Area Control Simulator Program
Volume 3: Program Listing

EL-1648, Volume 3
Research Project 1048-4

Final Report, December 1980
Work Completed, September 1979

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ABSTRACT

The purpose of this EPRI-sponsored study was to develop a digital computer simulation program for a single-area power system, and to hold a Workshop at which this simulation package would be presented. This and the companion volumes present our philosophy of modeling a power system and demonstrate the simulation capabilities of the Area Control Simulator. The results of this research study have been the development of the Area Control Simulator, the Area Control Simulator Workshop held May 1-3, 1979 and the creation of the Technical Manual (Volume 1), the Programming Manual (Volume 2), and the Program Listing (Volume 3).

The above-mentioned three volumes in addition to a fourth volume covering a multi-area model development serve as a final report for this project.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

Over the past 50 years, all electric utilities have increased their interconnections with each other. In fact, there are currently just three groups of interconnected networks of utilities for all the power generated in the United States and Canada. Historically, area control of generation was accomplished manually. Then, analog computer generation control was developed to reduce manual control requirements. More recently, direct digital computer control systems have been installed, which provide the potential for improved control.

The growth of the interconnected networks has placed increasing demands on our ability to analyze and control each generator's performance. This has stimulated a need to mathematically simulate the control system in the interconnected networks both to evaluate current control strategies and to develop improved strategies.

PROJECT OBJECTIVES

This project under RP1048-1 had two objectives:

1. To develop a digital computer, two-area control simulator program for use by EPRI member utilities to evaluate and improve their current control strategies. This program was also being developed for use in a companion project, RP1048-1, where interconnected control performance was being analyzed by Control Data Corporation (CDC).

2. To develop a multiarea control simulator program for use by CDC on RP1048-1.

PROJECT RESULTS

The simulator programs that were developed during this project were based on a digital computer program developed by Philadelphia Electric Company (PECO) to analyze control strategies in the Pennsylvania-Maryland-New Jersey (PJM) Power Pool. The simulator program developed for EPRI can be used to analyze control actions of generators in one control area (usually a single utility) that is part of a larger interconnected network. The simulator has two features not available in other simulators currently in use:

1. It includes mathematical models and representative data for most types of generators commonly used in the United States and Canada (fossil, hydro, gas turbine, and boiling water nuclear reactor).

2. It is based on generation models that were already developed and extensively field-tested by PECO and PJM prior to the EPRI contract.

The area control simulators developed in this project were successfully used by CDC while performing the research on RP1048-1. Two versions of the area control simulator were supplied to CDC. The first used two control areas: one for the control area to be analyzed and one for the remaining interconnected utilities. The second allowed up to 10 control areas to be analyzed simultaneously. The CDC research showed that the first version was preferable for analyzing control strategies. A copy of this first version of the simulator is available from the Electric Power Software Center.

The computer program developed for this project might be classified as an engineering-grade program. This means it has been tested thoroughly as to the integrity of the programming and the accuracy of the results. However, several limitations in the use of the simulator should be pointed out:

1. The data input requires a user with good knowledge of the models.
2. The input is not user-oriented for entering large amounts of data.
3. Many of the models and their data are imbedded in the computer program and limit the flexibility of the simulator usage.

If EPRI finds there is sufficient demand by users of the area control simulator program, a production-grade version of the simulator could be developed which overcomes the above limitations. In the production-grade development, the simulator data requirements would be coordinated with the data requirements of the long-term dynamics program being developed in RP1469.

Charles J. Frank, Project Manager
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SUMMARY

This research project has resulted in the development of two power system models that are similar. The first is a single-area power system simulation, the Area Control Simulator, the second is a multi-area power system simulation that was used in a companion research project. Both computer programs are FORTRAN stand-alone structures that offer such user-oriented features as print and plot options, load data or available space for a load model, optional external area power systems to be tied into the system under study, optional statistical variations to the load data (sine wave, random noise, frequency feedback) and functions designed to simulate dynamic behavior (limits, deadspaces, delays, etc.). One workshop has been given to date on the Area Control Simulator with the material in Volumes 1, 2 and 3 serving as User's Manuals, detailing design features. These simulation programs are available through EPRI and provide an engineering-grade tool to quantitatively and qualitatively analyze new control structures and strategies. They provide a test bed on which repeatable case studies can be analyzed and system sensitivities can be determined.

These simulators are designed to have new or existing automatic generation control algorithms as their input and basis of analysis. The algorithms included with these programs are merely intended to make the simulation whole and operable and should be replaced or restructured by the user.

This volume presents the computer listing of the Area Control Simulator. The user can refer to the Programming Manual, Volume 2, to gain an understanding of program changes and their effect on the simulator program. The Technical Manual, Volume 1, covers the dynamics that are simulated in this listing. Both of the previous volumes refer to specific sections of the simulator listing by subroutine, function or data set name. In this simulator listing, all data sets are grouped at the beginning, followed by the subroutines then functions. There are comments and instructions throughout the listing.

INTRODUCTION

The Program Listing, (Volume 3), is a self-contained digital computer program of the Area Control Simulator. It is a FORTRAN stand-alone program and the listing includes both instructions and comments to the user. The time-sharing version of this program (80 character width for CRT display) has prompting messages to help specify the most used (or changed) system variables. There is a duplicate version for batch running (132 character width for printout paper). The simulator requires, as an input, either load data from a disk file (as in this version) or a load model (to be programmed by the user and added to the listing). The output is in the form of printout and plots. The plot information requires a second disk file (temporary data set) to store the plot information between computation and plot printout.

The listing has been arranged to include the data sets at the beginning of the program, followed by the subroutines then the functions. The data sets include input and output data in addition to the system variable storage areas. There is a cross-reference in the first page of the listing that shows where each data set or common area is used throughout the program. The block data sets are then sequenced, explained, and listed. All of the parameters are dimensioned in these explanations, some of the unitless variables are left undimensioned. The subroutines are developed in the Technical Manual, Volume 1, and the Programming Manual, Volume 2, of this report. There are further descriptions given throughout the subroutine and function listings. The subsections of each subroutine are separated and titled for easier reference.

```
BLKDATA
C                                                                       COMM0010
C                                                                       COMM0020
C ***************************************************************     COMM0030
C **                                                           **        COMM0040
C **   TITLE:  EPRI POWER SYSTEM MODEL-FORTRAN STAND ALONE PROGRAM **    COMM0050
C **                                                           **        COMM0060
C **                      SINGLE AREA MODEL                    **        COMM0070
C **                                                           **        COMM0080
C ***************************************************************     COMM0090
C                                                                       COMM0100
C                                                                       COMM0110
C   ---------------------------------------------------------------     COMM0120
C   .                 COMMON AREA REFERENCE MATRIX                .     COMM0130
C   .-------------------------------------------------------------.     COMM0140
C   .    SUB-     '    I  L  E     B     G  N     O        I  P    .     COMM0150
C   .  ROUTINE    '    N  O  X     O  H  A  U  P  U  D  A  N  A    .     COMM0160
C   .     ----->' M  E  A  T     I  Y  S  C  R  T  E  F  T  G  P  S .     COMM0170
C   .-----------' A  R  D  R  L  L  D  T  L  I  P  L  G  G  E  L  I .     COMM0180
C   .    COMMON ' I  T  E  N  D  E  R  U  E  N  U  A  E  R  H  O  N .     COMM0190
C   .     AREA  ' N  A  R  L  O  R  O  B  R  T  T  Y  N  L  D  T  E .     COMM0200
C   .-------------------------------------------------------------.     COMM0210
C   . 8  ATTOM  .                          X                    .     COMM0220
C   . 5  BOILRS .                    X                          .     COMM0230
C   . 2  CONST1 .                 X                             .     COMM0240
C   . 4  COST   . X                                    X        .     COMM0250
C   . 1  CURVAL . X  X  X  X  X  X  X  X  X  X  X  X  X  X        X  .     COMM0260
C   . 11 DELLAY .                                      X        .     COMM0270
C   . 7  GAS    .                       X                       .     COMM0280
C   . 3  INITAL . X              X  X  X  X  X                  .     COMM0290
C   . 13 NALARM . X                                    X     X  .     COMM0300
C   . 12 PASSES .                    X                 X     X  .     COMM0310
C   . 10 PLOTT  .                                            X  .     COMM0320
C   . 9  PRTCNL . X                  X  X  X  X  X  X           X  .     COMM0330
C   . 6  WATT   .                       X                    .     COMM0340
C   ---------------------------------------------------------------     COMM0350
C                                                                       COMM0360
C                                                                       COMM0370
C                                                                       COMM0380
C                                                                       COMM0390
C                                                                       COMM0400
```

```
C     ------------------------------------------------------------      COMM0410
C     *     1                COMMON / CURVAL /                     *      COMM0420
C     ------------------------------------------------------------      COMM0430
C                                                                         COMM0440
C     COMMON /CURVAL/ CONTAINS INITIAL CONDITIONS AND CONSTANTS           COMM0450
C            FOR THE INERTIA, EXTERNAL AREA, DISPATCH OFFICE, AND         COMM0460
C            LOADER MODELS                                                COMM0470
C                                                                         COMM0480
C            THE FOLLOWING SUBROUTINES PASS COMMON /CURVAL/ IN ITS        COMM0490
C            ENTIRETY:     MAIN   INERTA   LOADER   EXTERNL   LOO        COMM0500
C                                                                         COMM0510
C            THE REMAINING SUBROUTINES USING COMMON /CURVAL/ GENERALLY    COMM0520
C            PASS ONLY TIME, DELT, AND KEEP                               COMM0530
C                                                                         COMM0540
      BLOCK DATA                                                          COMM0550
      COMMON / CURVAL / TIME   , DELT   , KEEP   , NUNIT , GOTIME, N      , COMM0560
     1                  FREQHZ, PM(20), OMEGA , TM    , PMSYS , PMTOT , COMM0570
     2                  PELSY , PACCEL, LOAD  , LODTOT, H     , PTINET, COMM0580
     3                  PMEXT , LODEXT, OUTE02, SPIEX , OUTIE3, OUTIE4, COMM0590
     4                  OUTIE5, OUTIE6, DEDIEX, CEXT01, CEXT02, CEXT03, COMM0600
     5                  CEXT04, CEXT05, CEXT06, CEXT07, CEXT08, CEXT09, COMM0610
     6                  CEXT10, CEXT11, ACEEXT, OUTE03, OUTE04, OUTE05, COMM0620
     7                  PDROP , DEDEXT, PGOVEX, SPEXT , CTIMR , CBIAS , COMM0630
     8                  CADD  , CKCR  , KLR   , DUM   , CLSUP , KLP   , COMM0640
     9                  CSKEDF, INADV , LAM   , SKDTI , TIMBS , FRQBS , COMM0650
     A                  ACE   , AR    , MWNEW , LNEW  , PEC(20)       , COMM0660
     B                  SP(20), PEB(20)       , UCE(20)       , UCE1  , COMM0670
     C                  PMS(20)       , FINTIM, KEXTRN, PFREQ , AMPLTD, COMM0680
     D                  WAVEON, WAVEFR, WAVEPH, PNOISE, NSEED , MU    , COMM0690
     E                  SIGMA                                            COMM0700
C                                                                         COMM0710
      REAL*4     LOAD  , LODTOT, LODEXT, KLR   , KLP   , INADV , LAM   , COMM0720
     1           MWNEW , LNEW  , MU                                       COMM0730
C                                                                         COMM0740
C              ------------------------------                             COMM0750
C                       INERTIA MODEL                                     COMM0760
C              INITIAL CONDITIONS AND CONSTANTS                           COMM0770
C              ------------------------------                             COMM0780
C                                                                         COMM0790
      DATA TIME,DELT,KEEP,NUNIT,GOTIME,N/0.,1.,0,8,39668.2,1/             COMM0800
```

```
      DATA FREQHZ,PM,PTINET,TM,PMSYS,PMTOT,PELSY /60.,25*0./                COMM0810
      DATA PACCEL,LOAD,LODTOT/3*0./                                         COMM0820
      DATA H,OMEGA/36990.,1./                                               COMM0830
      DATA FINTIM,KEXTRN /300.,1 /                                          COMM0840
C                                                                           COMM0850
C                                                                           COMM0860
C     ..................................................                    COMM0870
C     .                  NOMENCLATURE                  .                    COMM0880
C     ..................................................                    COMM0890
C                                                                           COMM0900
C     TIME       TIME FROM START OF RUN                    -- SEC         COMM0910
C     DELT       INTRGRATION INTERVAL                      -- SEC         COMM0920
C     KEEP       INTEGRATION TIME STEP COUNTER (KEEP)                     COMM0930
C     NUNIT      NUMBER OF UNITS ON SYSTEM                                COMM0940
C     GOTIME     STARTING TIME IN SECONDS FROM 12 MIDNIGHT                COMM0950
C                                                          -- SEC         COMM0960
C     N          MODEL UNIT NUMBER (SEQUENTIAL)                           COMM0970
C     FREQHZ     SYSTEM FREQUENCY                          -- HZ          COMM0980
C     PM         UNIT MECHANICAL POWER                     -- MW          COMM0990
C     PTINET     NET TIE FLOW (+ IS OUT)                   -- MW          COMM1000
C     TM         TIME READ FROM LOAD TAPE                  -- SEC         COMM1010
C     PMSYS      MECHANICAL POWER                          -- MW          COMM1020
C     PELSY      ELECTRICAL POWER                          -- MW          COMM1030
C     PACCEL     ACCELERATING POWER                        -- MW          COMM1040
C     LOAD       COMPANY LOAD                              -- MW          COMM1050
C     H          INERTIA CONSTANT FOR SYSTEM               -- MW-SEC      COMM1060
C     OMEGA      SYSTEM SPEED                              -- P.U.        COMM1070
C     FINTIM     FINISH TIME                               -- SEC         COMM1080
C     KEXTRN     SET EQUAL TO 1 TO USE EXTERNAL AREA MODEL                COMM1090
C                                                                         COMM1100
C                                                                         COMM1110
C     PM IS DIMENSIONED BY THE MAXIMUM NUMBER OF UNITS                    COMM1120
C                                                                         COMM1130
C                                                                         COMM1140
C                  ---------------------------------                      COMM1150
C                          EXTERNAL AREA                                  COMM1160
C                  INITIAL CONDITIONS AND CONSTANTS                       COMM1170
C                  ---------------------------------                      COMM1180
C                                                                         COMM1190
      DATA PMEXT,LODEXT,OUTE02/50000.,50070.,0./                          COMM1200
```

```
      DATA SPIEX,OUTIE3,OUTIE4,OUTIE5/50000.,-8000.,-59524.,-59524./     COMM1210
      DATA OUTIE6,DEDIEX,CEXT01,CEXT02/25000.,50000.,-970.,-.05/         COMM1220
      DATA CEXT03,CEXT04,CEXT05,CEXT06,CEXT07/108.,.16,360.,60.,.75/     COMM1230
      DATA CEXT08,CEXT09,CEXT10,CEXT11/.005,.5,8.,500000./               COMM1240
      DATA ACEEXT,OUTE03,OUTE04,OUTE05,PDROP,DEDEXT,PGOVEX,SPEXT/0.,     COMM1250
     1   -8000.,-59524.,-59524.,0.,50000.,50000.,50000./                 COMM1260
C                                                                        COMM1270
C                                                                        COMM1280
C     ..................................................                 COMM1290
C     .                  NOMENCLATURE                  .                 COMM1300
C     ..................................................                 COMM1310
C                                                                        COMM1320
C     PMEXT      MECHANICAL POWER FOR THE EXTERNAL AREA  -- MW           COMM1330
C     LOADEXT    EXTERNAL SYSTEM LOAD                    -- MW           COMM1340
C     OUTE02     OUTPUT OF A.G.C. TIME LAG               -- MW           COMM1350
C     SPIEX      INITIAL CONDITION OF GOVERNOR           -- MW           COMM1360
C     OUTIE3     INITIAL CONDITION OF BOILER LAG         -- MW           COMM1370
C     OUTIE4     INITIAL CONDITION OF INTEGRAL CONTROLLER-- MW           COMM1380
C     OUTIE5     INITIAL CONDITION OF FIRING LAG         -- MW           COMM1390
C     OUTIE6     INITIAL CONDITION OF TURBINE REHEAT LAG -- MW           COMM1400
C     DEDIEX     INITIAL CONDITION OF GOVERNOR DEADBAND  -- MW           COMM1410
C     CEXT01     FREQUENCY BIAS                          -- MW/.1HZ      COMM1420
C     CEXT02     ACE GAIN                                                COMM1430
C     CEXT03     DEADBAND                                -- MW           COMM1440
C     CEXT04     BOILER PRESSURE DROP FACTOR                             COMM1450
C     CEXT05     BOILER LAG                              -- SEC          COMM1460
C     CEXT06     FIRING LAG                              -- SEC          COMM1470
C     CEXT07     BOILER PROPORTIONAL CONTROL GAIN                        COMM1480
C     CEXT08     BOILER INTEGRAL CONTROL GAIN                            COMM1490
C     CEXT09     NONREHEAT PORTION OF TURBINE                            COMM1500
C     CEXT10     TURBINE REHEAT LAG                      -- SEC          COMM1510
C     CEXT11     SPEED DROOP FACTOR                                      COMM1520
C     ACEEXT     AREA CONTROL ERROR                      -- MW           COMM1530
C     OUTE03     OUTPUT OF BOILER LAG                    -- MW           COMM1540
C     OUTE04     OUTPUT OF INTEGRAL CONTROL              -- MW           COMM1550
C     OUTE05     OUTPUT OF FIRING LAG                    -- MW           COMM1560
C     PDROP      SUM OF BOILER STATE AND PRESSURE DROP FACTOR            COMM1570
C                                                        -- MW           COMM1580
C     DEDEXT     GOVERNOR DEADBAND OUTPUT                -- MW           COMM1590
C     PGOVEX     INPUT TO GOVERNOR DEADBAND              -- MW           COMM1600
C     SPEXT      GOVERNOR SET POINT                      -- MW           COMM1610
```

```
C                                                                       COMM1620
C                                                                       COMM1630
C                    -------------------------------                    COMM1640
C                           DISPATCH OFFICE                             COMM1650
C                      INITIAL CONDITIONS AND CONSTANTS                 COMM1660
C                    -------------------------------                    COMM1670
C                                                                       COMM1680
      DATA CTIMR,CBIAS,CADD,CKCR/-19.4,-97.,0.,.15/                     COMM1690
      DATA KLR,DUM,CLSUP,KLP/.0491,0.,0.,1./                            COMM1700
      DATA CSKEDF,INADV,LAM/60.,0.,0./                                  COMM1710
      DATA SKDTI,TIMBS,FRQBS,ACE,AR,MWNEW/6*0./                         COMM1720
      DATA LNEW,PEC,SP,PEB,UCE,UCE1/82*0./                              COMM1730
      DATA PMS/20*0./                                                   COMM1740
C                                                                       COMM1750
C        .....................................................          COMM1760
C        .                  NOMENCLATURE                     .          COMM1770
C        .....................................................          COMM1780
C                                                                       COMM1790
C        CTIMR      SYSTEM TIME ERROR BIAS                  -- MW/SEC  COMM1800
C        CBIAS      SYSTEM FREQUENCY BIAS                   -- MW/.1HZ COMM1810
C        CADD       AGC MANUAL ADD                          -- MW      COMM1820
C        CKCR       ACE TO AR FILTER CONSTANT                          COMM1830
C        KLR        LAMBDA RESET                                       COMM1840
C        DUM        DUMMY                                              COMM1850
C        CLSUP      MANUAL ADD TO SYSTEM COST               -- MILS/KWH COMM1860
C        KLP        PROPORTIONAL GAIN FOR SYSTEM COST                  COMM1870
C        CSKEDF     SCHEDULED FREQUENCY                     -- HZ      COMM1880
C        INADV      INADVERTANT INTERCHANGE OF POWER        -- MW      COMM1890
C        LAM        SYSTEM COST                             -- MILS/KWH COMM1900
C        SKDTI      SCHEDULED TIE LINE FLOW                 -- MW      COMM1910
C        TIMBS      TIME ERROR BIAS                         -- MW/SEC  COMM1920
C        FRQBS      FREQUENCY ERROR BIAS                    -- MW/.1HZ COMM1930
C        ACE        AREA CONTROL ERROR                      -- MW      COMM1940
C        AR         AUTOMATIC REGULATION                    -- MW      COMM1950
C        MWNEW      SYSTEM MW DEMAND                        -- MW      COMM1960
C
C        LNEW       RESULT OF TABULAR LOOKUP ON AR LAMBDA CURVE        COMM1970
C                                                          -- MILS/KWH COMM1980
C        PEC        ECONOMIC POWER DEMAND FOR EACH UNIT     -- MW      COMM1990
C        SP         GOVERNOR SET POINT                      -- MW      COMM2000
C        PEB        PRESSURE ERROR BIAS BOILER COORDINATED CONTROLS    COMM2010
```

```
C                                                                  -- MW/P.U.    COMM2020
C       UCE         UNIT CONTROL ERROR                             -- MW         COMM2030
C       UCE1        UCE                                            -- MW         COMM2040
C       PMS         TELEMETERED UNIT OUTPUT POWER                  -- MW         COMM2050
C                                                                                COMM2060
C                                                                                COMM2070
C       PEC, SP, PEB, UCE, AND PMS ARE DIMENSIONED BY THE MAXIMUM                COMM2080
C            NUMBER OF UNITS                                                     COMM2090
C                                                                                COMM2100
C                                                                                COMM2110
C                        ----------------------                                  COMM2120
C                        LOADER MODEL PARAMETERS                                 COMM2130
C                        ----------------------                                  COMM2140
C                                                                                COMM2150
      DATA PFREQ/0./                                                             COMM2160
      DATA AMPLTD,WAVEON,WAVEFR,WAVEPH/0.,0.,0.,0./                              COMM2170
      DATA PNOISE,NSEED,MU,SIGMA/0.0,7,0.,1./                                    COMM2180
C                                                                                COMM2190
C       .....................................                                    COMM2200
C       .          NOMENCLATURE             .                                    COMM2210
C       .....................................                                    COMM2220
C                                                                                COMM2230
C       PFREQ       FREQUENCY FEEDBACK GAIN IN LOADER VARIATIONS                 COMM2240
C       AMPLTD      AMPLITUDE OF SINUSOIDAL WAVE                   -- MW         COMM2250
C       WAVEON      INITIATION TIME OF SINUSOIDAL WAVE             -- SEC        COMM2260
C       WAVEFR      FREQUENCY OF SINUSOIDAL WAVE                   -- RAD/SEC    COMM2270
C       WAVEPH      PHASE SHIFT OF SINUSOIDAL WAVE                 -- RAD        COMM2280
C       PNOISE      NOISE AMPLITUDE                                -- MW         COMM2290
C       NSEED       ANY ODD INTEGER (SEED FOR NOISE GENERATOR)                   COMM2300
C       MU          MEAN OF NORMAL GAUSSIAN DISTRIBUTION  (NOISE GENER-          COMM2310
C                   ATOR)                                                        COMM2320
C       SIGMA       STANDARD DEVIATION OF NORMAL GAUSS. DIST.                    COMM2330
C                                                                                COMM2340
C                                                                                COMM2350
      END                                                                        COMM2360
```

```
C     ------------------------------------------------------------      COMM0010
C     *     2              COMMON / CONST1 /                       *    COMM0020
C     ------------------------------------------------------------      COMM0030
C                                                                       COMM0040
C     COMMON /CONST1/ CONTAINS CONSTANTS THAT WILL BE FOUND IN THE      COMM0050
C            LDD OFFICE                                                 COMM0060
C                                                                       COMM0070
      BLOCK DATA                                                        COMM0080
      COMMON / CONST1 / CLDD(4)        , CD1(20)        , CD2(20)       , COMM0090
     1                  CD3(20)        , CD4(20)        , CD5(20)       COMM0100
      DATA CLDD/2.,60.,1.,2./                                           COMM0110
      DATA CD1/0.25,0.38,0.13,0.15,0.067,0.067,0.833,1.0,12*0./         COMM0120
      DATA CD2/0.,0.37,0.17,0.16,0.,0.30,14*0./                         COMM0130
      DATA CD3/1.,1.,1.,1.,1.,1.,1.,1.,12*0./                           COMM0140
      DATA CD4/1.,.0094,0.1,.0094,0.1,0.095,1.,1.,12*0./                COMM0150
      DATA CD5/20*0./                                                   COMM0160
C                                                                       COMM0170
C        ..................................................             COMM0180
C        .                NOMENCLATURE                    .             COMM0190
C        ..................................................             COMM0200
C                                                                       COMM0210
C        CLDD      CONSTANTS FOR CALCULATION OF AR AND LAM              COMM0220
C        CD1       GOVERNOR RATE LIMITS                  -- MW/SEC      COMM0230
C        CD2       UNIT PARTICIPATION IN AR              -- %           COMM0240
C        CD3       TELEMETRY TIME DELAY                  -- SEC         COMM0250
C        CD4       GOV. CONTROLLER PROPORTIONAL GAIN                    COMM0260
C        CD5       GOV. CONTROLLER RESET GAIN                           COMM0270
C                                                                       COMM0280
C                                                                       COMM0290
C                                                                       COMM0300
C     THE CONSTANT ARRAYS CD1 THROUGH CD5 ARE DIMENSIONED BY THE        COMM0310
C         THE MAXIMUM NUMBER OF UNITS                                   COMM0320
C                                                                       COMM0330
C                                                                       COMM0340
      END                                                               COMM0350
```

```
C     ------------------------------------------------------------      COMM0010
C     *     3              COMMON / INITAL /                       *      COMM0020
C     ------------------------------------------------------------      COMM0030
C                                                                         COMM0040
C     COMMON /INITAL/ CONTAINS THE INITIAL MW SETTING OF EACH PRIME       COMM0050
C           MOVER, THE MWR OF EACH UNIT, AND THE UNIT TYPE FOR EACH       COMM0060
C           UNIT                                                          COMM0070
C                                                                         COMM0080
C           MAIN PROGRAM AND SUBROUTINE LOD USE COMMON /INITAL/ IN        COMM0090
C           ITS ENTIRETY                                                  COMM0100
C                                                                         COMM0110
C           SUBROUTINES BOILER, HYDRO, GASTUB, AND NUCLER USE             COMM0120
C           COMMON /INITAL/ TO PASS MWR                                   COMM0130
C                                                                         COMM0140
      BLOCK DATA                                                          COMM0150
      REAL*4    MWR   , INITAL                                            COMM0160
      COMMON / INITAL / PI(20), UNTYPE(20)    , MWR(20)                   COMM0170
      DATA PI/1550.,1620.,330.,500.,175.,538.,310.,301.,12*0./            COMM0180
      DATA UNTYPE/1.,7.,8.,7.,8.,2.,6.,6.,12*0./                          COMM0190
      DATA MWR/1550.,1749.,346.,516.,190.,550.,654.,690.,12*0./           COMM0200
C                                                                         COMM0210
C        .................................................                COMM0220
C        .                  NOMENCLATURE                 .                COMM0230
C        .................................................                COMM0240
C                                                                         COMM0250
C         PI(N)          INITIAL SETTINGS FOR THE PRIMEMOVERS-- MW        COMM0260
C         UNTYPE(N)      ARRAY USED TO DISTINGUISH THE TYPE OF UNIT       COMM0270
C         MWR(N)         MEGAWATT RATING OF THE UNIT          -- MW       COMM0280
C         N              UNIT SEQUENTIAL NUMBER                           COMM0290
C                                                                         COMM0300
C                                                                         COMM0310
C                  --------- KEY TO UNIT TYPE ---------                  COMM0320
C                                                                         COMM0330
C         UNTYPE(N)= 1---NUCLEAR UNIT                                     COMM0340
C                    2---BOILER, SUPERCRITICAL ONCE THROUGH UNIT          COMM0350
C                    3---BOILER, SUBCRITICAL ONCE THROUGH    .            COMM0360
C                    4---BOILER, DRUM TYPE UNIT,OIL                       COMM0370
C                    5---HYDRO UNIT                                       COMM0380
C                    6---GASTURBINE UNIT                                  COMM0390
C                    7---BOILER, DRUM TYPE UNIT,COAL                      COMM0400
```

```
C                    8---BOILER, NON-REHEAT DRUM TYPE UNIT                  COMM0410
C                                                                           COMM0420
C                                                                           COMM0430
C           PI, UNTYPE, AND MWR ARE DIMENSIONED BY THE MAXIMUM NUMBER       COMM0440
C               OF UNITS                                                    COMM0450
C                                                                           COMM0460
C                                                                           COMM0470
      END                                                                   COMM0480
```

```
C     ------------------------------------------------------------------  COMM0010
C     *     4                COMMON / COST /                           *  COMM0020
C     ------------------------------------------------------------------  COMM0030
C                                                                         COMM0040
C     COMMON /COST/ CONTAINS COST CURVES FOR EACH UNIT FOLLOWED BY        COMM0050
C            OTHER FUNCTION GENERATOR CURVES                              COMM0060
C                                                                         COMM0070
C            COMMON /COST/ IS FOUND IN THE AFGEN FUNCTION SUBROUTINE      COMM0080
C                                                                         COMM0090
C            THE AFGEN FUNCTION SUBROUTINE IS CALLED FROM:                COMM0100
C                -- EXTRNL TO COMPUTE SKEDTX                              COMM0110
C                -- LOD TO COMPUTE SKDTI, MW1, AND PEC                    COMM0120
C                                                                         COMM0130
      BLOCK DATA                                                          COMM0140
      COMMON / COST   / UNIT1(20)     , UNIT2(20)     , UNIT3(20)     ,   COMM0150
     1                  UNIT4(20)     , UNIT5(20)     , UNIT6(20)     ,   COMM0160
     2                  UNIT7(20)     , UNIT8(20)     , SKEDTX(20)    ,   COMM0170
     3                  SKDTI(20)                                        COMM0180
      DATA UNIT1/  0.,   500.,  4.4,  500.,  4.5,  1100.,  4.6,  1550.,   COMM0190
     1             60.,  1550.,  10*0./                                   COMM0200
      DATA UNIT2/  0.,   200.,  5.5,  200.,  5.9,  800.,  6.2,  1128.,    COMM0210
     1             6.3,  1230.,  6.7,  1490.,  6.9,  1620.,  60.,  1620., COMM0220
     2             4*0./                                                  COMM0230
      DATA UNIT3/  0.,   10.,   7.0,  10.,   8.0,  57.,   8.6,  154.,     COMM0240
     1             9.1,  240.,  9.5,  294.,  10.3,  330.,  60.,  330.,    COMM0250
     2             4*0./                                                  COMM0260
      DATA UNIT4/  0.,   15.,   7.8,  15.,   7.9,  52.,   8.3,  139.,     COMM0270
     1             8.5,  203.,  8.8,  413.,  9.2,  482.,  9.4,  500.,     COMM0280
     2             60.,  500.,  2*0./                                     COMM0290
      DATA UNIT5/  0.,   10.,   9.8,  10.,   11.1,  70.,   12.4,  100.,   COMM0300
     1             13.3,  135.,  16.3,  171.,  33.7,  181.,  46.5,  190.,  COMM0310
     2             60.,  190.,  2*0./                                     COMM0320
      DATA UNIT6/  0.,   20.,   7.5,  20.,   7.6,  325.,  7.9,  400.,     COMM0330
     1             8.3,  475.,  8.6,  538.,  60.,  538.,  6*0./           COMM0340
      DATA UNIT7/  0.,   60.,   21.0,  60.,   22.9,  214.,  24.,  310.,   COMM0350
     1             25.8,  480.,  60.,  480.,  8*0./                       COMM0360
      DATA UNIT8/  0.,   40.,   19.9,  40.,   23.8,  278.,  26.0,  534.,  COMM0370
     1             31.2,  690.,  60.,  690.,  8*0./                       COMM0380
C                                                                         COMM0390
C                                                                         COMM0400
```

```
C                ********************************************                COMM0410
C                THIS SPACE RESERVED FOR FUTURE UNITS                        COMM0420
C                ********************************************                COMM0430
C                                                                            COMM0440
C                                                                            COMM0450
      DATA SKEDTX/0.,0.,3600.,0.,16*0./                                      COMM0460
      DATA SKDTI /0.,0.,3600.,0.,16*0./                                      COMM0470
C                                                                            COMM0480
C                                                                            COMM0490


C        ..................................................                  COMM0500
C        .                  NOMENCLATURE                  .                  COMM0510
C        ..................................................                  COMM0520
C                                                                            COMM0530
C         SKEDTX         EXTERNAL TIE FLOW                  -- MW           COMM0540
C         SKDTI          SCHEDULED TIE LINE FLOW            -- MW           COMM0550
C                                                                            COMM0560
C                                                                            COMM0570
C         THE ARRAYS ABOVE ARE DIMENSIONED FOR TEN SETS OF DATA PAIRS        COMM0580
C             FOR A TOTAL OF 20 STORAGE LOCATIONS.  ANY MODIFICATION         COMM0590
C             OF THIS DIMENSIONING WILL REQUIRE NEW CODING IN THE AFGEN      COMM0600
C             FUNCTION SUBROUTINE.                                           COMM0610
C                                                                            COMM0620
C         COST CURVES FOR ADDITIONAL UNITS SHOULD BE PLACED IN THE           COMM0630
C             SPACE RESERVED ABOVE.  SPECIFICALLY, THEY MUST BE PLACED       COMM0640
C             BEFORE ANY OTHER FUNCTION GENERATOR CURVES.  THE ADDED         COMM0650
C             COST CURVES SHOULD HAVE PRECISELY TEN DATA PAIRS.              COMM0660
C                                                                            COMM0670
      END                                                                    COMM0680
```

```
C     ------------------------------------------------------------------  COMM0010
C     *     5                COMMON / BOILRS /                          *  COMM0020
C     ------------------------------------------------------------------  COMM0030
C                                                                         COMM0040
C     COMMON /BOILRS/ CONTAINS THE PARAMETERS FOR EACH OF THE 5 TYPES     COMM0050
C           OF BOILER UNITS USED IN SUBROUTINE BOILER                     COMM0060
C                                                                         COMM0070
      BLOCK DATA                                                          COMM0080
      COMMON / BOILRS / HUNT1(150)                                        COMM0090
      DIMENSION HUNT2(30)     , HUNT3(30)     , HUNT4(30)                 COMM0100
      DIMENSION HUNT5(30)     , HUNT6(30)                                 COMM0110
      EQUIVALENCE(HUNT1(1),HUNT2(1))                                      COMM0120
      EQUIVALENCE(HUNT1(31),HUNT3(1))                                     COMM0130
      EQUIVALENCE(HUNT1(61),HUNT4(1))                                     COMM0140
      EQUIVALENCE(HUNT1(91),HUNT5(1))                                     COMM0150
      EQUIVALENCE(HUNT1(121),HUNT6(1))                                    COMM0160
C                                                                         COMM0170
C                                                                         COMM0180
C-----------------------------------------------------------------------  COMM0190
C                    SUPERCRITICAL ONCE THROUGH                           COMM0200
C                                                                         COMM0210
      DATA HUNT2/20.00    ,                                               COMM0220
     1          10.       ,1.0      ,1.0      ,00.85    ,0.0      ,      COMM0230
     210.00    ,0.025    ,0.10     ,8.00     ,0.28     ,1.0      ,      COMM0240
     33.877115 ,1.062857 ,6.59378  ,13.25411 ,1.76     ,0.115    ,      COMM0250
     40.0      ,0.0      ,9.0      ,0.9881   ,0.0214   ,20.00    ,      COMM0260
     56.00     ,44.00    ,0.514    ,1.0      ,0.006    ,745.     /      COMM0270
C-----------------------------------------------------------------------  COMM0280
C                    SUBCRITICAL ONCE THROUGH                             COMM0290
C                                                                         COMM0300
      DATA HUNT3/20.00    ,                                               COMM0310
     1          3.0       ,1.0      ,1.0      ,00.85    ,0.0      ,      COMM0320
     210.00    ,00.025   ,00.10    ,8.00     ,00.28    ,1.00     ,      COMM0330
     36.041757 ,1.076923 ,27.04244 ,10.91322 ,4.50     ,00.03    ,      COMM0340
     40.0      ,0.0      ,9.00     ,0.9881   ,0.0214   ,20.00    ,      COMM0350
     56.00     ,44.00    ,0.0382   ,  3.926  ,0.004    ,191.     /      COMM0360
C-----------------------------------------------------------------------  COMM0370
C                           OIL FIRED DRUM                                COMM0380
C                                                                         COMM0390
      DATA HUNT4/20.00    ,                                               COMM0400
```

