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BIRD MODEL DESCRIPTION AND DOCUMENTATION

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ABSTRACT

BIRD is a simulation model which projects the dynamics of age classes of bird populations using basic life history information and calculates the metabolically based energy demands of this simulated population. Here we describe the various subroutines of the model in terms of their coding and computational mechanics, and document the interrelationships of these subroutines. Detailed examples of model output are provided, employing data from a Dickcissel (*Spiza americana*) population at the tallgrass Osage Site in Oklahoma.

CHAPTER 1

INTRODUCTION

The purpose of this technical report is to provide a modeling description of the BIRD Model. Descriptions of the biological assumptions are found in Wiens and Innis (in press) and Wiens and Innis (1973). Fig. 1.1, taken from Wiens and Innis (in press), is a Forrester (1961) diagram of the basic model structure that is reported here. However, a model such as BIRD, which is developed as a multi-purpose tool, is subject to continuing revision and sharpening. We thus include several sets of calculations which are not part of the structure described in Wiens and Innis (in press). These additional functions or calculations are clearly indicated where they occur.

The model first simulates population dynamics using the life history information and initial conditions for the populations. Once the population density in each age class is determined, then weights for each age class are determined. Weight, together with ambient temperature, determines the existence (metabolic) energy requirements for individuals in each age class. These requirements are further modified by such things as egg and molt costs, digestive efficiencies, activity costs, and growth costs to determine the energy requirements of individuals in each of the age classes. The individual energy requirements in each age class are summed to give a population energy demand for the class, and then sums over the various classes are computed to give a total population energy demand. Readers interested in the biological assumptions are referred to the papers mentioned above for more details. In this document our focus will be on the computer

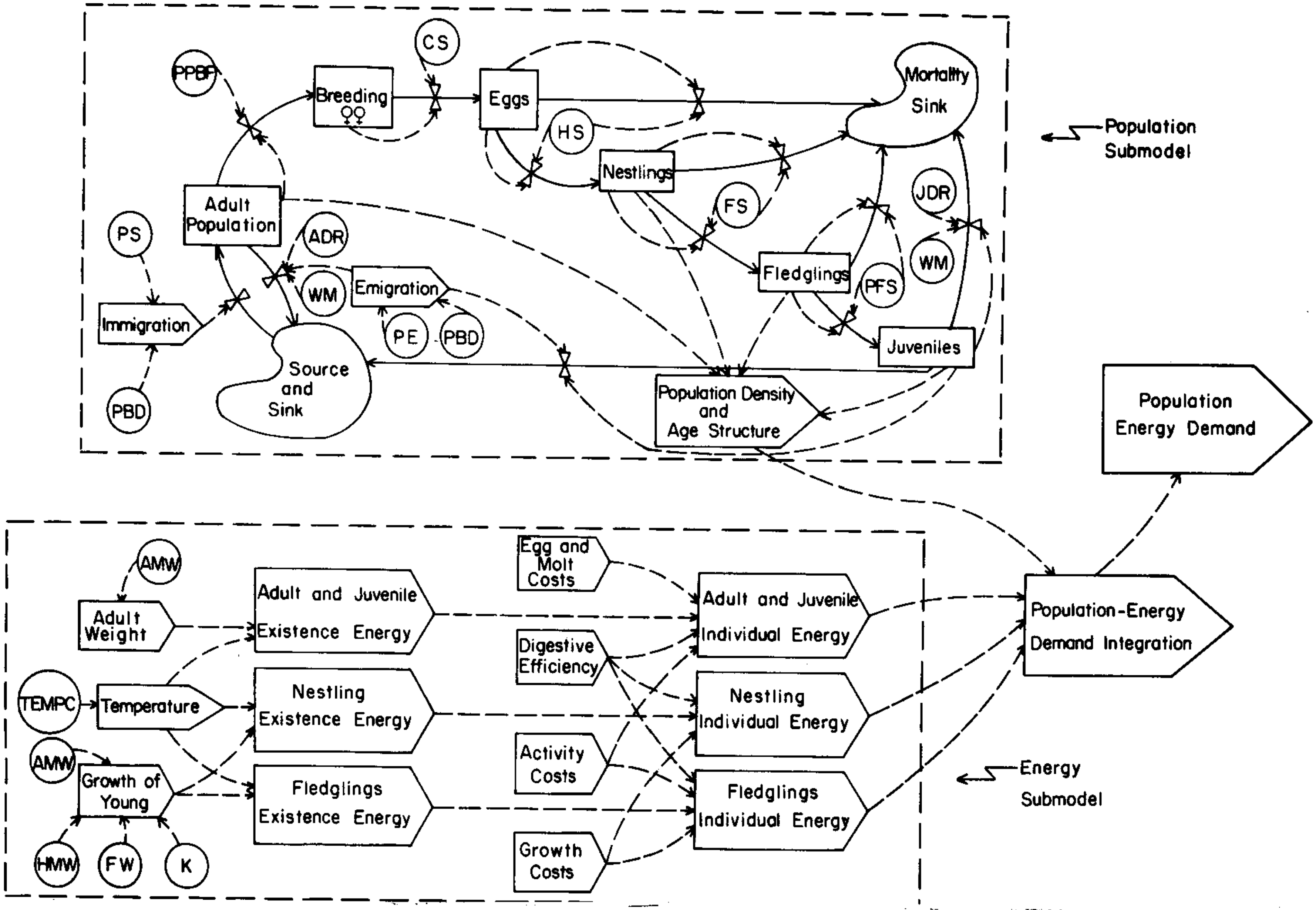

Fig.1.1. Generalized Forrester diagram of the BIRD model structure. Rectangular boxes indicate state variables; five-sided boxes, computational controls; and circles, input variables. Solid arrows indicate flows of materials or energy or changes of state; dashed arrows indicate controls or computational transfers. Input variable codes are defined in Chapter 4.

code which implements this model; it purports to provide interested users with a sufficient description of the model structure to allow them to operate and modify the model in its reported and extended forms.

The study began as a collaborative effort involving Wiens and Innis. Wiens provided the biological information, and Innis structured the initial forms of the model. Chuculate joined the group later, first executing a large number of model runs and then making a number of modifications and improvements in the model. Miskimins assisted in the sharpening and extension of the model from the form reported in Wiens and Innis (in press).

(1-2).

FLOW = 0.

(2-3).

FLOW = 0.

CHAPTER 2

SIMCOMP

The model is coded in SIMCOMP Version 3.0. This is a simulation language developed at Colorado State University (Gustafson and Innis 1973, Stevens and Gustafson 1973) and is quite similar to the DYNAMO language developed at MIT. This language is basically a flow-oriented, difference equation-based simulation language designed specifically to support biological simulations.

The reader will notice rather quickly that much of the real power of SIMCOMP has been left unused in this modeling effort. Indeed, the main reason for coding in SIMCOMP was to use that system's organization and its input-output capabilities. The reason for this unusual structure is that we originally coded the model in accordance with the Forrester (1961) diagram of Fig. 1.1. The population submodel consisted of a sequence of flows of animal numbers from one age class to the next for each species. Clearly, as the number of species changed, the numbers of flows that had to be incorporated in the model had to change. This was unfortunate because every time we changed the number of species, we actually had to change the structure of the model by either inserting or deleting flows. After some experience with the model in this form and finding that we could not make these changes without occasional errors, we decided to solve the difference equations in CYCL1 (the block of code appearing at the end of SUBROUTINE CYCL1). The two dummy flows which appear in the code are a concession to the system which was designed to take flows; at last report, they generated diagnostics if the simulation was coded without any flows and generated errors if the model was coded with just a single flow.

```
      SUBROUTINE START
      DIMENSION CG(20)
C NSP IS THE NUMBER OF SPECIES BEING CONSIDERED.
      DO 1 I = 1,NSP
      DO 2 J=1,3
    2 CE(I,J)=0.
      K = 5*(I-1)+2
C CG(I) IS JUST AN INTERMEDIATE VARIABLE.
      CG(I) = EXP(-AK(I)*PN(I))
      IF(FW(I).EQ.0..AND.HMW(I).EQ.0.) GO TO 3
      BG(I) = (HMW(I)-FW(I))/(FW(I)*CG(I)-HMW(I))
      AG(I) = HMW(I)*(1.0 + BG(I))
C BG AND AG ARE CONSTANTS USED IN THE NESTLING GROWTH RATE.
      GO TO 4
    3 AG(I) = 0.
      BG(I) = 0.
    4 CONTINUE
    1 X(K) = PS(I)
```

SUBROUTINE START

SUBROUTINE START serves the purposes of initialization of variables, the computation of constants, and the normalization of certain input variables.

The DO loop through the statement labeled I at the beginning of START sets the CE (cumulative energy) array to zero. The first index is for species, and the second index is for age class (reader is referred to Chapter 4 for a complete variable list). The state variables (the X array in SIMCOMP) are defined as follows:

X(1) = source/sink

X(2) = adult numbers for species 1

X(3) = egg numbers for species 1

X(4) = nestling numbers for species 1

X(5) = fledgling numbers for species 1

X(6) = juvenile numbers for species 1

X(7) = adult numbers for species 2

X(8) = egg numbers for species 2, etc.

In general then, adult numbers of species I (I = 1, NSP [NSP is the number of species being considered]) are located in state variable X(K) where K = 5 * (I-1) + 2. The last statement of the DO loop to the statement labeled 1 sets the adult population of species I to PS(I), the population at the start of the run.

The intervening block of code establishes the constants AG and BG in the logistic equation for nestling growth rate, given the fledging weight (FW) and the hatching mean weight (HMW) for each species. AG and BG are then used as the constants in the logistic equation later in the simulation.

```
C      ****************************************************************
C                NORMALIZATION OF DIET SELECTION
C      ****************************************************************
C
C      DIET(I,J,K) IS THE AMOUNT OF THE TOTAL FOOD INTAKE BY SPECIES K
C               OBTAINED FROM FOOD CATEGORY I ON THE JTH MEASUREMENT DAY
C      CALV(I) IS THE CALORIC VALUE OF FOOD CATEGORY I  (KCAL/GMS DRY WT)
C      NDA IS THE NUMBER OF MEASUREMENT DAYS
C      NCAT IS THE NUMBER OF FOOD CATEGORIES
C      NDT IS A FLAG. IF NDT=1,WE DO NOT MAKE CALCULATIONS ABOUT THE DIET.
C                     IF NDT=0,WE DO MAKE CALCULATIONS  ABOUT THE DIET.
       IF(NDT.EQ.1) GO TO 600
C      NDAT(J)  ARE THE DAYS (SINCE JAN 1) ON WHICH THE DATA ARE RECORDED
       DO 8002 K=1,NSP
       DO 8002 J=1,NDA
C      INITIALIZE SUMMING VARIABLE
       SUMM=0.0
       DO 8001 I=1,NCAT
       SUMM=SUMM+DIET(I,J,K)
 8001  CONTINUE
       IF(SUMM.EQ.0.) SUMM=1.
       DO 8002 I=1,NCAT
       DIET(I,J,K)=DIET(I,J,K)/SUMM
 8002  CONTINUE
       DO 8005 I=1,NCAT
       DO 8005 K=1,NSP
 8005  TOT(I,K)=0.0
  600  CONTINUE




     IF(NOACB.EQ.1) RETURN
```

The next block of calculations is concerned with diet composition and is not included in the version of BIRD reported by Wiens and Innis (in press). Immediately following the statement labeled 1, we check the flag NDT (no diet selection) which is set equal to 1 if no calculation of diet composition is to be undertaken and if it equals 0 when this section of code is to be employed. If dietary calculations are performed, each of the bird species, K, selects a diet from several prey categories, I, $1 \leq I \leq$ NCAT; NCAT is the total number of prey categories considered (NCAT $\leq$ 20). The same prey categories are used for all species considered in a run, and the diet composition routine is applied to all of the bird species included.

For each of several days, NDA, during the run, a measurement (percentage total volume or weight, etc.) is entered for each prey category, I, of the diet of bird species K. The measurement which was taken on the Jth measurement day is stored in DIET(I,J,K). This array is normalized in order that the entry DIET(I,J,K) is the fraction of the diet of bird species K filled by prey category I on the Jth measurement day.

The variable TOT(I,K), which is the amount (g/m^2) of prey category I consumed during the season by bird species K, is initialized at 0.

Following these diet normalization calculations, we check the flag NOACB (no activity budget) which is set to 1 if there will NOT be any activity budget calculations. In the event there is an activity budget calculation, the remaining block of code in START is executed. The rationale and assumptions underlying activity budget calculations are described by Wiens and Innis (1973).

```
C                 **************************************
C                 *NORMALIZATION OF ACTIVITY BUDGET DATA*
C                 **************************************
C AMACT(I,J,K) IS THE TIME SPENT BY AMALE OF SPECIES K ON THE ITH
C ACTIVITY ON THE JTH MEASUREMENT DAY.
C AFACT(I,J,K) IS THE SAME VARIABLE AS AMACT EXCEPT FOR FEMALES
C ACTC(I,K) IS THE COEFFICIENT OF ENERGY EXPENDITURE OF THE KTH SPECIES
C ON THE ITH ACTIVITY
      DO 20003 K=1,NSP
      DO 20003 J = 1,NUMDY
C INTIALIZE SUMMING VARIABLES
      SUMM1=0.0
      SUMF1=0.0
C NORMALIZE DATA
      DO 20000 I=1,7
      SUMM1=SUMM1+AMACT(I,J,K)
      SUMF1=SUMF1+AFACT(I,J,K)
20000 CONTINUE
      IF(SUMM1.EQ.0.) SUMM1=1.
      IF(SUMF1.EQ.0.) SUMF1=1.
      DO 20003 I=1,7
      AMACT(I,J,K)= ACTC(I,K)*AMACT(I,J,K)/SUMM1
      AFACT(I,J,K)= ACTC(I,K)*AFACT(I,J,K)/SUMF1
20003 CONTINUE
C AMACT(I,J,K) AND AFACT(I,J,K) ARE LATER CHANGED TO THE ENERGY EXPENDITURE
C BY A MALE AND FEMALE ON THE ITH ACTIVITY ON THE JTH DAY OF MEASUREMENT
C ( K REPRESENTS THE SPECIES ).
      RETURN
      END
```

Activity budgets for males and females, stored as AMACT(I,J,K) and AFACT(I,J,K) respectively, are entered as numbers indicating the proportion (fraction, hours) of the 24-hr period on day J when the species K is in activity I. In order to prevent the person supplying these data from having to be sure that these activities sum to one or 24 or whatever his unit might be, these values are normalized by first summing all of the activities for each date and each species, and then dividing AMACT and AFACT by the appropriate sum.

There are, however, different energy costs associated with different activities; so rather than have this activity cost appearing time and again later in the model, it is presented here as ACTC(I,K) which is indexed by activity I and species K, and this is multiplied by the normalized activity budget. Thus, upon exit from this activity budget calculation, AMACT and AFACT contain a "normalized weighted" activity budget.

```
      SUBROUTINE CYCL1
C.... NAMW IS A FLAG.  NAMW=1 INDICATES AMW(I) IS CONSTANT THROUGHOUT
C....           A RUN.  OTHERWISE, WE USE AMWA(J,I) AND INTERPOLATE
C.... DA(J,I) IS AN ARRAY OF DATES(FROM JAN 1) ON WHICH AVERAGE ADULT
C....                   WEIGHTS OF SPECIES I ARE RECORDED
C.... IF NAMW IS NOT 1, THEN
C.... AMWA(J,I) IS THE AVERAGE ADULT WEIGHT OF THE ITH SPECIES ON DA(J,I)
C            AND
C.... AMW(I) IS A LINEAR INTERPOLATION OF THE ARRAY AMWA
C.... NUDAS(I) IS THE NUMBER OF ACTUAL ENTRIES FOR SPECIES I IN THE ARRAY
C....               DA(J,I).  THE REST  OF DA(J,I) IS FILLED IN WITH ZEROS.
      IF(NAMW.EQ.1) GO TO 32
      DO 31 I=1,NSP
      NU=NUDAS(I)
      DO 11 J=1,NU
      IF(TIME.GT.DA(J,I))11,12
   11 CONTINUE
   12 IF(J.EQ.1)14,15
   14 AMW(I)=AMWA(1,I)
      GO TO 30
   15 IF(J.EQ.NU.AND.TIME.GT.DA(J,I))17,18
   17 AMW(I)=AMWA(NU,I)
      GO TO 30
   18 L=J-1
      AMW(I)=AMWA(L)+(AMWA(J)-AMWA(L))/(DA(J,I)-DA(L,I))*(TIME-DA(L,I))
   30 CONTINUE
   31 CONTINUE
   32 CONTINUE

C     *****************************************************************
C                 CALCULATION OF DIET COMPOSITION
C     *****************************************************************
C
C     DIET(I,J,K) IS THE AMOUNT OF THE TOTAL FOOD INTAKE BY SPECIES K
C                 OBTAINED FROM FOOD CATEGORY I ON THE JTH MEASUREMENT DAY
C     CALV(I) IS THE CALORIC VALUE OF FOOD CATEGORY I   (KCAL/GMS DRY WT)
C     NDA IS THE NUMBER OF MEASUREMENT DAYS
C     NCAT IS THE NUMBER OF FOOD CATEGORIES
C     NDAT(J)  ARE THE DAYS (SINCE JAN 1) ON WHICH THE DATA ARE RECORDED
C     NDT IS A FLAG. IF NDT=1,WE DO NOT MAKE CALCULATIONS ABOUT THE DIET.
C                    IF NDT=0,WE DO MAKE CALCULATIONS  ABOUT THE DIET.
      IF(NDT.EQ.1) GO TO 601
C     INTERPOLATE DIET ARRAY
      DO 69 I=1,NCAT
      DO 70 K=1,NSP
      GPREY(I,K)=0.0
      DO 71 J=1,NDA
      IF(TIME.GT.NDAT(J)) 71,72
   71 CONTINUE
   72 IF(J.EQ.1) 74,75
   74 AVDT=DIET(I,1,K)
      GO TO 76
   75 IF(J.EQ.NDA.AND.TIME.GT.NDAT(J)) 77,78
   77 AVDT=DIET(I,NDA,K)
      GO TO 76
   78 L=J-1
      AVDT=DIET(I,L,K)+(DIET(I,J,K)-DIET(I,L,K))/(NDAT(J)-NDAT(L))*
     "    (TIME-NDAT(L))
   76 CONTINUE
C.....AVDT IS THE INTERPOLATED DIET COMPOSITION
```

SUBROUTINE CYCL1

SUBROUTINE CYCL1 contains five major components. The first two components are recent additions and are not included in the description in Wiens and Innis (in press). The first section of code permits the adult mean body weight (AMW(I)) to be treated as a variable rather than a constant. If the flag NAMW is set equal to 1, the adult mean weight is held constant and is initialized by input data. If NAMW is not equal to 1, then adult mean weight is treated as a variable. In this case, a linear interpolation function is used to obtain the daily adult mean weight from the tables AMWA, the dependent variable, and DA, the independent variable.

For each bird species, I, the adult mean weights are recorded for a selected number (NUDAS(I)) of days. The Julian dates of these days are entered into the array DA(J,I), and the corresponding adult mean weights are entered into the array AMWA(J,I). Note that the entries in the array NUDAS are integral and those in DA(J,I) are floating point.

The results of the linear interpolation of the array AMWA(J,I) are stored in the array AMW(I) and enter into the calculations where appropriate.

The next block of code couples diet composition to energy demands. If the flag NDT is equal to 0, indicating that calculations of diet composition are to be undertaken, the array DIET(I,J,K) will contain as entries the fractions of the diet of bird species K filled by prey category I on day J. There are NSP bird species, NCAT prey categories, and NDA measurement days. The Julian dates of the measurement days are entered in the array NDAT(J).

A linear interpolation function, using NDAT as the independent variable and DIET as the dependent variable, calculates the daily fraction (AVDT) which prey category I contributes to the diet of bird species K. This value

```
C.....GPREY(I,K) IS THE DAILY CONSUMPTION OF CATEGORY I BY
C             SPECIES K   (GMS/M**2)
      GPREY(I,K)=GPREY(I,K) + ( AVDT * ERA(K) ) / CALV(I)
C.....TOT(I,K) IS THE TOTAL SEASONAL CONSUMPTION OF CATEGORY I
C                BY SPECIES K    (GMS/M**2)
      TOT(I,K)=TOT(I,K) + GPREY(I,K)
   70 CONTINUE
   69 CONTINUE
      DO 8010 I=1,NCAT
      PTOT(I)=0.0
      PREY(I)=0.0
      DO 8009 K=1,NSP
C.....PTOT IS THE TOTAL SEASONAL CONSUMPTION OF FOOD CATEGORY I
      PTOT(I) = PTOT(I) + TOT(I,K)
C.....PREY IS THE TOTAL DAILY CONSUMPTION OF FOOD CATEGORY I
 8009 PREY(I) = PREY(I) + GPREY(I,K)
 8010 CONTINUE
  601 CONTINUE


C...DATE ARRAY CONTAINS DATE IN DAYS SINCE 1 JAN
C...TEMPC ARRAY CONTAINS TEMPERATURE (DEG C) AT DATE
C...AVDEGC = LINEAR INTERPOLATION FOR AVERAGE TEMP ESTIMATE
      DO 1 I=1,NOTMP
      IF (TIME.GT.DATE(I))1,2
    1 CONTINUE
    2 IF(I.EQ.1) 4,5
    4 AVDEG  = TEMPC(1)
      GO TO 6
    5 IF (I.EQ.NOT MP.AND.TIME.GT.DATE(I)) 7,8
    7 AVDEG  = TEMPC(NOT MP)
      GO TO 6
    8 AVDEG  = TEMPC(I-1) + (TEMPC(I) - TEMPC(I-1))/(DATE(I) - DATE(I-1)
     *  )*(TIME-DATE(I-1))


    6 DO 3 I = 1,NSP
      T = TIME-PI(I)
      EV1(I) = EVST(T,1)
      EP1(I) = EPD2(T,1)
      T = T-PN(I)
      EV2(I) = EVST(T,1)
      EP2(I) = EPD2(T,1)
      T = T-PF(I)
      EV3(I) = EVST(T,1)
      EP3(I) = EPD2(T,1)


      J=5*(I-1)+2
```

(AVDT), multiplied by the energy requirements (ERA(K)) of the Kth species and divided by the caloric value (CALV(I)) of the Ith prey category (kcal/g dry wt), yields the daily consumption (g dry wt/m^2) of prey category I by species K (GPREY(I,K)). GPREY(I,K) is then added to TOT(I,K) to update this cumulative consumption of prey category I by species K. In addition, the variables PREY(I), the total daily consumption of prey category I by all NSP bird species, and PTOT(I), the cumulative consumption of prey category I by all species, are calculated.

The third component of CYCL1 encompasses the block of code down through the statement labeled 8. This block of code is used to interpolate within the table TEMPC (which contains the air temperature in degrees centigrade) on the dates (DATE) to provide the temperatures at a given time during the simulation. The calculation is a straightforward linear interpolation.

The next block, which is the first nine lines of code within the DO loop to the statement labeled 3, that is, the first nine instructions following the statement labeled 6, are used to compute the "potential" number of nestlings, fledglings, and juveniles for the first clutch (EV1, EV2, EV3, respectively) and the potential numbers of nestlings, fledglings, and juveniles for the second clutch (EP1, EP2, EP3, respectively). This is called the potential number of animals of this age because it is actually a calculation of the number of eggs that were produced at the proper time in the past to result in animals of that age class on the given date. These potential numbers are reduced as a result of losses; calculated in the last block of code in CYCL1.

The last block of code in CYCL1 begins with the computation of the index J. This is an index of the location of the adults of species I.

```
C THE NUMBER OF ADULTS IS CALCULATED IN THIS FLOW (X(J))
      F = FLIN(PS(I),PBD(I),TS(I),TIN(I),TIME)   +
     *     FLIN (X(J),PE(I),TD(I),TE(I),TIME)
      IF(TIME.LE.TS(I))F = PS(I)
      IF(TIME.GE.TE(I)) F = X(J) - WM(I)*PE(I)/(365.-TE(I))
      IF(TIME.GT.TIN(I).AND.TIME.LT.TD(I)) F = X(J)
      F = (F-X(J))/DT - ADR(I)*X(J)
      X(J)=X(J)+F*DT
```

In the next block of code the numbers of adults in the population is calculated from life history information. The variable F is computed first as the sum of two terms, the first of which gives the immigration rate and the second provides for *the negative* of the emigration rate. The FUNCTION FLIN provides for a linear interpolation between points with Y values as the first and second arguments, associated X values as the third and fourth arguments, and the fifth argument is the independent variable. If the independent variable lies between the third and fourth arguments, then a linear interpolation is performed. If the independent variable lies outside the interval specified by the third and fourth arguments, then FLIN returns zero as a value (see the discussion of FUNCTION FLIN in Chapter 3). The variable TS represents the time of the start of the run. If time is earlier than TS, then setting F equal to PS (population at the start of the run) results in the adult population being held at the level PS until the time TS arrives. The population then rises approximately linearly to the population breeding density (PBD) at the time initiation of nesting (TIN). The population begins its departure on date TD (time of departure), and emigration proceeds at a constant rate to the population PE (population at the end of the run) which is achieved at time TE (time of the end of the run). In the event time proceeds beyond TE, winter mortality (WM) sets in and animals are lost at a constant rate. Between the time of initiation of nesting and the time that emigration begins, the population remains constant unless there is an adult death rate (ADR) operational.

The rather clumsy appearance of this code stems from the fact that much of our information is essentially state variable information from which we compute rates. However, we must then operate on these rates, because we want the model to be sufficiently general to deal with situations in

```
C THE NUMBER OF EGGS IS CALCULATED HERE (X(J+1))
      T = TIME
      F = EVST(T,I) - EV1(I)*(1.-HS(I))
      G = EPD2(T,I) - EP1(I)*(1.-HS(I))
      F = (F  +G)*X(J)
      X(J+1)=X(J+1)+F*DT
```

```
C THE EGGS WHICH SURVIVE TO PRODUCE NESTLINGS IS CALCULATED HERE (X(J+2))
      F = (EV1(I) + EP1(I))      *HS(I)    *PBD(I)
      X(J+1)=X(J+1)-F*DT
      X(J+2)=X(J+2)+F*DT
```

```
C THE MORTALITY OF NESTLINGS IS CALCULATED HERE
      F = -(EV2(I)+EP2(I))*(1.-FS(I))*HS(I)*PBD(I)
      X(J+2)=X(J+2)+F*DT
```

which there is not an active adult death rate nor an active winter mortality, as well as with situations in which one or both of these functions are operational.

The number of eggs at any point in time is determined by adding those eggs produced on that date to the egg population and subtracting from the population those eggs that hatch. F represents the additions to the population (EVST), as a result of new eggs from the first clutch being formed, minus eggs which hatch (EV1), adjusted for hatching success (HS). G represents the same calculation for the second clutch. The total number of eggs produced is then determined by multiplying this egg production per adult in the population (F + G) times the population breeding density at the time of production (X(J)). The last equation merely updates the state variable.

In the next block of code the number of eggs which survive to produce nestlings is calculated. EV1 and EP1 are the potential number of eggs which would hatch on a given day. If we multiply that sum by the hatching success, we obtain the number of eggs per adult which would actually hatch on that day; to obtain the number of eggs which actually hatch, we have to multiply that by the population breeding density (PBD). Those eggs which hatch have to be removed from the egg compartment and an appropriate number of individuals entered into the nestling compartment. The next two equations are simply the solutions to the difference equations for egg hatching -- removal from the egg state variable and addition to the nestling state variable.

The mortality of nestlings is just those nestlings which do not fledge. Thus we take the total number of nestlings (EV2 + EP2) multiplied by the hatching success times the population breeding density and multiply that by 1-FS, where FS is the fledging success. The minus sign on F is to indicate that the flow is out of X(J+2) and not into it.

```
C THE NESTLINGS WHICH SURVIVE TO BECOME FLEDGLINGS IS CALCULATED HERE (X(J+3)
      F = (EV2(I)+EP2(I))*HS(I)*FS(I)*PBD(I)
      X(J+2)=X(J+2)-F*DT
      X(J+3)=X(J+3)+F*DT




C THE FLEDGLING MORTALITY IS CALCULATED HERE
      F = -(EV3(I)+EP3(I))*(1.-PFS(I))*FS(I)*HS(I)*PBD(I)
      X(J+3)=X(J+3)+F*DT




C THE FLEDGLINGS WHICH SURVIVE TO BECOME JUVENILES IS CALCULATED HERE (X(J+4))
      F = (EV3(I)+EP3(I))*PFS(I)*FS(I)*HS(I)*PBD(I)
      X(J+3)=X(J+3)-F*DT
      X(J+4)=X(J+4)+F*DT




C MIGRATION IS CALCULATED HERE
      F = FLIN(X(J+4),0.,TDJ(I),TEJ(I),TIME)
      IF (TIME.LT.TDJ(I))F = X(J+4)
      F = (F-X(J+4))/DT - JDR(I)*X(J+4)
      X(J+4)=X(J+4)+F*DT




    3 CONTINUE
      RETURN
      END
```

The nestlings which fledge are simply the nestlings which are formed (EV2 + EP2) times the hatching success (HS) times the population breeding density (PBD), but then multiplied by the fledging success (FS). These fledglings come out of X(J+2) and go into X(J+3), and thus we have the two difference equation solutions.

