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DOCUMENTATION FEATURES FOR COMPUTER PROGRAMS

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Abrom Hisler
Information Processing Division

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SUMMARY

Computer programs may best be prepared by means of documentation features. These features, as demonstrated, may also be used in the computer program gamut of planning, development, and operation. By automating these features, the documentation (and development) effort should be further eased.

CONTENTS

DOCUMENTATION FEATURES FOR COMPUTER PROGRAMS

INTRODUCTION

How can one possibly compare the present day burgeoning technology with biblical times? Impossible? And yet both are similar in these two ways — there is a flood of information* and to the extent that this information remains "undigested," it reminds one of the Tower of Babel.

This is true in many technical areas and especially in the all-encompassing area of computer programs. These programs, for the most part, represent the state-of-the-art in particular fields of interest.

Translation of technical computational techniques into neat packages — computer programs — is the effort to prepare such techniques for immediate use. Obviously, there is no difficulty where the originating team of engineer (scientist) and programmer is concerned. However, transmit the same program to another engineer-programmer team and the immediate-use advantage vanishes and may return only after much head scratching if the documentation of the program is not adequate.

How then to best document a computer program? How can computer automation aid in this effort? Answers to these questions have become the concern of many people who realize that the generation of computer programs has proliferated to the point where a vast number of these programs are now available after considerable expense.

DOCUMENTATION FEATURES

The obvious approach to the documentation problem may be to develop and refine those documentation features which are most effective.

What may those documentation features be? And how readily may they be automated?

The nature of documentation features developed thus far can be readily grasped by thumbing through Appendices A through G. Having done so, one can then notice how these features cover the various facets of computer program

*Coughlen, William J.: The Flood. Technology Week. Vol. 50, No. 1, p. 50, 1966.

planning, development, and operation. The appendixes appear in the order they would in a typical documentation presentation. They are referenced in the text in the order they would be developed.

The appendixes contain not only the documentation features but also some points of information relating to a particular feature. The documentation features themselves were taken from a preliminary report on PUTT (Propellant Utilization Time Trace), a computer program to simulate the vertical ascent of a boost-sustain sounding rocket.

Engineering Analysis

The planning effort is first noted in the engineering analysis documentation feature (Appendix C). It tends to unify and integrate the scope of the intended sequence of computations as initially envisaged by the engineer (scientist).

Decision Circle Flow Pattern

As the engineering analysis is translated into the computer program itself by the programmer, the decision circle flow pattern (Appendix E) emerges to follow the ramifications of the program's logic as developed by the programmer. Where the program operates in a simple calculation sequence, no major problems are anticipated. Straightforward computation flow occurs between decision circles.

The programmer's greatest debugging efforts usually concern the manner in which the program pivots about each decision circle as conditions change during the course of the computation.

Program Listing with Running Commentary

With the program finally debugged and operational, one may then begin to go into the innards of the program by preparing a running commentary of the computer program's listing (Appendix B). The documentation feature developed for this purpose allows for simple comments where these are adequate. Where this is not possible, a complete discussion may be appropriately appended onto the listing.

Likewise, as appropriate references to the literature become known, they too may be appended in the proper place for later discussion or for suggesting new follow-on efforts.

The running commentary effort need not await that point in time when the computer program is all checked out and operational. During the development of a computer program, it may be wise to "freeze" it at some point in time to append the information known then. This was done with the PUTT computer program about which the documentation features were developed.

Decoding Sheet

By sorting the parameters in the listing, alphabetically, the decoding sheet (Appendix D) may be next prepared. Here it is possible, in one swoop, to indicate which parameter must be inputted initially, which is outputted as a result of computer computations or important initial conditions, and which remains in the program, merely awaiting an appropriate writeout statement.

At this point, the program is no longer the black box* it was before the start of the documentation effort.

Additional Documentation Features

However, the problem of operating the computer program remains. The correlating input format (Appendix F) helps to feed the necessary data into the program as for a test run. It is at this point that the decoding sheet proves worthwhile in refreshing one's memory about unfamiliar parameters.

The data display sheet(s) (Appendix G) of the input and output data completes the test run picture.

A computer program brief sheet (Appendix A) then gathers together all tidbits of information which still remain after the above documentation efforts.

DOCUMENTATION FEATURE AUTOMATION

How readily can these documentation features be automated?

The engineering analyses sheet may require the use of computer-aided techniques whereby the engineer reacts directly with the computer to order the sequential arrangement of the various engineering equations. A photograph taken of the final sequence or engineering analysis pattern records the engineer's thinking at that particular point in time. Without computer-aided techniques, the engineer must resort to simple pencil (with eraser) and paper trial and error. At any rate the programmer should more readily appreciate the nature of the problem to be programmed with the engineering analysis before him than

*Hisler, Abrom: Avoiding "Black Box" Computer Programs. X-671-64-34. GSFC, October 1964.

receiving a helter-skelter list of engineering equations without apparent relationship.

Again, with computer-aided techniques, the decision circle flow pattern can be generated. And yet present-day automation techniques prepare flow charts in the more traditional fashion. It should be a simpler matter to do so with the less sophisticated decision circle concept.

To aid in the preparation of a running commentary of the computer program listing, present-day automation techniques should again be adequate to print out the listing with appropriate columns for card numbers, references, discussion, and comments, and to consecutively number the statements of the program. Thereafter, the programmer-engineer team need only complete this listing format with appropriate information, which would be typed on duplicate listing.

The self-same automation techniques would prepare the decoding sheet with parameters listed in alphabetical order, as input, output, and internal. Again, a typewritten decoding sheet would follow rough-draft efforts.

Similarly, correlated input formats, data output sheets, and computer program brief sheets would be prepared. To be sure, the data display sheets are the sole present-day example of an automated documentation feature.

Once these documentation features have been developed and compiled, the documentation report body will require only broad stroke discussion of the program's objectives and general flow to present the big picture since the program details would be imbedded in the documentation features, automated or not.

And yet it would be a mistake to "freeze" any set of documentation features as the only acceptable set and so "strait-jacket" the documenting programmer. The important thing is to expand our "pool" of documentation features so that from this pool, documentation features mutually acceptable to programmer and user, may appear in the final computer program documentation report.

A growing set of documentation features, then, is one way to cope with the rising flood of computer programs and so reduce Tower of Babel complaints.

APPENDIX A

COMPUTER PROGRAM DOCUMENTATION BRIEF

The computer program documentation brief as presented on the following page may still be too brief, even for a brief. It may be advisable to expand it by extracting items of information from the two GSFC short forms (p. A-3 to A-6) for programs and subprogram documentation.

PUTT COMPUTER PROGRAM DOCUMENTATION BRIEF

1. FORTRAN IV
2. Running Time - 2.22 seconds/4 flights
3. Computer - IBM 7094 and 7040
4. Lines of Output - 4000 lines/2.22 second run
5. Information Retrieval - Key Concepts and Areas

   Sounding Vehicle

   Computer Program

   Vertical Ascent

   Documentation

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SUBPROGRAM DOCUMENTATION – SHORT FORM

Form initiated ____/____/____

Est. completion ____/____/____

Actual completion ____/____/____

DISPOSITION

☐ Routine written

☐ Used existing routine

☐ Task discontinued

Access No. ____________

Program No. ____________

Parent Prog. No. ____________ (INDICATE REASON FOR CHANGE IN ABSTRACT)

Subject codes: (primary) ________ (secondary) ________ ________ ________ ________

Title: ____________

Author: ____________ (REGISTERED ID, FULL NAME) Phone: ____________

Author Location: ____________ (GSFC CODE, BLDG. & ROOM NO. OR COMPANY, CONTRACT NO. & ADDRESS OR USER'S GROUP ID)

Task Sponsor: ____________ GSFC Code: ____________ Ext. ____________

Sponsor No. ____________ Project: ____________ Field of Application: ____________

Purpose (CONCISE STATEMENT OF FUNCTION OF ROUTINE):

Access No.

Program No.

NOTE: USE ADDENDUM SHEETS, IF NECESSARY, TO EXTEND ANY OF THE FOLLOWING ITEMS FOR WHICH MORE SPACE IS NEEDED. DATE AND LABEL EACH SHEET WITH THE ACCESS NO., AND INDICATE ITEM NO. OF EACH CONTINUED ITEM

1. Computer Type: ____________ (E.G., 360, 7094, 1108, . . .) 2. System or Monitor: ____________ (E.G., OS/360, FMS, EXEC II, . . .)

3. Source Language(s): ____________ (PRIMARY) (%); ____________ (SECONDARY, IF MIXED) (%)

4. Memory Required, other than Monitor: ____________ (INDICATE BASE (OCTAL, DECIMAL, . . .) AND UNITS (WORDS, BYTES, . . .))