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     1          4.0       ,1.0       ,1.0       ,00.85     ,0.0       ,    COMM0410
     210.00     ,00.025   ,00.10     ,8.00      ,00.28     ,1.00      ,    COMM0420
     311.178    ,1.060606 ,25.634    ,11.39730  ,00.9      ,00.015    ,    COMM0430
     40.0       ,1.00     ,9.00      ,1.00      ,00.5      ,25.00     ,    COMM0440
     56.00      ,40.0     ,0.0       ,0.0       ,0.0       ,225.      /    COMM0450
C-------------------------------------------------------------------------  COMM0460
C                          COAL FIRED DRUM                                  COMM0470
C                                                                           COMM0480
      DATA HUNT5/20.00,                                                     COMM0490

     1          4.0       ,1.0       ,1.0       ,.85       ,0.0       ,    COMM0500
     210.0      ,.025     ,.10       ,8.0       ,.28       ,1.0       ,    COMM0510
     311.178    ,1.060606 ,25.634    ,11.39730  ,.9        ,.015      ,    COMM0520
     40.0       ,1.       ,30.       ,1.0       ,.5        ,25.0      ,    COMM0530
     525.0      ,40.      ,0.0       ,0.0       ,0.0       ,225.      /    COMM0540
C-------------------------------------------------------------------------  COMM0550
C                          NON-REHEAT DRUM                                  COMM0560
C                                                                           COMM0570
      DATA HUNT6/20.00,                                                     COMM0580
     1          1.0       ,1.0       ,1.0       ,00.85     ,0.0       ,    COMM0590
     210.0      ,.0222    ,.0222     ,1.0       ,1.0       ,1.0       ,    COMM0600
     34.15835   ,1.064189 ,16.20734  ,5.37715   ,2.0       ,.04       ,    COMM0610
     40.0       ,1.0      ,3.0       ,1.0       ,5.0       ,25.       ,    COMM0620
     52.0       ,7.       ,0.        ,0.        ,0.        ,80.       /    COMM0630
C                                                                           COMM0640
C                                                                           COMM0650
C         ..................................................                COMM0660
C         .                  NOMENCLATURE                  .                COMM0670
C         ..................................................                COMM0680
C                                                                           COMM0690
C         HUNT1(1)=CYS02   SPEED DROOP (1/REGULATION)                       COMM0700
C         HUNT1(2)=CYS03   DEADBAND                                         COMM0710
C         HUNT1(3)=CYS04   K1, INDICATES FIRST STAGE PRESSURE FEEDBACK      COMM0720
C         HUNT1(4)=CYS05   PRESSURE SET POINT                -- P.U.        COMM0730
C         HUNT1(5)=CYS06   INITIAL PRESSURE LIMITER SET POINT-- P.U.        COMM0740
C         HUNT1(6)=        DUMMY                                            COMM0750
C         HUNT1(7)=CYS07   INITIAL PRESSURE LIMITER GAIN                    COMM0760
C         HUNT1(8)=CYS09   VALVE OPENING TRAVEL TIME         -- SEC        COMM0770
C         HUNT1(9)=CYS10   VALVE CLOSING TRAVEL TIME         -- SEC        COMM0780
C         HUNT1(10)=CYS02  REHEATER TIME CONSTANT            -- SEC        COMM0790
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C         HUNT1(11)=CYS11  F, POWER DEVELOPED BEFORE REHEATER              COMM0800
C         HUNT1(12)=PT     THROTTLE PRESSURE                               COMM0810
C         HUNT1(13)=C(2)   CAPACITY OF SECONDARY SUPERHEATER               COMM0820
C         HUNT1(14)=PD     DRUM OR PRIMARY SUPERHEATER PRESSURE            COMM0830
C         HUNT1(15)=C(1)   CAPACITY OF DRUM+PSH OR TRANSITION ZONE+PSH     COMM0840
C         HUNT1(16)=K'     BOILER PRESSURE/FLOW CONSTANT                   COMM0850
C         HUNT1(17)=KP     BOILER PRESSURE CONTROL PROPORTIONAL GAIN        COMM0860
C         HUNT1(18)=KI     BOILER PRESSURE CONTROL INTEGRAL GAIN           COMM0870
C         HUNT1(19)=       DUMMY                                           COMM0880
C         HUNT1(20)=K      FUEL SYSTEM GAIN                                COMM0890
C         HUNT1(21)=TF     FUEL SYSTEM TIME CONSTANT        -- SEC         COMM0900
C         HUNT1(22)=K1     FEEDWATER SYSTEM PROPORTIONAL GAIN              COMM0910
C         HUNT1(23)=K2     FEEDWATER SYSTEM INTEGRAL GAIN                  COMM0920
C         HUNT1(24)=M      FEEDWATER SYSTEM TIME CONSTANT   -- SEC         COMM0930
C         HUNT1(25)=CYF03  FUEL SYSTEM FIRING DELAY         -- SEC         COMM0940
C         HUNT1(26)=KD     BOILER PRESSURE CONTROL DERIVATIVE GAIN         COMM0950
C         HUNT1(27)=MWBYX  COORDINATED CONTROL SYSTEM MEGAWATT BIAS        COMM0960
C         HUNT1(28)=PEBYXX COORDINATED CONTROL SYSTEM PRESS. ERROR BIAS    COMM0970
C         HUNT1(29)=PEBDB  COORDINATED CONTROL PRESSURE ERROR DEADBAND     COMM0980
C         HUNT1(30)=CYS01  BASE MW VALUE OF UNIT SIMULATED   -- MW         COMM0990
C                                                                          COMM1000
C                                                                          COMM1010
C         HUNT1 IS DIMENSIONED FOR 5 TYPES OF BOILER UNITS AT 30           COMM1020
C               VARIABLES PER UNIT.  NOT TO BE CHANGED.                    COMM1030
C                                                                          COMM1040
C                                                                          COMM1050
      END                                                                  COMM1060
```

```
C     ------------------------------------------------------------      COMM0010
C     *     6                COMMON / WATT /                       *    COMM0020
C     ------------------------------------------------------------      COMM0030
C                                                                       COMM0040
C     COMMON /WATT/ CONTAINS THE PARAMETERS USED FOR THE HYDRO UNITS    COMM0050
C           IN SUBROUTINE HYDRO                                         COMM0060
C                                                                       COMM0070
      BLOCK DATA                                                        COMM0080
      COMMON / WATT   / WATER1(36)                                      COMM0090
      DATA WATER1/0.05, 0.125, 1.0, 8.0, 43.33, 2.0,                    COMM0100
     1           0.05, 0.125, 1.0, 8.0, 43.33, 2.0,                    COMM0110
     2           0.05, 0.125, 1.0, 8.0, 43.33, 2.0,                    COMM0120
     3           0.05, 0.125, 1.0, 8.0, 43.33, 2.0,                    COMM0130
     4           0.05, 0.125, 1.0, 8.0, 43.33, 2.0,                    COMM0140
     5           0.05, 0.125, 1.0, 8.0, 43.33, 2.0/                    COMM0150
C                                                                       COMM0160
C                                                                       COMM0170
C        .....................................................          COMM0180
C        .                    NOMENCLATURE                   .          COMM0190
C        .....................................................          COMM0200
C                                                                       COMM0210
C        WATER1(1)=       REGULATION I.E. 5%                            COMM0220
C        WATER1(2)=       REGULATION/TRANSIENT REGULATION               COMM0230
C        WATER1(3)=       DEADBAND                          -- MW       COMM0240
C        WATER1(4)=TR     TRANSIENT DROP TIME CONSTANT                  COMM0250
C        WATER1(5)=       RATE OF GATE LIMIT                -- MW/SEC   COMM0260
C        WATER1(6)=       WATER STARTING TIME               -- SEC      COMM0270
C                                                                       COMM0280
C                                                                       COMM0290
C        WATER1 IS DIMENSIONED FOR 6 UNITS AT 6 VARIABLES PER UNIT.     COMM0300
C                                                                       COMM0310
C                                                                       COMM0320
      END                                                               COMM0330
```

```
C     ------------------------------------------------------------      COMM0010
C     *     7                COMMON / GAS /                        *    COMM0020
C     ------------------------------------------------------------      COMM0030
C                                                                       COMM0040
C     COMMON /GAS/ CONTAINS THE PARAMETERS USED FOR THE GAS TURBINES    COMM0050
C           IN SUBROUTINE GASTUB                                        COMM0060
C                                                                       COMM0070
      BLOCK DATA                                                        COMM0080
      COMMON / GAS    / GASS1(60)                                       COMM0090
      DATA GASS1/1.0, 0.05, 54.,                                        COMM0100
     1          1.0, 0.05, 54.,                                        COMM0110
     2          1.0, 0.05, 54.,                                        COMM0120
     3          1.0, 0.05, 54.,                                        COMM0130
     4          1.0, 0.05, 54.,                                        COMM0140
     5          1.0, 0.05, 54.,                                        COMM0150
     6          1.0, 0.05, 54.,                                        COMM0160
     7          1.0, 0.05, 54.,                                        COMM0170
     8          1.0, 0.05, 54.,                                        COMM0180
     9          1.0, 0.05, 54.,                                        COMM0190
     A          1.0, 0.05, 54.,                                        COMM0200
     B          1.0, 0.05, 54.,                                        COMM0210
     C          1.0, 0.05, 54.,                                        COMM0220
     D          1.0, 0.05, 54.,                                        COMM0230
     E          1.0, 0.05, 54.,                                        COMM0240
     F          1.0, 0.05, 54.,                                        COMM0250
     G          1.0, 0.05, 54.,                                        COMM0260
     H          1.0, 0.05, 54.,                                        COMM0270
     I          1.0, 0.05, 54.,                                        COMM0280
     J          1.0, 0.05, 54./                                        COMM0290
C                                                                       COMM0300
C         .....                                                         COMM0310
C         .              NOMENCLATURE                   .               COMM0320
C         .....                                                         COMM0330
C                                                                       COMM0340
C                                                                       COMM0350
C         GASS1(1)=      DEADBAND                          -- MW        COMM0360
C         GASS1(2)=      REGULATION    E.G.  14.2%         -- %         COMM0370
C         GASS1(3)=      AMBIENT TEMPERATURE DEGREES C   E.G.  29.5 FOR COMM0380
C                        WINTER                                         COMM0390
C        GASS1 IS DIMENSIONED FOR 20 UNITS AT 3 VARIABLES PER UNIT.     COMM0420
C                                                                       COMM0430
C                                                                       COMM0440
      END                                                               COMM0450
```