Fledgling mortality is computed as all birds that fledge but do not become juveniles. Thus we take EV3 + EP3, multiply that by the fledging success, the hatching success, and the population breeding density, and then multiply all of that by 1 minus the post-fledging success (PFS). Again; F is computed as negative because the flow is out of X(J+3), not into it.

The fledglings which do not die become juveniles, and the next sequence of three equations applies.

Finally, we have to be concerned about the emigration of juveniles, for which we use the FUNCTION FLIN again. Notice that this function is set up so that during the time interval from the time of departure of juveniles (TDJ) to the time of the end of the juvenile run (TEJ), all of the juveniles X(J+4) emigrate. The IF statement sets the emigration flow to zero if time is less than the time of departure of the juveniles (TDJ) and the next line corrects the flow rate for a juvenile death rate (JDR) when JDR is nonzero. And again the juvenile population equation is updated.

As indicated earlier, this last part of CYCL1 is where the difference equations for the population are solved. This block of code would normally not exist in the SIMCOMP program but would be handled by the compiler. The chief advantage is that we can simply write a DO loop, (DO 3 I = 1, NSP) where the upper limit is NSP, the number of species being considered. Thus, we are able to change the number of species considered by simply changing input variables.

```
BMTOT = 0.
ANTOT = 0.  $  ATOT = 0.  $  ANFTOT = 0.  $  ANFJTO = 0.
TEITOT = 0.  $  ERATOT = 0.  $  ERFTOT = 0.  $  ERNTOT = 0.
```

```
DO 1 I=1,NSP
```

```
J=2+(I-1)*5
```

The effects of these calculations on adult population density are shown in Fig. 2.1. Here we see that from the start of the run to TS, the population is held constant at the number PS. This population corresponds to the "resident" or "permanent" population at the site. From TS to TIN the population rises as immigration occurs. Over the period from TIN to TD the population either remains the same or drops as a result of adult death. And from TD to TE the population drops sharply as a result of emigration. From TE to the end of the run the population drops as a result of winter mortality.

SUBROUTINE CYCL2

On entry in the subroute CYCL2 the population variables have all been updated. TIME has been advanced from TIME to TIME plus DT (daily time increment), and we are in a position to perform the energy calculations in the lower half of Fig. 1.1. This routine also accumulated a number of variables for output and contains a wide variety of options for different kinds of birds and different kinds of runs. In large part, the complexity found in this submodel stems from the calculation of these accumulations and the provision of the many options.

The first three lines of code initialize variables for biomass accumulation (BMTOT), numbers accumulation (the next line), and energy requirements accumulations (the next line).

Having initialized these variables, we enter into a DO loop which occupies essentially the remainder of SUBROUTINE CYCL2. Within this DO loop we perform, species by species, all the calculations that are needed to obtain the energetics requirements of individuals, species, and finally communities.

The first line of code sets J to the index of the adult populations of the species under consideration.

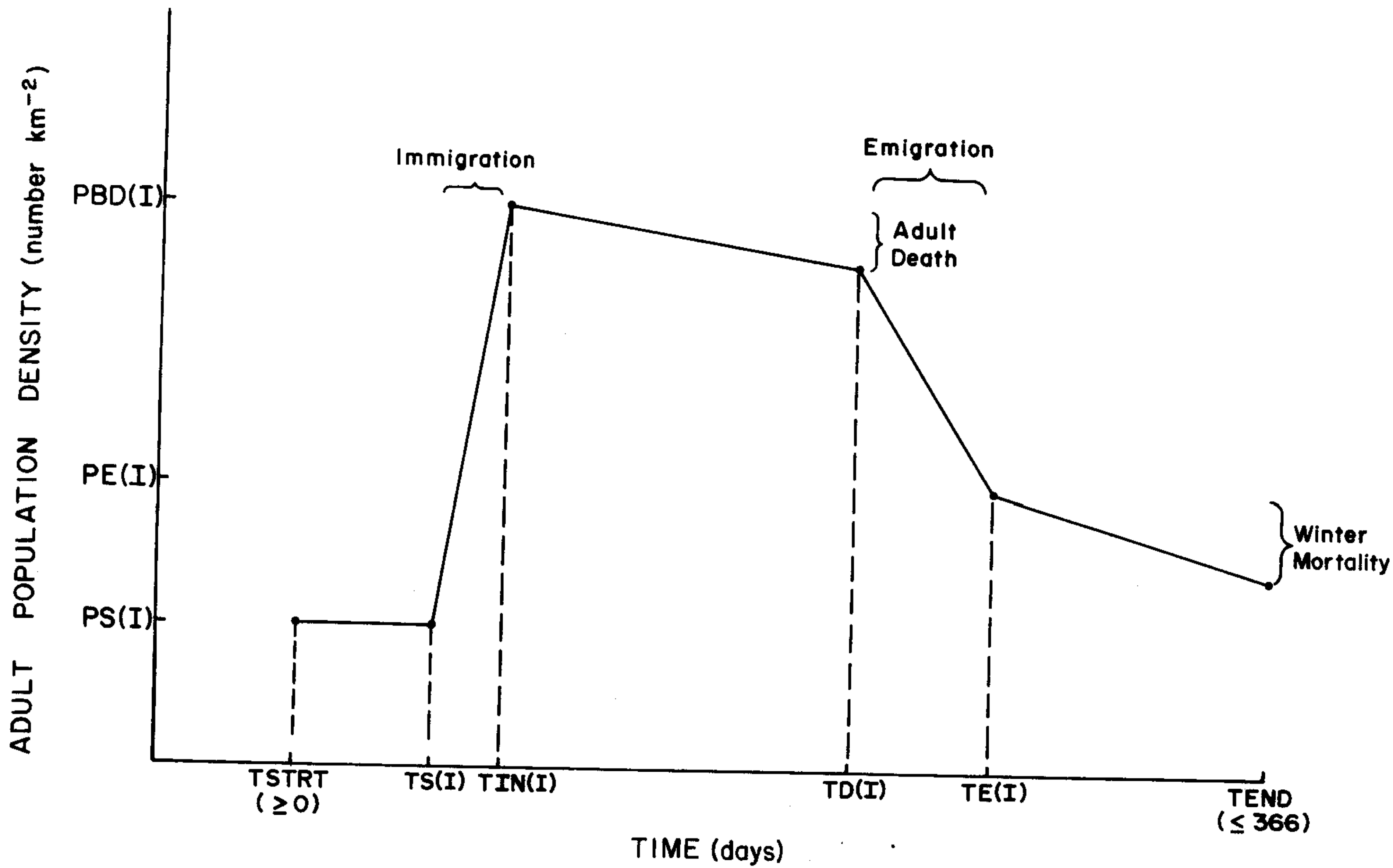

Fig.2.1. BIRD calculations of adult population density. The population density of species I is set at PS at the start of a model run (TSTRT). Immigration occurs between days TS and TIN, and elevates (or reduces) the population density to PBD. Over the breeding period (times TIN to TD), this breeding population density may be reduced by adult mortality. Emigration occurs between days TD and TE and changes the density level to PE. Subsequently, the population density may be reduced through winter mortality.

```
      DO 2 K = 1,5
      KK = K - 1 + J
      IF(X(KK).LT..00000001) X(KK) = 0.
    2 CONTINUE
```

```
      A2 = X(J)+X(J+4)
      IF(A2.LE.0.)30,31
   30 ERA(I) = 0.
      ER=0.0
      A1(I) = 0.
      GO TO 34
   31 CONTINUE
      CALL APER (NP(I),AMW(I),AVDEG,ER)
```

```
      FAC2 = 1.4*ER
```

The DO loop to 2, which sets X(KK) equal to zero if X(KK) is sufficiently small, is a concession to the vagaries of numerical computation. In the population computations, for example, hatching success determines the number of eggs that produce nestlings, and one minus hatching success determines the number of eggs which die. One would expect algebraically that these two computations would remove all eggs of a given age from the egg population; unfortunately, HS + (1-HS) may not add to 1, exactly, in a digital computer. In order to avoid having to explain extremely small numbers of eggs, fledglings, nestlings, etc., this block of code was inserted to set any population which got sufficiently small (less than 1 animal, or egg, per $10^8 km^2$) to zero.

We begin the next block of code by determining if the summed adult and juvenile populations are positive. If they are not, that is, if A2 is less than or equal to zero, then the energy requirement of adults (ERA(I)) is set to zero, a branch is made to the statement labeled 34 where the biomass of adults is also set to zero, and the cumulative adult energy requirement is not increased. In the event there are either adults or juveniles in the population, a branch to the statement labeled 31 is executed where, as a first stage for the energy calculation, SUBROUTINE APER is called. APER is discussed in detail in Chapter 3. It is important to note, for the present discussion, that it takes the flag NP, indicating whether the birds are passerines or nonpasserines, the adult mean weight (AMW), and the average temperature in degrees centigrade (AVDEG) and returns the variable ER (energy requirement) for passerines or nonpasserines of the given adult weight at the given temperature[1/]. Next FAC2 which is 1.4 times ER is computed. The factor 1.4 is a generalized correction factor

1/ A basic modification of these calculations is discussed on p. 37.

```
 FAC1 = 0.0
 IF(TIME.GE.DOM1(I).AND.TIME.LT.DOM1(I)+PM1(I).AND.DOM1(I).NE.0.)
1FAC1 = .12*ER
 IF(TIME.GE.DOM2(I).AND.TIME.LT.DOM2(I)+PM2(I).AND.DOM2(I).NE.0.)
1FAC1 = .12*ER
```

```
 FAC1 = 0.0
 IF(TIME.GE.DOM1(I).AND.TIME.LT.DOM1(I)+PM1(I).AND.DOM1(I).NE.0.)
1 CALL MOLT(DOM1(I),PM1(I),AMW(I),TIME,FAC1)
 IF(TIME.GE.DOM2(I).AND.TIME.LT.DOM2(I)+PM2(I).AND.DOM2(I).NE.0.)
1 CALL MOLT(DOM2(I),PM2(I),AMW(I),TIME,FAC1)
```

for activity; in the event the option is taken to use the activity budget, then the 1.4 is replaced by a more detailed calculation.

The factor FAC1 is computed in the next three FORTRAN statements (requiring five lines of printed information). FAC1 is a factor which represents the effect of molt on energy requirements. Normally, FAC1 is zero, which represents the situation in which the birds are not molting. If, on the other hand, we are either in the first or second molt period, corresponding to the two IF statements, then FAC1 is computed as 12% of the metabolic energy requirement.

An alternative form of the calculations for molt costs calls SUBROUTINE MOLT, which in essence calculates the cost of a complete molt as a function of body weight and then distributes this cost over the molt period, rather than calculating a fixed proportion of the daily existence energy requirement, as was done above. The two methods may yield rather different results: for Dickcissels undergoing a 30-day molt, for example, the former method (using SUBROUTINE MOLT) gives a total molt cost of 197 kcal, the latter method a total cost of 47 kcal. The former procedure probably does provide a valid estimation of total molt costs, but ignores the effects of alterations in activity costs or thermoregulatory abilities which may accompany molt. Until better information on the energetics of molt is available, it is probably best to follow a conservative approach and employ the latter procedure (i.e., exclude SUBROUTINE MOLT).

The next several lines of code are used to compute the egg costs in energetic terms, if egg costs are to be considered. The flag IDDAT, which is indexed by species, can be used to determine that no egg cost will be calculated, that is, IDDAT is zero, or that passerine, shorebird, cormorant, or alcid data are used, corresponding to IDDAT of 1, 2, 3, or 4, respectively.

```
      A1(I) = (FAC1 + FAC2)* DEF
      IF(IDDAT(I).EQ.0) GO TO 33
C THE VARIABLE IDDAT(I) IDENTIFIES THE DATA BLOCK TO BE USED TO CALCULATE
C EGG COSTS
C              IDDAT(I)   = 1  PASSERINE DATA ARE TO BE USED
C              IDDAT(I)   = 2  SHOREBIRD DATA ARE TO BE USED
C              IDDAT(I)   = 3  CORMORANT DATA ARE TO BE USED
C              IDDAT(I) = 4  ALCID DATA ARE TO BE USED
C IF  IDDAT = 0 NO EGG COST IS CALCULATED.
      EC1(I) = 0.
      EC2(I) = 0.
      IF(TIME.GE.DOI1(I)-CS1(I)-3..AND.TIME.LE.DCI1(I))
     1CALL EGG (I,J,EC1(I),1,IDDAT(I))
      IF(TIME.GE.DOI2(I)-CS2(I)-3..AND.TIME.LE.DCI2(I))
     1CALL EGG (I,J,EC2(I),2,IDDAT(I))
C EC1 IS THE DAILY INDIVIDUAL ENERGY COST ASSOCIATED WITH PRODUCING THE
C FIRST CLUTCH
C EC2 IS THE SAME VARIABLE FOR THE SECOND CLUTCH.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      A1(I) = A1(I) + ((EC1(I) + EC2(I))* DEF)
   33 CONTINUE
```

```
          IF(NOACB.EQ.1) GO TO 32
          CALL EZ(TIME,I,ER)
```

As with molt, in general, the egg costs are zero because the birds are not producing eggs. Therefore, EC1 and EC2 (daily energy cost to produce clutch 1 and clutch 2, respectively) are set to zero. However, should the time be right for the production of a clutch, SUBROUTINE EGG is called which determines the energetic demands for egg production. The variable A1 is then increased by this egg production term and all of the factors multiplied by the variable DEF which represents digestive efficiency. For the purpose of this model, all the birds are assumed to have approximately 70% digestive efficiency; therefore, they must take in 43% more than their metabolic (existence) energy requirements in order to provide for those energy requirements. DEF thus generally equals 1.43. From here on then, the energy demand that we are working with is really the load or burden that the birds place on the system in which they feed, rather than the physiological energy needs of the bird. The variable A1 is in the units of kilocalories per bird-day.

If NOACB (no activity budget) is to used, that is, if NOACB is equal to 1, we then branch to the statement labeled 32 and proceed with the calculations. On the other hand, if there is to be an activity budget calculation, the SUBROUTINE EZ is called. The routine EZ is discussed in more detail in Chapter 3, but suffice it to say that EZ returns two values: TEDF (total daily energy demand for females) and TEDM (total daily energy demand for males), where the word total is meant in the sense of totaling over the activities in which the bird participates for the given day.

The energy demand of the female individual of species I (FA1) is then computed as the sum of the molt cost, the accumulative energy demands from activities, and the egg costs (where this latter has to be divided by the proportion of the population that is breeding females (PPBF) in order to

```
C FA1(I) IS THE ENERGY DEMAND OF A FEMALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      FA1(I) = (FAC1 + TEDF(I) + (EC1(I) + EC2(I))/PPBF(I))* DEF
C MA1(I) IS THE ENERGY DEMAND OF A MALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      MA1(I) = (FAC1 + TEDM(I))* DEF
C JA1(I) IS THE ENERGY DEMAND FOR A JUVENILE  OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      JA1(I) =  (1.-PPBF(I))*MA1(I) + PPBF(I)*((FAC1 + TEDF(I))* DEF)
      A1(I) = PPBF(I)*FA1(I) + (1.-PPBF(I))*MA1(I)
C A1 IS THE INDIVIDUAL ENERGY DEMAND WITH UNITS KCAL/BIRD-DAY.
      ERA(I) = (X(J)*A1(I) + X(J+4)*JA1(I))*1.E-6
      GO TO 34
```

```
32 CONTINUE
   ERA(I)=(X(J)*A1(I)+X(J+4)*(A1(I)-((EC1(I) + EC2(I))*1.43)))*1.E-6
```

convert it from an egg cost per individual to an egg cost per female), all multiplied by DEF for digestive efficiency. The energy demand of a male individual of species I (MA1) is simply the demand associated with molt plus the energy demand from activities multiplied by the digestive efficiency. The energy demand for a juvenile of species I (JA1) is computed by assuming that the juveniles have the same ratios of females to males as the adult population. Also, the activity pattern for the juveniles is assumed to be exactly that of the adults with the exception that juveniles are not egg producers. Thus, we multiply the energy demand for male individuals times 1-PPBF and add to that PPBF times the energy demands from molt and activities for the females.

Again, the energy demand for an individual is computed as the proportion of the population that is breeding females (PPBF) times female energy demand plus 1 minus PPBF times the male energy demand. Finally, to get the energy demand per m^2 for the adults and juveniles of the species, we simply take the number of adults times the energy demand per individual plus the number of juveniles times the energy demand per juvenile individual and divide that by 10^6, the number of m^2 in a km^2.

In the event the no activity budget option was chosen a few statements earlier, the energy requirement for adults per m^2 would be computed by taking the number of adults times the adult energy requirement plus the number of juveniles times the juvenile energy requirement, which is the adult requirement reduced by the costs associated with egg production. Thus, the coefficient of the juvenile population is somewhat smaller than that for the adult population in the event egg costs are involved. Again, the multiplicative factor of 10^{-6} adjusts from km^2 to m^2.

```
   34 BMA(I) = (X(J) + X(J+4))*AMW(I)*.000001
      CAER(I) = CAER(I) + ERA(I)*DT
      IF(ERA(I).GT.PAER(I))PAER(I)=ERA(I)
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      CEC(I)=CEC(I)+((((EC1(I)+EC2(I))* DEF)*X(J))*1.E-6)*DT
```

```
      BMN2 = 0.
      BMN(I) = 0.
      ERN(I) = 0.
      AMPY = 1.
      IF (X(J+2).EQ.0.) GO TO 10
      MA = MAX1(DOI1(I),TIME-P1(I)-PN(I))
      MB = MIN1(DCI1(I),TIME-P1(I))
      IF(MB-MA.GT.49) 50,51
   50 PRINT 8000 ,MA,MB,I
 8000 FORMAT(1H ,I5,I5,I5,//,1H ,* MB IS TOO LARGE*)
```

The statement labeled 34 determines the biomass of adults and juveniles on a per m^2 basis by multiplying the population times the mean weight for adults times the 10^{-6} factor.

The cumulative adult energy requirement (CAER) is increased by the adult energy requirement rate times DT (daily time increment) at each time step so that the array CAER contains the total demand that the population has imposed on the ecosystem up to the present time in the run. The peak adult energy requirement (PAER) is computed in the next statement and is useful in accessing the time at which this peak arrives, particularly in comparison to the food availability at that time. The costs of egg production, expressed as population demands per m^2, are cumulated at each daily (DT) time step to give the array CEC (cumulative egg production costs). This value is useful in determining the proportional allocation to egg production in terms of total energy flow.

The next four large blocks of code compute the energy demand for nestlings of the first and second clutch and fledglings of the first and second clutch, respectively. Because of the similarity of these blocks of code, we shall describe only one of them in detail.

First, a number of intermediate variables are initialized at either 0 or 1. Next, we check to see if there are nestlings in the population; if there are none, we skip to the statement labeled 10. In order to compute an average weight for nestlings, we must know the numbers, weights, and age distribution of nestlings which are derived from the first clutch. We compute, therefore, MA and MB which are the beginning and ending Julian dates for nestlings of the first clutch of this species. If MB minus MA is greater than 49, then we must print a diagnostic because the array PCT (the percent of the total number of nestlings present in a specified time interval), used later, contains only 50 locations. MB minus MA is the number of different

```
      GO TO 1
   51 CONTINUE
      PCTT = 0.
      IF (MB.LT.MA) GO TO 13
      DO 11 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EVST(CK,I)
   11 PCTT = PCTT + PCT(KA)
      IF (PCTT.EQ.0.) GO TO 13
      DO 12 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)
      WTN = WNSLG(I,AGE)
      BMN(I) = BMN(I) + WTN*PCT(KA)
      CALL APER (NP(I),WTN,AVDEG,ER)
   12 ERN(I) = ERN(I) + ER*PCT(KA)
C...
C...SECOND CLUTCH NESTLING ENERGY CALCULATION
C...
   13 IF(PPBF2(I).EQ.0.) GO TO 10
      MA = MAX1(DOI2(I),TIME-PI(I)-PN(I))
      MB = MIN1(DCI2(I),TIME-PI(I))
      IF(MB-MA.GT.49) GO TO 50
      IF (MB.LT.MA)GO TO 10
      PCTT = 0.
      DO 14 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EPD2(CK,I)
   14 PCTT = PCTT + PCT(KA)
      DO 15 K = MA,MB
      ERN2 = 0.
      IF (PCTT.EQ.0.) GO TO 10
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)
      WTN = WNSLG(I,AGE)
      BMN2 = BMN2 + WTN*PCT(KA)
      CALL APER (NP(I),WTN,AVDEG,ER)
   15 ERN2 = ERN2 + ER*PCT(KA)
      IF (ERN(I)*ERN2.NE.0.)AMPY = .5
      ERN(I) =(ERN(I) + ERN2)
   10 ERN(I) = ERN(I)*1.988*.000001*X(J+2)*AMPY
      BMN(I) = (BMN(I) + BMN2)*AMPY*X(J+2)*.000001
```

age classes of nestlings of the given species. Thus, if this number exceeds 50, we would have to enlarge the PCT array. The variable PCTT (a summing variable used to normalize PCT) is set to zero to be used to accumulate the nestlings of a given age, and then the DO loop to the statement labeled 11 actually performs that accumulation, storing the total number of nestlings in the populatio in the PCTT array. If that sum turns out to be zero, then we exit (GO TO 13); otherwise we enter the DO loop to the statement labeled 12 in which we actually compute the weights and energy requirements of the individuals. The PCT array is divided by PCTT which is the sum of the PCT array, and therefore, PCT is reduced to a decimal fraction between 0 and 1. The AGE of a given class within the nestling group is computed, and then the routine WNSLG (weight of nestling) is called to return the weight of the nestlings for species I of age AGE. The weight of an average individual is then accumulated by taking the weight of a specific individual times the proportion of the population which is at that weight and accumulating that in the BMN (biomass of nestlings) array. Given the average weight WTN, the energy calculation routine APER is called which returns the energy requirement ER. Then, in the statement labeled 12, the energy requirement for the average nestling is computed by taking ER and multiplying it by the PCT for the appropriate index.

The block of instructions from the statement labeled 13 down to the statement labeled 10 perform the same function for the second clutch of nestlings. The statement labeled 10 and the one following it recalculate the energy requirement for nestlings and the biomass of nestlings on a unit area basis (the multiplication by 10^{-6}) for the population (the multiplication by X(J+2)) corrected for growth and digestive efficiency, NDEF (the multiplication of DEF by 1.2), and averaged if the two clutches overlap (then AMPY is set to 0.5). Although these averaging procedures are approximate and there is the potential for some error in the event of the overlap of two clutches, repeated runs of the model indicate that these calculations do provide an adequate approximation to the animal weights and energy requirements.

The next block of code computes the fledgling energy requirements for animals of the first clutch using a procedure very similar to the one described for nestlings. The fourth block of code computes the biomass and energy requirement for the second clutch of fledglings for a given species (not shown on facing pages --- see Chapters 5 and 6).

At this point it is necessary to describe a fundamental modification of the energy calculations in CYCL2 which was developed subsequent to the description in Wiens and Innis (in press). When calculated as described above, existence energy requirements (ER) include the costs of thermoregulation at ambient temperatures below the thermoneutral zone. When the calculated values of ER are then multiplied by 0.12 to account for molt costs or by 1.4 to account for activity costs, the costs of thermoregulation are also multiplied by these factors. The effect of this procedure is quite small at relatively high ambient temperatures (we calculated errors of 0.8% to 3.2% in the total breeding season energy demands of 3 to 6 species communities in a series of temperate North American grassland runs), but at low temperatures (e.g., arctic habitats, winter season runs) the overestimation of energy demands may be substantial (15% for a run on longspurs at Point Barrow, Alaska). To adjust for this, several changes in the above calculations were implemented. The first modification immediately follows the statement labeled 31. As before, SUBROUTINE APER is called, but now TC(I) is substituted for AVDEG. TC(I) is the lower critical temperature (the lower

```
   31 CONTINUE
      CALL APER (NP(I),AMW(I),TC(I),ER)
      CALL APER (NP(I),AMW(I),AVDEG,ERT)
      THERM(I) = ERT -ER
      IF(THERM(I).LE.0.0)  THERM(I) = 0.0
      FAC2 = 1.4*ER


        A1(I) = (FAC1 + FAC2 + THERM(I) )*DEF


C FA1(I) IS THE ENERGY DEMAND OF A FEMALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      FA1(I)=(FAC1 +TEDF(I) +THERM(I) + (EC1(I) + EC2(I))/PPBF(I))*DEF
C MA1(I) IS THE ENERGY DEMAND OF A MALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      MA1(I) = (FAC1 + TEDM(I) + THERM(I) )*DEF
C JA1(I) IS THE ENERGY DEMAND FOR A JUVENILE  OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      JA1(I)=(1.-PPBF(I))*MA1(I)+PPBF(I)*((FAC1+TEDF(I)+THERM(I))*DEF)
      A1(I) = PPBF(I)*FA1(I) + (1.-PPBF(I))*MA1(I)


C...CTHER IS THE CUMULATIVE THERMOREGULATION ENERGY COST
      CTHER(I)=CTHER(I)+((THERM(I)*X(J)+THERF(I)*X(J+3)
     *    +THERM(I)*X(J+4))*1.E-6)*DT

      BMN(I) = BMN(I) + WTN*PCT(KA)
      CALL APER(NP(I),WTN,TC(I),ER)
   12 ERN(I) = ERN(I) + ER*PCT(KA)

      BMN2 = BMN2 + WTN*PCT(KA)
      CALL APER(NP(I),WTN,TC(I),ER)
   15 ERN2 = ERN2 + ER*PCT(KA)

      BMF(I) = BMF(I) + WTF*PCT(KA)
      CALL APER(NP(I),WTF,TC(I),ER)
      CALL APER(NP(I),WTF,AVDEG,ERT)
      THERF(I)=ERT-ER
      IF(THERF(I).LE.0.0) THERF(I)=0.0
   22 ERF(I) = ER*PCT(KA)+ ERF(I)
```

limit of the thermoneutral zone) for the Ith species, and is supplied as input. This statement returns ER, which now represents the existence energy demands for passerines or nonpasserines of the given adult weight at thermoneutrality (temperature TC(I)) and is thus constant for a species throughout a simulation run. The following statement calls APER and, using AVDEG, returns ERT, which is the temperature-dependent daily existence energy requirement. The difference ERT - ER thus represents the costs of thermoregulation below the thermoneutral zone for the Ith species (THERM(I)). The relationships among these components are depicted in Fig. 2.2. Now, the calculations of FAC1 and FAC2 are based on ER, the daily existence energy requirements at thermoneutrality. When the variable A1(I) is then calculated, the thermoregulation costs must be added as a separate entry. Similarly, if an activity budget is used (NOACB = 1), the computations of the daily energy demands of females (FA1(I)), males (MA1(I)), and juveniles (JA1(I)) must include THERM(I). Following the calculations of CAER, PAER, and CEC, the population costs of thermoregulation (per m^2) are cumulated by daily increments in the array CTHER(I). Finally, the energy calculations for nestlings and fledglings must also be adjusted to reflect the new meaning of ER and the thermoregulation costs. Nestlings are assumed to devote no energy to thermoregulation (i.e., they are maintained at thermoneutrality (TC), either by the sheltered nest microclimate or by brooding adults). Thus when APER is called in the nestling calculations, TC(I) rather than AVDEG is used. Fledgling thermoregulation costs are computed as are those of adults and juveniles, but are coded differently (THERF) to allow separate consideration of age classes.

