	2647	3.	Primary drive system weight factor. Number of gears in system.
KTRDS	2648	0.	Tail rotor drive system weight factor.
KADS	2649	0.	Auxiliary drive system weight factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
k <sub>ADSZ</sub>	2650	1.	Auxiliary drive system weight factor (number of gears in system).
k <sub>FS</sub>	2651	.15	Fuel system weight factor.
k <sub>PE</sub>	2652	.3	Primary engine installation weight factor.
k <sub>AE1</sub>	2653	0.	Auxiliary engine installation weight factor.
K <sub>1</sub>	2654	1.	Main rotor control weight factor.
K <sub>2</sub>	2655	1.206	Main rotor system controls weight multiplicative factor.
K <sub>3</sub>	2656	1.	Fixed wing controls weight multiplicative factor.
K <sub>4</sub>	2657	1.	Auxiliary rotor controls weight multiplicative factor.
K <sub>5</sub>	2658	1.	Auxiliary rotor system controls weight multiplicative factor.
K <sub>6</sub>	2659	0.85	Body weight multiplicative factor.
K <sub>7</sub>	2660	.85	Landing gear weight multiplicative factor.
K <sub>8</sub>	2661	1.	Wing weight multiplicative factor.
K <sub>9</sub>	2662	.85	Horizontal tail weight multiplicative factor.
K <sub>10</sub>	2663	1.	Primary nacelle weight multiplicative factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
K11	2664	1.	Auxiliary nacelle weight multiplicative factor.
K12	2665	1.	Primary rotor blade weight multiplicative factor.
K13	2666	1.6	Primary rotor hub weight multiplicative factor.
K14	2667	1.	Tail rotor weight multiplicative factor.
K15	2668	1.	Auxiliary rotor weight multiplicative factor.
K16	2669	.93	Primary drive system weight multiplicative factor.
K17	2670	1.	Auxiliary drive system weight multiplicative factor.
K18	2671	1.	Primary engine weight multiplicative factor.
K19	2672	1.	Auxiliary engine weight multiplicative factor.
K20	2673	1.	Tail rotor drive system weight multiplicative factor.

TAXI INFORMATION (SGTIND = 1)

ATMIND	0401	0.	Standard atmosphere selected.
t <sub>J</sub> (HR)	0411	.033	Time in hours to taxi.
$\left(\frac{N_I}{N_{I\text{MAX}}}\right)$	0441	.943	Operating point for engine power turbine during taxi.

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

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
TAKEOFF, HOVER, AND LANDING INFORMATION (SGTIND = 2)			
TOLIND	0461	2.	Specify power fraction and vertical rate of climb.
	0462	1.	Specify required T/W for hover out-of-ground effect.
ATMIND	0481	1.	Standard atmosphere plus an incremental temperature specified in location 0501.
	0482	0.	Standard atmosphere.
PEHF	0491	1.	Power fraction - 100% of power available at these ambient conditions is being used.
$\Delta T_{IN} (^{\circ}F)$	0501	30.8	Incremental temperature above standard, in degrees.
$V_{R/C}$ (FPM)	0511	0.	} Off/min vertical rate of climb capability desired.
	0512	0.	
T/W	0522	1.03	Hover thrust/weight ratio specified.
$\Delta t_H$ (HR)	0531	.025	} Time increments for takeoff, hover or landing computations in hours.
	0532	.1	
$\left(\frac{N_{II}}{N_{II\text{MAX}}}\right)$ (PRIMARY ENGINE)	0541	.943	} Operating point for engine power turbine during takeoff, hover or landing.
	0542	.943	
			$\left(\frac{N_{II}}{N_{II\text{MAX}}}\right) = \frac{V_{T\text{OPERATING}}}{V_T \left(\frac{N_{II\text{MAX}}}{N_{II*}}\right)}$
$t_H$ (HR)	0551	.	Takeoff, hover, or landing total time in hours.
	0552	.2	

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
CLIMB INFORMATION (SGTIND = 3)			
CLMIND	0511	1.	Maximum rate of climb desired.
ATMIND	0591	1.	Standard atmosphere plus an incremental temperature specified in location 0611.
$\Delta T_{IN} (^{\circ}F)$	0611	30.8	Incremental temperatures above standard, in degrees.
$\Delta h (FT)$	0621	1000.	Altitude increments for climb calculations.
POWIND	0631	1.	Climb at maximum rate of climb limited by military power available.
hMAX (FT)	0641	4000.	Final altitudes for climb.
$\left( \frac{N_{II}}{N_{II_{MAX}}} \right)$ (PRIMARY ENGINE)	0651	10.943	This location specifies the operating point for engine power turbine at design climb conditions. However, in this example since $\frac{N_{II}}{N_{II_{MAX}}}$ is between 10. and 20., the program assumes a $V_{TIP}$ schedule mix of $MADV_{TIP}$ and $V_{TIP}$ as designated by locations 1258-1278.
$\Delta F_{e_{CL}} (FT^2)$	0661	0.	Incremental drag area in climb.
NPSD <sub>CL</sub>	0681	0.	Number of primary engines shut down during climb.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
TAUX/TTOT	0691	1000.	This value signifies that the propulsive thrust provided by auxiliary propulsion at CLIMB condition follows the input schedule in locations 1671-1692.
CRUISE INFORMATION (SGTIND = 4)			
CRSIND	0721	1.	Cruise at specified power setting.
ATMIND	0741	1.	Standard atmosphere plus an incremental temperature specified in location 0611.
$\Delta T_{IN} (^{\circ}F)$	0761	30.8	Incremental temperature above standard, in degrees.
$\Delta R (NM)$	0771	40.	Calculation and printout increments during cruise in nautical miles.
POWIND	0781	2.	Cruise speed by normal rated primary engine power.
$R_{MAX} (NM)$	0791	200.	Values of range at end of each cruise segment.
$\left( \frac{N_{II}}{N_{II_{MAX}}} \right)$ (PRIMARY ENGINE)	0801	10.943	This location specifies the operating point for engine power turbine at design cruise conditions. However, in this example since $N_{II}$ is between $N_{II_{MAX}}$ 10. and 20., the program assumes a $V_{TIP}$ schedule mix of $MADV_{TIP}$ and $V_{TIP}$ as designated by locations 1258-1278.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\Delta F_{eCR}$ (FT <sup>2</sup> )	0811	0.	Increment in cruise equivalent flat plate area (FT <sup>2</sup> ).
$N_{PSDCR}$	0831	0.	Number of primary engines shut down in cruise.
$T_{AUX}/T_{TOT}$	0841	1000.	This value signifies that the propulsive thrust provided by auxiliary propulsion at cruise condition follows the input schedule in locations 1671-1692.
DESCENT INFORMATION (SGTIND = 5)			
DESIND	0871	1.	Constant True Airspeed descent specified by location 0881.
TAS	0881	170.	Descend at a constant 170 knots.
RMAXIND	0891	0.	Terminal descent range specified. Location 0961 must be input.
ATMIND	0911	1.	Standard atmosphere plus an incremental temperature specified in location 0931.
$\Delta h$ (FT)	0921	1000.	Calculation and printout increments during descent in nautical miles.
$\Delta T_{IN}$ (°F)	0931	30.8	Incremental temperature above standard, in degrees.
$\eta_{MIN}$ (FT)	0941	0.	Specified minimum descent altitude (FT).
R/D (FPM)	0951	1000.	Rate of descent in ft/min.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
RMAX (NM)	0961	200.	Maximum range at end of descent.
$\frac{N_{II}}{N_{II\text{MAX}}}$ (PRIMARY ENGINE)	0971	10.943	This location specifies the operating point for engine power turbine at design descent conditions. However, in this example since $\frac{N_{II}}{N_{II\text{MAX}}}$ is between 10. and 20., the program assumes a VTIP schedule mix of $M_{ADV\text{TIP}}$ and VTIP as designated by locations 1258-1278.
$\Delta F_{e\text{DSC}}$ (FT <sup>2</sup> )	0981	0.	Increment in descent equivalent flat plate drag area. (FT <sup>2</sup> )
$N_{\text{PSD}\text{DSC}}$	1001	0.	Number of primary engines shut down during descent.
T <sub>AUX</sub> /T <sub>TOT</sub>	1011	1000.	This value signifies that the propulsive thrust provided by auxiliary propulsion at descent conditions follows the input schedule in locations 1671-1692.
CHANGE IN PAYLOAD WEIGHT (SGTIND = 8)			
$\Delta W_{\text{PL}}$ (LBS)	1161	-2000.	Unload 2000 pounds of payload.
t <sub>pw</sub> (LBS)	1171	.01	Time in hours necessary to unload payload.
WGTIND	1191	1.	No weight restriction.
TRANSFER ALTITUDE (SGTIND = 9)			
h <sub>FINAL</sub> (FT)	1181	1000.	Transfer altitude to 1000 ft.



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VP</u>	<u>E ASSIGNED</u>	<u>REMARKS</u>
LOITER INFORMATION, FOR RESERVE FUEL (SGTIND = 0)				
ATMIND	1031		0.	Standard atmosphere.
$\Delta t_L$ (HR)	1061		.25	Calculation and printout increments, time in hours, during loiter.
$\frac{N_{II}}{N_{II\text{MAX}}}$	1071		10.943	This location specifies the operating point for engine power turbine at design loiter conditions. However, in this example since $\frac{N_{II}}{N_{II\text{MAX}}}$ is between 10. and 20., the program assumes a $V_{TIP}$ schedule mix of $M_{ADV_{TIP}}$ and $V_{TIP}$ as designated by locations 1258-1278.
$t_L$ (HR)	1081		.75	Maximum time in hours for loiter.
$N_{PSD\_LOITER}$	1101		0.	Number of primary engines shut down during loiter.
$T_{AUX}/T_{TOT}$	1111		1000.	This value signifies that the propulsive thrust provided by auxiliary propulsion at loiter conditions follows the input schedule in locations 1671-1692.
$\Delta F_{eL}$ (FT <sup>2</sup> )	1131		0.	Increment in loiter equivalent flat plate drag area (FT <sup>2</sup> ).

PRIMARY ENGINE CYCLE DATA, NONSTANDARD PERFORMANCE

WDTIND	1201		0.	No fuel flow cutoffs
N1IND	1202		0.	No N1 cutoffs
N10IND	1203		0.	No referred N1 cutoffs

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
N2IND	1204	2.	Free turbine engine to be simulated.
QIND	1205	0.	No torque limit imposed.
RNOIND	1206	0.	No Reynold's number corrections
$N_{II\text{MAX}}/N_{II}^*$	1223	1.026	Value for $N_{II}$ cutoff referred to $N_{II}^*$

**ROTOR TIP SPEED OR MACH NUMBER SCHEDULE**

No. of Pairs in $V_{TIP}/M_{T90}$ Table	1258	4.	This value indicates that there are 4 pairs of input values in locations 1259 to 1278.
Values of M	1259	0.	In this example problem, it was desired to have the rotor tip speed schedule follow 700 FPS up to 180 kts forward flight speed. At this point, the schedule will then follow the necessary tip speed to produce a
	1260	.2722	
	1261	.3781	
	1262	.4539	
Corresponding Values of $V_{TIPREF}$ and $M_{T90REF}$	1269	723.51	
	1270	723.51	
	1271	.9	
	1272	.9	

constant tip sea level standard Mach number of 0.9 at 90°. The schedule is a plot of Tip Speed (FPS) versus True Airspeed (kts) for lines of constant  $\mu$ . The 180 kt transition point is shown in location 1260, where  $M = \frac{V_{TIP}}{a} = \frac{180 \text{ kt}}{661.2 \text{ kt}} = .2722$

and  $a$  = speed of sound at sea level standard. The corresponding reference tip speed in location 1270 is 723.51 FPS, obtained through the relation;  $V_{TREF} = \frac{V_T}{\left(\frac{N_{II}}{N_{II\text{MAX}}}\right)\left(\frac{N_{II\text{MAX}}}{N_{II}^*}\right)}$

where  $\frac{N_{II}}{N_{II\text{MAX}}}$  is input in location 0230, and  $\frac{N_{II\text{MAX}}}{N_{II}^*}$  is input in

location 1223.  $V_T$  is found in location 0181.

For this case:

$$V_{TREF} = \frac{700}{(.943)(1.026)} = 723.51$$

Assuming that the maximum true airspeed will not exceed 300 kts. this velocity was chosen for the end point on the  $M_{T90}$  line. This velocity is input in location 1262 as .4539. The corresponding  $V_{TREF}$  is simply the limiting tip Mach number = 0.9. The same reasoning is similar for location 1261 and 1271 using a true airspeed of 250 kts. Note, actual  $V_{TIP}$  can be calculated from the following equation:

$$V_T = a M_{T190} - V_{FWD}$$

• **AUXILIARY PROPULSION SCHEDULE ( $TAUX/T$ )**

The Tip Speed versus True Airspeed plot used for the Rotor Tip Speed or Mach Number Schedule can be used for the determination of  $\mu$  in the  $TAUX/T$  Schedule.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
No. of Pairs in $TAUX/T$ Table	1671	4.	This location indicates that there are 4 pairs of input values in locations 1672-1691.
Values of $\mu$	1672	0.	In this example, the design criteria was to have auxiliary propulsion after a true airspeed of 100 kts, up to a maximum of 300 kts. For the 100 kt minimum airspeed necessary for auxiliary propulsion, location 1673 is obtained from:
	1673	.202	
	1674	.5062	
	1675	1.0	
Corresponding Values of $TAUX/T$	1682	0.	
	1683	0.	
	1684	.5	
	1685	1.0	

$$M_{T90REF} = \frac{V_{FWD} + V_T}{a}, \text{ where } V_{FWD} = 100 \text{ kts}$$

$$\text{solving for } V_T = (.9)(661.2) - 100 = 495 \text{ kts}$$

$$\text{and } \mu = \frac{V_{FWD}}{V_{TIP}} = \frac{100}{495} = .202$$

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>KNOTS</u>
(TAUX/TTOT)C	0239	2000.	These values signify that the maximum thrust available by auxiliary propulsion at cruise condition for engine sizing follows the input schedule in locations 1671-1692 up to the transition $\mu$ indicated by location 1692. Above that $\mu$ , the maximum L/D <sub>g</sub> is used. This option used only with ROTIND > 2. This TAUX/TTOT input can be used in all TAUX/TTOT locations.
(TAUX/TTOT) FOR:			
climb	0691		
cruise	0841		
descent	1011		

Values of VTIPREF	1271	596.4	These values replace the Mach numbers in the same locations as used in Run 1. Since $N_{II}$ is $\frac{N_{II}}{N_{II\text{MAX}}}$
	1272	510.7	

greater than 20, the program assumes VTIP schedule is in VTIP only. For location 1271, the Mach number = .3791. Therefore, VT in ft/second equals:

$$V_T = 1.6744 (a(MT90) - VFWD) = 577 \text{ FPS}$$

where 1.6744 converts knots to FPS.

