NOTICE

NASA CR-152303

GASP - GENERAL AVIATION SYNTHESIS PROGRAM

VOLUME VII - ECONOMICS

PART 1 - THEORETICAL DEVELOPMENT

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Ames Research Center
Moffett Field, California

Under

CONTRACT NAS 2-9352

AEROPHYSICS RESEARCH CORPORATION

FOREWORD

The General Aviation Synthesis Program (GASP) was initially developed by engineers in the Mission Analysis Division at the National Aeronautics and Space Administration's Ames Research Center, Moffett Field, CA. Improvements continue to be implemented by individuals in the V/STOL Systems Technology Branch at Ames. Those people providing the major development contributions are:

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This documentation was prepared by the staff of Aerophysics Research Corporation, Bellevue, WA., under NASA contract NAS 2-9352. In addition to the contributions from the NASA personnel, Aerophysics people contributing to the documentation are:

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The NASA technical monitor for the documentation was Mr. T. L. Galloway. The Aerophysics Research Corporation project leader was Mr. D. S. Hague. The GASP program has been used by a number of companies and universities through NASA contracted studies and is under continuing development. Prospective users should consult NASA's Ames Research Center regarding the latest details of the computer code.

TABLE OF CONTENTS

LIST OF FIGURES

VII.1 ECONOMICS

The cost breakdown for aircraft manufacture and operation can often be estimated with remarkable accuracy, if the aircraft does not represent a radical departure from prior designs on which the cost estimates are based. Subroutine GACOST estimates a number of economic parameters using about 30 descriptive aircraft input quantities. Many of the computations take the form of regression equations, in which the component cost is expressed as a nonlinear numerical function of one or more known parameters; e.g.,

$$COST = .251\, X_1^{.7561}\, X_2^{.216}$$

Here, the quantities X_1 and X_2 may be weights, areas, lengths, etc., or other descriptive parameters. These parameters should have a plausible influence on the cost, and the numerical factors have been found so as to provide a good fit to a large number of representative cost data.

The subroutine deals with basic performance characteristics of several types of aircraft, and these gross descriptors of the aircraft are such as to predict conceptual initial design and operating costs with reasonable accuracy from minimum design and performance inputs. In addition, the procedure can be used to evaluate the effects of basic technology tradeoffs, performance and production rates on costs.

VII.1.1 Engine and Performance Parameters

The subroutine involves no iterative loops and is initiated with the specification of the integers to obtain the maximum sea level static thrust or horsepower of the different engine types;

$$I_{SEGX} = 0 \,, \tag{VII.1.1}$$

and

$$K_{ENG} = \begin{cases} 3, & NTYE \neq 7 \\ 5, & NTYE = 7 \text{ (turbojet/turbofan engine)} \end{cases} \tag{VII.1.2}$$

where

NTYE = integer denoting engine type from COMMON/PROPCT/.

This is followed by a group of statements with a call to subroutine ASPEED to determine the cruise MACH number at normal rated power (EMNP) and cruise altitude. If the aircraft has a fixed pitch propeller, denoted by NTYP equal to 1 or 11 the cruise MACH number is passed from subroutine XRANGE via COMMON/CSTRGE/as EMCOST.

The computation continues with a call to subroutine TPALT, which permits computation of pressure and temperature at the cruise altitude H_{CRU}. The maximum cruise velocity is then expressed in kts as

$$V_{CRMX} = .5921\ EM_{NP} \cdot 49.1\ \sqrt{T_O} \qquad \text{(VII.1.3)}$$

where

T_O = static temperature at altitude H_{CRU}, deg R.

The weight-speed product is defined in terms of the empty weight W_{EMP},

$$WSP = 1.15\ W_{EMP}\ V_{CRMX} \qquad \text{(VII.1.4)}$$

where the scale factor expresses the speed in statute miles per hour.

VII.1.2 Initial Airplane Cost

The majority of the initial cost estimating relationships were based on data developed during the study reported in a Lockheed-Georgia study and represented the 1970 time period. A simplified block flow of the initial cost computation procedure is shown in Figure VII.1.1. With the developed fundamental cost quantities, manhours and material cost as a function of aircraft physical parameters, along with propulsion, other equipment, marketing and other expense trends the procedure estimates the initial cost of conceptual fixed-wing aircraft.

VII.1.3 Manufacturing Labor Costs

First the manufacturing labor hours, DMLH, are determined based on the aircraft empty weight or the empty weight-speed product. Figures

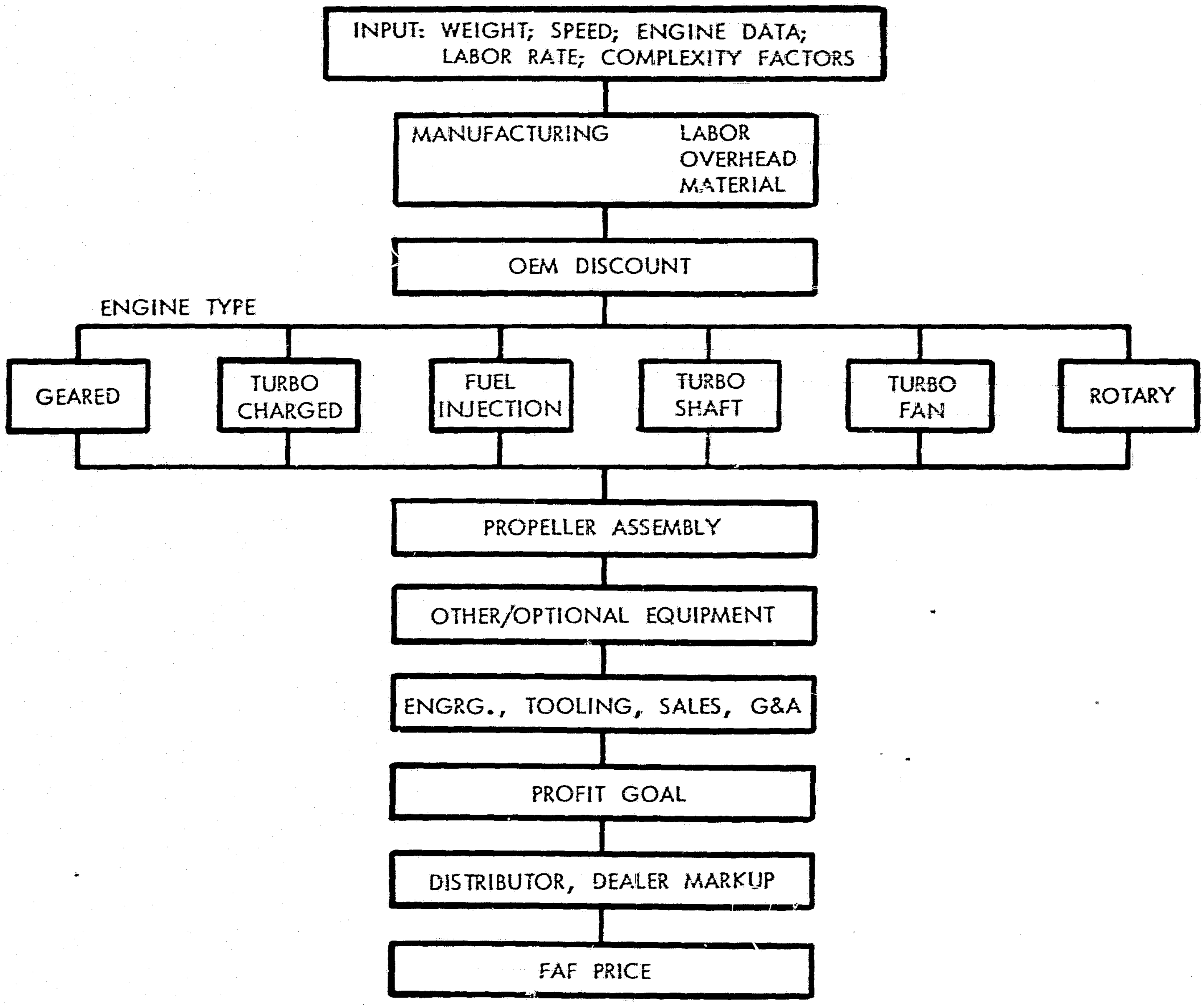

FIGURE VII.1.1- INITIAL COST ESTIMATING MODEL BLOCK FLOW DIAGRAM

VII.1.2a and VII.1.3a show this correlation for some single and twin engine aircraft. Each of these options will give about the same results, but Figure VII.1.2a is preferred for the lighter aircraft while Figure VII.1.3a is preferred for heavier, high performance aircraft.

$$D_{MLH} = (.22 + 1.35 * 10^{-4} W_{EMP}) W_{EMP} \qquad (VII.1.5)$$

unless the gross weight exceeds 12,500 pounds or NTYE = 7. In this latter case, the weight-speed product is the independent variable,

$$D_{MLH} = (.0025 + 3.9 * 10^{-10} WSP) WSP \qquad (VII.1.6)$$

Now, the cost of manufacturing labor is

$$CS_{ML} = D_{MLH} A_{LR} C_{LF} PROD_{FL} \qquad (VII.1.7)$$

where

A_{LR} = Input average labor rate in manufacturing, dollars/hour (default - $3.40)

C_{LF} = } currently set to 1, could be used in future for

$PROD_{FL}$ = } complexity or production factors

The manufacturing labor overhead percentage is a linear function of the weight-speed product,

$$OH_{ML} = 1.31 + 7 * 10^{-8} WSP \qquad (VII.1.8)$$

and thus the manufacturing overhead cost is the product

$$CS_{OH} = OH_{ML} CS_{ML} \qquad (VII.1.9)$$

The next component related to manufacturing cost is the manufacturing materials. Correlations for material cost were developed in a manner similar to the labor hours. Figures VII.1.2b and VII.1.3b show the material cost correlations for some single and twin engine aircraft in terms of empty weight and the empty weight-speed product. Again, there are two options, Figure VII.1.2b being preferred for the lighter aircraft and Figure VII.1.3b for the heavier, high performance aircraft.