```
C     ------------------------------------------------------------      COMM0010
C     *     8                COMMON / ATTOM /                       *   COMM0020
C     ------------------------------------------------------------      COMM0030
C                                                                       COMM0040
C     COMMON /ATTOM/ CONTAINS THE PARAMETERS USED FOR THE NUCLEAR       COMM0050
C           UNITS IN SUBROUTINE NUCLER                                  COMM0060
C                                                                       COMM0070
      BLOCK DATA                                                        COMM0080
      COMMON / ATTOM  / ATOM1(110)                                      COMM0090
      DATA ATOM1/0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0100
     1          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0110
     2          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0120
     3          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0130
     4          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0140
     5          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0150
     6          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0160
     7          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0170
     8          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50,          COMM0180
     9          0.0,7.0,0.15,1.0,0.1,0.6,2.0,5.0,0.3,4.5,.50/          COMM0190
C                                                                       COMM0200
C                                                                       COMM0210
C        .....................................................          COMM0220
C        .                    NOMENCLATURE                   .          COMM0230
C        .....................................................          COMM0240
C                                                                       COMM0250
C        ATOM1(1)=CYB02   PROPORTIONAL PART OF RECIRCULATION CONTROL    COMM0260
C        ATOM1(2)=CYB03   IN-CORE THERMAL TIME CONSTANT     -- SEC     COMM0270
C        ATOM1(3)=CYB04   INTEGRAL PART OF RECIRCULATION CONTROL        COMM0280
C        ATOM1(4)=CYB05   POWER CORRESPONDING TO FULL RECIRCULATION     COMM0290
C                         FLOW IN STEADY STATE              -- MW       COMM0300
C        ATOM1(5)=CYB06   PRESSURE REGULATOR LIMIT                      COMM0310
C        ATOM1(6)=CYB07   PRESSURE REGULATOR GAIN                       COMM0320
C        ATOM1(7)=CYB08   PRESSURE REGULATOR TIME CONSTANT T1           COMM0330
C                                                           -- SEC      COMM0340
C        ATOM1(8)=CYB09   PRESSURE REGULATOR TIME CONSTANT T2           COMM0350
C                                                           -- SEC      COMM0360
C        ATOM1(9)=CYB10   TURBINE POWER BEFORE CROSSOVER AND MOISTURE   COMM0370
C                         SEPARATOR                         -- MW       COMM0380
C        ATOM1(10)=CYB11  TIME CONSTANT OF STEAM FLOW IN MOISTURE       COMM0390
C                         SEPARATOR AND CROSSOVER           -- SEC      COMM0400
```

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C       ATOM1(11)=CYB12  REGULATION                              -- %        COMM0410
C                                                                            COMM0420
C                                                                            COMM0430
C       ATOM1 IS DIMENSIONED FOR 10 UNITS AT 11 VARIABLES PER UNIT.          COMM0440
C                                                                            COMM0450
C                                                                            COMM0460
      END                                                                    COMM0470
```

```
C     ------------------------------------------------------------------   COMM0010
C     *     9                COMMON / PRTCNL /                          *   COMM0020
C     ------------------------------------------------------------------   COMM0030
C                                                                          COMM0040
C     COMMON /PRTCNL/ CONTAINS PARAMETERS USED TO CONTROL VARIOUS          COMM0050
C            OUTPUT ROUTINES                                               COMM0060
C                                                                          COMM0070
C            COMMON /PRTCNL/ IS UTILIZED IN MAIN PROGRAM AND THE           COMM0080
C            SUBROUTINES PRINT, OUTPUT, AND PAGEHD                         COMM0090
C                                                                          COMM0100
C            COMMON /PRTCNL/ IS PRESENTLY NOT USED IN SUBROUTINES          COMM0110
C            BOILER, HYDRO, GASTUB, AND NUCLER, BUT IS PLACED IN THESE     COMM0120
C            ROUTINES TO PERMIT THE USER TO PRINT ANY VARIABLE USED        COMM0130
C            WITHIN THESE ROUTINES                                         COMM0140
C                                                                          COMM0150
      BLOCK DATA                                                           COMM0160
      REAL*4    VALUE(44)                                                  COMM0170
      REAL*8    SYMBOL(44)                                                 COMM0180
      COMMON / PRTCNL / ICOUNT, TLAST , SYMBOL, VALUE , LINES , IPAGES,    COMM0190
     1                  CURPRT, PRNTIM                                     COMM0200
C                                                                          COMM0210
      DATA ICOUNT,TLAST,SYMBOL,VALUE,LINES,IPAGES/0,0.0,44*0.,44*0.,       COMM0220
     1     0,1/                                                            COMM0230
      DATA CURPRT,PRNTIM/0.0,10.0 /                                        COMM0240
C                                                                          COMM0250
C                                                                          COMM0260
C          .....................................................           COMM0270
C          .                    NOMENCLATURE                   .           COMM0280
C          .....................................................           COMM0290
C                                                                          COMM0300
C          ICOUNT         INDEX USED TO LOCATE PRINT VARIABLES IN THE     COMM0310
C                         ARRAYS SYMBOL AND VALUE                         COMM0320
C          TLAST          STORES TIME OF LAST PRINT                       COMM0330
C          SYMBOL         ARRAY TO STORE PRINT VARIABLE NAMES             COMM0340
C          VALUE          ARRAY TO STORE PRINT VARIABLE VALUES            COMM0350
C          LINES          LINE COUNTER                                    COMM0360
C          IPAGES         PAGE COUNTER                                    COMM0370
C          CURPRT         CURRENT PRINT TIME                              COMM0380
C          PRINTIM        PRINT INTERVAL                                  COMM0390
C                                                                          COMM0410
      END                                                                  COMM0420
```

```
C     ------------------------------------------------------------------   COMM0010
C     *     10              COMMON / PLOTT /                            *   COMM0020
C     ------------------------------------------------------------------   COMM0030
C                                                                           COMM0040
C     COMMON /PLOTT/ CONTAINS THE PRINT SYMBOLS AS WELL AS THE DATA         COMM0050
C            USED TO INITIALIZE PLOT SCALES AND LIMITS USED IN              COMM0060
C            SUBROUTINES PLOT AND DOODLE                                    COMM0070
C                                                                           COMM0080
C     THE MAXIMUM NUMBER OF VARIABLES THAT CAN BE PLOTTED IS 14             COMM0090
C                                                                           COMM0100
      BLOCK DATA                                                            COMM0110
      COMMON / PLOTT  / XOUT(15)      , AMAX(15)      , AMIN(15)      ,     COMM0120
     1                  POINT(15)     , INT   , ITIC  , NPLVAR, ACR   ,     COMM0130
     2                  UP    , BLANK , PLUS  , BPP(60)       ,           COMM0140
     3                  D(1,60)       , APP(5), NWRITE, NEGATE, AFFIRM      COMM0150
C                                                                           COMM0160
      REAL*4    NEGATE                                                      COMM0170
C                                                                           COMM0180
      DATA AMAX/0.,100.,5500.,50500.,60.05,100.,5500.,100.,7*0./            COMM0190
      DATA AMIN/0.,-100.,4500.,49500.,59.95,-200.,5200.,-100.,7*0./         COMM0200
      DATA POINT/' ','A','M','X','F','T','L','R',7*0./                      COMM0210
      DATA INT,ITIC/1,5/                                                    COMM0220
      DATA NPLVAR/7/                                                        COMM0230
      DATA ACR,UP,BLANK,PLUS/'-','|',' ','+'/                               COMM0240
      DATA NWRITE/0/                                                        COMM0250
      DATA NEGATE,AFFIRM/'N','Y'/                                           COMM0260
C                                                                           COMM0270
C                                                                           COMM0280
C         .....................................................             COMM0290
C         .                    NOMENCLATURE                   .             COMM0300
C         .....................................................             COMM0310
C                                                                           COMM0320
C         XOUT      VALUES READ FROM DISK TO BE PLOTTED                     COMM0330
C         AMAX      UPPER GRAPH LIMIT                                       COMM0340
C         AMIN      LOWER GRAPH LIMIT                                       COMM0350
C         POINT     SYMBOLS USED IN PLOTS OF SIMULATION VARIABLES           COMM0360
C         INT       PLOT INTERVAL DESIRED IN SECONDS                        COMM0370
C         ITIC      TIME TIC MARK IN SECONDS                                COMM0380
C         NPLVAR    TOTAL NUMBER OF VARIABLES TO BE PLOTTED                 COMM0390
C         ACR       USED TO PRINT -         >                               COMM0400
C         UP        USED TO PRINT I         >  USED PRIMARILY TO PRINT      COMM0410
```

```
C          BLANK    USED TO PRINT A BLANK  >  AXES AND REFERENCE POINTS  COMM0420
C          PLUS     USED TO PRINT +        >                            COMM0430
C          BPP      PRINTS LEFT MARGIN OF GRAPH                         COMM0440
C          D        PLOTS LINE OF DATA                                  COMM0450
C          APP      PRINTS SCALE HEADINGS OF VARIABLES                  COMM0460
C          NWRITE   NUMBER OF TIMES LINE OF DATA IS WRITTEN TO UNIT 11  COMM0470
C          NEGATE   READS ANSWER OF N (NO) IN RESPONSE TO PROMPT        COMM0480
C          AFFIRM   READS ANSWER OF Y (YES) IN RESPONSE TO PROMPT       COMM0490

C                                                                       COMM0500
C                                                                       COMM0510
C     SET UP THE SCALE (AMAX, AMIN) DESIRED FOR EACH VARIABLE TO BE     COMM0520
C          PLOTTED IN THE SAME ORDER AS THEY APPEAR ON THE PREPAR       COMM0530
C          CARD (I.E., THE WRITE(11) STATEMENT IN MAIN). THE FIRST      COMM0540
C          DATA SET ENTRY FOR AMAX AND AMIN IS RESERVED FOR THE         COMM0550
C          INDEPENDENT VARIABLE, IN THIS PROGRAM THIS SCALE IS          COMM0560
C          NOT USED.                                                    COMM0570
C                                                                       COMM0580
C     SET UP THE POINT CONFIGURATION (SYMBOL TO BE USED TO PLOT         COMM0590
C          VARIABLE) DESIRED FOR EACH VARIABLE, MAINTAINING THE         COMM0600
C          SAME ORDER AS THEY APPEAR ON THE PREPAR CARD.  THE FIRST     COMM0610
C          DATA ENTRY IN THE ARRAY POINT IS ALSO A DUMMY ENTRY.         COMM0620
C                                                                       COMM0630
C                                                                       COMM0640
      END                                                               COMM0650
```

```
C     ------------------------------------------------------------------   COMM0010
C     *     11              COMMON / DELLAY /                           *   COMM0020
C     ------------------------------------------------------------------   COMM0030
C                                                                           COMM0040
C     COMMON /DELLAY/ CONTAINS THE STORAGE VARIABLES FOR THE DELAY          COMM0050
C            FUNCTION.  THE COMMON AREA IS DISPLAYED BELOW FOR              COMM0060
C            NOMENCLATURE PURPOSES ONLY.  NO INITIALIZATION OCCURS.         COMM0070
C                                                                           COMM0080
C     COMMON /DELLAY/ C(1000),DLAY(8,21,6)                                  COMM0090
C                                                                           COMM0100
C                                                                           COMM0110
C         .....................................................             COMM0120
C         .                    NOMENCLATURE                   .             COMM0130
C         .....................................................             COMM0140
C                                                                           COMM0150
C         C         ARRAY TO STORE DELAY POINTS                             COMM0160
C         DLAY      WORK AREA FOR TEMPORARY STORAGE OF DELAY POINTS         COMM0170
C                   DLAY IS DIMENSIONED AS   DLAY(X,Y,Z)   WHERE:          COMM0180
C                            X= TOTAL NUMBER OF INDEXED SUBROUTINES         COMM0190
C                            Y= MAXIMUM NUMBER OF UNITS PLUS 1              COMM0200
C                            Z= GREATER THAN OR EQUAL TO THE GREATEST       COMM0210
C                               NUMBER OF DELAY FUNCTIONS CALLED IN         COMM0220
C                               ANY SUBROUTINE                              COMM0230
C                                                                           COMM0240
C                                                                           COMM0250
C                                                                           COMM0260
C     ------------------------------------------------------------------   COMM0270
C     *     12              COMMON / PASSES /                           *   COMM0280
C     ------------------------------------------------------------------   COMM0290
C                                                                           COMM0300
C     COMMON /PASSES/ CONTAINS THE COUNTERS USED TO CONTROL THE             COMM0310
C            PASSES THROUGH THE BOILER SUBROUTINE.  THE COMMON AREA         COMM0320
C            IS DISPLAYED BELOW FOR NOMENCLATURE PURPOSES ONLY.             COMM0330
C            NO INITIALIZATION OCCURS.                                      COMM0340
C                                                                           COMM0350
C     COMMON /PASSES/ KONT,AEEP                                             COMM0360
C                                                                           COMM0370
C                                                                           COMM0380
C         .....................................................             COMM0390
C         .                    NOMENCLATURE                   .             COMM0400
```

```
C          ..................................................          COMM0410
C                                                                      COMM0420
C          KONT       A COUNTER THAT ACCUMULATES 4 PASSES THROUGH      COMM0430
C                     BOILER EACH TIME THE BOILER SUBROUTINE IS CALLED.COMM0440
C                     THIS COUNTER IS NEEDED BECAUSE THE INTEGRATORS IN COMM0450
C                     SUBROUTINE BOILER ARE ON A .5 SECOND INTEGRATION COMM0460
C                     STEP SIZE.                                       COMM0470
C          AEEP       INTEGRATION TIME STEP COUNTER NEEDED IN THE      COMM0480
C                     BOILER SUBROUTINE BECAUSE OF THE .5 SECOND       COMM0490

C                     INTEGRATION TIME STEP                            COMM0500
C                                                                      COMM0510
C                                                                      COMM0520
C     ---------------------------------------------------------------- COMM0530
C     *     13              COMMON / NALARM /                        *  COMM0540
C     ---------------------------------------------------------------- COMM0550
C                                                                      COMM0560
C     COMMON /NALARM/ CONTAINS AN ERROR FLAG THAT TERMINATES THE       COMM0570
C           SIMULATION IF AN ERROR IS DETECTED BY THE PROGRAM.         COMM0580
C           THE COMMON AREA IS DISPLAYED BELOW FOR NOMENCLATURE        COMM0590
C           PURPOSES ONLY.  NO INITIALIZATION OCCURS.                  COMM0600
C                                                                      COMM0610
C     COMMON /NALARM/ IERR                                             COMM0620
C                                                                      COMM0630
C                                                                      COMM0640
C          ..........................................                  COMM0650
C          .                NOMENCLATURE            .                 COMM0660
C          ..........................................                  COMM0670
C                                                                      COMM0680
C          IERR       ERROR FLAG                                       COMM0690
C                                                                      COMM0700
C                                                                      COMM0710
C ---------------------------------------------------------------------- MAIN0010
C *                                                                    * MAIN0020
C *                    M A I N   P R O G R A M                         * MAIN0030
C *                                                                    * MAIN0040
C ---------------------------------------------------------------------- MAIN0050
C                                                                      MAIN0060
      COMMON / CURVAL / TIME   , DELT   , KEEP   , NUNIT , GOTIME, N      , MAIN0070
     1                  FREQHZ, PM(20), OMEGA , TM    , PMSYS , PMTOT , MAIN0080
     2                  PELSY , PACCEL, LOAD  , LODTOT, H     , PTINET, MAIN0090
```

```
     3                  PMEXT , LODEXT, OUTE02, SPIEX , OUTIE3, OUTIE4, MAIN0100
     4                  OUTIE5, OUTIE6, DEDIEX, CEXT01, CEXT02, CEXT03, MAIN0110
     5                  CEXT04, CEXT05, CEXT06, CEXT07, CEXT08, CEXT09, MAIN0120
     6                  CEXT10, CEXT11, ACEEXT, OUTE03, OUTE04, OUTE05, MAIN0130
     7                  PDROP , DEDEXT, PGOVEX, SPEXT , CTIMR , CBIAS , MAIN0140
     8                  CADD  , CKCR  , KLR   , DUM   , CLSUP , KLP   , MAIN0150
     9                  CSKEDF, INADV , LAM   , SKDTI , TIMBS , FRQBS , MAIN0160
     A                  ACE   , AR    , MWNEW , LNEW  , PEC(20)       , MAIN0170
     B                  SP(20), PEB(20)       , UCE(20)       , UCE1  , MAIN0180
     C                  PMS(20)       , FINTIM, KEXTRN, PFREQ , AMPLTD, MAIN0190
     D                  WAVEON, WAVEFR, WAVEPH, PNOISE, NSEED , MU    , MAIN0200
     E                  SIGMA                                           MAIN0210
      COMMON / COST   / UNIT1(20)                                        MAIN0220
      COMMON / INITAL / PI(20), UNTYPE(20)    , MWR(20)                  MAIN0230
      COMMON / PRTCNL / ICOUNT, TLAST , SYMBOL, VALUE , LINES , IPAGES, MAIN0240
     1                  CURPRT, PRNTIM                                  MAIN0250
      COMMON / PLOTT  / XOUT(15)      , AMAX(15)      , AMIN(15)      , MAIN0260
     1                  POINT(15)     , INT   , ITIC  , NPLVAR, ACR   , MAIN0270

     2                 UP    , BLANK , PLUS  , BPP(60)       ,         MAIN0280
     3                 D(1,60)       , APP(5), NWRITE, NEGATE, AFFIRM  MAIN0290
      COMMON / NALARM / IERR                                             MAIN0300
C                                                                        MAIN0310
      REAL*4     VALUE(44)                                             MAIN0320
      REAL*8     SYMBOL(44)                                            MAIN0330
      REAL*4     LOAD  , LODTOT, LODEXT, KLR   , KLP   , INADV , LAM   , MAIN0340
     1           MWNEW , LNEW  , INITAL, MWR   , NEGATE, NOLOAD, NSCALE MAIN0350
C                                                                        MAIN0360
C                                                                        MAIN0370
C                                                                        MAIN0380
C                          -------------                                 MAIN0390
C                          INITIALIZATION                                MAIN0400
C                          -------------                                 MAIN0410
C                                                                        MAIN0420
      WRITE(6,10)                                                        MAIN0430
   10 FORMAT(' ENTER FINISH TIME IN SECONDS')                            MAIN0440
      READ(5,20) FINTIM                                                  MAIN0450
   20 FORMAT(E14.7)                                                      MAIN0460
      WRITE(6,30)                                                        MAIN0470
   30 FORMAT(' DO YOU WISH TO ADD VARIATIONS IN LOAD?')                  MAIN0480
      READ(5,40) NOLOAD                                                  MAIN0490
```

```
 40 FORMAT(A1)                                                          MAIN0500
    IF(NOLOAD .EQ. NEGATE) GO TO 130                                    MAIN0510
    WRITE(6,50)                                                         MAIN0520
 50 FORMAT(' ENTER FREQUENCY FEEDBACK GAIN')                            MAIN0530
    READ(5,20) PFREQ                                                    MAIN0540
    WRITE(6,60)                                                         MAIN0550
 60 FORMAT(' ENTER SINUSOIDAL WAVE AMPLITUDE')                          MAIN0560
    READ(5,20) AMPLTD                                                   MAIN0570
    IF(AMPLTD .EQ. 0.) GO TO 100                                        MAIN0580
    WRITE(6,70)                                                         MAIN0590
 70 FORMAT(' ENTER INITIATION TIME OF WAVE IN SECONDS')                 MAIN0600
    READ(5,20) WAVEON                                                   MAIN0610
    WRITE(6,80)                                                         MAIN0620
 80 FORMAT(' ENTER WAVE FREQUENCY IN RADIANS PER SECOND')               MAIN0630
    READ(5,20) WAVEFR                                                   MAIN0640
    WRITE(6,90)                                                         MAIN0650
 90 FORMAT(' ENTER PHASE SHIFT OF WAVE IN RADIANS')                     MAIN0660
    READ(5,20) WAVEPH                                                   MAIN0670
100 WRITE(6,110)                                                        MAIN0680
110 FORMAT(' ENTER AMPLITUDE GAIN OF NOISE GENERATOR')                  MAIN0690
    READ(5,20) PNOISE                                                   MAIN0700
    IF(PNOISE .EQ. 0.) GO TO 130                                        MAIN0710
    WRITE(6, 120)                                                       MAIN0720
120 FORMAT(' ENTER AN ODD INTEGER')                                     MAIN0730
    READ(5,40) NSEED                                                    MAIN0740
130 CONTINUE                                                            MAIN0750
    WRITE(6,140)                                                        MAIN0760
```

```
  140 FORMAT(' DO YOU WISH TO MODIFY ANY OF THE SCALES FOR THE PLOT VARIMAIN0770
     1ABLES?')                                                          MAIN0780
      READ(5,40) NSCALE                                                 MAIN0790
      IF(NSCALE .EQ. NEGATE) GO TO 150                                  MAIN0800
      CALL PLOTMD                                                       MAIN0810
  150 WRITE(6,270) BLANK                                                MAIN0820
      WRITE(6,160)                                                      MAIN0830
  160 FORMAT(' CLEAR THE SCREEN AND HIT ENTER TO START PRINT ROUTINE')  MAIN0840
      READ(5,260) DUMM3                                                 MAIN0850
      IF(TIME .LT. DELT) GO TO 170                                      MAIN0860
      GO TO 190                                                         MAIN0870
  170 CONTINUE                                                          MAIN0880
      DO 180 L=1,NUNIT                                                  MAIN0890
      PM(L)=PI(L)                                                       MAIN0900
      SP(L)=PI(L)                                                       MAIN0910
  180 PMS(L)=PI(L)                                                      MAIN0920
  190 CONTINUE                                                          MAIN0930
C                                                                       MAIN0940
C                              ----------                               MAIN0950
C                              SIMULATION                               MAIN0960
C                              ----------                               MAIN0970
  200 CALL INERTA                                                       MAIN0980
C                                                                       MAIN0990
C  ------------------------------------------------------------------   MAIN1000
C  *  IF EXTERNAL AREA IS TO BE USED, SET KEXTRN=1 IN COMMON /CURVAL/   MAIN1010
C  *                                                                    MAIN1020
C                                                                       MAIN1030
      IF(KEXTRN .EQ. 1) CALL EXTRNL                                     MAIN1040
C                                                                       MAIN1050
C  ------------------------------------------------                     MAIN1060
C  *  NUNIT IS THE TOTAL NUMBER OF UNITS IN THE MODEL                   MAIN1070
C  *                                                                    MAIN1080
C                                                                       MAIN1090
      DO 210 N=1,NUNIT                                                  MAIN1100
      CALL LDO                                                          MAIN1110
  210 CONTINUE                                                          MAIN1120
      IF(KEEP .NE. 1) GO TO 220                                         MAIN1130
C                                                                       MAIN1140
C  *-------------------------------------------------------------       MAIN1150
C  *  WRITE(11) IS USED TO WRITE DATA ON DISK TO BE PLOTTED LATER       MAIN1160
```

```
C  *  IT IS REFERRED TO AS THE 'PREPAR' CARD IN COMMON /PLOTT/          MAIN1170
C  *                                                                    MAIN1180
C                                                                      MAIN1190
      WRITE(11) TIME,ACE,PMSYS,PMEXT,FREQHZ,PTINET,LOAD,AR             MAIN1200
      NWRITE=NWRITE+1                                                  MAIN1210
  220 CONTINUE                                                         MAIN1220
      IF(KEEP .EQ. 0) GO TO 230                                        MAIN1230
      IF(TIME .LT. CURPRT) GO TO 230                                   MAIN1240
C                                                                      MAIN1250
C  *-----------------------------------------------------------       MAIN1260
C  *  THE PRINT VARIABLES ARE ENTERED AS PAIRS:                       MAIN1270
C  *       VARIABLE NAME,VARIABLE VALUE                               MAIN1280
C  *  PRECISELY SIX PRINT VARIABLES MUST BE CODED PER PRINT CALL.     MAIN1290
C  *  THE LAST VARIABLE TO BE PRINTED IS FOLLOWED BY A BLANK.         MAIN1300
C  *  NO VARIABLE NAME MAY EXCEED EIGHT CHARACTERS.                   MAIN1310
C  *                                                                  MAIN1320
C                                                                      MAIN1330
      CALL PRINT( 'LOAD    ', LOAD    , 'PMSYS   ', PMSYS   ,         MAIN1340
     1            'LODEXT  ', LODEXT  , 'PMEXT   ', PMEXT   ,         MAIN1350
     2            'PACCEL  ', PACCEL  , 'FREQHZ  ', FREQHZ   )        MAIN1360
      CALL PRINT( 'PTINET  ', PTINET  , 'ACEEXT  ', ACEEXT  ,         MAIN1370
     1            'SKDTI   ', SKDTI   , 'ACE     ', ACE     ,         MAIN1380
     2            'AR      ', AR      , 'LAM     ', LAM      )        MAIN1390
      CALL PRINT( 'PM(1)   ', PM(1)   , 'PM(2)   ', PM(2)   ,         MAIN1400
     1            'PM(3)   ', PM(3)   , 'PM(4)   ', PM(4)   ,         MAIN1410
     2            'PM(5)   ', PM(5)   , 'PM(6)   ', PM(6)    )       MAIN1420
      CALL PRINT( 'PM(7)   ', PM(7)   , 'PM(8)   ', PM(8)   ,         MAIN1430
     1            '        ', A       , 'B       ', B       ,         MAIN1440
     2            'C       ', C       , 'D       ', D        )       MAIN1450
C                                                                      MAIN1460
C  *--------------------------------------                           MAIN1470
C  *  CALL OUTPUT WRITES THE PRINT VARIABLES                          MAIN1480
C  *                                                                  MAIN1490
C                                                                      MAIN1500
      CALL OUTPUT                                                      MAIN1510
      CURPRT=CURPRT+PRNTIM                                             MAIN1520
  230 CONTINUE                                                         MAIN1530
      IF(TIME .LE. FINTIM) GO TO 290                                   MAIN1540
  240 WRITE(6,270) BLANK                                               MAIN1550
      WRITE(6,250)                                                     MAIN1560
```

```
250 FORMAT(' CLEAR SCREEN AND HIT ENTER TO START PLOT ROUTINE')       MAIN1570
    READ(5,260) DUMM3                                                MAIN1580
260 FORMAT(1A5)                                                      MAIN1590
    CALL PLOT                                                        MAIN1600
    WRITE(6,270) BLANK                                               MAIN1610
270 FORMAT(2A1)                                                      MAIN1620
    WRITE(6,280)                                                     MAIN1630
280 FORMAT(' DO YOU WISH TO MODIFY ANY OF THE SCALES FOR THE PLOT VARIMAIN1640
   1ABLES AND SEE THE          PLOT AGAIN?')                         MAIN1650
    READ(5,40) NSCALE                                                MAIN1660
    IF(NSCALE .EQ. NEGATE) GO TO 320                                 MAIN1670
    CALL PLOTMD                                                      MAIN1680
    GO TO 240                                                        MAIN1690
290 CONTINUE                                                         MAIN1700
    IF(KEEP .EQ. 1) KEEP=-1                                          MAIN1710
    KEEP=KEEP+1                                                      MAIN1720
    IF(TIME .GT. FINTIM) GO TO 320                                   MAIN1730
    IF(KEEP .EQ. 0)TIME=TIME+DELT                                    MAIN1740

    IF (IERR .EQ. 1) GO TO 300                                       MAIN1750
    GO TO 200                                                        MAIN1760
300 WRITE(6,310)                                                     MAIN1770
310 FORMAT(' SIMULATION TERMINATES DUE TO ERROR')                    MAIN1780
320 WRITE(6,270) BLANK                                               MAIN1790
    WRITE(6,330)                                                     MAIN1800
330 FORMAT(' END OF PROGRAM')                                        MAIN1810
    STOP                                                             MAIN1820
    END                                                              MAIN1830
```

```
INERTA
C ------------------------------------------------------------------- INER0010
C *                                                                   * INER0020
C *                        INERTA- THE INERTIA MODEL                  * INER0030
C *                  A SINGLE SHAFT COMMON FREQUENCY MODEL            * INER0040
C *                                                                   * INER0050
C ------------------------------------------------------------------- INER0060
C                                                                     INER0070
      SUBROUTINE INERTA                                               INER0080
C                                                                     INER0090
      COMMON / CURVAL / TIME  , DELT  , KEEP  , NUNIT , GOTIME, N     , INER0100
     1                  FREQHZ, PM(20), OMEGA , TM    , PMSYS , PMTOT , INER0110
     2                  PELSY , PACCEL, LOAD  , LODTOT, H     , PTINET, INER0120
     3                  PMEXT , LODEXT, OUTE02, SPIEX , OUTIE3, OUTIE4, INER0130
     4                  OUTIE5, OUTIE6, DEDIEX, CEXTO1, CEXTO2, CEXTO3, INER0140
     5                  CEXTO4, CEXTO5, CEXTO6, CEXTO7, CEXTO8, CEXTO9, INER0150
     6                  CEXT10, CEXT11, ACEEXT, OUTE03, OUTE04, OUTE05, INER0160
     7                  PDROP , DEDEXT, PGOVEX, SPEXT , CTIMR , CBIAS , INER0170
     8                  CADD  , CKCR  , KLR   , DUM   , CLSUP , KLP   , INER0180
     9                  CSKEDF, INADV , LAM   , SKDTI , TIMBS , FRQBS , INER0190
     A                  ACE   , AR    , MWNEW , LNEW  , PEC(20)       , INER0200
     B                  SP(20), PEB(20)       , UCE(20)       , UCE1  , INER0210
     C                  PMS(20)       , FINTIM, KEXTRN                  INER0220
C                                                                     INER0230
      REAL*4    INITAL, INADV , INTGRL, KLP   , KLR   , LAM   , LNEW  , INER0240
     1          LOAD  , LODEXT, LODTOT, MWNEW                         INER0250
C                                                                     INER0260
      ISUB=1                                                          INER0270
C                                                                     INER0280
C *-------------------------------------------------------------*     INER0290
C *  ISUB IS A SUBROUTINE INDEX NUMBER.  EVERY SUBROUTINE THAT       INER0300
C *       USES EITHER A DELAY OR AN INTGRL FUNCTION MUST HAVE A       INER0310
C *       UNIQUE SUBROUTINE INDEX NUMBER.  THIS NUMBER IS USED        INER0320
C *       FOR INDEXING THE DELAY AND INTGRL FUNCTIONS.  SEE COMMENTS  INER0330
C *       IN EITHER THE DELAY OR INTGRL FUNCTION SUBROUTINES FOR      INER0340
C *       FURTHER DETAILS.                                            INER0350
C *                                                                   INER0360
C                                                                     INER0370
C                                                                     INER0380
C                                                                     INER0390
      HTOT=0.                                                         INER0400
      IF(KEXTRN .EQ. 1) HTOT=340000.                                  INER0410
```

```
      PMSYS=0.                                                          INER0420
      HTOT=HTOT+H                                                       INER0430
      DO 10 L=1,NUNIT                                                   INER0440
   10 PMSYS=PMSYS+PM(L)                                                 INER0450
      CALL LOADER                                                       INER0460
      PACCEL=PMSYS-LOAD+PMEXT-LODEXT                                    INER0470
      IF (TIME .LT. DELT) OMEGAO=OMEGA                                  INER0480
      OMEGA=INTGRL(ISUB,0,1,OMEGAO,PACCEL/(OMEGA*2.*HTOT),OMEGA)        INER0490

C                                                                       INER0500
C  *-------------------------------------------------------------       INER0510
C  *  THE CALLING FORMAT FOR THE INTGRL FUNCTION SUBROUTINE IS:        INER0520
C  *   INTGRL(ISUB,KUNIT,KINGRL,INITIAL CONDITION,INPUT,OUTPUT)        INER0530
C  *  SEE COMMENTS IN THE INTGRL FUNCTION SUBROUTINE FOR FURTHER       INER0540
C  *       DETAILS.                                                    INER0550
C  *                                                                   INER0560
C                                                                       INER0570
      FREQHZ=60.*OMEGA                                                  INER0580
      PELSY=PMSYS-PACCEL*H/HTOT                                         INER0590
      PTINET=PELSY-LOAD                                                 INER0600
      RETURN                                                            INER0610
      END                                                               INER0620
```

```
LOADER C ------------------------------------------------------------------ LOAD0010
       C *                                                                  * LOAD0020
       C *                        LOADER- A LOAD MODEL                      * LOAD0030
       C *              THIS SUBROUTINE IS USED TO INPUT SYSTEM LOAD        * LOAD0040
       C *              EITHER AS DATA (THIS CASE) OR BY INSERTING A        * LOAD0050
       C *                           LOAD MODEL                             * LOAD0060
       C *                                                                  * LOAD0070
       C ------------------------------------------------------------------ LOAD0080
       C                                                                    LOAD0090
            SUBROUTINE LOADER                                               LOAD0100
       C                                                                    LOAD0110
            COMMON / CURVAL / TIME  , DELT  , KEEP  , NUNIT , GOTIME, N     , LOAD0120
           1                  FREQHZ, PM(20), OMEGA , TM    , PMSYS , PMTOT , LOAD0130
           2                  PELSY , PACCEL, LOAD  , LODTOT, H     , PTINET, LOAD0140
           3                  PMEXT , LODEXT, OUTE02, SPIEX , OUTIE3, OUTIE4, LOAD0150
           4                  OUTIE5, OUTIE6, DEDIEX, CEXT01, CEXT02, CEXT03, LOAD0160
           5                  CEXT04, CEXT05, CEXT06, CEXT07, CEXT08, CEXT09, LOAD0170
           6                  CEXT10, CEXT11, ACEEXT, OUTE03, OUTE04, OUTE05, LOAD0180
           7                  PDROP , DEDEXT, PGOVEX, SPEXT , CTIMR , CBIAS , LOAD0190
           8                  CADD  , CKCR  , KLR   , DUM   , CLSUP , KLP   , LOAD0200
           9                  CSKEDF, INADV , LAM   , SKDTI , TIMBS , FRQBS , LOAD0210
           A                  ACE   , AR    , MWNEW , LNEW  , PEC(20)       , LOAD0220
           B                  SP(20), PEB(20)       , UCE(20)       , UCE1  , LOAD0230
           C                  PMS(20)       , FINTIM, KEXTRN, PFREQ , AMPLTD, LOAD0240
           D                  WAVEON, WAVEFR, WAVEPH, PNOISE, NSEED , MU    , LOAD0250
           E                  SIGMA                                         LOAD0260
       C                                                                    LOAD0270
            REAL*4    MIN   , LOAD  , MU    , NOISE                       LOAD0280
       C                                                                    LOAD0290
            DATA JUMP1/0/                                                   LOAD0300
       C                                                                    LOAD0310
            ISUB=2                                                          LOAD0320
       C                                                                    LOAD0330
       C                                                                    LOAD0340
       C                                                                    LOAD0350
            IF(KEEP .EQ. 0 .AND. TIME .GE. TM) GO TO 10                     LOAD0360
            GO TO 40                                                        LOAD0370
         10 CONTINUE                                                        LOAD0380
            BLOAD=ALOAD                                                     LOAD0390
         20 READ(10) HR,MIN,SEC,ALOAD                                       LOAD0400
            TM=HR*3600.+MIN*60.+SEC-GOTIME                                  LOAD0410
```

```
      IF(JUMP1 .NE. 0) GO TO 30                                          LOAD0420
      BLOAD=ALOAD                                                        LOAD0430
      JUMP1=1                                                            LOAD0440
   30 CONTINUE                                                           LOAD0450
      IF(TM .LE. 0.) GO TO 20                                            LOAD0460
   40 IF(KEEP .NE. 0) GO TO 50                                           LOAD0470
      LOAD=BLOAD                                                         LOAD0480
C                                                                        LOAD0490

C  *-----------------------------------------------------------------    LOAD0500
C  *  SKIP THE VARIATIONS IN LOAD IF NO FREQUENCY FEEDBACK, NOISE,       LOAD0510
C  *       OR SINUSOIDAL WAVES ARE USED.                                 LOAD0520
C  *                                                                     LOAD0530
C                                                                        LOAD0540
      IF(PFREQ.EQ.0. .AND. AMPLTD.EQ.0. .AND. PNOISE.EQ.0.) GO TO 50     LOAD0550
C                                                                        LOAD0560
C     ***************************************************************    LOAD0570
C     *                                                             *    LOAD0580
C     *    VARIATIONS IN LOAD SHOULD BE ADDED TO THE FOLLOWING LINE *    LOAD0590
C     *     BY ADJUSTING LOADER MODEL PARAMETERS IN COMMON /CURVAL/ *    LOAD0600
C     *                                                             *    LOAD0610
C     ***************************************************************    LOAD0620
C                                                                        LOAD0630
      LOAD=BLOAD*(1.+PFREQ*(FREQHZ-CSKEDF))+AMPLTD*SINE(WAVEON,WAVEFR,   LOAD0640
     1      WAVEPH)+PNOISE*NOISE(NSEED,MU,SIGMA)                         LOAD0650
   50 RETURN                                                             LOAD0660
      END                                                                LOAD0670
```

```
EXTRNL
C ------------------------------------------------------------------- EXTR0010
C *                                                                   * EXTR0020
C *                    EXTRNL- AN EXTERNAL AREA MODEL                 * EXTR0030
C *                  ONE LUMPED (50000 MW) AGC CONTROLLED             * EXTR0040
C *                       BOILER-TURBINE-GENERATOR                    * EXTR0050
C *                                                                   * EXTR0060
C ------------------------------------------------------------------- EXTR0070
C                                                                     EXTR0080
      SUBROUTINE EXTRNL                                               EXTR0090
C                                                                     EXTR0100
      COMMON / CURVAL / TIME  , DELT  , KEEP  , NUNIT , GOTIME, N     , EXTR0110
     1                  FREQHZ, PM(20), OMEGA , TM    , PMSYS , PMTOT , EXTR0120
     2                  PELSY , PACCEL, LOAD  , LODTOT, H     , PTINET, EXTR0130
     3                  PMEXT , LODEXT, OUTE02, SPIEX , OUTIE3, OUTIE4, EXTR0140
     4                  OUTIE5, OUTIE6, DEDIEX, CEXT01, CEXT02, CEXT03, EXTR0150
     5                  CEXT04, CEXT05, CEXT06, CEXT07, CEXT08, CEXT09, EXTR0160
     6                  CEXT10, CEXT11, ACEEXT, OUTE03, OUTE04, OUTE05, EXTR0170
     7                  PDROP , DEDEXT, PGOVEX, SPEXT , CTIMR , CBIAS , EXTR0180
     8                  CADD  , CKCR  , KLR   , DUM   , CLSUP , KLP   , EXTR0190
     9                  CSKEDF, INADV , LAM   , SKDTI , TIMBS , FRQBS , EXTR0200
     A                  ACE   , AR    , MWNEW , LNEW  , PEC(20)       , EXTR0210
     B                  SP(20), PEB(20)       , UCE(20)       , UCE1  , EXTR0220
     C                  PMS(20)       , FINTIM, KEXTRN                  EXTR0230
C                                                                     EXTR0240
      REAL*4     INADV , INTGRL, KLP   , KLR   , LAM   , LNEW  , LOAD  , EXTR0250
     1           LODEXT, LODTOT, MWNEW                                 EXTR0260
C                                                                     EXTR0270
      ISUB=3                                                          EXTR0280
C                                                                     EXTR0290
C                                                                     EXTR0300
C                                                                     EXTR0310
      PTIE=-1.*PTINET                                                 EXTR0320
C                                                                     EXTR0330
C  *-------------------------------------------------                 EXTR0340
C  *  PTIE IS THE EXTERNAL TIE FLOW                                  EXTR0350
C  *       SIGN CONVENTION:  __ INTO EXTERNAL SYSTEM IS -            EXTR0360
C  *                         __ OUT OF EXTERNAL SYSTEM IS +          EXTR0370
C  *                                                                 EXTR0380
C                                                                     EXTR0390
      SKEDTX=AFGEN(TIME,NUNIT+1)                                      EXTR0400
```

```
      ACEEXT=PTIE-SKEDTX-CEXT01*10.*(FREQHZ-CSKEDF)                    EXTR0410
      IF(KEEP .EQ. 0 .AND. TIME .EQ. 0.) OUTE02=ACEEXT                 EXTR0420
      OUTE02=ACEEXT*(DELT/(DELT+3.))+(3./(DELT+3.))*                   EXTR0430
     1       DELAY(ISUB,0,1,1,DELT,OUTE02)                             EXTR0440
C                                                                      EXTR0450
C  *-----------------------------------------------------------------  EXTR0460
C  *  THE CALLING FORMAT FOR THE DELAY FUNCTION SUBROUTINE IS:        EXTR0470
C  *     DELAY(ISUB,KUNIT,IDLAY,# SAMPLED POINTS,DELAY TIME,INPUT)    EXTR0480
C  *  SEE COMMENTS IN THE DELAY FUNCTION SUBROUTINE FOR FURTHER        EXTR0490

C  *       DETAILS.                                                    EXTR0500
C  *                                                                   EXTR0510
C                                                                      EXTR0520
      SPEXT=INTGRL(ISUB,0,1,SPIEX,CEXT02*OUTE02,SPEXT)                 EXTR0530
      PGOVEX=SPEXT-(CEXT11/60.)*(FREQHZ-CSKEDF)                        EXTR0540
      IF(KEEP .EQ. 0) GO TO 60                                         EXTR0550
      A=PGOVEX-DEDIEX                                                  EXTR0560
      IF(TIME .GE. DELT) GO TO 10                                      EXTR0570
      T1=CEXT03                                                        EXTR0580
      T2=CEXT03                                                        EXTR0590
      CDBEXT=T1+T2                                                     EXTR0600
   10 IF(A-T1) 20, 50, 40                                              EXTR0610
   20 IF(A-T2) 30, 50, 50                                              EXTR0620
   30 T2=A                                                             EXTR0630
      T3=A+CDBEXT/2.                                                   EXTR0640
      T1=A+CDBEXT                                                      EXTR0650
      GO TO 50                                                         EXTR0660
   40 T1=A                                                             EXTR0670
      T2=A-CDBEXT                                                      EXTR0680
      T3=A-CDBEXT/2.                                                   EXTR0690
   50 A=T3                                                             EXTR0700
      DEDEXT=A+DEDIEX                                                  EXTR0710
   60 CONTINUE                                                         EXTR0720
      PDROP=-(CEXT04*DEDEXT+OUTE03)                                    EXTR0730
      OUTE04=INTGRL(ISUB,0,2,OUTIE4,CEXT08*PDROP,OUTE04)               EXTR0740
      OUTE05=INTGRL(ISUB,0,3,OUTIE5,((CEXT07*PDROP+OUTE04)-OUTE05)/    EXTR0750
     1       CEXT06,OUTE05)                                            EXTR0760
      OUTE03=INTGRL(ISUB,0,4,OUTIE3,((1.-CEXT04)*(DEDEXT+OUTE05)       EXTR0770
     1       -OUTE03)/CEXT05,OUTE03)                                   EXTR0780
      OUTE07=DEDEXT+PDROP                                              EXTR0790
```

```
PMEXT1=INTGRL(ISUB,0.5,OUTIE6,(1./CEXT10)*(OUTE07-PMEXT),PMEXT1)   EXTR0800
PMEXT=CEXT09*OUTE07+PMEXT1                                         EXTR0810
RETURN                                                             EXTR0820
END                                                                EXTR0830
```

```
LDD
C ------------------------------------------------------------------ LD000010
C *                                                                  * LD000020
C *                  LDD- LOAD DISPATCH OFFICE MODELS                * LD000030
C *                                                                  * LD000040
C ------------------------------------------------------------------ LD000050
C                                                                     LD000060
      SUBROUTINE LDD                                                  LD000070
C                                                                     LD000080
      COMMON / CURVAL / TIME  , DELT  , KEEP  , NUNIT , GOTIME, N     , LD000090
     1                  FREQHZ, PM(20), OMEGA , TM    , PMSYS , PMTOT , LD000100
     2                  PELSY , PACCEL, LOAD  , LODTOT, H     , PTINET, LD000110
     3                  PMEXT , LODEXT, OUTE02, SPIEX , OUTIE3, OUTIE4, LD000120
     4                  OUTIE5, OUTIE6, DEDIEX, CEXT01, CEXT02, CEXT03, LD000130
     5                  CEXT04, CEXT05, CEXT06, CEXT07, CEXT08, CEXT09, LD000140
     6                  CEXT10, CEXT11, ACEEXT, OUTE03, OUTE04, OUTE05, LD000150
     7                  PDROP , DEDEXT, PGOVEX, SPEXT , CTIMR , CBIAS , LD000160
     8                  CADD  , CKCR  , KLR   , DUM   , CLSUP , KLP   , LD000170
     9                  CSKEDF, INADV , LAM   , SKDTI , TIMBS , FRQBS , LD000180
     A                  ACE   , AR    , MWNEW , LNEW  , PEC(20)       , LD000190
     B                  SP(20), PEB(20)       , UCE(20)       , UCE1  , LD000200
     C                  PMS(20)       , FINTIM, KEXTRN                  LD000210
      COMMON / INITAL / PI(20), UNTYPE(20)    , MWR(20)                 LD000220
      COMMON / CONST1 / CLDD(4)       , CO1(20)       , CO2(20)       , LD000230
     1                  CO3(20)       , CO4(20)       , CO5(20)         LD000240
C                                                                     LD000250
      DIMENSION C2MCD(20)     , C2MODO(20)    , SPR1(20)      ,       LD000260
     1          SPR2(20)      , NUMBER(20)                            LD000270
C                                                                     LD000280
      REAL*4    INADV , INITAL, INTGRL, KLP   , KLR   , LAM   , LCHNGI, LD000290
     1          LIMIT , LL101 , LL102 , LNEW  , LOAD  , LODEXT, LODTOT, LD000300
     2          LOLD1 , LRSET1, LRSET , MW    , MWNEW , MWOLD1, MWR   , LD000310
     3          MW1                                                   LD000320
C                                                                     LD000330
      DATA JUMP/0/                                                    LD000340
C                                                                     LD000350
      ISUB=4                                                          LD000360
C                                                                     LD000370
C                                                                     LD000380
C                                                                     LD000390
C                              -------------                          LD000400
```

```
C                              INITIALIZATION                                   LD000410
C                              --------------                                   LD000420
C                                                                               LD000430
      IF(JUMP .EQ. 1) GO TO 20                                                  LD000440
      N1=0                                                                      LD000450
      N2=0                                                                      LD000460
      N3=0                                                                      LD000470
      N4=0                                                                      LD000480
      DO 10 M=1,NUNIT                                                           LD000490

      PEB(M)=0.                                                                 LD000500
      C2MOD(M)=0.                                                               LD000510
      C2MODD(M)=0.                                                              LD000520
      IF(UNTYPE(M) .EQ. 1.) N1=N1+1                                             LD000530
      IF(UNTYPE(M) .EQ. 1.) NUMBER(M)=N1                                        LD000540
      IF(UNTYPE(M) .EQ. 2.) N2=N2+1                                             LD000550
      IF(UNTYPE(M) .EQ. 2.) NUMBER(M)=N2                                        LD000560
      IF(UNTYPE(M) .EQ. 3.) N2=N2+1                                             LD000570
      IF(UNTYPE(M) .EQ. 3.) NUMBER(M)=N2                                        LD000580
      IF(UNTYPE(M) .EQ. 4.) N2=N2+1                                             LD000590
      IF(UNTYPE(M) .EQ. 4.) NUMBER(M)=N2                                        LD000600
      IF(UNTYPE(M) .EQ. 5.) N3=N3+1                                             LD000610
      IF(UNTYPE(M) .EQ. 5.) NUMBER(M)=N3                                        LD000620
      IF(UNTYPE(M) .EQ. 6.) N4=N4+1                                             LD000630
      IF(UNTYPE(M) .EQ. 6.) NUMBER(M)=N4                                        LD000640
      IF(UNTYPE(M) .EQ. 7.) N2=N2+1                                             LD000650
      IF(UNTYPE(M) .EQ. 7.) NUMBER(M)=N2                                        LD000660
      IF(UNTYPE(M) .EQ. 8.) N2=N2+1                                             LD000670
      IF(UNTYPE(M) .EQ. 8.) NUMBER(M)=N2                                        LD000680
   10 JUMP=1                                                                    LD000690
   20 CONTINUE                                                                  LD000700
C                                                                               LD000710
C  *-------------------------------------------------------------------         LD000720
C  *  UNTYPE(M) IS THE ACRONYM FOR THE UNIT TYPE OF UNIT M                      LD000730
C  *  NUMBER(M) IS THE SEQUENTIAL NUMBER FOR UNIT M WITHIN A GIVEN              LD000740
C  *        UNIT TYPE  (NUCLEAR, BOILER, HYDRO, GAS TURBINE)                    LD000750
C  *  N1= THE TOTAL NUMBER OF NUCLEAR UNITS                                     LD000760
C  *  N2= THE TOTAL NUMBER OF BOILER UNITS                                      LD000770
C  *  N3= THE TOTAL NUMBER OF HYDRO UNITS                                       LD000780
C  *  N4= THE TOTAL NUMBER OF GAS TURBINES                                      LD000790
C  *                                                                            LD000800
```

```
C                                                                       LD000810
C                                                                       LD000820
C  *-------------------------------------------------------------       LD000830
C  *  CALCULATION OF THE REGULATION SIGNAL (AR) AND COST SIGNAL (LAM)    LD000840
C  *      IS PERFORMED ONLY DURING THE FIRST PASS FOR THE FIRST UNIT     LD000850
C  *      (N EQUAL 1) FOR EACH TIME STEP                                 LD000860
C  *                                                                     LD000870
C                                                                       LD000880
C                          ----------------                             LD000890
C                          CALCULATION OF AR                            LD000900
C                          ----------------                             LD000910
C                                                                       LD000920
      IF(N.NE.1) GO TO 140                                              LD000930
      IF(KEEP .EQ. 1) GO TO 30                                          LD000940
      TIOLD1=PTITM                                                      LD000950
      IF(TIME.LE.DELT) TIOLD1=PTINET                                    LD000960
   30 PTITM=(DELT/(DELT+CLDO(4)))*PTINET+(CLDO(4)/(DELT+CLDO(4)))*      LD000970
     1     TIOLD1                                                       LD000980

      SKDTI=AFGEN(TIME,NUNIT+2)                                         LD000990
      DTFLO=PTITM-SKDTI                                                 LD001000
      TIMER=INTGRL(ISUB,0,1,0.,(FREQHZ-CSKEDF)/60.,TIMER)               LD001010
      TIMBS=0.                                                          LD001020
C                                                                       LD001030
C  *-------------------------------------------------------------       LD001040
C  *  INADV IS THE INADVERTANT INTERCHANGE OF ENERGY.  IT ACTS AS A     LD001050
C  *        SWITCH AND IF EXCEEDED THE ALGORITHM CALCULATES THE TIME    LD001060
C  *        BIAS  (TIMBS)                                              LD001070
C  *                                                                   LD001080
C                                                                       LD001090
      IF(TIMER.GT.0..AND.INADV.LT.0.) GO TO 40                          LD001100
      IF(TIMER.LT.0..AND.INADV.GT.0.) GO TO 40                          LD001110
      GO TO 50                                                          LD001120
   40 TIMBS=CTIMR*TIMER                                                 LD001130
   50 FRQBS=CBIAS*10.*(FREQHZ-CSKEDF)                                   LD001140
C                                                                       LD001150
C  *-----------------------------                                       LD001160
C  *  - ACE MEANS UNDERGENERATION                                      LD001170
C  *  + ACE MEANS OVERGENERATION                                       LD001180
C  *                                                                   LD001190
C                                                                       LD001200
```

```
      ACE=DTFLO-FRGBS+CADD-TIMBS                                        LD001210
      IF(KEEP .EQ. 1) GO TO 60                                          LD001220
      FDBAK1=AR                                                         LD001230
   60 AR=LIMIT(-75.,75.,ACE*CKCR+(1.-CKCR)*FDBAK1)                      LD001240
      IF(KEEP .EQ. 1) GO TO 70                                          LD001250
      MWOLD1=MWNEW                                                      LD001260
      IF(TIME.LT.DELT) MWOLD1=PMSYS                                     LD001270
   70 MWNEW=MWOLD1-AR                                                   LD001280
      IF(TIME.LT.DELT) LOLD1=LNEW                                       LD001290
      IF(KEEP .EQ. 1) GO TO 80                                          LD001300
      LOLD1=LNEW                                                        LD001310
C                                                                       LD001320
C  *--------------------------------------------                        LD001330
C  *  SLOPE OF 650. MW/MIL FOR STEAM GENERATION                        LD001340
C  *                                                                   LD001350
C                                                                       LD001360
   80 LNEW=MWNEW/650.                                                   LD001370
C                                                                       LD001380
C                                                                       LD001390
C                          -----------------                            LD001400
C                          CALCULATION OF LAM                           LD001410
C                          -----------------                            LD001420
C                                                                       LD001430
C  *-----------------------------------------------------------------   LD001440
C  *  CALCULATION OF COMPANY STARTING COST SIGNAL (LAM) BASED ON        LD001450
C  *          AVAILABLE GENERATION LEVEL (PELSY)                       LD001460
C  *                                                                   LD001470

C                                                                       LD001480
      IF(TIME .EQ. 0. .AND. KEEP .EQ. 0) GO TO 90                       LD001490
      GO TO 120                                                         LD001500
   90 CONTINUE                                                          LD001510
      MW=0.                                                             LD001520
      LAM=1.                                                            LD001530
  100 MW=0.                                                             LD001540
      DO 110 M=1,NUNIT                                                  LD001550
      MW1=AFGEN(LAM,M)                                                  LD001560
  110 MW=MW+MW1                                                         LD001570
      IF(MW.GE.PELSY) GO TO 120                                         LD001580
      LAM=LAM+1.                                                        LD001590
      GO TO 100                                                         LD001600
```

```
0074          120 CONTINUE                                                          LD001610
0075              LCHNG1=LNEW-LOLD1                                                 LD001620
0076              IF(TIME .LT. DELT) LCHNG1=0.                                      LD001630
0077              IF(KEEP .EQ. 1) GO TO 130                                         LD001640
0078              LRSET1=LRSET                                                      LD001650
0079              IF(TIME.LT.DELT) LRSET1=LAM                                       LD001660
0080          130 LRSET=LRSET1+KLR*LCHNG1+CLSUP                                     LD001670
0081              LAM=LRSET+KLP*LCHNG1                                              LD001680
0082              LL101=DELAY(ISUB,0,1,1,DELT,LAM)                                  LD001690
0083              LL102=LIMIT(-CLDD(3),CLDD(3),LAM-LL101)                           LD001700
0084              LAM=LIMIT(CLDD(1),CLDD(2),LL102+LL101)                            LD001710
                C                                                                   LD001720
                C                          ------------------                       LD001730
                C                          GOVERNOR CONTROLLER                      LD001740
                C                          ------------------                       LD001750
                C                                                                   LD001760
0085          140 PEC(N)=AFGEN(LAM,N)                                               LD001770
0086              PMS(N)=PM(N)*(DELT/(DELT+CO3(N)))+(CO3(N)/(DELT+CO3(N)))*         LD001780
                 1       DELAY(ISUB,N,2,1,DELT,PMS(N))                            LD001790
0087              UCE(N)=PEC(N)-CO2(N)*AR-PMS(N)                                    LD001800
0088              UCE1=UCE(N)                                                       LD001810
0089              IF(UNTYPE(N) .EQ. 2. .OR. UNTYPE(N) .EQ. 3.) UCE(N)=UCE(N)-PEB(N) LD001820
0090              C2MOD(N)=INTGRL(ISUB,N,2,C2MODO(N),UCE(N),C2MOD(N))               LD001830
0091              SPR1(N)=CO4(N)*UCE(N)+CO5(N)*C2MOD(N)                             LD001840
0092              SPR2(N)=LIMIT(-CO1(N),CO1(N),SPR1(N))                             LD001850
                C                                                                   LD001860
                C  ################## UNIT GENERATION CHANGE ######################  LD001870
                C  #       THIS SPACE ALLOCATED FOR SPECIFYING TURBINE TRIPS OR     #  LD001880
                C  #                  PRIME MOVERS COMING ON LINE                   #  LD001890
                C  ##############################################################  LD001900
                C                                                                   LD001910
0093              SP(N)=INTGRL(ISUB,N,3,PI(N),SPR2(N),SP(N))                        LD001920
0094              IF(SP(N).LT.0.) SP(N)=0.                                          LD001930
0095              IF(SP(N).GE.MWR(N)) SP(N)=MWR(N)                                  LD001940
                C                                                                   LD001950
                C  *----------------------------------------------------------------- LD001960

                C  *  PI(N)      INITIAL POWER FROM UNIT N                          LD001970
                C  *  SP(N)      THE GOVERNOR SET POINT FOR UNIT N                  LD001980
                C  *  PM(N)      THE MECHANICAL POWER FROM UNIT N                   LD001990
                C  *  PEB(N)     THE PRESSURE ERROR BIAS SETTING USED WITH ONCE-THROUGH LD002000
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C  *              UNITS THAT HAVE AN INTEGRATED BOILER-TURBINE CONTROLLER LD002010
C  *  PMS(N)      SENSED MECHANICAL POWER(TELEMETERED) FOR UNIT N          LD002020
C  *  C2MOD(N)    OUTPUT OF THE DIAT (THREE MODE CONTROLLER) INTEGRATOR    LD002030
C  *              FOR UNITS THAT HAVE THESE CONTROLLERS                    LD002040
C  *  C2MODO(N)   INITIAL CONDITION OF THE DIAT INTEGRATOR FOR UNIT N      LD002050
C  *  SPR2(N)     GOVERNOR SET POINT RATE (INPUT TO GOVERNOR MOTOR) FOR    LD002060
C  *              UNIT N                                                   LD002070
C  *  SPLAST(N)   LAST VALUE OF THE GOVERNOR MOTOR SET POINT FOR UNIT N    LD002080
C  *  SPR1(N)     OUTPUT OF THE CONTROLLER (E.G. A DIAT IF USED) FOR       LD002090
C  *              UNIT N.  IT COULD BE  1.*UCE(N)  IN THE ABSENCE OF A     LD002100
C  *              CONTROLLER.                                              LD002110
C  *  PEC(N)      POWER REQUIREMENT THAT RESULTS FROM THE ECONOMIC CURVE   LD002120
C  *              FOR UNIT N                                               LD002130
C  *  UCE(N)      UNIT CONTROL ERROR FOR UNIT N.  UCE= PEC+AR-PMS          LD002140
C  *                                                                       LD002150
C                                                                          LD002160
C                          ----------------------                          LD002170
C                          GO TO PRIME MOVER MODEL                         LD002180
C                          ----------------------                          LD002190
C                                                                          LD002200
      ITYPE=UNTYPE(N)                                                      LD002210
      GO TO ( 150, 160, 160, 150, 170, 180, 160, 160 ), ITYPE              LD002220
  150 CALL NUCLER(CSKEDF,OMEGA,SP(N),PM(N),NUMBER(N),N)                    LD002230
      GO TO 190                                                            LD002240
  160 IF(KEEP .NE. 1) GO TO 190                                            LD002250
      CALL BOILER(CSKEDF,OMEGA,SP(N),PM(N),NUMBER(N),ITYPE,                LD002260
     1     UCE(N),N,PEB(N),UCE1)                                           LD002270
      GO TO 190                                                            LD002280
  170 CALL HYDRO(CSKEDF,OMEGA,SP(N),PM(N),NUMBER(N),N)                     LD002290
      GO TO 190                                                            LD002300
  180 CALL GASTUB(CSKEDF,OMEGA,SP(N),PM(N),NUMBER(N),N)                    LD002310
  190 CONTINUE                                                             LD002320
C                                                                          LD002330
C  *-------------------------------------------------------               LD002340
C  *  ITYPE IS UNIT TYPE                                                   LD002350
C *                                                                        LD002360
C  *  1---NUCLEAR UNIT                                                     LD002370
C  *  2,3,4,7,8---BOILER UNITS                                             LD002380
C  *           2---SUPERCRITICAL ONCE THROUGH UNIT                         LD002390
C  *           3---SUBCRITICAL ONCE THROUGH UNIT                           LD002400
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C   *          4---DRUM TYPE UNIT, OIL FIRED                          LDD02410
C   *          7---DRUM TYPE UNIT, COAL FIRED                         LDD02420
C   *          8---DRUM TYPE UNIT, NON-REHEAT                         LDD02430
C   *  5---HYDRO UNIT                                                 LDD02440
C   *  6---GAS TURBINE UNIT                                           LDD02450
 C                                                                     LDD02460
       RETURN                                                         LDD02470
       END                                                            LDD02480
```