   Above figure ☐ includes ☐ does not include system library routines

5. List Program Numbers of any required subprograms that are documented separately

6. Special Configuration Requirements: ____________ (E.G., 2250, 65K, 1004, ETC.)

7. I/O Configuration

FILE NAME, LOGICAL OR PHYSICAL UNIT NO.	DEVICE TYPE	REQUIRED	OPTIONAL	INPUT	OUTPUT	SCRATCH	DESCRIPTION/REMARKS

540-1 (5/66)

8. **ABSTRACT** (BRIEF DESCRIPTION OF ROUTINE):

9. **KNOWN RESTRICTIONS** (E.G., LIMITS, PHYSICAL CONDITIONS NOT HANDLED, ARRAY SIZES, ETC.):

10. **FILE DESCRIPTION** (EXPLAIN FORMAT AND CONTENT OF EACH EXTERNAL I/O FILE, IF ANY, INCLUDING LABELS, BLOCKING, RECORDING MODE, NUMERICAL REPRESENTATION, UNITS, ETC.):

11. USAGE (DETAILED DEFINITION OF CALLING SEQUENCE, ARGUMENTS, COMMON STORAGE, ETC.):

12. OPERATING INSTRUCTIONS (CONSOLE COMMUNICATIONS, SWITCH SETTINGS, ETC.):

13. TERMINATING CONDITIONS (NORMAL AND ALTERNATE RETURNS, ERROR EXITS, ETC.):

14. TIMING (STATE CONDITIONS UNDER WHICH FIGURES ARE OBTAINED OR ESTIMATED):

15. SOURCE MATERIAL FOR DERIVATION, TEXT REFERENCES, etc.:

16. REVISION OR MODIFICATION HISTORY:

REV. NO.	DATE	PROGRAMMER, LOC., EXT.	REASON

17. LIBRARY MATERIAL AVAILABLE:

☐ Source program Form ______ (E.G., HOLLERITH CARDS, 7-TRACK BCD TAPE, ETC.) Count ______ (INDICATE STATEMENTS, CARDS, RECORDS, ...)

☐ Reloc. object program Form ______ Count ______

☐ Abs. object program Form ______ Count ______

☐ Additional Documentation (specify): ______ (E.G., WRITEUP, FLOWCHART, LISTING, TEST CASE, ETC.)

☐ Submitted to other libraries: ______ NAME OF ORGANIZATION ______ DATE ______ NUMBER ASSIGNED

18. ESTIMATED TIME AND COST FOR DEVELOPMENT:

Manmonths ______ Machine hours ______ Total cost $ ______

APPENDIX B

COMPUTER PROGRAM LISTING WITH RUNNING COMMENTARY

The format of the computer program listing with running commentary accomplishes a number of things:

- Consecutively numbers the program statements via the C (card number) column
- Notes references of interest pertinent to a particular statement via the R (reference) column
- Comments on particular statements with the opportunity to go into discussion of greater depth through the use of the D (discussion) column
- Prepares a computer program deck of cards from the listing.

The exact manner in which the above is done is illustrated below:

- Card number 4 (p. B-2) is used to identify the Card 4 discussion which appears on page B-10.
- Card number 758 (p. B-6) has associated with it reference (1) appearing at the end of this appendix which refers to the particular Runge Kutta method that was selected to program the KRPAR integration subroutine.
- For those who would wish to prepare a program deck of cards from the listing as given, it might be difficult to punch cards 584 and 585 (p. B-4) since exact spacing is necessary in the location of the output headings. To assist in this problem of proper column collation, it would be advisable to incorporate the technique shown in the reference below. Whereas this reference calls for placing the numbered columns at the top of the listing, it would be less obvious to set it at the bottom. Here then is an example of assimilating other valuable documentation techniques into the present group of documentation features.

REFERENCE: A Study of Performance Trade-offs for Solid Propellant Propulsion Systems. Final Report No. AFRPL-TR-6565, Vol. 1. Lockheed Propulsion Company, Redlands, Cal. 1 March 1965. pp. 2-64.

PUTT COMPUTER PROGRAM LISTING

C = Card Number
R = Reference
D = Discussion in Appendix B2, p.29

```
$JOB   1501P005  405 N22AH N2004B1091
$EXECUTE        IBJOB
$IBJOB          GO,SOURCE,MAP
$IBFTC PROPE    LIST,DD,NODECK
C  PROPELLANT UTILIZATION TIME TRACE     PUTT      A.HISLER                 11
      REAL ISP,ISPAV,    MRAV,IT,ISPDT,MRDT,ISPAV1,ISPAV2,IT1,IT2
      DIMENSION XMR(250),CSTAR(250),WDT(250),PC(250), XMCH(250),QB(250),
     1D(250),CFY(250),FY(250),R(250),GSTAR(250),WPTL(250),WG(250),
     2     AR(250),   TH(250),PAZ(250),VS(250),CD(250),TVO(250),THO(250),
     3TVFX(250),THFX(250),DPFY(250),WDFY(250),VFT(250),WFT(250),AY(250),
     4DPO(250),WDO(250),VOT(250),WOT(250),          PHRG(250),PCG(250),
     5TM(250),AV(250),VV(250),HV(250),TPA(250),          TPC(250),HP(2   ),
     6PPT(2   ),DPP(2   ),WDP(2   ),VPT(2   ),WPT(2   ),TIPC(10),TRPC(10),
     7TPPT(250),           VPT1(2   ),VPT2(2   ),WPT1(2   ),WPT2(2   ),
     8          HFY(250),HOY(250),VSY(250),PFT(250),POT(250),   YMCH(250),
     9                        CDY(250),                        STY(250),
     APV(2),STE(2),          RT(250),TR(250),TS(250)

  901 FORMAT(42H1CALCULATION OPERATION PASSED THIS POINT-1)
  902 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-2)
  903 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-3)
  904 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-4)
  905 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-5)
  906 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-6)
  907 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-7)
  908 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-8)
  909 FORMAT(42H/CALCULATION OPERATION PASSED THIS POINT-9)
  910 FORMAT(43H/CALCULATION OPERATION PASSED THIS POINT-10)
  911 FORMAT(43H/CALCULATION OPERATION PASSED THIS POINT-11)
  912 FORMAT(43H/CALCULATION OPERATION PASSED THIS POINT-12)
  913 FORMAT(43H/CALCULATION OPERATION PASSED THIS POINT-13)

      READ          (5,88)JAL,JVS,JMC,JVD,JVFX,KH,KP,JAM
   88 FORMAT(4I3,I4,I3,I2,I3)

      READ          (5,45)RO,XMU
   45 FORMAT  (E14.7,E14.5)

      READ          (5,74)FY(2),HMM,WIC,AT,SBIG
   74 FORMAT  (5F10.2)

      READ          (5,80)TM2,WG1,WG2,FB2,DTO1,DTO2,WB3,WS3,FB3,FIBFX
   80 FORMAT(F7.2,2F7.1,F7.0,2F7.3,2F7.2,F7.0,F7.1)

      READ          (5,81)WOL,WFL,SPGFX,SPGO,UFX,UO,VFTO,VOTO,AKFX,AKO
   81 FORMAT(2F7.3,4F7.4,3F7.3,F7.4)

      READ          (5,83)(TPA(L),L=1,JAL)
      READ          (5,83)(VS(N),N=1,JVS)
   83 FORMAT(6E12.5)

      READ          (5,82)(TH(L),L=1,JAM)
   82 FORMAT(7E10.3)

      READ          (5,84)(XMCH(M),M=1,JMC)
   84 FORMAT(14F5.2)

      READ          (5,85)(CD(M),M=1,JMC)
   85 FORMAT(14F5.3)
```

C	R	D	COMMENTS
1		1	
		4	Replace DD by REF to obtain Symbol Reference Data
			A debugging technique to follow the sequence of calculations and to determine the trouble area within the program where it hangs up.
			Delete card nos. 18-30 with corresponding cards such as card no. 480 from operating program.
		31	Read in table lengths
			See decoding sheet for definitions
			To understand grouped input and other parameters see the PUTT decoding sheet.
			Tables of atmospheric pressure and velocity of sound versus corresponding table of altitude
			Table of Mach numbers with corresponding table of drag coefficients

```
      AKO1 = AKO
      IF (CNO1.NE.CNF )  CNO2 = CNO1
      CNO1 = CNF
      IF (FB31.NE.FB3 )  FB32 = FB31                                              530
      FB31 = FB3
      IF (CSTF1.NE.CSTC ) CSTF2 = CSTF1
      CSTF1 = CSTC
      GO TO 423

  701 KAL = 5                                                                       535
   17 WRITE (6,32)
   32 FORMAT(112H1AVERAGE  AVERAGE   AVERAGE   TOTAL    AVERAGE   LAUNC
     1H    FUEL     OXIDIZER     PEAK     MAXIMUM   BURNOUT/109H  IS
     2P      MIXTURE   CHAMBER   IMPULSE   CSTAR     WEIGHT    FLOW
     3 FLOW          ALTITUDE  VELOCITY  TIME/ 80H              RATIO              540
     4PRESSURE                                  CONSTANT  CONSTANT)
      WRITE (6,58) ISPAV,PCAV,CSTAV,AKFX,HVP,BT
   58 FORMAT(X,E10.4,10X,E10.4,10X,E10.4,10X,E10.4,10X,E10.4,10X,E10.4)
      WRITE (6,49) MRAV,IT,WG1,AKO,VVM
   49 FORMAT(10X,E10.4,10X,E10.4,10X,E10.4,10X,E10.4,10X,E10.4)                     545

      WRITE (6,1)
    1 FORMAT(120HOFUEL     OXIDIZER  MAXIMUM   DPT      BTCF      BTCO
     1     TI/B       S8          S9          S10        S11             /
     224H    PERCENT            G S/11H      ULLAGE)
      WRITE (6,5)  UFX,AVM,BTCF,TIB                                                550
    5 FORMAT (X,E10.4,10X,E10.4,10X,E10.4,10X,E10.4)
      WRITE (6,2) UO,DPT,BTCO
    2 FORMAT(10X,E10.4,10X,E10.4,10X,E10.4)
      WRITE             (6,15)
   15 FORMAT(1H0)                                                                   555

      R 1 = ISPAV1
      R 2 = DISP
      R 3 = ISPAV2
      R 4 = CSTF1
      R 5 = CSTC                                                                    560
      R 6 = CSTF2

      R13 = TIB1
      R14 = DTIB
      R15 = TIB2
      R16 = FB31                                                                    565
      R17 = FB3
      R18 = FB32

      R25 = IT1
      R26 = DIT
      R27 = IT2                                                                     570
      R28 = CNO1
      R29 = CNF
      R30 = CNO2

      R37 = BTCO1
      R38 = DBTCO                                                                   575
      R39 = BTCO2
      R40 = AKO1
      R41 = AKO
      R42 = AKO2
      NO = NO + 1                                                                   580
      R32 = FLOAT(NO)

  602 FORMAT (1H ,11E10.3,E9.2)
      WRITE (6,702)
```