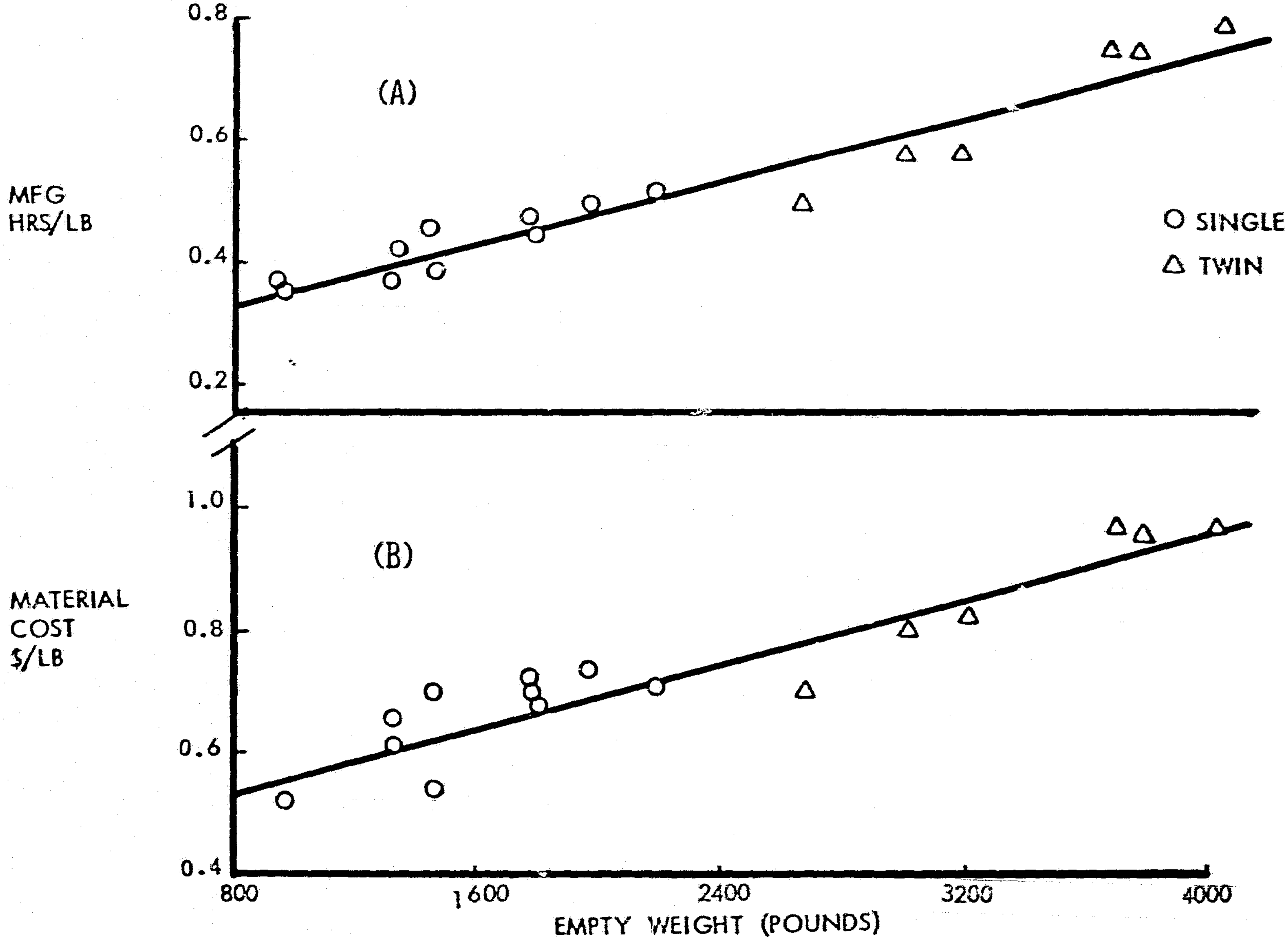

FIGURE VII.1.2 - MANUFACTURING MANHOURS AND MATERIAL COST PER POUND OF EMPTY WEIGHT

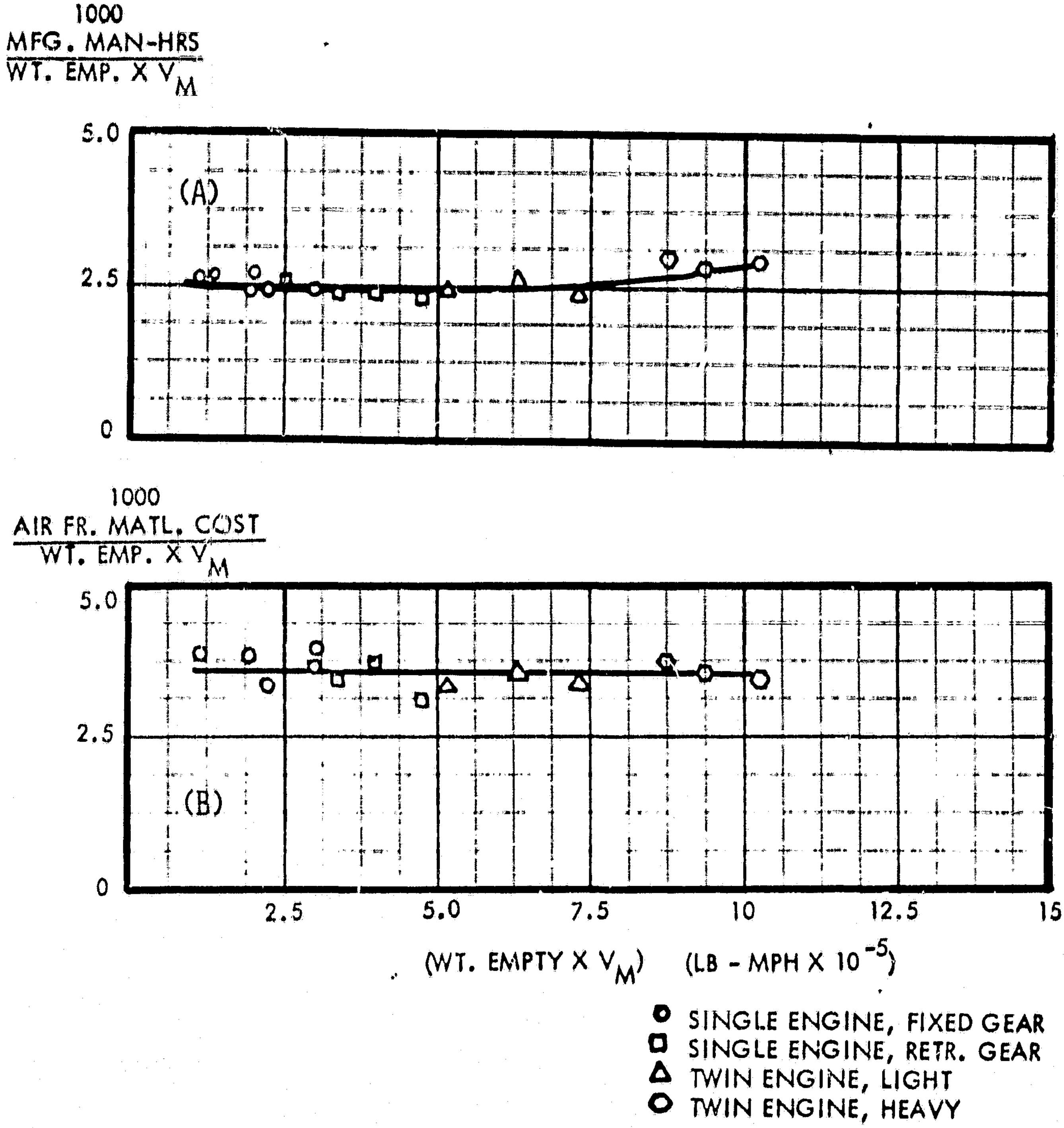

FIGURE VII.1.3 - MANUFACTURING MANHOURS AND MATERIAL COST DIVIDED BY WEIGHT EMPTY x MAXIMUM SPEED FACTOR

The resulting computerized equations are

$$CS_{MM} = (1.5 * 10^{-4} W_{EMP} + .38) W_{EMP} (1. + ADV_{MF}) PROD_{FM} \qquad (VII.1.10)$$

where

$ADV_{MF} = 0.,$ $PROD_{FM} = 1.,$ } These parameters are currently set internally to 0 and 1, could be used in future for advanced material and production factors.

This equation is replaced by

$$CS_{MM} = 3.7 * 10^{-3} WSP (1 + ADV_{MF}) PROD_{FM} , \qquad (VII.1.11)$$

if the gross weight exceeds 12,500 pounds or if NTYE = 7. In either case, the total airframe manufacturing cost is the three-term sum,

$$CS_{AFF} = CS_{ML} + CS_{OH} + CS_{MM} \qquad (VII.1.12)$$

VII.1.4 Engine Cost

Engine cost may be input as a unit cost based on power ($UCS_{ENG} \neq 0$) or calculated based on trend data from previous work by Lockheed. This reference developed the trends shown in Figures VII.1.4, VII.1.5 and VII.1.6 for reciprocating, rotary combustion and turboprop/turboshaft engines respectively. These are given as functions of rated sea level static horsepower. For the reciprocating engines the data was based on new engine list price and not the price to the original equipment manufacturer (OEM), therefore, an expression was developed that estimated the OEM discount factor based on the weight speed product.

$$OE_{MF} = 7.5 * 10^{-8} WSP + .6 \qquad (VII.1.13)$$

These equations are used for estimating the reciprocating engine costs based on type of fuel distribution system and gearing. A factor is also included for turbocharging (KSPCHG = 1).