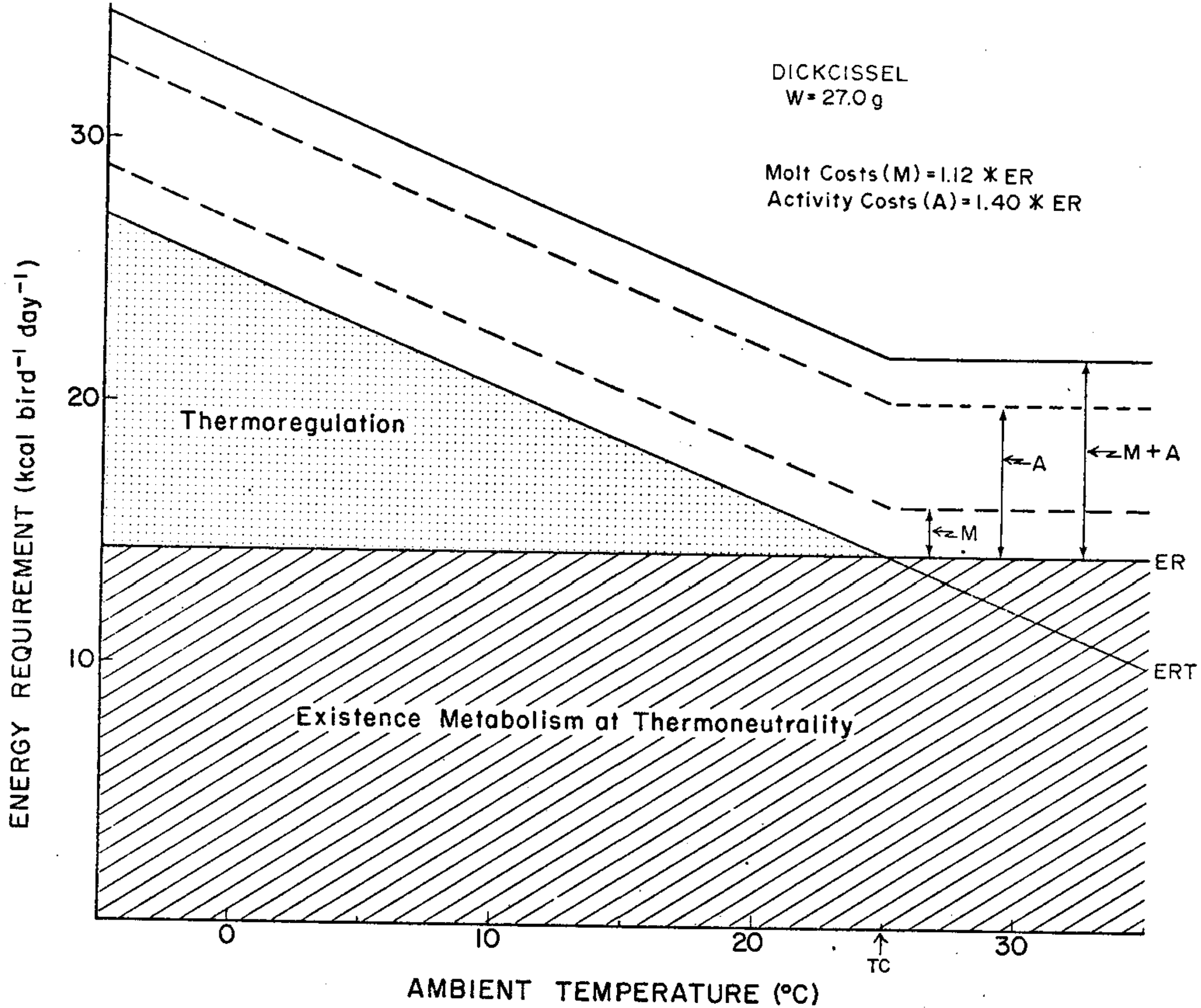

Fig 2.2. Calculations of daily individual energy requirements in relation to ambient temperature. ER represents the existence energy requirement at thermoneutrality (temperatures ≥ TC), as determined from the equations in SUBROUTINE APER for TC degrees. At temperatures below TC, the additional energy costs of thermoregulation are represented by ERT-ER, where ERT is the existence energy demand calculated in APER using the variable AVDEG. The costs of such functions as activity or molt increase energy requirements as shown.

```
      BMF2 = BMF2 + WTF*PCT(KA)
      CALL APER(NP(I),WTF,TC(I),ER)
      CALL APER(NP(I),WTF,AVDEG,ERT)
      THERF(I)=ERT-ER
      IF(THERF(I).LE.0.0) THERF(I)=0.0
   25 ERF2 = ERF2 + ER*PCT(KA)
      IF (ERF(I)*ERF2.NE.0.)AMPY = .5
      ERF(I) =(ERF(I) + ERF2)
C.....FDEF IS THE DIETARY EFFICIENCY OF FLEDGLINGS
   20 FDEF=DEF
      ERF(I) = ((ERF(I)*1.15 + THERF(I))*FDEF)*.000001*X(J+3)*AMPY
      BMF(I) =(BMF(I) + BMF2)*AMPY*X(J+3)*.000001


C...COMPUTE POPULATION TOTALS
C...
      AN(I) = X(J) + X(J+2)
      ANF(I) = AN(I) + X(J+3)
      ANFJ(I) = ANF(I) + X(J+4)
      ANTOT = ANTOT + AN(I)
      ATOT = ATOT + X(J)
      ANFTOT = ANFTOT + ANF(I)
      ANFTO = ANFTOT
      ANFJTO = ANFJTO + ANFJ(I)
      ANFJT = ANFJTO
      TEI(I) = ERA(I)+ERF(I)+ERN(I)
      CTEI(I) = CTEI(I) + TEI(I)
      TBM(I) = BMN(I) + BMF(I) + BMA(I)
C...THERE IS NO BIOMASS COMPUTED FOR EGGS
      TEITOT = TEITOT + TEI(I)
      TEITO = TEITOT
      BMTOT = BMTOT + TBM(I)
      ERATOT = ERATOT + ERA(I)
      ERATO = ERATOT
      ERFTOT = ERFTOT + ERF(I)
      ERFTO = ERFTOT
      ERNTOT=ERNTOT+ERN(I)
      ERNTO = ERNTOT
      CE(I,1) = CE(I,1) + DT*ERA(I)
      CE(I,2) = CE(I,2) + DT*ERF(I)
      CE(I,3) = CE(I,3) + DT*ERN(I)
    1 CONTINUE
      RETURN
      END
```

The last large block of code in SUBROUTINE CYCL2 consists of approximately 20 statements concerned primarily with the accumulation of variables for the purposes of output. First, population numbers for adults and nestlings are computed; then, to that is added the fledgling population to obtain adults, nestlings, and fledglings; and finally, juveniles are added to get adults, nestlings, fledglings, and juveniles, each for species I. In the next five lines, we get accumulations for the entire population of adults, nestlings, and fledglings; and adults, nestlings, fledglings, and juveniles. Two statements are used merely to reduce the number of characters in the variable names from 6 to 5 for plotting purposes (a limitation of SIMCOMP).

In the next line of code, TEI (total energy requirement for species I) is computed by adding energy requirements for adults to that for fledglings to that for nestlings. Next the cumulative total energy requirement for species I (CTEI) is gotten by adding CTEI to TEI. Thus, CTEI is an accumulation to the present day in the run of the energy demands on the system. The total biomass is computed as the sum of the biomass in nestlings, fledglings, and adults. (Notice that there is no weight associated with eggs.) The next nine lines of code produce energy variables summed over all the species. TEITOT is the total energy requirement summed over all species; BMTOT is the same for biomass; ERATOT is energy requirement for adults; ERFTOT is energy requirement for fledglings; and ERNTOT is energy requirement for nestlings. Finally, the three calculations involving the variable CE calculate the assumulations of energy demand for the species I in age class 1 for adults, 2 for fledglings, and 3 for nestlings for the entire run.

At this point, we can see the reason for the early statement that CYCL2 is the main part of this entire program. It certainly contains the heart of all of the energy demand calculations for the individuals, species, and populations.

```
      SUBROUTINE FINIS
      PRINT 8000
8000  FORMAT (20X, *CUMULATIVE ENERGY REQUIREMENTS*//
     *20X,*NSP*,11X,*NESTLINGS*,10X,*FLEDGLINGS*,14X,*ADULTS*)
      PRINT 8001, ((I,CE(I,3),CE(I,2),CE(I,1)), I = 1,NSP)
8001  FORMAT (20X,I3,3E20.10)
      PRINT 8002,((PAER(I),I),I = 1,NSP)
8002  FORMAT(20X,*PEAK ADULT ENERGY REQUIREMENT = *,E20.10,10X,*SPECIES
     1NO. = *,I3)
      RETURN
      END
```

SUBROUTINE FINIS

SUBROUTINE FINIS is called only once after the simulation is complete (Gustafson and Innis 1973, Stevens and Gustafson 1973). The responsibility of SUBROUTINE FINIS is to print out the cumulative energy requirements of the various species by age class and the peak adult energy requirement for each species. An example of this result is found in Chapter 8.

```
      SUBROUTINE APER(J,Y,T,ER)
C...
C...Y=AVERAGE WEIGHT
C...T=TEMPERATURE IN DEG C.
C...ER=ENERGY REQUIREMENT.
C...
      IF(Y.LE.0.)100,101
  100 ER=0.
      RETURN
  101 GO TO (10,20),J
C...SUBROUTINE TO CALCULATE THE ENERGY REQUIREMENT FOR NON-PASSERINES
   10 T1 = 4.3372*(Y)**.53
      T2 = .5464*(Y)**.7545
   21 ER=FLIN2(T1,T2,0.,30.,T)
      RETURN
C...SUBROUTINE TO COMPUTE ENERGY REQUIREMENTS FOR PASSERINES.
   20 T1 = 4.3372 *(Y)**.53
      T2 = 1.572 * (Y)**.621
      GO TO 21
      END
```

CHAPTER 3

USER-DEFINED FUNCTIONS

A great many of the detailed calculations are carried out in function and subroutine subprograms supplied by the user. Placing these activities in subroutines facilitates the organization of the program and also simplifies modifications. There are basically two kinds of subroutines; the first provides biological input to the main program, and the second performs purely mathematical functions. We shall describe the biological routines first and the mathematical functions second.

SUBROUTINE APER

This subroutine is called with four arguments--J, Y, T, and ER. The argument J is used to determine whether nonpasserine or passerine equations are used to compute the energy demand, depending on whether J is 1 or 2, respectively; Y is the weight of the bird in grams; T is the air temperature in degrees centigrade; and ER (energy requirement for an individual of the given weight at the given temperature, expressed in kilocalories per day) is the variable returned by the subroutine.

If the average weight is less than or equal to zero, the subroutine sets ER to 0 and returns. Otherwise, a branch to the statement labeled 10 or the statement labeled 20, depending upon J, chooses the appropriate set of energy equations from Kendeigh (1970):
for both passerines and nonpasserines,

$$T1 + 4.337\ Y^{.53} \text{ for } T = 0°C$$

for passerines,

$$T2 = 1.572\ Y^{.62} \text{ for } T = 30°C$$

```
      SUBROUTINE EGG(I,J,Y,K,L)
      DIMENSION TBEW(15,4),TBAW(15,4),TABL1(15),TABL2(15),NUM(4)
C TBEW IS A TWO DIMENSIONAL ARRAY CONTAINING ALL EGG WEIGHT DATA
C             TBEW(N,1) = EGG WEIGHTS FOR PASSERINES    N = 1,2,...,NUM(1)
C             TBEW(N,2) = EGG WEIGHTS FOR SHOREBIRDS    N = 1,2,...,NUM(2)
C             TBEW(N,3) = EGG WEIGHTS FOR CORMORANTS    N = 1,2,...,NUM(3)
C             TBEW(N,4) = EGG WEIGHTS FOR ALCIDS        N = 1,2,...,NUM(4)
C TBAW IS A TWO DIMENSIONAL ARRAY CONTAINING ALL ANIMAL WEIGHT DATA
C             TBAW(N,1) = ANIMAL WEIGHTS FOR PASSERINES.    N = 1,2,...,NUM(1)
C             TBAW(N,2) = ANIMAL WEIGHTS FOR SHOREBIRDS     N = 1,2,...,NUM(2)
C             TBAW(N,3) = ANIMAL WEIGHTS FOR CORMORANTS     N = 1,2,...,NUM(3)
C             TBAW(N,4) = ANIMAL WEIGHTS FOR ALCIDS         N = 1,2,...,NUM(4)
      DATA TBEW/
     10.,.74,1.04,1.3,1.92,2.35,3.08,3.41,4.23,6.02,7.13,10.27,12.05,
     *16.15,20.00,
     20.,5.7,9.37,12.1,17.7,28.6,47.5,54.3,60.,6*0.,
     30.,49.,48.,44.,51.,58.,70.,8*0.,
     40.,24.,52.,55.,65.,94.,110.,113.,150.,6*0./
C
      DATA TBAW/
     10.,6.,8.,11.7,17.1,22.8,30.,37.9,51.6,67.7,97.5,168.3,206.3,
     *396.3,700.,
     20.,26.7,43.6,59.,109.3,212.1,475.,750.,1100.,6*0.,
     30.,1760.,1870.,2000.,2430.,2500.,4000.,8*0.,
     40.,125.,425.,450.,500.,700.,930.,1000.,1500.,6*0./
C
C NUM(L) IS THE NUMBER OF SIGNIFICANT ENTRIES IN THE L-TH BLOCK. L=1,2,3, OR 4
      DATA NUM/15,9,7,9/
C
C I IS THE INDEX FOR SPECIES.  J IS THE INDEX OF THE STATE VARIABLE REPRESENTING
C THE ADULT POPULATION OF THE ITH SPECIES.  K IS A FLAG.  IF K = 1 THEN WE USE
C THOSE CALCULATIONS INVOLVING THE FIRST CLUTCH.  K = 2 CORRESPONDS TO SECOND
C CLUTCH EQUATIONS.
```

for nonpasserines,

$$T2 = 0.546\ Y^{.754} \text{ for } T = 30°C$$

The temperature T1 corresponds to the energy demand at 0°C, and the temperature T2 corresponds to the energy demand at 30°C. The return variable ER is calculated at the statement labeled 21 where FLIN2 (a linear interpolation/extrapolation function) extrapolates or interpolates for the temperature T, given the values T1 and T2 at 0° and 30°C, respectively. The functions T1 and T2 are illustrated in Fig. 3.1.

SUBROUTINE EGG

SUBROUTINE EGG computes not only the weight of the individual eggs as a function of adult weight, but also computes the energy requirement for the production of these eggs. It is called with five parameters I, J, Y, K and L. I is the species index; J is the index locating the adults of species I in the state variable array (J = 5 * (I-1) + 2); and Y is the energy requirement for egg production in the units of kilocalories per adult per day. Thus, it is the total energy requirement for the production of that fraction of the clutch produced on that given day per adult. The index K is 1 for computation of first clutch costs; it is 2 for second clutch costs. L is used to determine whether the egg weight/adult weight calculation is based on passerine, shorebird, cormorant, or alcid data depending on L being 1, 2, 3, or 4, respectively.

SUBROUTINE EGG contains separate tables of egg weights and adult weights for passerines, shorebirds, cormorants, and alcids. It is assumed that egg weight is a function of adult weight, and the actual weight of the eggs in any given run is determined by linear interpolation from the adult weight for the appropriate bird type to determine the egg weight. In order to do a generalized

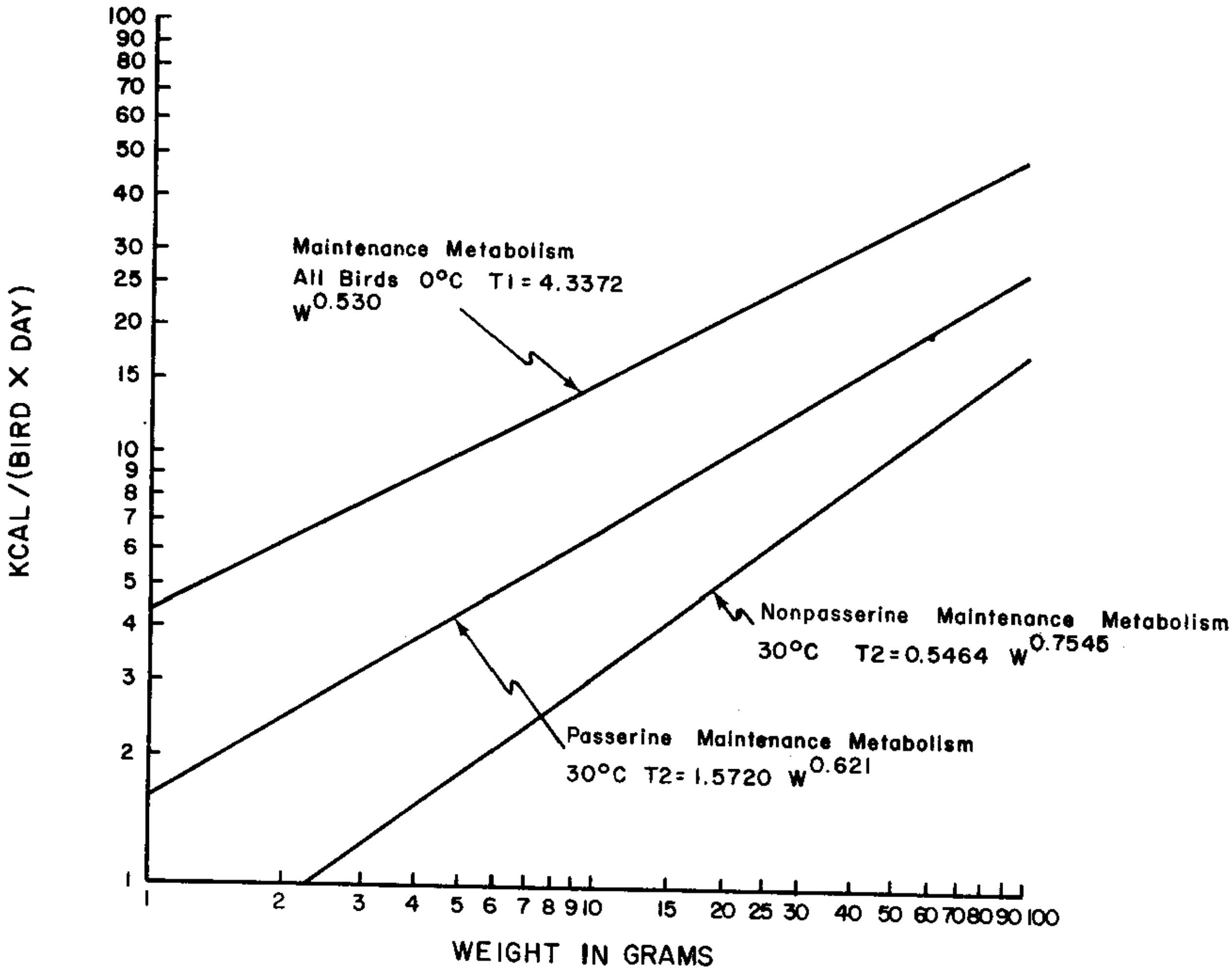

Fig. 3.1. Relationship between body weight and daily individual existence energy demands, as considered in SUBROUTINE APER.

```
      N = NUM(L)
      DO 100 M = 1,N
      TABL2(M) = TBEW(M,L)
      TABL1(M) = TBAW(M,L)
  100 CONTINUE
      CALL TABLF(TABL1,TABL2,N,AMW(I),EW)
C EW IS THE EGG WEIGHT.
      GO TO (1,2) K
    1 TH=(DOI1(I)-CS1(I)-3.+DCI1(I))/2.
      IF(TIME.GT.TH) GO TO 3
      Y=CS1(I)*4.*(TIME-DOI1(I)+CS1(I)+3.)
     1/(DCI1(I)-DOI1(I)+CS1(I)+3.)**2
C THE ABOVE EQUATIONS ARE USED IN ORDER TO DISTRIBUTE ENERGY COST OVER
C THE TIME AVAILABLE FOR EGG PRODUCTION.
      Y=1.10*1.37*EW*Y*PPBF(I)
      RETURN
    3 Y=CS1(I)*4.*(DCI1(I)-TIME)/(DCI1(I)-DOI1(I)+CS1(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPBF(I)
      RETURN
    2 TH=(DOI2(I)-CS2(I)-3.+DCI2(I))/2.
      IF(TIME.GT.TH) GO TO 4
      Y=CS2(I)*4.*(TIME-DOI2(I)+CS2(I)+3.)
     1/(DCI2(I)-DOI2(I)+CS2(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPBF2(I)
      RETURN
    4 Y=CS2(I)*4.*(DCI2(I)-TIME)
     1/(DCI2(I)-DOI2(I)+CS2(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPBF2(I)
      RETURN
      END
```

table look up, two dummy tables are set up at TABL1 and TABL2, and then the call to TABLF is made. The variable EW (egg weight in grams) is returned by TABLF.

Total energy required to produce a clutch is the product of egg weight, clutch size, 1.23, and 1.37. According to King (1973), the caloric value of a gram of egg for passerines is approximately 1.10 kcal. Production efficiency for eggs is estimated at 73% by El-Wailly (1966) and King (1973), resulting in the additional factor of 1.37 (= 1/.73). However, it is desired that the cost of producing the clutch be distributed as the clutch is distributed over the total period of egg production. In SUBROUTINE EVST, we explain how this distribution of the eggs over the egg production interval is obtained. In SUBROUTINE EGG, we do the same things except we distribute the cost over a somewhat longer period, that being from DOI1(I)-CS1(I)-3 to DCI1(I) (where DOI is the date the first female of the population to complete a clutch initiates incubation, CS is the mean number of eggs, and DCI is the date the last female in the population to complete a clutch initiates incubation). This longer interval is associated with the fact that egg production begins approximately three plus the number of eggs in the clutch days prior to the appearance of the first egg. This distribution is handled by the equation Y = 1.10 · 1.37 · EW · Y', where Y' is the amount of the clutch produced on the day TIME and its value is given by:

$$Y' = \frac{CS1(I) \cdot 4 \cdot (TIME - DOI1(I) + CS1(I) + 3)}{(DCI1(I) - DOI1(I) + CS1(I) + 3)^2}$$

if time is less than or equal to

$$\frac{DCI1(I) + DOI1(I) - CS1(I) - 3}{2}$$

```
      FUNCTION EVST(T,I)
C...
C...FUNCTION TO COMPUTE EGG PRODUCTION PER DAY PER PRODUCING FEMALE
C...
    1 IF(T.LT.DOI1(I).OR.T.GT.DCI1(I))110,111
  110 EVST = 0.
      RETURN
  111 TL = DCI1(I)-DOI1(I)
      IF (TL.LE.0.) GO TO 110
      TM =  (DOI1(I)+DCI1(I))/2.
      IF  (T.LE.TM)113,114
  113 EVST =CS1(I)*PPBF(I)*4.*(T-DOI1(I))/(TL*TL)
      RETURN
  114 EVST =CS1(I)*PPBF(I)*4.*(DCI1(I)-T)/(TL*TL)
      RETURN
      END
```

and by

$$Y' = \frac{CS1(I) \cdot 4 \cdot (DCI1(I) - TIME)}{(DCI1(I) - DOI1(I) + CS1(I) + 3)^2}$$

when time is greater than

$$\frac{DCI1(I) + DOI1(I) - CS1(I) - 3}{2}$$

Thus, the block of code following the GO TO (1,2) K merely carries out these calculations. If K is 1, then we are performing computations for the first clutch; if K is 2, we are performing computations for the second clutch. In each case decisions based on TIME are needed to choose the appropriate equation.

FUNCTION EVST

The function SUBROUTINE EVST is called with two variables, T and I. Egg production per producing female for the species I is assumed to be distributed (see Fig. 3.2) over the time interval from DOI1(I) to DCI1(I) for the first clutch. In order to have the average clutch size be given by CS1 and the production rate be given as in the figure, we obtain the equations

$$EVST = CS1(I) \cdot PPBF(I) \cdot 4. \cdot (T - DOI1(I)/(DCI1 - DOI1(I))^2$$

if time T is less than the time at the mid-point of the interval (DOI1(I) + DCI1(I)/2 and the equation

$$EVST = CS1(I) \cdot PPBF(I) \cdot 4. \cdot (DCI1(I) - T)/(DCI1(I) - DOI1(I))^2$$

if time is greater than or equal to the time at the mid-point of the interval. DCI1(I) must be at least 2 days greater than DOI1(I) for the function to generate meaningful output.

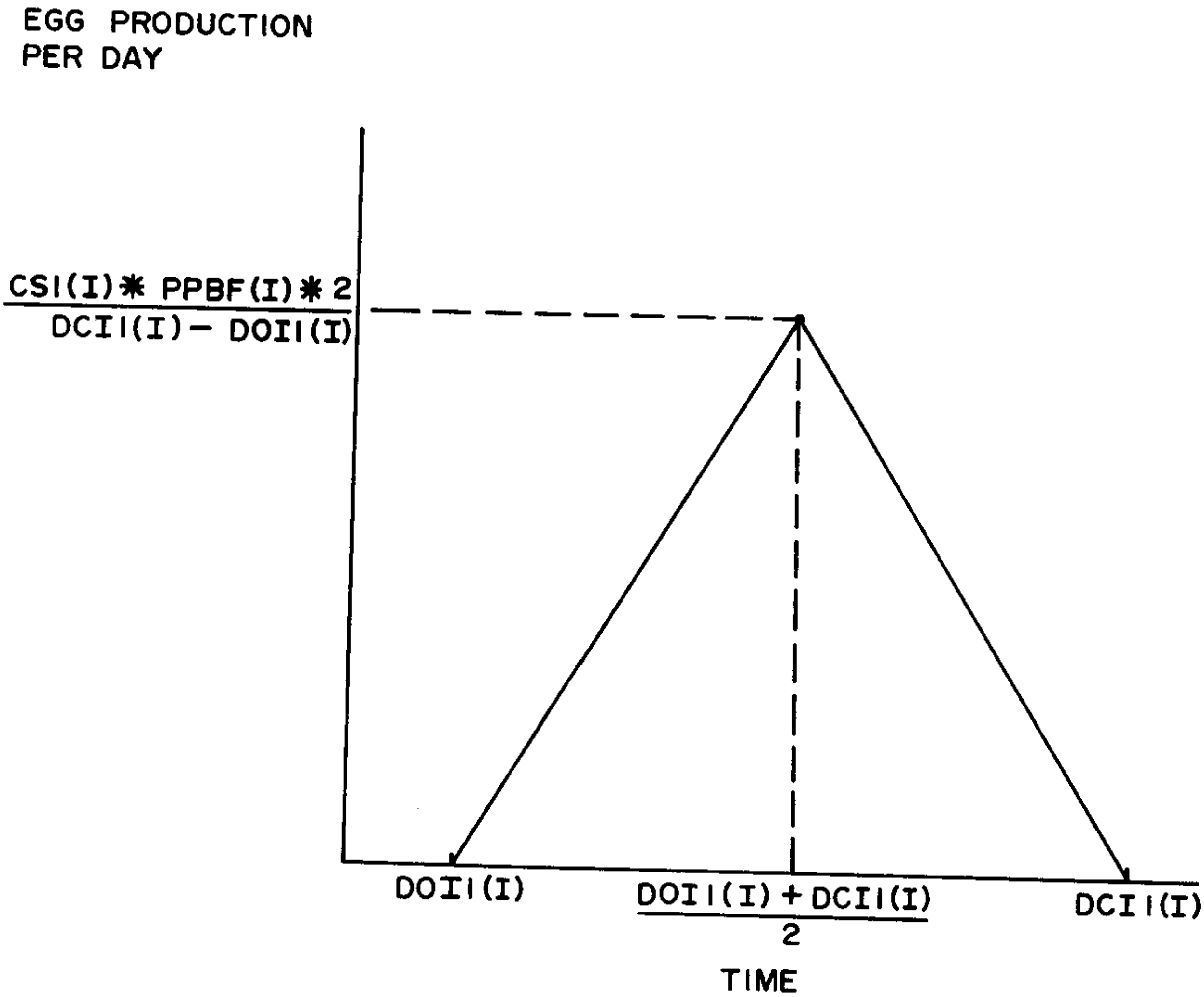

Fig. 3.2. Distribution of egg production through time, as calculated in SUBROUTINE EVST. See text.

```
      FUNCTION EPD2(T    ,I)
C...
C...FUNCTION TO COMPUTE EGG LAYING PATTERN FOR SECOND CLUTCH
C...
1     IF (T.LT.DOI2(I).OR.T.GT.DCI2(I)) 110,111
110   EPD2 = 0.0
      RETURN
111   TL = DCI2(I) - DOI2(I)
      IF (TL.LE.0.0) GO TO 110
      TM = (DOI2(I) + DCI2(I))/2.0
      IF (T.LE.TM) 113,114
113   EPD2 =CS2(I) * PPBF2(I)* 4.0 * (T-DOI2 (I))/(TL*TL)
      RETURN
114   EPD2 =CS2(I) * PPBF2(I) * 4.0 * (DCI2(I)-T)/(TL*TL)
      RETURN
      END
```

```
      SUBROUTINE E2(T,I,ER)
C J WILL INDEX THE DAYS OF MEASUREMENT. I INDEXES THE  SPECIES. M IS
C THE INDEX FOR THE ACTIVITIES.
C EEATM(L,I) IS THE ENERGY EXPENDITURE FOR A MALE OF SPECIES I ON THE
C LTH ACTIVITY. EEATF IS THE SAME FOR FEMALES.
C THE ACTIVITIES ARE AS FOLLOWS
C  I=1.  INACTIVE
C     2.  SINGING
C     3.  FLIGHT
C     4.  FORAGING
C     5.  AGGRESSION AND DISPLAY
C     6.  COURTSHIP
C     7.  INCUBATION AND BROODING.
C T REPRESENTS TIME.
      IF(T.GE.TE(I)) GO TO 85
```

The IF statements in EVST merely check to be sure the time is in the appropriate interval for the given species for egg production. If not, EVST is returned as zero. Otherwise, the block of code from the statement labeled 111 to that labeled 114 is used to carry out the computations indicated above.