Comments:

(Card 535) This indicates the previous flight has not passed the stated requirements

(Cards 542–544) Readout of average values of sustainer specific impulses, chamber pressure, C*, fuel flow constant, oxidizer flow constant, total impulse, burnout time, etc.

(Card 556) A debugging technique consisting of cards 556 to 579
Define R-number with parameter of interest and read valve from Card Number 584 table as output data.

(Card 580) Counts number of vehicle flights

```
702 FORMAT (117H1     R1          R2          R3          R4          R5
   1 R6          R7          R8          R9          R10         R11         R12)
    WRITE (6,602) R1,R2,R3,R4,R5,R6,R7,R8,R9,R10,R11,R12
    WRITE (6,703)
703 FORMAT (117H      R13         R14         R15         R16         R17
   1 R18         R19         R20         R21         R22         R23         R24)
    WRITE (6,602) R13,R14,R15,R16,R17,R18,R19,R20,R21,R22,R23,R24
    WRITE (6,601)
601 FORMAT (117H      R25         R26         R27         R28         R29
   1 R30         R31         R32         R33         R34         R35         R36)
    WRITE (6,602) R25,R26,R27,R28,R29,R30,R31,R32,R33,R34,R35,R36
    WRITE (6,704)
704 FORMAT (117H      R37         R38         R39         R40         R41
   1 R42         R43         R44         R45         R46         R47         R48)
    WRITE (6,602) R37,R38,R39,R40,R41,R42,R43,R44,R45,R46,R47,R48


    IF (KAL.EQ.2.OR.KAL.EQ.5)  GO TO 56      Call for re-flights
    IF (KAL.EQ.4)              GO TO 9       Preparations for interpolation if required
    GO TO 423

C   CALCULATION OF NEW ALTITUDE AND VELOCITY

 63 JPV = 4                                  Fourth stage of Runge Kutta integration
    MT = 3                                   Is there a need for MT?
    A = AX

C RUNGE-KUTTA FINAL SUMMATION

    CALL KRPAR (TI,HI,VI,V,A,JPV,HO,VO,TO,TC,DT,ST,GSTARX)

    HV2 = HO                                 Vehicle altitude at new point in time

    VV2 = VO                                 Vehicle velocity at new point in time

    AV2 =       0.1666666*(AV11+4.*AV12+AV13)   Vehicle acceleration at new point in time

    R43 = WDODT                              Debugging aid
    R44 = WG(1)
    R45 = DWG
    R47 = WPTLX
    R48 = WGX

C   SET OF NEW PARAMETERS

 47 J=J+1                                    Advance time point by one
    JT = J                                   Total number of time points

 22 TM(J)=TI + ST                            New point in time

    AR(J)=ARX                                New parameters at time t
    AV(J) = AV2
    AY(J) = AX
    CDY(J) = CDX
    CFY(J)=CFX
    CSTAR(J)=CSTARX
    D(J)=DX
    DPFY(J)=DPFX
    DPO(J)=DPOX
    FY(J)=FX
    GSTAR(J)=GSTARX
    HFY(J) = HFX
```

```
  415 IF (IT.LT.971000..OR .IT.GT.972000.)    GO TO 67
      WRITE                (6,905)                                                  675
  422 IF (ISPAV.GT.230.0.OR .ISPAV.LT.220.)   GO TO 54                              675
      WRITE                (6,906)


  417 IF (BTCF.LT.1.001.OR .BTCF.GT.1.5   )  GO TO 69                               675
      WRITE                (6,908)
  416 IF (BTCO.LT..99.OR .BTCO.GT.1.1   )  GO TO 68                                 675
      WRITE                (6,907)

C      GO TO 17                                                                          Delete

   97 WRITE (6,610)
  610 FORMAT     (115H1 J                    TM                AV                        Time trace of last flight results
     1    VV                  HV                  STY                  PAZ)
      WRITE (6,611)
  611 FORMAT     (104H        HOY                 HFX                  DPFY
     1           DPO                 WDFY                WDO)
      DO 612 J=1,JT
      WRITE (6,613)J,TM(J),AV(J),VV(J),HV(J),STY(J),PAZ(J)
  613 FORMAT(X,I3,9X,E10.3,9X,E10.3,9X,E10.3,9X,E10.3,9X,E10.3,9X,E10.3)
      WRITE (6,614) HOY(J),HFY(J),DPFY(J),DPO(J),WDFY(J),WDO(J)
  614 FORMAT(4X,E10.3,9X,E10.3,9X,E10.3,9X,E10.3,9X,E10.3,9X,E10.3,)
  612 CONTINUE


      WRITE (6,620)
  620 FORMAT     (115H1 J                    VOT               VFT                       Time trace of last flight results
     1    WOT                 WFT                 TM                   XMR)
      WRITE (6,621)
  621 FORMAT     (104HO       CSTAR               WDT                  WPTL
     1           PC                  CFY                 FY )
      DO 622 J=1,JT
      WRITE (6,613)J,VOT(J),VFT(J),WOT(J),WFT(J), TM(J), XMR(J)
      WRITE (6,614) CSTAR(J),WDT(J),WPTL(J),PC(J),CFY(J),FY(J)
  622 CONTINUE


      WRITE (6,630)
  630 FORMAT     (115H1 J                    AY                TM                        Time trace of last flight results
     1    GSTAR               R                   PFT                  POT   )
      WRITE (6,631)
  631 FORMAT     (104HO       WG                  VSY                  YMCH
     1           CDY                 QB                  D  )
      DO 632 J=1,JT
      WRITE (6,613)J,AY(J),TM(J),GSTAR(J),R(J),PFT(J),POT(J)
      WRITE (6,614) WG(J),VSY(J),YMCH(J),CDY(J),QB(J),D(J)
  632 CONTINUE




      STOP
      END

$IBFTC TERPU                                                                             Linear interpolation subroutine when input table
      SUBROUTINE TERPU (R,TR,S,TS,MDIM,NDIM)
```

```
C TERPU = SINGLE INTERPOLATION-INCREASING  R VALUES
      DIMENSION TR(MDIM),TS(NDIM)
      K = 1
    1 IF (TR(K)-R) 2,3,4
    2 K = K+1
      GO TO 1
    3 S = TS(K)
      GO TO 7
    4 IF (TS(K)   -TS(K-1))5,3,6
    5 S = TS(K) + ((TR(K)-R)/(TR(K)-TR(K-1)))*(TS(K-1)-TS(K))
      GO TO 7
    6 S = TS(K-1) + ((R-TR(K-1))/(TR(K)-TR(K-1)))*(TS(K)-TS(K-1))
    7 RETURN
      END
```

Values increase with table lengths

```
$IBFTC TERPD
      SUBROUTINE TERPD(RV,TR,SV,TS,JVP)
C     COMMON/DTP/RV,TR,SV,TS,U3,V3,W3,X3,Y3,JVP
C TERPD = SINGLE INTERPOLATION-DECREASING  R VALUES
      DIMENSION TR(JVP),TS(JVP)
      K = 1
    1 IF(RV-TR(K)) 2,3,4
    2 K = K+1
      GO TO 1
    3 SV= TS(K)
      GO TO 7
    4 IF (TS(K)   -TS(K-1))5,3,6
    5 SV= TS(K) +((RV-TR(K))/(TR(K-1)-TR(K)))*(TS(K-1)-TS(K))
      GO TO 7
    6 SV= TS(K-1) +((TR(K-1)-RV)/(TR(K-1)-TR(K)))*(TS(K)-TS(K-1))
    7 U3= K
      V3= TR(K)
      W3= TR(K-1)
      X3= TS(K)
      Y3= TS(K-1)
      RETURN
      END
```

Linear interpolation subroutine where input table values decrease with table length
Delete

```
$IBFTC KRPAR
      SUBROUTINE KRPAR (TI,HI,VI,V,A,J,HO,VO,TO,TC,DT,ST,GS)
      GO TO (1,2,3,4),J
    1 C1P = ST*A*GS
      C1 = ST*V
      DT = ST/3.
      TO = TI + DT
      VO = VI + C1P/3.
      HO = HI + C1/3.
      GO TO 5
    2 C2P = ST*A*GS
      IF (ABS((C2P-C1P)/C2P).GT.0.25)   C1P = C2P      *
      C2 = ST*V
      IF (ABS((C2 -C1 )/C2 ).GT.0.25)   C1  = C2       *
      TO = TI + 2.*DT
      VO = VI - C1P/3. +C2P
      HO = HI - C1/3. + C2
      GO TO 5
    3 C3P = ST*A*GS
      C3 = ST*V
      TO = TI + ST
      VO = VI + C1P-C2P+C3P
      HO = HI + C1-C2+C3
    5 TC = TO - 0.6
      RETURN
    4 C4P = ST*A*GS
```

1

This integration subroutine could stand a more consolidated re-write or substitution by an established FORTRAN subroutine. It is patterned after the information of reference 1 & represents an effort to stay clear of black box FORTRAN subroutines which are not readily understood, correct though they may be.