The VT is now put in its referred form

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

$$V_{TREF} = \frac{577}{(.943)(1.026)} = 596.4 \text{ FPS}$$

The same procedure can be repeated to determine location 1272.

Likewise, locations 1674 and 1675 were calculated using forward flight speeds of 200 kts and 300 kts, respectively. The corresponding  $T_{AUX}/T$  locations were arbitrarily chosen.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
SAMPLE CASE NO. 4 RUN 2			
ROTIND	0009	6.	L/D <sub>E</sub> rotor map input. Rotor is operated at maximum configuration L/D <sub>E</sub> with $T_{AUX}/T$ as output. Program accepts VTIP schedule. Location 0006 must be greater than 2, and location 0253 must equal 0.
SAMPLE CASE NO. 4 RUN 3			
$\frac{N_{II}}{N_{II\text{MAX}}}$ C	0238	20.943	These locations specify the operating point for engine power turbine at design cruise conditions. However, in this example since $\frac{N_{II}}{N_{II\text{MAX}}}$ is greater than 20, the program assumes a VTIP schedule only and not a mixture of VTIP and MADVTIP. This value can be used on all locations of $N_{II}/N_{II\text{MAX}}$ .
	0801		
	0971	20.943	
	1071		

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-01

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. (MAX. 5)
VAL1 VALUE CORRESPONDING TO LOC. (1)
VAL2 VALUE CORRESPONDING TO LOC. (2)
LTC.

Table with columns: LOC., NUM, VAL, VAL1, VAL2, VAL3, VAL4. It contains a list of location numbers and their corresponding values for variables VAL through VAL4.

NOTE: IN USING AUXILIARY ENGINES: 1. AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 16666 CARD IN FRONT AND REWIND A STANDARD ENGINE CYCLE







3901	10.25	6.600	8.900	10.25	8.900	10.25
3906	0.55	6.550	7.120	0.55	7.120	0.55
3911	0.00	4.275	6.750	0.00	6.750	0.00
3916	2.00	6.100	7.350	2.00	7.350	2.00
3921	0.00	3.750	5.400	0.00	5.400	0.00
3926	0.00	6.450	6.000	0.00	6.000	0.00
3931	0.00	0.750	0.750	0.00	0.750	0.00
3936	0.00	1.500	1.200	0.00	1.200	0.00
3941	0.00	3.450	3.450	0.00	3.450	0.00
3946	0.00	1.850	0.950	0.00	0.950	0.00
3951	0.00	5.750	5.300	0.00	5.300	0.00
3956	0.00	2.520	2.100	0.00	2.100	0.00
3961	0.00	7.250	7.050	0.00	7.050	0.00
3966	0.00	3.975	3.975	0.00	3.975	0.00
3971	0.00	6.100	6.700	0.00	6.700	0.00
3976	0.00	5.625	4.825	0.00	4.825	0.00
3981	0.00	8.400	9.450	0.00	9.450	0.00
3986	0.00	7.050	5.775	0.00	5.775	0.00
3991	0.00	4.175	9.900	0.00	9.900	0.00
3996	0.00	7.275	6.300	0.00	6.300	0.00
4001	0.00	6.000	8.000	0.00	8.000	0.00
4006	0.00	6.600	5.250	0.00	5.250	0.00
4011	0.00	6.075	6.650	0.00	6.650	0.00
4016	0.00	3.750	5.100	0.00	5.100	0.00
4021	0.00	1.170	4.875	0.00	4.875	0.00
4026	0.00	1.170	1.170	0.00	1.170	0.00
4031	0.00	1.200	1.200	0.00	1.200	0.00
4036	0.00	4.125	3.500	0.00	3.500	0.00
4041	0.00	1.125	1.125	0.00	1.125	0.00
4046	0.00	6.450	6.450	0.00	6.450	0.00
4051	0.00	2.775	2.775	0.00	2.775	0.00
4056	0.00	7.575	7.575	0.00	7.575	0.00
4061	0.00	3.975	3.975	0.00	3.975	0.00
4066	0.00	5.775	7.600	0.00	7.600	0.00
4071	0.00	6.650	6.650	0.00	6.650	0.00
4076	0.00	7.500	7.500	0.00	7.500	0.00
4081	0.00	5.550	5.550	0.00	5.550	0.00
4086	0.00	6.250	6.250	0.00	6.250	0.00
4091	0.00	4.575	7.350	0.00	7.350	0.00
4096	0.00	5.475	4.350	0.00	4.350	0.00
4101	0.00	5.700	7.425	0.00	7.425	0.00
4106	0.00	4.500	3.225	0.00	3.225	0.00
4111	0.00	4.125	5.400	0.00	5.400	0.00
4116	0.00	3.375	2.550	0.00	2.550	0.00
4121	0.00	3.600	5.025	0.00	5.025	0.00
4126	0.00	2.475	2.475	0.00	2.475	0.00
1	0.00	2.000	1.000	0.00	1.000	0.00
6	0.00	1.000	1.000	0.00	1.000	0.00
12	0.00	2.000	2.000	0.00	2.000	0.00
15	0.00	4.000	4.000	0.00	4.000	0.00
17	0.00	4.000	4.000	0.00	4.000	0.00
22	0.00	4.000	4.000	0.00	4.000	0.00
27	0.00	4.000	4.000	0.00	4.000	0.00
32	0.00	2.000	2.000	0.00	2.000	0.00
75	0.00	4.000	4.000	0.00	4.000	0.00
80	0.00	4.000	4.000	0.00	4.000	0.00
112	0.00	4.000	4.000	0.00	4.000	0.00
120	0.00	4.000	4.000	0.00	4.000	0.00
122	0.00	4.000	4.000	0.00	4.000	0.00
124	0.00	4.000	4.000	0.00	4.000	0.00







PRIMARY ENGINE NACELLE

LN 1.0 FT.  
 PW 2 FT.  
 SN 0.0 SQ. FT.  
 LENGTH 7.0 FT.  
 MEAN DIAMETER 2 FT.  
 WEIGHT AIRFACIAL TOTAL 10.0 ALL ENGINE(S) 0.0 SQ. FT.

AUXILIARY INDEPENDENT ENGINE NACELLE -NO AUXILIARY INDEPENDENT ENGINE USED  
 PROPELLER(AUXILIARY PROPELLER)

DAP 6.0 FT.  
 AP 190.0  
 SIGAP (.163  
 MRA 2  
 WTA 4  
 VTP 27. FT./SEC  
 DIAMETER 6.0 FT.  
 ACTIVITY FACTOR PER PLANE 190.0  
 SOLIDITY (.163  
 NO. OF PROPELLERS 2  
 NO. OF PLANES/PROP 4  
 TIP SPEED 27. FT./SEC

MAIN ROTOR

DWR 20.0 FT.  
 RTMP 10.10  
 WC/A 1500 LBS/SQ. FT.  
 CY/SIN/A 1  
 IP 1  
 NO. OF PLANES 1  
 THETA 0  
 FC 1  
 VTP 7.0 FT./SEC  
 DIAMETER 20.0 FT.  
 SOLIDITY 10.10  
 DISC LOADING 1500 LBS/SQ. FT.  
 THRUST COEFF./SOLIDITY 1  
 NO. OF ROTORS 1  
 NO. OF BLADES/RTMP 0  
 PLATE THICK 1  
 PLANE CUTOUT/RADIUS RATIO 1  
 TIP SPEED 7.0 FT./SEC

MUST BE NO TAIL ROTOR USE.

M - S P O P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM

M I S P O P P A Y P I N L O C

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL PRICE
0000	PRINCIPAL'S GROUP			
0001	WATER			
0002	ULTIMATE LOAD FACTOR			
0003	TOTAL MAIN MOTOR GROUP	5245		5245
0004	MAIN MOTOR BLADE GEAR SYSTEM	2210		2210
0005	MAIN MOTOR HUB AND SHAFT	2150		2150
0006	BLADE CALCULATOR MOTOR	450		450
0007	AUXILIARY CALCULATOR MOTOR GROUP	200		200
0008	CRUISE CYCLE	200		200
0009	MAIN MOTOR DRIVE SYSTEM	200		200
0010	TAIL MOTOR DRIVE SYSTEM	200		200
0011	AUXILIARY CALCULATOR MOTOR SYSTEM	100		100
0012	CONSUMABLES GROUP			
0013	AUXILIARY ENGINE	100		100
0014	HEAVY DUTY INSTALLATION	100		100
0015	AUXILIARY ENGINE INSTALLATION	100		100
0016	FUEL SYSTEM	700		700
0017	ON PULSION MOTOR WEIGHT INFORMATION			
0018	ON PULSION MOTOR WEIGHT INFORMATION			
0019	TOTAL CONSUMABLES GROUP TOTAL			1300
0020	WING			
0021	TAIL GROUP			
0022	WING TAIL	720		720
0023	TAIL MOTOR	200		200
0024	FUEL	300		300
0025	LAND	1300		1300
0026	WING			
0027	WING			
0028	WING			
0029	WING			
0030	WING			
0031	WING			
0032	WING			
0033	WING			
0034	WING			
0035	WING			
0036	WING			
0037	WING			
0038	WING			
0039	WING			
0040	WING			
0041	WING			
0042	WING			
0043	WING			
0044	WING			
0045	WING			
0046	WING			
0047	WING			
0048	WING			
0049	WING			
0050	WING			
0051	WING			
0052	WING			
0053	WING			
0054	WING			
0055	WING			
0056	WING			
0057	WING			
0058	WING			
0059	WING			
0060	WING			
0061	WING			
0062	WING			
0063	WING			
0064	WING			
0065	WING			
0066	WING			
0067	WING			
0068	WING			
0069	WING			
0070	WING			
0071	WING			
0072	WING			
0073	WING			
0074	WING			
0075	WING			
0076	WING			
0077	WING			
0078	WING			
0079	WING			
0080	WING			
0081	WING			
0082	WING			
0083	WING			
0084	WING			
0085	WING			
0086	WING			
0087	WING			
0088	WING			
0089	WING			
0090	WING			
0091	WING			
0092	WING			
0093	WING			
0094	WING			
0095	WING			
0096	WING			
0097	WING			
0098	WING			
0099	WING			
0100	WING			

WFC	WEIGHT OF FIBER COMPONENT	0.5270
WFC	CONTROL WEIGHT IMPERFECT	0.0520
WFC	TOTAL CONTROL WEIGHT	0.5790
WFC	WEIGHT EMPTY	0.0000
WFC	FIBER WEIGHT LOSS	0.0000
WFC	WEIGHTING WEIGHT EMPTY	0.5790
WFC	WEIGHT	0.5790
WFC	FIBER	0.5790
WFC	WEIGHT	0.5790

SAMPLE CASE NO. 4 RUN 3 PAGE 4

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

R T O P D A T A

FIBER MAIN ROTOR SOLIDITY INPUT

SAMPLE CASE NO. 4 PUM 1

PAGE 2

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM M-41

ROTOR TYPE: 4 BLADE  
PROPULSION CYCLE: TURBOPROP  
ENGINE: 1.000

4. CRUISE

MAX. STANDARD 90% STATIC M.P. 64170 M.P.  
ENGINE SIZED FOR TAKEOFF AT 7/8 81-13  
100% PERCENT MILITARY POWER SETTINGS  
M.P. 0.7% TEMPERATURE 5 49.00 100%  
0.6 ENGINE'S OPERATIVE AND 10 PERCENT VERTICAL RATE OF CLIMB.

NO AUX. INDEPENDENT ENGINE CYCLE SELECTED

MAIN ROTOR DRIVE SYSTEM RATING 6110 M.P.

WHEN SIZED AT 90 PERCENT OF MAIN ROTOR DRIVE POWER REQUIRED  
AT M.P. 0.7% TEMP 5 49.00 100% PERCENT POWER RPM

AUXILIARY PROPULSION DRIVE SYSTEM RATING 481 M.P.

WHEN SIZED AT 90 PERCENT OF TOTAL CAPABILITY FOUR REQUIRED TO HOVER  
AT M.P. 0.7% TEMP 5 49.00 100% PERCENT POWER RPM





HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-03

MISSION PERFORMANCE DATA

TIME (HRS)	FUEL USED (LBS)		WEIGHT (LBS.)	PRESS. ALT. (FT)	TAS (KTS)	PRIM. THUR. TEMP. (R)		PRIM. ENG. CODE	PRIM. ENG. RPM	TOTAL FUEL FLOW (LBS/HRS)	AUX. THUR. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. RPM	AUX. FUEL FLOW (LBS/HRS)	AUX. TEMP. (R)
	WGT	WGT				WGT	WGT								
0.0	0.0	0.0	4819.	0.	0.0	1740.0	7	0.0	0.0	300.0	0.0	0.0	0.0	0.0	0.0
0.033	0.0	23.0	4686.	0.	0.0	1701.0	7	0.0	0.0	300.0	0.0	0.0	0.0	0.0	0.0

TAKOFF. POWER. OR LAMB AT PTF = 1.03 FOR (0.15) MRS.

TIME (HRS)	FUEL USED (LBS)		WEIGHT (LBS.)	PRFS. ALT. (FT)	TAS (KTS)	PRIM. THUR. TEMP. (R)		PRIM. ENG. CODE	PRIM. ENG. RPM	TOTAL FUEL FLOW (LBS/HRS)	AUX. THUR. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. RPM	AUX. FUEL FLOW (LBS/HRS)	AUX. TEMP. (R)
	WGT	WGT				WGT	WGT								
0.033	0.0	57.0	4486.	0.	0.0	2630.3	7	1.11	1.11	372.0	0.0	0.0	0.0	0.0	0.0
0.058	0.0	126.1	4052.	0.	0.0	2630.3	7	1.00	1.00	372.0	0.0	0.0	0.0	0.0	0.0

INSUFFICIENT POWER AVAILABLE TO HOVER

(T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN CONFIG

0.033 7.39. 0.0 0.0 3720. A

INSUFFICIENT POWER AVAILABLE TO HOVER

(T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN CONFIG

0.058 7.17. 0.0 0.0 3720. A

INSUFFICIENT POWER AVAILABLE TO HOVER

(T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN CONFIG

0.003 6.99. 0.0 0.0 3720. A

CLIMB TO 4000. FT. WITH MAXIMUM R/C AT MILITARY ENGINE RATING

0.033 7.39. 0.0 0.0 3720. A

0.058 7.17. 0.0 0.0 3720. A

0.003 6.99. 0.0 0.0 3720. A

CLIMB TO 4000. FT. WITH MAXIMUM R/C AT MILITARY ENGINE RATING

0.033 7.39. 0.0 0.0 3720. A

0.058 7.17. 0.0 0.0 3720. A

0.003 6.99. 0.0 0.0 3720. A





700.0	5497.	0.0	0.	3332.	----	A	59.8	0.0	6.700	0.0	0.0	0.0
1.104	200.00	3187.4	37532.	0.	2374.9	P	3109.	1.030	0.700	5604.	0.0122	0.000
700.0	5436.	0.0	0.	3109.	----	A	59.8	0.0	0.700	0.0	0.0	0.0
1.204	200.00	3498.3	37221.	0.	2369.2	P	3086.	1.030	0.707	5543.	0.0121	0.007
700.0	5375.	0.0	0.	3086.	----	A	59.8	0.0	0.707	0.0	0.0	0.0

CHANGE PAYLOAD, REMOVE 2000. LB.