For direct drive reciprocating engines with carburetor (NTYE = 1),

$$CS_{ENG} = 21.66 HP_{MSLS} OE_{MF} (1 + .3 K_{SPCHG}) \qquad (VII.1.14)$$

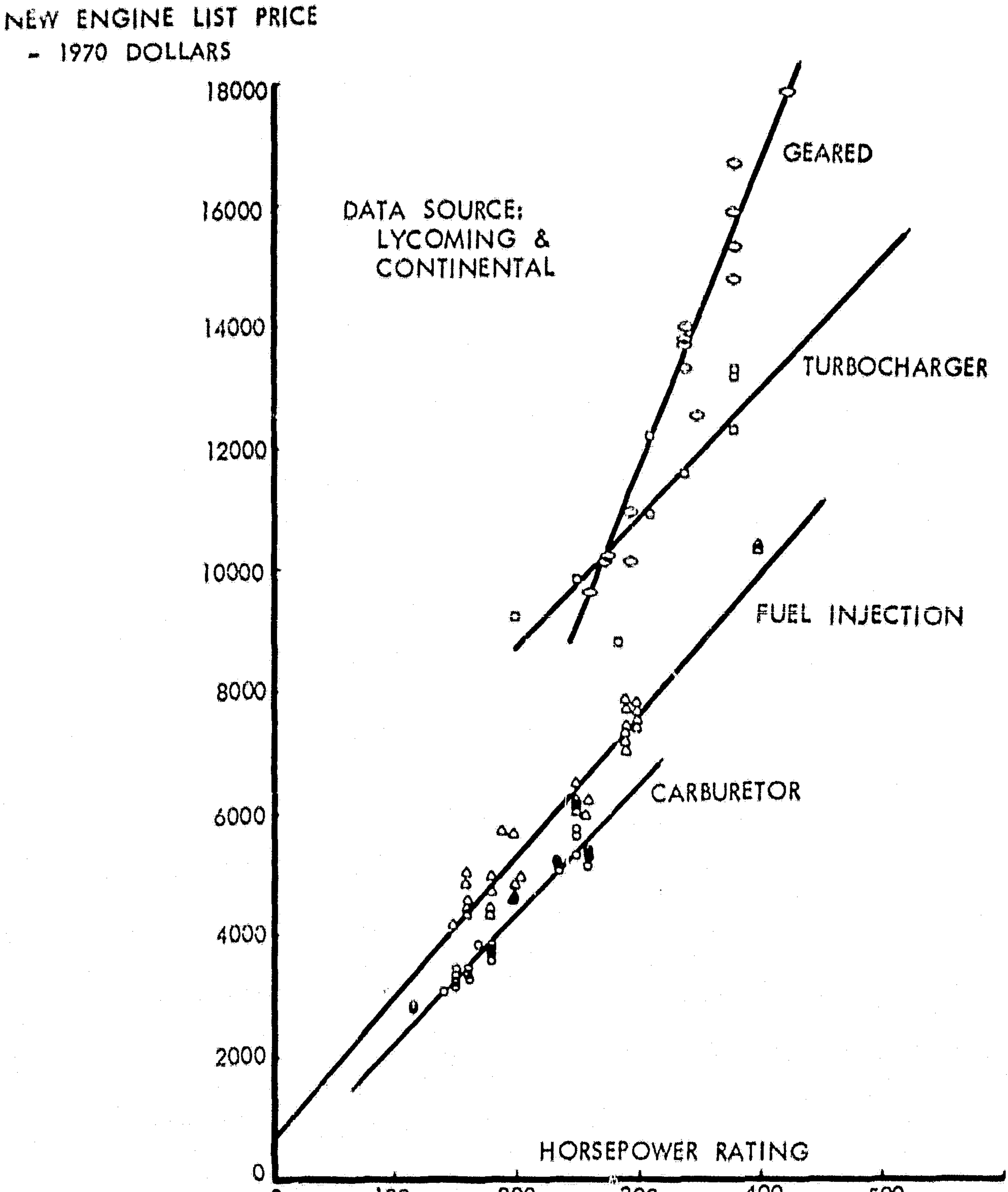

FIGURE VII.1.4 - RECIPROCATING ENGINE PRICE VERSUS HORSEPOWER

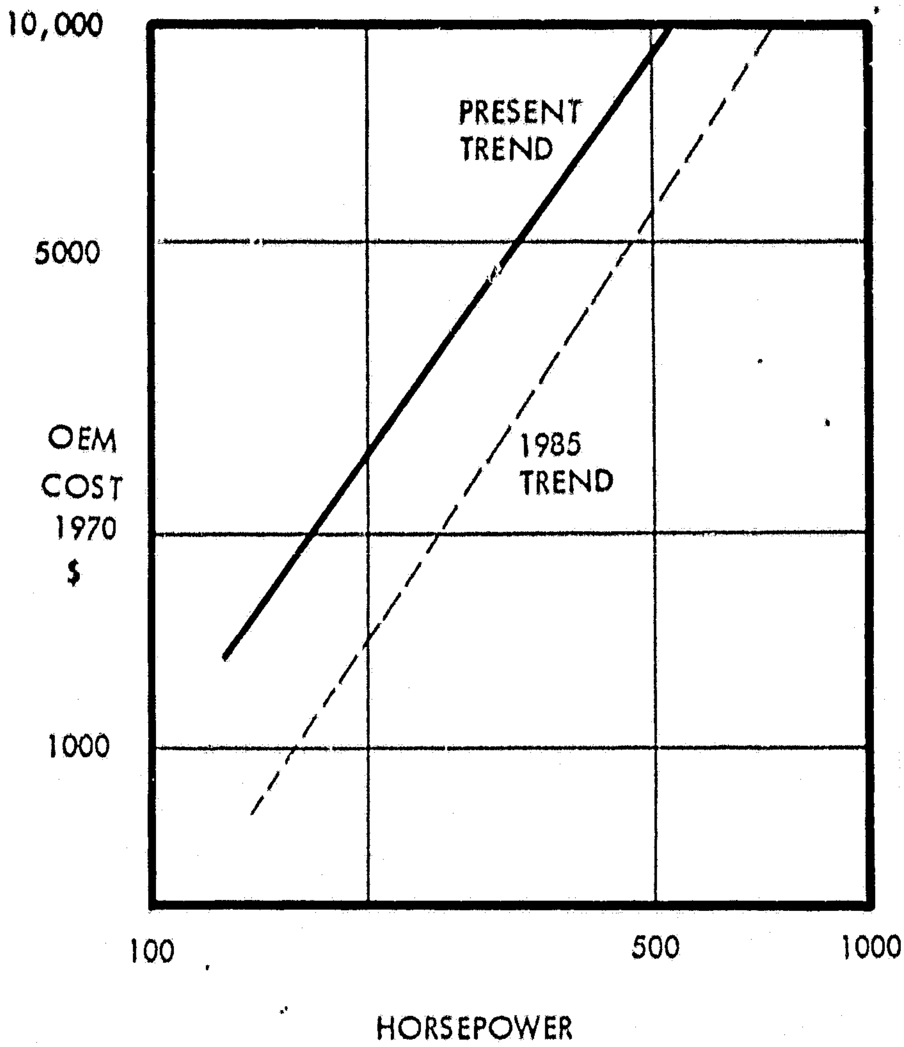

FIGURE VII.1.5 - Cost Versus Horsepower Trend For Rotating Combustion Engines

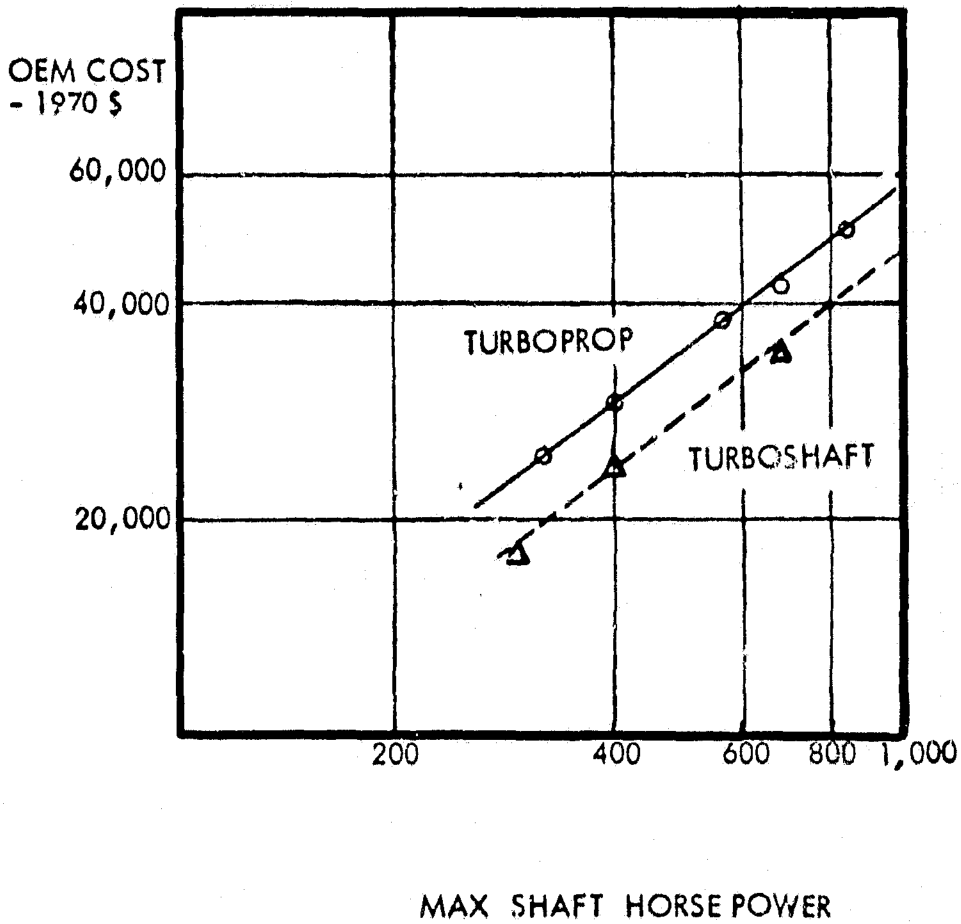

FIGURE VII.1.6 - TURBINE ENGINE COST TREND

For direct-drive reciprocating fuel-injected engines (NTYE = 2),

$$CS_{ENG} = (23.5\ HPM_{SLS} + 500.)\ OE_{MF}\ (1 + .3\ K_{SPCHG}) \qquad (VII.1.15)$$

For reciprocating fuel-injected geared engines (NTYE = 3),

$$CS_{ENG} = (23.315\ HPM_{SLS} + 26.745\ DIM\ (HPM_{SLS},\ 255.) + 3500)$$

$$*\ OE_{MF}\ (1 + .3\ K_{SPCHG}) \qquad (VII.1.16)$$

The equations used for the rotary combustion and turboshaft/turboprop engines are based on the OEM as shown in Figures VII.1.5 and VII.1.6 and the equations are

For rotary combustion engines (NTYE = 4),

$$CS_{ENG} = 1.184\ HPM_{SLS}^{1.447}\ (1. + .3\ K_{SPCHG}) \qquad (VII.1.17)$$

For turboshaft engines (NTYE = 5),

$$CS_{ENG} = 116.4\ HPM_{SLS}^{.88} \qquad (VII.1.18)$$

For turboprop engines (NTYE = 6),

$$CS_{ENG} = 358\ HPM_{SLS}^{.739} \qquad (VII.1.19)$$

For turbojet or turbofan engines (NTYE = 7), the sea level static thrust T_{SLS} is first computed by ENGINE, in terms of which the cost is simply estimated as

$$CS_{ENG} = 27.2\ T_{SLS} \qquad (VII.1.20)$$

Between statements 38 and 39, the nonzero input engine cost parameter UCS_{ENG} multiplies the horsepower (or thrust) of the engine,

$$CS_{ENG} = UCS_{ENG} * HPM_{SLS} \qquad (VII.1.21)$$

VII.1.5 Propeller Cost

Three options are provided for computing propeller cost. The propeller cost may be input as a unit cost based on weight ($UCS_{pp} \neq 0$), computed based on the methodology of Hamilton Standard or computed using the trend equation based on data of Figure VII.1.7.