*When an acceleration regime change occurs, the first stage Runge Kutta value assumes the value of the second. This change is considered to have occured when the acceleration difference ratio is greater than 25%.

```
      C4 = ST*V
      VO = VI+ (0.125)*(C1P+3.*(C2P+C3P)+C4P)
      HO = HI + 0.125*(C1+3.*(C2+C3)+C4)
      TO = TI + ST
      GO TO 5
      END

$IBFTC TERPO
      SUBROUTINE TERPO (R1,R,R2,S1,S,S2,P)
C INTERPOLATION FOR DESIRED DESIGN VALUES
      IF (R2.GT.R1) GO TO 1
      IF (R-R1)  11,12,13
   11 IF (R-R2) 15,16,17
   15 IF (S2.GT.S1)   GO TO 19
      S = S1- ((R1-R)/(R1-R2))*(S1-S2)
      P = 15.
      RETURN
   16 S = S2
      P = 16.
      RETURN
   17 IF (S2.GT.S1) GO TO 14
      GO TO 20
   12 S = S1
      P = 12.
      RETURN
   13 IF (S2.GT.S1)  GO TO 14
   20 S = S2 + ((R-R2)/(R1-R2))*(S1-S2)
      P = 20.
      RETURN
    1 IF  (R-R2) 2,3,4
    2 IF (R-R1) 6,7,8
    6 IF (S2.GT.S1)  GO TO 10
      S = S1- ((R2-R)/(R2-R1))*(S1-S2)
      P =  6.
      RETURN
    7 S = S1
      P =  7.
      RETURN
    8 IF (S2.GT.S1)  GO TO 5
      GO TO 9
    3 S = S2
      P =  3.
      RETURN
    4 IF (S2.GT.S1)  GO TO 5
    9 S = S2 + ((R-R1)/(R2-R1))*(S1-S2)
      P =  9.
      RETURN
    5 S = S1 + ((R-R1)/(R2-R1))*(S2-S1)
      P =  5.
      RETURN
   10 S = S2-((R2-R)/(R2-R1))*(S2-S1)
      P = 10.
      RETURN
   14 S = S1 + ((R-R2)/(R1-R2))*(S2-S1)
      P = 14.
      RETURN
   19 S = S2-((R1-R)/(R1-R2))*(S2-S1)
      P = 19.
      RETURN
      END
$DATA
 78 54 28 48  36 54 7 77
 2.0902900E+07 140.57849E+14
  47300.   263000.     1636.5      36.96      2.64
   0.6  7390.9 7223.6 51057.  2.60   0.80  627.7  231.5  43710. 8010.
```

New vehicle velocity
New vehicle altitude
New trajectory time

Linear interpolation for flight parameter adjustments
The P value indicates the particular interpolation equation which was employed. This was done to re-check the chosen equation.

The TERPO subroutine might possibly replace the TERPU and TERPD subroutines but this would require a look-see.

Read card correspondence - See Column C (card number)
31
33
35
37

```
 4.3   60.9    1.064  1.541  1.6800 1.26  17.002   33.348   1.810 4.741                    39
0.21162E 04 0.19667E 04 0.18277E 04 0.16960E 04 0.15721E 04 0.14556E 04         12         41 - Table of atmospheric pressure
0.13462E 04 0.12436E 04 0.11475E 04 0.10575E 04 0.97327E 03 0.89459E 03   850  (p.B-1)
0.82116E 03 0.75271E 03 0.68896E 03 0.62966E 03 0.57458E 03 0.52347E 03
0.47612E 03 0.43263E 03 0.39312E 03 0.35723E 03 0.32462E 03 0.29499E 03
0.26807E 03 0.24361E 03 0.19180E 03 0.15103E 03 0.11893E 03 0.93672E 02
0.73784E 02 0.58125E 02 0.45827E 02 0.36292E 02 0.28878E 02 0.23085E 02
0.14947E 02 0.98372E 01 0.65735E 01 0.44552E 01 0.30597E 01 0.21247E 01   855
0.14784E 01 0.10272E 01 0.47151E 00 0.19835E 00 0.74774E-01 0.24460E-01
0.23030E-01 0.21670E-01 0.20380E-01 0.13270E-01 0.71940E-02 0.39020E-02
0.21180E-02 0.11770E-02 0.67920E-03 0.40550E-03 0.24940E-03 0.15760E-03
0.10570E-03 0.76560E-04 0.58370E-04 0.46200E-04 0.37620E-04 0.31320E-04
0.26550E-04 0.22840E-04 0.19890E-04 0.17510E-04 0.15550E-04 0.13910E-04   860
0.12540E-04 0.11370E-04 0.10560E-04 0.10560E-04 0.10560E-04 0.10560E-04
0.11164E 04 0.11087E 04 0.11010E 04 0.10932E 04 0.10853E 04 0.10774E 04         12         42 - Table of velocity of sound
0.10694E 04 0.10614E 04 0.10533E 04 0.10451E 04 0.10369E 04 0.10286E 04        (p.B-1)
0.10203E 04 0.10119E 04 0.10034E 04 0.99485E 03 0.98622E 03 0.97752E 03
0.96875E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03   865
0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03
0.96808E 03 0.96808E 03 0.97344E 03 0.98346E 03 0.99338E 03 0.10032E 04
0.10225E 04 0.10415E 04 0.10601E 04 0.10783E 04 0.10963E 04 0.11057E 04
0.11057E 04 0.10934E 04 0.10387E 04 0.98116E 03 0.92011E 03 0.85480E 03
0.85140E 03 0.84800E 03 0.84650E 03 0.84650E 03 0.84650E 03 0.84650E 03   870
0.0  E 00 0.2  E 04 0.4  E 04 0.6  E 04 0.8  E 04 0.1  E 05 0.12 E 05            12         44 - Table of altitude
0.14 E 05 0.16 E 05 0.18 E 05 0.20 E 05 0.22 E 05 0.24 E 05 0.26 E 05
0.28 E 05 0.30 E 05 0.32 E 05 0.34 E 05 0.36 E 05 0.38 E 05 0.40 E 05           (p.B-1)
0.42 E 05 0.44 E 05 0.46 E 05 0.48 E 05 0.50 E 05 0.55 E 05 0.60 E 05
0.65 E 05 0.70 E 05 0.75 E 05 0.80 E 05 0.85 E 05 0.90 E 05 0.95 E 05      875
0.10 E 06 0.11 E 06 0.12 E 06 0.13 E 06 0.14 E 06 0.15 E 06 0.16 E 06
0.17 E 06 0.18 E 06 0.20 E 06 0.22 E 06 0.24 E 06 0.26 E 06 0.261E 06
0.262E 06 0.263E 06 0.27 E 06 0.28 E 06 0.29 E 06 0.30 E 06 0.31 E 06
0.32 E 06 0.33 E 06 0.34 E 06 0.35 E 06 0.36 E 06 0.37 E 06 0.38 E 06
0.39 E 06 0.40 E 06 0.41 E 06 0.42 E 06 0.43 E 06 0.44 E 06 0.45 E 06      880
0.46 E 06 0.47 E 06 0.48 E 06 0.49 E 06 0.50 E 06 0.999E 06 0.999E 08
0.70 0.80 0.91 1.01 1.11 1.21 1.51 2.00 3.00 3.50 4.00 5.0   7.00 9.00            12         46 - Table of Mach numbers
11.0                                                                            (p.B-2)
.95  .98  .08  .15  .15  .14  .03  .865 .595 .503 .44  .366 .242 .133            12         48 - Table of drag coefficients
.03                                                                       885  (p.B-2)
35.   34.   33.   32.   31.   30.   29.   28.   27.   26.   25.   24.              12         50 - Table of oxidizer tank volumes
23.   22.   21.   20.   19.   18.   17.   16.   15.   14.   13.   12.             (p.B-3)
11.   10.   9.    8.    7.    6.    5.    4.    3.    2.    1.65  1.25
  .85   .45   .05   .025
180.82176.23171.65167.06162.48150.89149.31148.72144.13139.54130.95130.36   890   12         52 - Table of oxidizer tank heights
125.77121.18116.59110.00107.41102.92 98.33 93.75 80.15 80.00 79.97 75.38        (p.B-3)
 70.79 60.20 59.51 57.02 52.44 47.85 40.26 38.68 34.10 29.51 27.91 20.01
 19.01 18.71 16.91  8.46
20.   19.   18.   17.   16.   15.   14.   13.   12.   11.   10.   9.                12         53 - Table of fuel tank volumes
8.    7.    6.    5.    4.    3.    2.59  2.19  1.79  1.39  .99   .5          895  (p.B-4)
                                                                                           Blank card is needed
258.97254.38249.8 244.76240.63236.04231.46226.87222.29217.70213.12208.52            12         54 - Table of fuel tank heights
203.95199.36194.78190.19185.61181.02179.13177.23175.13173.03168.13  0.0          (p.B-4)
                                                                                           Blank card is needed
 0.0      2.0290  3.0650  4.0640  5.0620  6.0610  7.0590  8.0580  9.0560   900              56 - Table of time related to helium regulator pressure
 10.0540 11.0530 12.0510 13.0500 14.0480 15.0460 16.0450 17.0430 18.0420
 19.0400 20.0380 21.0370 22.0350 23.0340 24.0320 25.0300 26.0290 27.0270
 28.0260 29.0240 30.0220 31.0210 32.0190 33.0180 34.0160 35.0140 36.0130
 37.0110 38.0100 39.0080 40.0070 41.0050 42.0030 43.0020 44.0000 45.0750
 46.0740 47.0720 48.0710 49.0690 50.0030 51.0020 52.0000 52.5120 53.0110   905
 461.17   461.17   465.57   467.07   467.87   468.47   469.67   472.07   472.87                58 - Table of helium regulator pressure
 473.37   475.27   475.77   476.27   477.57   478.97   480.67   481.27   483.17
 483.67   485.27   487.07   488.46   488.86   490.26   491.36   492.96   492.26
 488.16   485.47   478.67   470.57   463.02   455.32   448.82   444.69   441.76
 488.86   487.67   486.47   484.87   483.67   483.77   486.27   487.47   488.36   910
 492.06   492.86   492.86   492.26   491.26   491.36   492.06   491.16   489.36
   0.0       1.504     1.645     1.811     2.029     3.065     4.064                         60 - Table of time related to transient sustainer chamber pressure
   0.0      68.535   290.466   297.122   301.264   296.048   296.398        913              61 - Table of transient sustainer chamber pressure
```