FUEL USED		WEIGHT		PRES. ALT.	
TIME (HRS)	RANGE (N.M.)	USED (LBS)	(LBS.)	(FT)	(FT)
1-214	200.00	3498.3	37221.	0.	0.
1-214	200.00	3498.3	35221.	0.	0.

TRANSFER ALTITUDE TO 1000. FT.

FUEL USED		WEIGHT		PRES. ALT.	
TIME (HRS)	RANGE (N.M.)	USED (LBS)	(LBS.)	(FT)	(FT)
1-214	200.00	3498.3	35221.	0.	1000.

LOTTER FOR 0.750 HRS. FOR RESERVE FUEL

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WTIP (FPS)	T. ROTOR RMP (FPS)	PROP WTIP (FPS)	PROP ALT. (FT)	PRF. ALT. (FT)	YAS (PTS)	PRIM. TURB. TEMP. (RI)	PRIM. ENG. CODE	PRIM. ENG. CODE	FTAP PROP	AUX. ENG. TAUR/T	AUX. ENG. FUEL FLOW (LBS/HR)	EAS (KTS)	MU	CT OVER SIGMA	ALPHA D/L (OLE)	TOTAL FUEL FLOW (LBS/HR)	RMP
1-214	200.00	3498.3	35221.	1000.	0.0	0.0	0.0	0.0	1961.9	P	0.175	0.175	67.7	0.166	0.086	5.0	1993.	1487.		
700.0	513.	0.0	0.0	0.0	0.0	0.0	0.0	988.	988.	0.800	9.929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1-064	200.00	3096.5	34822.	1000.	0.0	0.0	0.0	0.0	1957.7	P	0.172	0.172	67.7	0.166	0.085	5.0	1984.	1462.		
700.0	499.	0.0	0.0	0.0	0.0	0.0	0.0	948.	948.	0.800	9.824	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1-714	200.00	4292.6	34426.	1000.	0.0	0.0	0.0	0.0	1954.6	P	0.169	0.169	66.7	0.163	0.084	5.0	1976.	1436.		
700.0	499.	0.0	0.0	0.0	0.0	0.0	0.0	922.	922.	0.800	9.809	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1-964	200.00	4606.6	34032.	1000.	0.0	0.0	0.0	0.0	1931.4	P	0.166	0.166	66.7	0.163	0.083	5.0	1968.	1412.		
700.0	484.	0.0	0.0	0.0	0.0	0.0	0.0	912.	912.	0.800	9.803	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

MISSION FUE REQUIRED = 3498.29  
RESERVE FUEL REQUIRED = 1461.75  
TOTAL FUEL REQUIRED = 4960.04

.....

END OF SUCCESSFUL CASE

.....

H E L I C O P T E R  
 HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 8-91

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. +0901  
 VAL2 VALUE CORRESPONDING TO LOC. +0802  
 ETC.

LOC.	NUM	VAL	VAL1	VAL2	VAL3	VAL4
------	-----	-----	------	------	------	------

NOTE : IN USING AUXILIARY ENGINES 1 AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE

U <sub>9</sub>	=	0.400000E+05	WFA	=	0.495000E+04	WFR	=	0.495000E+04
U <sub>6</sub>	=	0.400000E+05	WFA	=	0.458196E+04	WFR	=	0.493387E+04
W <sub>1</sub>	=	0.405027E+05	WFA	=	0.483934E+04	WFR	=	0.492233E+04

H F S C O Y P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER

SIZE DATA THIS RUN CONVERGED IN 3 ITERATIONS

GROSS WEIGHT = 49889. LB

FUSELAGE

LF	LENGTH(BODY+TAILPOOP)	50.1 FT.
LC	LENGTH(CARIN)	23.5 FT.
LR	LENGTH(BODY)	42.8 FT.
LTB	LENGTH(TAILPOOP)	7.3 FT.
XM	FWO. MOTOR LOCATION	29.7 FT.
WF	WIDTH	8.3 FT.
SF	WETTED AREA	1767.3 SQ. FT.

WING - NO WING USED

HOR. TAIL

ARHT	ASPECT RATIO	4.174
SHT	AREA	104.5 SQ. FT.
RHT	SPAN	20.9 FT.
CRARHT	MEAN CHORD	5.0 FT.
LAMBDA H	TAPER RATIO	0.755
TY/CJHT	THICKNESS/CHORD	0.150
LTH	HOR. TAIL ARM	23.2 FT.

VERT. TAIL

ARVT	ASPECT RATIO	1.500
SVT	AREA	57.3 SQ. FT.
PVT	SPAN	9.3 FT.
CBARVT	MEAN CHORD	6.2 FT.
LAMBDA VT	TAPER RATIO	0.580
ZTR	TAIL RCTOR(VERT.) LOCATION	9.0 FT.
ZETAVT	TAIL RCTOR/VERT. TAIL OVERLAP RATIO	0.0
TY/CJVT	THICKNESS/CHORD	0.151

MAIN ROTOR PYLON

AR	ASPECT RATIO	0.193
SFP	WETTED AREA	43.6 SQ. FT.
FAPF	FRONTAL AREA	4.4 SQ. FT.
HPI	HEIGHT	2.9 FT.
CBARFP	MEAN CHORD	13.4 FT.
LAMBDA FP	TAPER RATIO	0.638
TY/CJRP	ROOT THICKNESS/CHORD	0.212
TY/CJTP	TIP THICKNESS/CHORD	0.216



PRIMARY ENGINE MACELLE

LENGTH 0.0 FT.  
MEAN DIAMETER 0. FT.  
WETTED AREA (TOTAL FOR ALL ENGINES) 0.0 SQ. FT.

AUXILIARY INDEPENDENT ENGINE MACELLE -NO AUXILIARY INDEPENDENT ENGINE USED

PROPELLER (AUXILIARY PROPULSION)

DAR 6.0 FT.  
AF 100.0  
SIGAR 0.163  
NRA 2.  
NO. OF PROPELLERS 4.  
VTIP 927. FT./SEC  
NO. OF BLADES/PROP

MAIN ROTOR

DWR 58.9 FT.  
SIGMR 0.140  
WG/A 15.0 LP/SQ. FT.  
CT/SIGI 0.0  
NR 1.  
NO. OF ROTORS A.  
NO. OF BLADES/ROTOR -10,000 DEG.  
THETA 0.100  
PC 700. FT./SEC.  
VTIP

- NO TAIL ROTOR USED

H F S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM D-91

W E I G H T S O A T A I N LBS

MLF	MANUEVER LOAD FACTOR	3.070
ULF	ULTIMATE LOAD FACTOR	4.500
PROPULSION GROUP		
VPRC	TOTAL MAIN ROTOR GROUP	5523.
K12 WPR2	MAIN ROTOR PLANE (PER ROTOR)	2290.
K13 WPM	MAIN ROTOR HUB (PER ROTOR)	2183.
WRF	PLANE FOLDING (PER ROTOR)	847.
K14 WAB	AUXILIARY PROPULSION ROTOR GROUP	245.
DS	DRIVE SYSTEM	2901.
K16 WPS	MAIN ROTOR DRIVE S.STEM	2001.
K22 WTRDS	TAIL ROTOR DRIVE SYSTEM	0.
K17 WAD5	AUXILIARY PROPULSION DRIVE SYSTEM	0.
K18 WFP	PRIMARY ENGINE S	1141.
K19 WEA	AUXILIARY ENGINE S	0.
WPI1	PRIMARY ENGINE INSTALLATION	7.
WPI2	AUXILIARY ENGINE INSTALLATION	0.
WFS	FUEL SYSTEM	756.
DELTA WP	PROPULSION GROUP WEIGHT INCREMENT	0.
WP	TOTAL PROPULSION GROUP WEIGHT	31793.
STRUCTURES GROUP		
KP WU	WING	0.
WTC	TAIL GROUP	222.
K9 WMT	HOR. TAIL	222.
K14 WTR	TAIL ROTOR	0.
K6 WR	FUSelage	3619.
K7 WLG	LANDING GEAR	3390.
WNG	NOSE GEAR	278.
WMC	MAIN GEAR	3112.
WFS	TOTAL ENGINE SECTION	0.
WPT5	PRIMARY ENGINE SECTION	0.
WAF5	AUXILIARY ENGINE SECTION	0.
DELTA WST	STRUCTURE WEIGHT INCREMENT	700.
WST	TOTAL STRUCTURE WEIGHT	5718.
FLIGHT CONTROLS GROUP		
WPFC	PRIMARY FLIGHT CONTROLS	1669.
WCC	COCKPIT CONTROL	330.
K1 WRC	MAIN ROTOR CONTROL	520.
K2 WSC	MAIN ROTOR SYSTEMS CONTROL	743.
WV	FIXED WING CONTROL	204.
WVM	TILT MECHANISM	0.
WRAB	BAR	75.
WVFC	AUXILIARY FLIGHT CONTROLS	4873.
K9 WPCA	AUX. PROPULSION ROTOR CONTROL	4773.
K9 WPCA	AUX. PROPULSION ROTOR SYS. CONTROLS	111.

WMC DELTA WFC WFC	MISCELLANEOUS CONTROLS CONTROL WEIGHT INCREMENT TOTAL CONTROL WEIGHT	B.
WFE	WEIGHT OF FIRED EQUIPMENT	6342.
WE	WEIGHT EMPTY	5622.
WFUL	FIXED USEFUL LOAD	28672.
WUF	OPERATING WEIGHT EMPTY	1958.
WPL	PAYLOAD	38222.
WFLA	FUEL	5630.
WG	GROSS WEIGHT	5037.
		4889.

SAMPLE CASE NO. 4 RUN 2 PAGE 4

M F R C O M P  
HELICOPTER SIZING 1 PERFORMANCE COMPUTER PROGRAM P-91

P R I N T E R O U T P U T

FIRST MAIN ROTOR SOLICITY INPUT

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-91  
M I C R O M P

P R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE I.C. 1-420  
TURBOSHAFT ENGINE

4. ENGINES

PMHP	MAX. STANDARD S.L. STATIC M.P.	8693.	M.P.
	ENGINE SIZED FOR TAKEOFF AT 74% EFF.		
	100% PERCENT MILITARY POWER SETTING		
	M = 3.75, TEMPERATURE = 29.80 DEG.F.		
	100% ENGINE IMPERATIVE AND 0.00 FT/MIN VERTICAL RATE OF CLIMB.		
	NO CRUISE CONDITION SPECIFIED.		

NO AUX. INDEPENDENT ENGINE CYCLE SELECTED

	MAIN ACION DRIVE SYSTEM RATING	8438.	M.P.
	MSM SIZED AT 84. PERCENT OF MAIN MOTOR POWER REQUIRED		
	AT M = 3.75, TEMP = 29.80 DEG.F. 100.0 PERCENT MOTOR RPM		
	AUXILIARY PROPULSION DRIVE SYSTEM RATING	8438.	M.P.
	MSM SIZED AT 84. PERCENT OF TOTAL COMPENSATION POWER REQUIRED IN MOTOR		
	AT M = 3.75, TEMP = 29.80 DEG.F. 100.0 PERCENT MOTOR RPM		

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM M-91  
 H E L I C O P

A E R O N A U T I C S O A T A	TOTAL FIVE-TIVE FLATPLATE AREA	22.918	SGFT
FE	TOTAL WETTED AREA	1437.	SGFT
CBARF	MEAN SKIN FRICTION COEFF.	0.018948	
O R B G P R F A N O N M	IN SGFT		
FFV	WING FE	0.0	
FFV	FUSELAGE FE	22.918	
FFPP	FORWARD(MAIN) ROTOR PYLON FE	3.0	
FFAP	AFT ROTOR PYLON FE	0.1	
FFMPM	MAIN ROTOR HUB FE	0.0	
FFTPM	TAIL ROTOR HUB FE	0.0	
FFVT	VERTICAL TAIL FE	0.0	
FFHT	HORIZONTAL TAIL FE	0.0	
FFN	PRIMARY ENGINE NACELLE FE	0.0	
FFNI	AUX. INDEPENDENT CRUISE ENG. NAC. FE	0.0	
FFNS	AUX. INDEPENDENT CRUISE ENG. STRUT FE	0.0	
FFNS	INCREMENTAL FE	0.0	
A E R O N A U T I C C O E F F .			
AS		22.91754	
AT		0.0	
AP		0.0	
AP		0.0	
AP		0.024194	
FFV	WING LIFT EFFICIENCY FACTOR	0.0	
FFV	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.026171	

M T S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 9-73

KINOSTON PERFORMANCE DATA

TAXI FOR 0.033 MRS. AT GROUND IDLE ENGINE RATING

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRESS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/MR)	AUX. TURB. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. PEMP	AUX. FUEL FLOW (LBS/MR)	AUX. ENG. TEMP. DEG. (F)
0.0	0.1	0.0	4088.0	0.	0.0	1750.0	T	0.0	100%	----	----	----	----	99.0
0.033	0.0	33.3	4085.6	0.	0.0	1750.0	T	0.0	100%	----	----	----	----	99.0

TAREOFF, HOVER, OR LAND AT PEMP = 1.000 FOR 0.033 MRS.