If the Hamilton standard methodology is used (NTYP > 10) the propeller cost (CPROP) is computed in subroutine COST (Volume IV) via a call to ENGINE.

$$CS_{pp} = C_{PROP} \qquad \text{if NTYP} > 10$$

where

$$C_{PROP} = \text{propeller cost, dollars}$$

If NTYP < 10 the trend data from Figure VII.1.7 is used discounted by the OEM factor as

$$CS_{pp} = (16.8\ W_{PROP1} - 280.)\ OE_{MF}\ 1.4$$

where

$$W_{PROP1} = \text{propeller weight, lb, from COMMON/EGPROP}$$

If the unit propeller cost (UCSPP) is input

$$CS_{pp} = UCS_{pp}\ W_{PROP1}$$

The propeller and propulsion cost is then the sum

$$CS_{PPUL} = EN_P\ (CS_{ENG} + C_{PROP} + CS_{TGB}) \qquad \text{(VII.1.22)}$$

where

$$CS_{TGB} = \text{cost of gear box}$$

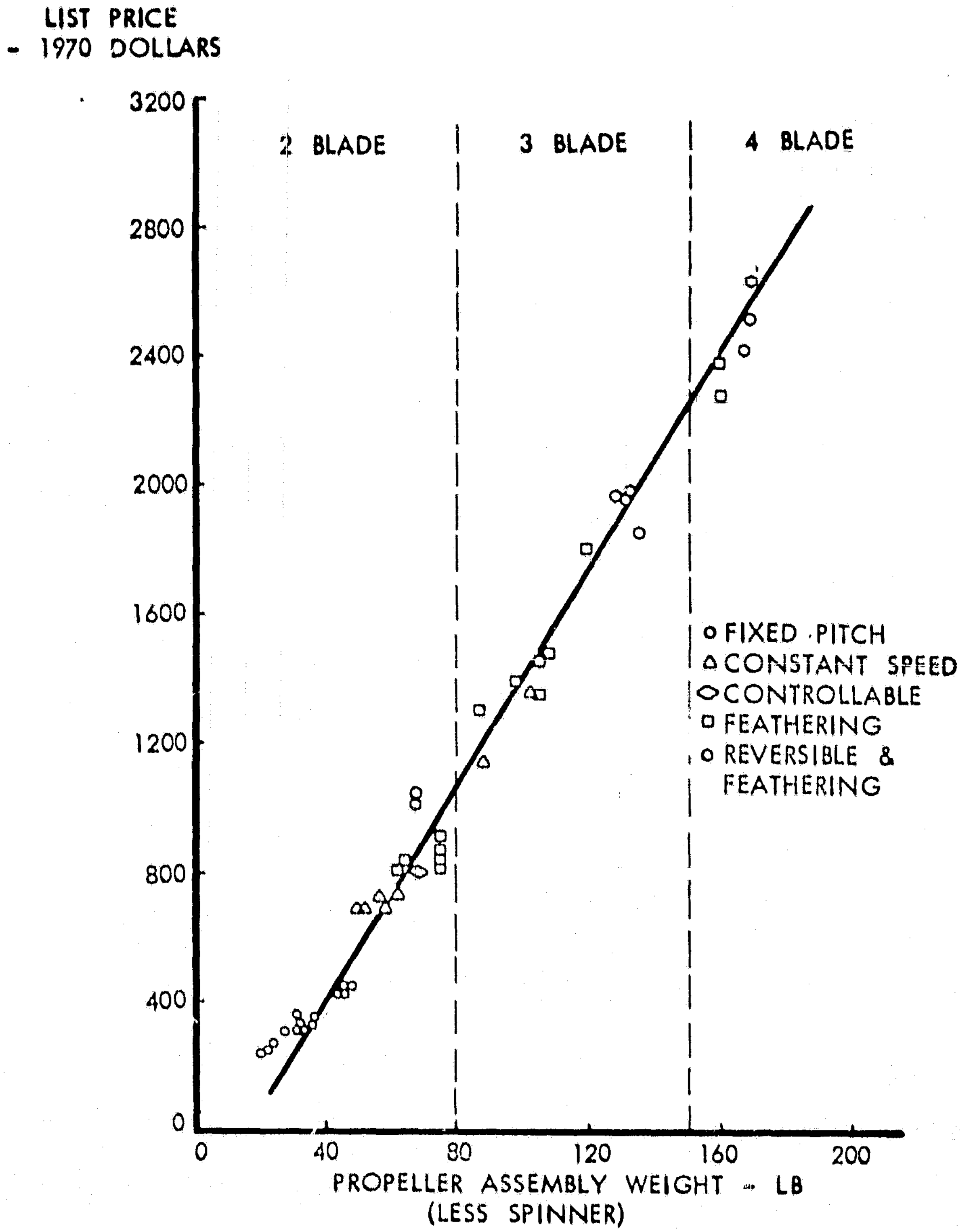

FIGURE VII.1.7 - PROPELLER ASSEMBLY PRICE - WEIGHT TREND

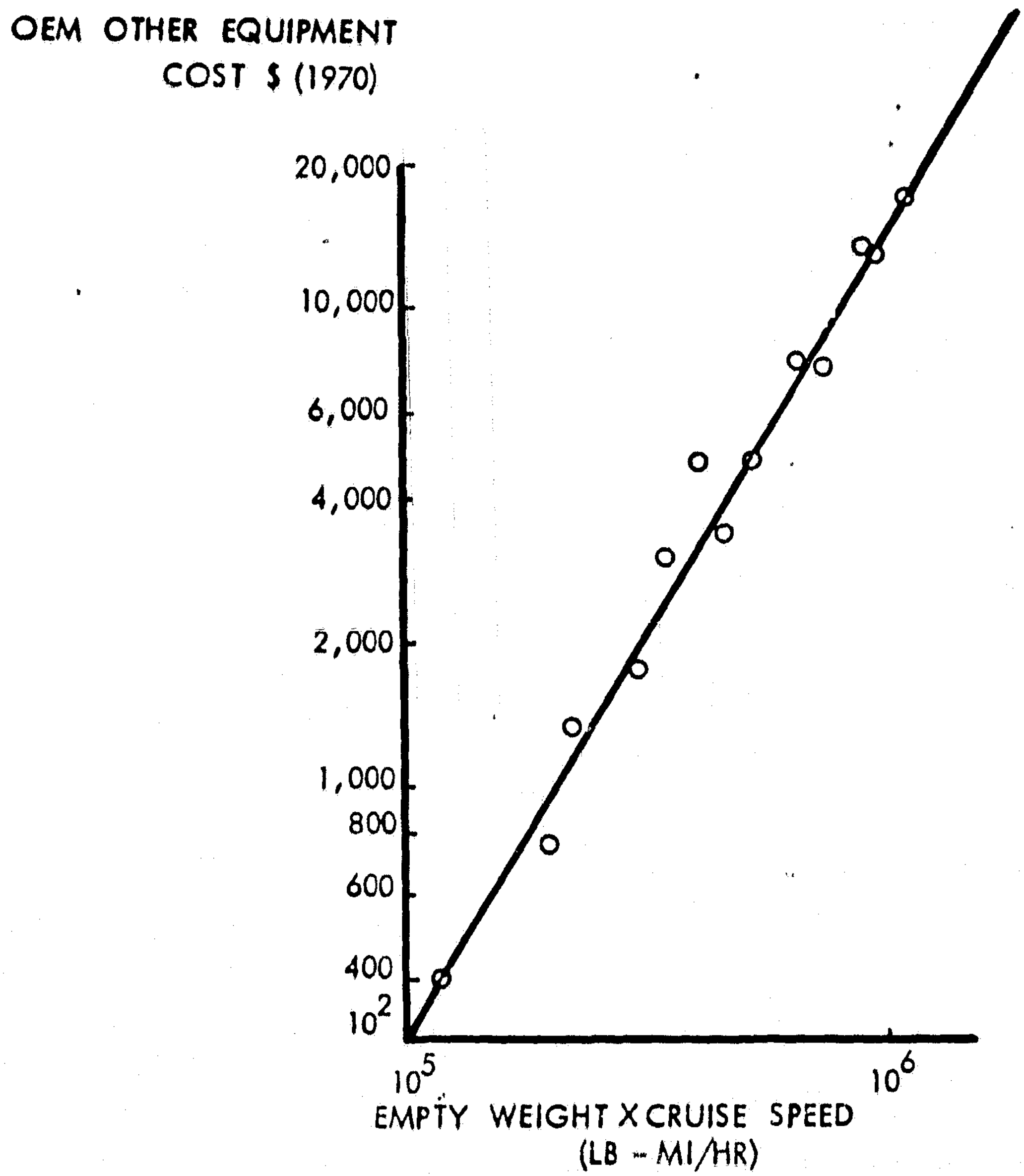

FIGURE VII.1.8 - OEM OTHER EQUIPMENT COST TREND WITH WEIGHT - SPEED PRODUCT

VII.1.6 Other Purchased Equipment Cost

In addition to engines and propellers the airframe manufacturer purchases other components that go into the completed aircraft. A previous Lockheed study developed a correlation for the cost of this equipment based on a number of single and twin engine general aviation aircraft. This is shown in Figure VII.1.8 as a function of the weight-speed product. The resulting equation is

$$CS_{OEQ} = 9.6 * 10^{-7} \, WSP^{1.698} \qquad \text{(VII.1.23)}$$

which is added to the propulsion system cost to give the total equipment cost

$$CS_{TEQ} = CS_{PPUL} + CS_{OEQ} \qquad \text{(VII.1.24)}$$

VII.1.7 Total Manufacturing Cost and Markups

The "flyaway" factory list price of general aviation type aircraft consist of the direct manufacturing, materials, and equipment costs plus percentage markups to account for engineering, sales, administration, profit and in most cases distributor markup.