Appendix B2

PUTT CARD DISCUSSIONS

Card 1 Discussion

The listing format provisions permit the future incorporation of critiques into follow-on versions of this documentation report.

Card 4 Discussion

The program documentation effort consisted in first setting up the decoding sheet from the alphabetical ordering of the Symbol Reference Data. Thereafter emphasis was shifted to the listing to complete the detailed information input into the decoding sheet. All information indicated by the decoding sheet was not inserted for this would have prolonged the documentation effort. However, since the decoding sheet is also a worksheet, appropriate information of interest to the reader may be inserted in the appropriate place by him.

The ordering in the Symbol Reference Data is not strictly alphabetical. P appears for instance between PPTY and PV and not above PAX. The subroutine should also be altered so that PC1 would follow PCX or after PCZ if such did exist. The R numbers also do not appear in numerical order so that R1 occurs between R19 and R20.

There is a need for a subroutine to aid somewhat in the automatic documentation of computer programs. The subroutine would start with the alphabetically listed parameters in the Symbol Reference Data and set up a FORTRAN decoding form to be employed by the programmer to personally input that information he has acquired in the course of the computer program development.

A subroutine is also required to sequentially number the cards in the source deck for later reference by the adequately documented report in discussing the more interesting cards.

In preparing the PUTT Fortran Decoding and Worksheet, the IBFTC PROPE card requested REF, the Symbol Reference Data. This data arranges the PUTT parameters in alphabetical order which is then helpful in readily preparing the decoding sheet.

REFERENCES

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13. Aerobee 350, Propulsion Final Acceptance Test Results, R. Fleming and J. Ryan, July 1964, Report No. 265 FR-13, Space-General Corp. Contract No. NAS5-2252.

14. Aerobee 350 Flight Performance and Propulsion Analysis — C. P. Chalfant and R. M. Kramer, February 1963, Final Report 265 FR-1, Vol 1, Figure 2, after page A-8.

APPENDIX C

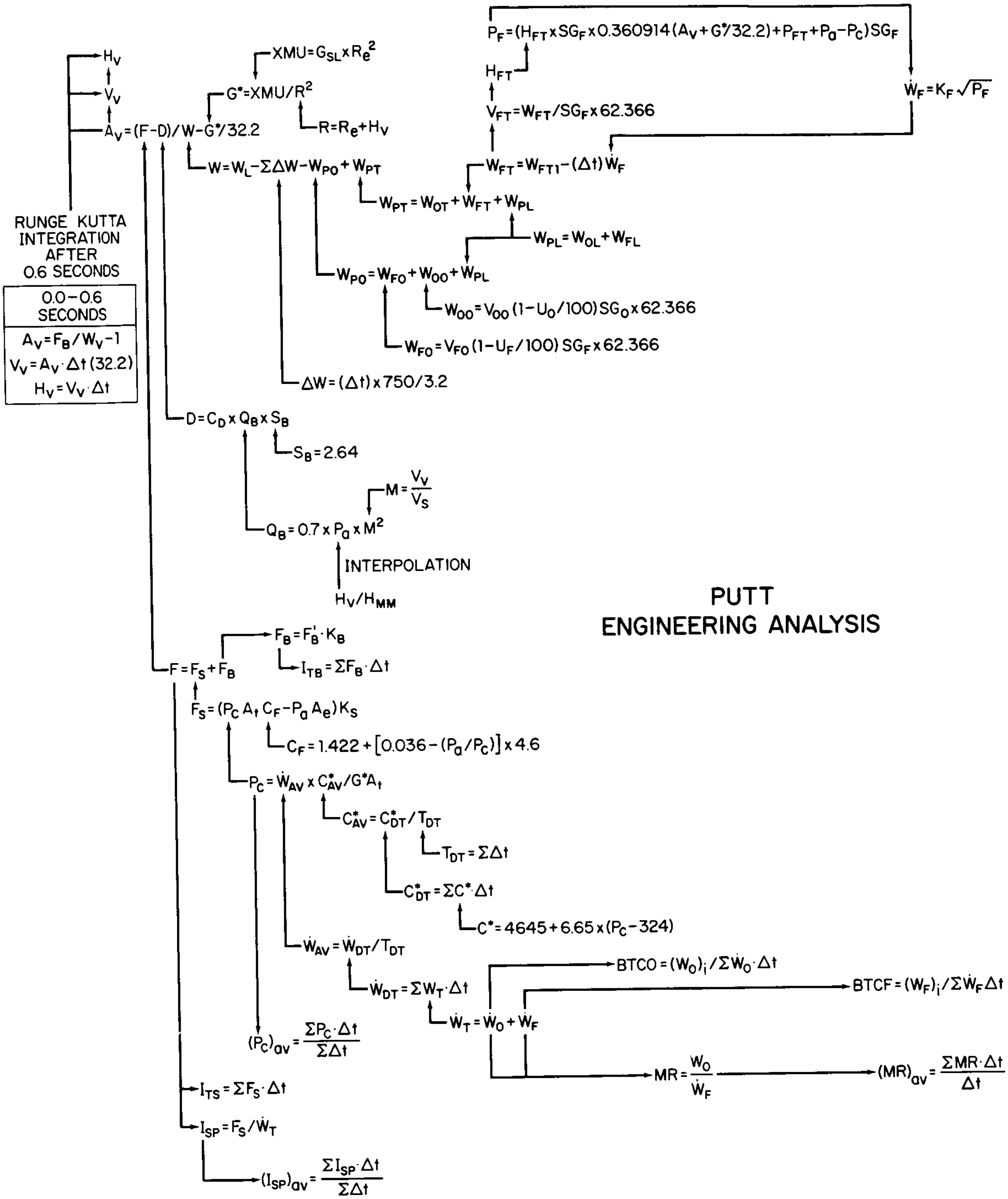
ENGINEERING ANALYSIS

The engineering analysis outlines the basic nature of the computations. It shows the necessary input information at a glance together with the calculation flow to provide the desired output.

In the case of the PUTT program, the computation input is into the f = ma equation so that this acceleration equation may be integrated twice employing the Range Kutta technique.

The parameters themselves are defined in another documentation feature, the decoding work sheet.

For purposes of developing composite computer programs, the underlying engineering analyses of comparable computer programs must be known to expedite the effort. Why develop composite computer programs? One must realize that computer programs are developed after much preliminary thought and effort. A particular computer program represents the very best thinking of those people who have decided that the computer program development would be worthwhile. By consolidating the efforts of such people, one is, as it were, paraphasing the words of Newton, "standing on the shoulders of many giants" in a particular technical area.



PUTT
ENGINEERING ANALYSIS

APPENDIX D

DECODING WORKSHEET

The FORTRAN decoding worksheet provides for the following:

- Input parameters
- Internal parameters
- Output parameters
- Notation for the engineering analysis documentation feature
- Parameter definition
- Applicable card numbers as assigned in the listing documentation feature
- Reference and comment column to refer to appropriate comments or discussions in the discussion appendix.