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/MR)	THRUST TO WEIGHT	WGT CT	CT/SIGMA		
M-ROTOR VTIIP	MIP	T-ROTOR VTIIP (FPS)	T-ROTOR AMP	VAC AMP	PRIM. ENG. FUEL FLOW (LBS/MR)	AUX. ENG. FUEL FLOW (LBS/MR)	ROTLIM CODE	1.000	TEMP REG. (F)	DELOCH	FMI	CPRO	CPIND	COO

INSUFFICIENT POWER AVAILABLE TO HOVER  
(T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN DOWNLOAD

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/MR)	THRUST TO WEIGHT	WGT CT	CT/SIGMA		
0.033	0.0	33.3	4085.6	0.	0.0	2639.3	T	1.000	373.0	1.124	0.729	7887.	0.0154	0.116
700.0	0.0	0.0	0.	0.	3730.		A		29.0	0.0	0.729	0.0	0.0	0.0

INSUFFICIENT POWER AVAILABLE TO HOVER  
(T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN DOWNLOAD

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/MR)	THRUST TO WEIGHT	WGT CT	CT/SIGMA		
0.033	0.0	33.3	4076.3	0.	0.0	2639.3	T	1.000	373.0	1.124	0.729	7887.	0.0154	0.116
700.0	0.0	0.0	0.	0.	3730.		A		29.0	0.0	0.729	0.0	0.0	0.0

INSUFFICIENT POWER AVAILABLE TO HOVER  
(T/W) AVAILABLE LESS THAN (T/W) REQUIRED AT DESIGN DOWNLOAD

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/MR)	THRUST TO WEIGHT	WGT CT	CT/SIGMA		
0.033	0.0	33.3	4066.9	0.	0.0	2639.3	T	1.000	373.0	1.124	0.729	7887.	0.0154	0.116
700.0	0.0	0.0	0.	0.	3730.		A		29.0	0.0	0.729	0.0	0.0	0.0

CLIMB TO 4000. FT. WITH MAXIMUM R/C AT MILITARY ENGINE RATING  
OF TAREOFF TAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (MRS)	RANGE (M.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEMP	TOTAL FUEL FLOW (LBS/MR)	THRUST TO WEIGHT	WGT CT	CT/SIGMA	
M-ROTOR VTIIP	T-ROTOR VTIIP	T-ROTOR AMP	PRIM. ENG. FUEL FLOW (LBS/MR)	PROP VTIIP	PRIM. ENG. FUEL FLOW (LBS/MR)	AUX. FUEL FLOW (LBS/MR)	CLAP PROP	TAUNT/Y	AUX. FUEL FLOW (LBS/MR)	TURB. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. PEMP	AUX. TEMP. DEG. (F)



0.816	161.37	2459.0	38936.	4000.	280.5	2822.0	7	0.839	206.3	0.610	0.130	-1.9	0.7416	5799.
624.0	3893.	0.0	0.0	0.0	3041.	1783.	0.000	0.594	0.000	0.000	0.000	0.000	0.000	0.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000010	A	0.000	0.000	0.000	0.000	0.000	0.000
0.937	188.69	2827.4	38962.	4000.	226.1	2822.0	7	0.840	206.8	0.612	0.129	-2.0	0.7413	5793.
623.1	3871.	0.0	0.0	0.0	3041.	1802.	0.000	0.607	0.000	0.000	0.000	0.000	0.000	0.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000019	A	0.000	0.000	0.000	0.000	0.000	0.000

DESCEND TO M = 0. FT. @ 210.0 M.MI. AT CONSTANT TAS

TIME (HRS)	RANGE (N.M.P.)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TEMP. (R)	PRIM. CODE	PRIM. ENG. RPM	CAS (KTS)	MU	CT OVER SIGNA	ALPHA D/L (DEG)	GAMMA B/P (PPM)	A/S (PPM)
M. ROTOR VTIP (FPS)	M. ROTOR RMP	T. ROTOR VTIP (FPS)	T. ROTOR RMP	PROP FUEL FLOW (LBS/HR)	PROP FUEL FLOW (LBS/HR)	PROP FUEL FLOW (LBS/HR)	PROP FUEL FLOW (LBS/HR)	AUX. ENG. RPM	AUX. ENG. RPM	AUX. TEMP. (R)	AUX. TEMP. (R)	AUX. TEMP. (R)	AUX. TEMP. (R)	AUX. TEMP. (R)

TIME (HRS)	RANGE (N.M.P.)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TEMP. (R)	PRIM. CODE	PRIM. ENG. RPM	CAS (KTS)	MU	CT OVER SIGNA	ALPHA D/L (DEG)	GAMMA B/P (PPM)	A/S (PPM)
0.937	188.69	2827.4	38962.	4000.	280.5	2822.0	7	0.839	206.3	0.610	0.130	-1.9	0.7416	5799.
780.0	2827.4	0.0	0.0	0.0	3041.	1783.	0.000	0.594	0.000	0.000	0.000	0.000	0.000	0.000
0.937	188.69	2827.4	38962.	4000.	226.1	2822.0	7	0.840	206.8	0.612	0.129	-2.0	0.7413	5793.
623.1	3871.	0.0	0.0	0.0	3041.	1802.	0.000	0.607	0.000	0.000	0.000	0.000	0.000	0.000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000019	A	0.000	0.000	0.000	0.000	0.000	0.000

TAKEOFF, HOWER, OR LAND AT 1/2 = 1.03 FOR 0.200 MRS.

TIME (HRS)	RANGE (N.M.P.)	FUEL USED (LBS)	WEIGHT (LBS)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TEMP. (R)	PRIM. CODE	PRIM. ENG. RPM	CAS (KTS)	MU	CT OVER SIGNA	ALPHA D/L (DEG)	GAMMA B/P (PPM)	A/S (PPM)
1.004	26.00	2960.1	37924.	0.	0.0	2794.2	P	0.427	314.0	1.636	4.764	4.474.	0.125	0.164
M. ROTOR VTIP (FPS)	M. ROTOR RMP	T. ROTOR VTIP (FPS)	T. ROTOR RMP	PROP FUEL FLOW (LBS/HR)	PROP FUEL FLOW (LBS/HR)	PROP FUEL FLOW (LBS/HR)	PROP FUEL FLOW (LBS/HR)	AUX. ENG. RPM	AUX. ENG. RPM	AUX. TEMP. (R)	AUX. TEMP. (R)	AUX. TEMP. (R)	AUX. TEMP. (R)	AUX. TEMP. (R)



700.0	5556.	0.0	0.	0.	3140.	----	A	0.000	59.0	0.0	0.708	0.0	0.007
1.104	290.06	3274.1	0.	0.	0.0	2373.0	P	0.000	3116.	1.000	0.707	0.0122	0.007
700.0	5444.	0.0	0.	0.	3116.	----	A	0.000	59.0	0.0	0.707	0.0	0.007
1.204	201.08	3545.7	0.	0.	0.0	2367.9	P	0.000	3093.	1.000	0.707	0.0121	0.007
700.0	5343.	0.0	0.	0.	3103.	----	A	0.000	59.0	0.0	0.707	0.0	0.007

CHANGE PAYLOAD, REMOVE 200. LP.

TIME (MRS)	RANGE (N.M.)	FUEL USED (LBS)	WRIGHT (LBS)	WTIF (LBS)	PREP. ALT. (FT)
1.204	200.00	3545.7	3730.4	0.	0.
1.214	200.00	3485.7	3530.4	0.	0.

TRANSFER ALTITUDE TO 1000. FT.

TIME (MRS)	RANGE (N.M.)	FUEL USED (LBS)	WRIGHT (LBS)	WTIF (LBS)	PREP. ALT. (FT)
1.214	200.00	3545.7	3530.4	0.	1000.
1.214	200.00	3485.7	3530.4	0.	1000.

LITER FOR 1.7% MRS. FOR RESERVE FUEL

TIME (MRS)	RANGE (N.M.)	FUEL USED (LBS)	WRIGHT (LBS)	WTIF (LBS)	PREP. ALT. (FT)	TAO (MRS)	PRIM. ENG. CODE	PRIM. ENG. PEMP	EAS (MRS)	MU	CT OVER SIGMA	ALPHA D/L (FEET)	TOTAL FULL FLW (LBS/MR)	ENG. PMU OR THRUST
1.214	210.00	3545.7	3530.4	1.00	71.7	1956.	P	0.0171	70.7	0.173	0.100	1577.	1454.	
700.0	1419.	0.0	0.0	0.0	0.0	0.0	0.000123	0.019	0.000	0.000	0.000	0.000	0.000	
1.214	210.00	3545.7	3450.7	1.00	76.7	1952.4	P	0.0167	75.6	0.100	0.004	1577.	1424.	
700.0	1381.	0.0	0.0	0.0	0.0	0.0	0.000142	0.015	0.000	0.000	0.000	0.000	0.000	
1.214	210.00	3545.7	3451.3	1.00	79.7	1945.9	P	0.0165	69.7	0.173	0.003	1577.	1466.	
700.0	1362.	0.0	0.0	0.0	0.0	0.0	0.000120	0.020	0.000	0.000	0.000	0.000	0.000	
1.264	210.00	4769.2	3412.0	1.00	70.7	1945.9	P	0.0167	69.7	0.170	0.002	1562.	1341.	
700.0	1339.	0.0	0.0	0.0	0.0	0.0	0.000120	0.020	0.000	0.000	0.000	0.000	0.000	

MISSION FUEL REQUIRED = 3985.71  
 RESERVE FUEL REQUIRED = 1451.53  
 TOTAL FUEL REQUIRED = 5437.25

.....  
 END OF SUCCESSFUL CASE  
 .....

SAMPLE CASE NO. 6 RUN 3

PAGE 1

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-93  
 H E S C O M P

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. 25)  
 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
------	-----	-----	------	------	------	------

714	2	20.943				
601	1	2400.7			2000.0	
871	1	20.943				
971	1	20.943				
1011	1	2000.0				
1471	1	20.943				
1271	2	596.40			511.70	
VR = 0.400000E+04	MFA = 0.503730E+04	MFR = 1.303226E+04				
VR = 0.400000E+04	MFA = 0.481945E+04	MFR = 1.192634E+04				
VR = 0.400000E+04	MFA = 0.483303E+04	MFR = 0.498360E+04				

NOTE: IN USING AUXILIARY ENGINES 3 AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66566 CARD IN FRONT AND REFINO A STANDARD ENGINE CYCLE

M I S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

SINGLE ROTOR AUXILIARY PROPULSION HELICOPTER

SIZE C A T A THIS RUN CONVERGED IN 3 ITERATIONS

GROSS WEIGHT = 40721.14

FUSELAGE

LF	LENGTH(BODY+TAILBOOP)	57.1 FT.
LC	LENGTH(CABIN)	23.5 FT.
LP	LENGTH(BODY)	42.4 FT.
LTH	LENGTH(TAILBOOP)	7.3 FT.
XP	POS. ROTOR LOCATION	26.7 FT.
WF	WIDTH	8.3 FT.
SF	WETTED AREA	163.2 SQ. FT.

WING - 40 WING USED

HOR. TAIL

ARVT	ASPECT RATIO	4.174
SVT	AREA	154.9 SQ. FT.
FVT	SPAN	27.0 FT.
CHARVT	MEAN CHORD	6.444
LAMPDA HT	TAPER RATIO	.14
CT/CHT	THICKNESS/CHORD	23.2 FT.
LTH	HOR. TAIL ARM	

VERT. TAIL

ARVT	ASPECT RATIO	1.540
SVT	AREA	97.3 SQ. FT.
FVT	SPAN	9.3 FT.
CHARVT	MEAN CHORD	1.2 FT.
LAMPDA VT	TAPER RATIO	.500
776	TAIL ROTOR(VERT.) LOCATION	. FT.
ZETA VT	TAIL ROTOR(VERT.) TAIL OVERLAP RATIO	
CT/CHVT	THICKNESS/CHORD	0.146

MAIN ROTOR PYLON

AP	ASPECT RATIO	.1143
SFP	WETTED AREA	43.6 SQ. FT.
FAEP	FRONTAL AREA	4.4 SQ. FT.
MPJ	HEIGHT	2.0 FT.
CHARFP	MEAN CHORD	1.4 FT.
LAMPDA FP	TAPER RATIO	1.438
CT/CHP	THICKNESS/CHORD	.212
CT/CHY	YIP THICKNESS/CHORD	0.216

**PRIMARY ENGINE NACELLE**

LN                    LENGTH                    0.0 FT.  
 DN                    MEAN DIAMETER            1.0 FT.  
 SW                    WETTED AREA(TOTAL FOR ALL ENGINES)    0.9 SQ. FT.

**AUXILIARY INDEPENDENT ENGINE NACELLE -NO AUXILIARY INDEPENDENT ENGINE USED  
 PROPELLER(AUXILIARY PROPULSION)**

DAR                    DIAMETER                    4.0 FT.  
 AF                    ACTIVITY FACTOR PER BLADE            100.0  
 SIGR                    SOLIDITY                    0.165  
 MRA                    NO. OF PROPELLERS            2  
 NO. BLADES            NO. OF BLADES/PROP            4  
 VTIP                    TIP SPEED                    927. FT./SEC

**MAIN ROTOR**

DMR                    DIAMETER                    54.9 FT.  
 SIGMR                    SOLIDITY                    0.140  
 W6/A                    DISC LOADING                15.0 LB/SQ. FT.  
 CT/SIGMA                THRUST COEFF./SOLIDITY            7.0  
 NP                    NO. OF ROTORS                1  
 NO. BLADES            NO. OF BLADES/ROTOR            6  
 THETA                    BLADE TWIST                -10.000 DEG.  
 XC                    BLADE CUTOUT/RADIUS RATIO        0.10  
 VTIP                    TIP SPEED                    710. FT./SEC.

- NO TAIL ROTOR USED

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91

WEIGHTS DATA IN LBS

MLF	MANEUVER LOAD FACTOR	3.070
ULF	ULTIMATE LOAD FACTOR	4.500
<b>PROPULSION GROUP</b>		
K12 WPRG	TOTAL MAIN ROTOR GROUP	5318.
K13 WPH	MAIN ROTOR BLADE (PER ROTOR)	2289.
K15 WAF	MAIN ROTOR HUB (PER ROTOR)	2162.
K16 WAP	BLADE FOLDING (PER ROTOR)	867.
K17 WAP	AUXILIARY PROPULSION ROTOR GROUP	285.
K18 WAP	DRIVE SYSTEM	2900.
K19 WAP	MAIN ROTOR DRIVE SYSTEM	2900.
K20 WTRD	TAIL ROTOR DRIVE SYSTEM	0.
K21 WAP	AUXILIARY PROPULSION DRIVE SYSTEM	0.
K22 WAP	PRIMARY ENGINES	1190.
K23 WAP	AUXILIARY ENGINES	0.
K24 WAP	PRIMARY ENGINE INSTALLATION	357.
K25 WAP	AUXILIARY ENGINE INSTALLATION	0.
K26 WAP	FUEL SYSTEM	754.
K27 WAP	PROPULSION GROUP WEIGHT INCREMENT	0.
K28 WAP	TOTAL PROPULSION GROUP WEIGHT	1785.
<b>STRUCTURES GROUP</b>		
K29 WAP	WING	0.
K30 WAP	TAIL GROUP	222.
K31 WAP	HOR. TAIL	222.
K32 WAP	TAIL ROTOR	0.
K33 WAP	FUSELAGE	3613.
K34 WAP	LANDING GEAR	1390.
K35 WAP	NOSE GEAR	278.
K36 WAP	MAIN GEAR	1112.
K37 WAP	TOTAL ENGINE SECTION	0.
K38 WAP	PRIMARY ENGINE SECTION	0.
K39 WAP	AUXILIARY ENGINE SECTION	0.
K40 WAP	STRUCTURE WEIGHT INCREMENT	700.
K41 WAP	TOTAL STRUCTURE WEIGHT	5716.
<b>FLIGHT CONTROLS GROUP</b>		
K42 WAP	PRIMARY FLIGHT CONTROLS	1668.
K43 WAP	COCKPIT CONTROLS	119.
K44 WAP	MAIN ROTOR CONTROLS	529.
K45 WAP	MAIN ROTOR SYSTEMS CONTROLS	741.
K46 WAP	FIXED WING CONTROLS	204.
K47 WAP	TILT MECHANISM	0.
K48 WAP	SAS	75.
K49 WAP	AUXILIARY FLIGHT CONTROLS	4872.
K50 WAP	AUX. PROPULSION ROTOR CONTROLS	477.
K51 WAP	AUX. PROPULSION ROTOR SYS. CONTROLS	111.