FUNCTION EPD2

This function is used to carry out precisely the same computations as EVST, but for the second clutch rather than the first. Since all of the calculations are identical, it is unnecessary to describe this function in detail.

SUBROUTINE EZ

SUBROUTINE EZ computes the energy demand for males and females of a given species from activity budget information. It is called only if the variable NOACB is set to a value different from 1, and it has three parameters T, I, and ER. T is the time; I is the species index; and ER is the energy requirement as calculated in SUBROUTINE APER.

This routine considers seven "activities" of individuals: (i) inactive, (ii) singing, (iii) flight, (iv) foraging, (v) aggression and display, (vi) courtship, and (vii) incubation and brooding. Specification of the activities included in each category is not rigid and may be altered to suit the investigator's purposes. The entire routine is really concerned with a linear interpolation/extrapolation in the arrays AMACT and AFACT, which were set up in START as normalized weighted activity budgets.

On entry into the routine, we first check to see that TIME has not exceeded the time of the end of the run (TE) for the species I. If it has,

```
C NUMDY IS THE NUMBER OF ENTRIES IN THE DAY ARRAY.
      K=NUMDY-1
      IF(T.LT.DAY(1))1,2
    1 DO 81 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,1,I),AMACT(M,2,I),DAY(1),DAY(2),T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,1,I),AFACT(M,2,I),DAY(1),DAY(2),T)*ER
      IF(EEATM(M,I).LT.0.) EEATM(M,I) = 0.
      IF(EEATF(M,I).LT.0.) EEATF(M,I) = 0.
   81 CONTINUE
      GO TO 87
    2 IF(T.GT.DAY(NUMDY))3,4
    3 DO 82 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,K,I),AMACT(M,NUMDY,I),DAY(K),DAY(NUMDY),
     1T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,K,I),AFACT(M,NUMDY,I),DAY(K),DAY(NUMDY),
     1T)*ER
      IF(EEATM(M,I).LT.0.) EEATM(M,I) = 0.
      IF(EEATF(M,I).LT.0.) EEATF(M,I) = 0.
   82 CONTINUE
      GO TO 87
    4 DO 83 J=1,K
      L=J+1
      IF(T.LE.DAY(L).AND.T.GE.DAY(J))5,83
    5 DO 84 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,J,I),AMACT(M,L,I),DAY(J),DAY(L),T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,J,I),AFACT(M,L,I),DAY(J),DAY(L),T)*ER
   84 CONTINUE
   83 CONTINUE
      GO TO 87
   85 DO 86 M = 1,7
      EEATM(M,I) = 0.
   86 EEATF(M,I) = 0.
   87 CONTINUE
      TEDM(I) = 0.
      TEDF(I) = 0.
      DO 88 II = 1,7
      TEDM(I) = TEDM(I) + EEATM(II,I)
   88 TEDF(I) = TEDF(I) + EEATF(II,I)
C TEDM(I) IS THE MALE TOTAL ENERGY DEMAND FOR ALL ACTIVITIES COMBINED TEDF(I)
C  IS THE SAME FOR FEMALES.  THEIR UNITS ARE KCAL/BIRD-DAY
      RETURN
      END
```

then control is transferred to the statement labeled 85, wherein the intermediate variables EEATM and EEATF are set to 0. EEATM and EEATF are, respectively, the male and female energy requirements for activity M of species I (these two arrays each have two indices).

If time is less than DAY(1), where DAY(1) is the first date on which an activity budget is specified, then the DO loop to the statement labeled 81 does a linear extrapolation to determine EEATM and EEATF. Similarly, if time is greater than DAY(NUMDY) (NUMDY being the number of entries in the array day), the DO loop to the statement labeled 82 carries out a linear extrapolation to determine these two indexed arrays. Normally, however, the branch leads to the statement labeled 4, where time is somewhere between DAY(1) and DAY(NUMDY). In this case, a linear interpolation is performed in the AMACT and AFACT arrays.

In any event, we eventually branch to the statement labeled 87 where, after initializing two arrays TEDM and TEDF, we enter the DO loop to the statement labeled 88 in which EEATM and EEATF are accumulated to form TEDM and TEDF, respectively. TEDM and TEDF are the total energy demands for males and females for all activities combined, respectively, in the units of kilocalories per bird-day. These variables appear in storage and, hence, are effectively returned to the main program in spite of the fact that they are not call parameters.

SUBROUTINE MOLT

This subroutine has four input arguments and one output argument. It calculates the energy cost of molt according to the relation:

M = 8.375*(W**.959)

where M = total cost of a complete molt, and W = adult mean weight (AMW). The total energy cost of molting is normally distributed over a period of P days.

```
      SUBROUTINE MOLT(D,P,W,T,M)
      REAL M,MU
C.....THIS SUBROUTINE CALCULATES THE MOLTING COST WHICH IS NORMALLY
C.....     DISTRIBUTED OVER A PERIOD OF P DAYS AND STARTS ON DAY D
C.....W IS THE ADULT MEAN WEIGHT AND T IS THE TIME(IN DAYS)
C.....THE MOLTING COST IS GIVEN BY
C.....      MOLT=8.375*(W**.959)
C.....M IS THE MOLT AT TIME T+.5
      PI=3.14159
C.....CALCULATE SQUARE ROOT OF 2 PI
      SR2PI=SQRT(2*PI)
C.....CALCULATE DISTRIBUTION MEAN
      MU=D+P/2.
C.....CALCULATE STANDARD DEVIATION
      SIG=P/6.
C.....CALCULATE MOLT COST AT T+.5
      R=1./(SIG*SR2PI)
      S=(T+.5-MU)/SIG
      Y=R*EXP(-.5*S*S)
      M=(1./.9973)*8.375*(W**.959)*Y
      RETURN
      END
```

```
      FUNCTION WNSLG (I,AGE)
C...
C...FUNCTION TO COMPUTE NESTLING WEIGHTS
C...
      WNSLG = AG(I)/(1.0 + BG(I)*EXP(-AK(I)*AGE))
      RETURN
      END
```

```
      FUNCTION WFLG(I,AGE)
C...
C...FUNCTION TO COMPUTE THE FLEDGLING WEIGHTS
C...
      WFLG = FLIN(FW(I),AMW(I),0., PF(I),AGE)
      RETURN
      END
```

Molt begins at the start of day D, and hence, stops at the end of day D + P - 1.

The subroutine is constructed so that the beginning of day D corresponds to the mean, MU, minus three standard deviations, and the end of day D + P - 1 corresponds to MU plus three standard deviations. As this construction corresponds approximately to 99.73% of the area under a normal curve, the constant (1./.9973) is included in the calculations to compensate for this approximation. An additional adjustment in the calculations is taken which evaluates the normal distribution, on day T, at T + .5. This step is included in order that the Riemann sum more accurately approximates the area under the normal curve.

FUNCTION WNSLG

This function uses the logistic equation to compute the weights of nestlings. There are two call parameters, I and AGE. The index I determines the species, and the variable AGE is the nestling age of the individuals in question; that is, it is the number of days that these individuals have been nestlings. The two constants AG and BG were computed from other parameters in SUBROUTINE START.

FUNCTION WFLG

This function is similar to FUNCTION WMSLG, except that it computes the weights of fledglings. Again I and AGE are the two call parameters. I is the species index, and AGE is the fledgling age of the individuals. The weight is computed by linear interpolation between the fledge weight (FW) and the adult mean weight (AMW) where the independent variable AGE runs from 0 to the period of fledgling (PF).

```
      FUNCTION FLIN(A,B,C,D,T)
C...
C...GENERAL LINEAR INTERPOLATION ROUTINE
C...
      IF(T.GT.D.OR.T.LT.C)1,2
    1 FLIN=0.
      RETURN
    2 CONTINUE
      IF (D.EQ.C) 3,4
    3 FLIN=(A+B)/2.0
      RETURN
    4 FLIN=(B-A)/(D-C)*(T-C)+A
      RETURN
C...THIS COMPUTES A LINEAR INTERPOLATION BETWEEN A AT T = C AND B AT T =
C...    D USING T AS THE INDEPENDENT VARIABLE
C IF T LIES OUTSIDE THE INTERVAL C TO D THE FUNCTION RETURNS THE VALUE 0.
      END
C.................

      FUNCTION FLIN2(A,B,C,D,T)
C FLIN2 IS A LINEAR INTERPOLATION WHICH EXTRAPOLATES IF T FALLS OUTSIDE
C THE INTERVAL C TO D.
      IF(C.EQ.D)1,2
    1 FLIN2=(A+B)/2.
      RETURN
    2 FLIN2=(B-A)/(D-C)*(T-C)+A
      RETURN
      END
C.................

      SUBROUTINE TABLF(TABL1,TABL2,N,A,Y)
      DIMENSION TABL1(15),TABL2(15)
C TABL1 IS THE INDEPENDENT VALUES, WHILE TABL2 IS THE DEPENDENT VALUES.
      IF(A.LE.TABL1(1)) GO TO 10
      IF(A.GE.TABL1(N)) GO TO 20
      DO 100 I = 2,N
      IF(A.LE.TABL1(I)) GO TO 30
  100 CONTINUE
   30 Y=(A-TABL1(I-1))*(TABL2(I)-TABL2(I-1))/(TABL1(I)-TABL1(I-1))
     1+TABL2(I-1)
      RETURN
   20 Y=TABL2(N)
      RETURN
   10 Y=TABL2(1)
      RETURN
      END
```

Mathematical Subroutines

There are three mathematical subroutines used to perform linear interpolations/extrapolations and table look ups. The first is FLIN, which has five call parameters A, B, C, D, and T. T is the independent variable; if T lies between C and D, then a linear interpolation is performed between the points (C,A) and (D,B). If T is not between C and D, then the function returns to the value 0. In the event C = D, then the value (A+B)/2 is returned. The second is FLIN2, which has the same five call parameters and performs the same function except that for T outside the interval from C to D, the function does a linear extrapolation.

The third such mathematical subroutine is SUBROUTINE TABLF, which also has five call parameters (TABL1, TABL2, N, A, and Y). This function does a linear interpolation is a table of dependent variables (TABL2) given another table (TABL1) of independent variables; N is the number of entries in these two tables; A is the independent variable; and Y is the return value.

If A is less than or equal to TABL1 (1), then TABL2 (1) is returned. If A is greater than or equal to TABL1 (N), then TABL2 (N) is returned. In any other case, which would be the more normal use of the function, a linear interpolation is performed between the points (TABL2(I-1),TABL1(I-1)) and (TABL2(I),TABL1(I)). The routine assumes that the TABL1 array is in monotone increasing order.

CHAPTER 4

VARIABLE LIST

This chapter contains a list of the variables which appear in the bird model. They are separated into two groups, input variables which must be assigned in the data deck and temporary variables which are essential to the understanding of the simulation, but which are computed internal to the system. There are also a number of other variables in the model which are used as temporary variables and which are not defined in this list. Such temporary variables (the call parameters in the mathematical subroutines as described above, for example) may take on different meanings for different calls and really have biological meaning only in the context of the particular calculations under consideration. It is therefore necessary for the latter group of variables to spend some time with that part of the code in which they are used to determine just what the variable means. Any such variable of the third class should be explicable in terms of the variables listed below.

```
C                                        ****************
C                                        *VARIABLE LIST*
C                                        ****************
C
C INPUT VARIABLES.  THE FOLLOWING VARIABLES NEED TO BE ASSIGNED VALUES IN THE
C                   DATA DECK.
C
C THE INDEX I APPEARING IN THE VARIABLES OF THE LIST WILL ALWAYS DENOTE
C SPECIES WHETHER INDICATED OR NOT.
C
C ACTC(J,I)     WEIGHTING COEFFICIENT (ACTIVITY COST) OF THE JTH ACTIVITY FOR
C           THE ITH SPECIES.
C ADR(I)    ADULT DEATH RATE.(PERCENT/DAY)
C AFACT(J,K,I) TIME SPENT ON THE JTH ACTIVITY ON THE KTH DAY OF MEASUREMENT BY
C                A FEMALE OF THE ITH SPECIES.(HOURS)
C AK(I)     GROWTH CONSTANT USED IN THE NESTLING GROWTH FUNCTION.
C AMACT(J,K,I) TIME SPENT ON THE JTH ACTIVITY ON THE KTH DAY OF MEASUREMENT BY
C                A MALE OF THE ITH SPECIES.(HOURS)
C AMW(I)    THE AVERAGE ADULT WEIGHT OF THE ITH SPECIES.(GRAMS)
C AMWA(J,I)  THE AVERAGE ADULT BODY WEIGHT OF THE ITH SPECIES ON DA(J,I).
C             (GRAMS)
C CALV(I)   THE CALORIC VALUE OF THE ITH PREY CATEGORY. (KCAL/G DRY WT)
C CS1(I)    THE MEAN NUMBER OF EGGS IN A CLUTCH FOR THE FIRST BROOD.
C CS2(I)    THE MEAN NUMBER OF EGGS IN A CLUTCH FOR THE SECOND BROOD.
C DA(J,I)   DATES ON WHICH MEASUREMENTS OF MEAN ADULT BODY WEIGHT OF SPECIES I
C           ARE RECORDED. (DAYS SINCE JAN 1)
C DATE(I)   DATES ON WHICH TEMPERATURES ARE RECORDED.(DAYS SINCE JAN1)
C DAY(K)    THE DAYS OF MEASUREMENT USED IN THE ACTIVITY BUDGET.(DAYS SINCE JAN1)
C DCI1(I)   THE DATE ON WHICH THE  LAST FEMALE IN THE POPULATION TO COMPLETE
C           A FIRST CLUTCH INITIATES INCUBATION.(DAYS SINCE JAN1)
C DCI2(I)   THE DATE ON WHICH THE LAST FEMALE IN THE POPULATION TO COMPLETE A
C           SECOND CLUTCH INTIATES INCUBATION.(DAYS SINCE JAN1)
C DEF       DIGESTIVE OR ASSIMILATION EFFICIENCY OF ALL SPECIES CONSIDERED
C           IN A RUN. (1.0/PERCENT OF ENERGY INTAKE ASSIMILATED)
C DIET(I,J,K)    AMOUNT (G DRY WT, PERCENT OF TOTAL PREY) OF THE ITH PREY
C                CATEGORY ON THE JTH MEASUREMENT DAY IN THE DIET OF THE KTH
C                SPECIES.
C DOI1(I)   THE DATE ON WHICH THE FIRST FEMALE IN THE POPULATION TO COMPLETE
C           A CLUTCH INIATES INCUBATION.(DAYS SINCE JAN1)
C DOI2(I)   THE DATE ON WHICH THE FIRST FEMALE IN THE POPULATION TO COMPLETE
C           A SECOND CLUTCH INITIATES INCUBATION.(DAYS SINCE JAN1)
C DOM1(I)   DATE OF ONSET OF THE FIRST MOLT.(DAYS SINCE JAN1)
C DOM2(I)   DATE OF ONSET OF THE SECOND MOLT.(DAYS SINCE JAN1)
C FS(I)     DECIMAL FRACTION WHICH REPRESENTS THE NUMBER OF NESTLINGS WHICH
C           SURVIVE TO THE FLEDGLING STAGE.
C FW(I)     FLEDGLING WEIGHT OF SPECIES I. (GRAMS)
C HMW(I)    THE AVERAGE NESTLING WEIGHT AT HATCHING FOR THE ITH SPECIES (GRAMS).
C HS(I)     DECIMAL FRACTION WHICH REPRESENTS THE HATCHING SUCCESS FOR THE ITH
C           SPECIES.
C IDDAT(I)  A FLAG WHICH DETERMINES WHETHER AN EGG COST IS TO BE RUN.  IF AN EGG
C           COST IS TO BE RUN THEN IT ALSO IDENTIFIES THE TYPE OF DATA TO BE
C           USED.
C JDR(I)    JUVENILE DEATH RATE.(PERCENT/DAY)
C NAMW      A FLAG WHICH DETERMINES WHETHER ADULT BODY WEIGHT IS CALCULATED
C           AS A CONSTANT OR A VARIABLE.
C NCAT      NUMBER OF PREY CATEGORIES CONSIDERED IN THE DIET ARRAY.
C NDA       NUMBER OF ENTRIES IN THE ARRAY NDAT(J).
C NDAT(J)   DATES ON WHICH MEASUREMENTS OF DIETARY COMPOSITION ARE RECORDED.
C           (DAYS SINCE JAN 1)
C NDT       A FLAG USED TO INDICATE WHETHER DIET COMPOSITION CALCULATIONS
C           ARE TO BE RUN.
C NOACB     A FLAG USED TO DETERMINE WHETHER AN ACTIVITY BUDGET SHOULD BE
C           CALCULATED.
```

```
C NOTMP     NUMBER OF TEMPERATURES PROVIDED IN THE TEMP. TABLE.
C NP(I)     A FLAG WHICH IDENTIFIES THE ITH SPECIES AS A PASSERINE OR
            NON-PASSERINE.
C NSP       NUMBER OF SPECIES MODELED.
C NUDAS     NUMBER OF ENTRIES IN THE ARRAY DA(J.I).
C NUMDY     THE NUMBER OF ENTRIES IN THE ARRAY DAY.
C PBD(I)    POPULATION BREEDING DENSITY FOR SPECIES I.(INDIVIDUALS/KM**2)
C PE(I)     ADULT POPULATION DENSITY AT TIME TE(I).(INDIVIDUALS/KM**2)
C PF(I)     THE LENGTH OF TIME FOR A FLEDGLING TO GROW TO A JUVENILE.(DAYS)
C PFS(I)    THE DECIMAL FRACTION OF FLEDGLINGS WHICH SURVIVE TO BECOME JUVENILES.
C PI(I)     THE LENGTH OF TIME BETWEEN THE COMPLETION OF A CLUTCH AND THE
C           HATCHING OF THAT CLUTCH.(DAYS)
C PM1(I)    PERIOD OF FIRST MOLT.(DAYS)
C PM2(I)    PERIOD OF SECOND MOLT.(DAYS)
C PN(I)     THE LENGTH OF TIME FOR A NESTLING TO GROW TO A FLEDGLING.(DAYS)
C PPBF(I)   DECIMAL FRACTION OF ADULT POPULATION WHICH IS BREEDING FEMALES FOR
            FIRST BROOD.
C PPBF2(I)  DECIMAL FRACTION OF ADULT POPULATION WHICH IS BREEDING FEMALES FOR
C           THE SECOND BROOD.
C PS(I)     ADULT POPULATION DENSITY AT TIME TS(I).(INDIVIDUALS/KM**2)
C TC(I)     LOWER CRITICAL TEMPERATURE (THE LOWER LIMIT OF THE THERMONEUTRAL
C           ZONE) OF THE ITH SPECIES. (DEGREES CENTIGRADE)
C TD(I)     TIME AT WHICH EMIGRATION BEGINS FOR SPECIES I. (DAYS SINCE JAN1)
C TDJ(I)    DATE ON WHICH JUVENILE EMIGRATION BEGINS.(DAYS SINCE JAN1)
C TE(I)     TIME AT WHICH EMIGRATION IS COMPLETED FOR SPECIES I.(DAYS SINCE JAN1)
C TEJ(I)    DATE ON WHICH JUVENILE EMIGRATION ENDS.(DAYS SINCE JAN1)
C TEMPC(I)  TEMPERATURES.(DEGREES CENTIGRADE)
C TEND      TIME OF END OF RUN.(DAYS SINCE JAN1)
C TIN(I)    TIME OF COMPLETION OF IMMIGRATION.(DAYS SINCE JAN1)
C TS(I)     TIME OF ARRIVAL OF THE FIRST IMMIGRANT INDIVIDUALS OF SPECIES I
            (DAYS AFTER JAN 1).
C TSTRT     TIME OF START OF RUN.(DAYS SINCE JAN1)
C WM(I)     THAT PORTION OF THE ADULT POPULATION AT TIME TE(I) WHICH DIES PRIOR
            TO TIME TEND.
C
C
THE FOLLOWING VARIABLES ARE NOT INPUT VARIABLES, BUT ARE ESSENTIAL IN UNDER-
C STANDING THE SIMULATION.
C
C AG(I)     A PARAMETER USED IN THE NESTLING GROWTH FUNCTION.(GRAMS)
C AGE       AN INTERMEDIATE VARIABLE USED IN CALCULATING GROWTH.(DAYS)
C AI(I)     DAILY ENERGY REQUIREMENT FOR AN ADULT.(KCAL/KM**2-INDIVIDUAL)
C AN(I)     THE NUMBER OF ADULTS AND NESTLINGS OF SPECIES I.
C ANF(I)    THE NUMBER OF ADULTS, NESTLINGS, AND FLEDGLINGS OF SPECIES I.
C ANFJ(I)   THE NUMBER OF ADULTS, NESTLINGS, FLEDGLINGS, AND JUVENILES OF
C           SPECIES I.
C ANFJT     THE TOTAL NUMBER OF ADULTS, NESTLINGS, FLEDGLINGS, AND JUVENILES (ALL
C           SPECIES).
C ANFTO     THE TOTAL NUMBER OF ADULTS, NESTLINGS, AND FLEDGLINGS (ALL SPECIES)
C ANTOT     THE TOTAL NUMBER OF ADULTS AND NESTLINGS (ALL SPECIES)
C ATOT      THE TOTAL NUMBER OF ADULTS (ALL SPECIES)
C AVDEG     THE CALCULATED DAILY TEMPERATURE.(DEGREES CENTIGRADE)
C AVDT      THE CALCULATED DAILY DIET COMPOSITION.
C BG(I)     A PARAMETER USED IN THE NESTLING GROWTH FUNCTION.
C BMA(I)    BIOMASS OF ADULTS AND JUVENILES OF THE ITH SPECIES.(GRAMS/KM**2)
C BMF(I)    BIOMASS OF FLEDGLINGS OF THE ITH SPECIES.(GRAMS/KM**2)
C BMN(I)    BIOMASS OF NESTLINGS OF THE ITH SPECIES.(GRAMS/KM**2)
C BMTOT     TOTAL BIOMASS OF THE ENTIRE POPULATION (ALL SPECIES).(GRAMS/KM**2)
C CAER(I)   CUMULATIVE ENERGY REQUIREMENT FOR ADULTS OF THE ITH SPECIES.  NOTE
C           CAER(I) = CE(I.1).  THE VALUE OF CAER(I) IS PRINTED DAILY WHILE
C           CE(I.J) IS PRINTED AT THE END OF THE RUN.(KCAL/KM**2)
C CE(I.J)   THE CUMMULATIVE ENERGY OF NESTLINGS (J=1), FLEDGLINGS (J=2), AND
C           ADULTS (J=3) OF SPECIES I.(KCAL/KM**2)
C CEC(I)    CUMULATIVE ENERGY REQUIREMENT FOR EGG PRODUCTION (BOTH BROODS).
C           (KCAL/INDIVIDUAL)
```

```
C CTEI(I)  CUMULATIVE TOTAL ENERGY INTAKE FOR ALL ORGANISMS OF THE ITH SPECIES.
C          (KCAL/KM**2)
C CTHER(I) CUMULATIVE ENERGY REQUIREMENT FOR THERMOREGULATION BY ALL AGE
C          CLASSES OF THE ITH SPECIES. (KCAL/M**2)
C FC1(I)   DAILY ENERGY COST TO PRODUCE A CLUTCH IN THE FIRST BROOD.
C          (KCAL/FEMALE-DAY)
C FC2(I)   DAILY ENERGY COST TO PRODUCE A CLUTCH IN THE SECOND BROOD.
C          (KCAL/FEMALE-DAY)
C EEATF(J,I)   ENERGY EXPENDITURE BY A FEMALE OF SPECIES I ON THE JTH ACTIVITY
C              (KCAL/KM**2-FEMALE)
C EEATM(J,I)   ENERGY EXPENDITURE BY A MALE OF SPECIES I ON THE JTH ACTIVITY
C              (KCAL/KM**2-MALE)
C EPJ(I)   J=1,2,3. INTERMEDIATE VARIABLE SERVING THE SAME PURPOSES AS EVJ(I)
C          EXCEPT FOR THE SECOND CLUTCH.
C ER       THE DAILY MINIMAL EXISTENCE ENERGY REQUIREMENT.(KCAL/DAY-INDIVIDUAL)
C ER       THE DAILY EXISTENCE ENERGY REQUIREMENT AT TEMPERATURE TC(I).
C          (KCAL/DAY - INDIVIDUAL)
C ERA(I)   ENERGY REQUIREMENTS FOR ADULTS AND JUVENILES OF THE ITH SPECIES.
C          (KCAL/KM**2)
C ERATO    TOTAL ENERGY REQUIREMENT FOR ADULTS (ALL SPECIES).(KCAL/KM**2)
C ERF(I)   ENRGY REQUIREMENTS FOR FLEDGLINGS OF THE ITH SPECIES.(KCAL/KM**2)
C ERFTO    TOTAL ENERGY REQUIREMENT FOR FLEDGLINGS (ALL SPECIES).(KCAL/KM**2)
C ERN(I)   ENERGY REQUIREMENTS FOR NESTLINGS OF THE ITH SPECIES.(KCAL/KM**2)
C ERNTO    TOTAL ENERGY REQUIREMENT FOR NESTLINGS (ALL SPECIES).(KCAL/KM**2)
C ERT      THE DAILY EXISTENCE ENERGY REQUIREMENT. (KCAL/DAY - INDIVIDUAL)
C EVJ(I)   J=1,2,3. INTERMEDIATE VARIABLE USED TO DETERMINE THE NUMBER OF EGGS
C          PRODUCED PER DAY PER FEMALE(J=1).NESTLINGS (J=2),AND FLEDGLINGS
C          (J=3) FROM THE FIRST CLUTCH.
C EW       EGG WEIGHT.(GRAMS)
C FDEF     DIGESTIVE EFFICIENCY OF FLEDGLINGS.
C GPREY(I,K)   AMOUNT OF PREY CATEGORY I CONSUMED BY THE KTH SPECIES.
C              (G/M**2)
C NDEF     DIGESTIVE EFFICIENCY OF NESTLINGS.
C PAER(I)  PEAK DAILY ENERGY REQUIREMENT FOR ADULTS.(KCAL/KM**2)
C PCT(K)   IS A VARIABLE REPRESENTING THE PERCENT OF THE TOTAL NUMBER
C          OF NESTLINGS (FLEDGLINGS) PRESENT IN A SPECIFIED TIME INTERVAL.
C PCTT     A SUMMING VARIABLE USED TO NORMALIZE THE VARIABLE PCT(K).
C PREY(I)  AMOUNT OF PREY CATEGORY I CONSUMED BY ALL NSP SPECIES. (G/M**2/DAY)
C PTOT(I)  TOTAL SEASONAL CONSUMPTION OF THE ITH PREY CATEGORY BY ALL SPECIES
C          (G/M**2)
C TBM(I)   TOTAL BIOMASS OF THE ENTIRE POPULATION OF SPECIES I.(GRAMS)
C TEI(I)   TOTAL ENERGY INTAKE FOR ALL ORGANISMS OF THE ITH SPECIES.(KCAL/KM**2)
C TEITO    TOTAL ENERGY INTAKE OF ENTIRE POPULATION (ALL SPECIES).(KCAL/KM**2)
C THERF(I) THE ENERGY COST OF THERMOREGULATION FOR FLEDGLINGS OF THE ITH
C          SPECIES. (KCAL/DAY - INDIVIDUAL)
C THERM(I) THE ENERGY COST OF THERMOREGULATION FOR ADULTS AND JUVENILES OF THE
C          ITH SPECIES. (KCAL/DAY - INDIVIDUAL)
C TOT(I,K) AMOUNT OF PREY CATEGORY I CONSUMED BY THE KTH SPECIES OVER THE
C          DURATION OF A RUN (G/M**2).
C WTF      AN INTERMEDIATE VARIABLE USED IN CALCULATING FLEDGLING BIOMASS.
C          (GRAMS)
C WTN      AN INTERMEDIATE VARIABLE USED IN CALCULATING NESTLING BIOMASS.(GRAMS)
```

CHAPTER 5

INPUT LIST

This chapter contains simply a list (in old jargon, an 80-80 list) of the input deck which is used to perform the sample simulation contained in Chapter 7.