Numbers in parenthesis in the Reference/Comment column would be references, although none is shown on page D-2.

This documentation feature is regarded as a worksheet since it provides the framework of reference for appropriate follow-on annotations and insertions by those working with the program during its development and by those studying the computer program documentation to learn the ramifications of the program.

PUTT FORTRAN DECODING WORKSHEET

PUTT Fortran Decoding Worksheet

Fortran Code			Notation	Definition	Applicable Card No.*	Reference/ Comment	Typical Value	Dimension	Card No.	Col. Nos.
In	Neither	Out								
		A		Acceleration acting on propellants during flight				g's		
AKFX		AKFX	K_F	Propellant constant for fuel to compute fuel flow rate	316		1.60			
	AKFX1									
	AKFX2									
AKO		AKO	K_o	Oxidizer propellant flow constant			3.83			
	AKO1									
	AKO2									
AKP				Propellant constant for oxidizer to compute oxidizer flow rate						
ANE			A_e	Sustainer exit nozzle arch			1.188	feet		
AR						Obsolete ?				
	ARX					Obsolete ?				
AT			A_t	Total throat area			36.96	in^2		
		AV	A_v	Acceleration of vehicle				g's		
		AVM		Maximum vehicular acceleration at time of sustainer burnout						
	AV2									
	AV11			Vehicle acceleration at 1/3 time increment (DT)	233					
	AV12			Vehicle acceleration increment at 2/3 time increment						
	AV13			Vehicle acceleration increment at end of time increment						
	AX			Computed vehicle acceleration increment						
		AY								
BWG				Weight of Nike booster			1265.7	lb		
	BDT			1/3 time increment to compute Nike propellant weight consumed	135					
		BT				Obsolete ?				
		BTCF	BTCF	Index of fuel consumption	385					
	BTCF1									
	BTCF2									
		BTCO	BTCO	Index of oxidizer consumption	387					

*See C column (Card Number) of program listing

APPENDIX E

DECISION CIRCLE FLOW

The decision circle flow pattern reveals the decision-making nature of the program.

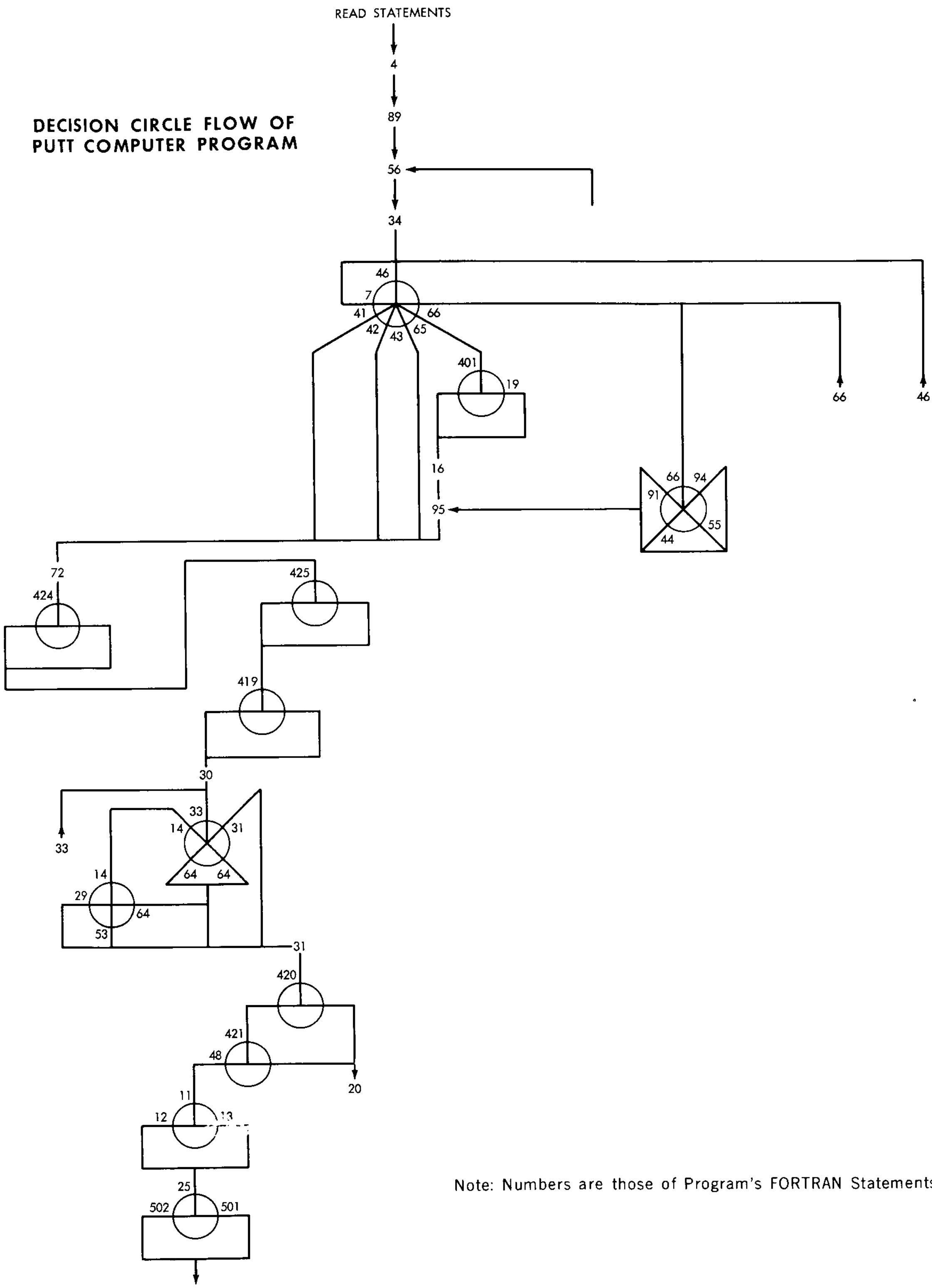
As an example, statement number 46 provides the "46" decision circle whereby the circle radius pivots about to statements 7, 41, 42, 43, 65, 66 depending upon the value of the appropriate (MPV) pivot control number at the time before decision.

It may be said of this pattern that it reflects the skeletal logic of the computer program. Traditional computer program flow charts "flesh out" this skeleton. Both serve a purpose from the points of view of simplicity and comprehensiveness. One gives a fast bird's eyeview without the appended details which otherwise may hamper debugging efforts. With the decision circle approach, logic decisions stand out to facilitate these efforts.

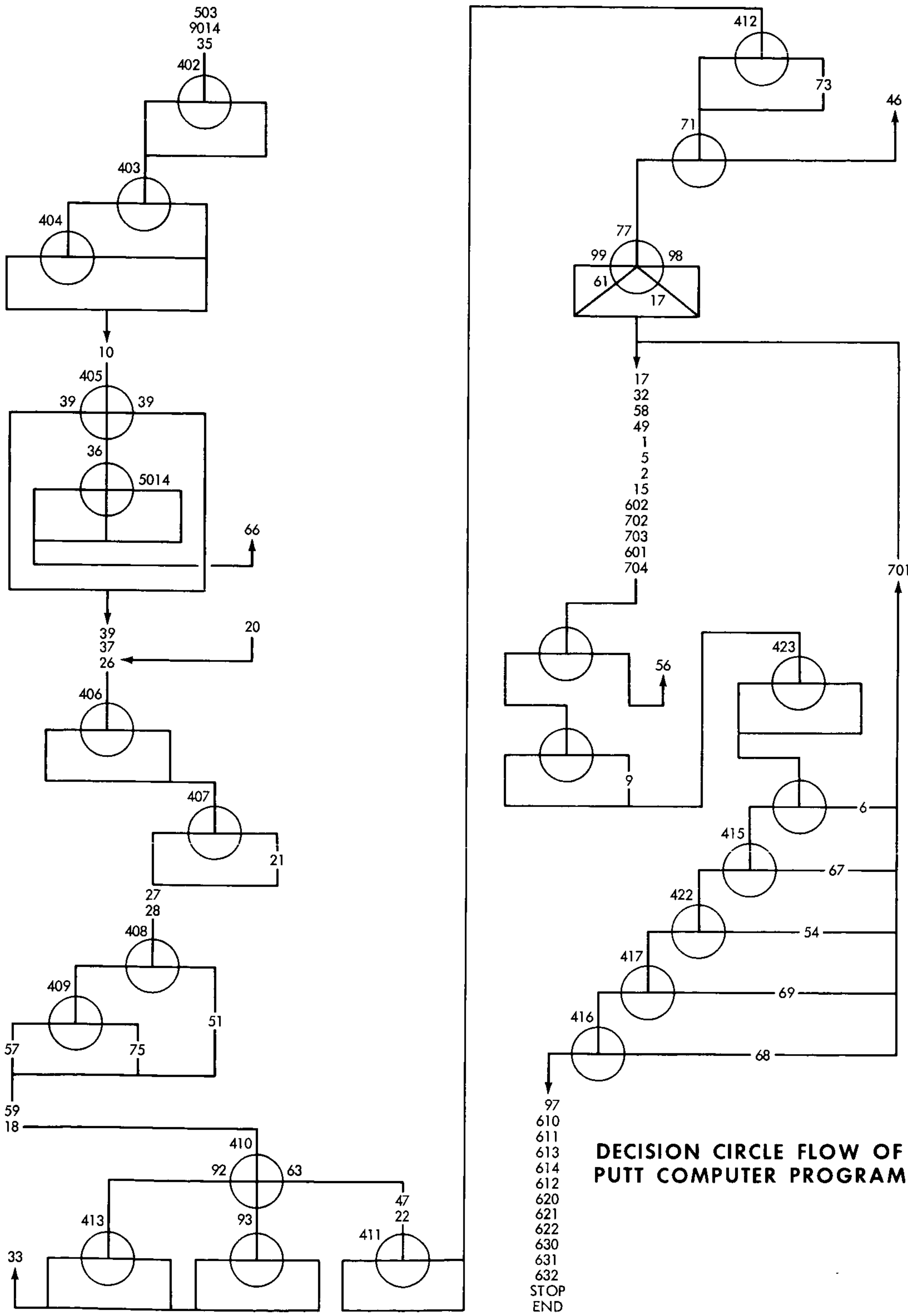
The traditional flow charts present a more complete picture which is desirable in the final computer program documentation report.