UMC	MISCELLANEOUS CONTROLS	0.
DELTA WFC	CONTROL WEIGHT INCREMENT	0.
WFC	TOTAL CONTROL WEIGHT	6540.
WFE	WEIGHT OF FIXED EQUIPMENT	5622.
WFE	WEIGHT EMPTY	28663.
WFUL	FIXED USEFUL LOAD	1550.
OVF	OPERATING WEIGHT EMPTY	3213.
WPL	PAYLOAD	5630.
WVFA	FUEL	5028.
WG	GROSS WEIGHT	4671.

SAMPLE CASE NO. 4 RUN 3 PAGE 4

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91  
H F S C O M P

R O T O R D A T A  
FIXED MAIN ROTOR SOLIDITY INPUT

SAMPLE CASE NO. 4 RUN 2

PAGE 4

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-91  
H E S C O M P

P R O P U L S I O N D A T A  
PRIMARY PROPULSION CYCLE NO. 1.820  
TURBOSHAFT ENGINE

4. ENGINES

BHP	MAX. STANDARD S.L. STATIC M.P.	8649.	M.P.
ENGINE SIZED FOR TAKEOFF AT T/U = 1.15			
100.0 PERCENT MILITARY POWER SETTING.			
H =	0. FT. TEMPERATURE = 89.80 DEG.F.		
0.0	ENGINES IMPERATIVE, AND 0.0 FT/MIN VERTICAL RATE OF CLIMB.		

NO CRUISE CONDITION SPECIFIED.

NO AUX. INDEPENDENT ENGINE / CYCLE SELECTED

MAIN ROTOR DRIVE SYSTEM RATING	6825.	H.P.
--------------------------------	-------	------

XMSN SIZED AT 94. PERCENT OF MAIN ROTOR HOVER POWER REQUIRED		
AT H = 0. FT. TEMP = 89.80 DEG.F.	100.0 PERCENT HOVER RPM	

AUXILIARY PROPULSION DRIVE SYSTEM RATING	6835.	H.P.
XMSN SIZED AT 94. PERCENT OF TOTAL CONFIGURATION POWER REQUIRED TO HOVER		
AT H = 0. FT. TEMP = 89.80 DEG.F.	100.0 PERCENT HOVER RPM	

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-01

H I S C O U P

A F R C D V N A M I C S O A T A			
FF	TOTAL EFFECTIVE PLATE AREA	22.013	SQFT
SMET	TOTAL WETTED AREA	1437.	SQFT
CPARC	MEAN SWIRL FRICTION COEFF.	0.18497	
U R A G M R F A K O O M M	1 P. COEF		
FFM	WING CF	0.015	
FFF	FUSelage CF	0.0	
FFFP	FORWARD MAIN ROTOR PYLON CF	0.0	
FFAP	AFT ROTOR PYLON CF	0.0	
FFAMH	MAIN ROTOR HUB CF	0.0	
FFTHH	TAIL ROTOR HUB CF	0.0	
FFVT	VERTICAL TAIL CF	0.0	
FFHT	HORIZONTAL TAIL CF	0.0	
FFA	PRIMARY ENGINE FACILITY CF	0.0	
FFM1	AUX. INDEPENDENT ENGINE FAC. CF	0.0	
FFAS	AUX. INDEPENDENT ENGINE STRUT CF	0.0	
DELTA FF	INCREMENTAL CF	0.0	
A F R C D V N A M I C C O F F			
AC		2.5124	
A7		0.0	
AC		0.0	
AL		0.02408	
FVT	WING LIFT EFFICIENCY FACTOR	0.0	
	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.0471	



M F S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM R-91

MISSION PERFORMANCE DATA

TAKEOFF FOR 0.033 MRS. AT GROUND IDLE ENGINE RATING

TIME (MRS)	RANGE (M.F.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRFSS. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERM	TOTAL FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. CODE	AUX. ENG. PERM	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. TEMP. (R)
0.0	0.0	0.0	40871.	0.	0.0	0.0	175.60	Y	0.0	100.0	----	----	----	----	59.0
0.033	0.0	33.1	40837.	0.	0.0	0.0	170.00	Y	0.0	100.0	----	----	----	----	59.0

TAKEOFF, HOVER, OR LAND AT PTF = 1.000 FOR 0.000 MRS.

TIME (MRS)	RANGE (M.F.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRFSS. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERM	TOTAL FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. CODE	AUX. ENG. PERM	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. TEMP. (R)
0.000	0.0	0.0	40871.	0.	0.0	0.0	175.60	Y	0.0	100.0	----	----	----	----	59.0
0.033	0.0	33.1	40837.	0.	0.0	0.0	170.00	Y	0.0	100.0	----	----	----	----	59.0

INSUFFICIENT POWER AVAILABLE TO HOVER

TIME (MRS)	RANGE (M.F.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRFSS. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERM	TOTAL FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. CODE	AUX. ENG. PERM	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. TEMP. (R)
0.033	0.0	33.1	40837.	0.	0.0	0.0	263.00	Y	1.000	373.0	89.8	1.129	0.729	0.0194	0.110
700.0	700.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSUFFICIENT POWER AVAILABLE TO HOVER

TIME (MRS)	RANGE (M.F.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRFSS. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERM	TOTAL FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. CODE	AUX. ENG. PERM	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. TEMP. (R)
0.000	0.0	126.5	40744.	0.	0.0	0.0	263.00	Y	1.000	373.0	89.8	1.129	0.729	0.0194	0.110
700.0	700.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSUFFICIENT POWER AVAILABLE TO HOVER

TIME (MRS)	RANGE (M.F.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRFSS. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERM	TOTAL FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. CODE	AUX. ENG. PERM	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. TEMP. (R)
0.000	0.0	219.9	40651.	0.	0.0	0.0	263.00	Y	1.000	373.0	89.8	1.129	0.729	0.0194	0.110
700.0	700.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CLIMB TO 4000. FT. WITH MAXIMUM P/C AT MILITARY ENGINE RATING  
P/C IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (MRS)	RANGE (M.F.)	FUEL USED (LBS)	WEIGHT (LBS.)	ALT. (FT)	PRFSS. (FT)	TAS (KTS)	PRIM. TURN. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PERM	TOTAL FUEL FLOW (LBS/HR)	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. CODE	AUX. ENG. PERM	AUX. FUEL FLOW (LBS/HR)	AUX. ENG. TEMP. (R)
0.000	0.0	0.0	40871.	0.	0.0	0.0	175.60	Y	0.0	100.0	----	----	----	----	59.0
0.033	0.0	33.1	40837.	0.	0.0	0.0	170.00	Y	0.0	100.0	----	----	----	----	59.0

CPY	DATE	TIME	FROM	TO	AMOUNT	REMARKS	INITIALS	RECEIVED	DATE	BY	AMOUNT	REMARKS
0001	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0002	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0003	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0004	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0005	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0006	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0007	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0008	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0009	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT
0010	1970	12:00	1000	1000	1000.00	INITIAL DEPOSIT					1000.00	INITIAL DEPOSIT





MISSION FUEL REQUIRED 2 376.55  
RESERVE FUEL REQUIRED 5 1486.17  
TOTAL FUEL REQUIRED 8 5197.42

.....

END OF SUCCESSFUL CASE

.....

### 7.3.5 Single Rotor Winged Helicopter

The design mission profile is illustrated in Figure 7-5. The engine and rotor cycles are not discussed in this case. A complete copy of the program printout follows the description of the input.

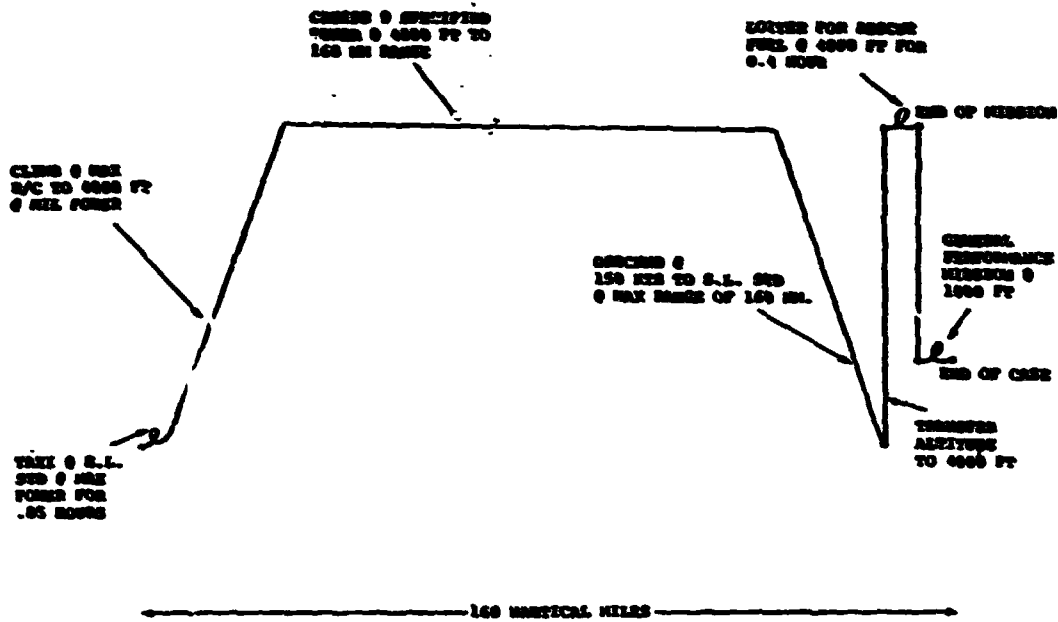


Figure 7-5. Design Mission - Sample Case No. 5

SAMPLE CASE NO. 5

GENERAL INFORMATION SHEET

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
OPTIND	0001	1.	Sizing run
OPTIONAL PRINT	0002	1.	Detailed printout desired
DRGIND	0003	2.	GW/Fe drag trend utilized
OSWIND	0004	0	User inputs Oswald's efficiency factor (e)
CNFIND	0005	1.	Single rotor helicopter desired
AUXIND	0006	2.	Configuration includes wings only
RDMIND	0007	3.	User inputs the diameter, location 0182, $C_T/\sigma$
FIXIND	0008	1.	Program sizes primary engines
ROTIND	0009	1.	Performance calculated by short method
SWIND	0010	3.	Size for maneuver
BWIND	0011	2.	User inputs wing aspect ratio
ENGIND	0013	.0	Turboshaft (power producing) cycle
TRDIND	0015	1.	Use trend of diameter main/diameter tail = fn (W/A) MAIN
TRSIND	0016	2.	Input $C_T/\sigma$
VTFIND	0017	1.	Input locations 0135 + 0138 $AR_{VT}$ and $\zeta_{VT}$ respectively

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
HTIND	0018	2.	Horizontal tail volume coefficient input
MRPIND	0019	0.	Main rotor position on fuselage input by user
ESCIND	0022	1.	Program will size engines for takeoff only
WG <sub>0</sub>	0023	9000.	First guess at design gross weight
h <sub>0</sub>	0024	.0	Initial altitude } Normally Initial range } 0.0 Starting time } except for mission analysis
R <sub>0</sub>	0025	.0	
t <sub>0</sub>	0026	.0	
h <sub>OPT</sub> IND	0027	.0	Cruise at specified altitude
M <sub>MO</sub>	0028	.333	Maximum operating Mach number
V <sub>MO</sub>	0029	220.	Maximum operating equivalent airspeed knots
V <sub>DIVE</sub>	0030	240.	Dive speed - approximately equal to 1.2 x V <sub>MO</sub> in knots
M <sub>LF</sub>	0031	3.	Maneuver load factor
K <sub>1</sub>	0032	1.	Factor on mission fuel burned to give reserve fuel. 1.111 results in 10% of initial fuel for reserve
δW <sub>F</sub>	0033	.0	Fixed fuel increment for reserves or other use
K <sub>FF</sub>	0034	1.05	Increase basic engine SFC by 5 percent



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
SGTIND	0035	1.0	Taxi
	0036	3.	Climb
	0037	4.	Cruise
	0038	5.	Descent
	0039	9.	Transfer altitude
	0040	60.0	Loiter for reserve fuel
	0041	0.0	End of mission
	0042	11.	General performance
	0043	100.0	End of case

Sequence  
of  
design  
mission

#### HELICOPTER DIMENSIONAL INFORMATION SHEET

AR	0104	4.5	Wing aspect ratio
(+/c)R	0105	.17	Wing root thickness to chord ratio
(+/c)T	0106	.13	Wing tip thickness to chord ratio
$\Lambda_{c/4}$	010	.0	Sweep angle of wing quarter chord (degrees)
$\lambda$	0108	.6	Taper ratio of wing
$C_{F/C}$	0109	.3	Ratio of download alleviating flap chord to wing chord
$h' / n_f$	0110	.5	Ratio of wing height on fuselage (relative to the bottom of the fuselage), $h'$ , to the total fuselage height, $h_f$
$C_{LD}$	0111	.313	Wing design lift coefficient

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$AR_{HT}$	0112	4.	Horizontal tail aspect ratio
$l'_{TH}$	0113	1.	Ratio of horizontal tail moment arm to main rotor radius
$(t/c)_{HT}$	0114	.15	Horizontal tail thickness/chord ratio
$\bar{V}_H$	0115	.0149	Horizontal tail volume coefficient referred to main rotor diameter and tail arm
$\lambda_H$	0116	1.	Horizontal tail taper ratio
$\Delta S_{WET}/Sp$	0120	.1	Fuselage wetted area ratio
$\Delta S_{WT}$	0121	.0	Incremental fuselage wetted area
$h_F$	0122	5.862	Fuselage height
$W_F$	0123	5.862	Fuselage width
$(l/d)_p$	0124	1.4357	Fineness ratio of nose
$(l/d)_T$	0125	.583	Fineness ratio of tail
$l_c$	0126	6.833	Constant diameter section length
$l_{RW}$	0127	.0	Length of ramp well
$(X_M/l_B)$	0128	.6	Main rotor position aft of the nose as a fraction of main fuselage length
$(l_{TB}/d_{TB})$	0129	3.33	Fineness ratio of tail boom
$(d_{TT}/d_{TB})$	0130	.3	Ratio of average tail boom tip diameter to average tail boom diameter