CONTROL CARDS

```
TA856,AFZRJNM5,T150,CM115000,GSI/BRO
ATTACH,SIMCOM,SIMCOM3,ID=NRFL,CY=1,MR=1.
SIMCOM.
&
```

STORAGE DECLAMATION

```
STORAGE.            THERF(20)
STORAGE.   NCAT,GPREY(20,20),TOT(20,20)
STORAGE.            PREY(20),PTOT(20)
STORAGE.   DIET(20,20,20),NDAT(20),CALV(20),NDA,NDT
STORAGE.       THERM(20),TC(20)
STORAGE.            CTHER(20)
STORAGE.            NSP,AVDEG  ,NOTMP,NOACR,NP(20),NUMDY
STORAGE.            TEMPC(26),DATE(26)
STORAGE.            TS(20),PS(20),PE(20),PBD(20),TIN(20),TD(20),TE(20)
STORAGE.            PPBF(20),HS(20),PI(20),DOI1(20),DCI1(20),PPBF2(20)
STORAGE.            PN(20),FS(20),PFS(20),PF(20),AMW(20),HMW(20),DOI2(20)
STORAGE.            FW(20),ADR(20),DCI2(20)
STORAGE.            WTF,WTN,AN(20),ANF(20),ANFJ(20)
STORAGE.            ERF(20),ERA(20),TEI(20),ERN(20),CTEI(20)
STORAGE.            CE(20,3),PCT(50),WM(20),IDDAT(20)
STORAGE.            DEF,NDEF,FDEF
STORAGE.            AG(20),BG(20),AK(20)
STORAGE.            EV1(20),EV2(20),EV3(20),EP1(20),EP2(20),EP3(20)
STORAGE.            BMN(20),BMF(20),BMA(20),TBM(20),BMTOT
STORAGE.            TDJ(20),TEJ(20)
STORAGE.            ATOT,ANTOT,ANFTO,ANFJT
STORAGE.            ERNTO,ERFTO,ERATO,TEITO
STORAGE.            AMACT(7,15,20),AFACT(7,15,20),ACTC(7,20),DAY(26)
STORAGE.            EEATF(7,20),EEATM(7,20)
STORAGE.            CS1(20),CS2(20)
STORAGE.            DOM1(20),DOM2(20),PM1(20),PM2(20)
STORAGE.            EC1(20),EC2(20)
STORAGE.            CAER(20),PAER(20)
STORAGE.            CEC(20)
STORAGE.            A1(20),TEDM(20),TEDF(20),FA1(20)
STORAGE.   AMWA(10,20),NUDAS(20),DA(10,20),NAMW
REAL.               JER(20),MA1(20),JA1(20)
C...
C...
```

FLOWS

```
(1-2).
      FLOW = 0.
(2-3).
      FLOW = 0.
C...
```

SUB-ROUTINES

```
      SUBROUTINE START
      DIMENSION CG(20)
C NSP IS THE NUMBER OF SPECIES BEING CONSIDERED.
      DO 1 I = 1,NSP
      DO 2 J=1,3
    2 CE(I,J)=0.
      K = 5*(I-1)+2
C CG(I) IS JUST AN INTERMEDIATE VARIABLE.
      CG(I) = EXP(-AK(I)*PN(I))
      IF(FW(I).EQ.0..AND.HMW(I).EQ.0.) GO TO 3
      BG(I) = (HMW(I)-FW(I))/(FW(I)*CG(I)-HMW(I))
      AG(I) = HMW(I)*(1.0 + BG(I))
C BG AND AG ARE CONSTANTS USED IN THE NESTLING GROWTH RATE.
      GO TO 4
    3 AG(I) = 0.
      BG(I) = 0.
    4 CONTINUE
    1 X(K) = PS(I)
C
C     ****************************************************************
```

```
C               NORMALIZATION OF DIET SELECTION
C      ****************************************************************
C
C      DIET(I,J,K) IS THE AMOUNT OF THE TOTAL FOOD INTAKE BY SPECIES K
C               OBTAINED FROM FOOD CATEGORY I ON THE JTH MEASUREMENT DAY
C      CALV(I) IS THE CALORIC VALUE OF FOOD CATEGORY I  (KCAL/GMS DRY WT)
C      NDA IS THE NUMBER OF MEASUREMENT DAYS
C      NCAT IS THE NUMBER OF FOOD CATEGORIES
C      NDT IS A FLAG. IF NDT=1,WE DO NOT MAKE CALCULATIONS ABOUT THE DIET.
C                     IF NDT=0,WE DO MAKE CALCULATIONS  ABOUT THE DIET.
       IF(NDT.EQ.1) GO TO 600
C      NDAT(J)  ARE THE DAYS (SINCE JAN 1) ON WHICH THE DATA ARE RECORDED
       DO 8002 K=1,NSP
       DO 8002 J=1,NDA
C      INITIALIZE SUMMING VARIABLE
       SUMM=0.0
       DO 8001 I=1,NCAT
       SUMM=SUMM+DIET(I,J,K)
  8001 CONTINUE
       IF(SUMM.EQ.0.) SUMM=1.
       DO 8002 I=1,NCAT
       DIET(I,J,K)=DIET(I,J,K)/SUMM
  8002 CONTINUE
       DO 8005 I=1,NCAT
       DO 8005 K=1,NSP
  8005 TOT(I,K)=0.0
   600 CONTINUE
       IF(NOACB.EQ.1) RETURN
C              **************************************
C              *NORMALIZATION OF ACTIVITY BUDGET DATA*
C              **************************************
C AMACT(I,J,K) IS THE TIME SPENT BY AMALE OF SPECIES K ON THE ITH
C ACTIVITY ON THE JTH MEASUREMENT DAY.
C AFACT(I,J,K) IS THE SAME VARIABLE AS AMACT EXCEPT FOR FEMALES
C ACTC(I,K) IS THE COEFFICIENT OF ENERGY EXPENDITURE OF THE KTH SPECIES
C ON THE ITH ACTIVITY
      DO 20003 K=1,NSP
      DO 20003 J = 1,NUMDY
C INTIALIZE SUMMING VARIABLES
      SUMM1=0.0
      SUMF1=0.0
C NORMALIZE DATA
      DO 20000 I=1,7
      SUMM1=SUMM1+AMACT(I,J,K)
      SUMF1=SUMF1+AFACT(I,J,K)
20000 CONTINUE
      IF(SUMM1.EQ.0.) SUMM1=1.
      IF(SUMF1.EQ.0.) SUMF1=1.
      DO 20003 I=1,7
      AMACT(I,J,K)= ACTC(I,K)*AMACT(I,J,K)/SUMM1
      AFACT(I,J,K)= ACTC(I,K)*AFACT(I,J,K)/SUMF1
20003 CONTINUE
C AMACT(I,J,K) AND AFACT(I,J,K) ARE LATER CHANGED TO THE ENERGY EXPENDITURE
C BY A MALE AND FEMALE ON THE ITH ACTIVITY ON THE JTH DAY OF MEASUREMENT
C ( K REPRESENTS THE SPECIES ).
      RETURN
      END
C..................
      SUBROUTINE CYCL1
C.... NAMW IS A FLAG.  NAMW=1 INDICATES AMW(I) IS CONSTANT THROUGHOUT
C....           A RUN.  OTHERWISE, WE USE AMWA(J,I) AND INTERPOLATE
C.... DA(J,I) IS AN ARRAY OF DATES(FROM JAN 1) ON WHICH AVERAGE ADULT
C....                WEIGHTS OF SPECIES I ARE RECORDED
C.... IF NAMW IS NOT 1, THEN
C.... AMWA(J,I) IS THE AVERAGE ADULT WEIGHT OF THE ITH SPECIES ON DA(J,I)
C          AND
```

```
C.... AMW(I) IS A LINEAR INTERPOLATION OF THE ARRAY AMWA
C.... NUDAS(I) IS THE NUMBER OF ACTUAL ENTRIES FOR SPECIES I IN THE ARRAY
C....            DA(J,I).  THE REST  OF DA(J,I) IS FILLED IN WITH ZEROS.
      IF(NAMW.EQ.1) GO TO 32
      DO 31 I=1,NSP
      NU=NUDAS(I)
      DO 11 J=1,NU
      IF(TIME.GT.DA(J,I))11,12
   11 CONTINUE
   12 IF(J.EQ.1)14,15
   14 AMW(I)=AMWA(1,I)
      GO TO 30
   15 IF(J.EQ.NU.AND.TIME.GT.DA(J,I))17,18
   17 AMW(I)=AMWA(NU,I)
      GO TO 30
   18 L=J-1
      AMW(I)=AMWA(L)+(AMWA(J)-AMWA(L))/(DA(J,I)-DA(L,I))*(TIME-DA(L,I))
   30 CONTINUE
   31 CONTINUE
   32 CONTINUE
C
C     ****************************************************************
C                 CALCULATION OF DIET COMPOSITION
C     ****************************************************************
C
C     DIET(I,J,K) IS THE AMOUNT OF THE TOTAL FOOD INTAKE BY SPECIES K
C              OBTAINED FROM FOOD CATEGORY I ON THE JTH MEASUREMENT DAY
C     CALV(I) IS THE CALORIC VALUE OF FOOD CATEGORY I   (KCAL/GMS DRY WT)
C     NDA IS THE NUMBER OF MEASUREMENT DAYS
C     NCAT IS THE NUMBER OF FOOD CATEGORIES
C     NDAT(J)  ARE THE DAYS (SINCE JAN 1) ON WHICH THE DATA ARE RECORDED
C     NDT IS A FLAG. IF NDT=1,WE DO NOT MAKE CALCULATIONS ABOUT THE DIET.
C                    IF NDT=0,WE DO MAKE CALCULATIONS  ABOUT THE DIET.
      IF(NDT.EQ.1) GO TO 601
C     INTERPOLATE DIET ARRAY
      DO 69 I=1,NCAT
      DO 70 K=1,NSP
      GPREY(I,K)=0.0
      DO 71 J=1,NDA
      IF(TIME.GT.NDAT(J)) 71,72
   71 CONTINUE
   72 IF(J.EQ.1) 74,75
   74 AVDT=DIET(I,1,K)
      GO TO 76
   75 IF(J.EQ.NDA.AND.TIME.GT.NDAT(J)) 77,78
   77 AVDT=DIET(I,NDA,K)
      GO TO 76
   78 L=J-1
      AVDT=DIET(I,L,K)+(DIET(I,J,K)-DIET(I,L,K))/(NDAT(J)-NDAT(L))*
     "   (TIME-NDAT(L))
   76 CONTINUE
C.....AVDT IS THE INTERPOLATED DIET COMPOSITION
C.....GPREY(I,K) IS THE DAILY CONSUMPTION OF CATEGORY I BY
C            SPECIES K   (GMS/M**2)
      GPREY(I,K)=GPREY(I,K)  + ( AVDT * ERA(K) ) / CALV(I)
C.....TOT(I,K) IS THE TOTAL SEASONAL CONSUMPTION OF CATEGORY I
C            BY SPECIES K    (GMS/M**2)
      TOT(I,K)=TOT(I,K)  + GPREY(I,K)
   70 CONTINUE
   69 CONTINUE
      DO 8010 I=1,NCAT
      PTOT(I)=0.0
      PREY(I)=0.0
      DO 8009 K=1,NSP
C.....PTOT IS THE TOTAL SEASONAL CONSUMPTION OF FOOD CATEGORY I
      PTOT(I) = PTOT(I)  + TOT(I,K)
```

```
C.....PREY IS THE TOTAL DAILY CONSUMPTION OF FOOD CATEGORY I
 8009 PREY(I) = PREY(I) + GPREY(I,K)
 8010 CONTINUE
  601 CONTINUE
C...DATE ARRAY CONTAINS DATE IN DAYS SINCE 1 JAN
C...TEMPC ARRAY CONTAINS TEMPERATURE (DEG C) AT DATE
C...AVDEGC = LINEAR INTERPOLATION FOR AVERAGE TEMP ESTIMATE
      DO 1 I=1,NOTMP
      IF (TIME.GT.DATE(I))1,2
    1 CONTINUE
    2 IF(I.EQ.1) 4,5
    4 AVDEG  = TEMPC(1)
      GO TO 6
    5 IF (I.EQ.NOT MP.AND.TIME.GT.DATE(I)) 7,8
    7 AVDEG  = TEMPC(NOT MP)
      GO TO 6
    8 AVDEG  = TEMPC(I-1) + (TEMPC(I) - TEMPC(I-1))/(DATE(I) - DATE(I-1)
     *  )*(TIME-DATE(I-1))
    6 DO 3 I = 1,NSP
      T = TIME-PI(I)
      EV1(I) = EVST(T,I)
      EP1(I) = EPD2(T,I)
      T = T-PN(I)
      EV2(I) = EVST(T,I)
      EP2(I) = EPD2(T,I)
      T = T-PF(I)
      EV3(I) = EVST(T,I)
      EP3(I) = EPD2(T,I)
      J=5*(I-1)+2
C HERE IS WHERE THE ACTUAL FLOWS ARE CALCULATED.
C X(J) WHERE J = 5*(I-1) + 2, I = 1,2,...,NSP IS THE STATE VARIABLE REPRESENTING
C THE ADULT POPULATION.
C.................
C THE NUMBER OF ADULTS IS CALCULATED IN THIS FLOW (X(J))
      F = FLIN(PS(I),PBD(I),TS(I),TIN(I),TIME)  +
     *    FLIN (X(J),PE(I),TP(I),TE(I),TIME)
      IF(TIME.LE.TS(I))F = PS(I)
      IF(TIME.GE.TE(I)) F = X(J) - WM(I)*PE(I)/(365.-TE(I))
      IF(TIME.GT.TIN(I).AND.TIME.LT.TD(I)) F = X(J)
      F = (F-X(J))/DT - ADR(I)*X(J)
      X(J)=X(J)+F*DT
C.................
C THE NUMBER OF EGGS IS CALCULATED HERE (X(J+1))
      T = TIME
      F = EVST(T,I) - EV1(I)*(1.-HS(I))
      G = EPD2(T,I) - EP1(I)*(1.-HS(I))
      F = (F +G)*X(J)
      X(J+1)=X(J+1)+F*DT
C.................
C THE EGGS WHICH SURVIVE TO PRODUCE NESTLINGS IS CALCULATED HERE (X(J+2))
      F = (EV1(I) + EP1(I))      *HS(I)   *PBD(I)
      X(J+1)=X(J+1)-F*DT
      X(J+2)=X(J+2)+F*DT
C.................
C THE MORTALITY OF NESTLINGS IS CALCULATED HERE
      F = -(EV2(I)+EP2(I))*(1.-FS(I))*HS(I)*PBD(I)
      X(J+2)=X(J+2)+F*DT
C.................
C THE NESTLINGS WHICH SURVIVE TO BECOME FLEDGLINGS IS CALCULATED HERE (X(J+3))
      F = (EV2(I)+EP2(I))*HS(I)*FS(I)*PBD(I)
      X(J+2)=X(J+2)-F*DT
      X(J+3)=X(J+3)+F*DT
C.................
C THE FLEDGLING MORTALITY IS CALCULATED HERE
      F = -(EV3(I)+EP3(I))*(1.-PFS(I))*FS(I)*HS(I)*PBD(I)
      X(J+3)=X(J+3)+F*DT
```

```
C.................
C THE FLEDGLINGS WHICH SURVIVE TO BECOME JUVENILES IS CALCULATED HERE (X(J+4))
      F = (EV3(I)+EP3(I))*PFS(I)*FS(I)*HS(I)*PBD(I)
      X(J+3)=X(J+3)-F*DT
      X(J+4)=X(J+4)+F*DT
C.................
C MIGRATION IS CALCULATED HERE
      F = FLIN(X(J+4),0.,TDJ(I),TEJ(I),TIME)
      IF (TIME.LT.TDJ(I))F = X(J+4)
      F = (F-X(J+4))/DT - JDR(I)*X(J+4)
      X(J+4)=X(J+4)+F*DT
C.................
    3 CONTINUE
      RETURN
      END
C.................
      FUNCTION EVST(T,I)
C...
C...FUNCTION TO COMPUTE EGG PRODUCTION PER DAY PER PRODUCING FEMALE
C...
    1 IF(T.LT.DOI1(I).OR.T.GT.DCI1(I))110,111
  110 EVST = 0.
      RETURN
  111 TL = DCI1(I)-DOI1(I)
      IF (TL.LE.0.) GO TO 110
      TM = (DOI1(I)+DCI1(I))/2.
      IF (T.LE.TM)113,114
  113 EVST =CS1(I)*PPBF(I)*4.*(T-DOI1(I))/(TL*TL)
      RETURN
  114 EVST =CS1(I)*PPBF(I)*4.*(DCI1(I)-T)/(TL*TL)
      RETURN
      END
C.................
      FUNCTION EPD2(T    ,I)
C...
C...FUNCTION TO COMPUTE EGG LAYING PATTERN FOR SECOND CLUTCH
C...
1     IF (T.LT.DOI2(I).OR.T.GT.DCI2(I)) 110,111
110   EPD2 = 0.0
      RETURN
111   TL = DCI2(I) - DOI2(I)
      IF (TL.LE.0.0) GO TO 110
      TM = (DOI2(I) + DCI2(I))/2.0
      IF (T.LE.TM) 113,114
113   EPD2 =CS2(I) * PPBF2(I)* 4.0 * (T-DOI2 (I))/(TL*TL)
      RETURN
114   EPD2 =CS2(I) * PPBF2(I) * 4.0 * (DCI2(I)-T)/(TL*TL)
      RETURN
      END
C.................
      FUNCTION FLIN(A,B,C,D,T)
C...
C...GENERAL LINEAR INTERPOLATION ROUTINE
C...
      IF(T.GT.D.OR.T.LT.C)1,2
    1 FLIN=0.
      RETURN
    2 CONTINUE
      IF (D.EQ.C) 3,4
    3 FLIN=(A+B)/2.0
      RETURN
    4 FLIN=(B-A)/(D-C)*(T-C)+A
      RETURN
C...THIS COMPUTES A LINEAR INTERPOLATION BETWEEN A AT T = C AND B AT T =
C...   D USING T AS THE INDEPENDENT VARIABLE
C IF T LIES OUTSIDE THE INTERVAL C TO D THE FUNCTION RETURNS THE VALUE 0.
```

```
      END
C..................
      FUNCTION FLIN2(A,B,C,D,T)
C FLIN2 IS A LINEAR INTERPOLATION WHICH EXTRAPOLATES IF T FALLS OUTSIDE
C THE INTERVAL C TO D.
      IF(C.EQ.D)1,2
    1 FLIN2=(A+B)/2.
      RETURN
    2 FLIN2=(B-A)/(D-C)*(T-C)+A
      RETURN
      END
C..................
      SUBROUTINE TABLF(TABL1,TABL2,N,A,Y)
      DIMENSION TABL1(15),TABL2(15)
C TABL1 IS THE INDEPENDENT VALUES, WHILE TABL2 IS THE DEPENDENT VALUES.
      IF(A.LE.TABL1(1)) GO TO 10
      IF(A.GE.TABL1(N)) GO TO 20
      DO 100 I = 2,N
      IF(A.LE.TABL1(I)) GO TO 30
  100 CONTINUE
   30 Y=(A-TABL1(I-1))*(TABL2(I)-TABL2(I-1))/(TABL1(I)-TABL1(I-1))
     1+TABL2(I-1)
      RETURN
   20 Y=TABL2(N)
      RETURN
   10 Y=TABL2(1)
      RETURN
      END
C..................
      FUNCTION WNSLG (I,AGE)
C...
C...FUNCTION TO COMPUTE NESTLING WEIGHTS
C...
      WNSLG = AG(I)/(1.0 + BG(I)*EXP(-AK(I)*AGE))
      RETURN
      END
C..................
      FUNCTION WFLG(I,AGE)
C...
C...FUNCTION TO COMPUTE THE FLEDGLING WEIGHTS
C...
      WFLG = FLIN(FW(I),AMW(I),0., PF(I),AGE)
      RETURN
      END
C..................
      SUBROUTINE APER(J,Y,T,ER)
C...
C...Y=AVERAGE WEIGHT
C...T=TEMPERATURE IN DEG C.
C...ER=ENERGY REQUIREMENT.
C...
      IF(Y.LE.0.)100,101
  100 ER=0.
      RETURN
  101 GO TO (10,20),J
C...SUBROUTINE TO CALCULATE THE ENERGY REQUIREMENT FOR NON-PASSERINES
   10 T1 = 4.3372*(Y)**.53
      T2 = .5464*(Y)**.7545
   21 ER=FLIN2(T1,T2,0.,30.,T)
      RETURN
C...SUBROUTINE TO COMPUTE ENERGY REQUIREMENTS FOR PASSERINES.
   20 T1 = 4.3372 *(Y)**.53
      T2 = 1.572 * (Y)**.621
      GO TO 21
      END
C................
```

```
      SUBROUTINE EGG(I,J,Y,K,L)
      DIMENSION TBEW(15,4),TBAW(15,4),TABL1(15),TABL2(15),NUM(4)
C TBEW IS A TWO DIMENSIONAL ARRAY CONTAINING ALL EGG WEIGHT DATA
C             TBEW(N,1) = EGG WEIGHTS FOR PASSERINES     N = 1,2,...,NUM(1)
C             TBEW(N,2) = EGG WEIGHTS FOR SHOREBIRDS     N = 1,2,...,NUM(2)
C             TBEW(N,3) = EGG WEIGHTS FOR CORMORANTS     N = 1,2,...,NUM(3)
C             TBEW(N,4) = EGG WEIGHTS FOR ALCIDS         N = 1,2,...,NUM(4)
C TBAW IS A TWO DIMENSIONAL ARRAY CONTAINING ALL ANIMAL WEIGHT DATA
C             TBAW(N,1) = ANIMAL WEIGHTS FOR PASSERINES.     N = 1,2,...,NUM(1)
C             TBAW(N,2) = ANIMAL WEIGHTS FOR SHOREBIRDS      N = 1,2,...,NUM(2)
C             TBAW(N,3) = ANIMAL WEIGHTS FOR CORMORANTS      N = 1,2,...,NUM(3)
C             TBAW(N,4) = ANIMAL WEIGHTS FOR ALCIDS          N = 1,2,...,NUM(4)
       DATA TBEW/
     10.,.74,1.04,1.3,1.92,2.35,3.08,3.41,4.23,6.02,7.13,10.27,12.05,
     *16.15,20.00,
     20.,5.7,9.37,12.1,17.7,28.6,47.5,54.3,60.,6*0.,
     30.,49.,48.,44.,51.,58.,70.,8*0.,
     40.,24.,52.,55.,65.,94.,110.,113.,150.,6*0./
C
       DATA TBAW/
     10.,6.,8.,11.7,17.1,22.8,30.,37.9,51.6,67.7,97.5,168.3,206.3,
     *396.3,700.,
     20.,26.7,43.6,59.,109.3,212.1,475.,750.,1100.,6*0.,
     30.,1760.,1870.,2000.,2430.,2500.,4000.,8*0.,
     40.,125.,425.,450.,500.,700.,930.,1000.,1500.,6*0./
C
C NUM(L) IS THE NUMBER OF SIGNIFICANT ENTRIES IN THE L-TH BLOCK. L=1,2,3, OR 4
       DATA NUM/15,9,7,9/
C
C I IS THE INDEX FOR SPECIES.  J IS THE INDEX OF THE STATE VARIABLE REPRESENTING
C THE ADULT POPULATION OF THE ITH SPECIES.  K IS A FLAG.  IF K = 1 THEN WE USE
C THOSE CALCULATIONS INVOLVING THE FIRST CLUTCH.  K = 2 CORRESPONDS TO SECOND
C CLUTCH EQUATIONS.
      N = NUM(L)
      DO 100 M = 1,N
      TABL2(M) = TBEW(M,L)
      TABL1(M) = TBAW(M,L)
  100 CONTINUE
      CALL TABLF(TABL1,TABL2,N,AMW(I),EW)
C EW IS THE EGG WEIGHT.
      GO TO (1,2) K
    1 TH=(DOI1(I)-CS1(I)-3.+DCI1(I))/2.
      IF(TIME.GT.TH) GO TO 3
      Y=CS1(I)*4.*(TIME-DOI1(I)+CS1(I)+3.)
     1/(DCI1(I)-DOI1(I)+CS1(I)+3.)**2
C THE ABOVE EQUATIONS ARE USED IN ORDER TO DISTRIBUTE ENERGY COST OVER THE TIME
C AVAILABLE FOR EGG PRODUCTION.
      Y=1.10*1.37*EW*Y*PPHF(I)
      RETURN
    3 Y=CS1(I)*4.*(DCI1(I)-TIME)/(DCI1(I)-DOI1(I)+CS1(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPHF(I)
      RETURN
    2 TH=(DOI2(I)-CS2(I)-3.+DCI2(I))/2.
      IF(TIME.GT.TH) GO TO 4
      Y=CS2(I)*4.*(TIME-DOI2(I)+CS2(I)+3.)
     1/(DCI2(I)-DOI2(I)+CS2(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPHF2(I)
      RETURN
    4 Y=CS2(I)*4.*(DCI2(I)-TIME)
     1/(DCI2(I)-DOI2(I)+CS2(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPHF2(I)
      RETURN
      END
C...............
      SUBROUTINE MOLT(D,P,W,T,M)
      REAL M,MU
```

```
C.....THIS SUBROUTINE CALCULATES THE MOLTING COST WHICH IS NORMALLY
C.....     DISTRIBUTED OVER A PERIOD OF P DAYS AND STARTS ON DAY D
C.....W IS THE ADULT MEAN WEIGHT AND T IS THE TIME(IN DAYS)
C.....THE MOLTING COST IS GIVEN BY
C.....       MOLT=8.375*(W**.959)
C.....M IS THE MOLT AT TIME T+.5
      PI=3.14159
C.....CALCULATE SQUARE ROOT OF 2 PI
      SR2PI=SQRT(2*PI)
C.....CALCULATE DISTRIBUTION MEAN
      MU=D+P/2.
C.....CALCULATE STANDARD DEVIATION
      SIG=P/6.
C.....CALCULATE MOLT COST AT T+.5
      R=1./(SIG*SR2PI)
      S=(T+.5-MU)/SIG
      Y=R*EXP(-.5*S*S)
      M=(1./.9973)*8.375*(W**.959)*Y
      RETURN
      END
C.................
      SUBROUTINE CYCL2
C...
C... THIS ROUTINE REALLY DOES ALL THE WORK.
C... MOST INTERESTING OUTPUT IS COMPUTED HERE.
C...
      BMTOT = 0.
      ANTOT = 0.  $  ATOT = 0.  $  ANFTOT = 0.  $  ANFJTO = 0.
      TEITOT = 0.  $  ERATOT = 0.  $  ERFTOT = 0.  $  ERNTOT = 0.
      DO 1 I=1,NSP
C... INDEX CALCULATION TO GO TO NEW SPECIES.
      J=2+(I-1)*5
      DO 2 K = 1,5
      KK = K - 1 + J
      IF(X(KK).LT..00000001) X(KK) = 0.
    2 CONTINUE
      A2 = X(J)+X(J+4)
      IF(A2.LE.0.)30,31
   30 ERA(I) = 0.
      ER=0.0
      A1(I) = 0.
      GO TO 34
   31 CONTINUE
      CALL APER (NP(I),AMW(I),TC(I),ER)
      CALL APER (NP(I),AMW(I),AVDEG,ERT)
      THERM(I) = ERT -ER
      IF(THERM(I).LE.0.0)  THERM(I) = 0.0
      FAC2 = 1.4*ER
C NP IS A FLAG.  IF NP=1 THE NONPASSERINE EGUATIONS ARE USED.  IF NP=2 THE
C PASSERINE EQUATIONS ARE USED.
      FAC1 = 0.0
      IF(TIME.GE.DOM1(I).AND.TIME.LT.DOM1(I)+PM1(I).AND.DOM1(I).NE.0.)
     1 CALL MOLT(DOM1(I),PM1(I),AMW(I),TIME,FAC1)
      IF(TIME.GE.DOM2(I).AND.TIME.LT.DOM2(I)+PM2(I).AND.DOM2(I).NE.0.)
     1 CALL MOLT(DOM2(I),PM2(I),AMW(I),TIME,FAC1)
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      A1(I) = (FAC1 + FAC2 + THERM(I) )*DEF
      IF(IDDAT(I).EQ.0) GO TO 33
C THE VARIABLE IDDAT(I) IDENTIFIES THE DATA BLOCK TO BE USED TO CALCULATE
C EGG COSTS
C           IDDAT(I)  = 1  PASSERINE DATA ARE TO BE USED
C           IDDAT(I)  = 2  SHOREBIRD DATA ARE TO BE USED
C           IDDAT(I)  = 3  CORMORANT DATA ARE TO BE USED
C           IDDAT(I) = 4  ALCID DATA ARE TO BE USED
C IF IDDAT = 0 NO EGG COST IS CALCULATED.
      EC1(I) = 0.
```

```
      EC2(I) = 0.
      IF(TIME.GE.DOI1(I)-CS1(I)-3..AND.TIME.LE.DCI1(I))
     1CALL EGG (I,J,EC1(I),1,IDDAT(I))
      IF(TIME.GE.DOI2(I)-CS2(I)-3..AND.TIME.LE.DCI2(I))
     1CALL EGG (I,J,EC2(I),2,IDDAT(I))
C EC1 IS THE DAILY INDIVIDUAL ENERGY COST ASSOCIATED WITH PRODUCING THE
C FIRST CLUTCH
C EC2 IS THE SAME VARIABLE FOR THE SECOND CLUTCH.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      A1(I) = A1(I) + ((EC1(I) + EC2(I))* DEF)
   33 CONTINUE
      IF(NOACB.EQ.1) GO TO 32
      CALL EZ(TIME,I,ER)
CALCULATE SEX SPECIFIC INDIVIDUAL ENERGY DEMANDS
C FA1(I) IS THE ENERGY DEMAND OF A FEMALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      FA1(I)=(FAC1 +TEDF(I) +THERM(I) + (EC1(I) + EC2(I))/PPBF(I))*DEF
C MA1(I) IS THE ENERGY DEMAND OF A MALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      MA1(I) = (FAC1 + TEDM(I) + THERM(I) )*DEF
C JA1(I) IS THE ENERGY DEMAND FOR A JUVENILE  OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      JA1(I)=(1.-PPBF(I))*MA1(I)+PPBF(I)*((FAC1+TEDF(I)+THERM(I))*DEF)
      A1(I) = PPBF(I)*FA1(I) + (1.-PPBF(I))*MA1(I)
C A1 IS THE INDIVIDUAL ENERGY DEMAND WITH UNITS KCAL/BIRD-DAY.
      ERA(I) = (X(J)*A1(I) + X(J+4)*JA1(I))*1.E-6
      GO TO 34
   32 CONTINUE
      ERA(I)=(X(J)*A1(I)+X(J+4)*(A1(I)-((EC1(I) + EC2(I))*1.43)))*1.E-6
   34 BMA(I) = (X(J) + X(J+4))*AMW(I)*.000001
      CAER(I) = CAER(I) + ERA(I)*DT
      IF(ERA(I).GT.PAER(I))PAER(I)=ERA(I)
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      CEC(I)=CEC(I)+((((EC1(I)+EC2(I))* DEF)*X(J))*1.E-6)*DT
C...CTHER IS THE CUMULATIVE THERMOREGULATION ENERGY COST
      CTHER(I)=CTHER(I)+((THERM(I)*X(J)+THERF(I)*X(J+3)
     *   +THERM(I)*X(J+4))*1.E-6)*DT
C CAER AND PAER ARE THE CUMULATIVE ADULT ENERGY REQUIREMENT, AND THE PEAK
C ADULT ENERGY REQUIREMENT RESPECTIVELY.
C...
C...THIS BLOCK OF CODE COMPUTES THE ENERGY DISTRIBUTION IN THE NESTLINGS
C...IN THE FIRST CLUTCH ACCORDING TO AGE DISTRIBUTION
C...
      BMN2 = 0.
      BMN(I) = 0.
      ERN(I) = 0.
      AMPY = 1.
      IF (X(J+2).EQ.0.) GO TO 10
      MA = MAX1(DOI1(I),TIME-PI(I)-PN(I))
      MB = MIN1(DCI1(I),TIME-PI(I))
      IF(MB-MA.GT.49) 50,51
   50 PRINT 8000 ,MA,MB,I
 8000 FORMAT(1H ,I5,I5,I5,//,1H ,* MB IS TOO LARGE*)
      GO TO 1
   51 CONTINUE
      PCTT = 0.
      IF (MB.LT.MA) GO TO 13
      DO 11 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EVST(CK,I)
   11 PCTT = PCTT + PCT(KA)
      IF (PCTT.EQ.0.) GO TO 13
      DO 12 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
```

```
      AGE = TIME-K-PI(I)
      WTN = WNSLG(I,AGE)
      BMN(I) = BMN(I) + WTN*PCT(KA)
      CALL APER(NP(I),WTN,TC(I),ER)
   12 ERN(I) = ERN(I) + ER*PCT(KA)
C...
C...SECOND CLUTCH NESTLING ENERGY CALCULATION
C...
   13 IF(PPHF2(I).EQ.0.) GO TO 10
      MA = MAX1(DOI2(I),TIME-PI(I)-PN(I))
      MB = MIN1(DCI2(I),TIME-PI(I))
      IF(MB-MA.GT.49) GO TO 50
      IF (MB.LT.MA)GO TO 10
      PCTT = 0.
      DO 14 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= FPD2(CK,I)
   14 PCTT = PCTT + PCT(KA)
      DO 15 K = MA,MB
      ERN2 = 0.
      IF (PCTT.EQ.0.) GO TO 10
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)
      WTN = WNSLG(I,AGE)
      BMN2 = BMN2 + WTN*PCT(KA)
      CALL APER(NP(I),WTN,TC(I),ER)
   15 ERN2 = ERN2 + ER*PCT(KA)
      IF (ERN(I)*ERN2.NE.0.)AMPY = .5
      ERN(I) =(ERN(I) + ERN2)
C.....NDEF IS THE DIETARY EFFICIENCY OF NESTLINGS
   10 NDEF=DEF*1.2
      ERN(I) = ERN(I)* NDEF*.000001*X(J+2)*AMPY
      BMN(I) = (BMN(I) + BMN2)*AMPY*X(J+2)*.000001
C...
C...CALCULATE FLEDGLING ENERGY REQUIREMENTS AS A FUNCTION OF AGE FOR
C...THE FIRST CLUTCH
C...
      AMPY = 1.
      ERF(I) = 0.
      BMF2 = 0.
      BMF(I) = 0.
      IF (X(J+3).EQ.0.) GO TO 20
      MA = MAX1(DOI1(I),TIME-PI(I)-PN(I)-PF(I))
      MB = MIN1(DCI1(I),TIME-PI(I)-PN(I))
      IF(MB-MA.GT.49) GO TO 50
      PCTT = 0.
      DO 21 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= FVST(CK,I)
   21 PCTT = PCTT + PCT(KA)
      IF(PCTT.EQ.0.) GO TO 23
      DO 22 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)-PN(I)
      WTF = WFLG(I,AGE)
      BMF(I) = BMF(I) + WTF*PCT(KA)
      CALL APER(NP(I),WTF,TC(I),ER)
      CALL APER(NP(I),WTF,AVDEG,ERT)
      THERF(I)=ERT-ER
      IF(THERF(I).LE.0.0) THERF(I)=0.0
   22 ERF(I) = ER*PCT(KA)+ ERF(I)
C...
```

```
C...SECOND CLUTCH FLEDGLING ENERGY CALCULATION
C...
   23 IF (PPBF2(I).EQ.0.) GO TO 20
      MA = MAX1(DOI2(I),TIME-PI(I)-PN(I)-PF(I))
      MB = MIN1(DCI2(I),TIME-PI(I)-PN(I))
      IF(MB-MA.GT.49) GO TO 50
      IF (MB.LT.MA) GO TO 20
      PCTT = 0.
      DO 24 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= FPD2(CK,I)
   24 PCTT = PCTT + PCT(KA)
      IF (PCTT.EQ.0.) GO TO 20
      ERF2 = 0.
      DO 25 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)-PN(I)
      WTF = WFLG(I,AGE)
      BMF2 = BMF2 + WTF*PCT(KA)
      CALL APER(NP(I),WTF,TC(I),ER)
      CALL APER(NP(I),WTF,AVDEG,ERT)
      THERF(I)=ERT-ER
      IF(THERF(I).LE.0.0) THERF(I)=0.0
   25 ERF2 = ERF2 + ER*PCT(KA)
      IF (ERF(I)*ERF2.NE.0.)AMPY = .5
      ERF(I) =(ERF(I) + ERF2)
C.....FDEF IS THE DIETARY EFFICIENCY OF FLEDGLINGS
   20 FDEF=DEF
      ERF(I) = ((ERF(I)*1.15 + THERF(I))*FDEF)*.000001*X(J+3)*AMPY
      BMF(I) =(BMF(I) + BMF2)*AMPY*X(J+3)*.000001
C...
C...COMPUTE POPULATION TOTALS
C...
      AN(I) = X(J) + X(J+2)
      ANF(I) = AN(I) + X(J+3)
      ANFJ(I) = ANF(I) + X(J+4)
      ANTOT = ANTOT + AN(I)
      ATOT = ATOT + X(J)
      ANFTOT = ANFTOT + ANF(I)
      ANFTO = ANFTOT
      ANFJTO = ANFJTO + ANFJ(I)
      ANFJT = ANFJTO
      TEI(I) = ERA(I)+ERF(I)+ERN(I)
      CTEI(I) = CTEI(I) + TEI(I)
      TBM(I) = BMN(I) + BMF(I) + BMA(I)
C...THERE IS NO BIOMASS COMPUTED FOR EGGS
      TEITOT = TEITOT + TEI(I)
      TEITO = TEITOT
      BMTOT = BMTOT + TBM(I)
      ERATOT = ERATOT + ERA(I)
      ERATO = ERATOT
      ERFTOT = ERFTOT + ERF(I)
      ERFTO = ERFTOT
      ERNTOT=ERNTOT+ERN(I)
      ERNTO = ERNTOT
      CE(I,1) = CE(I,1) + DT*ERA(I)
      CE(I,2) = CE(I,2) + DT*ERF(I)
      CE(I,3) = CE(I,3) + DT*ERN(I)
    1 CONTINUE
      RETURN
      END
C..................
      SUBROUTINE EZ(T,I,ER)
C J WILL INDEX THE DAYS OF MEASUREMENT. I INDEXES THE  SPECIES. M IS
```

```
C THE INDEX FOR THE ACTIVITIES.
C EEATM(L,I) IS THE ENERGY EXPENDITURE FOR A MALE OF SPECIES I ON THE
C LTH ACTIVITY. EEATF IS THE SAME FOR FEMALES.
C THE ACTIVITIES ARE AS FOLLOWS
C  I=1.  INACTIVE
C    2.  SINGING
C    3.  FLIGHT
C    4.  FORAGING
C    5.  AGGRESSION AND DISPLAY
C    6.  COURTSHIP
C    7.  INCUBATION AND BROODING.
C T REPRESENTS TIME.
      IF(T.GE.TF(I)) GO TO 85
C NUMDY IS THE NUMBER OF ENTRIES IN THE DAY ARRAY.
      K=NUMDY-1
      IF(T.LT.DAY(1))1,2
    1 DO 81 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,1,I),AMACT(M,2,I),DAY(1),DAY(2),T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,1,I),AFACT(M,2,I),DAY(1),DAY(2),T)*ER
      IF(EEATM(M,I).LT.0.) EEATM(M,I) = 0.
      IF(EEATF(M,I).LT.0.) EEATF(M,I) = 0.
   81 CONTINUE
      GO TO 87
    2 IF(T.GT.DAY(NUMDY))3,4
    3 DO 82 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,K,I),AMACT(M,NUMDY,I),DAY(K),DAY(NUMDY),
     1T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,K,I),AFACT(M,NUMDY,I),DAY(K),DAY(NUMDY),
     1T)*ER
      IF(EEATM(M,I).LT.0.) EEATM(M,I) = 0.
      IF(EEATF(M,I).LT.0.) EEATF(M,I) = 0.
   82 CONTINUE
      GO TO 87
    4 DO 83 J=1,K
      L=J+1
      IF(T.LE.DAY(L).AND.T.GE.DAY(J))5,83
    5 DO 84 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,J,I),AMACT(M,L,I),DAY(J),DAY(L),T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,J,I),AFACT(M,L,I),DAY(J),DAY(L),T)*ER
   84 CONTINUE
   83 CONTINUE
      GO TO 87
   85 DO 86 M = 1,7
      EEATM(M,I) = 0.
   86 EEATF(M,I) = 0.
   87 CONTINUE
      TEDM(I) = 0.
      TEDF(I) = 0.
      DO 88 II = 1,7
      TEDM(I) = TEDM(I) + EEATM(II,I)
   88 TEDF(I) = TEDF(I) + EEATF(II,I)
C TEDM(I) IS THE MALE TOTAL ENERGY DEMAND FOR ALL ACTIVITIES COMBINED TEDF(I) IS
C THE SAME FOR FEMALES.  THEIR UNITS ARE KCAL/BIRD-DAY
      RETURN
      END
C..................
      SUBROUTINE FINIS
      PRINT 8000
 8000 FORMAT (20X, *CUMULATIVE ENERGY REQUIREMENTS*//
     *20X,*NSP*,11X,*NESTLINGS*,10X,*FLEDGLINGS*,14X,*ADULTS*)
      PRINT 8001, ((I,CE(I,3),CE(I,2),CE(I,1)), I = 1,NSP)
 8001 FORMAT (20X,I3,3E20.10)
      PRINT 8002,((PAER(I),I),I = 1,NSP)
 8002 FORMAT(20X,*PEAK ADULT ENERGY REQUIREMENT = *,E20.10,10X,*SPECIES
     1NO. = *,I3)
      RETURN
```