The one emphasizes the pivoting decisions and the other encompasses these decisions with details of additional information.

DECISION CIRCLE FLOW OF PUTT COMPUTER PROGRAM



Note: Numbers are those of Program's FORTRAN Statements



DECISION CIRCLE FLOW OF PUTT COMPUTER PROGRAM

Note: Numbers are those of Program's FORTRAN Statements

APPENDIX F

DATA READ-INPUT CORRESPONDENCE

The data read-input correspondence proves of value in setting up for a run. Here the data are inserted, sandwich-like, between the read and format statements.

For example, the READ (5, 88) card on the following page readily shows the correspondence of JAL to 78, JVS to 54, etc. The 88 statement shows its present form and the manner in which it would have to be changed if additional values were to be read in.

The columns below, 1 to 0, enable one to readily place new data in proper columns.

Without the above correspondence, one would have to cope with the problem of locating the data as they appear in the program listing (Appendix B) to modify the read-input in one way or another. This would make the task more formidable, time consuming, and less palatable.

DATA READ-INPUT CORRESPONDENCE

```
$DATA

     READ             (5,88)JAL,JVS,JMC,JVO,JVFX,KH,KP,JAM
 78 54 28 48  36 54 7 77
   88 FORMAT(4I3,I4,I3,I2,I3)

     READ             (5,45)RO,XMU
 2.0902900E+07 140.57849E+14
   45 FORMAT (E14.7,E14.5)

     READ             (5,74)FY(2),HMM,WIC,AT,SBIG
  47300.   263000.     1636.5      36.96       2.64
   74 FORMAT (5F10.2)

     READ             (5,80)TM2,WG1,WG2,FB2,DT01,DT02,WB3,WS3,FB3,FIBFX
   0.6  6809.4 6642.1 51057.  2.6    0.8    627.7  231.5  47300. 8010.
   80 FORMAT(F7.2,2F7.1,F7.0,2F7.3,2F7.2,F7.0,F7.1)

     READ             (5,81)WOL,WFL,SPGFX,SPGO,UFX,UO,VFTO,VOTO,AKFX,AKO
  4.3    60.9   1.064  1.541  6.9286 6.66  17.002  33.348  1.65  4.1
   81 FORMAT(2F7.3,4F7.4,3F7.3,F7.4)

     READ             (5,83)(TPA(L),L=1,JAL)
 0.21162E 04 0.19667E 04 0.18277E 04 0.16960E 04 0.15721E 04 0.14556E 04
 0.13462E 04 0.12436E 04 0.11475E 04 0.10575E 04 0.97327E 03 0.89459E 03
 0.82116E 03 0.75271E 03 0.68896E 03 0.62966E 03 0.57458E 03 0.52347E 03
 0.47612E 03 0.43263E 03 0.39312E 03 0.35723E 03 0.32462E 03 0.29499E 03
 0.26807E 03 0.24361E 03 0.19180E 03 0.15103E 03 0.11893E 03 0.93672E 02
 0.73784E 02 0.58125E 02 0.45827E 02 0.36292E 02 0.28878E 02 0.23085E 02
 0.14947E 02 0.98372E 01 0.65735E 01 0.44552E 01 0.30597E 01 0.21247E 01
 0.14784E 01 0.10272E 01 0.47151E 00 0.19835E 00 0.74774E-01 0.24460E-01
 0.23030E-01 0.21670E-01 0.20380E-01 0.13270E-01 0.71940E-02 0.39020E-02
 0.21160E-02 0.11770E-02 0.67920E-03 0.40550E-03 0.24940E-03 0.15760E-03
 0.10570E-03 0.76560E-04 0.58370E-04 0.46200E-04 0.37620E-04 0.31320E-04
 0.26550E-04 0.22840E-04 0.19890E-04 0.17510E-04 0.15550E-04 0.13910E-04
 0.12540E-04 0.11370E-04 0.10560E-04 0.10560E-04 0.10560E-04 0.10560E-04
   83 FORMAT(6E12.5)

     READ             (5,83)(VS(N),N=1,JVS)
 0.11164E 04 0.11087E 04 0.11010E 04 0.10932E 04 0.10853E 04 0.10774E 04
 0.10694E 04 0.10614E 04 0.10533E 04 0.10451E 04 0.10369E 04 0.10286E 04
 0.10203E 04 0.10119E 04 0.10034E 04 0.99485E 03 0.98622E 03 0.97752E 03
 0.96875E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03
 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03 0.96808E 03
 0.96808E 03 0.96808E 03 0.97344E 03 0.98346E 03 0.99338E 03 0.10032E 04
 0.10225E 04 0.10415E 04 0.10601E 04 0.10783E 04 0.10963E 04 0.11057E 04
 0.11057E 04 0.10934E 04 0.10387E 04 0.98116E 03 0.92011E 03 0.85480E 03
 0.85140E 03 0.84800E 03 0.84650E 03 0.84650E 03 0.84650E 03 0.84650E 03
   83 FORMAT(6E12.5)

1234567890
          1-1234567890
                      2-1234567890
                                  3-1234567890
                                              4-1234567890
                                                          5-1234567890
                                                                      6-1234567890
```

DATA READ-INPUT CORRESPONDENCE

```
     READ              (5,82)(TH(L),L=1,JAM)
 0.0  E 00 0.2  E 04 0.4  E 04 0.6  E 04 0.8  E 04 0.1  E 05 0.12 E 05
 0.14 E 05 0.16 E 05 0.18 E 05 0.20 E 05 0.22 E 05 0.24 E 05 0.26 E 05
 0.28 E 05 0.30 E 05 0.32 E 05 0.34 E 05 0.36 E 05 0.38 E 05 0.40 E 05
 0.42 E 05 0.44 E 05 0.46 E 05 0.48 E 05 0.50 E 05 0.55 E 05 0.60 E 05
 0.65 E 05 0.70 E 05 0.75 E 05 0.80 E 05 0.85 E 05 0.90 E 05 0.95 E 05
 0.10 E 06 0.11 E 06 0.12 E 06 0.13 E 06 0.14 E 06 0.15 E 06 0.16 E 06
 0.17 E 06 0.18 E 06 0.20 E 06 0.22 E 06 0.24 E 06 0.26 E 06 0.261E 06
 0.262E 06 0.263E 06 0.27 E 06 0.28 E 06 0.29 E 06 0.30 E 06 0.31 E 06
 0.32 E 06 0.33 E 06 0.34 E 06 0.35 E 06 0.36 E 06 0.37 E 06 0.38 E 06
 0.39 E 06 0.40 E 06 0.41 E 06 0.42 E 06 0.43 E 06 0.44 E 06 0.45 E 06
 0.46 E 06 0.47 E 06 0.48 E 06 0.49 E 06 0.50 E 06 0.999E 06 0.999E 08
   82 FORMAT(7E10.3)

     READ              (5,84)(XMCH(M),M=1,JMC)
 0.70 0.80 0.91 1.01 1.11 1.21 1.51 2.00 3.00 3.50 4.00 5.0  7.00 9.00
11.0
   84 FORMAT(14F5.2)

     READ              (5,85)(CD(M),M=1,JMC)
 .95  .98  .08  .15  .15  .14  .03  .865 .595 .503 .44  .366 .242 .133
 .03
   85 FORMAT(14F5.3)

     READ              (5,86)(TVO(N),N=1,JVO)
35.   34.   33.   32.   31.   30.   29.   28.   27.   26.   25.   24.
23.   22.   21.   20.   19.   18.   17.   16.   15.   14.   13.   12.
11.   10.    9.    8.    7.    6.    5.    4.    3.    2.   1.65  1.25
  .85   .45   .05  .025
   86 FORMAT(12F6.3)

     READ              (5,87)(THO(N),N=1,JVO)
180.82176.23171.65167.06162.48150.89149.31148.72144.13139.54130.95130.36
125.77121.18116.59110.00107.41102.92 98.33 93.75 80.15 80.00 79.97 75.38
 70.79 60.20 59.51 57.02 52.44 47.85 40.26 38.68 34.10 29.51 27.91 20.01
 19.01 18.71 16.91  8.46
   87 FORMAT(12F6.2)

     READ              (5,87)(TVFX(N),N=1,JVFX)
20.   19.   18.   17.   16.   15.   14.   13.   12.   11.   10.    9.
 8.    7.    6.    5.    4.    3.    2.59  2.19  1.79  1.39   .99   .5

   87 FORMAT(12F6.2)

1234567890
          1-1234567890
                    2-1234567890
                              3-1234567890
                                        4-1234567890
                                                  5-1234567890
                                                            6-1234567890
```

```
      READ            (5,87)(THFX(N),N=1,JVFX)
258.97254.38249.8 244.76240.63236.04231.46226.87222.29217.70213.12208.52
203.95199.36194.78190.19185.61181.02179.13177.23175.13173.03168.13  0.0
   87 FORMAT(12F6.2)

      READ            (5,23)(RT(LH),LH=1,KH)
  0.0     2.0290  3.0650  4.0640  5.0620  6.0610  7.0590  8.0580  9.0560
 10.0540 11.0530 12.0510 13.0500 14.0480 15.0460 16.0450 17.0430 18.0420
 19.0400 20.0380 21.0370 22.0350 23.0340 24.0320 25.0300 26.0290 27.0270
 28.0260 29.0240 30.0220 31.0210 32.0190 33.0180 34.0160 35.0140 36.0130
 37.0110 38.0100 39.0080 40.0070 41.0050 42.0030 43.0020 44.0000 45.0750
 46.0740 47.0720 48.0710 49.0690 50.0030 51.0020 52.0000 52.5120 53.0110
   23 FORMAT(9F8.4)

      READ            (5,24)(PHRG(LH),LH=1,KH)
  461.17  461.17  465.57  467.07  467.87  468.47  469.67  472.07  472.87
  473.37  475.27  475.77  476.27  477.57  478.97  480.67  481.27  483.17
  483.67  485.27  487.07  488.46  488.86  490.26  491.36  492.96  492.26
  492.06  492.86  492.86  492.26  491.26  491.36  492.06  491.16  489.36
  488.86  487.67  486.47  484.87  483.67  483.77  486.27  487.47  488.36
  488.16  485.47  478.67  470.57  463.02  455.32  448.82  444.69  441.78
   24 FORMAT(9F8.2)

      READ            (5,3)(TIPC(JP),JP=1,KP)
    0.0       1.504     1.645     1.811     2.029     3.065     4.064
    3 FORMAT(7F10.4)

      READ            (5,3)(PCG(JP),JP=1,KP)
    0.0      68.535   290.466   297.122   301.264   296.048   296.398
    3 FORMAT(7F10.4)


1234567890
          1-1234567890
                    2-1234567890
                              3-1234567890
                                        4-1234567890
                                                  5-1234567890
                                                            6-1234567890
```