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$K_T$ STING	0131	-.558	Tail boom (on single rotor helicopter) length extending aft of tail rotor center as a fraction of tail rotor radius
$AR_{UT}$	0135	1.5	Vertical tail aspect ratio
$\lambda_{VT}$	0136	.7	Vertical tail taper ratio
$(t/c)_{VT}$	0137	.15	Thickness/chord ratio of vertical tail
$\zeta_{VT}$	0138	1.	Vertical tail span overlap distance/tail rotor radius ratio - input as a function of tail rotor radius
$K_Z$	0139	1.	Vertical position of the tail rotor center (relative to the vertical fin root chord) as a fraction of tail rotor radius. When TRDIND=0, (as in this example), vertical tail span is input into this location.
$Z_1$	0142	.0	Primary engine nacelle dimensional factors
$Z_2$	0143	.0	
$Z_3$	0144	.0	
$l_{AIP}/l_C$	0145	.0	Ratio of air induction system length to primary engine length
$(t/c)_{RF}$	0152	.45	Main rotor pylon root thickness/chord ratio
$(t/c)_{TF}$	0153	.25	Main rotor pylon tip thickness/chord ratio
$AR_{FP}$	0154	.21	Main rotor pylon aspect ratio

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\lambda_{FP}$	0155	.74	Forward rotor pylon taper ratio
$h_{p1}$	0156	.75	Main rotor pylon height
ROTOR DIMENSIONAL DATA FOR SIZING MAIN ROTOR			
ROTOR CYCLE NO.	0171	6.5	Rotor cycle number
$N_p$	0172	1.	Number of rotors
W/A	0173	8.	Main rotor disc loading
$D_{MR}$	0174	38.	Main rotor diameter
$b_{MR}$	0176	4.	Number of main rotor blades
$\theta_{TMR}$	0177	-12.	Main rotor twist (degrees)
$X_{C_{MR}}$	0178	.2	Main rotor blade cutout as a fraction of radius
$X_{MR}$	0179	.07	Main rotor blade attachment point as a fraction of radius
$(t/c)_{.25R}$	0180	.12	Rotor blade thickness/chord at 25 percent radius
$V_T$	0181	760.7	Main rotor tip speed
$(C_T/\sigma)_H$	0182	.14	Ratio of thrust coefficient to rotor solidity (helicopter $C_T = \text{Thrust} / (PAV_{TIP}^2)$ , includes $(C_T/\sigma)$ , $(C_T/\sigma)Des(H)$ , $(C_T/\sigma)CR$ )
T/W	0183	1.03	Configuration thrust/weight ratio (hover)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$V_{KT}(c)$	0184	180.	Velocity in knots for cruise condition for rotor and wing sizing
$h_c(c)$	0185	2000.	Cruise altitude for sizing main rotor solidity
$\Delta TINC$	0186	18.1	Temperature increment for cruise condition for rotor and wing sizing
$(C_T/\sigma)_{CR}$	0187	.07518	Ratio of thrust coefficient to rotor solidity (helicopter $C_T = Thrust/PAV_{TIP}^2$ ). includes $(C_T/\sigma)$ , $(C_T/\sigma)_{Des(H)}$ , $(C_T/\sigma)_{CR}$
$g_{REQM'T}$	0188	1.	Total maneuver g requirement helicopter must satisfy (wing + rotor)-g
$g(ROTOR)$	0189	.7	Maneuver g's which rotor must carry. In the case of a pure helicopter, $g_{REQMT} = g_{ROT}$
$N^{(ROTOR LOADING)}$	0190	.7	Rotor loading (rotor lift/GW)
$V_{CEH1}$	0191	1.53	Main rotor vertical rate of climb efficiency factors
$V_{CEH2}$	0192	.0	
$K_{pCLIMB}$	0193	.85	Helicopter forward flight climb efficiency
$K_{pDESCENT}$	0194	.85	Helicopter forward flight descent efficiency
bTR	0203	4.	Blade number per tail rotor or propeller

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$\theta_{TR}$	0204	-9.	Tail rotor blade twist
$X_{CTR}$	0205	.05	Tail rotor blade cutout (end of blade shank, beginning of rotor airfoil sections) position as a fraction of rotor radius
$X_{TR}$	0206	.02	Tail rotor blade attachment point as a fraction of rotor radius
$V_{TTR\_REF}$	0207	766.7	Tail rotor design tip speed (hover) - (fps)
$(C_T/\sigma)_{DES} (M)$	0208	.14	Ratio of thrust coefficient to rotor solidity (helicopter $C_T = Thrust/PAV_{TIP}^2$ )
YAW ACCEL ( $\ddot{\psi}$ )	0209	1.	Helicopter yaw acceleration, $rad/sec^2$
YAW RATE ( $\dot{\psi}$ )	0210	0.	Helicopter yaw rate, $rad/sec^2$
$CT_G/CT_{NET}$	0211	1.07	Ratio of tail rotor total thrust coefficient to net thrust coefficient, where $C_{TNET} = C_{TG-Fin}$ blocking losses
$K_{ZZZ}$	0213	1.	Single rotor helicopter yaw moment of inertia adjustment factor

ROTOR DIMENSIONAL DATA FOR SIZING TAIL ROTOR

$g_{MR/TR}$	0214	.5	Gap between main and tail rotor disc (FT). When TRDIND=0, represents gap between main rotor disc and end of tail boom (FT). Negative number implies tail boom ends under the main rotor disc.
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<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$K_{TRS}$	0215	1.	Tail rotor solidity multiplicative factor (used to determine tail rotor solidity)
$C_{L_{FIN}}$	0216	.2	Vertical tail fin operating cruise lift coefficient

**PRIMARY ENGINE SIZING INFORMATION SHEET**

Primary Engine Cycle No.	0217	3.11	Primary engine selection
$N_p$	0219	1.	Number of primary engines
$SHP_{MRX}/SHP_{MR}^*$	0221	.7625	Main rotor drive system is rated at 102% of main rotor design power
$\eta_T$	0223	.0	Transmission efficiency
$\Delta SHP_{ACC}$	0224	.97	Accessory power losses
$SHP_{TRX}/TRP^*$	0225	.1	Ratio of tail rotor drive system XMSN rating to tail rotor design power
$H_{TO(H)}$	0227	4000.	Design power hover altitude for engine sizing
$(T/W)_D$	0228	1.03	Configuration design point hover thrust/weight ratio
$\Delta T_{IN TO (H)}$	0229	50.3	Temperature increment in degrees above standard at altitude for engine sizing
$(N_{II}/N_{II_{MAX}})_{T.O.}$	0230	1.	Operating point for engine power turbine. Operating tip speed is computed from

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
			$V_{T \text{ OPERATING}} = V_T \left[ \frac{N_{II}}{N_{II \text{ MAX}}} \right] \left[ \frac{N_{II \text{ MAX}}}{N_{II}^*} \right]$ <p>To operate at <math>V_T = 625</math> ft/sec requires that <math>N_{II}/N_{II \text{ MAX}}</math> be the reciprocal of <math>\frac{N_{II \text{ MAX}}}{N_{II}^*}</math></p>
$N_{\text{PSD}}$	0231	.0	Number of engines in-operative at hover design point conditions
$\text{SHP}_E/\text{SHP}^*$	0232	.95	Engines sized to permit operation at 100% of maximum rated power
$(V_{R/C})_D$	0233	450.	500 ft/min vertical rate of climb capability required at hover design point.
POWIND	0234	2.0	Maximum engine rating for cruise engine sizing. For this example, normal rated power is the maximum rating to be used.
$h_C$	0235	2000.	Design point cruise altitude for engine sizing.
$V_C$	0236	180.	Design point cruise speed for engine sizing.
$\Delta T_{\text{INCE}}$	0237	18.1	Temperature increment above standard for cruise engine sizing.



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$(N_{II}/N_{II_{MAX}})_C$	0238	1.	
$C_{L_{DP}}$	0240	.4873	Wing operating lift coefficient at cruise condition for engine sizing
$(N_{PSD})_C$	0241	.3	No. of primary engines shut down during cruise (for engine sizing)

#### HELICOPTER AERODYNAMICS INFORMATION SHEET

GN/Fe	0312	1097.6	} Drag trend constants are derived from data such as illustrated by Figure 4-30, Section 4.9
$K_{FED}$	0313	.51108	
TPEF	0315	1.	Tail fin aspect ratio effectiveness factor
$K_N$	0327	1.	Wing multiplicative drag factor
$(Re/l)_i$	0328	.195 E+07	Mean Reynolds number per foot of mission
Cl <sub>a</sub>	0329	6.28	Two-dimensional wing lift coefficient slope (Rad <sup>-1</sup> )
NO. OF PAIRS IN $C_{L+C_{D_{wi}}}$ TABLE	0330	2.	
CLW	0331	.0	Wing lift coefficient
	0332	10.	
$C_{D_{wi}}$	0339	.009	Profile drag coefficient of wing at Fe = 10 (based on wing planform area)
	0340	.009	
No. of $C_X/\sigma$	0347	3.	Specifies number of $C_X/\sigma$ values in table locations 0349-0353.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
No. of $\mu$	0348	3.	Specifies number of $\mu$ values in table locations 0354-0360.
VALUES OF $C_X/\sigma$	0349	-1.	Rotor propulsive thrust coefficient divided by main rotor solidity. Used in defining rotor limits
	0350	0.	
	0351	-1.	
			$C_X/\sigma = \frac{\text{THRUST REQUIRED}}{4 \rho D_{MR}^2 N_R V_{TIP}^2 \sigma_{MR}}$
VALUES OF $\mu$	0354	.0	Rotor forward flight advance ratio
	0355	.5	
	0356	1.	
			$\mu = \frac{V_{FPS}}{V_{TIP}}$
VALUES OF $C_T'/\sigma$	0361	1.	Values of $C_T'/\sigma$ corresponding to $(C_X/\sigma)_1$ , location 0349 and $\mu_1, \mu_2$ , and $\mu_3$
	0362	.	
	0363	1.	
	0368	1.	Value of $C_T'/\sigma$ corresponding to $(C_X/\sigma)_2$ location 0350 and $\mu_1, \mu_2$ , and $\mu_3$
	0369	1.	
	0370	1.	
	0375	1.	Values of $C_T'/\sigma$ corresponding to $(C_X/\sigma)_3$ location 0351 and $\mu_1, \mu_2$ , and $\mu_3$
	0376	1.	
	0377	1.	

HELICOPTER WEIGHT INFORMATION SHEET

$W_{FE}$	2602	1784.	Weight of fixed equipment in Lbs.
$W_{FUL}$	2603	1250.	Weight of fixed useful load in Lbs.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$W_{PL}$	2604	530.	Weight of payload in Lbs.
$\Delta W_{FL}$	2605	50.	Flight controls group incremental weights in Lbs.
$\Delta W_D$	2606	100.	Propulsion group incremental weights in Lbs.
$\Delta W_{ST}$	2607	.0	Structures group incremental in Lbs.
$RM_1$	2608	.0	Wing relief as percentage of GW.
$W_i$	2609	.0	Weight of inboard store.
$W_o$	2610	.0	Weight of outboard store
$d_i$	2611	.0	Position of inboard underwing store (fraction of wing semi-span).
$d_o$	2612	.0	Position of outboard underwing store (fraction of wing semi-span)
$k_u$	2613	26.	Cockpit controls weight factor
$k_{RL}$	2614	20.	Main rotor controls weight factor
$k_{SL}$	2615	30.	Main rotor system controls weight factor
$k_{FW}$	2616	.0	Fixed wing controls
$k_{TM}$	2617	.015	Tilt mechanism weight factor
$k_{SAS}$	2618	75.	Stability Augmentation System (SAS) weight factor. Usually in the range of 20-100 pounds.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{RCA}$	2619	.0	Auxiliary rotor controls weight factor.
$k_{SCA}$	2620	.0	Auxiliary rotor system controls weight factor.
$k_{KMC}$	2621	.0	Miscellaneous controls weight factor in Lbs.
$k_B$	2622	125.	Body group weight factor.
$\Delta C.G.$	2623	.8	Helicopter c.g. travel (ft).
$k_{LG}$	2624	.03	Landing gear weight factor. Percentage of gross weight.
$k_{MG}$	2625	.8	Main landing gear weight factor.
$k_{WW}$	2626	.8	Detailed wing weight factor. This adjusts the constant 220 in $W_w = 220(k)^{0.585}$ up or down depending on the complexity of the control surfaces.
CF	2627	1.	Wing unload factor. Entered as a fraction of design gross weight.
$k_{WS}$	2628	.0	Wing stores only weight trend factor.
$k_{ap}$	2629	4.	Wing weight/area factor (psf)
$k_{HT}$	2630	1.5	Horizontal tail unit weight in PSF.
$k_{CLF}$	2631	.0	Crash load factor.
$k_{NAC}$	2632	.0	Primary cowling weight factor (PSF)
$k_{AIP}$	2633	125.	Primary air induction system weight factor.
$k_{NACA}$	2634	.0	Auxiliary cowling weight factor (PSF)