The direct manufacturing cost becomes

$$CS_{DMF} = CS_{TEQ} + CS_{AFF}$$

where

CS_{TEQ} includes all purchased equipment

CS_{AFF} includes manufacturing labor and materials

The total manufacturing cost involves engineering, sales, and administration factors

$$CS_{MANF} = CS_{DMF} + CS_{GA} \qquad \text{(VII.1.25)}$$

where

$$CS_{GA} = CS_{DMF} \, (.167 \, W_{EMP}^{.08743}) \qquad \text{(VII.1.26)}$$

The dealer's cost is the manufacturing cost plus the manufacturer's profit

$$CS_{DLR} = CS_{MANF} \ (1 + PROF_G) \qquad \text{(VII.1.27)}$$

where

$PROF_G$ is the manufacturer's profit goal

$PROF_G = .066 + 2.33 * 10^{-5} \ W_{EMP}$ but

$PROF_G$ cannot exceed .18

The total "flyaway" factory price, which includes the distributor markup is computed as

$$CS_{FAF} = CS_{DLR} \ (1 + DD_{MARK}) \qquad \text{(VII.1.28)}$$

where

DD_{MARK} is the distributor's markup or

$DD_{MARK} = .1695 \ W_{EMP}^{.08743}$ but

DD_{MARK} cannot exceed .30

VII.1.8 Consumer Price

The price the consumer pays can be more than the factor "list" price and usually is based on the type of avionics and other options that are selected by the purchaser. Based on data collected from a number of pilot reports on new airplanes and the avionics manufacturer's trade organization, Figure VII.1.9 was compiled to establish a correlation for the cost of optional equipment.

The additional equipment cost is next found by,

$$C_{ADE} = \begin{cases} 10^{CADEL} \ , & N_{CADE} \neq 0 \\ 0 \ , & N_{CADE} = 0 \end{cases} \qquad \text{(VII.1.29)}$$

(1968 Industry Averages
Are Labelled Ticks)

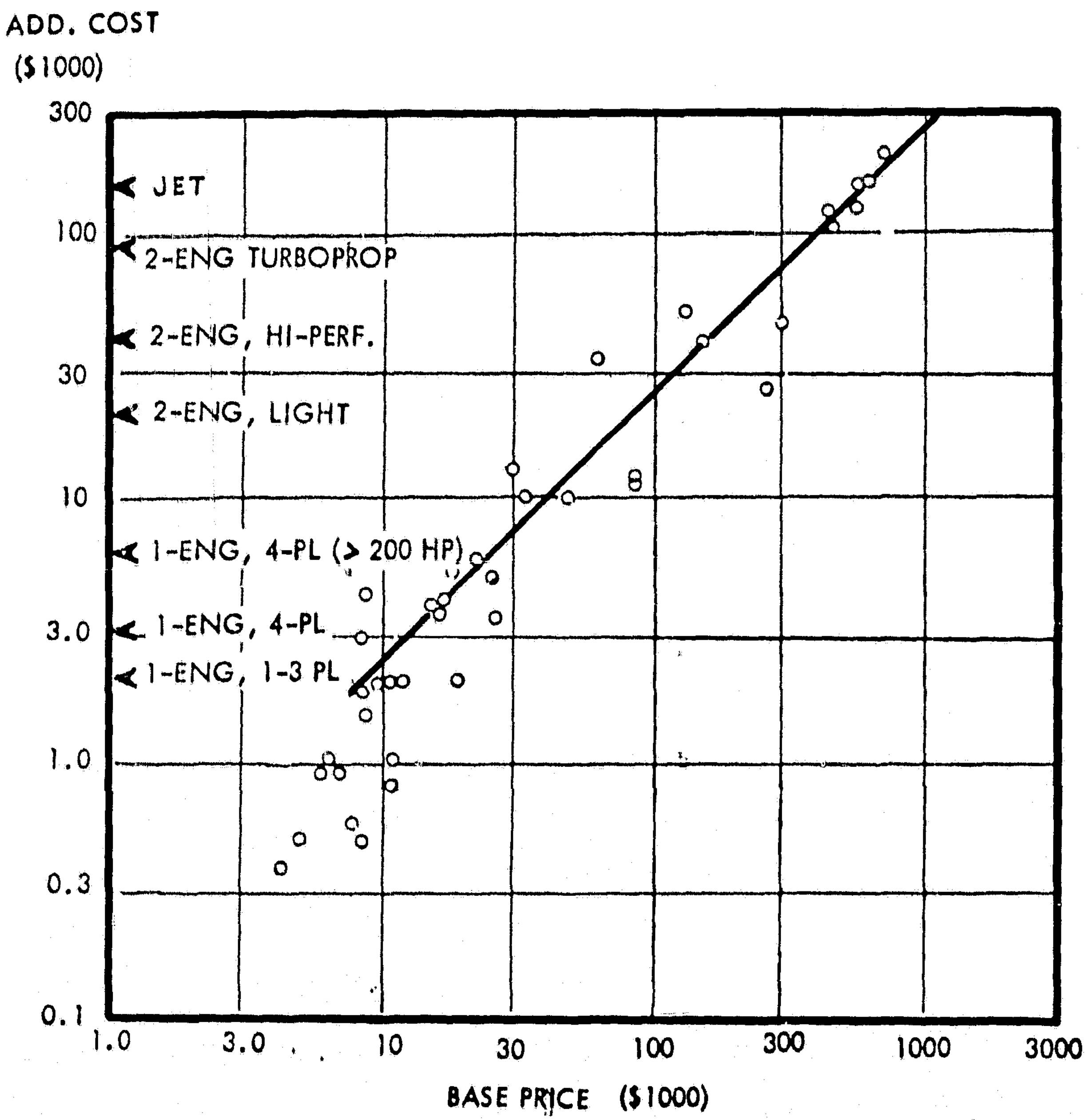

FIGURE VII.1.9 - General Aviation Avionics Cost

where

$$CADEL = 1.015 \log (CS_{FAF}) - .70782 \quad (VII.1.30)$$

and the consumer price is the sum

$$CP = CS_{FAF} + C_{ADE}$$

VII.1.9 Operating Costs

The operating cost model is based on cost information obtained from various sources such as pilot reports, trade journals, insurance companies, and manufacturer's brochures. The cost elements are separated into variable or direct costs, which vary with flying time, and fixed or indirect costs, which accrue on an annual basis independent of aircraft flying time. Total operating costs are finally computed for a range of annual flying hours. The operating cost calculations start at program statement 200.

VII.1.10 Variable Operating Costs

The first element of the variable cost is the fuel and oil cost (FOC) in dollars per hour. The fuel consumption is expressed in gallons per hour by

$$F_{CON} = W_F/(ST * F_{WTF}) \quad (VII.1.31)$$

where W_F is fuel weight (lb), ST is block time (hr), and

F_{WTF} = fuel density = 6 lb per gallon for gasoline
= 6.7 lb per gallon for turbine fuel

Oil consumption in gals/hr is proportional to number of engines; i.e.,

$$O_{CON} = .135 \, EN_P \, (4./8.1) \quad (VII.1.32)$$

The total fuel and oil cost per hour is next given by

$$FOC = F_{CON} \, F_{CSF} + 2. * O_{CON} \quad (VII.1.33)$$

where

$$F_{CSF} = \text{fuel cost, dollars per gallon}$$

and oil cost is assumed to be $2 per gallon.

The next variable cost element is inspection and maintenance

$$A_{IC} = C_{INP}/HR_I \tag{VII.1.34}$$

where

C_{INP} = cost of inspection, input in namelist, INGASP, dollars

HR_I = hours between inspection, input in namelist INGASP, hours

The third variable cost element is engine overhaul costs which are proportional to total power or thrust,

$$OH_C = \begin{cases} EN_P * HPM_{SLS} * OH_R/TB_O , & NTYE \leq 6 \\ EN_P * T_{SLS} * OH_R/TB_O , & NTYE = 7 \end{cases} \tag{VII.1.35}$$

where

OH_R = overhaul rate, in dollars per horsepower or pound thrust, input in INGASP

TB_O = time between overhaul, in hours, input in INGASP

The total variable costs in dollars per hour then is the sum,

$$C_{VAR} = FOC + A_{IC} + OH_C + C_{MV} \tag{VII.1.36}$$

where

C_{MV} = other variable costs (parking, landing fees, spare parts inventory, etc.) in dollars per hour

VII.1.11 Fixed Operating Costs

The fixed yearly costs are next itemized, beginning with the FAA tax, which is weight dependent,

$$FAA_{TAX} = \begin{cases} 25. & W_G \leq 2500. \\ 25. + .02\,(W_G - 2500.) & , W_G > 2500, NTYE \leq 4 \\ 25. + .035\,W_G & , W_G > 2500, NTYE \geq 5 \end{cases} \quad \text{(VII.1.37)}$$

The input crew cost (C_{CRW}) is augmented by the crew overhead percentage (CRW_{OH}),

$$C_{CRW} = C_{CRW}\,(1 + CRW_{OH}) \quad \text{(VII.1.38)}$$

where C_{CRW} is input in dollars per year. Storage cost (SR_{PM}) is input in dollars per month, so that a yearly cost is

$$SC = 12. * SR_{PM} \quad \text{(VII.1.39)}$$

Insurance is another fixed cost, which is the sum of liability and hull insurance, the latter being proportional to consumer price CP; i.e.,

$$C_I = C_{LIAB} + H_{IR} * CP \quad \text{(VII.1.40)}$$

where C_{LIAB} and H_{IR} are input in namelist INGASP. Depreciation expense is expressed in terms of the consumer price and two input parameters;

$$DEP = CP\,(1 - PR_V)/D_{YR}\ , \quad \text{(VII.1.41)}$$

where PR_V is the residual value in percent and D_{YR} is the depreciation period, typically 8-10 years.

The next component of fixed expense is the sum of loan and tax expenses,

$$C_{FO} = T_{IC} + T_C + C_{MF}\ . \quad \text{(VII.1.42)}$$

Here the total interest and tax costs are

$$T_{IC} = .80\ CP * R_I \quad \text{(VII.1.43)}$$

$$T_C = T_R * CP/1000. \quad \text{(VII.1.44)}$$

and C_{MF} is input variable to account for other fixed expenses. R_I is the loan interest rate, and T_R is property tax rate in dollars per thousand.