APPENDIX G

DATA DISPLAY FORMAT

A typical data display format is shown on page G-2 of this appendix as called for by card numbers 709, 710, 715, and 716 on the program listing (Appendix B, page B-5.)

ABBREVIATED DATA DISPLAY FORMAT

J	AY	TM	GSTAR	R	PFT	POT	WG	VSY	YMCH	CDY	CB	D
1	-0.000E-19	0.	-0.000E-19	-0.000E-19	-0.000E-19	-0.000E-19	0.739E 04	-0.000E-19	-0.000E-19	-0.000E-19	-0.000E-19	-0.000E-19
2	-0.000E-19	0.600E 00	-0.000E-19	-0.000E-19	-0.000E-19	-0.000E-19	0.725E 04	-0.000E-19	-0.000E-19	-0.000E-19	-0.000E-19	-0.000E-19
3	0.686E 01	0.610E 00	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.725E 04	0.112E 04	0.106E-00	0.950E 00	0.167E 02	0.419E 02
4	0.389E 01	0.868E 00	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.717E 04	0.112E 04	0.136E-00	0.950E 00	0.273E 02	0.685E 02
5	0.596E 01	0.113E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.707E 04	0.112E 04	0.172E-00	0.950E 00	0.436E 02	0.109E 03
6	0.634E 01	0.138E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.698E 04	0.112E 04	0.214E-00	0.950E 00	0.673E 02	0.169E 03
7	0.655E 01	0.164E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.689E 04	0.112E 04	0.266E-00	0.950E 00	0.104E 03	0.260E 03
8	0.670E 01	0.190E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.681E 04	0.112E 04	0.316E-00	0.950E 00	0.146E 03	0.367E 03
9	0.682E 01	0.216E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.672E 04	0.111E 04	0.367E-00	0.950E 00	0.196E 03	0.493E 03
10	0.693E 01	0.242E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.664E 04	0.111E 04	0.419E-00	0.950E 00	0.254E 03	0.638E 03
11	0.702E 01	0.267E 01	0.322E 02	0.209E 08	0.438E 03	0.428E 03	0.655E 04	0.111E 04	0.471E-00	0.950E 00	0.320E 03	0.803E 03
12	0.712E 01	0.293E 01	0.322E 02	0.209E 08	0.439E 03	0.429E 03	0.647E 04	0.111E 04	0.524E 00	0.950E 00	0.394E 03	0.989E 03
13	0.721E 01	0.319E 01	0.322E 02	0.209E 08	0.440E 03	0.430E 03	0.639E 04	0.111E 04	0.577E 00	0.950E 00	0.476E 03	0.119E 04
14	0.822E 01	0.320E 01	0.322E 02	0.209E 08	0.440E 03	0.430E 03	0.568E 04	0.111E 04	0.580E 00	0.950E 00	0.481E 03	0.121E 04
15	0.192E 01	0.321E 01	0.322E 02	0.209E 08	0.440E 03	0.430E 03	0.568E 04	0.111E 04	0.581E 00	0.950E 00	0.482E 03	0.121E 04
16	0.183E 01	0.371E 01	0.322E 02	0.209E 08	0.442E 03	0.432E 03	0.564E 04	0.111E 04	0.609E 00	0.950E 00	0.523E 03	0.131E 04
17	0.179E 01	0.421E 01	0.322E 02	0.209E 08	0.443E 03	0.433E 03	0.561E 04	0.111E 04	0.636E 00	0.950E 00	0.564E 03	0.141E 04
18	0.176E 01	0.471E 01	0.322E 02	0.209E 08	0.444E 03	0.434E 03	0.557E 04	0.111E 04	0.663E 00	0.950E 00	0.604E 03	0.151E 04
19	0.175E 01	0.521E 01	0.322E 02	0.209E 08	0.444E 03	0.434E 03	0.552E 04	0.111E 04	0.689E C0	0.950E 00	0.644E 03	0.161E 04
20	0.175E 01	0.571E 01	0.322E 02	0.209E 08	0.445E 03	0.435E 03	0.548E 04	0.111E 04	0.715E 00	0.955E 00	0.684E 03	0.172E 04
21	0.174E 01	0.621E 01	0.322E 02	0.209E 08	0.445E 03	0.435E 03	0.544E 04	0.110E 04	0.742E 00	0.962E 00	0.724E 03	0.184E 04
22	0.175E 01	0.671E 01	0.322E 02	0.209E 08	0.445E 03	0.435E 03	0.540E 04	0.110E 04	0.768E 00	0.970E 00	0.765E 03	0.196E 04
23	0.175E 01	0.721E 01	0.322E 02	0.209E 08	0.446E 03	0.436E 03	0.536E 04	0.110E 04	0.795E 00	0.978E 00	0.806E 03	0.208E 04
24	0.184E 01	0.771E 01	0.322E 02	0.209E 08	0.446E 03	0.436E 03	0.531E 04	0.110E 04	0.822E 00	0.800E 00	0.849E 03	0.179E 04
25	0.196E 01	0.821E 01	0.322E C2	0.209E 08	0.448E 03	0.438E 03	0.527E 04	0.110E 04	0.850E 00	0.571E 00	0.892E 03	0.134E 04
26	0.210E 01	0.871E 01	0.322E 02	0.209E 08	0.449E 03	0.439E 03	0.523E 04	0.110E 04	0.881E 00	0.320E-00	0.941E 03	0.795E 03
27	0.225E 01	0.921E 01	0.322E 02	0.209E 08	0.449E 03	0.439E 03	0.519E 04	0.109E 04	0.914E 00	0.827E-01	0.994E 03	0.217E 03
28	0.228E 01	0.971E 01	0.322E 02	0.209E 08	0.450E 03	0.440E 03	0.514E 04	0.109E 04	0.949E 00	0.107E-00	0.105E 04	0.298E 03
29	0.231E 01	0.102E 02	0.322E 02	0.209E 08	0.450E 03	0.440E 03	0.510E 04	0.109E 04	0.985E 00	0.133E-00	0.111E 04	0.390E 03
30	0.234E 01	0.107E 02	0.322E 02	0.209E 08	0.450E 03	0.440E 03	0.506E 04	0.109E 04	0.102E 01	0.150E-00	0.117E 04	0.464E 03
31	0.238E 01	0.112E 02	0.321E 02	0.209E 08	0.451E 03	0.441E 03	0.501E 04	0.108E 04	0.106E 01	0.150E-00	0.123E 04	0.487E 03