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{AIA}$	2635	.0	Auxiliary air induction system weight factor.
$k_{NS}$	2636	.0	Nacelle strut weight factor.
$k_{PRB}$	2637	44.	Primary rotor blade weight factor.
$k_{RBF}$	2638	2.2	Rotor type factor; hingeless for this example.
$k_{PH}$	2639	61.	Primary hub weight factor.
$k_{amd}$	2640	.54	Main rotor weight factor.
$k_{BLFD}$	2641	1.	Blade fold weight factor. Input as a fractional part of the total rotor weight.
$k_{TR}$	2642	13.	Tail rotor weight factor.
$k_{AR}$	2643	.0	Auxiliary rotor weight factor. This is the average value for the rotor or propeller weight (LB). $W_R = 14.2 a(k) \cdot 67$
$k_{PA}$	2644	1.	Auxiliary rotor multiplicative input power, expressed here as 100% input power.
$k_{VTAR}$	2645	1.	Auxiliary tail rotor multiplicative tip speed factor, expressed here as 100% input speed.
$k_{PDS}$	2646	230.	Primary drive system weight factor.
$k_{PDSZ}$	2647	3.	Primary drive system weight factor. Number of gears on system.
$k_{TRDS}$	2648	275.	Tail rotor drive system weight factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$k_{ADS}$	2649	.0	Auxiliary drive system weight factor.
$k_{ADSZ}$	2650	.0	Auxiliary drive system weight factor (number of gears in system).
$k_{FS}$	2651	.15	Fuel system weight factor.
$k_{PEI}$	2652	.0	Primary engine installation weight factor.
$k_{AEI}$	2653	.0	Auxiliary engine installation weight factor.
$K_1$	2654	1.	Main rotor controls weight factor.
$K_2$	2655	.9	Main rotor system controls weight multiplicative factor.
$K_3$	2656	1.	Fixed wing controls weight multiplicative factor.
$K_4$	2657	1.	Auxiliary rotor controls weight multiplicative factor.
$K_5$	2658	1.	Auxiliary rotor system controls weight multiplicative factor.
$K_6$	2659	.85	Body weight multiplicative factor.
$K_7$	2660	.85	Landing gear weight multiplicative factor.
$K_8$	2661	1.	Wing weight multiplicative factor.
$K_9$	2662	1.	Horizontal tail weight multiplicative factor.
$K_{10}$	2663	1.	Primary nacelle weight multiplicative factor.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
K <sub>11</sub>	2664	1.	Auxiliary nacelle weight multiplicative factor.
K <sub>12</sub>	2665	.9	Primary rotor blade weight multiplicative factor.
K <sub>13</sub>	2666	.8	Primary rotor hub weight multiplicative factor.
K <sub>14</sub>	2667	1.	Tail rotor weight multiplicative factor.
K <sub>15</sub>	2668	1.	Auxiliary rotor weight multiplicative factor.
K <sub>16</sub>	2669	.9	Primary drive system weight multiplicative factor.
K <sub>17</sub>	2670	1.	Auxiliary drive system weight multiplicative factor.
K <sub>18</sub>	2671	1.2	Primary engine weight multiplicative factor.
K <sub>19</sub>	2672	1.	Auxiliary engine weight multiplicative factor.
K <sub>20</sub>	2673	1.	Tail rotor drive system weight multiplicative factor.
AT MIND	0401	.0	Standard atmosphere selected.
t <sub>T(NR)</sub>	0411	.05	Time in hours to taxi.
(N <sub>II</sub> /N <sub>II</sub> MAX)	0441	1.	
CLMIND	0571	1.	Maximum rate of climb desired.
ATMIND	0591	0.	Standard atmosphere selected.
C <sub>L</sub> WING	0601	.4873	Wing lift coefficient.
Δh (FT)	0621	1000.0	Altitude increments for climb calculations.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
POWIND	0631	1.	Climb at maximum rate of climb, limited by military power available.
$h_{\max}$ (ft)	0641	4000.	Final altitudes for climb.
$(N_{II}/N_{II_{\max}})$	0651	1.	Operating point for engine turbine during climb.
$\Delta fe_{CL}$ (ft <sup>2</sup> )	0661	.0	Incremental drag area in climb.
$N_{PSD_{CL}}$	0681	.0	Number of primary engines shut down in climb.
CRSIND	0721	1.	Cruise at specified power.
ATMIND	0741	.0	Standard atmosphere selected.
$CL_{WING}$	0751	.4873	Wing lift coefficient.
$\Delta R$ (N.M.)	0771	40.	Calculation increments during cruise in nautical miles.
POWIND	0781	2.	Cruise speed by normal rated primary engine power.
$R_{\max}$ (N.M.)	0791	160.	Value of range at end of each cruise segment.
$(N_{II}/N_{II_{\max}})$ (PRIM ENG)	0801	1.	
$\Delta fe_{CR}$ (FT <sup>2</sup> )	0811	.0	Increment in cruise equivalent flat plate area.
$N_{PSD CR}$	08311	.0	Number of primary engines shut down in cruise.
$N_{PSD i CR}$	0851	.0	Number of auxiliary independent engines shut down during cruise.



<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
DESIND	0871	1.	Descend at constant TAS.
TAS	0881	150.	True airspeed in knots.
R <sub>MAXIND</sub>	0891	.0	Descent flight path ends at specified terminal range (cruise segment must be input previous to descent.
C <sub>LW</sub>	0901	.4873	Wing lift coefficient.
ATMIND	0911	.0	Standard atmosphere selected.
$\Delta h$ (FT)	0921	1000.	Step size for descent.
b <sub>MIN</sub> (FT)	0941	.0	Minimum altitude during descent.
R/D (FPM)	0951	1000.	Rate of descent.
R <sub>MAX</sub> (N.M.)	0961	160.	Range at end of descent.
N <sub>II</sub> /N <sub>II MAX</sub> (PRIM ENG)	0971	1.	
Fe <sub>DSC</sub> (FT <sup>2</sup> )	0981	.0	Increment in equivalent flat plate area parasite drag (descent performance segment)
N <sub>PSD DSC</sub>	1001	.0	Number of primary engines shut down during descent.
ATMIND	1031	.0	Standard atmosphere selected.
C <sub>LW</sub>	1041	.4873	Wing lift coefficient.
$\Delta t_L$ (HR)	1061	.1	Step size for loiter.
N <sub>II</sub> /N <sub>II MAX</sub> (PRIM ENG)	1071	1.	
t <sub>L</sub> (HR)	1081	.4	Incremental time for loiter.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIGNED</u>	<u>REMARKS</u>
$N_{\text{PSD LOITER}}$	1101	.0	Number of primary engines shut down during loiter.
$\Delta F_{eL}(\text{FT}^2)$	1131	.0	Increment in equivalent flat plate area parasite drag (loiter performance segment).
$h_{\text{FINAL}}(\text{FT})$	1181	4000.	Transfer altitude to these final values with no time, fuel or distance credits.

GENERAL PERFORMANCE INFORMATION STGIND = 11

GWIND	4140	1.	User inputs difference in gross weight, in location 4150.
$\Delta \text{GW}(\text{LB})$	4150	.0	Change in gross weight.
ATMIND	4160	.0	Standard atmosphere selected.
$C_{L\text{WING}}$	4170	.313	Wing lift coefficient
$\Delta F_{eCR}(\text{FT}^2)$	4190	.0	Increment in equivalent flat plate area parasite (cruise performance segment).
ALTITUDE (FT)	4200	1000.	Altitude for general performance segment.
T/W	4210	1.03	Configuration thrust/weight ratio (general performance segment).
$N_{\text{II}}/N_{\text{II MAX}}$ (PRIM ENG)	4220	1.	
$\Delta V(\text{KTS})$	4230	20.	Calculation and printout velocity increments in knots during general performance information in location 4250.

<u>VARIABLE</u>	<u>LOCATION</u>	<u>VALUE ASSIG</u>	<u>REMARKS</u>
$V_{MAX}$ (KTS)	4250	220.	Maximum calculation and printout velocity in knots during general performance information.
ENGINE CYCLE DATA; NON-STANDARD PERFORMANCE			
WDTIND	1201	1.	Fuel flow cutoff, refer location 1220.
NIIND	1202	1.	NI cutoff, refer location 1221.
NI0IND	1203	.0	No referred NI cutoff.
N2IND	1204	2.	Free turbine engine to be simulated.
QIND	1205	1.	Torque cutoff, refer location 1224.
RNOIND	1206	.0	No Reynolds No. corrections.
$W_{MAX}/W^*$	1220	1.205	Fuel flow limit - ratio of maximum fuel flow to fuel flow at maximum static power, sea level, standard atmosphere.
$N_{I_{MAX}}/N_I^*$	1221	1.017	Gas generator RPM limit - ratio of max gas generator RPM to RPM at maximum static power, sea level, standard atmosphere.
$N_{II_{MAX}}/N_{II}^*$	1223	.913	Value for referred NI limit
$Q_{MAX}/Q^*$	1224	1.	Value of torque cutoff referred to value at sea level standard static condition.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-93  
M E S C O M P

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	1.0000	1.0000	.0	2.0000	1.0000
1206	1	.0	1.0170			
1220	2	1.2050	1.0000			
1223	2	1.0000	1.0000			
1231	3	3.1100	1.0000	02.000		
1300	2	1.0000	1.0000	2600.0		
1307	3	2.9500	1.0000			
1310	1	2.0000	1.0000			
1311	5	1.0000	1.0000	2000.0	2400.0	2600.0
1316	3	2.9000	1.0000	3000.0		
1319	1	3.0000	1.0000			
1320	3	.0	1.0000			
1326	3	.0	1.0000			
1332	3	1.8000	1.0000			
1338	3	3.1000	1.0000			
1344	3	5.9100	1.0000			
1350	3	9.2900	1.0000			
1356	3	1.2110	1.0000			
1362	3	1.0000	1.0000			
1368	3	1.0000	1.0000			
1374	1	2.0000	1.0000			
1375	5	1.0000	1.0000	2000.0	2300.0	2600.0
1380	3	2.9000	1.0000	3000.0		
1383	1	3.0000	1.0000			
1384	1	.0	1.0000			
1390	3	3.1000	1.0000			
1396	3	1.2000	1.0000			
1402	3	2.1400	1.0000			
1408	3	3.3400	1.0000			
1414	3	4.7700	1.0000			
1420	3	5.9900	1.0000			
1426	3	6.9200	1.0000			
1432	3	7.7800	1.0000			
1438	1	8.0000	1.0000			
1439	5	1.0000	1.0000	2000.0	2300.0	2600.0
1444	3	2.9000	1.0000	3000.0		
1447	1	3.0000	1.0000			
1448	3	.0	1.0000			

NOTE: 1. IN USING AUXILIARY ENGINES 3, AUXILIARY ENGINE CYCLE INPUT LOCATIONS CAN BE CREATED BY PLACING A 66666 CARD IN FRONT AND BEHIND A STANDARD ENGINE CYCLE



214	5	.20000E-01	766.70	.14000	1.0000	.0
215	1	1.0700	.00000	1.0000		
216	1	1.0000				
217	1	.20000				
218	1	3.1100				
219	1	1.0000				
221	5	.76250	.0	.97000	20.000	.10000
227	4	1.0000	1.0000	90.300	1.0000	2000.0
231	2	.0	10.100	100.000	2.0000	
236	2	100.00		1.0000		
240	2	.00730				
312	4	1.0976		.70000	1.0000	
330	1	2.0000				
327	1	1.0000				
331	2	.0	10.000			
320	1	.15000E+07				
329	1	6.2000				
331	2	.0	10.000			
339	2	.90000E-02	.90000E-02			1.0000
347	2	3.0000	3.0000	-1.0000	.0	
354	3	.0	.00000	1.0000		
361	3	1.0000	1.0000	1.0000		
368	3	1.0000	1.0000	1.0000		
370	3	1.0000	1.0000	1.0000		
2602	4	170.2	120.0	20.00	90.000	
2616	0	100.00	.0	.0	.0	.0
2611	0	.0	.0	26.000	20.000	30.000
2616	0	.0	.0	70.000	.0	.0
2621	0	.0	10.000E-01	.00000	.00000	.00000
2626	0	.0	100.00	.0	0.0000E-01	1.0000
2631	0	.0	.0	100.00	.0	.0
2636	0	.0	4.0000	2.2000	.0	.0
2641	0	1.0000	1.0000	61.000	1.0000	1.0000
2646	0	20.00	3.0000	.0	.0	.0
2651	0	.10000	.0	.0	1.0000	.00000
2656	0	1.0000	1.0000	1.0000	1.0000	.00000
2661	0	1.0000	1.0000	1.0000	1.0000	.00000
2666	0	.00000	1.0000	1.0000	1.0000	.00000
2671	0	1.2000	1.0000	1.0000	.90000	1.0000
401	1	.0	.0			
411	1	.00000E-01	.00000E-01			
441	1	1.0000	1.0000			
571	1	1.0000				
591	1	.0				
601	1	.00730				
621	1	1.0000				
631	1	1.0000				
641	1	4.0000				
651	1	1.0000				
661	1	.0				
681	1	.0				
701	1	1.0000				
721	1	.0				
741	1	.00730				
751	1	4.0000				
781	1	2.0000				
791	1	10.00				
801	1	1.0000				
811	1	.0				
831	1	.0				

051	1	0.0	
071	1	1.0000	
081	1	150.06	
091	1	0.0	
901	1	-40730	
911	1	0.0	
921	1	1000.0	
941	1	0.0	
951	1	1000.0	
961	1	160.00	
971	1	1.0000	
981	1	0.0	
1001	1	0.0	
1031	1	0.0	
1041	1	-40730	
1051	1	1.0000	
1071	1	1.0000	
1081	1	-40000	
1101	1	0.0	
1131	1	0.0	
1151	1	4.0000	
0100	1	1.0000	
0100	1	0.0	
0160	1	0.0	
0170	1	-3300	
0190	1	0.0	
0200	1	1000.0	
0210	1	1.0000	
0220	1	1.0000	
0230	1	20.000	
0250	1	20.00	
US = 0.90000E+04	MFA = 0.0	MFA = 0.0	MFA = 0.0
US = 0.90000E+04	MFA = 0.20460E+04	MFA = 0.079777E+03	MFA = 0.079777E+03
US = 0.076106E+04	MFA = 0.90000E+04	MFA = 0.076106E+03	MFA = 0.076106E+03

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM n-91

SINGLE ROTOR WINGED HELICOPTER

S I Z E D A T A THIS RUN CONVERGED IN 3 ITERATIONS

GROSS WEIGHT = 8555. LB

FUSELAGE

LF	LENGTH(COY+TAILROOM)	32.3 FT.
LC	LENGTH(CABIN)	6.8 FT.
LB	LENGTH(BODY)	18.7 FT.
LTB	LENGTH(TAILROOM)	13.7 FT.
KM	FWO. ROTOR LOCATION	11.2 FT.
WF	WIDTH	5.9 FT.
SP	WETTED AREA	462.7 SQ. FT.

WING

AR	ASPECT RATIO	4.98
SA	AREA	82.0 SQ. FT.
SW	SPAN	19.2 FT.
CBARU	MEAN CHORD	4.3 FT.
LAMBDA C/4	QUARTER CHORD SLEEP	0.0 DEG.
LAMBDA	TAPER RATIO	0.600
CT/C3R	ROOT THICKNESS/CHORD	0.170
CT/C3T	TIP THICKNESS/CHORD	0.130
WB/SW	WING LOADING	104.4 LBS/SQ. FT.
GRV	ROTOR/WING GAP	3.7 FT.
CP/C	FLAP CHORD/MEAN CHORD R. D	0.308

HOR. TAIL

ARMT	ASPECT RATIO	4.000
SAHT	AREA	26.8 SQ. FT.
SWHT	SPAN	10.3 FT.
CBARHT	MEAN CHORD	2.6 FT.
LAMBDA H	TAPER RATIO	1.000
CT/C3HT	THICKNESS/CHORD	0.150
LTH	HOR. TAIL ARM	19.0 FT.

VERT. TAIL

ARVT	ASPECT RATIO	1.500
SAVT	AREA	9.2 SQ. FT.
SWVT	SPAN	3.7 FT.
CBARVT	MEAN CHORD	2.5 FT.
LAMBDA VT	TAPER RATIO	0.700
ZTR	TAIL ROTOR(VERT.) LOCATION	3.7 FT.
ZTAVT	TAIL OVERLAP RATIO	1.600



(T/C)VT /THICKNESS/CHORD 0.188

MAIN ROTOR PYLON

AR 0.218  
 SPP 6.0 80. FT.  
 FAPP 1.0 80. FT.  
 MP1 8.8 FT.  
 CSARFP 3.4 FT.  
 LAMBDA FP 0.740  
 (T/C)R 0.488  
 (T/C)T 0.259

PRIMARY ENGINE NACELLE

LN 0.0 FT.  
 ON 9. FT.  
 SN 0.0 80. FT.