SUB-
ROUTINES

FILE CARD

DATA

```
      END
 &
 AVDEG = 0. $
 ADR = 20*0. $
 JDR = 20*0. $
 WTF = 0. $
 WTN = 0. $
 AN = 20*0. $
 ANF = 20*0. $
 ANFJ = 20*0. $
 FRA = 20*0. $
 TFI = 20*0. $
 CTEI = 20*0. $
 FRN = 20*0. $
 FRF = 20*0. $
 PM1 = 20*0. $  PM2 = 20*0. $
 DOM1 = 20*0. $
 DOM2 = 20*0. $
 WM = 20*0. $
 ATOT = 0. $ ANTOT = 0. $ ANFTO = 0. $ ANFJT = 0. $ ERNTO = 0. $ ERFTO = 0. $
 FRATO = 0. $
 CAER = 20*0. $ PAER = 20*0. $
 NAMW = 1 $
 NUDAS = 20*0 $
 AMWA = 200*0. $
 DA = 200*0. $
 NDEF = 0 $
 FDEF = 0. $
 DEF = 1.43 $
 CTHER = 20*0. $
 CFC = 20*0. $
 IDDAT = 20*0 $
 NOACR = 1 $
 ACTC = 140*0. $
 FEATM = 140*0. $  EEATF = 140*0. $
 AMACT = 2100*0. $
 TC = 20*0. $
 THERM = 20*0. $
 THERF = 20*0. $
 AFACT = 2100*0. $
 FC1 = 20*0. $  FC2 = 20*0. $
 X(1) = 99*0. $
 NDT = 1 $
 NDA = 20*0 $
 NDAT = 20*0 $
 PREY = 20*0. $
 PTOT = 20*0. $
 CALV = 20*0. $
 NCAT = 20*0 $
 DIET = 8000*0. $
 DT = 1.0 $  DTPR = 5.0 $
 DTPL = 1.0 $
 NSP = 1  $
 TC = 25. $
 NP = 2 $
 TSTRT = 110. $
 TEND = 260. $
 TS = 122.  $  PS = 0.  $  PF = 0.  $  PBD = 81.  $  TIN = 132.  $  TD = 234.  $
 TF=250. $ CS1 = 4.1 $ CS2 = 0.0 $ PPBF=.6 $ BS=.6 $ PI= 11. $
 DOI1 = 153.  $  DCI1 = 174.  $  PPBF2 = 0.  $  DOI2 = 0.  $  DCI2 = 0.  $
 NUDAS = 7 $
 NOTMP = 7  $
 TEMPC = 13.1, 21.3, 19.7, 24.4, 26.2, 30.5, 27.3  $
 DATE = 106. , 136. , 166. , 196. , 226. , 256. , 286.  $
 NUMDY = 6 $
 AFACT= 65.7,0.,18.7,15.6,0.,0.,0.,71.8,0.,9.4,18.8,0.,0.,0.,
```

```
       60.,0.,9.4,15.6,0.,0.,15.,44.4,0.,3.1,17.5,0.,0.,35.,
       62.5,0.,12.5,25.0,0.,0.,0.,65.7,0.,18.7,15.6,0.,0.,0. $
DAY= 124.,134.,150.,170.,200.,250. $
NOACR = 0 $
AMACT = 42.4,37.5,7.,11.1,2.,0.,0.,47.,35.,4.,12.,1.,1.,0.,
       41.4,32.,12.,11.3,1.3,2.,0.,47.,28.,5.4,11.3,1.3,7.,0.,
       49.9,29.3,4.8,11.,1.,4.,0.,55.5,29.,3.,12.5,0.,0.,0. $
IDDAT = 1 $
AMWA = 29.5,27.,25.,26.,27.,28.5,30.5,3*0. $
DA = 125.,145.,165.,185.,205.,220.,230.,3*0. $
NAMW = 0 $
ADR = .00039 $
JDR = .002 $
PN = 9.  $  FS = 0.58  $  PFS = 0.67  $  PF = 28.0  $
PMW = 2.0  $                  FW = 23.0  $  TDJ = 234.  $  TEJ = 250.  $
AK = .624 $
ACTC = .811,.876,6.,1.3,1.3,1.3,0. $
PFF = 1.43 $
DOM2 = 225. $
PM2 = 30. $
NGT = 0 $
NCA = 4 $
NDAT = 135,165,185,205,16*0 $
CALV = 4.5,5.5,5.3,5.1,5.5,5.7,4.9,4.4,12*0. $
NCAT = 8 $
PTFT = 4.,15.,0.,20.,2.,15.,2.,42.,12*0.,2.,9.,3.,35.,1.,10.,1.,39.,12*0.,
3.,12.,4.,40.,0.,10.,4.,27.,12*0.,0.,5.,0.,38.,0.,12.,4.,41.,12*0.,320*0. $
PRINT.X(2),X(3),X(4),X(5),X(6)
PRINT.FRN(1),FRF(1),ERA(1),TFI(1)
PRINT.BMN(1),BMF(1),BMA(1),TBM(1)
PRINT.A1
PRINT.FA1(1),MA1(1),JA1(1)
PRINT.TFITO
PRINT. FC1(1),EC2(1)
PRINT.CAER(1)
PRINT. CTFI(1)
PRINT. CFC(1)
PRINT. CTHER(1)
PRINT. FEATM(1),EEATM(2),EEATM(3),EEATM(4)
PRINT. FEATM(5),EEATM(6),EEATM(7)
PRINT. FEATF(1),EEATF(2),EEATF(3),EEATF(4)
PRINT. FEATF(5),FEATF(6),EEATF(7)
PRINT.TEDM(1),TEDF(1)
PRINT. THERM(1)
PRINT. THERF(1)
PRINT. GPREY(1),GPREY(2),GPREY(3),GPREY(4),GPREY(5),GPREY(6),GPREY(7),GPREY(8)
PRINT. TOT(1),TOT(2),TOT(3),TOT(4),TOT(5),TOT(6),TOT(7),TOT(8)
PRINT. PREY(1),PREY(2),PREY(3),PREY(4),PREY(5),PREY(6),PREY(7),PREY(8)
PRINT. PTOT(1),PTOT(2),PTOT(3),PTOT(4),PTOT(5),PTOT(6),PTOT(7),PTOT(8)
PLOT.(X(2),AN,ANF,ANFJ)
PLOT.(FRN(1),ERF(1),ERA(1),TEI(1)),(AVDEG )
PLOT.(A1)
PLOT.(FA1(1))
PLOT.(MA1(1))
PLOT.(JA1(1))
PLOT.(TFITO)
PLOT. (FEATM(1),FEATF(1))
PLOT. (FEATM(2),EEATF(2))
PLOT. (FEATM(3),EEATF(3))
PLOT. (FEATM(4),EEATF(4))
PLOT. (FEATM(5),EEATF(5))
PLOT. (EEATM(6),EEATF(6))
PLOT. (FEATM(7),EEATF(7))
PLOT. (AMW(1))
PLOT.(EC1(1),EC2(1))
PLOT. (THERM(1),THERF(1))
PLOT. (GPREY(1),GPREY(2),GPREY(3),GPREY(4))
PLOT. (GPREY(5),GPREY(6),GPREY(7),GPREY(8))
#
```