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BOILER  C ------------------------------------------------------------------ BOIL0010
        C *                                                                  * BOIL0020
        C *                S U B R O U T I N E   B O I L E R                 * BOIL0030
        C *                                                                  * BOIL0040
        C ------------------------------------------------------------------ BOIL0050
        C                                                                    BOIL0060
              SUBROUTINE BOILER(CSKEDF,OMEGA,SPYS,PMYS,NUMBER,ITYPE,UCE,     BOIL0070
             1           N,PEB,UCE1)                                         BOIL0080
        C                                                                    BOIL0090
              COMMON / CURVAL / TIME  , DELT  , KEEP                         BOIL0100
              COMMON / BOILRS / HUNTI(150)                                   BOIL0110
              COMMON / PASSES / KONT  , AEEP                                 BOIL0120
              COMMON / INITAL / DUMMY(40)     , MWR(20)                      BOIL0130
              COMMON / PRTCNL / ICOUNT, TLAST , SYMBOL, VALUE , LINES , IPAGES BOIL0140
        C                                                                    BOIL0150
              DIMENSION HUNT(1340)                                           BOIL0160
        C                                                                    BOIL0170
              REAL*4    INTGRL, LIMIT , LOODEM, MWR                        BOIL0180
              REAL*4    VALUE(44)                                          BOIL0190
              REAL*8    SYMBOL(44)                                         BOIL0200
        C                                                                    BOIL0210
              ISUB=5                                                         BOIL0220
        C                                                                    BOIL0230
        C                                                                    BOIL0240
        C                                                                    BOIL0250
        C     THE ARRAY HUNTI IS THE DATA STORAGE AREA USED TO STORE THE     BOIL0260
        C          PARAMETERS FOR THE 5 TYPES OF BOILER UNITS.  IT IS       BOIL0270
        C          DIMENSIONED FOR 5 TYPES OF UNITS AT 30 VARIABLES PER     BOIL0280
        C          UNIT.  NOT TO BE CHANGED.                                BOIL0290
        C                                                                    BOIL0300
        C     THE ARRAY HUNT IS THE WORKING AREA REPRESENTING THE DYNAMIC    BOIL0310
        C          EQUATIONS FOR EACH BOILER UNIT.  IT IS DIMENSIONED FOR   BOIL0320
        C          20 UNITS AT 67 VARIABLES PER UNIT.                       BOIL0330
        C                                                                    BOIL0340
        C     SUBROUTINE BOILER IS DESIGNED TO REPRESENT 5 TYPES OF BOILER   BOIL0350
        C          UNITS.  THE TYPE OF UNIT IS TRIGGERED BY ITYPE WHICH IS  BOIL0360
        C          EQUIVALENT TO UNTYPE.                                    BOIL0370
        C                                                                    BOIL0380
        C           ---------------- KEY TO ITYPE ----------------           BOIL0390
        C                                                                    BOIL0400
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C            ITYPE=  2  SUPERCRITICAL ONCE THROUGH                          BOIL0410
C                    3  SUBCRITICAL ONCE THROUGH                            BOIL0420
C                    4  OIL FIRED DRUM                                      BOIL0430
C                    7  COAL FIRED DRUM                                     BOIL0440
C                    8  NONREHEAT DRUM                                      BOIL0450
C                                                                           BOIL0460
C      THIS SUBROUTINE IS ON A HALF SECOND INTEGRATION STEP FOR             BOIL0470
C           NUMERICAL STABILITY.  THE FUNCTION SUBROUTINE INTGRL            BOIL0480
C           AUTOMATICALLY USES A .5 SECOND INTEGRATION STEP SIZE            BOIL0490