Total fixed costs are then given by the sum,

$$C_{FIX} = SC + C_I + DEP + C_{FO} + C_{CRW} + FAA_{TAX} \qquad \text{(VII.1.45)}$$

VII.1.12 Total Operating Cost

The remaining computations deal with total operating costs in dollars per year, corresponding to the number of operating hours per year. Thus, U (I) measures use of the aircraft in hour/year, and hence total operating cost in dollars/hour is

$$TOC\ (I) = C_{VAR} + C_{FIX}/U\ (I) \qquad \text{(VII.1.46)}$$

The remainder of the subroutine deals with write and format statements.

GASP - GENERAL AVIATION SYNTHESIS PROGRAM

VOLUME VII - ECONOMICS

PART 2 - USER'S MANUAL

JANUARY 1978

Prepared for

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Ames Research Center
Moffett Field, California

Under

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AEROPHYSICS RESEARCH CORPORATION

VII.2.1 Economics Model User's Manual

The cost of general aviation aircraft is estimated using about 35 input parameters. Many component costs are calculated before the final "consumer price" is output. Only these output quantities are passed to MAIN, although several lines of printed output define the components of the consumer price, and additional details related to depreciation, interest, taxes and operating costs.

FIGURE VII.2.1 - SUBROUTINE GACOST - INPUT

Variable	Description
ALR	average labor rate in manufacturing, dollars/hour
CCRW	crew costs, dollars/year
CINP	cost of an inspection, dollars
CLIAB	liability insurance cost, dollars
CMF	increment to fixed annual cost, dollars
CMV	miscellaneous variable costs, dollars per hour
CRWOH	crew overhead percentage
DYR	depreciation life time, years
EMCOST	cruise Mach number at normal rated power
ENP	number of engines
FCSF	fuel cost, dollars/gallon
H	cruise altitude, feet
HIR	hull insurance rate, fraction of consumer price
HNCRU	design cruise altitude, feet
HPMSLS	sea level static maximum horsepower
HRI	hours between inspections
KSPCHG	supercharged engine indicator
NTYE	engine type, 1 to 14
OHR	one engine overhaul, cost dollars/pound thrust, or dollars/hp
PRV	residual value used for depreciation
R	design range, nm
RI	loan interest rate
SRPM	storage rate for aircraft, dollars/month
ST	mission block time, hour
TBO	time between engine overhauls, hours
TR	property tax rate, fraction of aircraft value

Variable	Description
UCSENG	unit engine cost dollars/horsepower or dollars/ pound thrust
UCSPP	unit cost of propeller, dollars/pound weight
WEMP	empty weight, pound
WF	fuel weight, pound
WG	gross takeoff weight, pound
WPROP1	weight of one propeller, pound
WTGB	weight of gear box

FIGURE VII.2.2 - PROGRAM GACOST - OUTPUT

Variable	Description
AIC	inspection and maintenance cost, dollars/hour
CADE	cost of optional equipment, dollars
CCRW	crew cost, dollars/year
CFIX	total annual fixed operating cost, dollars
CFO	other annual cost, dollars/year
CI	annual insurance cost, dollars/year
CMV	other hourly operating cost, dollars /hour
CP	consumer price, dollars
CRWOH	crew overhead rate, percent
CSDLR	dealer cost, dollars
CSDMF	total direct manufacturing cost, dollars
CSEND	cost of engines, dollars
CSFAF	basic flyaway factor price, dollars
CSGA	cost of engineering, sales, and general administration, dollars
CSMANF	total manufacturing cost, dollars
CSML	cost of direct manufacturing labor, dollars
CSMM	cost of airframe materials, dollars
CSOEQ	cost of other purchased equipment, dollars
CSPP	cost of propellers, dollars
CSTEQ	cost of all purchased equipment, dollars
CSTGB	cost of gearbox, dollars
CVAR	total variable operating cost, dollars/hour
DDMARK	dealer-distributor markup, percent
DEP	annual depreciation cost, dollars /year
DMLH	direct manufacturing labor hours
DMUP	dealer-distributor markup, dollars
DYR	depreciation period, years

Variable	Description
ETSGA	percent markup for engineering, sales, and general administrative cost, percent
FAATAX	FAA annual aircraft tax, dollars
FCON	block fuel consumption, gallons/hour
FOC	fuel and oil cost, dollars/hour
FPRO	factory profit, dollars
HRI	time between inspections, hours
OHC	overhaul cost, dollars/hour
OHML	manufacturing labor overhead rate, percent
PROFG	factory profit, percent
R	block range, n. mi.
SC	annual storage cost, dollars/year
ST	block time, hours
TOC	total operating cost
TBO	time between overhauls, hours
U	annual utilization, hours
WF	block fuel, pound
ZIR	hull insurance rate, percent
ZRV	residual depreciated value, percent

GASP - GENERAL AVIATION SYNTHESIS PROGRAM

VOLUME VII - ECONOMICS

PART 3 - PROGRAMMER'S MANUAL

JANUARY 1978

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VII.3.1 Economics Model Programmer's Manual

Subroutine GACOST follows a straightforward programming sequence, in which no iterative loops occur. Several IF-tests are needed to distinguish between engine types and aircraft size, for example, since cost estimation equations take different forms as these gross characteristics vary. A specific aircraft, however, has its cost components estimated according to the straightforward procedures described in Part I of this volume.