DATA

PRINT AND PLOT CONTROL

PRINT AND PLOT CONTROL

FILE CARD

CHAPTER 6

LISTING

This chapter contains a listing of the SIMCOMP source deck of Chapter 5. It is highly redundant with the early text and with Chapter 5, but provides the reader with a list of the documental program as it appears after SIMCOMP compilation.

```
STORAGE.                   THERF(20)
STORAGE.             NCAT,GPREY(20,20),TOT(20,20)
STORAGE.                   PREY(20),PTOT(20)
STORAGE.             DIET(20,20,20),NDAT(20),CALV(20),NDA,NDT
STORAGE.                THERM(20),TC(20)
STORAGE.                   CTHER(20)
STORAGE.                   NSP,AVDEG ,NOTMP,NOACB,NP(20),NUMDY
STORAGE.                   TEMPC(26),DATE(26)
STORAGE.                   TS(20),PS(20),PE(20),PBD(20),TIN(20),TD(20),TE(20)
STORAGE.                   PPBF(20),HS(20),PI(20),DOI1(20),DCI1(20),PPBF2(20)
STORAGE.                   PN(20),FS(20),PFS(20),PF(20),AMW(20),HMW(20),DOI2(20)
STORAGE.                   FW(20),ADR(20),DCI2(20)
STORAGE.                   WTF,WTN,AN(20),ANF(20),ANFJ(20)
STORAGE.                   ERF(20),ERA(20),TEI(20),ERN(20),CTEI(20)
STORAGE.                   CE(20,3),PCT(50),WM(20),IDDAT(20)
STORAGE.                   DEF,NDEF,FDEF
STORAGE.                   AG(20),BG(20),AK(20)
STORAGE.                   EV1(20),EV2(20),EV3(20),EP1(20),EP2(20),EP3(20)
STORAGE.                   BMN(20),BMF(20),BMA(20),TBM(20),BMTOT
STORAGE.                   TDJ(20),TEJ(20)
STORAGE.                   ATOT,ANTOT,ANFTO,ANFJT
STORAGE.                   ERNTO,ERFTO,ERATO,TEITO
STORAGE.                   AMACT(7,15,20),AFACT(7,15,20),ACTC(7,20),DAY(26)
STORAGE.                   EEATF(7,20),EEATM(7,20)
STORAGE.                   CS1(20),CS2(20)
STORAGE.                   DOM1(20),DOM2(20),PM1(20),PM2(20)
STORAGE.                   EC1(20),EC2(20)
STORAGE.                   CAER(20),PAER(20)
STORAGE.                   CEC(20)
STORAGE.                   A1(20),TEDM(20),TEDF(20),FA1(20)
STORAGE.             AMWA(10,20),NUDAS(20),DA(10,20),NAMW
REAL.                         JDR(20),MA1(20),JA1(20)
             C...
             C...
(1-2).

                   FLOW = 0.
(2-3).

                   FLOW = 0.
             C...

                   SUBROUTINE START
                   DIMENSION CG(20)
             C NSP IS THE NUMBER OF SPECIES BEING CONSIDERED.
                   DO 1 I = 1,NSP
                   DO 2 J=1,3
                 2 CE(I,J)=0.
                   K = 5*(I-1)+2
             C CG(I) IS JUST AN INTERMEDIATE VARIABLE.
                   CG(I) = EXP(-AK(I)*PN(I))
                   IF(FW(I).EQ.0..AND.HMW(I).EQ.0.) GO TO 3
                   BG(I) = (HMW(I)-FW(I))/(FW(I)*CG(I)-HMW(I))
```

```
      AG(I) = HMW(I)*(1.0 + BG(I))
C BG AND AG ARE CONSTANTS USED IN THE NESTLING GROWTH RATE.
      GO TO 4
    3 AG(I) = 0.
      BG(I) = 0.
    4 CONTINUE
    1 X(K) = PS(I)
C
C     ******************************************************************
C              NORMALIZATION OF DIET SELECTION
C     ******************************************************************
C
C     DIET(I,J,K) IS THE AMOUNT OF THE TOTAL FOOD INTAKE BY SPECIES K
C              OBTAINED FROM FOOD CATEGORY I ON THE JTH MEASUREMENT DAY
C     CALV(I) IS THE CALORIC VALUE OF FOOD CATEGORY I  (KCAL/GMS DRY WT)
C     NDA IS THE NUMBER OF MEASUREMENT DAYS
C     NCAT IS THE NUMBER OF FOOD CATEGORIES
C     NDT IS A FLAG. IF NDT=1,WE DO NOT MAKE CALCULATIONS ABOUT THE DIET.
C                    IF NDT=0,WE DO MAKE CALCULATIONS  ABOUT THE DIET.
      IF(NDT.EQ.1) GO TO 600
C     NDAT(J)  ARE THE DAYS (SINCE JAN 1) ON WHICH THE DATA ARE RECORDED
      DO 8002 K=1,NSP
      DO 8002 J=1,NDA
C     INITIALIZE SUMMING VARIABLE
      SUMM=0.0
      DO 8001 I=1,NCAT
      SUMM=SUMM+DIET(I,J,K)
 8001 CONTINUE
      IF(SUMM.EQ.0.) SUMM=1.
      DO 8002 I=1,NCAT
      DIET(I,J,K)=DIET(I,J,K)/SUMM
 8002 CONTINUE
      DO 8005 I=1,NCAT
      DO 8005 K=1,NSP
 8005 TOT(I,K)=0.0
  600 CONTINUE
      IF(NOACB.EQ.1) RETURN
C             ***************************************
C             *NORMALIZATION OF ACTIVITY BUDGET DATA*
C             ***************************************
C AMACT(I,J,K) IS THE TIME SPENT BY AMALE OF SPECIES K ON THE ITH
C ACTIVITY ON THE JTH MEASUREMENT DAY.  .
C AFACT(I,J,K) IS THE SAME VARIABLE AS AMACT EXCEPT FOR FEMALES
C ACTC(I,K) IS THE COEFFICIENT OF ENERGY EXPENDITURE OF THE KTH SPECIES
C ON THE ITH ACTIVITY
      DO 20003 K=1,NSP
      DO 20003 J = 1,NUMDY
C INTIALIZE SUMMING VARIABLES
      SUMM1=0.0
      SUMF1=0.0
C NORMALIZE DATA
      DO 20000 I=1,7
      SUMM1=SUMM1+AMACT(I,J,K)
```

```
      SUMF1=SUMF1+AFACT(I,J,K)
20000 CONTINUE
      IF(SUMM1.EQ.0.) SUMM1=1.
      IF(SUMF1.EQ.0.) SUMF1=1.
      DO 20003 I=1,7
      AMACT(I,J,K)= ACTC(I,K)*AMACT(I,J,K)/SUMM1
      AFACT(I,J,K)= ACTC(I,K)*AFACT(I,J,K)/SUMF1
20003 CONTINUE
C AMACT(I,J,K) AND AFACT(I,J,K) ARE LATER CHANGED TO THE ENERGY EXPENDITURE
C BY A MALE AND FEMALE ON THE ITH ACTIVITY ON THE JTH DAY OF MEASUREMENT
C ( K REPRESENTS THE SPECIES ).
      RETURN
      END
C.................

      SUBROUTINE CYCL1
C.... NAMW IS A FLAG.  NAMW=1 INDICATES AMW(I) IS CONSTANT THROUGHOUT
C....          A RUN.  OTHERWISE, WE USE AMWA(J,I) AND INTERPOLATE
C.... DA(J,I) IS AN ARRAY OF DATES(FROM JAN 1) ON WHICH AVERAGE ADULT
C....                WEIGHTS OF SPECIES I ARE RECORDED
C.... IF NAMW IS NOT 1, THEN
C.... AMWA(J,I) IS THE AVERAGE ADULT WEIGHT OF THE ITH SPECIES ON DA(J,I)
C         AND
C.... AMW(I) IS A LINEAR INTERPOLATION OF THE ARRAY AMWA
C.... NUDAS(I) IS THE NUMBER OF ACTUAL ENTRIES FOR SPECIES I IN THE ARRAY
C....             DA(J,I).  THE REST  OF DA(J,I) IS FILLED IN WITH ZEROS.
      IF(NAMW.EQ.1) GO TO 32
      DO 31 I=1,NSP
      NU=NUDAS(I)
      DO 11 J=1,NU
      IF(TIME.GT.DA(J,I))11,12
   11 CONTINUE
   12 IF(J.EQ.1)14,15
   14 AMW(I)=AMWA(1,I)
      GO TO 30
   15 IF(J.EQ.NU.AND.TIME.GT.DA(J,I))17,18
   17 AMW(I)=AMWA(NU,I)
      GO TO 30
   18 L=J-1
      AMW(I)=AMWA(L)+(AMWA(J)-AMWA(L))/(DA(J,I)-DA(L,I))*(TIME-DA(L,I))
   30 CONTINUE
   31 CONTINUE
   32 CONTINUE
C
C    ******************************************************************
C              CALCULATION OF DIET COMPOSITION
C    ******************************************************************
C
C    DIET(I,J,K) IS THE AMOUNT OF THE TOTAL FOOD INTAKE BY SPECIES K
C              OBTAINED FROM FOOD CATEGORY I ON THE JTH MEASUREMENT DAY
C    CALV(I) IS THE CALORIC VALUE OF FOOD CATEGORY I  (KCAL/GMS DRY WT)
C    NDA IS THE NUMBER OF MEASUREMENT DAYS
C    NCAT IS THE NUMBER OF FOOD CATEGORIES
```

```
C       NDAT(J)  ARE THE DAYS (SINCE JAN 1) ON WHICH THE DATA ARE RECORDED
C       NDT IS A FLAG. IF NDT=1,WE DO NOT MAKE CALCULATIONS ABOUT THE DIET.
C                      IF NDT=0,WE DO MAKE CALCULATIONS  ABOUT THE DIET.
        IF(NDT.EQ.1) GO TO 601
C       INTERPOLATE DIET ARRAY
        DO 69 I=1,NCAT
        DO 70 K=1,NSP
        GPREY(I,K)=0.0
        DO 71 J=1,NDA
        IF(TIME.GT.NDAT(J)) 71,72
   71 CONTINUE
   72 IF(J.EQ.1) 74,75
   74 AVDT=DIET(I,1,K)
      GO TO 76
   75 IF(J.EQ.NDA.AND.TIME.GT.NDAT(J)) 77,78
   77 AVDT=DIET(I,NDA,K)
      GO TO 76
   78 L=J-1
      AVDT=DIET(I,L,K)+(DIET(I,J,K)-DIET(I,L,K))/(NDAT(J)-NDAT(L))*
     "   (TIME-NDAT(L))
   76 CONTINUE
C.....AVDT IS THE INTERPOLATED DIET COMPOSITION
C.....GPREY(I,K) IS THE DAILY CONSUMPTION OF CATEGORY I BY
C             SPECIES K   (GMS/M**2)
      GPREY(I,K)=GPREY(I,K) + ( AVDT * ERA(K) ) / CALV(I)
C.....TOT(I,K) IS THE TOTAL SEASONAL CONSUMPTION OF CATEGORY I
C                BY SPECIES K    (GMS/M**2)
      TOT(I,K)=TOT(I,K) + GPREY(I,K)
   70 CONTINUE
   69 CONTINUE
      DO 8010 I=1,NCAT
      PTOT(I)=0.0
      PREY(I)=0.0
      DO 8009 K=1,NSP
C.....PTOT IS THE TOTAL SEASONAL CONSUMPTION OF FOOD CATEGORY I
      PTOT(I) = PTOT(I) + TOT(I,K)
C.....PREY IS THE TOTAL DAILY CONSUMPTION OF FOOD CATEGORY I
 8009 PREY(I) = PREY(I) + GPREY(I,K)
 8010 CONTINUE
  601 CONTINUE
C...DATE ARRAY CONTAINS DATE IN DAYS SINCE 1 JAN
C...TEMPC ARRAY CONTAINS TEMPERATURE (DEG C) AT DATE
C...AVDEGC = LINEAR INTERPOLATION FOR AVERAGE TEMP ESTIMATE
      DO 1 I=1,NOTMP
      IF (TIME.GT.DATE(I))1,2
    1 CONTINUE
    2 IF(I.EQ.1) 4,5
    4 AVDEG  = TEMPC(1)
      GO TO 6
    5 IF (I.EQ.NOT MP.AND.TIME.GT.DATE(I)) 7,8
    7 AVDEG  = TEMPC(NOT MP)
      GO TO 6
    8 AVDEG  = TEMPC(I-1) + (TEMPC(I) - TEMPC(I-1))/(DATE(I) - DATE(I-1)
```

```
     *   )*(TIME-DATE(I-1))
    6 DO 3 I = 1,NSP
      T = TIME-PI(I)
      EV1(I) = EVST(T,I)
      EP1(I) = EPD2(T,I)
      T = T-PN(I)
      EV2(I) = EVST(T,I)
      EP2(I) = EPD2(T,I)
      T = T-PF(I)
      EV3(I) = EVST(T,I)
      EP3(I) = EPD2(T,I)
      J=5*(I-1)+2
C HERE IS WHERE THE ACTUAL FLOWS ARE CALCULATED.
C X(J) WHERE J = 5*(I-1) + 2, I = 1,2,...,NSP IS THE STATE VARIABLE REPRESENTING
C THE ADULT POPULATION.
C.................
C THE NUMBER OF ADULTS IS CALCULATED IN THIS FLOW (X(J))
      F = FLIN(PS(I),PBD(I),TS(I),TIN(I),TIME)  +
     *    FLIN (X(J),PE(I),TD(I),TE(I),TIME)
      IF(TIME.LE.TS(I))F = PS(I)
      IF(TIME.GE.TE(I)) F = X(J) - WM(I)*PE(I)/(365.-TE(I))
      IF(TIME.GT.TIN(I).AND.TIME.LT.TD(I)) F = X(J)
      F = (F-X(J))/DT - ADR(I)*X(J)
      X(J)=X(J)+F*DT
C.................
C THE NUMBER OF EGGS IS CALCULATED HERE (X(J+1))
      T = TIME
      F = EVST(T,I) - EV1(I)*(1.-HS(I))
      G = EPD2(T,I) - EP1(I)*(1.-HS(I))
      F = (F +G)*X(J)
      X(J+1)=X(J+1)+F*DT
C.................
C THE EGGS WHICH SURVIVE TO PRODUCE NESTLINGS IS CALCULATED HERE (X(J+2))
      F = (EV1(I) + EP1(I))     *HS(I)   *PBD(I)
      X(J+1)=X(J+1)-F*DT
      X(J+2)=X(J+2)+F*DT
C.................
C THE MORTALITY OF NESTLINGS IS CALCULATED HERE
      F = -(EV2(I)+EP2(I))*(1.-FS(I))*HS(I)*PBD(I)
      X(J+2)=X(J+2)+F*DT
C.................
C THE NESTLINGS WHICH SURVIVE TO BECOME FLEDGLINGS IS CALCULATED HERE (X(J+3))
      F = (EV2(I)+EP2(I))*HS(I)*FS(I)*PBD(I)
      X(J+2)=X(J+2)-F*DT
      X(J+3)=X(J+3)+F*DT
C.................
C THE FLEDGLING MORTALITY IS CALCULATED HERE
      F = -(EV3(I)+EP3(I))*(1.-PFS(I))*FS(I)*HS(I)*PBD(I)
      X(J+3)=X(J+3)+F*DT
C.................
C THE FLEDGLINGS WHICH SURVIVE TO BECOME JUVENILES IS CALCULATED HERE (X(J+4))
      F = (EV3(I)+EP3(I))*PFS(I)*FS(I)*HS(I)*PBD(I)
      X(J+3)=X(J+3)-F*DT
```

```
      X(J+4)=X(J+4)+F*DT
C.................
C MIGRATION IS CALCULATED HERE
      F = FLIN(X(J+4),0.,TDJ(I),TEJ(I),TIME)
      IF (TIME.LT.TDJ(I))F = X(J+4)
      F = (F-X(J+4))/DT - JDR(I)*X(J+4)
      X(J+4)=X(J+4)+F*DT
C.................
    3 CONTINUE
      RETURN
      END
C.................

      FUNCTION EVST(T,I)
C...
C...FUNCTION TO COMPUTE EGG PRODUCTION PER DAY PER PRODUCING FEMALE
C...
    1 IF(T.LT.DOI1(I).OR.T.GT.DCI1(I))110,111
  110 EVST = 0.
      RETURN
  111 TL = DCI1(I)-DOI1(I)
      IF (TL.LE.0.) GO TO 110
      TM = (DOI1(I)+DCI1(I))/2.
      IF (T.LE.TM)113,114
  113 EVST =CS1(I)*PPBF(I)*4.*(T-DOI1(I))/(TL*TL)
      RETURN
  114 EVST =CS1(I)*PPBF(I)*4.*(DCI1(I)-T)/(TL*TL)
      RETURN
      END
C.................

      FUNCTION EPD2(T    ,I)
C...
C...FUNCTION TO COMPUTE EGG LAYING PATTERN FOR SECOND CLUTCH
C...
1     IF (T.LT.DOI2(I).OR.T.GT.DCI2(I)) 110,111
110   EPD2 = 0.0
      RETURN
111   TL = DCI2(I) - DOI2(I)
      IF (TL.LE.0.0) GO TO 110
      TM = (DOI2(I) + DCI2(I))/2.0
      IF (T.LE.TM) 113,114
113   EPD2 =CS2(I) * PPBF2(I)* 4.0 * (T-DOI2 (I))/(TL*TL)
      RETURN
114   EPD2 =CS2(I) * PPBF2(I) * 4.0 * (DCI2(I)-T)/(TL*TL)
      RETURN
      END
C..................

      FUNCTION FLIN(A,B,C,D,T)
C...
C...GENERAL LINEAR INTERPOLATION ROUTINE
C...
```

```
      IF(T.GT.D.OR.T.LT.C)1,2
    1 FLIN=0.
      RETURN
    2 CONTINUE
      IF (D.EQ.C) 3,4
    3 FLIN=(A+B)/2.0
      RETURN
    4 FLIN=(B-A)/(D-C)*(T-C)+A
      RETURN
C...THIS COMPUTES A LINEAR INTERPOLATION BETWEEN A AT T = C AND B AT T =
C...    D USING T AS THE INDEPENDENT VARIABLE
C IF T LIES OUTSIDE THE INTERVAL C TO D THE FUNCTION RETURNS THE VALUE 0.
      END
C.................

      FUNCTION FLIN2(A,B,C,D,T)
C FLIN2 IS A LINEAR INTERPOLATION WHICH EXTRAPOLATES IF T FALLS OUTSIDE
C THE INTERVAL C TO D.
      IF(C.EQ.D)1,2
    1 FLIN2=(A+B)/2.
      RETURN
    2 FLIN2=(B-A)/(D-C)*(T-C)+A
      RETURN
      END
C.................

      SUBROUTINE TABLF(TABL1,TABL2,N,A,Y)
      DIMENSION TABL1(15),TABL2(15)
C TABL1 IS THE INDEPENDENT VALUES, WHILE TABL2 IS THE DEPENDENT VALUES.
      IF(A.LE.TABL1(1)) GO TO 10
      IF(A.GE.TABL1(N)) GO TO 20
      DO 100 I = 2,N
      IF(A.LE.TABL1(I)) GO TO 30
  100 CONTINUE
   30 Y=(A-TABL1(I-1))*(TABL2(I)-TABL2(I-1))/(TABL1(I)-TABL1(I-1))
     1+TABL2(I-1)
      RETURN
   20 Y=TABL2(N)
      RETURN
   10 Y=TABL2(1)
      RETURN
      END
C.................

      FUNCTION WNSLG (I,AGE)
C...
C...FUNCTION TO COMPUTE NESTLING WEIGHTS
C...
      WNSLG = AG(I)/(1.0 + BG(I)*EXP(-AK(I)*AGE))
      RETURN
      END
C.................
```

```
      FUNCTION WFLG(I,AGE)
C...
C...FUNCTION TO COMPUTE THE FLEDGLING WEIGHTS
C...
      WFLG = FLIN(FW(I),AMW(I),0., PF(I),AGE)
      RETURN
      END
C.................

      SUBROUTINE APER(J,Y,T,ER)
C...
C...Y=AVERAGE WEIGHT
C...T=TEMPERATURE IN DEG C.
C...ER=ENERGY REQUIREMENT.
C...
      IF(Y.LE.0.)100,101
  100 ER=0.
      RETURN
  101 GO TO (10,20),J
C...SUBROUTINE TO CALCULATE THE ENERGY REQUIREMENT FOR NON-PASSERINES
   10 T1 = 4.3372*(Y)**.53
      T2 = .5464*(Y)**.7545
   21 ER=FLIN2(T1,T2,0.,30.,T)
      RETURN
C...SUBROUTINE TO COMPUTE ENERGY REQUIREMENTS FOR PASSERINES.
   20 T1 = 4.3372 *(Y)**.53
      T2 = 1.572 * (Y)**.621
      GO TO 21
      END
C.................

      SUBROUTINE EGG(I,J,Y,K,L)
      DIMENSION TBEW(15,4),TBAW(15,4),TABL1(15),TABL2(15),NUM(4)
C TBEW IS A TWO DIMENSIONAL ARRAY CONTAINING ALL EGG WEIGHT DATA
C          TBEW(N,1) = EGG WEIGHTS FOR PASSERINES    N = 1,2,...,NUM(1)
C          TBEW(N,2) = EGG WEIGHTS FOR SHOREBIRDS    N = 1,2,...,NUM(2)
C          TBEW(N,3) = EGG WEIGHTS FOR CORMORANTS    N = 1,2,...,NUM(3)
C          TBEW(N,4) = EGG WEIGHTS FOR ALCIDS        N = 1,2,...,NUM(4)
C TBAW IS A TWO DIMENSIONAL ARRAY CONTAINING ALL ANIMAL WEIGHT DATA
C          TBAW(N,1) = ANIMAL WEIGHTS FOR PASSERINES.    N = 1,2,...,NUM(1)
C          TBAW(N,2) = ANIMAL WEIGHTS FOR SHOREBIRDS     N = 1,2,...,NUM(2)
C          TBAW(N,3) = ANIMAL WEIGHTS FOR CORMORANTS     N = 1,2,...,NUM(3)
C          TBAW(N,4) = ANIMAL WEIGHTS FOR ALCIDS         N = 1,2,...,NUM(4)
      DATA TBEW/
     10.,.74,1.04,1.3,1.92,2.35,3.08,3.41,4.23,6.02,7.13,10.27,12.05,
     *16.15,20.00,
     20.,5.7,9.37,12.1,17.7,28.6,47.5,54.3,60.,6*0.,
     30.,49.,48.,44.,51.,58.,70.,8*0.,
     40.,24.,52.,55.,65.,94.,110.,113.,150.,6*0./
C
      DATA TBAW/
     10.,6.,8.,11.7,17.1,22.8,30.,37.9,51.6,67.7,97.5,168.3,206.3,
     *396.3,700.,
```

```
     20.,26.7,43.6,59.,109.3,212.1,475.,750.,1100.,6*0.,
     30.,1760.,1870.,2000.,2430.,2500.,4000.,8*0.,
     40.,125.,425.,450.,500.,700.,930.,1000.,1500.,6*0./
C
C NUM(L) IS THE NUMBER OF SIGNIFICANT ENTRIES IN THE L-TH BLOCK. L=1,2,3, OR 4
      DATA NUM/15,9,7,9/
C
C I IS THE INDEX FOR SPECIES.  J IS THE INDEX OF THE STATE VARIABLE REPRESENTING
C THE ADULT POPULATION OF THE ITH SPECIES.  K IS A FLAG.  IF K = 1 THEN WE USE
C THOSE CALCULATIONS INVOLVING THE FIRST CLUTCH.  K = 2 CORRESPONDS TO SECOND
C CLUTCH EQUATIONS.
      N = NUM(L)
      DO 100 M = 1,N
      TABL2(M) = TBEW(M,L)
      TABL1(M) = TBAW(M,L)
  100 CONTINUE
      CALL TABLF(TABL1,TABL2,N,AMW(I),EW)
C EW IS THE EGG WEIGHT.
      GO TO (1,2) K
    1 TH=(DOI1(I)-CS1(I)-3.+DCI1(I))/2.
      IF(TIME.GT.TH) GO TO 3
      Y=CS1(I)*4.*(TIME-DOI1(I)+CS1(I)+3.)
     1/(DCI1(I)-DOI1(I)+CS1(I)+3.)**2
C THE ABOVE EQUATIONS ARE USED IN ORDER TO DISTRIBUTE ENERGY COST OVER THE TIME
C AVAILABLE FOR EGG PRODUCTION.
      Y=1.10*1.37*EW*Y*PPBF(I)
      RETURN
    3 Y=CS1(I)*4.*(DCI1(I)-TIME)/(DCI1(I)-DOI1(I)+CS1(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPBF(I)
      RETURN
    2 TH=(DOI2(I)-CS2(I)-3.+DCI2(I))/2.
      IF(TIME.GT.TH) GO TO 4
      Y=CS2(I)*4.*(TIME-DOI2(I)+CS2(I)+3.)
     1/(DCI2(I)-DOI2(I)+CS2(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPBF2(I)
      RETURN
    4 Y=CS2(I)*4.*(DCI2(I)-TIME)
     1/(DCI2(I)-DOI2(I)+CS2(I)+3.)**2
      Y=1.10*1.37*EW*Y*PPBF2(I)
      RETURN
      END
C...............

      SUBROUTINE MOLT(D,P,W,T,M)
      REAL M,MU
C.....THIS SUBROUTINE CALCULATES THE MOLTING COST WHICH IS NORMALLY
C.....    DISTRIBUTED OVER A PERIOD OF P DAYS AND STARTS ON DAY D
C.....W IS THE ADULT MEAN WEIGHT AND T IS THE TIME(IN DAYS)
C.....THE MOLTING COST IS GIVEN BY
C.....      MOLT=8.375*(W**.959)
C.....M IS THE MOLT AT TIME T+.5
      PI=3.14159
C.....CALCULATE SQUARE ROOT OF 2 PI
```

```
      SR2PI=SQRT(2*PI)
C.....CALCULATE DISTRIBUTION MEAN
      MU=D+P/2.
C.....CALCULATE STANDARD DEVIATION
      SIG=P/6.
C.....CALCULATE MOLT COST AT T+.5
      R=1./(SIG*SR2PI)
      S=(T+.5-MU)/SIG
      Y=R*EXP(-.5*S*S)
      M=(1./.9973)*8.375*(W**.959)*Y
      RETURN
      END
C.................

      SUBROUTINE CYCL2
C...
C... THIS ROUTINE REALLY DOES ALL THE WORK.
C... MUST INTERESTING OUTPUT IS COMPUTED HERE.
C...
      BMTOT = 0.
      ANTOT = 0.  $  ATOT = 0.  $  ANFTOT = 0.  $  ANFJTO = 0.
      TEITOT = 0.  $  EHATOT = 0.  $  ERFTOT = 0.  $  ERNTOT = 0.
      DO 1 I=1,NSP
C... INDEX CALCULATION TO GO TO NEW SPECIES.
      J=2+(I-1)*5
      DO 2 K = 1,5
      KK = K - 1 + J
      IF(X(KK).LT..00000001) X(KK) = 0.
    2 CONTINUE
      A2 = X(J)+X(J+4)
      IF(A2.LE.0.)30,31
   30 ERA(I) = 0.
      ER=0.0
      A1(I) = 0.
      GO TO 34
   31 CONTINUE
      CALL APER (NP(I),AMW(I),TC(I),ER)
      CALL APER (NP(I),AMW(I),AVDEG,ERT)
      THERM(I) = ERT -ER
      IF(THERM(I).LE.0.0)  THERM(I) = 0.0
      FAC2 = 1.4*ER
C NP IS A FLAG.  IF NP=1 THE NONPASSERINE EQUATIONS ARE USED.  IF NP=2 THE
C PASSERINE EQUATIONS ARE USED.
      FAC1 = 0.0
      IF(TIME.GE.DOM1(I).AND.TIME.LT.DOM1(I)+PM1(I).AND.DOM1(I).NE.0.)
     1 CALL MOLT(DOM1(I),PM1(I),AMW(I),TIME,FAC1)
      IF(TIME.GE.DOM2(I).AND.TIME.LT.DOM2(I)+PM2(I).AND.DOM2(I).NE.0.)
     1 CALL MOLT(DOM2(I),PM2(I),AMW(I),TIME,FAC1)
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      A1(I) = (FAC1 + FAC2 + THERM(I) )*DEF
      IF(IDDAT(I).EQ.0) GO TO 33
C THE VARIABLE IDDAT(I) IDENTIFIES THE DATA BLOCK TO BE USED TO CALCULATE
C EGG COSTS
```

```
C           IDDAT(I)  = 1  PASSERINE DATA ARE TO BE USED
C           IDDAT(I)  = 2  SHOREBIRD DATA ARE TO BE USED
C           IDDAT(I)  = 3  CORMORANT DATA ARE TO BE USED
C           IDDAT(I) = 4  ALCID DATA ARE TO BE USED
C IF IDDAT = 0 NO EGG COST IS CALCULATED.
      EC1(I) = 0.
      EC2(I) = 0.
      IF(TIME.GE.DOI1(I)-CS1(I)-3..AND.TIME.LE.DCI1(I))
     1CALL EGG (I,J,EC1(I),1,IDDAT(I))
      IF(TIME.GE.DOI2(I)-CS2(I)-3..AND.TIME.LE.DCI2(I))
     1CALL EGG (I,J,EC2(I),2,IDDAT(I))
C EC1 IS THE DAILY INDIVIDUAL ENERGY COST ASSOCIATED WITH PRODUCING THE
C FIRST CLUTCH
C EC2 IS THE SAME VARIABLE FOR THE SECOND CLUTCH.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      A1(I) = A1(I) + ((EC1(I) + EC2(I))* DEF)
   33 CONTINUE
      IF(NOACB.EQ.1) GO TO 32
      CALL EZ(TIME,I,ER)
CALCULATE SEX SPECIFIC INDIVIDUAL ENERGY DEMANDS
C FA1(I) IS THE ENERGY DEMAND OF A FEMALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      FA1(I)=(FAC1 +TEDF(I) +THERM(I) + (EC1(I) + EC2(I))/PPBF(I))*DEF
C MA1(I) IS THE ENERGY DEMAND OF A MALE INDIVIDUAL OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      MA1(I) = (FAC1 + TEDM(I) + THERM(I) )*DEF
C JA1(I) IS THE ENERGY DEMAND FOR A JUVENILE  OF THE ITH SPECIES.
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      JA1(I)=(1.-PPBF(I))*MA1(I)+PPBF(I)*((FAC1+TEDF(I)+THERM(I))*DEF)
      A1(I) = PPBF(I)*FA1(I) + (1.-PPBF(I))*MA1(I)
C A1 IS THE INDIVIDUAL ENERGY DEMAND WITH UNITS KCAL/BIRD-DAY.
      ERA(I) = (X(J)*A1(I) + X(J+4)*JA1(I))*1.E-6
      GO TO 34
   32 CONTINUE
      ERA(I)=(X(J)*A1(I)+X(J+4)*(A1(I)-((EC1(I) + EC2(I))*1.43)))*1.E-6
   34 BMA(I) = (X(J) + X(J+4))*AMW(I)*.000001
      CAER(I) = CAER(I) + ERA(I)*DT
      IF(ERA(I).GT.PAER(I))PAER(I)=ERA(I)
C.....DEF IS THE DIETARY EFFICIENCY OF ADULTS
      CEC(I)=CEC(I)+((((EC1(I)+EC2(I))* DEF)*X(J))*1.E-6)*DT
C...CTHER IS THE CUMULATIVE THERMOREGULATION ENERGY COST
      CTHER(I)=CTHER(I)+((THERM(I)*X(J)+THERF(I)*X(J+3)
     *    +THERM(I)*X(J+4))*1.E-6)*DT
C CAER AND PAER ARE THE CUMULATIVE ADULT ENERGY REQUIREMENT, AND THE PEAK
C ADULT ENERGY REQUIREMENT RESPECTIVELY.
C...
C...THIS BLOCK OF CODE COMPUTES THE ENERGY DISTRIBUTION IN THE NESTLINGS
C...IN THE FIRST CLUTCH ACCORDING TO AGE DISTRIBUTION
C...
      BMN2 = 0.
      BMN(I) = 0.
      ERN(I) = 0.
      AMPY = 1.
```

```
      IF (X(J+2).EQ.0.) GO TO 10
      MA = MAX1(DOI1(I),TIME-PI(I)-PN(I))
      MB = MIN1(DCI1(I),TIME-PI(I))
      IF(MB-MA.GT.49) 50,51
   50 PRINT 8000 ,MA,MB,I
 8000 FORMAT(1H ,I5,I5,I5,//,1H ,* MB IS TOO LARGE*)
      GO TO 1
   51 CONTINUE
      PCTT = 0.
      IF (MB.LT.MA) GO TO 13
      DO 11 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EVST(CK,I)
   11 PCTT = PCTT + PCT(KA)
      IF (PCTT.EQ.0.) GO TO 13
      DO 12 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)
      WTN = WNSLG(I,AGE)
      BMN(I) = BMN(I) + WTN*PCT(KA)
      CALL APER(NP(I),WTN,TC(I),ER)
   12 ERN(I) = ERN(I) + ER*PCT(KA)
C...
C...SECOND CLUTCH NESTLING ENERGY CALCULATION
C...
   13 IF(PPBF2(I).EQ.0.) GO TO 10
      MA = MAX1(DOI2(I),TIME-PI(I)-PN(I))
      MB = MIN1(DCI2(I),TIME-PI(I))
      IF(MB-MA.GT.49) GO TO 50
      IF (MB.LT.MA)GO TO 10
      PCTT = 0.
      DO 14 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EPD2(CK,I)
   14 PCTT = PCTT + PCT(KA)
      DO 15 K = MA,MB
      ERN2 = 0.
      IF (PCTT.EQ.0.) GO TO 10
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)
      WTN = WNSLG(I,AGE)
      BMN2 = BMN2 + WTN*PCT(KA)
      CALL APER(NP(I),WTN,TC(I),ER)
   15 ERN2 = ERN2 + ER*PCT(KA)
      IF (ERN(I)*ERN2.NE.0.)AMPY = .5
      ERN(I) =(ERN(I) + ERN2)
C.....NDEF IS THE DIETARY EFFICIENCY OF NESTLINGS
   10 NDEF=DEF*1.2
      ERN(I) = ERN(I)* NDEF*.000001*X(J+2)*AMPY
```

```
      BMN(I) = (BMN(I) + BMN2)*AMPY*X(J+2)*.000001
C...
C...CALCULATE FLEDGLING ENERGY REQUIREMENTS AS A FUNCTION OF AGE FOR
C...THE FIRST CLUTCH
C...
      AMPY = 1.
      ERF(I) = 0.
      BMF2 = 0.
      BMF(I) = 0.
      IF (X(J+3).EQ.0.) GO TO 20
      MA = MAX1(DOI1(I),TIME-PI(I)-PN(I)-PF(I))
      MB = MIN1(DCI1(I),TIME-PI(I)-PN(I))
      IF(MB-MA.GT.49) GO TO 50
      PCTT = 0.
      DO 21 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EVST(CK,I)
   21 PCTT = PCTT + PCT(KA)
      IF(PCTT.EQ.0.) GO TO 23
      DO 22 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)-PN(I)
      WTF = WFLG(I,AGE)
      BMF(I) = BMF(I) + WTF*PCT(KA)
      CALL APER(NP(I),WTF,TC(I),ER)
      CALL APER(NP(I),WTF,AVDEG,ERT)
      THERF(I)=ERT-ER
      IF(THERF(I).LE.0.0) THERF(I)=0.0
   22 ERF(I) = ER*PCT(KA)+ ERF(I)
C...
C...SECOND CLUTCH FLEDGLING ENERGY CALCULATION
C...
   23 IF (PPBF2(I).EQ.0.) GO TO 20
      MA = MAX1(DOI2(I),TIME-PI(I)-PN(I)-PF(I))
      MB = MIN1(DCI2(I),TIME-PI(I)-PN(I))
      IF(MB-MA.GT.49) GO TO 50
      IF (MB.LT.MA) GO TO 20
      PCTT = 0.
      DO 24 K = MA,MB
      CK = K
      KA = K-MA+1
      PCT(KA)= EPD2(CK,I)
   24 PCTT = PCTT + PCT(KA)
      IF (PCTT.EQ.0.) GO TO 20
      ERF2 = 0.
      DO 25 K = MA,MB
      KA = K-MA+1
      PCT(KA) = PCT(KA)/PCTT
      AGE = TIME-K-PI(I)-PN(I)
      WTF = WFLG(I,AGE)
      BMF2 = BMF2 + WTF*PCT(KA)
```

```
      CALL APER(NP(I),WTF,TC(I),ER)
      CALL APER(NP(I),WTF,AVDEG,ERT)
      THERF(I)=ERT-ER
      IF(THERF(I).LE.0.0) THERF(I)=0.0
   25 ERF2 = ERF2 + ER*PCT(KA)
      IF (ERF(I)*ERF2.NE.0.)AMPY = .5
      ERF(I) =(ERF(I) + ERF2)
C.....FDEF IS THE DIETARY EFFICIENCY OF FLEDGLINGS
   20 FDEF=DEF
      ERF(I) = ((ERF(I)*1.15 + THERF(I))*FDEF)*.000001*X(J+3)*AMPY
      BMF(I) =(BMF(I) + BMF2)*AMPY*X(J+3)*.000001
C...
C...COMPUTE POPULATION TOTALS
C...
      AN(I) = X(J) + X(J+2)
      ANF(I) = AN(I) + X(J+3)
      ANFJ(I) = ANF(I) + X(J+4)
      ANTOT = ANTOT + AN(I)
      ATOT = ATOT + X(J)
      ANFTOT = ANFTOT + ANF(I)
      ANFTO = ANFTOT
      ANFJTO = ANFJTO + ANFJ(I)
      ANFJT = ANFJTO
      TEI(I) = ERA(I)+ERF(I)+ERN(I)
      CTEI(I) = CTEI(I) + TEI(I)
      TBM(I) = BMN(I) + BMF(I) + BMA(I)
C...THERE IS NO BIOMASS COMPUTED FOR EGGS
      TEITOT = TEITOT + TEI(I)
      TEITO = TEITOT
      BMTOT = BMTOT + TBM(I)
      ERATOT = ERATOT + ERA(I)
      ERATO = ERATOT
      ERFTOT = ERFTOT + ERF(I)
      ERFTO = ERFTOT
      ERNTOT=ERNTOT+ERN(I)
      ERNTO = ERNTOT
      CE(I,1) = CE(I,1) + DT*ERA(I)
      CE(I,2) = CE(I,2) + DT*ERF(I)
      CE(I,3) = CE(I,3) + DT*ERN(I)
    1 CONTINUE
      RETURN
      END
C.................

      SUBROUTINE EZ(T,I,ER)
C J WILL INDEX THE DAYS OF MEASUREMENT. I INDEXES THE  SPECIES. M IS
C THE INDEX FOR THE ACTIVITIES.
C EEATM(L,I) IS THE ENERGY EXPENDITURE FOR A MALE OF SPECIES I ON THE
C LTH ACTIVITY. EEATF IS THE SAME FOR FEMALES.
C THE ACTIVITIES ARE AS FOLLOWS
C  I=1.  INACTIVE
C    2.  SINGING
C    3.  FLIGHT
```

```
C     4.  FORAGING
C     5.  AGGRESSION AND DISPLAY
C     6.  COURTSHIP
C     7.  INCUBATION AND BROODING.
C T REPRESENTS TIME.
      IF(T.GE.TE(I)) GO TO 85
C NUMDY IS THE NUMBER OF ENTRIES IN THE DAY ARRAY.
      K=NUMDY-1
      IF(T.LT.DAY(1))1,2
    1 DO 81 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,1,I),AMACT(M,2,I),DAY(1),DAY(2),T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,1,I),AFACT(M,2,I),DAY(1),DAY(2),T)*ER
      IF(EEATM(M,I).LT.0.) EEATM(M,I) = 0.
      IF(EEATF(M,I).LT.0.) EEATF(M,I) = 0.
   81 CONTINUE
      GO TO 87
    2 IF(T.GT.DAY(NUMDY))3,4
    3 DO 82 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,K,I),AMACT(M,NUMDY,I),DAY(K),DAY(NUMDY),
     1T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,K,I),AFACT(M,NUMDY,I),DAY(K),DAY(NUMDY),
     1T)*ER
      IF(EEATM(M,I).LT.0.) EEATM(M,I) = 0.
      IF(EEATF(M,I).LT.0.) EEATF(M,I) = 0.
   82 CONTINUE
      GO TO 87
    4 DO 83 J=1,K
      L=J+1
      IF(T.LE.DAY(L).AND.T.GE.DAY(J))5,83
    5 DO 84 M=1,7
      EEATM(M,I)=FLIN2(AMACT(M,J,I),AMACT(M,L,I),DAY(J),DAY(L),T)*ER
      EEATF(M,I)=FLIN2(AFACT(M,J,I),AFACT(M,L,I),DAY(J),DAY(L),T)*ER
   84 CONTINUE
   83 CONTINUE
      GO TO 87
   85 DO 86 M = 1,7
      EEATM(M,I) = 0.
   86 EEATF(M,I) = 0.
   87 CONTINUE
      TEDM(I) = 0.
      TEDF(I) = 0.
      DO 88 II = 1,7
      TEDM(I) = TEDM(I) + EEATM(II,I)
   88 TEDF(I) = TEDF(I) + EEATF(II,I)
C TEDM(I) IS THE MALE TOTAL ENERGY DEMAND FOR ALL ACTIVITIES COMBINED TEDF(I) IS
C THE SAME FOR FEMALES.  THEIR UNITS ARE KCAL/BIRD-DAY
      RETURN
      END
C.................

      SUBROUTINE FINIS
      PRINT 8000
8000  FORMAT (20X, *CUMULATIVE ENERGY REQUIREMENTS*//
```

```
     *20X,*NSP*,11X,*NESTLINGS*,10X,*FLEDGLINGS*,14X,*ADULTS*)
      PRINT 8001, ((I,CE(I,3),CE(I,2),CE(I,1)), I = 1,NSP)
8001  FORMAT (20X,I3,3E20.10)
      PRINT 8002,((PAER(I),I),I = 1,NSP)
 8002 FORMAT(20X,*PEAK ADULT ENERGY REQUIREMENT = *,E20.10,10X,*SPECIES
     1NO. = *,I3)
      RETURN
      END
```