C           BY CHECKING THE VALUE OF ISUB TO DETERMINE WHEN INTEGRALS       BOIL0500
C           FROM BOILER ARE BEING UPDATED.  THE COUNTER KONT CONTROLS       BOIL0510
C           THE NUMBER OF PASSES THROUGH BOILER AND THEREBY ENSURES         BOIL0520
C           THAT BOILER INTEGRALS ARE PROPERLY UPDATED.                     BOIL0530
C                                                                           BOIL0540
C                                                                           BOIL0550
C      HUNT(L)=T1SY         DEADBAND UPPER VALUE                 -- MW     BOIL0560
C      HUNT(L+1)=T2SY       DEADBAND LOWER VALUE                 -- MW     BOIL0570
C      HUNT(L+2)=T3SY       OUTPUT OF DEADBAND                   -- MW     BOIL0580
C      HUNT(L+3)=CYS01      UNIT MW RATING                       -- MW     BOIL0590
C      HUNT(L+4)=CYS02      SPEED DROOP                          -- MW/HZ  BOIL0600
C      HUNT(L+5)=CYS03      DEADBAND WIDTH                       -- MW     BOIL0610
C      HUNT(L+6)=           OUTPUT OF DEADBAND                   -- MW     BOIL0620
C      HUNT(L+7)=CYS04      K, FIRST STAGE PRESSURE FEEDBACK               BOIL0630
C      HUNT(L+8)=XLAST                                                     BOIL0640
C      HUNT(L+9)=STMFLO     STEAM FLOW                           -- P.U.   BOIL0650
C      HUNT(L+10)=CYS05     PRESSURE SETPOINT (THROTTLE),        -- P.U.   BOIL0660
C      HUNT(L+11)=CYS06     INITIAL PRESSURE LIMITER SETPOINT    -- P.U.   BOIL0670
C      HUNT(L+12)=          BOILER CONTROLLER COMPENSATION RATIO           BOIL0680
C      HUNT(L+13)=K(IPL)    CYS07, INITIAL PRESSURE LIMITER CONSTANT       BOIL0690
C      HUNT(L+14)=CYS08     LOAD LIMIT                           -- MW     BOIL0700
C      HUNT(L+15)=CVDEM     CONTROL VALVE DEMAND                           BOIL0710
C      HUNT(L+16)=          LEG CONTAINING K(IPL),INPUT TO LOW VALVE GATE  BOIL0720
C      HUNT(L+17)=          INPUT AND OUTPUT TO RATE LIMIT                 BOIL0730
C      HUNT(L+18)=CVAREA    CONTROL VALVE AREA                             BOIL0740
C      HUNT(L+19)=CYS09     YALLOW, VALVE OPENING TRAVEL TIME INVERSE      BOIL0750
C      HUNT(L+20)=CYS10     BALLOW, VALVE CLOSING TRAVEL TIME INVERSE      BOIL0760
C      HUNT(L+21)=T(RH)     CYS12                                          BOIL0770
C      HUNT(L+22)=F         CYS11, PERCENT POWER FROM NON-REHEAT TURBINE   BOIL0780
C      HUNT(L+23)=TMYS      TURBINE OUTPUT                       -- P.U.   BOIL0790
C      HUNT(L+24)=          OUTPUT OF REHEAT TURBINE INTEGRATOR            BOIL0800
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C     HUNT(L+25)=          INITIAL CONDITION FOR INTEGRATOR NO. 1          BOIL0810
C     HUNT(L+26)=PMYS      MECHANICAL POWER OUTPUT                         BOIL0820
C     HUNT(L+27)=W         FEEDWATER FLOW                    -- P.U.       BOIL0830
C     HUNT(L+28)=          OUTPUT OF SQUARE ROOT IN BOILER REPRESENTATION  BOIL0840
C     HUNT(L+29)=P(T)      THROTTLE PRESSURE                 -- P.U.       BOIL0850
C     HUNT(L+30)=          INITIAL CONDITION FOR INTEGRATOR NO. 2          BOIL0860
C     HUNT(L+31)=C(2)      SECONDARY SUPERHEATER STEAM CAPACITY            BOIL0870
C     HUNT(L+32)=P(D)      DRUM PRESSURE OR PRIMARY SUPERHEATER OUTLET     BOIL0880
C                               PRESSURE                                   BOIL0890
C     HUNT(L+33)=          INITIAL CONDITION FOR INTEGRATOR NO. 3          BOIL0900
C     HUNT(L+34)=C(1)      DRUM OR WATERWALL STEAM CAPACITY                BOIL0910
C     HUNT(L+35)=K'                                                        BOIL0920
C     HUNT(L+36)=KP        PROPORTIONAL BOILER CONTROL CONSTANT            BOIL0930
C     HUNT(L+37)=KI        RESET BOILER CONTROL CONSTANT                   BOIL0940
C     HUNT(L+38)=          OUTPUT OF THE FIRST SUM BLOCK IN THE BOILER     BOIL0950
C                               CONTROLS                                   BOIL0960
C     HUNT(L+39)=          INITIAL CONDITION FOR INTEGRATOR NO. 4          BOIL0970
C     HUNT(L+40)=T(R)      BOILER CONTROL TIME CONSTANT.                   BOIL0980
C     HUNT(L+41)=          OUTPUT OF Z-FORM IN BOILER CONTROLS             BOIL0990
C     HUNT(L+42)=          2-SEC. DELAY OF HUNT(L+41)                      BOIL1000
C     HUNT(L+43)=          OUTPUT OF BOILER CONTROLS                       BOIL1010
C     HUNT(L+44)=          OUTPUT OF LIMITER BEFORE FUEL AND FEEDWATER     BOIL1020
C                               SYSTEMS                                    BOIL1030
C     HUNT(L+45)=K         FUEL SYSTEM GAIN                                BOIL1040
C     HUNT(L+46)=T(F)      FUEL SYSTEM TIME CONSTANT         -- SEC        BOIL1050
C     HUNT(L+47)=          OUTPUT OF D-DELAY IN FUEL SYSTEM                BOIL1060
C     HUNT(L+48)=          INITIAL CONDITION FOR INTEGRATOR NO. 5--DRUM    BOIL1070
C                               TYPE UNITS                                 BOIL1080
C     HUNT(L+49)=          OUTPUT OF FUEL SYSTEM                           BOIL1090
C     HUNT(L+50)=K(1)      GAIN IN FEEDWATER SYSTEM                        BOIL1100
C     HUNT(L+51)=K(2)      GAIN IN FEEDWATER SYSTEM                        BOIL1110
C     HUNT(L+52)=M         FEEDWATER SYSTEM TIME CONSTANT    -- SEC        BOIL1120
C     HUNT(L+53)=          OUTPUT OF FEEDWATER INTEGRATOR(7) IN FEED       BOIL1130
C                               FORWARD LOOP                               BOIL1140
C     HUNT(L+54)=          INITIAL CONDITION FOR INTEGRATOR NO. 5  (ONCE   BOIL1150
C                               THROUGH UNITS)                             BOIL1160
C     HUNT(L+55)=          OUTPUT OF SECOND FEEDWATER INTEGRATOR(7) (ONCE  BOIL1170
C                               THROUGH UNITS)                             BOIL1180
C     HUNT(L+56)=          INITIAL CONDITION FOR INTEGRATOR NO. 7 (ONCE    BOIL1190
C                               THROUGH UNITS)                             BOIL1200
C     HUNT(L+57)=          OUTPUT OF INTEGRATOR NO. 4                      BOIL1210
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C     HUNT(L+58)=CLOCK                                                    BOIL1220
C     HUNT(L+59)=D-DELAY CYF03                                            BOIL1230
C     HUNT(L+60)=        INPUT TO BOILER CONTROLS                         BOIL1240
C     HUNT(L+61)=        VALUE OF HUNT(L+60) AT LAST TIME STEP            BOIL1250
C     HUNT(L+62)=        OUTPUT OF DERIVATIVE CONTROL                     BOIL1260
C     HUNT(L+63)=        DERIVATIVE BOILER CONTROL CONSTANT               BOIL1270
C     HUNT(L+64)=        MW BIAS                                -- MW     BOIL1280
C     HUNT(L+65)=        PRESSURE FEEDBACK BIAS                           BOIL1290
C     HUNT(L+66)=        DEADBAND WITH IN THE PRESSURE FEEDBACK CIRCUIT   BOIL1300
C                                                                         BOIL1310
C                                                                         BOIL1320
C                                                                         BOIL1330
C                              -------------                              BOIL1340
C                              INITIALIZATION                             BOIL1350
C                              -------------                              BOIL1360
C                                                                         BOIL1370
C  *-------------------------------------------------------------------   BOIL1380
C  *  INITIALIZATION ROUTINE FOR EACH BOILER AT TIME LESS THAN           BOIL1390
C  *       DELT, THE SYSTEM INTEGRATION STEP.                            BOIL1400
C  *                                                                     BOIL1410
C  *  VALUES WHICH DEPEND ON THE UNIT RATING ARE CALCULATED USING MWR,   BOIL1420
C  *       PMYS, AND SPYS.  MWR IS THE MEGAWATT RATING OF THE UNIT.      BOIL1430
C  *       PMYS AND SPYS ARE ANALOGOUS TO PM(N) AND SP(N) WHICH ARE      BOIL1440
C  *       INITIALIZED IN INITAL.  SCALING IS USED TO ALLOW US TO BE     BOIL1450
C  *       ABLE TO USE ONE SET OF DATA TO TAKE CARE OF ALL UNITS OF THE  BOIL1460
C  *       SAME TYPE.  THIS IS ACCOMPLISHED BY SCALING DOWN SPYS AND     BOIL1470
C  *       PMYS WITH RESPECT TO THE RATING OF THE UNIT REPRESENTED BY    BOIL1480
C  *       THE DATA.                                                     BOIL1490
C  *                                                                     BOIL1500
C  *  HUNT IS INITIALIZED BY THE DATA SET HUNT1 AND HAS 67 LOCATIONS     BOIL1510
C  *       RESERVED FOR EACH BOILER.                                     BOIL1520
C  *                                                                     BOIL1530
C                                                                         BOIL1540
C                                                                         BOIL1550
C                                                                         BOIL1560
      KONT=1                                                              BOIL1570
      DELTD=.5                                                            BOIL1580
      AEEP=0.                                                             BOIL1590
      ICALC=NUMBER*67                                                     BOIL1600
      L=ICALC-66                                                          BOIL1610
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C                                                                       BOIL1620
C  *-----------------------------------------------------------------   BOIL1630
C  *  L IS USED TO INDEX TO THE APPROPRIATE LOCATION IN HUNT FOR THE    BOIL1640
C  *       UNIT PRESENTLY BEING UPDATED.                               BOIL1650
C  *                                                                   BOIL1660
C                                                                       BOIL1670
      IF(MWR(N) .LT. 1.) GO TO 130                                      BOIL1680
      IF(TIME .LT. DELT) GO TO 10                                       BOIL1690
      GO TO 20                                                          BOIL1700
   10 IITYPE=ITYPE                                                      BOIL1710
      IF(ITYPE .EQ. 7) IITYPE=5                                         BOIL1720
      IF(ITYPE .EQ. 8) IITYPE=6                                         BOIL1730
      LL=(IITYPE-2)*30                                                  BOIL1740
C                                                                       BOIL1750
C  *-----------------------------------------------                   BOIL1760
C  *  LL IS USED TO INDEX HUNT1 TO THE PROPER UNIT TYPE                BOIL1770
C  *                                                                   BOIL1780
C                                                                       BOIL1790
      HUNT(L+3)=HUNT1(LL+30)                                            BOIL1800
      PMYS=PMYS/MWR(N)*HUNT(L+3)                                        BOIL1810
      HUNT(L)=PMYS+HUNT1(LL+2)/2.                                       BOIL1820
      HUNT(L+1)=PMYS-HUNT1(LL+2)/2.                                     BOIL1830
      HUNT(L+2)=PMYS                                                    BOIL1840
      HUNT(L+4)=HUNT1(LL+1)                                             BOIL1850
      HUNT(L+5)=HUNT1(LL+2)                                             BOIL1860
      HUNT(L+6)=PMYS                                                    BOIL1870
      HUNT(L+7)=HUNT1(LL+3)                                             BOIL1880
      HUNT(L+8)=HUNT(L+2)/HUNT(L+3)                                     BOIL1890
      HUNT(L+9)=HUNT(L+8)                                               BOIL1900
      HUNT(L+10)=HUNT1(LL+4)                                            BOIL1910
      HUNT(L+11)=HUNT1(LL+5)                                            BOIL1920
      HUNT(L+12)=HUNT1(LL+6)                                            BOIL1930
      HUNT(L+13)=HUNT1(LL+7)                                            BOIL1940
      HUNT(L+14)=HUNT(L+3)                                              BOIL1950
      HUNT(L+15)=HUNT(L+8)                                              BOIL1960
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HUNT(L+17)=HUNT(L+8)                                                    BOIL1970
HUNT(L+18)=HUNT(L+8)                                                    BOIL1980
HUNT(L+19)=HUNT1(LL+8)                                                  BOIL1990
HUNT(L+20)=HUNT1(LL+9)                                                  BOIL2000
HUNT(L+21)=HUNT1(LL+10)                                                 BOIL2010
HUNT(L+22)=HUNT1(LL+11)                                                 BOIL2020
HUNT(L+23)=HUNT(L+8)                                                    BOIL2030
HUNT(L+24)=HUNT(L+8)*(1.-HUNT(L+22))                                    BOIL2040
HUNT(L+25)=HUNT(L+24)                                                   BOIL2050
HUNT(L+26)=PMYS                                                         BOIL2060
HUNT(L+27)=HUNT(L+8)                                                    BOIL2070
HUNT(L+28)=HUNT(L+8)                                                    BOIL2080
HUNT(L+29)=HUNT1(LL+12)                                                 BOIL2090
HUNT(L+30)=HUNT(L+29)                                                   BOIL2100
HUNT(L+31)=HUNT1(LL+13)                                                 BOIL2110
HUNT(L+32)=HUNT1(LL+14)                                                 BOIL2120
HUNT(L+33)=HUNT(L+32)                                                   BOIL2130
HUNT(L+34)=HUNT1(LL+15)                                                 BOIL2140
HUNT(L+35)=(HUNT(L+9)**2)/(HUNT(L+32)-HUNT(L+29))                       BOIL2150
HUNT(L+36)=HUNT1(LL+17)                                                 BOIL2160
HUNT(L+37)=HUNT1(LL+18)                                                 BOIL2170
HUNT(L+38)=HUNT(L+8)                                                    BOIL2180
HUNT(L+39)=HUNT(L+8)                                                    BOIL2190
HUNT(L+40)=HUNT1(LL+19)                                                 BOIL2200
HUNT(L+41)=HUNT(L+8)                                                    BOIL2210
HUNT(L+42)=HUNT(L+8)                                                    BOIL2220
HUNT(L+43)=HUNT(L+8)                                                    BOIL2230
HUNT(L+44)=HUNT(L+8)                                                    BOIL2240
HUNT(L+45)=HUNT1(LL+20)                                                 BOIL2250
HUNT(L+46)=HUNT1(LL+21)                                                 BOIL2260
HUNT(L+47)=HUNT(L+8)                                                    BOIL2270
HUNT(L+48)=HUNT(L+8)                                                    BOIL2280
HUNT(L+49)=HUNT(L+8)                                                    BOIL2290
HUNT(L+50)=HUNT1(LL+22)                                                 BOIL2300
HUNT(L+51)=HUNT1(LL+23)                                                 BOIL2310
HUNT(L+52)=HUNT1(LL+24)                                                 BOIL2320
HUNT(L+53)=HUNT(L+8)                                                    BOIL2330
HUNT(L+54)=HUNT(L+8)                                                    BOIL2340
HUNT(L+55)=HUNT(L+8)                                                    BOIL2350
HUNT(L+56)=HUNT(L+8)                                                    BOIL2360
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      HUNT(L+57)=HUNT(L+8)                                                  BOIL2370
      HUNT(L+58)=HUNT(L+8)                                                  BOIL2380
      HUNT(L+59)=HUNTI(LL+25)                                               BOIL2390
      HUNT(L+60)=0.0                                                        BOIL2400
      HUNT(L+61)=0.0                                                        BOIL2410
      HUNT(L+62)=0.0                                                        BOIL2420
      HUNT(L+63)=HUNTI(LL+26)                                               BOIL2430
      HUNT(L+64)=HUNTI(LL+27)                                               BOIL2440
      HUNT(L+65)=HUNTI(LL+28)                                               BOIL2450
      HUNT(L+66)=HUNTI(LL+29)                                               BOIL2460
      PMYS=PMYS/HUNT(L+3)*MWR(N)                                            BOIL2470
   20 CONTINUE                                                              BOIL2480
C                                                                           BOIL2490
C                          ------------------                               BOIL2500
C                          STEAM SUPPLY SYSTEM                              BOIL2510
C                          ------------------                               BOIL2520
C                                                                           BOIL2530
      PMYS=PMYS/MWR(N)*HUNT(L+3)                                            BOIL2540
      SPYS=SPYS/MWR(N)*HUNT(L+3)                                            BOIL2550
   30 HUNT(L+27)=HUNT(L+55)                                                 BOIL2560
      IF(HUNT(L+45).EQ.1.)HUNT(L+27)=HUNT(L+49)                             BOIL2570
      HUNT(L+29)=INTGRL(ISUB,N,1,HUNT(L+30),(HUNT(L+28)-HUNT(L+9))         BOIL2580
     1    /HUNT(L+31),HUNT(L+29))                                           BOIL2590
      HUNT(L+32)=INTGRL(ISUB,N,2,HUNT(L+33),(HUNT(L+27)-HUNT(L+28)))       BOIL2600
     1    /HUNT(L+34),HUNT(L+32))                                           BOIL2610
      B=HUNT(L+32)-HUNT(L+29)                                               BOIL2620
      IF(B .LE. 0.) B=0.                                                    BOIL2630
      HUNT(L+28)=SQRT(ABS(B)*HUNT(L+35))                                    BOIL2640
C                                                                           BOIL2650
C                            ---------------                                BOIL2660
C                            BOILER CONTROLS                                BOIL2670
C                            ---------------                                BOIL2680
      A2=0.0                                                                BOIL2690
      IF(HUNT(L+10)-HUNT(L+29) .GE. HUNT(L+66)/2.)A2=HUNT(L+10)-            BOIL2700
     1       HUNT(L+29)-HUNT(L+66)/2.                                       BOIL2710
      IF(HUNT(L+10)-HUNT(L+29) .LE. -HUNT(L+66)/2.)A2=HUNT(L+10)-           BOIL2720
     1       HUNT(L+29)+HUNT(L+66)/2.                                       BOIL2730
      PEB=MWR(N)*HUNT(L+65)*A2                                              BOIL2740
      HUNT(L+60)=HUNT(L+10)-HUNT(L+29)                                      BOIL2750
      IF(ITYPE.EQ.2 .OR. ITYPE.EQ.3) GO TO 40                               BOIL2760
      GO TO 50                                                              BOIL2770
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   40 HUNT(L+60)=HUNT(L+60)+UCE1*HUNT(L+64)/MWR(N)                    BOIL2780
   50 CONTINUE                                                       BOIL2790
      IF(AEEP.EQ.0.)GO TO 60                                         BOIL2800
      HUNT(L+62)=((HUNT(L+60)-HUNT(L+61))/DELTD)*HUNT(L+63)          BOIL2810
      HUNT(L+61)=HUNT(L+60)                                          BOIL2820
   60 CONTINUE                                                       BOIL2830
      HUNT(L+57)=INTGRL(ISUB,N,3,HUNT(L+39),(HUNT(L+60))*HUNT(L+37),  BOIL2840
     1    HUNT(L+57))                                               BOIL2850
      HUNT(L+38)=(HUNT(L+60))*HUNT(L+36)+HUNT(L+57)+HUNT(L+62)       BOIL2860
      HUNT(L+44)=LIMIT(0.,1.,HUNT(L+38))                             BOIL2870
C                                                                    BOIL2880
C                              ----------                            BOIL2890
C                              FUEL SYSTEM                           BOIL2900
C                              ----------                            BOIL2910
C                                                                    BOIL2920
C  *-----------------------------------------------------------------BOIL2930
C  *  FUEL SYSTEM DYNAMICS ARE REPRESENTED IN THE DRUM TYPE UNITS ONLY BOIL2940
C  *                                                                 BOIL2950
C                                                                    BOIL2960
      IF(HUNT(L+45).EQ.0.) GO TO 80                                  BOIL2970
      NN=IFIX(2.*HUNT(L+59))                                         BOIL2980
C                                                                    BOIL2990
C  *-----------------------------------------------------------------BOIL3000
C  *     DELAY FUNCTIONS IN BOILER MUST BE CODED SO THAT THEY ARE ONLY BOIL3010
C  *          COMPUTED IF KONT EQUALS 4.  IF ANY DELAY FUNCTIONS ARE BOIL3020
C  *          ADDED IN THE BOILER SUBROUTINE, THIS PROVISION MUST BE BOIL3030
C  *          MADE.                                                  BOIL3040
C  *                                                                 BOIL3050
C                                                                    BOIL3060
      IF(KONT .NE. 4) GO TO 70                                       BOIL3070
      HUNT(L+47)=DELAY(ISUB,N,1,NN,HUNT(L+59),HUNT(L+44))            BOIL3080
   70 HUNT(L+49)=INTGRL(ISUB,N,4,HUNT(L+48),                         BOIL3090
     1    (HUNT(L+47)-HUNT(L+49))/HUNT(L+46),HUNT(L+49))            BOIL3100
   80 CONTINUE                                                       BOIL3110
C                                                                    BOIL3120
C                              ---------------                       BOIL3130
C                              FEEDWATER SYSTEM                      BOIL3140
C                              ---------------                       BOIL3150
C                                                                    BOIL3160
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C  *-------------------------------------------------------------- BOIL3170
C  *  FEEDWATER DYNAMICS ARE REPRESENTED ON THE ONCE-THROUGH UNITS ONLY BOIL3180
C  *                                                               BOIL3190
C                                                                  BOIL3200
      IF(HUNT(L+45).EQ.1.) GO TO 90                                BOIL3210
      HUNT(L+53)=INTGRL(ISUB,N,5,HUNT(L+54),(HUNT(L+44)            BOIL3220
     1    -HUNT(L+55))*HUNT(L+51),HUNT(L+53))                      BOIL3230
      HUNT(L+55)=INTGRL(ISUB,N,6,HUNT(L+56),(HUNT(L+53)+(HUNT(L+44) BOIL3240
     1    -HUNT(L+55))*HUNT(L+50)-HUNT(L+55))/HUNT(L+52),HUNT(L+55)) BOIL3250
   90 CONTINUE                                                     BOIL3260
C                                                                  BOIL3270
      A=SPYS-(HUNT(L+3)*HUNT(L+4))*(OMEGA-CSKEDF/60.)              BOIL3280
C                                                                  BOIL3290
C,                                                                 BOIL3300
C                                 --------                         BOIL3310
C                                 DEADBAND                         BOIL3320
C                                 --------                         BOIL3330
C                                                                  BOIL3340
C  *-------------------------------------------------             BOIL3350
C  *  DEADBAND REPRESENTS THE STATISTICS OF LUMPED UNITS           BOIL3360
C  *                                                               BOIL3370
C                                                                  BOIL3380
      IF(TIME .LT. DELT) HUNT(L+6)=A                               BOIL3390
      HUNT(L)=(A-HUNT(L+6)/1.)*3.1212/HUNT(L+5)                    BOIL3400
      HUNT(L+1)=LIMIT(-1.5606,1.5606,HUNT(L))                      BOIL3410
      HUNT(L+2)=TAN(HUNT(L+1))                                     BOIL3420
      HUNT(L+6)=INTGRL(ISUB,N,7,A,.0213*HUNT(L+2),HUNT(L+6))       BOIL3430
C                                                                  BOIL3440
C                            --------------------                  BOIL3450
C                            VALVE AREA OF BOILER                  BOIL3460
C                            --------------------                  BOIL3470
C                                                                  BOIL3480
      HUNT(L+15)=HUNT(L+6)*HUNT(L+7)/HUNT(L+3)-HUNT(L+9)*(HUNT(L+7)-1.) BOIL3490
      IF(HUNT(L+14)/HUNT(L+3) .LT. HUNT(L+15))HUNT(L+15)=HUNT(L+14)/ BOIL3500
     1    HUNT(L+3)                                                BOIL3510
      HUNT(L+16)=(HUNT(L+29)-HUNT(L+11)*HUNT(L+10))*HUNT(L+13)     BOIL3520
      IF(HUNT(L+16) .LT. HUNT(L+15)) HUNT(L+15)=HUNT(L+16)         BOIL3530
      HUNT(L+17)=LIMIT(0.,1.,HUNT(L+15))                           BOIL3540
      IF(HUNT(L+17)-HUNT(L+6) .LT. 0.) GO TO 100                   BOIL3550
      IF(HUNT(L+17)-HUNT(L+8).GT.HUNT(L+19)*DELTD)HUNT(L+17)=HUNT(L+8)+ BOIL3560
     1    HUNT(L+19)*DELTD                                         BOIL3570
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      HUNT(L+8)=HUNT(L+17)                                                    BOIL3580
      GO TO 110                                                               BOIL3590
  100 IF(HUNT(L+8)-HUNT(L+17).GT.HUNT(L+20)*DELTD)HUNT(L+17)=HUNT(L+8)-       BOIL3600
     1    HUNT(L+20)*DELTD                                                   BOIL3610
      HUNT(L+8)=HUNT(L+17)                                                    BOIL3620
  110 CONTINUE                                                                BOIL3630
      HUNT(L+18)=HUNT(L+17)                                                   BOIL3640
      HUNT(L+9)=HUNT(L+18)*HUNT(L+29)                                         BOIL3650
      STMFLO=HUNT(L+9)                                                        BOIL3660
C                                                                             BOIL3670
C                              --------------                                 BOIL3680
C                              REHEAT TURBINE                                 BOIL3690
C                              --------------                                 BOIL3700
C                                                                             BOIL3710
      HUNT(L+24)=INTGRL(ISUB,N,8,HUNT(L+25),(HUNT(L+9)*(1.-HUNT(L+22))       BOIL3720
     1   -HUNT(L+24))*1./HUNT(L+21),HUNT(L+24))                               BOIL3730
      HUNT(L+23)=HUNT(L+24)+HUNT(L+9)*HUNT(L+22)                              BOIL3740
      HUNT(L+26)=HUNT(L+23)*HUNT(L+3)                                         BOIL3750
      PMYS=HUNT(L+26)                                                         BOIL3760
C                                                                             BOIL3770
C  *--------------------------------------------------------------------      BOIL3780
C  *  THE COUNTER KONT ACCUMULATES FOUR PASSES THROUGH BOILER EACH            BOIL3790
C  *       TIME SUBROUTINE BOILER IS ENTERED.  BEING A TWO STEP               BOIL3800
C  *       TRAPEZOIDAL INTEGRATION ROUTINE THERE ARE TWO PASSES FOR           BOIL3810
C  *       EACH .5 SECOND BOILER INTEGRATION INTERVAL AND TWO .5              BOIL3820
C  *       SECOND INTERVALS FOR EACH 1. SECOND SYSTEM MODES INTEGRA-          BOIL3830
C  *       TION STEP.                                                         BOIL3840
C  *                                                                          BOIL3850
C                                                                             BOIL3860
      IF(AEEP .EQ. 1.) AEEP=-1.                                               BOIL3870
      AEEP=AEEP+1.                                                            BOIL3880
      KONT=KONT+1                                                             BOIL3890
      IF(KONT .EQ. 5) GO TO 120                                               BOIL3900
      GO TO 30                                                                BOIL3910
  120 CONTINUE                                                                BOIL3920
C                                                                             BOIL3930
C  *--------------------------------------------------------------------      BOIL3940
C  *  PMYS (MECHANICAL POWER OUTPUT) AND SPYS (GOVERNOR SET POINT)            BOIL3950
C  *       ARE RESCALED FROM THE UNIT SIZE OF WHICHEVER OF THE SIX            BOIL3960
C  *       BASIC TYPES OF BOILER UNITS USED TO THE SIZE OF THE UNIT           BOIL3970
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C  *       REPRESENTED IN THE SYSTEM MODEL.  FOR EXAMPLE:                BOIL3980
C  *             PMYS=PMYS*MEGAWATT RATING/ 191.0 MW                     BOIL3990
C  *       FOR THE SUBCRITICAL ONCE-THROUGH UNIT (ITYPE=3)               BOIL4000
C  *                                                                     BOIL4010
C                                                                        BOIL4020
      PMYS=PMYS/HUNT(L+3)*MWR(N)                                         BOIL4030
      SPYS=SPYS/HUNT(L+3)*MWR(N)                                         BOIL4040
  130 CONTINUE                                                           BOIL4050
      IF(MWR(N) .LT. 1.) PMYS=0.                                         BOIL4060
      RETURN                                                             BOIL4070
      END                                                                BOIL4080
```

```
C ------------------------------------------------------------------- HYDR0010
C *                                                                 * HYDR0020
C *                  S U B R O U T I N E   H Y D R O                * HYDR0030
C *                                                                 * HYDR0040
C ------------------------------------------------------------------- HYDR0050
C                                                                     HYDR0060
      SUBROUTINE HYDRO(CSKEDF,OMEGA,SPYP,PMYP,NUMBER,N)               HYDR0070
C                                                                     HYDR0080
C                                                                     HYDR0090
      COMMON / CURVAL / TIME  , DELT  , KEEP                          HYDR0100
      COMMON / WATT   / WATER1(36)                                    HYDR0110
      COMMON / INITAL / DUMMY(40)     , MWR(20)                       HYDR0120
      COMMON / PRTCNL / ICOUNT, ILAST , SYMBOL, VALUE , LINES , IPAGES HYDR0130
C                                                                     HYDR0140
      DIMENSION WATER(132)                                            HYDR0150
C                                                                     HYDR0160
      REAL*4    LIMIT , INTGRL, MWR                                   HYDR0170
      REAL*4    VALUE(44)                                             HYDR0180
      REAL*8    SYMBOL(44)                                            HYDR0190
C                                                                     HYDR0200
      ISUB=6                                                          HYDR0210
C                                                                     HYDR0220
C                                                                     HYDR0230
C                                                                     HYDR0240
C     THIS SUBROUTINE REPRESENTS HIGH AND LOW HEAD HYDRO UNITS.       HYDR0250
C                                                                     HYDR0260
C     THE ARRAY WATER1 IS THE DATA STORAGE AREA USED TO STORE THE     HYDR0270
C           PARAMETERS AND INITIALIZATION DATA FOR EACH HYDRO UNIT.   HYDR0280
C           WATER1 IS DIMENSIONED FOR 6 UNITS AT 6 VARIABLES PER UNIT. HYDR0290
C                                                                     HYDR0300
C     THE ARRAY WATER IS THE WORKING AREA REPRESENTING THE DYNAMIC    HYDR0310
C           EQUATIONS FOR EACH HYDRO UNIT.  WATER IS DIMENSIONED FOR  HYDR0320
C           6 UNITS AT 22 VARIABLES PER UNIT.                         HYDR0330
C                                                                     HYDR0340
C     WATER(L)=TH1Y       DEADBAND UPPER VALUE                        HYDR0350
C     WATER(L+1)=TH2Y     DEADBAND LOWER VALUE                        HYDR0360
C     WATER(L+2)=TH3Y     DEADBAND OUTPUT                             HYDR0370
C     WATER(L+3)=CYP01    SPEED DROOP (1/R)                           HYDR0380
C     WATER(L+4)=CYP02    TRANSIENT REGULATION (R/R)                  HYDR0390
C     WATER(L+5)=CYP03    DEADBAND (T(R))                             HYDR0400
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C      WATER(L+6)=CYP04    TRANSIENT DROOP TIME CONSTANT                    HYDR0410
C      WATER(L+7)=CYP05    RATE OF GATE LIMIT (MW/SEC)                      HYDR0420
C      WATER(L+8)=CYP06    GATE UPPER LIMIT                                 HYDR0430
C      WATER(L+9)=CYP07    GATE LOWER LIMIT                                 HYDR0440
C      WATER(L+10)=CYP08   TW, WATER STARTING TIME                          HYDR0450
C      WATER(L+11)=T3PY    DEADBAND INPUT                                   HYDR0460
C      WATER(L+12)=S1PY    GOVERNOR STATE                                   HYDR0470
C      WATER(L+13)=SPYP    GOVERNOR SETPOINT                                HYDR0480
C      WATER(L+14)=PMYP    MECHANICAL POWER OUTPUT                          HYDR0490
C      WATER(L+15)=HY1                                                      HYDR0500
C      WATER(L+16)=P0      INITIALIZED TO T3PY,WATER(L+11)                  HYDR0510
C      WATER(L+17)=HY2     INITIALIZED TO HY1                               HYDR0520
C      WATER(L+18)=HY3     INITIALIZED TO P0                                HYDR0530
C      WATER(L+19)=G       OUTPUT OF GATE                                   HYDR0540
C      WATER(L+20)=DL1     INITIALIZE TO 3.*P0                              HYDR0550
C      WATER(L+21)=S2PY    HYDRAULIC TURBINE STATE                          HYDR0560
C                                                                           HYDR0570
C                                                                           HYDR0580
C                                 --------------                            HYDR0590
C                                 INITIALIZATION                            HYDR0600
C                                 --------------                            HYDR0610
C                                                                           HYDR0620
C  *-----------------------------------------------------------------       HYDR0630
C  *  INITIALIZATION ROUTINE FOR EACH HYDRO UNIT AT TIME LESS THAN          HYDR0640
C  *       DELT, THE SYSTEM INTEGRATION STEP.                               HYDR0650
C  *                                                                        HYDR0660
C  *  WATER IS INITIALIZED BY THE DATA SET WATER1 AND HAS 22 LOCATIONS      HYDR0670
C  *       RESERVED FOR EACH HYDRO UNIT.                                    HYDR0680
C  *                                                                        HYDR0690
C                                                                           HYDR0700
      ICALC=NUMBER*22                                                       HYDR0710
      L=ICALC-21                                                            HYDR0720
C                                                                           HYDR0730
C  *-----------------------------------------------------------------       HYDR0740
C  *  L IS USED TO INDEX TO THE APPROPRIATE LOCATION IN WATER FOR           HYDR0750
C  *       THE UNIT PRESENTLY BEING UPDATED.                                HYDR0760
C  *                                                                        HYDR0770
C                                                                           HYDR0780
      IF(TIME .LT. DELT)GO TO 10                                            HYDR0790
      GO TO 20                                                              HYDR0800
   10 LLCALC=NUMBER*6                                                       HYDR0810
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      LL=LLCALC-5                                                          HYDR0820
C                                                                          HYDR0830
C  *-----------------------------------------------------------------      HYDR0840
C  *  LL INDEXES WATER1 TO THE PROPER LOCATION FOR THE CURRENT UNIT'S      HYDR0850
C  *       PARAMETERS.                                                     HYDR0860
C  *                                                                       HYDR0870
C                                                                          HYDR0880
      WATER(L)=PMYP+WATER1(LL+2)/2.                                        HYDR0890
      WATER(L+1)=PMYP-WATER1(LL+2)/2.                                      HYDR0900
      WATER(L+2)=PMYP                                                      HYDR0910
      WATER(L+3)=MWR(N)*1./WATER1(LL)                                      HYDR0920
      WATER(L+4)=WATER1(LL+1)                                              HYDR0930
      WATER(L+5)=WATER1(LL+2)                                              HYDR0940
      WATER(L+6)=WATER1(LL+3)                                              HYDR0950
      WATER(L+7)=WATER1(LL+4)                                              HYDR0960
      WATER(L+8)=MWR(N)                                                    HYDR0970
      WATER(L+9)=.10*MWR(N)                                                HYDR0980
      WATER(L+10)=WATER1(LL+5)                                             HYDR0990
      WATER(L+11)=PMYP                                                     HYDR1000
      WATER(L+12)=PMYP*(1.-WATER1(LL+1))                                   HYDR1010
      WATER(L+13)=SPYP                                                     HYDR1020
      WATER(L+14)=PMYP                                                     HYDR1030
      WATER(L+15)=PMYP                                                     HYDR1040
      WATER(L+16)=PMYP                                                     HYDR1050
      WATER(L+17)=PMYP                                                     HYDR1060
      WATER(L+18)=PMYP                                                     HYDR1070
      WATER(L+19)=PMYP                                                     HYDR1080
      WATER(L+20)=3.*PMYP                                                  HYDR1090
      WATER(L+21)=3.*PMYP                                                  HYDR1100
   20 CONTINUE                                                             HYDR1110
C                                                                          HYDR1120
C                                 --------                                 HYDR1130
C                                 DYNAMICS                                 HYDR1140
C                                 --------                                 HYDR1150
C                                                                          HYDR1160
      IF(SPYP .LT. .5) GO TO 80                                            HYDR1170
      WATER(L+13)=SPYP                                                     HYDR1180
      WATER(L+11)=WATER(L+13)-WATER(L+3)*(OMEGA-CSKEDF/60.)                HYDR1190
C                                                                          HYDR1200
C                                 --------                                 HYDR1210
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C                                DEADBAND                                       HYDR1220
C                                --------                                       HYDR1230
C                                                                               HYDR1240
      IF(WATER(L+11)-WATER(L)) 30, 60, 50                                       HYDR1250
   30 IF(WATER(L+11)-WATER(L+1)) 40, 60, 60                                     HYDR1260
   40 WATER(L+1)=WATER(L+11)                                                    HYDR1270
      WATER(L+2)=WATER(L+11)+WATER(L+5)/2.                                      HYDR1280
      WATER(L)=WATER(L+11)+WATER(L+5)                                           HYDR1290
      GO TO 60                                                                  HYDR1300
   50 WATER(L)=WATER(L+11)                                                      HYDR1310
      WATER(L+1)=WATER(L+11)-WATER(L+5)                                         HYDR1320
      WATER(L+2)=WATER(L+11)-WATER(L+5)/2.                                      HYDR1330
   60 WATER(L+11)=WATER(L+2)                                                    HYDR1340
      CONTINUE                                                                  HYDR1350
C                                                                               HYDR1360
C                  ------------------------------------                         HYDR1370
C                  GATE RATE AND TRAVEL NON-WINDUP LIMITS                       HYDR1380
C                  ------------------------------------                         HYDR1390
C                                                                               HYDR1400
      WATER(L+12)=INTGRL(ISUB,N,1,WATER(L+15)*(1.-WATER(L+4)),                  HYDR1410
     1     LIMIT(-WATER(L+7)*(1.-WATER(L+4)),WATER(L+7)*(1.-WATER(L+4)),        HYDR1420
     2     (1./WATER(L+6))*(WATER(L+11)-WATER(L+15))),WATER(L+12))              HYDR1430
      IF(WATER(L+12) .GT. (1.-WATER(L+4))*WATER(L+8)) WATER(L+12)=              HYDR1440
     1     (1.-WATER(L+4))*WATER(L+8)                                           HYDR1450
      IF(WATER(L+12) .LT. (1.-WATER(L+4))*WATER(L+9)) WATER(L+12)=              HYDR1460
     1     (1.-WATER(L+4))*WATER(L+9)                                           HYDR1470
      WATER(L+15)=WATER(L+12)+WATER(L+11)*WATER(L+4)                            HYDR1480
      IF(KEEP .NE. 1.) GO TO 70                                                 HYDR1490
      WATER(L+17)=WATER(L+15)                                                   HYDR1500
      IF(ABS(WATER(L+15)-WATER(L+18)) .GT. WATER(L+7)*DELT) WATER(L+17)         HYDR1510
     1     =WATER(L+18)+WATER(L+7)*DELT*SIGN(1.,WATER(L+15)-WATER(L+18))        HYDR1520
      WATER(L+18)=WATER(L+17)                                                   HYDR1530
   70 CONTINUE                                                                  HYDR1540
      WATER(L+19)=LIMIT(WATER(L+9),WATER(L+8),WATER(L+17))                      HYDR1550
C                                                                               HYDR1560
C                                  -------                                      HYDR1570
C                                  TURBINE                                      HYDR1580
C                                  -------                                      HYDR1590
C                                                                               HYDR1600
      WATER(L+20)=DELAY(ISUB,N,1,1,DELT,WATER(L+21))                            HYDR1610
      WATER(L+21)=WATER(L+19)*3.*1./(1.+WATER(L+10)/(2.*DELT))+(1.-1./          HYDR1620
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     1     (1.+WATER(L+10)/(2.*DELT)))*WATER(L+20)                    HYDR1630
           PMYP=WATER(L+21)-2.*WATER(L+19)                            HYDR1640
    80 CONTINUE                                                       HYDR1650
           RETURN                                                     HYDR1660
           END                                                        HYDR1670
```