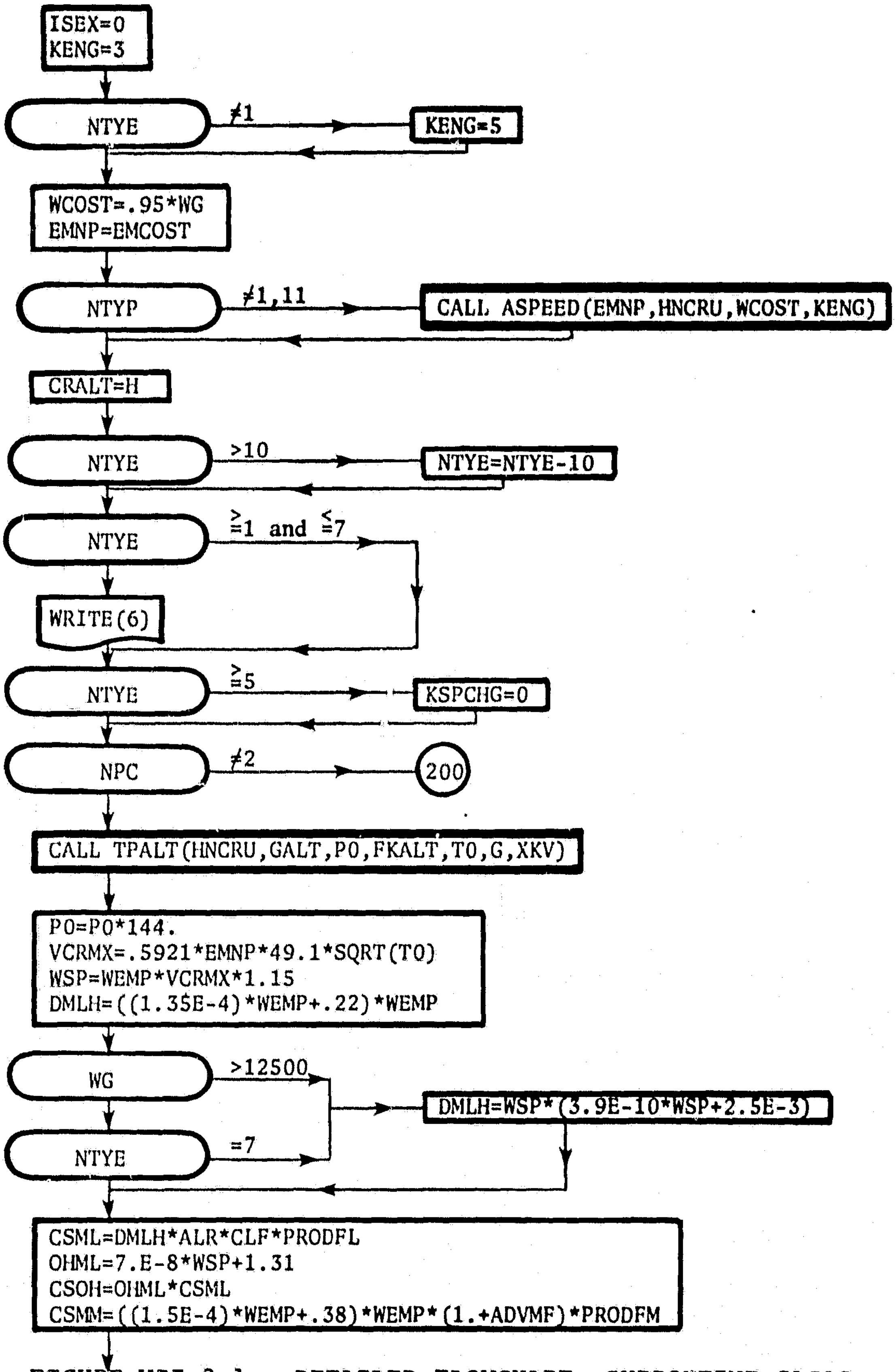
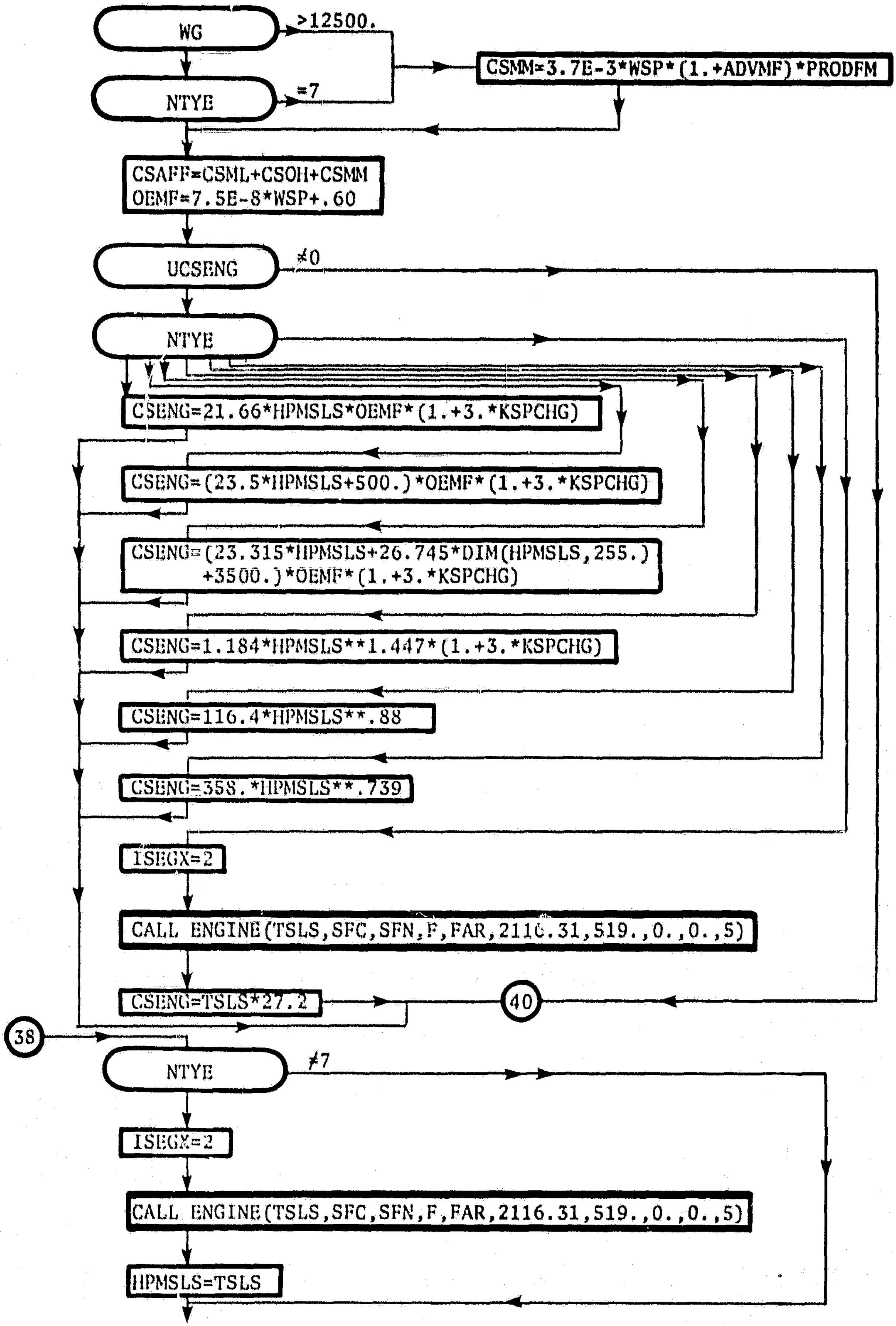
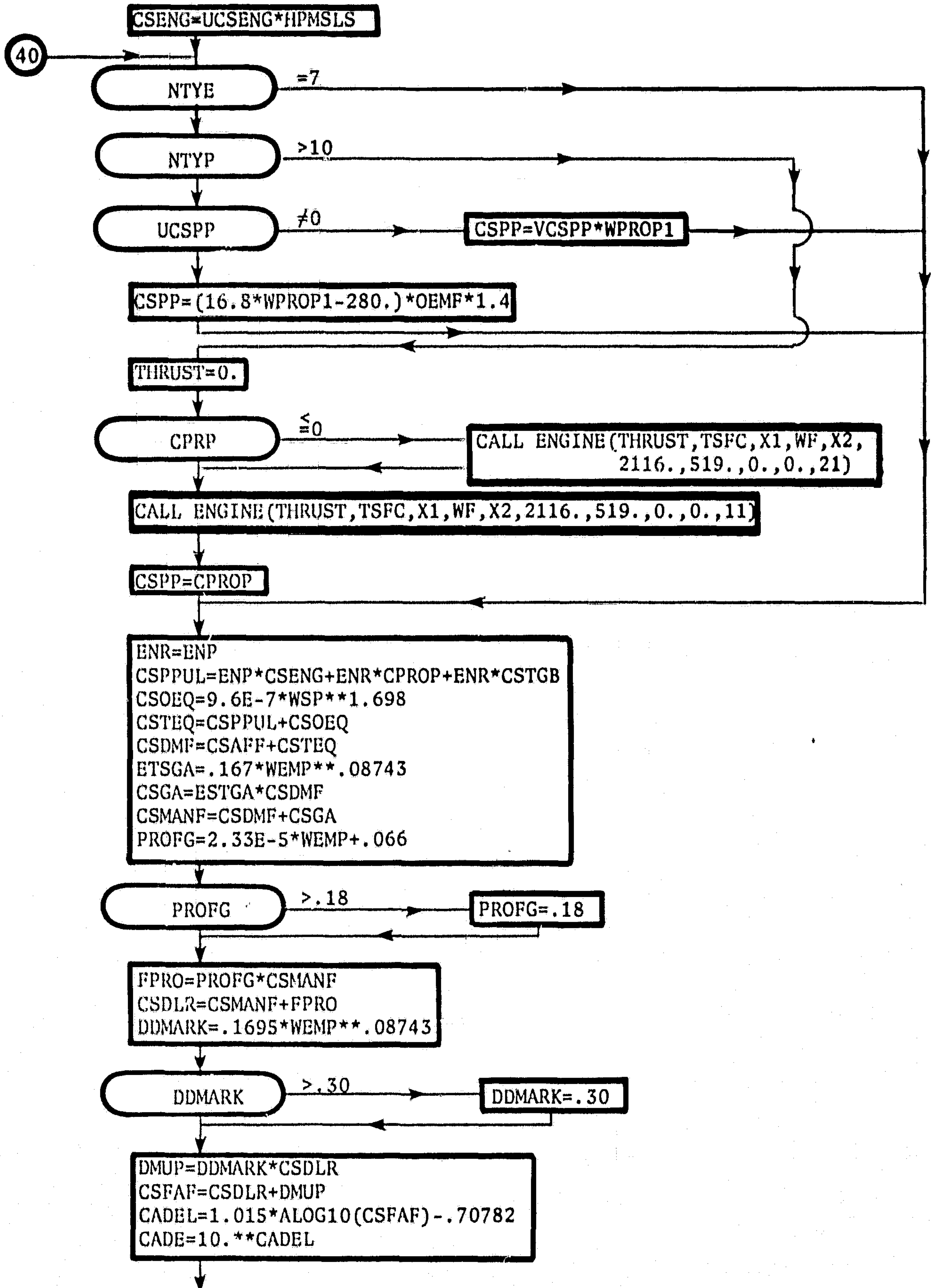
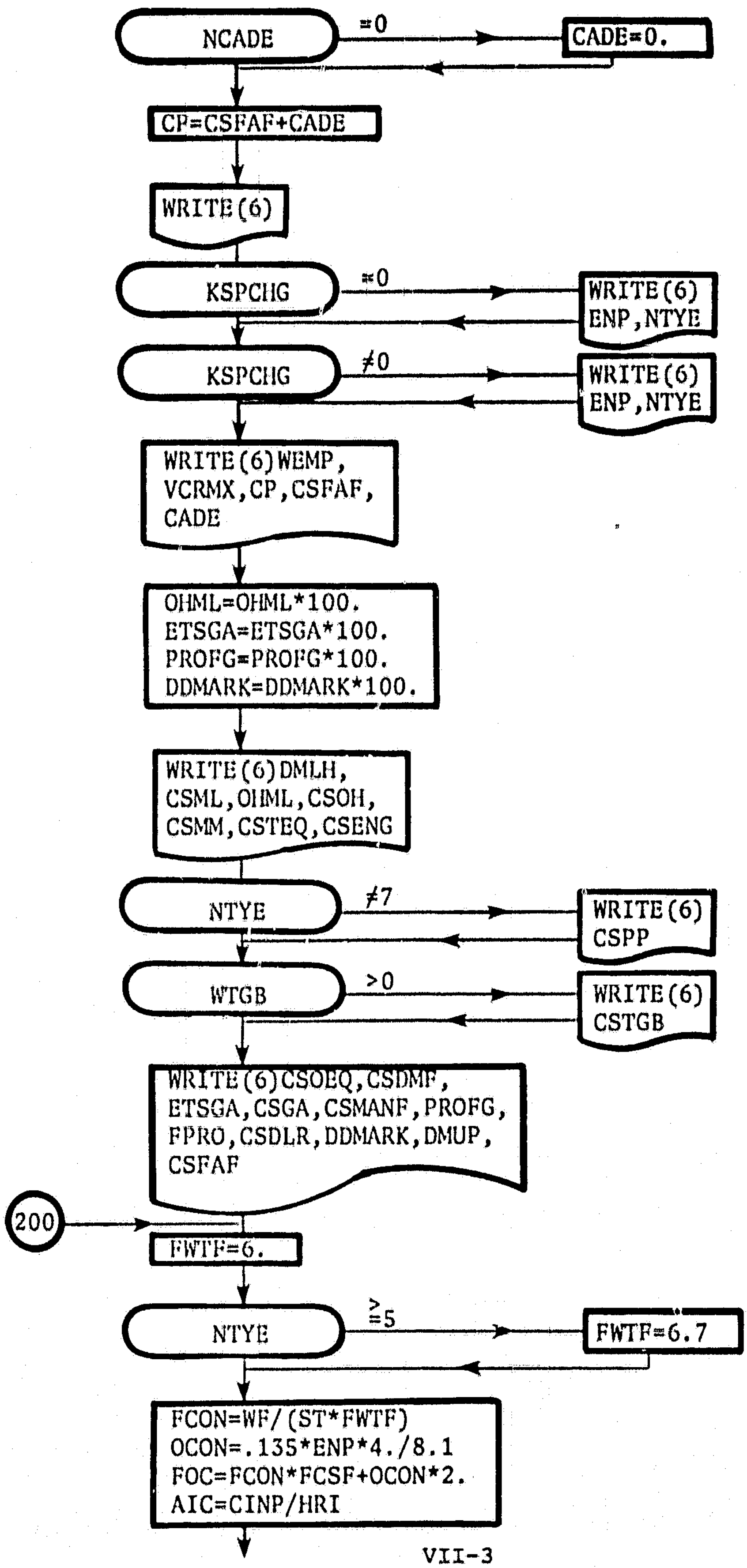
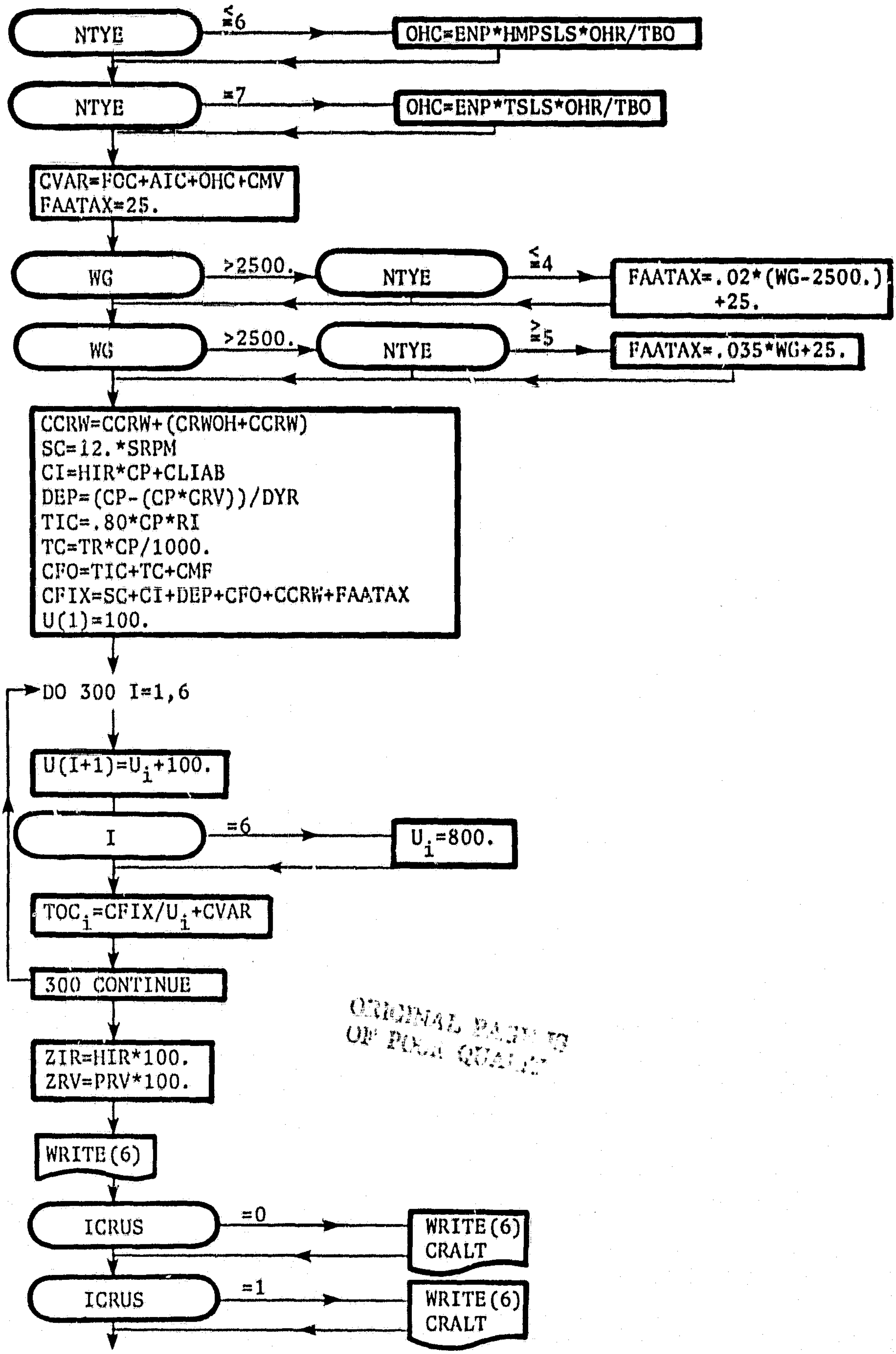