AUXILIARY INDEPENDENT ENGINE NACELLE -NO AUXILIARY INDEPENDENT ENGINE USED

PROPELLER(AUXILIARY PROPULSION) - NO PROPELLER USED

MAIN ROTOR

DNR 38.0 FT.  
 SIGMA 0.866  
 WS/A 7.5 LB/80. FT.  
 CT/SIGMA 0.075  
 NR 1.  
 NC BLADES/ROTOR 4.  
 THETA 9.  
 XC -12.000 DEG.  
 VTIP 0.200  
 700. FT./SEC.

TAIL ROTOR

DTR 7.4 FT.  
 SIGTR 0.183  
 (T/D)MET 15.1 LB./80. FT.  
 CT/SIGMA 0.140  
 NO. OF BLADES 4.  
 THETA 9.  
 KCTR -9.000 DEG.  
 S 0.050  
 0.5 FT.  
 700. FT./SEC.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM H-91  
M E S C O M P

W E I G H T S O A T A I N L B S

MLF	MANEUVER LOAD FACTOR	3.000
GLF	GUST LOAD FACTOR	1.759
ULF	ULTIMATE LOAD FACTOR	0.500
PROPULSION GROUP		
K12	UPRG	683.
K13	UPRH	347.
K14	UPR	286.
K15	UPR	0.
K16	UPR	723.
K17	UPR	672.
K18	UPR	52.
K19	UPR	0.
DELTA UP	UPR	566.
STRUCTURES GROUP		
K8	WU	0.
K9	WTG	0.
K10	WTR	0.
K11	WU	123.
K12	WU	100.
DELTA WT	WU	2110.
FLIGHT CONTROLS GROUP		
K1	UPPC	465.
K2	URC	63.
K3	URC	60.
K4	URC	139.
K5	URC	0.
K6	URC	120.
K7	URC	79.
K8	URC	0.

K5	WZCA	AUX. PROPULSION ROTOR SYS. CONTROLS	0.
	WMC	MISCELLANEOUS CONTROLS	0.
	DELTA WFC	CONTROL WEIGHT INCREMENT	50.
	WFC	TOTAL CONTROL WEIGHT	510.
	WFE	WEIGHT OF FIXED EQUIPMENT	1784.
	WE	WEIGHT EMPTY	8986.
	WFUL	FIXED USEFUL LOAD	1290.
	OWE	OPERATING WEIGHT EMPTY	7206.
	WPL	PAYLOAD	530.
	WFLA	FUEL	819.
	WG	GROSS WEIGHT	8555.

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM L-91  
H E S C O M P

R O T O R D A T A

ROTOR CYCLE NO. 6.5000

MAIN ROTOR SOLIDITY SIZED BY MANUEVER CONDITIONS

H = 2000.0 FT. \* TEMP = 70.0 DEG. \* V = 160.0 KT.  
1.00 PERCENT HOVER RPM  
ROTOR MANUEVER G'S = 0.700 \* CT/SIGMA = 0.075

TAIL ROTOR SIZED AT 1.00 TIMES THE SOLIDITY  
REQUIRED TO SATISFY HOVERING TURN REQUIREMENTS AT :  
H = 400.0 FT.  
TEMP = 95.035 DEG. \* F.  
CTG/CTNET = 1.070  
YAW RATE = C.0 RAD/SEC.  
YAW ACCELERATION = 1.500 RAD/SEC2  
TAIL ROTOR POLAR  
NUM. OF INERTIA (PER PLACE) = C.0 SLUG/FT2  
HELICOPTER YAW  
NUM. OF INERTIA = 7.5600 SLUG/FT2

H E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM B-31

P R O P U L S I O N   D A T A  
PRIMARY PROPULSION CYCLE NO.    3.110  
TURBOSHAFT ENGINE

## 1. ENGINES

RHP•P	MAX. STANDARD S.L. STATIC H.P.	2031.	H.P.
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ENGINE SIZED FOR TAKEOFF AT  $T/M = 1.05$   
95.0 PERCENT MILITARY POWER SETTING,  
 $H = 4000.$  FT., TEMPERATURE  $= 95.04$  DEG.F.,  
0.0 ENGINES IMPERATIVE, AND 450.00 FT/MIN VERTICAL RATE OF CLIMB.

NO CRUISE CONDITION SPECIFIED.

MAIN AND TAIL ROTOR DRIVE SYSTEM RATING	1751.	H.P.
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MAIN ROTOR DRIVE SYSTEM RATING	1546.	H.P.
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XMSN SIZED AT 76. PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.L. STATIC H.P.), 100.0 PERCENT HOVER RPM

TAIL ROTOR DRIVE SYSTEM RATING	203.	H.P.
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XMSN SIZED AT 10. PERCENT OF TOTAL PRIMARY ENGINE INSTALLED POWER  
(MAX. STANDARD S.L. STATIC H.P.), 100.0 PERCENT HOVER RPM

M E S C O M P  
HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 1-91

A E R O D Y N A M I C S D A T A			
FE	TOTAL EFFECTIVE FLATPLATE AREA	8.750	SOFT
SUET	TOTAL WETTED AREA	859.	SGFT
CRANF	MEAN SKIN FRICTION COEFF.	0.013268	
D R A G B R E A K D O W N	IN SOFT		
FEU	WING FE	9.760	
FEF	FUSELAGE FE	7.999	
FEFF	FORWARD(MAIN) ROTOR PYLON FE	0.0	
FEAF	AFT ROTOR PYLON FE	0.0	
FEMRH	HATH ROTOR HUBS) FE	0.0	
FETRH	TAIL ROTOR HUB FE	0.0	
FVTH	VERTICAL TAIL FE	0.0	
FHT	HORIZONTAL TAIL FE	0.0	
FTN	PRIMARY ENGINE NACELLE FE	0.0	
FENI	AUX. INDEPENDENT CRUISE ENG. NAC. FE	0.0	
FENS	AUX. INDEPENDENT CRUISE ENG. STRUT FE	0.0	
DELTA FE	INCREMENTAL FE	0.0	
A E R O D Y N A M I C C O E F F .			
A5		7.98982	
A6		1.03823	
A7		0.16105	
A8		0.00008	
A9		0.24095	
E	WING LIFT EFFICIENCY FACTOR	0.70000	
EVT	VERTICAL TAIL LIFT EFFICIENCY FACTOR	0.88071	

HELICOPTER SIZING & PERFORMANCE COMPUTER PROGRAM 8-91

MISSION PERFORMANCE DATA

TAXI FOR 0.050 HRS. AT GROUND IDLE ENGINE RATING														
TIME (HRS)	RANGE (N.M.)	FUEL USE (LBS)	WEIGHT (LBS.)	PRESS. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEF	TOTAL FUEL FLOW (LBS/HR)	AUX. TURB. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. PEF	AUX. FUEL FLOW (LBS/HR)	TEMP. DEG. (F)
0.0	0.0	0.0	8555.	0.	0.0	1900.0	T	0.0	192.	----	----	----	----	59.0
0.050	0.6	7.1	8548.	0.	0.0	1900.0	T	0.0	192.	----	----	----	----	59.0

CLIMB TO 4000 FT. WITH MAXIMUM R/C AT MILITARY ENGINE RATING  
 \*\* TASCAND EAS) IS THE HORIZONTAL COMPONENT OF THE FLIGHT PATH SPEED

TIME (HRS)	M-ROTOR VTIIP (FPS)	M-ROTOR BHP	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEF	EAS (KTS)	ML	AUX. TURB. TEMP. (R)	AUX. ENG. CODE	AUX. ENG. PEF	ALPHA D/L (DEG)	GAMMA (DEG)	BHP	R/C (FPM)	CT PRIME OVER SIGMA						
																			CP	CT	CLU	CDU	RM		
0.050	0.0	7.1	8548.	0.	0.0	1900.0	T	0.0	192.	----	----	----	----	----	----	----	----	----	----	0.088	0.188	-2.0	26.6	1709.	3947.
0.054	0.33	11.2	8544.	1000.	1000.	17.9	2556.2	Q	1.000	76.8	0.190	----	----	0.091	-2.0	26.7	1734.	4027.	----	0.091	0.190	0.487	0.009	0.984	----
0.058	0.66	15.1	8540.	2000.	2000.	76.9	2570.8	U	1.000	76.6	0.193	----	----	0.094	-2.0	26.7	1748.	4063.	----	0.094	0.193	0.487	0.009	0.984	----
0.062	0.98	19.0	8536.	3000.	3000.	79.9	2583.9	Q	1.000	76.5	0.195	----	----	0.097	-2.0	26.2	1738.	4033.	----	0.097	0.195	0.487	0.009	0.984	----
0.067	1.32	22.9	8532.	4000.	4000.	80.9	2602.5	Q	1.000	76.3	0.198	----	----	0.100	-2.0	25.8	1733.	4014.	----	0.100	0.198	0.487	0.009	0.984	----

CRUISE AT NORMAL ENGINE RATING

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEF	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	SPEC. RANGE (NMPP)	BHP
M. ROTOR RMP	M. ROTOR RMP	T. ROTOR VTIP (FPS)	T. ROTOR RMP	PROP VTIP (FPS)	PRIM. ENG. FUEL FLOW (LBS/HR)	BHP AUX	ETAP PROP	AUX. ENG. TAUX/T FUEL FLOW (LBS/HR)		AUX. TURB. TEMP.				AUX. ENG. BHP OR THRUST
CPPRO	CPIND	CPPAR	CPMUD	COO	DELCDS	DELCDM	CHK	ROTLIM CODE	J	CP	CT	CLV	CDM	RM
0.067	1.32	22.9	852.	4000.	196.3	2495.0	T	0.876	185.0	0.473	0.050	-18.1	0.23413	1523.
700.8	1343.	700.0	115.	---	836.	---	---	0.0	---	---	---	---	---	---
0.000363	0.00013	0.000518	0.00009	0.02149	0.00264	0.00042	0.001048	A	---	---	---	0.487	0.009	0.57
0.270	41.32	193.7	8361.	4100.	197.2	2495.0	T	0.876	185.9	0.476	0.047	-19.3	0.23526	1522.
700.0	1341.	700.0	116.	---	836.	---	---	0.0	---	---	---	---	---	---
0.000356	0.00011	0.000522	0.00009	0.02101	0.00228	0.00034	0.001097	A	---	---	---	0.487	0.009	0.442
0.473	81.32	363.7	8191.	4000.	198.1	2495.0	T	0.876	186.7	0.478	0.045	-20.5	0.23633	1521.
700.0	1339.	700.0	117.	---	836.	---	---	0.0	---	---	---	---	---	---
0.000350	0.00010	0.000528	0.00008	0.02056	0.00189	0.00025	0.00116	A	---	---	---	0.487	0.009	0.424
0.675	121.32	532.0	8022.	4000.	199.0	2495.0	T	0.876	187.5	0.480	0.042	-21.6	0.23734	1520.
700.0	1337.	700.0	118.	---	836.	---	---	0.0	---	---	---	---	---	---
0.000345	0.00009	0.000534	0.00008	0.02015	0.00157	0.00016	0.00114	A	---	---	---	0.487	0.009	0.416
0.819	150.02	653.9	7911.	4000.	194.5	2495.0	T	0.876	188.0	0.481	0.043	-22.9	0.23821	1521.
700.0	1336.	700.0	119.	---	836.	---	---	0.0	---	---	---	---	---	---
0.000341	0.00008	0.000535	0.00007	0.01967	0.00137	0.00016	0.00119	A	---	---	---	0.487	0.009	0.354

DESCEND TO H = 16000 N.M.I. AT CONSTANT TAS

TIME (HRS)	RANGE (N.M.)	FUEL USED (LBS)	WEIGHT (LBS.)	PRES. ALT. (FT)	TAS (KTS)	PRIM. TURB. TEMP. (R)	PRIM. ENG. CODE	PRIM. ENG. PEF	EAS (KTS)	MU	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	GAMMA (DEG)	R/S (FPM)
M. ROTOR RMP	M. ROTOR RMP	T. ROTOR VTIP (FPS)	T. ROTOR RMP	PROP VTIP (FPS)	PRIM. ENG. FUEL FLOW (LBS/HR)	BHP AUX	ETAP PROP	AUX. ENG. TAUX/T FUEL FLOW (LBS/HR)		AUX. TURB. TEMP.				AUX. ENG. BHP OR THRUST
CPPRO	CPIND	CPPAR	CPMUD	COO	DELCDS	DELCDM	CHK	ROTLIM CODE	J	CP	CT	CLV	CDM	RM
2.019	150.02	653.9	7911.	4000.	190.6	1956.3	T	0.304	141.4	0.362	0.067	-2.7	-3.4	527.1000.
700.0	459.	700.0	32.	---	394.	---	---	0.0	---	---	---	---	---	---
0.000165	0.000030	0.000075	0.000017	0.01394	0.00062	0.000250	0.000207	A	---	---	---	0.487	0.009	0.657



TIME (HRS)	RANGE (M.P.)	FUEL USED (LBS)	T-ROTOR RMP	T-ROTOR VTIFF (FPS)	FUEL USED (LBS)	WTIF (FPS)	FPROP (FPS)	PRIM. ENG. CODE	PRIM. ENG. PENF	EAS (KTS)	PL	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	TOTAL FUEL FLOW (LBS/HR)	MMP
0.836	152.52	660.5	7874	32.0	150.0	396	0.00000	F	0.304	141.4	0.362	0.067	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.853	155.01	667.1	7888	32.0	150.0	396	0.00000	F	0.304	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.869	157.51	673.7	7881	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.886	160.00	680.2	7874	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

TRANSFER ALTITUDE TO 4000 FT.

FUEL USED (LBS) 7874  
 WEIGHT (LBS) 680.3  
 PRES. ALT. (FT) 7874  
 TIAS (KTS) 7874  
 ALLC.

LOITER FOR 0.400 HRS. FOR RESERVE FUEL

TIME (HRS)	RANGE (M.P.)	FUEL USED (LBS)	T-ROTOR RMP	T-ROTOR VTIFF (FPS)	FUEL USED (LBS)	WTIF (FPS)	FPROP (FPS)	PRIM. ENG. CODE	PRIM. ENG. PENF	EAS (KTS)	PL	CT PRIME OVER SIGMA	ALPHA D/L (DEG)	TOTAL FUEL FLOW (LBS/HR)	MMP
0.866	160.00	680.2	7874	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.916	160.00	680.2	7874	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.066	160.00	680.2	7874	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.126	160.00	680.2	7874	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.285	160.00	680.2	7874	32.0	150.0	396	0.00000	F	0.303	141.4	0.362	0.066	-2.7	-3.6	526.1000
700.0	459.0	700.0	32.0	0.00000	396	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.000185	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000









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