```
C ------------------------------------------------------------------- GAST0010
C *                                                                   * GAST0020
C *                  S U B R O U T I N E   G A S T U B                * GAST0030
C *                                                                   * GAST0040
C ------------------------------------------------------------------- GAST0050
C                                                                     GAST0060
      SUBROUTINE GASTUB(CSKEDF,OMEGA,SPYT,PMYT,NUMBER,N)              GAST0070
C                                                                     GAST0080
      COMMON / CURVAL / TIME  , DELT  , KEEP                          GAST0090
      COMMON / GAS    / GASS1(60)                                     GAST0100
      COMMON / INITAL / DUMMY(40)     , MWR(20)                       GAST0110
      COMMON / PRTCNL / ICOUNT, ILAST , SYMBOL, VALUE , LINES , IPAGES GAST0120
C                                                                     GAST0130
      REAL*4    LIMIT , MWR                                         GAST0140
      REAL*4    VALUE(44)                                           GAST0150
      REAL*8    SYMBOL(44)                                          GAST0160
C                                                                     GAST0170
      DIMENSION GASS(140)                                           GAST0180
C                                                                     GAST0190
      ISUB=7                                                        GAST0200
C                                                                     GAST0210
C                                                                     GAST0220
C                                                                     GAST0230
C     SUBROUTINE GASTUB IS THE GAS TURBINE MODEL USED IN THE SYSTEM   GAST0240
C          MODEL                                                    GAST0250
C                                                                     GAST0260
C     THE ARRAY GASS1 IS THE DATA STORAGE AREA WHERE THE PARAMETERS   GAST0270
C          AND INITIALIZATION DATA FOR EACH GAS TURBINE UNIT ARE     GAST0280
C          STORED.  GASS1 IS DIMENSIONED FOR 20 UNITS AT 3 VARIABLES GAST0290
C          PER UNIT.                                                GAST0300
C                                                                   GAST0310
C     THE ARRAY GASS IS THE WORKING AREA REPRESENTING THE DYNAMIC    GAST0320
C          EQUATIONS FOR EACH GAS TURBINE.  GASS IS DIMENSIONED FOR  GAST0330
C          20 UNITS AT 7 VARIABLES PER UNIT.                        GAST0340
C                                                                   GAST0350
C                                                                   GAST0360
C     GASS(L)=TG1Y      DEADBAND UPPER LIMIT                        GAST0370
C     GASS(L+1)=TG2Y    DEADBAND LOWER LIMIT                        GAST0380
C     GASS(L+2)=TG3Y    DEADBAND OUTPUT                             GAST0390
C     GASS(L+3)=T3TY    DEADBAND INPUT                              GAST0400
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C      GASS(L+4)=CDBYT  DEADBAND WIDTH                                  GAST0410
C      GASS(L+5)=CYT01  SPEEDDROOP (1/R)                                GAST0420
C      GASS(L+6)=CYT02  EXHAUST TEMPERATURE POWER LIMIT                 GAST0430
C                                                                       GAST0440
C                                                                       GAST0450
C                                                                       GAST0460
C                                                                       GAST0470
C                              -------------                            GAST0480
C                              INITIALIZATION                           GAST0490
C                              -------------                            GAST0500
       ICALC=NUMBER*7                                                   GAST0510
       L=ICALC-6                                                        GAST0520
C                                                                       GAST0530
C  *-------------------------------------------------------------       GAST0540
C  *  L IS USED TO INDEX TO THE APPROPRIATE LOCATION IN GASS FOR THE     GAST0550
C  *      UNIT PRESENTLY BEING UPDATED.                                 GAST0560
C  *                                                                    GAST0570
C                                                                       GAST0580
       IF(TIME .LT. DELT) GO TO 10                                      GAST0590
       GO TO 20                                                         GAST0600
    10 LLCALC=NUMBER*3                                                  GAST0610
       LL=LLCALC-2                                                      GAST0620
C                                                                       GAST0630
C  *-------------------------------------------------------------       GAST0640
C  *  LL INDEXES GASS1 TO THE PROPER LOCATION FOR THE CURRENT UNIT'S    GAST0650
C  *      PARAMETERS.                                                   GAST0660
C  *                                                                    GAST0670
C                                                                       GAST0680
       GASS(L)=PMYT+GASS1(LL)/2.                                        GAST0690
       GASS(L+1)=PMYT-GASS1(LL)/2.                                      GAST0700
       GASS(L+2)=PMYT                                                   GAST0710
       GASS(L+3)=PMYT                                                   GAST0720
       GASS(L+4)=GASS1(LL)                                              GAST0730
       GASS(L+5)=MWR(N)*1./GASS1(LL+1)                                  GAST0740
C                                                                       GAST0750
C  *-------------------------------------------                       GAST0760
C  *  29.5 IS AMBIENT TEMPERATURE IN WINTER (DEGRESS F)                 GAST0770
C  *                                                                    GAST0780
C                                                                       GAST0790
       GASS(L+6)=(1.23-(.23/59.)*GASS1(LL+2))*MWR(N)                    GAST0800
```

```
   20 CONTINUE                                                          GAST0810
C                                                                       GAST0820
C                              --------                                 GAST0830
C                              DYNAMICS                                 GAST0840
C                              --------                                 GAST0850
C                                                                       GAST0860
      GASS(L+3)=SPYT-GASS(L+5)*(OMEGA-1.)                               GAST0870
      IF(KEEP .EQ. 0.) GO TO 70                                         GAST0880
      IF(GASS(L+3)-GASS(L)) 30, 60, 50                                  GAST0890
   30 IF(GASS(L+3)-GASS(L+1)) 40, 60, 60                                GAST0900
   40 GASS(L+1)=GASS(L+3)                                               GAST0910
      GASS(L+2)=GASS(L+3)+GASS(L+4)/2.                                  GAST0920
      GASS(L)=GASS(L+3)+GASS(L+4)                                       GAST0930
      GO TO 60                                                          GAST0940
   50 GASS(L)=GASS(L+3)                                                 GAST0950
      GASS(L+1)=GASS(L+3)-GASS(L+4)                                     GAST0960
      GASS(L+2)=GASS(L+3)-GASS(L+4)/2.                                  GAST0970
   60 GASS(L+3)=GASS(L+2)                                               GAST0980
   70 CONTINUE                                                          GAST0990
      PMYT=DELAY(ISUB,N,1,2,2.,LIMIT(0.,GASS(L+6),GASS(L+3)))           GAST1000
      RETURN                                                            GAST1010
      END                                                               GAST1020
```

```
C ------------------------------------------------------------------- NUCL0010
C *                                                                   * NUCL0020
C *                  S U B R O U T I N E   N U C L E R                * NUCL0030
C *                                                                   * NUCL0040
C ------------------------------------------------------------------- NUCL0050
C                                                                     NUCL0060
      SUBROUTINE NUCLER(CSKEDF,OMEGA,SPYB,PMYB,NUMBER,N)              NUCL0070
C                                                                     NUCL0080
      COMMON / CURVAL / TIME  , DELT  , KEEP                          NUCL0090
      COMMON / ATTOM  / ATOM1(110)                                    NUCL0100
      COMMON / INITAL / DUMMY(40)     , MWR(20)                       NUCL0110
      COMMON / PRTCNL / ICOUNT, TLAST , SYMBOL, VALUE , LINES , IPAGES NUCL0120
C                                                                     NUCL0130
      REAL*8    SYMBOL(44)                                          NUCL0140
      REAL*4    VALUE(44)                                           NUCL0150
      REAL*4    INITAL, INTGRL, LIMIT , MWR                         NUCL0160
C                                                                     NUCL0170
      DIMENSION ATOM(310)                                           NUCL0180
C                                                                     NUCL0190
      ISUB=8                                                        NUCL0200
C                                                                     NUCL0210
C                                                                     NUCL0220
C                                                                     NUCL0230
C     SUBROUTINE NUCLER REPRESENTS THE BOILING WATER NUCLEAR REACTOR  NUCL0240
C         UNITS ON THE SYSTEM.                                        NUCL0250
C                                                                     NUCL0260
C     THE ARRAY ATOM1 IS THE DATA STORAGE AREA WHERE THE PARAMETERS AND NUCL0270
C         INITIALIZATION DATA FOR EACH NUCLEAR UNIT ARE STORED.  IT IS NUCL0280
C         DIMENSIONED FOR 10 UNITS AT 11 VARIABLES PER UNIT.          NUCL0290
C                                                                     NUCL0300
C     THE ARRAY ATOM IS THE WORKING AREA REPRESENTING THE DYNAMIC     NUCL0310
C         EQUATIONS FOR EACH UNIT.  IT IS DIMENSIONED FOR 10 UNITS    NUCL0320
C         AT 31 VARIABLES PER UNIT.                                   NUCL0330
C                                                                     NUCL0340
C                                                                     NUCL0350
C     ATOM(L)=CYB01       UNIT MW RATING                              NUCL0360
C     ATOM(L+1)=CYB02     PROPORTIONAL PART OF RECIRCULATION CONTROL  NUCL0370
C     ATOM(L+2)=CYB03     IN-CORE THERMAL TIME CONSTANT               NUCL0380
C     ATOM(L+3)=CYB04     INTEGRAL PART OF RECIRCULATION CONTROL      NUCL0390
C     ATOM(L+4)=CYB05     POWER CORRESPONDING TO RECIRCULATION CONTROL NUCL0400
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```
C      ATOM(L+5)=CYB06      PRESSURE REGULATOR LIMIT                              NUCL0410
C      ATOM(L+6)=CYB07      PRESSURE REGULATOR GAIN                               NUCL0420
C      ATOM(L+7)=CYB08      TIME CONSTANT PRESSURE REGULATOR OFFSET               NUCL0430
C      ATOM(L+8)=CYB09      TIME CONSTANT PRESSURE REGULATOR OFFSET               NUCL0440
C      ATOM(L+9)=CYB10      TURBINE POWER BEFORE MOISTURE SEPARATOR               NUCL0450
C      ATOM(L+10)=CYB11     MOISTURE SEPARATOR STEAM FLOW TIME CONSTANT           NUCL0460
C      ATOM(L+11)=CYB12                                                           NUCL0470
C      ATOM(L+12)=S1BY      TURBINE INTEGRATOR                                    NUCL0480
C      ATOM(L+13)=S2BY      CORE THERMAL STORAGE INTEGRATOR                       NUCL0490
C      ATOM(L+14)=S3BY      PRESSURE REGULATOR OFFSET INTEGRATOR                  NUCL0500
C      ATOM(L+15)=S4BY      PRESSURE REGULATOR OFFSET INTEGRATOR                  NUCL0510
C      ATOM(L+16)=S5BY      PRESSURE REGULATOR OFFSET INTEGRATOR                  NUCL0520
C      ATOM(L+17)=PFLOW     INPUT TO TURBINE                                      NUCL0530
C      ATOM(L+18)=LODEM     LOAD DEMAND                                           NUCL0540
C      ATOM(L+19)=LDERR     LOAD DEMAND ERROR                                     NUCL0550
C      ATOM(L+20)=THRESH    PRESSURE REGULATOR THRESHOLD                          NUCL0560
C      ATOM(L+21)=THRES1                                                          NUCL0570
C      ATOM(L+22)=THRES2                                                          NUCL0580
C      ATOM(L+23)=P1PR      OUTPUT OF PRESSURE REGULATOR                          NUCL0590
C      ATOM(L+24)=RECIR1                                                          NUCL0600
C      ATOM(L+25)=RECIR2                                                          NUCL0610
C      ATOM(L+26)=RECFLO    RECIRCULATION FLOW                                    NUCL0620
C      ATOM(L+27)=PGEN      POWER CORRESPONDING TO RECIRCULATION FLOW             NUCL0630
C      ATOM(L+28)=PG DEL    PGEN DELIVERED                                        NUCL0640
C      ATOM(L+29)=MSEPC     TURBINE POWER BEFORE MOISTURE SEPARATOR               NUCL0650
C      ATOM(L+30)=DUMMY                                                           NUCL0660
C                                                                                 NUCL0670
C                                                                                 NUCL0680
C                                                                                 NUCL0690
C                           -------------                                         NUCL0700
C                           INITIALIZATION                                        NUCL0710
C                           -------------                                         NUCL0720
C                                                                                 NUCL0730
       ICALC=NUMBER*31                                                           NUCL0740
       L=ICALC-30                                                                NUCL0750
C                                                                                 NUCL0760
C  *-----------------------------------------------------------------------       NUCL0770
C  *  L INDEXES TO THE PROPER LOCATION IN ATOM FOR THE UNIT PRESENTLY             NUCL0780
C  *       BEING UPDATED                                                         NUCL0790
C  *                                                                             NUCL0800
C                                                                                 NUCL0810
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      IF(MWR(N) .LT. 1.) GO TO 30                                        NUCL0820
      IF(TIME .LT. DELT) GO TO 10                                        NUCL0830
      GO TO 20                                                           NUCL0840
   10 LLCALC=NUMBER*11                                                   NUCL0850
      LL=LLCALC-10                                                       NUCL0860
C                                                                        NUCL0870
C  *-------------------------------------------------------------------  NUCL0880
C  *  LL INDEXES ATOM1 TO THE PROPER LOCATIONS FOR THE CURRENT UNIT'S    NUCL0890
C  *       PARAMETERS.                                                  NUCL0900
C  *                                                                    NUCL0910
C                                                                        NUCL0920
      ATOM(L)=MWR(N)                                                     NUCL0930
      ATOM(L+1)=ATOM1(LL)                                                NUCL0940
      ATOM(L+2)=ATOM1(LL+1)                                              NUCL0950
      ATOM(L+3)=ATOM1(LL+2)                                              NUCL0960
      ATOM(L+4)=ATOM1(LL+3)                                              NUCL0970
      ATOM(L+5)=ATOM1(LL+4)                                              NUCL0980
      ATOM(L+6)=ATOM1(LL+5)                                              NUCL0990
      ATOM(L+7)=ATOM1(LL+6)                                              NUCL1000
      ATOM(L+8)=ATOM1(LL+7)                                              NUCL1010
      ATOM(L+9)=ATOM1(LL+8)                                              NUCL1020
      ATOM(L+10)=ATOM1(LL+9)                                             NUCL1030
      ATOM(L+11)=ATOM1(LL+10)                                            NUCL1040
      ATOM(L+13)=PMYB/ATOM(L)                                            NUCL1050
C                                                                        NUCL1060
C  *-------------------------------                                      NUCL1070
C  *  PO=PMYB/CYBO1 = S2BY = ATOM(L+13)                                 NUCL1080
C  *                                                                    NUCL1090
C                                                                        NUCL1100
      ATOM(L+12)= (1.-ATOM(L+9))*ATOM(L+13)                              NUCL1110
      ATOM(L+14)=(1.3*ATOM(L+13)/ATOM(L+4))-.3                           NUCL1120
      ATOM(L+15)=0.0                                                     NUCL1130
      ATOM(L+16)=0.0                                                     NUCL1140
      ATOM(L+17)=ATOM(L+16)+ATOM(L+13)                                   NUCL1150
      ATOM(L+22)=ATOM(L+15)                                              NUCL1160
      ATOM(L+23)=ATOM(L+16)                                              NUCL1170
      ATOM(L+28)=ATOM(L+13)                                              NUCL1180
      ATOM(L+30)=ATOM(L+12)                                              NUCL1190
   20 CONTINUE                                                           NUCL1200
```

```
C                                                                       NUCL1210
C                          --------                                     NUCL1220
C                          DYNAMICS                                     NUCL1230
C                          --------                                     NUCL1240
C                                                                       NUCL1250
      ATOM(L+18)=(SPYB/ATOM(L))-(OMEGA-CSKEDF/60.)/ATOM(L+11)           NUCL1260
      ATOM(L+19)=ATOM(L+18)-ATOM(L+17)                                  NUCL1270
      ATOM(L+20)=LIMIT(-ATOM(L+5),ATOM(L+5),ATOM(L+19))                 NUCL1280
      ATOM(L+21)=ATOM(L+6)*ATOM(L+20)                                   NUCL1290
      ATOM(L+22)=INTGRL(ISUB,N,1,ATOM(L+15),(ATOM(L+21)-ATOM(           NUCL1300
     1     L+22))/ATOM(L+7),ATOM(L+22))                                 NUCL1310
      ATOM(L+23)=INTGRL(ISUB,N,2,ATOM(L+16),(ATOM(L+21)-ATOM(           NUCL1320
     1     L+22)-ATOM(L+23))/ATOM(L+8),ATOM(L+23))                      NUCL1330
      ATOM(L+24)=ATOM(L+19)*ATOM(L+1)                                   NUCL1340
      ATOM(L+25)=INTGRL(ISUB,N,3,ATOM(L+14),ATOM(L+19)*                 NUCL1350
     1     ATOM(L+3),ATOM(L+25))                                        NUCL1360
      ATOM(L+26)=LIMIT(0.50,1.05,ATOM(L+25)+ATOM(L+24))                 NUCL1370
      ATOM(L+27)=(ATOM(L+26)+0.3)*(ATOM(L+4)/1.30)                      NUCL1380
      ATOM(L+28)=INTGRL(ISUB,N,4,ATOM(L+13),(ATOM(L+27)-ATOM(           NUCL1390
     1     L+28))/ATOM(L+2),ATOM(L+28))                                 NUCL1400
      ATOM(L+17)=ATOM(L+23)+ATOM(L+28)                                  NUCL1410
      ATOM(L+29)=ATOM(L+9)*ATOM(L+17)                                   NUCL1420
      ATOM(L+30)=INTGRL(ISUB,N,5,ATOM(L+12),((ATOM(L+17)-ATOM(          NUCL1430
     1     L+29))-ATOM(L+30))/ATOM(L+10),ATOM(L+30))                    NUCL1440
      PMYB=(ATOM(L+29)+ATOM(L+30))*ATOM(L)                              NUCL1450
   30 CONTINUE                                                          NUCL1460
      RETURN                                                            NUCL1470
      END                                                               NUCL1480
```

```
C ********************************************************************** AFGE0010
C *                                                                    * AFGE0020
C *                      AFGEN- A FUNCTION GENERATOR                   * AFGE0030
C *                                                                    * AFGE0040
C ********************************************************************** AFGE0050
C                                                                        AFGE0060
      FUNCTION AFGEN(ANPUT,N)                                            AFGE0070
C                                                                        AFGE0080
      COMMON / CURVAL / TIME  , DELT                                     AFGE0090
      COMMON / COST   / CURVE(1)                                         AFGE0100
C                                                                        AFGE0110
      DIMENSION LOC(100)                                                 AFGE0120
      DATA LOC/100*1/                                                    AFGE0130
C                                                                        AFGE0140
C                                                                        AFGE0150
C                                                                        AFGE0160
      M=20*(N-1)                                                         AFGE0170
      I1=LOC(N)                                                          AFGE0180
      DO 10 I=I1,19,2                                                    AFGE0190
      IF(CURVE(I+M) .GT. ANPUT) GO TO 20                                 AFGE0200
   10 CONTINUE                                                           AFGE0210
   20 I2=I-1                                                             AFGE0220
      DO 30 K=2,I2,2                                                     AFGE0230
      IF(CURVE(I-K+M) .LT. ANPUT) GO TO 40                               AFGE0240
   30 CONTINUE                                                           AFGE0250
   40 LOC(N)=I-K                                                         AFGE0260
      I=LOC(N)+2                                                         AFGE0270
      SLOPE=(CURVE(I+1+M)-CURVE(I-1+M))/(CURVE(I+M)-CURVE(I-2+M))        AFGE0280
      AFGEN=CURVE(I-1+M)+SLOPE*(ANPUT-CURVE(I-2+M))                      AFGE0290
      RETURN                                                             AFGE0300
      END                                                                AFGE0310
```

```
C                                                                       DEAD0010
C ***********************************************************************DEAD0020
C *                                                                     *DEAD0030
C *                    DEADSP --- DEAD SPACE FUNCTION                   *DEAD0040
C *                                                                     *DEAD0050
C ***********************************************************************DEAD0060
C                                                                       DEAD0070
      FUNCTION DEADSP( P1, P2, X )                                      DEAD0080
C                                                                       DEAD0090
      IF( X .GT. P2 ) GO TO 10                                          DEAD0100
      IF( X .LT. P1 ) GO TO 20                                          DEAD0110
      DEADSP = 0.0                                                      DEAD0120
      RETURN                                                            DEAD0130
   10 DEADSP = X - P2                                                   DEAD0140
      RETURN                                                            DEAD0150
   20 DEADSP = X - P1                                                   DEAD0160
      RETURN                                                            DEAD0170
      END                                                               DEAD0180
```

```
C                                                                       DELA0010
C ***********************************************************************DELA0020
C *                                                                     *DELA0030
C *                        DELAY- DELAY FUNCTION                        *DELA0040
C *                                                                     *DELA0050
C ***********************************************************************DELA0060
C                                                                       DELA0070
      FUNCTION DELAY(ISUB,KUNIT,IDLAY,NUM,P,X)                          DELA0080
C                                                                       DELA0090
C     ISUB --- SUBROUTINE INDEX NUMBER                                  DELA0100
C     KUNIT -- SEQUENTIAL UNIT NUMBER (0 OR N)                          DELA0110
C     IDLAY -- INDEX OF THE DELAY FUNCTION WITHIN THE SUBROUTINE        DELA0120
C     NUM ---- NUMBER OF POINTS SAMPLED IN INTERVAL P                   DELA0130
C     P ------ DELAY TIME IN SECONDS                                    DELA0140
C     X ------ INPUT                                                    DELA0150
C                                                                       DELA0160
C                        --------- KEY TO ISUB ---------               DELA0170
C                    SUBROUTINE                      SUBROUTINE         DELA0180
C     ISUB=     1..... INERTA          ISUB=    5..... BOILER         DELA0190
C               2..... LOADER                   6..... HYDRO          DELA0200
C               3..... EXTRNL                   7..... GASTUB         DELA0210
C               4..... LOO                      8..... NUCLER         DELA0220
C                                                                       DELA0230
C     TO INCORPORATE ADDITIONAL DELAYS OR INTEGRALS IN MODEL:           DELA0240
C                                                                       DELA0250
C        1)  PROVIDE A SUBROUTINE INDEX NUMBER FOR EVERY SUBROUTINE     DELA0260
C            THAT HAS A DELAY OR INTEGRAL BY CODING:                    DELA0270
C                     ISUB=K                                            DELA0280
C            AS ONE OF THE FIRST STATEMENTS IN THE SUBROUTINE WHERE     DELA0290
C            K IS AN INTEGER VALUE UNIQUE FOR EVERY SUCH SUBROUTINE.    DELA0300
C            (ISUB=K MUST PRECEDE ANY DELAY OR INTGRL FUNCTIONS IN      DELA0310
C            THE SUBROUTINE)                                            DELA0320
C                                                                       DELA0330
C        2)  IF THE DELAY OR INTEGRAL IS UNIT DEPENDENT, I.E., USED     DELA0340
C            BY A PRIME MOVER, THEN THE VALUE OF KUNIT MUST BE N.       DELA0350
C            IF THE DELAY OR INTEGRAL IS NOT UNIT DEPENDENT, I.E.,      DELA0360
C            THE FUNCTION IS CALCULATED FOR THE SYSTEM AS A WHOLE,      DELA0370
C            THEN THE VALUE OF KUNIT MUST BE 0.                         DELA0380
C                                                                       DELA0390
C        3)  NUMBER THE INTEGRALS SEQUENTIALLY FROM 1 TO K WHERE K IS   DELA0400
C            THE MAXIMUMUM NUMBER OF INTEGRATORS USED IN THE SUB-       DELA0410
```