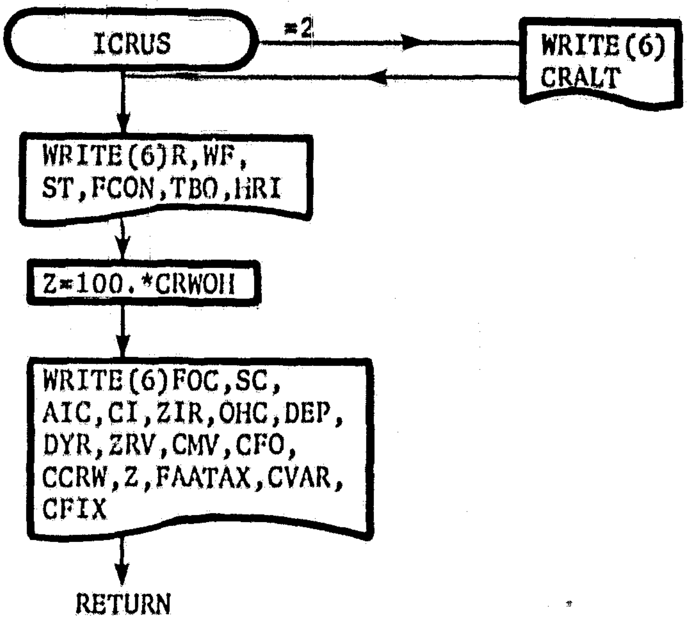
FIGURE VII.3.1 - DETAILED FLOWCHART, SUBROUTINE GACOST


WG
>12500.
NTYE
=7
CSMM=3.7E-3*WSP*(1.+ADVMF)*PRODFM
CSAFF=CSML+CSOH+CSMM
OEMF=7.5E-8*WSP+.60
UCSENG
≠0
NTYE
CSENG=21.66*HPMSLS*OEMF*(1.+3.*KSPCHG)
CSENG=(23.5*HPMSLS+500.)*OEMF*(1.+3.*KSPCHG)
CSENG=(23.315*HPMSLS+26.745*DIM(HPMSLS,255.)
+3500.)*OEMF*(1.+3.*KSPCHG)
CSENG=1.184*HPMSLS**1.447*(1.+3.*KSPCHG)
CSENG=116.4*HPMSLS**.88
CSENG=358.*HPMSLS**.739
ISEGX=2
CALL ENGINE(TSLS,SFC,SFN,F,FAR,2116.31,519.,0.,0.,5)
CSENG=TSLS*27.2
40
38
NTYE
≠7
ISEGX=2
CALL ENGINE(TSLS,SFC,SFN,F,FAR,2116.31,519.,0.,0.,5)
HPMSLS=TSLS


CSENG=UCSENG*HPMSLS
40
NTYE
=7
NTYP
>10
UCSPP
≠0
CSPP=VCSPP*WPROP1
CSPP=(16.8*WPROP1-280.)*OEMF*1.4
THRUST=0.
CPRP
≤0
CALL ENGINE(THRUST,TSFC,X1,WF,X2,
2116.,519.,0.,0.,21)
CALL ENGINE(THRUST,TSFC,X1,WF,X2,2116.,519.,0.,0.,11)
CSPP=CPROP
ENR=ENP
CSPPUL=ENP*CSENG+ENR*CPROP+ENR*CSTGB
CSOEQ=9.6E-7*WSP**1.698
CSTEQ=CSPPUL+CSOEQ
CSDMF=CSAFF+CSTEQ
ETSGA=.167*WEMP**.08743
CSGA=ESTGA*CSDMF
CSMANF=CSDMF+CSGA
PROFG=2.33E-5*WEMP+.066
PROFG
>.18
PROFG=.18
FPRO=PROFG*CSMANF
CSDLR=CSMANF+FPRO
DDMARK=.1695*WEMP**.08743
DDMARK
>.30
DDMARK=.30
DMUP=DDMARK*CSDLR
CSFAF=CSDLR+DMUP
CADEL=1.015*ALOG10(CSFAF)-.70782
CADE=10.**CADEL


NCADE
=0
CADE=0.
CP=CSFAF+CADE
WRITE(6)
KSPCHG
=0
WRITE(6)
ENP,NTYE
KSPCHG
≠0
WRITE(6)
ENP,NTYE
WRITE(6)WEMP,
VCRMX,CP,CSFAF,
CADE
OHML=OHML*100.
ETSGA=ETSGA*100.
PROFG=PROFG*100.
DDMARK=DDMARK*100.
WRITE(6)DMLH,
CSML,OHML,CSOH,
CSMM,CSTEQ,CSENG
NTYE
≠7
WRITE(6)
CSPP
WTGB
>0
WRITE(6)
CSTGB
WRITE(6)CSOEQ,CSDMF,
ETSGA,CSGA,CSMANF,PROFG,
FPRO,CSDLR,DDMARK,DMUP,
CSFAF
200
FWTF=6.
NTYE
≥5
FWTF=6.7
FCON=WF/(ST*FWTF)
OCON=.135*ENP*4./8.1
FOC=FCON*FCSF+OCON*2.
AIC=CINP/HRI


NTYE
≤6
OHC=ENP*HMPSLS*OHR/TBO
NTYE
=7
OHC=ENP*TSLS*OHR/TBO
CVAR=FOC+AIC+OHC+CMV
FAATAX=25.
WG
>2500.
NTYE
≤4
FAATAX=.02*(WG-2500.)
+25.
WG
>2500.
NTYE
≥5
FAATAX=.035*WG+25.
CCRW=CCRW+(CRWOH+CCRW)
SC=12.*SRPM
CI=HIR*CP+CLIAB
DEP=(CP-(CP*CRV))/DYR
TIC=.80*CP*RI
TC=TR*CP/1000.
CFO=TIC+TC+CMF
CFIX=SC+CI+DEP+CFO+CCRW+FAATAX
U(1)=100.
DO 300 I=1,6
U(I+1)=U_i+100.
I
=6
U_i=800.
TOC_i=CFIX/U_i+CVAR
300 CONTINUE
ZIR=HIR*100.
ZRV=PRV*100.
WRITE(6)
ICRUS
=0
WRITE(6)
CRALT
ICRUS
=1
WRITE(6)
CRALT


ICRUS
=2
WRITE(6)
CRALT
WRITE(6)R,WF,
ST,FCON,TBO,HRI
Z=100.*CRWOH
WRITE(6)FOC,SC,
AIC,CI,ZIR,OHC,DEP,
DYR,ZRV,CMV,CFO,
CCRW,Z,FAATAX,CVAR,
CFIX
RETURN