```
C            ROUTINE.  THIS NUMBER IS CODED IN THE KINGRL SPOT OF THE   DELA0420
C            CALLING ARGUMENTS.  SIMILARLY NUMBER THE DELAYS IN THE     DELA0430
C            SUBROUTINE FROM 1 TO M WHERE M IS THE MAXIMUM NUMBER OF    DELA0440
C            DELAYS USED IN THE SUBROUTINE.  THIS NUMBER IS CODED IN    DELA0450
C            THE IDLAY SPOT OF THE CALLING ARGUMENTS.                   DELA0460
C                                                                       DELA0470
C        4)  BE SURE THAT DLAY, SD, AND PD ARE DIMENSIONED ADEQUATELY.  DELA0480
C            (SEE COMMENTS IN COMMON /DELLAY/ ABOVE AND IN FUNCTION     DELA0490
C            INTGRL BELOW)                                              DELA0500
C                                                                       DELA0510
C        5)  IF A DELAY FUNCTION IS ADDED IN THE BOILER SUBROUTINE,     DELA0520
C            A BRANCHING STATEMENT MUST BE PROVIDED SO THAT THE DELAY   DELA0530
C            IS ONLY COMPUTED WHEN KONT EQUALS 4.  IF KONT DOES NOT     DELA0540
C            EQUAL 4, THE DELAY FUNCTION MUST BE SKIPPED.               DELA0550
C                                                                       DELA0560
      COMMON / CURVAL / TIME   , DELT   , KEEP                          DELA0570
      COMMON / DELLAY / C(1000)         , DLAY(8,21,6)                  DELA0580
      COMMON / PASSES / KONT                                            DELA0590
      COMMON / NALARM / IERR                                            DELA0600
C                                                                       DELA0610
      INTEGER*4 KC(1)                                                   DELA0620
C                                                                       DELA0630
      EQUIVALENCE (C(1),KC(1))                                          DELA0640
C                                                                       DELA0650
      DATA K1/3/                                                        DELA0660
C                                                                       DELA0670
C                                                                       DELA0680
C                                                                       DELA0690
      IF(ISUB.GT.8 .OR. KUNIT.GT.21 .OR. IDLAY.GT.6) GO TO 140          DELA0700
      IF(TIME .EQ. 0.) GO TO 10                                         DELA0710
      K=DLAY(ISUB,KUNIT+1,IDLAY)                                        DELA0720
      GO TO 40                                                          DELA0730
   10 IF(KEEP .EQ. 0 .OR. KONT .EQ. 4) GO TO 20                         DELA0740
      GO TO 30                                                          DELA0750
   20 DLAY(ISUB,KUNIT+1,IDLAY)=K1                                       DELA0760
      K1=K1+2*NUM+2                                                     DELA0770
   30 CONTINUE                                                          DELA0780
      K=DLAY(ISUB,KUNIT+1,IDLAY)                                        DELA0790
      IF(K.GT.999) GO TO 170                                            DELA0800
      IF(TIME .GT. 0.0) GO TO 40                                        DELA0810
```

```
      KC(K-1)=K                                                          DELA0820
      KC(K-2)=K+2*(NUM-1)                                                DELA0830
      C(K)=0.0                                                           DELA0840
      C(K+1)=X                                                           DELA0850
      DELAY=X                                                            DELA0860
      RETURN                                                             DELA0870
C     TEST IF TIME FOR OUTPUT                                            DELA0880
   40 TIMEX=TIME-P                                                       DELA0890
      IF(TIMEX .GE. 0.0) GO TO 50                                        DELA0900
      DELAY=X                                                            DELA0910
      GO TO 120                                                          DELA0920
   50 INDEX=KC(K-1)                                                      DELA0930
      IF(C(K) .LE. 0.0) GO TO 70                                         DELA0940
      KEND=KC(K-2)                                                       DELA0950
      IF(INDEX .EQ. KEND) GO TO 70                                       DELA0960
      INDEX2=INDEX+2                                                     DELA0970
      DO 60 II=INDEX2,KEND,2                                             DELA0980
      I=II                                                               DELA0990
      IF(TIMEX-C(I)) 100, 110, 60                                        DELA1000
   60 CONTINUE                                                           DELA1010
   70 DO 80 II=K,INDEX,2                                                 DELA1020
      I=II                                                               DELA1030
      IF(TIMEX-C(I)) 100, 110, 80                                        DELA1040
   80 CONTINUE                                                           DELA1050
      WRITE(6,90) NUM,P                                                  DELA1060
   90 FORMAT('0 DELAY BLOCK NEEDS MORE THAN THE ',I5,                    DELA1070
     1       'POINTS PROVIDED FOR DELAY OF',E12.5/)                      DELA1080
      GO TO 200                                                          DELA1090
  100 I=I-2                                                              DELA1100
      IF(I .LT. K) I=KEND                                                DELA1110
  110 DELAY=C(I+1)                                                       DELA1120
C     TEST IF TIME TO STORE INPUT                                        DELA1130
  120 IF(KEEP .LE. 0) RETURN                                             DELA1140
      INDEX=KC(K-1)+2                                                    DELA1150
      IF(INDEX .LE. KC(K-2)) GO TO 130                                   DELA1160
      INDEX=K                                                            DELA1170
  130 KC(K-1)=INDEX                                                      DELA1180
      C(INDEX)=TIME                                                      DELA1190
      C(INDEX+1)=X                                                       DELA1200
      GO TO 210                                                          DELA1210
```

```
  140 WRITE(6,150)                                                      DELA1220
      WRITE(6,160) ISUB,KUNIT,IDLAY                                     DELA1230
  150 FORMAT('0  A DLAY INDEX HAS EXCEEDED A MAXIMUM.  USER MUST INCREASDELA1240
     1E THE DIMENSION OF DLAY(8,21,6)')                                 DELA1250
  160 FORMAT('  THE ATTEMPTED INDICES WERE:  ISUB=',I5,'   KUNIT=',     DELA1260
     1I5,'    IDLAY=',I5/)                                             DELA1270
      GO TO 200                                                         DELA1280
  170 WRITE(6,180)                                                      DELA1290
  180 FORMAT(1HO,' MORE THAN 1000 STORAGE SPACES REQUIRED, USER MUST INCDELA1300
     1REASE DIMENSION OF C(1000).')                                     DELA1310
      WRITE(6,190) K                                                    DELA1320
  190 FORMAT(' THE ATTEMPTED INDEX WAS:  K=',I5/)                       DELA1330
      GO TO 200                                                         DELA1340
  200 IERR=1                                                            DELA1350
  210 CONTINUE                                                          DELA1360
      RETURN                                                            DELA1370
      END                                                               DELA1380
```

```
C                                                                       INTG0010
C ***********************************************************************INTG0020
C *                                                                     *INTG0030
C *          INTGRL- TRAPIZOIDAL INTEGRATION ROUTINE                    *INTG0040
C *                                                                     *INTG0050
C ***********************************************************************INTG0060
C                                                                       INTG0070
      REAL FUNCTION INTGRL(ISUB,KUNIT,KINGRL,B,C,Y)                     INTG0080
C                                                                       INTG0090
C     ISUB --- SUBROUTINE INDEX NUMBER                                  INTG0100
C     KUNIT -- SEQUENTIAL UNIT NUMBER (0 OR N)                          INTG0110
C     KINGRL - INDEX OF THE INTGRL FUNCTION WITHIN THE SUBROUTINE       INTG0120
C     B ------ INITIAL CONDITION OF INTEGRATOR                          INTG0130
C     C ------ INPUT                                                   INTG0140
C     Y ------ OUTPUT FROM LAST TIME STEP                               INTG0150
C                                                                       INTG0160
      COMMON / CURVAL / TIME  , DELT  , KEEP                            INTG0170
      COMMON / PASSES / KONT  , AEEP                                    INTG0180
      COMMON / NALARM / IERR                                            INTG0190
C                                                                       INTG0200
      DIMENSION SD(8,21,10)   , PD(8,21,10)                             INTG0210
C                                                                       INTG0220
C     SD AND PD ARE DIMENSIONED AS SD(X,Y,Z) , PD(X,Y,Z) WHERE:         INTG0230
C           X= TOTAL NUMBER OF INDEXED SUBROUTINES                      INTG0240
C           Y= MAXIMUM NUMBER OF UNITS PLUS ONE                         INTG0250
C           Z= GREATER THAN OR EQUAL TO THE GREATEST NUMBER OF          INTG0260
C                 INTEGRATORS USED IN ANY SUBROUTINE                    INTG0270
C                                                                       INTG0280
C     SEE FURTHER COMMENTS IN FUNCTION DELAY                            INTG0290
C                                                                       INTG0300
C                                                                       INTG0310
C                                                                       INTG0320
C                                                                       INTG0330
C  *--------------------------------------------------------------      INTG0340
C  *  IF THIS IS AN INTEGRATOR FROM THE BOILER SUBROUTINE, CHANGE      INTG0350
C  *       THE INTEGRATION INTERVAL TO 0.5 SECONDS (FOR NUMERICAL      INTG0360
C  *       STABILITY)                                                  INTG0370
C  *                                                                   INTG0380
C                                                                       INTG0390
      IF(ISUB .EQ. 5) DELT=0.5                                          INTG0400
      IF(ISUB.GT.8 .OR. KUNIT.GT.21 .OR. KINGRL.GT.8) GO TO 30          INTG0410
```

```
      IF(ISUB .NE. 5 .AND. KEEP .EQ. 1 .AND. TIME .NE. 0.) GO TO 10      INTG0420
      IF(ISUB .EQ. 5 .AND. AEEP .EQ. 1 .AND. TIME .NE. 0.) GO TO 10      INTG0430
      PD(ISUB,KUNIT+1,KINGRL)=C                                          INTG0440
      SD(ISUB,KUNIT+1,KINGRL)=Y                                          INTG0450
      IF(TIME .EQ. 0.) GO TO 20                                          INTG0460
      INTGRL=SD(ISUB,KUNIT+1,KINGRL)+DELT*C                              INTG0470
      GO TO 70                                                           INTG0480
   10 INTGRL=SD(ISUB,KUNIT+1,KINGRL)+.5*DELT*(PD(ISUB,KUNIT+1,KINGRL)+C)INTG0490

      GO TO 70                                                           INTG0500
   20 SD(ISUB,KUNIT+1,KINGRL)=B                                          INTG0510
      INTGRL=SD(ISUB,KUNIT+1,KINGRL)                                     INTG0520
      GO TO 70                                                           INTG0530
   30 WRITE(6,40)                                                        INTG0540
      WRITE(6,50) ISUB,KUNIT,KINGRL                                      INTG0550
   40 FORMAT('0  AN INTEGRATOR INDEX HAS EXCEEDED A MAXIMUM.  USER       INTG0560
     1MUST INCREASE THE DIMENSION OF PD(8,21,10) AND SD(8,21,10)')       INTG0570
   50 FORMAT('  THE ATTEMPTED INDICES WERE:  ISUB=',I5,'   KUNIT=',      INTG0580
     1I5,'    KINGRL=',I5/)                                             INTG0590
      GO TO 60                                                           INTG0600
   60 IERR=1                                                             INTG0610
   70 CONTINUE                                                           INTG0620
C                                                                        INTG0630
C  *-----------------------------------------------------               INTG0640
C  *  BE SURE DELT IS AT ITS ORIGINAL VALUE BEFORE RETURNING            INTG0650
C  *                                                                    INTG0660
C                                                                        INTG0670
      DELT=1.0                                                           INTG0680
      RETURN                                                             INTG0690
      END                                                                INTG0700
```

```
C                                                                       LIMI0010
C ***********************************************************************LIMI0020
C *                                                                     *LIMI0030
C *                      LIMIT --- LIMITER FUNCTION                     *LIMI0040
C *                                                                     *LIMI0050
C ***********************************************************************LIMI0060
C                                                                       LIMI0070
      REAL FUNCTION LIMIT( P1, P2, X )                                  LIMI0080
C                                                                       LIMI0090
      LIMIT = X                                                         LIMI0100
      IF( X .LT. P1 ) LIMIT=P1                                          LIMI0110
      IF( X .GT. P2 ) LIMIT = P2                                        LIMI0120
      RETURN                                                            LIMI0130
      END                                                               LIMI0140
```

```
C                                                                       NOISO010
C  ********************************************************************** NOISO020
C  *                                                                    * NOISO030
C  *                      NOISE --- NOISE GENERATOR                     * NOISO040
C  *                                                                    * NOISO050
C  ********************************************************************** NOISO060
C                                                                       NOISO070
      REAL FUNCTION NOISE( P1, P2, P3 )                                 NOISO080
C                                                                       NOISO090
      INTEGER*4 P1                                                      NOISO100
C                                                                       NOISO110
C     A NORMAL GAUSSIAN DISTRIBUTION AROUND THE MEAN 'P2' WITH STANDARD NOISO120
C         DEVIATION 'P3'.  'P1' IS ANY ODD INTEGER (SEED)               NOISO130
C                                                                       NOISO140
      IY=P1*65539                                                       NOISO150
      IF(IY .LT. 0) IY=IY+2147483647+1                                  NOISO160
      P1=IY                                                             NOISO170
      UNZRP1=IY*0.4656613E-09                                           NOISO180
      NOISE=P3*SQRT(-2.0*ALOG(UNZRP1))*COS(UNZRP1*6.283185)+P2          NOISO190
      RETURN                                                            NOISO200
      END                                                               NOISO210
```

```
C ***************************************************************      SINE0010
C *                                                             *      SINE0020
C *                    SINE --- SINUSOIDAL GENERATOR            *      SINE0030
C *                                                             *      SINE0040
C ***************************************************************      SINE0050
C                                                                        SINE0060
      FUNCTION SINE(P1,P2,P3)                                            SINE0070
C                                                                        SINE0080
      COMMON / CURVAL / TIME  , DELT                                     SINE0090
C                                                                        SINE0100
C     P1  INITIATION TIME OF WAVE IN SECONDS                             SINE0110
C     P2  FREQUENCY OF WAVE IN RADIANS PER SECOND                        SINE0120
C     P3  PHASE SHIFT OF WAVE IN RADIANS                                 SINE0130
C                                                                        SINE0140
C         IF P1<T , Y=0                                                  SINE0150
C         IF P1>T , Y=SIN(P2*(T-P1)+P3)                                  SINE0160
C                                                                        SINE0170
      X=TIME-P1                                                          SINE0180
      IF(X+0.5*DELT .GE. 0.0) GO TO 10                                   SINE0190
      SINE=0.0                                                           SINE0200
      RETURN                                                             SINE0210
   10 SINE=SIN(P2*X+P3)                                                  SINE0220
      RETURN                                                             SINE0230
      END                                                                SINE0240
```

```
C  ------------------------------------------------------------------- PLOT0010
C  *                                                                   * PLOT0020
C  *                S U B R O U T I N E   P L O T                      * PLOT0030
C  *                                                                   * PLOT0040
C  ------------------------------------------------------------------- PLOT0050
      SUBROUTINE PLOT                                                   PLOT0060
C                                                                       PLOT0070
      COMMON / PLOTT  / XOUT(15)      , AMAX(15)      , AMIN(15)      , PLOT0080
     1                  POINT(15)     , INT   , ITIC  , NPLVAR, ACR   , PLOT0090
     2                  UP    , BLANK , PLUS  , BPP(60)       ,       PLOT0100
     3                  D(1,60)       , APP(5), NWRITE                PLOT0110
C                                                                       PLOT0120
C                                                                       PLOT0130
C                                                                       PLOT0140
C     THE MAXIMUM NUMBER OF VARIABLES THAT CAN BE PLOTTED IS 14.        PLOT0150
C                                                                       PLOT0160
C     INT IS THE PLOT INTERVAL DESIRED IN SECONDS                       PLOT0170
C                                                                       PLOT0180
C     ITIC IS THE TIME TIC MARK IN SECONDS                              PLOT0190
C                                                                       PLOT0200
C     NPLVAR IS THE TOTAL NUMBER OF VARIABLES TO BE PLOTTED.            PLOT0210
C                                                                       PLOT0220
C                                                                       PLOT0230
C                                                                       PLOT0240
      REWIND 11                                                         PLOT0250
      NCOUNT=NPLVAR+1                                                   PLOT0260
      READ(11       ) (XOUT(I),I=1,NCOUNT)                              PLOT0270
      NREAD=NWRITE-1                                                    PLOT0280
      TIME=XOUT(1)                                                      PLOT0290
      DO 20 IT=1,22                                                     PLOT0300
      WRITE(6,10) BLANK                                                 PLOT0310
   10 FORMAT(23A1)                                                      PLOT0320
   20 CONTINUE                                                          PLOT0330
   30 LINCHK=NCOUNT+1                                                   PLOT0340
      ICALC=0                                                           PLOT0350
      JAN=1                                                             PLOT0360
      DO 60 L=2,NCOUNT                                                  PLOT0370
      DO 40 K=10,50,10                                                  PLOT0380
      I=K/10                                                            PLOT0390
      PP=K                                                              PLOT0400
      IF(K .EQ.K/10*10)APP(I)=AMIN(L)+PP/(60./(ABS(AMAX(L)-AMIN(L))))   PLOT0410
```

```
 40 CONTINUE                                                          PLOT0420
    WRITE(6,50) POINT(L),(APP(I),I=1,5,2)                             PLOT0430
 50 FORMAT(1X,A4,1X,3(F10.3,10X))                                     PLOT0440
 60 CONTINUE                                                          PLOT0450
    DO 70 K=1,60                                                      PLOT0460
    BPP(K)=ACR                                                        PLOT0470
    IF(K .EQ. K/10*10) BPP(K)=UP                                      PLOT0480
 70 CONTINUE                                                          PLOT0490
    START=UP                                                          PLOT0500
    WRITE(6,80)START, (BPP(I),I=1,60)                                 PLOT0510
 80 FORMAT(2X,61A1)                                                   PLOT0520
 90 CONTINUE                                                          PLOT0530
    IF(LINCHK .EQ. 24) GO TO 30                                       PLOT0540
    DO 100 J=1,60                                                     PLOT0550
100 D(1,J)=BLANK                                                      PLOT0560
    D(1,60)=UP                                                        PLOT0570
    ITIME=TIME                                                        PLOT0580
    ATIME=ITIME                                                       PLOT0590
    IF(ATIME-TIME .NE. 0.) ICALC=1                                    PLOT0600
    IF(ITIME .NE. ITIME/ITIC*ITIC) GO TO 120                          PLOT0610
    DO 110 J=10,50,10                                                 PLOT0620
110 D(1,J)=PLUS                                                       PLOT0630
120 CONTINUE                                                          PLOT0640
    START=UP                                                          PLOT0650
    DO 130 J=2,NCOUNT                                                 PLOT0660
    A=(XOUT(J)-AMIN(J))*(60./(ABS(AMAX(J)-AMIN(J))))                  PLOT0670
    L=A                                                               PLOT0680
    DIF=A-FLOAT(L)                                                    PLOT0690
    IF(DIF .GE. .51) L=L+1                                            PLOT0700
    IF(L .LT. 1) START=POINT(J)                                       PLOT0710
    IF(L .LT. 1) GO TO 130                                            PLOT0720
    IF(L .GT. 60) L=60                                                PLOT0730
    D(1,L)=POINT(J)                                                   PLOT0740
130 CONTINUE                                                          PLOT0750
    IF(ICALC .EQ. 1) GO TO 140                                        PLOT0760
    IF(ITIME .EQ. ITIME/ITIC*ITIC) GO TO 170                          PLOT0770
    GO TO 150                                                         PLOT0780
140 IF(JAN.EQ. JAN/ITIC*ITIC) GO TO 170                               PLOT0790
150 WRITE(6,160) START,(D(1,J),J=1,60)                                PLOT0800
160 FORMAT(2X,61A1)                                                   PLOT0810
```

```
      GO TO 190                                                          PLOT0820
  170 WRITE(6,180) START,(D(1,J),J=1,60),TIME                            PLOT0830
  180 FORMAT(2X,61A1,2X,F8.2)                                            PLOT0840
      JAN=JAN+1                                                          PLOT0850
  190 CONTINUE                                                           PLOT0860
      LINCHK=LINCHK+1                                                    PLOT0870
      DO 200 J=1,INT                                                     PLOT0880
      IF (NREAD .EQ. 0) GO TO 210                                        PLOT0890
  200 READ(11) (XOUT(I),I=1,NCOUNT)                                      PLOT0900
      NREAD=NREAD-1                                                      PLOT0910
      TIME=XOUT(1)                                                       PLOT0920
      GO TO 90                                                           PLOT0930
  210 RETURN                                                             PLOT0940
      END                                                                PLOT0950
```

```
C ------------------------------------------------------------------  PRIN0010
C *                                                                *  PRIN0020
C *             PRINT- A SUBROUTINE THAT SPECIFIES OUTPUT          *  PRIN0030
C *                                                                *  PRIN0040
C ------------------------------------------------------------------  PRIN0050
C                                                                      PRIN0060
      SUBROUTINE PRINT( SYM1, VAL1, SYM2, VAL2, SYM3, VAL3,            PRIN0070
     1                  SYM4, VAL4, SYM5, VAL5, SYM6, VAL6 )           PRIN0080
C                                                                      PRIN0090
      REAL*4     BLANKS/'    '/, VALUE(44)                           PRIN0100
      REAL*8     SYMBOL(44)    , SYM   , SYM1  , SYM2  , SYM3  , SYM4  , PRIN0110
     1           SYM5  , SYM6                                         PRIN0120
C                                                                      PRIN0130
      EQUIVALENCE (FIRST4,SYM)                                         PRIN0140
C                                                                      PRIN0150
      COMMON / CURVAL / TIME  , DELT                                   PRIN0160
      COMMON / PRTCNL / ICOUNT, TLAST , SYMBOL, VALUE , LINES , IPAGES PRIN0170
C                                                                      PRIN0180
C                                                                      PRIN0190
C                                                                      PRIN0200
C  *-------------------------------------                              PRIN0210
C  *  RESET THE COUNTER IF TIME HAS CHANGED                           PRIN0220
C  *                                                                  PRIN0230
C                                                                      PRIN0240
      IF( TIME .EQ. TLAST ) GO TO 10                                   PRIN0250
      ICOUNT = 0                                                       PRIN0260
      TLAST = TIME                                                     PRIN0270
   10 CONTINUE                                                         PRIN0280
C                                                                      PRIN0290
C  *-------------------------------------                              PRIN0300
C  *  NOW START SAVING THE SYMBOLS AND VALUES                         PRIN0310
C  *                                                                  PRIN0320
C                                                                      PRIN0330
      SYM = SYM1                                                       PRIN0340
      VAL = VAL1                                                       PRIN0350
      DO 70 I = 1, 6                                                   PRIN0360
C                                                                      PRIN0370
C  *------------------------------------------------------------------ PRIN0380
C  *  GO AWAY IF THERE IS A BLANK SYMBOL PASSED OR IF THE ARRAY IS FULL.PRIN0390
C  *                                                                  PRIN0400
C                                                                      PRIN0410
```

```
      IF( FIRST4 .EQ. BLANKS .OR. ICOUNT .GT. 44 ) GO TO 80          PRIN0420
C                                                                    PRIN0430
C  *-----------------------------------------------------------      PRIN0440
C  *  DUMP THE SYMBOLS AND VALUES INTO THE APPROPRIATE SPOTS IN THE  PRIN0450
C  *      TABLES                                                    PRIN0460
C  *                                                                PRIN0470
C                                                                    PRIN0480
      ICOUNT = ICOUNT + 1                                            PRIN0490

      SYMBOL(ICOUNT) = SYM                                           PRIN0500
      VALUE(ICOUNT) = VAL                                            PRIN0510
      GO TO (  20,  30,  40,  50,  60,  70 ), I                      PRIN0520
   20 SYM = SYM2                                                     PRIN0530
      VAL = VAL2                                                     PRIN0540
      GO TO 70                                                       PRIN0550
   30 SYM = SYM3                                                     PRIN0560
      VAL = VAL3                                                     PRIN0570
      GO TO 70                                                       PRIN0580
   40 SYM = SYM4                                                     PRIN0590
      VAL = VAL4                                                     PRIN0600
      GO TO 70                                                       PRIN0610
   50 SYM = SYM5                                                     PRIN0620
      VAL = VAL5                                                     PRIN0630
      GO TO 70                                                       PRIN0640
   60 SYM = SYM6                                                     PRIN0650
      VAL = VAL6                                                     PRIN0660
   70 CONTINUE                                                       PRIN0670
   80 RETURN                                                         PRIN0680
      END                                                            PRIN0690
```

```
C ------------------------------------------------------------------- PLOT0010
C *                                                                   * PLOT0020
C *            PLOTMD- A SUBROUTINE THAT MODIFIES PLOT SCALES         * PLOT0030
C *                                                                   * PLOT0040
C ------------------------------------------------------------------- PLOT0050
C                                                                     PLOT0060
      SUBROUTINE PLOTMD                                               PLOT0070
C                                                                     PLOT0080
      COMMON / PLOTT  / XOUT(15)      , AMAX(15)      , AMIN(15)      , PLOT0090
     1                  POINT(15)     , INT   , ITIC  , NPLVAR, ACR   , PLOT0100
     2                  UP    , BLANK , PLUS                          PLOT0110
C                                                                     PLOT0120
      DIMENSION PID(14)                                               PLOT0130
C                                                                     PLOT0140
C                                                                     PLOT0150
C                                                                     PLOT0160
      WRITE(6,10) BLANK                                               PLOT0170
   10 FORMAT(2A1)                                                     PLOT0180
      WRITE(6,20)                                                     PLOT0190
   20 FORMAT(' CLEAR SCREEN AND HIT ENTER TO START PLOT CHANGES')     PLOT0200
      READ(5,30) DUMMY                                                PLOT0210
   30 FORMAT(1A5)                                                     PLOT0220
      WRITE(6,40)                                                     PLOT0230
   40 FORMAT(' THE PLOT SCALES USED ARE SHOWN BELOW')                 PLOT0240
      WRITE(6,50)                                                     PLOT0250
   50 FORMAT(' VARIABLE      MINIMUM      MAXIMUM ')                 PLOT0260
      L=NPLVAR+1                                                      PLOT0270
      DO 70 N=2,L                                                     PLOT0280
      WRITE(6,60) POINT(N),AMIN(N),AMAX(N)                            PLOT0290
   60 FORMAT(5X,A1,5X,F10.3,3X,F10.3)                                 PLOT0300
   70 CONTINUE                                                        PLOT0310
      WRITE(6,80)                                                     PLOT0320
   80 FORMAT(' AFTER EACH PROMPT ENTER A PLOT SYMBOL WHOSE SCALE YOU WISPLOT0330
     1H TO CHANGE.  ENTER          A BLANK WHEN DONE.')              PLOT0340
      LINCHK=5+NPLVAR                                                 PLOT0350
      DO 150 N=1,NPLVAR                                               PLOT0360
      WRITE(6,90)                                                     PLOT0370
   90 FORMAT(' ?')                                                    PLOT0380
      READ(5,100) PID(N)                                              PLOT0390
  100 FORMAT(A1)                                                      PLOT0400
      LINCHK=LINCHK+2                                                 PLOT0410
```

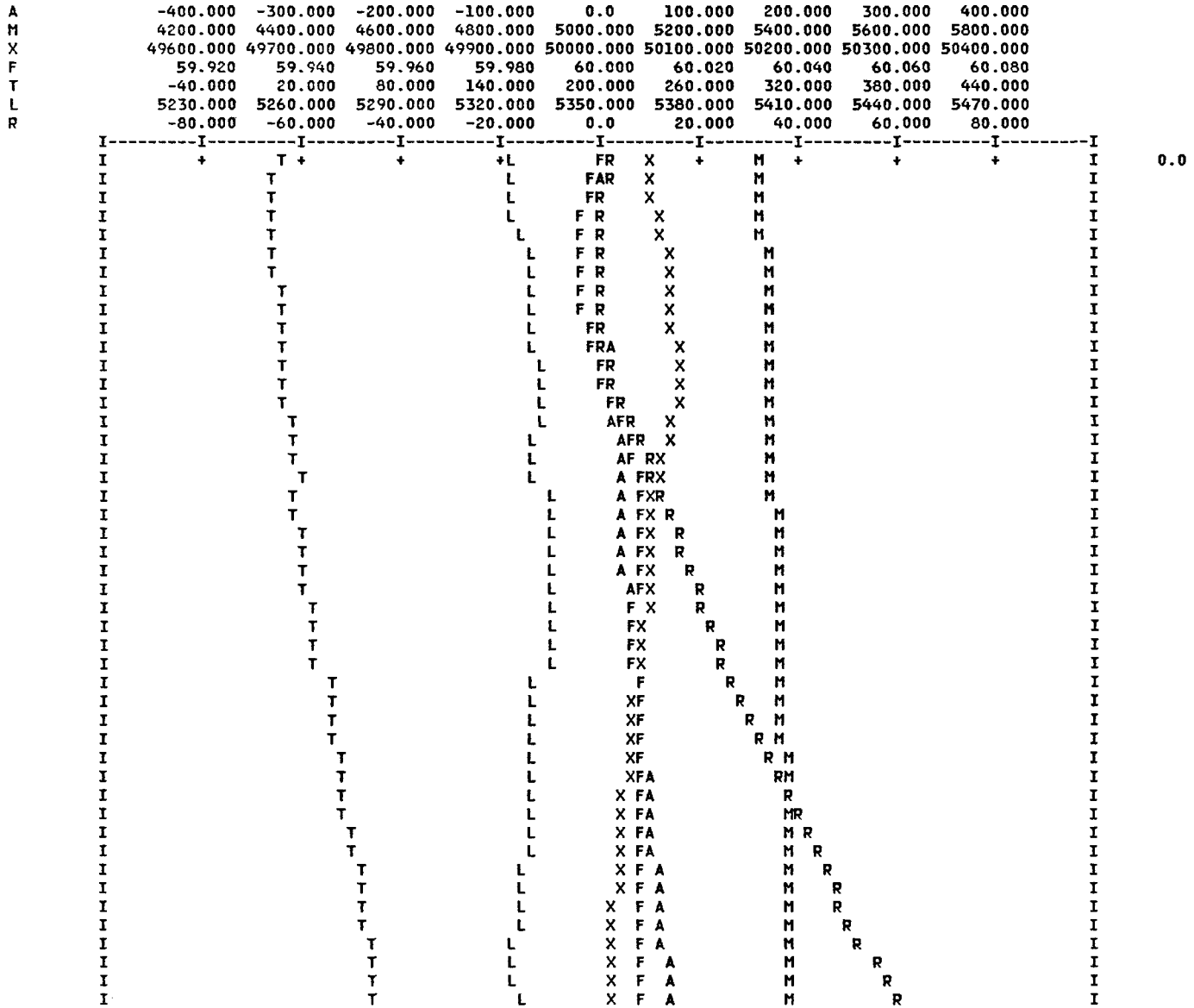
```
      IF(LINCHK .LE. 21) GO TO 140                                      PLOT0420
      IF(LINCHK .EQ. 22) WRITE(6,100) BLANK                             PLOT0430
      WRITE(6,100) BLANK                                                PLOT0440
      CONTINUE                                                          PLOT0450
      IF(PID(N) .EQ. BLANK) GO TO 160                                   PLOT0460
      WRITE(6,50)                                                       PLOT0470
      LINCHK=2+NPLVAR                                                   PLOT0480
      L=NPLVAR+1                                                        PLOT0490
      DO 130 I=2,L                                                      PLOT0500
      DO 110 J=1,NPLVAR                                                 PLOT0510
      IF(PID(J) .EQ. POINT(I)) GO TO 120                                PLOT0520
  110 CONTINUE                                                          PLOT0530
      WRITE(6,60) POINT(I),AMIN(I),AMAX(I)                              PLOT0540
      GO TO 130                                                         PLOT0550
  120 LINCHK=LINCHK-1                                                   PLOT0560
  130 CONTINUE                                                          PLOT0570
  140 IF(PID(N) .EQ. BLANK) GO TO 160                                   PLOT0580
  150 CONTINUE                                                          PLOT0590
  160 IF(PID(1) .EQ. BLANK) GO TO 320                                   PLOT0600
      IF (LINCHK .GE. 23) GO TO 180                                     PLOT0610
      M=24-LINCHK                                                       PLOT0620
      DO 170 I=1,M                                                      PLOT0630
      WRITE(6,100) BLANK                                                PLOT0640
  170 CONTINUE                                                          PLOT0650
  180 WRITE(6,190)                                                      PLOT0660
  190 FORMAT(' ALONG WITH THE PLOT VARIABLES WHOSE SCALES YOU WANTED CHAPLOT0670
     1NGED, YOU WILL BE          SHOWN THE PRESENT SCALE VALUES.')      PLOT0680
      WRITE(6,200)                                                      PLOT0690
  200 FORMAT(' ',' ENTER THE NEW MINIMUM AND MAXIMUM SCALE VALUES DESIREPLOT0700
     1D AFTER EACH DISPLAY.')                                           PLOT0710
      LINCHK=4                                                          PLOT0720
      DO 310 J=1,NPLVAR                                                 PLOT0730
      IF(PID(J) .EQ. BLANK) GO TO 320                                   PLOT0740
      L=NPLVAR+1                                                        PLOT0750
      DO 210 N=2,L                                                      PLOT0760
      IF(PID(J) .EQ. POINT(N)) GO TO 220                                PLOT0770
  210 CONTINUE                                                          PLOT0780
  220 WRITE(6,100) BLANK                                                PLOT0790
      WRITE(6,230) POINT(N),AMIN(N),AMAX(N)                             PLOT0800
  230 FORMAT(5X,A1,6X,'MIN=',F10.3,2X,'MAX=',F10.3/)                    PLOT0810
```

```
      WRITE(6,240) POINT(N)                                          PLOT0820
  240 FORMAT(' ENTER NEW MINIMUM FOR ',A1/)                          PLOT0830
      READ(5,260) AMIN(N)                                            PLOT0840
      WRITE(6,250) POINT(N)                                          PLOT0850
  250 FORMAT(' ENTER NEW MAXIMUM FOR ',A1/)                          PLOT0860
      READ(5,260) AMAX(N)                                            PLOT0870
  260 FORMAT(F10.3)                                                  PLOT0880
      LINCHK=LINCHK+9                                                PLOT0890
      IF(LINCHK .EQ. 22) GO TO 270                                   PLOT0900
      IF(LINCHK .EQ. 23) GO TO 280                                   PLOT0910
      IF(LINCHK .EQ. 24) GO TO 290                                   PLOT0920
      GO TO 310                                                      PLOT0930
  270 WRITE(6,100) BLANK                                             PLOT0940
  280 WRITE(6,100) BLANK                                             PLOT0950
  290 LINCHK=4                                                       PLOT0960
      WRITE(6,300) BLANK                                             PLOT0970
  300 FORMAT(4A1)                                                    PLOT0980

  310 CONTINUE                                                       PLOT0990
  320 RETURN                                                         PLOT1000
      END                                                            PLOT1010
```

```
OUTPUT  C ------------------------------------------------------------------- OUTP0010
        C *                                                                 * OUTP0020
        C *            OUTPUT- A SUBROUTINE THAT PRINTS THE OUTPUT          * OUTP0030
        C *                                                                 * OUTP0040
        C ------------------------------------------------------------------- OUTP0050
        C                                                                     OUTP0060
              SUBROUTINE OUTPUT                                               OUTP0070
        C                                                                     OUTP0080
              REAL*4     VALUE(44)                                          OUTP0090
              REAL*8     SYMBOL(44)                                         OUTP0100
        C                                                                     OUTP0110
              COMMON / CURVAL / TIME   , DELT                                 OUTP0120
              COMMON / PRTCNL / ICOUNT, TLAST , SYMBOL, VALUE , LINES , IPAGES OUTP0130
        C                                                                     OUTP0140
        C                                                                     OUTP0150
        C                                                                     OUTP0160
              LINCHK=LINES                                                    OUTP0170
              IF(IPAGES .EQ. 1) LINCHK=LINES+1                                OUTP0180
              IPAGES=IPAGES+1                                                 OUTP0190
           10 LINES=LINCHK+(ICOUNT+1)/2+1                                     OUTP0200
              IF(LINES .GE. 24) GO TO 30                                      OUTP0210
              WRITE(6,20) TIME, (SYMBOL(I), VALUE(I), I = 1 , ICOUNT )        OUTP0220
           20 FORMAT(' TIME  = ', E12.4,2(4X, A8,  '=',E12.4), /;             OUTP0230
             1       22(25X, A8,  '=',E12.4,4X,A8,'=',E12.4,/),//)           OUTP0240
              RETURN                                                          OUTP0250
           30 IF(LINCHK .GE. 23) GO TO 60                                     OUTP0260
              M=23-LINCHK                                                     OUTP0270
              DO 50 I=1,M                                                     OUTP0280
              WRITE(6,40)                                                     OUTP0290
           40 FORMAT('     ')                                                 OUTP0300
           50 CONTINUE                                                        OUTP0310
           60 LINES=0                                                         OUTP0320
              LINCHK=0                                                        OUTP0330
              GO TO 10                                                        OUTP0340
              END                                                             OUTP0350
```

TIME	=	0.0	LOAD	=	0.5324E 04	PMSYS	=	0.5324E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.5005E 05
			PACCEL	=	-0.6965E 02	FREQHZ	=	0.6000E 02	PTINET	=	0.7180E 01	ACEEXT	=	-0.7180E 01
			SKDTI	=	0.0	ACE	=	0.7180E 01	AR	=	0.1077E 01	LAM	=	0.2500E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1620E 04	PM(3)	=	0.3300E 03	PM(4)	=	0.5000E 03
			PM(5)	=	0.1750E 03	PM(6)	=	0.5380E 03	PM(7)	=	0.3100E 03	PM(8)	=	0.3010E 03
TIME	=	0.1000E 02	LOAD	=	0.5329E 04	PMSYS	=	0.5340E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.5008E 05
			PACCEL	=	0.1712E 02	FREQHZ	=	0.6000E 02	PTINET	=	0.9336E 01	ACEEXT	=	-0.2621E 02
			SKDTI	=	0.0	ACE	=	0.5219E 01	AR	=	0.9283E 00	LAM	=	0.2500E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1620E 04	PM(3)	=	0.3301E 03	PM(4)	=	0.5000E 03
			PM(5)	=	0.1753E 03	PM(6)	=	0.5381E 03	PM(7)	=	0.3170E 03	PM(8)	=	0.3094E 03
TIME	=	0.2000E 02	LOAD	=	0.5335E 04	PMSYS	=	0.5352E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.5005E 05
			PACCEL	=	-0.3438E 00	FREQHZ	=	0.6001E 02	PTINET	=	0.1743E 02	ACEEXT	=	0.5406E 02
			SKDTI	=	0.0	ACE	=	0.2300E 02	AR	=	0.1543E 02	LAM	=	0.2497E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1620E 04	PM(3)	=	0.3294E 03	PM(4)	=	0.5000E 03
			PM(5)	=	0.1754E 03	PM(6)	=	0.5375E 03	PM(7)	=	0.3229E 03	PM(8)	=	0.3168E 03
TIME	=	0.3000E 02	LOAD	=	0.5329E 04	PMSYS	=	0.5368E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.5003E 05
			PACCEL	=	0.2375E 01	FREQHZ	=	0.6001E 02	PTINET	=	0.3851E 02	ACEEXT	=	0.3298E 02
			SKDTI	=	0.0	ACE	=	0.4100E 02	AR	=	0.2995E 02	LAM	=	0.2493E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1619E 04	PM(3)	=	0.3285E 03	PM(4)	=	0.4998E 03
			PM(5)	=	0.1757E 03	PM(6)	=	0.5364E 03	PM(7)	=	0.3313E 03	PM(8)	=	0.3269E 03
TIME	=	0.4000E 02	LOAD	=	0.5326E 04	PMSYS	=	0.5383E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.5001E 05
			PACCEL	=	0.1926E 01	FREQHZ	=	0.6001E 02	PTINET	=	0.5629E 02	ACEEXT	=	0.2023E 02
			SKDTI	=	0.0	ACE	=	0.6014E 02	AR	=	0.4900E 02	LAM	=	0.2488E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1619E 04	PM(3)	=	0.3275E 03	PM(4)	=	0.4996E 03
			PM(5)	=	0.1759E 03	PM(6)	=	0.5348E 03	PM(7)	=	0.3395E 03	PM(8)	=	0.3367E 03
TIME	=	0.5000E 02	LOAD	=	0.5326E 04	PMSYS	=	0.5397E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.5000E 05
			PACCEL	=	0.1980E 01	FREQHZ	=	0.6001E 02	PTINET	=	0.7069E 02	ACEEXT	=	0.1087E 02
			SKDTI	=	0.0	ACE	=	0.7612E 02	AR	=	0.6730E 02	LAM	=	0.2481E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1618E 04	PM(3)	=	0.3264E 03	PM(4)	=	0.4994E 03
			PM(5)	=	0.1760E 03	PM(6)	=	0.5329E 03	PM(7)	=	0.3477E 03	PM(8)	=	0.3466E 03
TIME	=	0.6000E 02	LOAD	=	0.5324E 04	PMSYS	=	0.5411E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.4999E 05
			PACCEL	=	0.4422E 01	FREQHZ	=	0.6001E 02	PTINET	=	0.8701E 02	ACEEXT	=	0.1112E 02
			SKDTI	=	0.0	ACE	=	0.9280E 02	AR	=	0.7500E 02	LAM	=	0.2475E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1618E 04	PM(3)	=	0.3253E 03	PM(4)	=	0.4991E 03
			PM(5)	=	0.1760E 03	PM(6)	=	0.5311E 03	PM(7)	=	0.3557E 03	PM(8)	=	0.3563E 03
TIME	=	0.7000E 02	LOAD	=	0.5324E 04	PMSYS	=	0.5425E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.4997E 05
			PACCEL	=	0.4219E 01	FREQHZ	=	0.6001E 02	PTINET	=	0.1006E 03	ACEEXT	=	0.9767E 01
			SKDTI	=	0.0	ACE	=	0.1080E 03	AR	=	0.7500E 02	LAM	=	0.2469E 02
			PM(1)	=	0.1550E 04	PM(2)	=	0.1616E 04	PM(3)	=	0.3241E 03	PM(4)	=	0.4986E 03
			PM(5)	=	0.1760E 03	PM(6)	=	0.5299E 03	PM(7)	=	0.3638E 03	PM(8)	=	0.3660E 03
TIME	=	0.8000E 02	LOAD	=	0.5329E 04	PMSYS	=	0.5438E 04	LODEXT	=	0.5007E 05	PMEXT	=	0.4996E 05
			PACCEL	=	-0.1785E 01	FREQHZ	=	0.6001E 02	PTINET	=	0.1090E 03	ACEEXT	=	0.7496E 01
			SKDTI	=	0.0	ACE	=	0.1202E 03	AR	=	0.7500E 02	LAM	=	0.2464E 02
			PM(1)	=	0.1549E 04	PM(2)	=	0.1615E 04	PM(3)	=	0.3229E 03	PM(4)	=	0.4980E 03
			PM(5)	=	0.1759E 03	PM(6)	=	0.5289E 03	PM(7)	=	0.3717E 03	PM(8)	=	0.3756E 03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X 49600.000 49700.000 49800.000 49900.000 50000.000 50100.000 50200.000 50300.000 50400.000
F 59.920 59.940 59.960 59.980 60.000 60.020 60.040 60.060 60.080
T -40.000 20.000 80.000 140.000 200.000 260.000 320.000 380.000 440.000
L 5230.000 5260.000 5290.000 5320.000 5350.000 5380.000 5410.000 5440.000 5470.000
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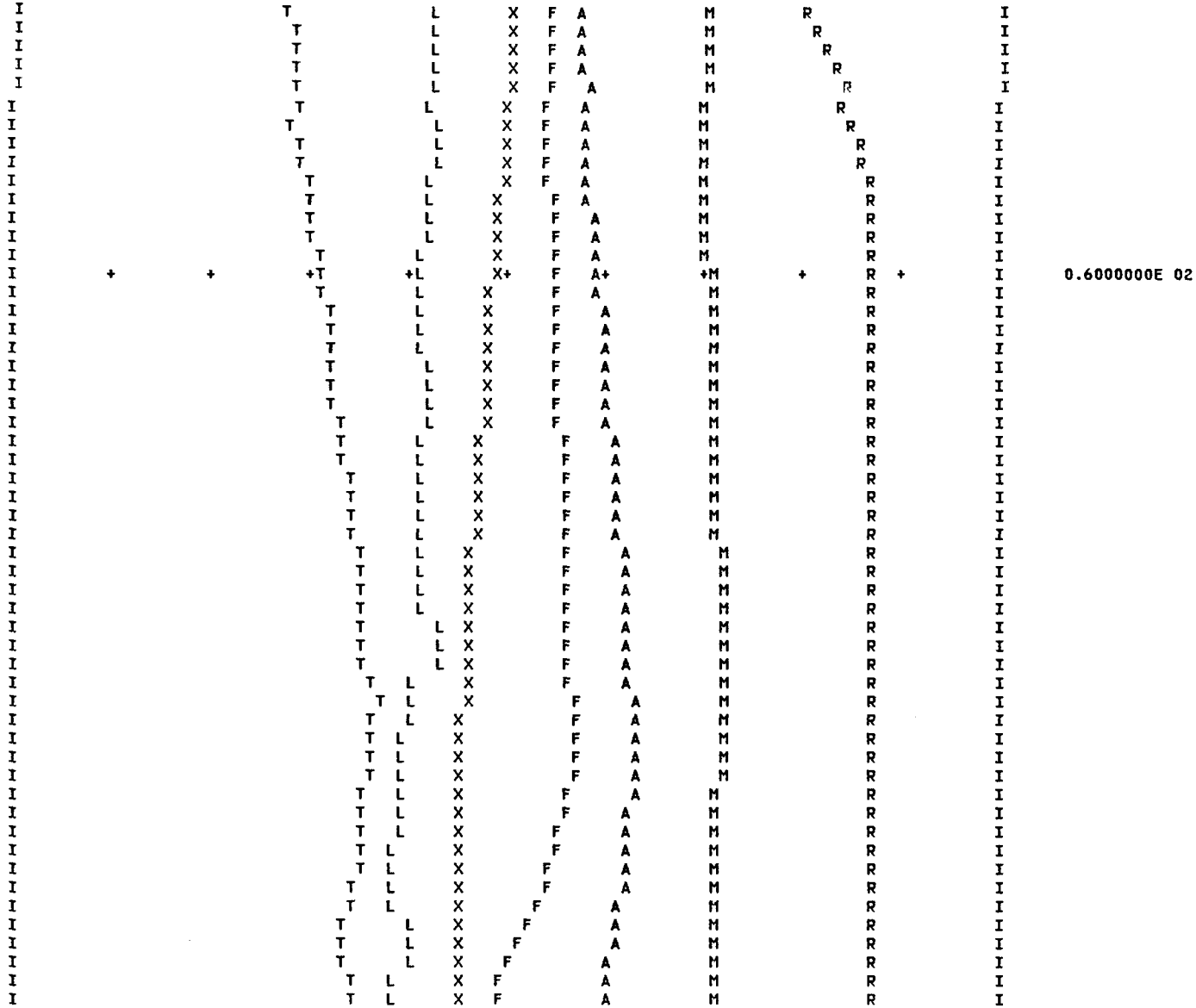
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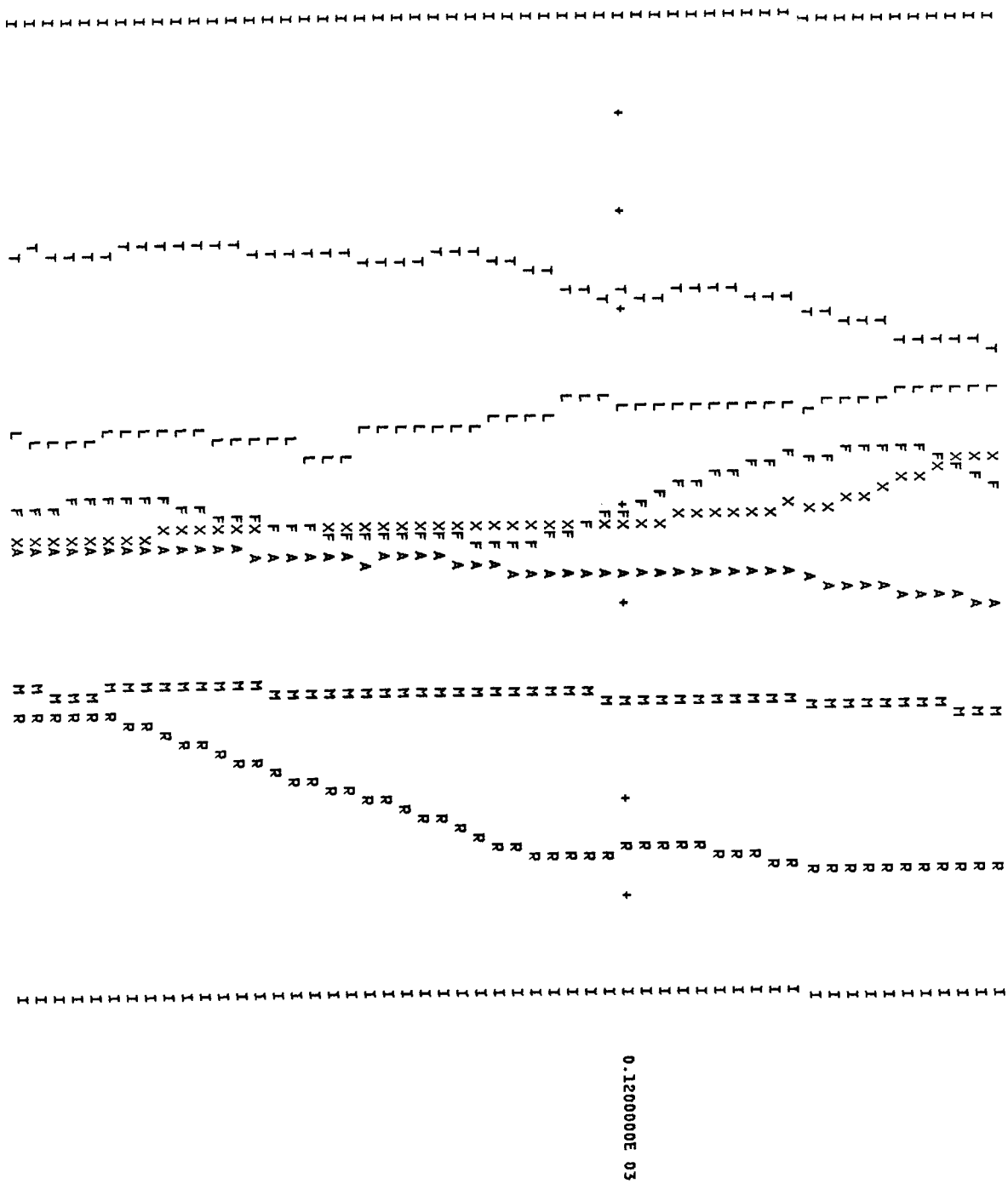
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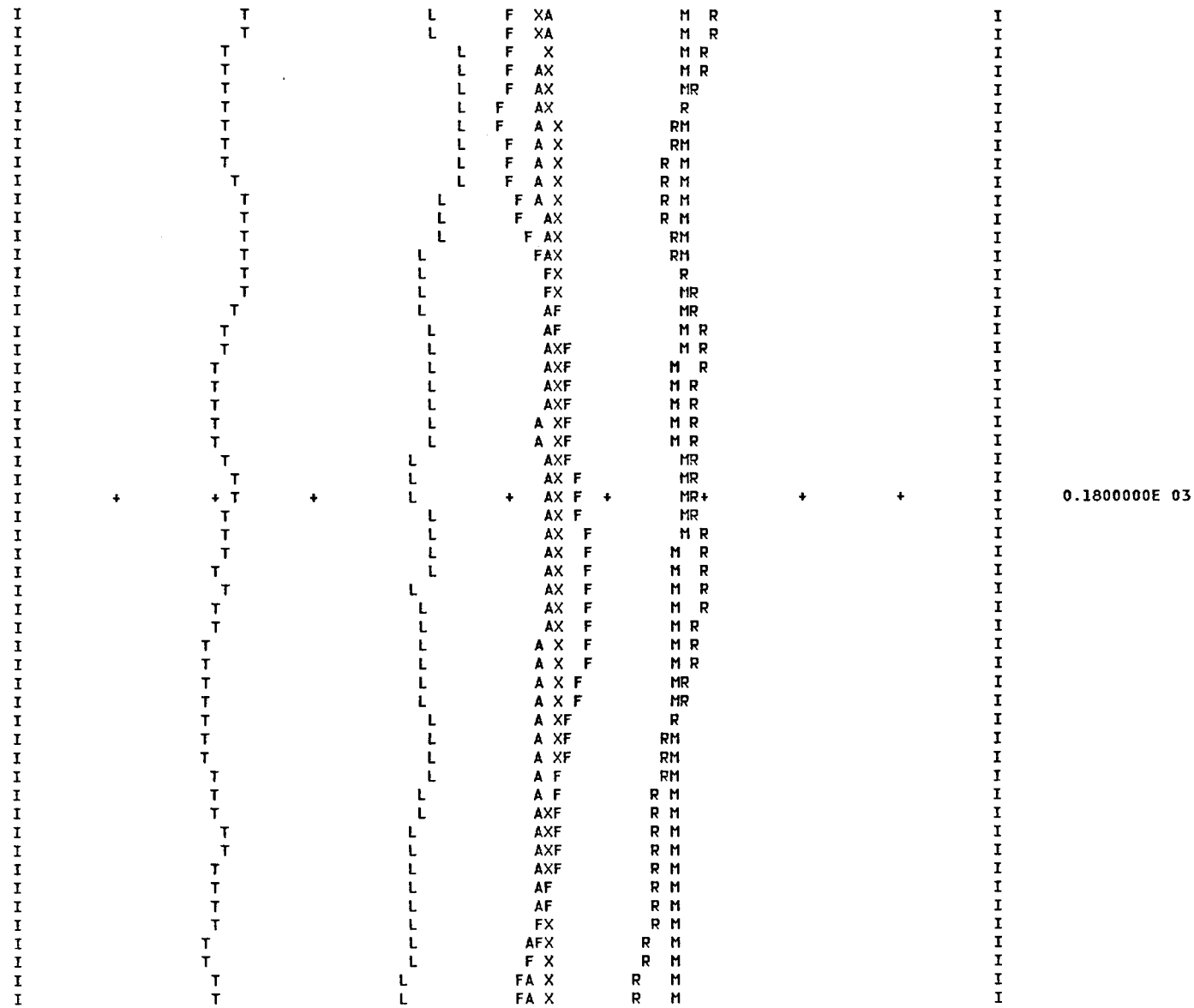
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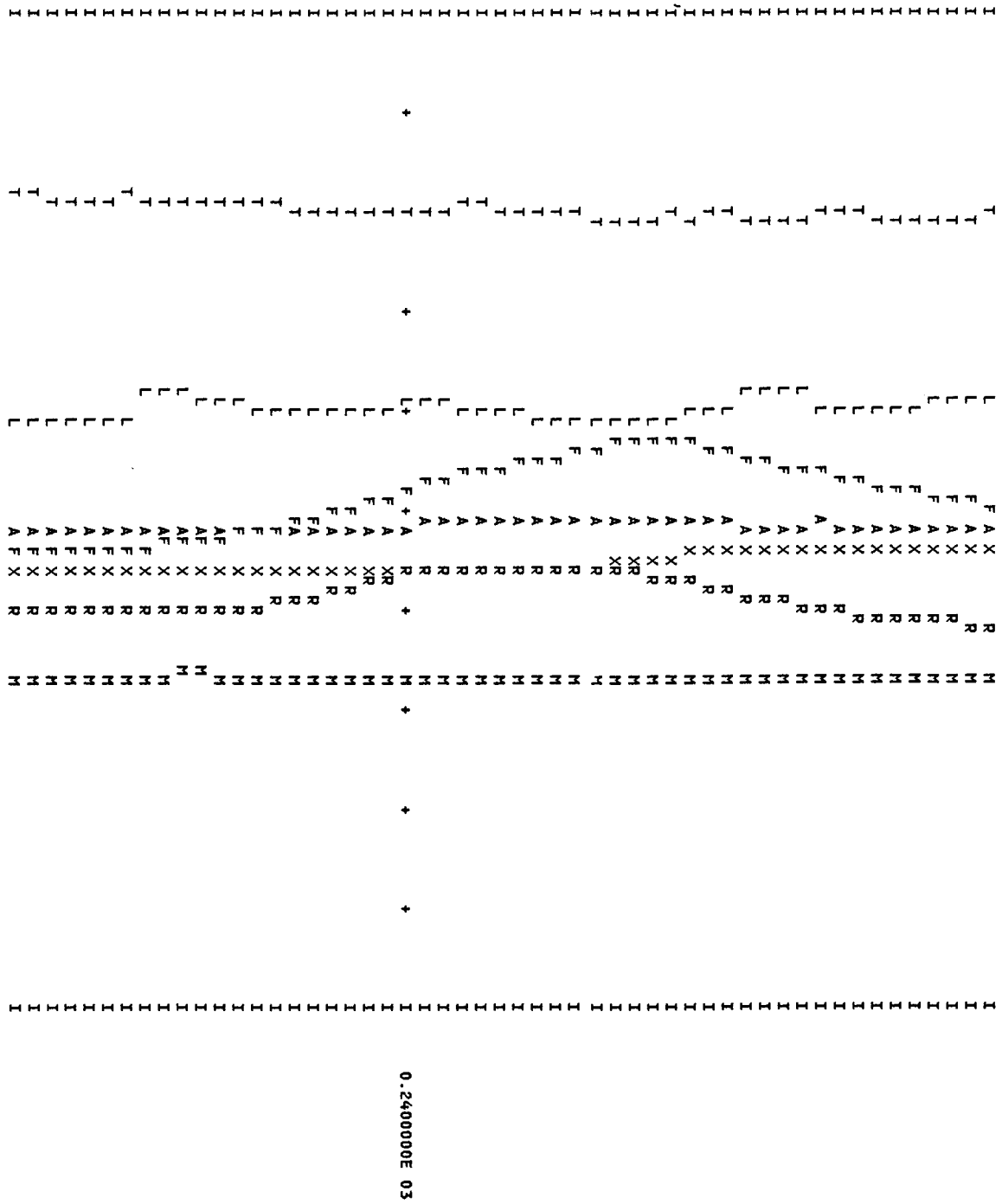
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