CHAPTER 7

SAMPLE OUTPUT

The BIRD Model displayed in Chapters 5 and 6 produced the output in this chapter using SIMCOMP Version 3.0 as implemented on the CDC 6400 at Colorado State University using SCOPE 3.3 on 7 March 1974. The run is of an Oklahoma population of Dickcissels (*Spiza americana*) and includes the activity budget, egg cost, molt cost, thermoregulation cost, and diet composition subroutines. The first two pages of the listing present initial conditions for the run after the data have been read, but before SUBROUTINE START has been called. The pages entitled SIMULATION RESULTS: present printed results of a run beginning on day 110 and going until day 260 -- printed at 5-day intervals. The last few lines of this output are printed by SUBROUTINE FINIS and present cumulative results for the entire run.

The pages entitled "GRAPHICAL SIMULATION RESULTS" define the variables plotted in the 19 graphs which follow. The 19 graphs plot the variables over the duration of the run. Reference to the first pages defines the plotted characters, and the scales to which each graph is plotted are defined on the graphs. The diagnostic found on plot 3 and others is informative and often indicates (as here) that one (or more) of the plotted variables was not initialized.

For interpretations of the output the reader is referred to the papers (Wiens and Innis 1973, in press).

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SIMCOMP VERSION 3.0   PARAMETER VALUES

- SIMULATION CONTROL PARAMETERS -

```
TIME  = NOT INITIALIZED
TSTRT =  110.000000
TEND  =  260.000000
DT    =  1.00000000
DTPR  =  5.00000000
DTPL  =  1.00000000
DTFL  = NOT INITIALIZED
```

- STATE VARIABLES -

```
X(  1- 99) =              0
```

- PRIMARY USER DEFINED VARIABLES -

```
ACTC(1,1) =  .811000000      ACTC(2,1) =  .876000000      ACTC(3,1) =  6.00000000      ACTC(4,1-6,1) =  1.30000000
ACTC(7,1-7,20) =            0 ADR(1) =  .390000000E-03     ADR(2-20) =              0    AFACT(1,1,1) =  65.7000000
AFACT(2,1,1) =            0  AFACT(3,1,1) =  18.7000000  AFACT(4,1,1) =  15.6000000  AFACT(5,1,1-7,1,1) =              0
AFACT(1,2,1) =  71.8000000  AFACT(2,2,1) =            0  AFACT(3,2,1) =  9.40000000  AFACT(4,2,1) =  18.8000000
AFACT(5,2,1-7,2,1) =            0                         AFACT(1,3,1) =  60.0000000  AFACT(2,3,1) =            0
AFACT(3,3,1) =  9.40000000  AFACT(4,3,1) =  15.6000000  AFACT(5,3,1-6,3,1) =            0
AFACT(7,3,1) =  15.0000000  AFACT(1,4,1) =  44.4000000  AFACT(2,4,1) =            0  AFACT(3,4,1) =  3.10000000
AFACT(4,4,1) =  17.5000000  AFACT(5,4,1-6,4,1) =            0                         AFACT(7,4,1) =  35.0000000
AFACT(1,5,1) =  62.5000000  AFACT(2,5,1) =            0  AFACT(3,5,1) =  12.5000000  AFACT(4,5,1) =  25.0000000
AFACT(5,5,1-7,5,1) =            0                         AFACT(1,6,1) =  65.7000000  AFACT(2,6,1) =            0
AFACT(3,6,1) =  18.7000000  AFACT(4,6,1) =  15.6000000  AFACT(5,6,1-7,15,20) =            0
AG(1-20) = NOT INITIALIZED  AK(1) =  .624000000        AK(2-20) = NOT INITIALIZED  AMACT(1,1,1) =  42.4000000
AMACT(2,1,1) =  37.5000000  AMACT(3,1,1) =  7.00000000  AMACT(4,1,1) =  11.1000000  AMACT(5,1,1) =  2.00000000
AMACT(6,1,1-7,1,1) =            0                         AMACT(1,2,1) =  47.0000000  AMACT(2,2,1) =  35.0000000
AMACT(3,2,1) =  4.00000000  AMACT(4,2,1) =  12.0000000  AMACT(5,2,1-6,2,1) =  1.00000000
AMACT(7,2,1) =            0  AMACT(1,3,1) =  41.4000000  AMACT(2,3,1) =  32.0000000  AMACT(3,3,1) =  12.0000000
AMACT(4,3,1) =  11.3000000  AMACT(5,3,1) =  1.30000000  AMACT(6,3,1) =  2.00000000  AMACT(7,3,1) =            0
AMACT(1,4,1) =  47.0000000  AMACT(2,4,1) =  28.0000000  AMACT(3,4,1) =  5.40000000  AMACT(4,4,1) =  11.3000000
AMACT(5,4,1) =  1.30000000  AMACT(6,4,1) =  7.00000000  AMACT(7,4,1) =            0  AMACT(1,5,1) =  49.9000000
AMACT(2,5,1) =  29.3000000  AMACT(3,5,1) =  4.80000000  AMACT(4,5,1) =  11.0000000  AMACT(5,5,1) =  1.00000000
AMACT(6,5,1) =  4.00000000  AMACT(7,5,1) =            0  AMACT(1,6,1) =  55.5000000  AMACT(2,6,1) =  29.0000000
AMACT(3,6,1) =  3.00000000  AMACT(4,6,1) =  12.5000000  AMACT(5,6,1-7,15,20) =            0
AMW(1-20) = NOT INITIALIZED AMWA(1,1) =  29.5000000    AMWA(2,1) =  27.0000000    AMWA(3,1) =  25.0000000
AMWA(4,1) =  26.0000000    AMWA(5,1) =  27.0000000    AMWA(6,1) =  28.5000000    AMWA(7,1) =  30.5000000
AMWA(8,1-10,20) =            0                         AN(1-20) =            0    ANF(1-20) =            0
ANFJ(1-20) =            0   ANFJT =            0        ANFTO =            0       ANTOT =            0
ATOT =            0         AVDEG =            0        A1(1-20) = NOT INITIALIZED  BG(1-20) = NOT INITIALIZED
BMA(1-20) = NOT INITIALIZED BMF(1-20) = NOT INITIALIZED BMN(1-20) = NOT INITIALIZED BMTOT = NOT INITIALIZED
CAER(1-20) =            0   CALV(1) =  4.50000000    CALV(2) =  5.50000000    CALV(3) =  5.30000000
CALV(4) =  5.10000000      CALV(5) =  5.60000000    CALV(6) =  5.70000000    CALV(7) =  4.90000000
CALV(8) =  4.40000000      CALV(9-20) =            0  CE(1,1-20,3) = NOT INITIALIZED
CEC(1-20) =            0    CS1(1) =  4.10000000     CS1(2-20) = NOT INITIALIZED  CS2(1) =            0
CS2(2-20) = NOT INITIALIZED CTEI(1-20) =            0  CTHER(1-20) =            0  DA(1,1) =  125.000000
DA(2,1) =  145.000000      DA(3,1) =  165.000000     DA(4,1) =  185.000000     DA(5,1) =  205.000000
DA(6,1) =  220.000000      DA(7,1) =  230.000000     DA(8,1-10,20) =            0  DATE(1) =  106.000000
DATE(2) =  136.000000      DATE(3) =  166.000000     DATE(4) =  196.000000     DATE(5) =  226.000000
DATE(6) =  256.000000      DATE(7) =  286.000000     DATE(8-26) = NOT INITIALIZED DAY(1) =  124.000000
DAY(2) =  134.000000       DAY(3) =  150.000000      DAY(4) =  170.000000      DAY(5) =  200.000000
DAY(6) =  250.000000       DAY(7-26) = NOT INITIALIZED  DCI1(1) =  174.000000   DCI1(2-20) = NOT INITIALIZED
DCI2(1) =            0     DCI2(2-20) = NOT INITIALIZED DEF =  1.43000000      DIET(1,1,1) =  4.00000000
DIET(2,1,1) =  15.0000000  DIET(3,1,1) =            0  DIET(4,1,1) =  20.0000000  DIET(5,1,1) =  2.00000000
DIET(6,1,1) =  15.0000000  DIET(7,1,1) =  2.00000000  DIET(8,1,1) =  42.0000000  DIET(9,1,1-20,1,1) =            0
DIET(1,2,1) =  2.00000000  DIET(2,2,1) =  9.00000000  DIET(3,2,1) =  3.00000000  DIET(4,2,1) =  35.0000000
DIET(5,2,1) =  1.00000000  DIET(6,2,1) =  10.0000000  DIET(7,2,1) =  1.00000000  DIET(8,2,1) =  39.0000000
DIET(9,2,1-20,2,1) =            0                        DIET(1,3,1) =  3.00000000  DIET(2,3,1) =  12.0000000
DIET(3,3,1) =  4.00000000  DIET(4,3,1) =  40.0000000  DIET(5,3,1) =            0  DIET(6,3,1) =  10.0000000
DIET(7,3,1) =  4.00000000  DIET(8,3,1) =  27.0000000  DIET(9,3,1-1,4,1) =            0
```

```
DIET(2,4,1) =  5.00000000    DIET(3,4,1) =             0  DIET(4,4,1) =  38.0000000   DIET(5,4,1) =             0
DIET(6,4,1) =  12.0000000    DIET(7,4,1) =  4.00000000    DIET(8,4,1) =  41.0000000   DIET(9,4,1-20,20,20) =            0
DOI1(1) =  153.000000        DOI1(2-20) = NOT INITIALIZED DOI2(1) =             0     DOI2(2-20) = NOT INITIALIZED
DOM1(1-20) =            0    DOM2(1) =  225.000000        DOM2(2-20) =            0   EC1(1-20) =            0
EC2(1-20) =             0    EEATF(1,1-7,20) =            0                           EEATM(1,1-7,20) =            0
EP1(1-20) = NOT INITIALIZED  EP2(1-20) = NOT INITIALIZED  EP3(1-20) = NOT INITIALIZED ERA(1-20) =            0
ERATO =            0         ERF(1-20) =             0    ERFTO =             0       ERN(1-20) =            0
ERNTO =            0         EV1(1-20) = NOT INITIALIZED  EV2(1-20) = NOT INITIALIZED EV3(1-20) = NOT INITIALIZED
FA1(1-20) = NOT INITIALIZED  FDEF =             0         FS(1) =  .580000000     FS(2-20) = NOT INITIALIZED
FW(1) =  23.0000000          FW(2-20) = NOT INITIALIZED   GPREY(1,1-19,1) =            0
GPREY(20,1-20,20) = NOT INITIALIZED                       HMW(1) =  2.00000000    HMW(2-20) = NOT INITIALIZED
HS(1) =  .600000000          HS(2-20) = NOT INITIALIZED   IDDAT(1) =            1     IDDAT(2-20) =            0
JA1(1-20) = NOT INITIALIZED  JDR(1) =  .200000000E-02     JDR(2-20) =            0    MA1(1-20) = NOT INITIALIZED
NAMW =            0          NCAT =            8          NDA =            4          NDAT(1) =          135
NDAT(2) =          165       NDAT(3) =          185       NDAT(4) =          205      NDAT(5-20) =            0
NDEF =            0          NDT =            0           NOACB =            0        NOTMP =            7
NP(1) =            2         NP(2-20) = NOT INITIALIZED   NSP =            1          NUDAS(1) =            7
NUDAS(2-20) =            0   NUMDY =            6         PAER(1-20) =            0   PBD(1) =  81.0000000
PBD(2-20) = NOT INITIALIZED  PCT(1-50) = NOT INITIALIZED  PE(1) =            0        PE(2-20) = NOT INITIALIZED
PF(1) =  28.0000000          PF(2-20) = NOT INITIALIZED   PFS(1) =  .670000000    PFS(2-20) = NOT INITIALIZED
PI(1) =  11.0000000          PI(2-20) = NOT INITIALIZED   PM1(1-20) =            0    PM2(1) =  30.0000000
PM2(2-20) =            0     PN(1) =  9.00000000          PN(2-20) = NOT INITIALIZED  PPBF(1) =  .600000000
PPBF(2-20) = NOT INITIALIZED PPBF2(1) =            0      PPBF2(2-20) = NOT INITIALIZED
PREY(1-20) =            0    PS(1) =            0         PS(2-20) = NOT INITIALIZED  PTOT(1-20) =            0
TBM(1-20) = NOT INITIALIZED  TC(1) =  25.0000000          TC(2-20) =            0     TD(1) =  234.000000
TD(2-20) = NOT INITIALIZED   TDJ(1) =  234.000000         TDJ(2-20) = NOT INITIALIZED TE(1) =  250.000000
TE(2-20) = NOT INITIALIZED   TEDF(1-20) = NOT INITIALIZED TEDM(1-20) = NOT INITIALIZED TEI(1-20) =            0
TEITO = NOT INITIALIZED      TEJ(1) =  250.000000         TEJ(2-20) = NOT INITIALIZED TEMPC(1) =  13.1000000
TEMPC(2) =  21.3000000       TEMPC(3) =  19.7000000       TEMPC(4) =  24.4000000      TEMPC(5) =  26.2000000
TEMPC(6) =  30.5000000       TEMPC(7) =  27.3000000       TEMPC(8-26) = NOT INITIALIZED
THERF(1-20) =            0   THERM(1-20) =            0   TIN(1) =  132.000000        TIN(2-20) = NOT INITIALIZED
TOT(1,1-20,20) = NOT INITIALIZED                          TS(1) =  122.000000         TS(2-20) = NOT INITIALIZED
WM(1-20) =            0      WTF =            0           WTN =            0
```

SIMULATION RESULTS

```
TIME =  110.000000
      X(2) =            0     X(3) =            0     X(4) =            0     X(5) =            0
      X(6) =            0     ERN(1) =            0   ERF(1) =            0   ERA(1) =            0
      TEI(1) =            0   BMN(1) = NOT INITIALIZED  BMF(1) = NOT INITIALIZED  BMA(1) = NOT INITIALIZED
      TBM(1) = NOT INITIALIZED  A1 = NOT INITIALIZED  FA1(1) = NOT INITIALIZED  MA1(1) = NOT INITIALIZED
      JA1(1) = NOT INITIALIZED  TEITO = NOT INITIALIZED  EC1(1) =            0  EC2(1) =            0
      CAEP(1) =            0  CTEI(1) =            0  CEC(1) =            0   CTHER(1) =            0
      EEATM(1) =            0  EEATM(2) =            0  EEATM(3) =            0  EEATM(4) =            0
      EEATM(5) =            0  EEATM(6) =            0  EEATM(7) =            0  EEATF(1) =            0
      EEATF(2) =            0  EEATF(3) =            0  EEATF(4) =            0  EEATF(5) =            0
      EEATF(6) =            0  EEATF(7) =            0  TEDM(1) = NOT INITIALIZED  TEDF(1) = NOT INITIALIZED
      THERM(1) =            0  THERF(1) =            0  GPREY(1) =            0  GPREY(2) =            0
      GPREY(3) =            0  GPREY(4) =            0  GPREY(5) =            0  GPREY(6) =            0
      TOT(3) =            0   TOT(4) =            0   TOT(1) =            0   TOT(2) =            0
      TOT(7) =            0   TOT(8) =            0   TOT(5) =            0   TOT(6) =            0
      PREY(3) =            0  PREY(4) =            0  PREY(1) =            0  PREY(2) =            0
      PREY(7) =            0  PREY(8) =            0  PREY(5) =            0  PREY(6) =            0
      PTOT(3) =            0  PTOT(4) =            0  PTOT(1) =            0  PTOT(2) =            0
      PTOT(7) =            0  PTOT(8) =            0  PTOT(5) =            0  PTOT(6) =            0
TIME =  115.000000
      X(2) =            0     X(3) =            0     X(4) =            0     X(5) =            0
      X(6) =            0     ERN(1) =            0   ERF(1) =            0   ERA(1) =            0
      TFI(1) =            0   BMN(1) =            0   BMF(1) =            0   BMA(1) =            0
      TBM(1) =            0   A1 =            0       FA1(1) = NOT INITIALIZED  MA1(1) = NOT INITIALIZED
      JA1(1) = NOT INITIALIZED  TEITO =            0  EC1(1) =            0  EC2(1) =            0
      CAER(1) =            0  CTEI(1) =            0  CEC(1) =            0   CTHER(1) =            0
      EEATM(1) =            0  EEATM(2) =            0  EEATM(3) =            0  EEATM(4) =            0
      EEATM(5) =            0  EEATM(6) =            0  EEATM(7) =            0  EEATF(1) =            0
      EEATF(2) =            0  EEATF(3) =            0  EEATF(4) =            0  EEATF(5) =            0
      EEATF(6) =            0  EEATF(7) =            0  TEDM(1) = NOT INITIALIZED  TEDF(1) = NOT INITIALIZED
      THERM(1) =            0  THERF(1) =            0  GPREY(1) =            0  GPREY(2) =            0
      GPREY(3) =            0  GPREY(4) =            0  GPREY(5) =            0  GPREY(6) =            0
      TOT(3) =            0   TOT(4) =            0   TOT(1) =            0   TOT(2) =            0
      TOT(7) =            0   TOT(8) =            0   TOT(5) =            0   TOT(6) =            0
      PREY(3) =            0  PREY(4) =            0  PREY(1) =            0  PREY(2) =            0
      PREY(7) =            0  PREY(8) =            0  PREY(5) =            0  PREY(6) =            0
      PTOT(3) =            0  PTOT(4) =            0  PTOT(1) =            0  PTOT(2) =            0
      PTOT(7) =            0  PTOT(8) =            0  PTOT(5) =            0  PTOT(6) =            0
TIME =  120.000000
      X(2) =            0     X(3) =            0     X(4) =            0     X(5) =            0
      X(6) =            0     ERN(1) =            0   ERF(1) =            0   ERA(1) =            0
      TEI(1) =            0   BMN(1) =            0   BMF(1) =            0   BMA(1) =            0
      TBM(1) =            0   A1 =            0       FA1(1) = NOT INITIALIZED  MA1(1) = NOT INITIALIZED
      JA1(1) = NOT INITIALIZED  TEITO =            0  EC1(1) =            0  EC2(1) =            0
      CAER(1) =            0  CTEI(1) =            0  CEC(1) =            0   CTHER(1) =            0
      EEATM(1) =            0  EEATM(2) =            0  EEATM(3) =            0  EEATM(4) =            0
      EEATM(5) =            0  EEATM(6) =            0  EEATM(7) =            0  EEATF(1) =            0
      EEATF(2) =            0  EEATF(3) =            0  EEATF(4) =            0  EEATF(5) =            0
      EEATF(6) =            0  EEATF(7) =            0  TEDM(1) = NOT INITIALIZED  TEDF(1) = NOT INITIALIZED
      THERM(1) =            0  THERF(1) =            0  GPREY(1) =            0  GPREY(2) =            0
      GPREY(3) =            0  GPREY(4) =            0  GPREY(5) =            0  GPREY(6) =            0
      TOT(3) =            0   TOT(4) =            0   TOT(1) =            0   TOT(2) =            0
      TOT(7) =            0   TOT(8) =            0   TOT(5) =            0   TOT(6) =            0
      PREY(3) =            0  PREY(4) =            0  PREY(1) =            0  PREY(2) =            0
      PREY(7) =            0  PREY(8) =            0  PREY(5) =            0  PREY(6) =            0
      PTOT(3) =            0  PTOT(4) =            0  PTOT(1) =            0  PTOT(2) =            0
      PTOT(7) =            0  PTOT(8) =            0  PTOT(5) =            0  PTOT(6) =            0
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TIME =  125.000000
        X(2) =  16.1968410             X(3) =               0         X(4) =               0         X(5) =               0
        X(6) =              0          ERN(1) =             0         ERF(1) =             0         ERA(1) =  .636229930E-03
        TEI(1) =  .636229930E-03       BMN(1) =             0         BMF(1) =             0         BMA(1) =  .477806809E-03
        TBM(1) =  .477806809E-03       A1 =  39.2811123               FA1(1) =  44.4068903           MA1(1) =  31.5924453
        JA1(1) =  39.2811123           TEITO =  .636229930E-03        EC1(1) =             0         EC2(1) =             0
        CAER(1) =  .961846891E-03      CTEI(1) =  .961846891E-03      CEC(1) =             0         CTHER(1) =  .756822679E-04
        EEATM(1) =  5.17917416         EEATM(2) =  4.94776631         EEATM(3) =  6.32591126         EEATM(4) =  2.17340237
        EEATM(5) =  .391604030         EEATM(6) =             0       EEATM(7) =             0       EEATF(1) =  8.02527695
        EEATF(2) =             0       EEATF(3) =  16.8992201         EEATF(4) =  3.05451144         EEATF(5) =             0
        EEATF(6) =             0       EEATF(7) =             0       TEDM(1) =  19.0178581          TEDF(1) =  27.9790085
        THERM(1) =  3.07476097         THERF(1) =             0       GPREY(1) =  .289437298E-05     GPREY(2) =  .888046255E-05
        GPREY(3) =             0       GPREY(4) =  .127692926E-04     GPREY(5) =  .116291772E-05     GPREY(6) =  .856886738E-05
        GPREY(7) =  .132904882E-05     GPREY(8) =  .310816189E-04     TOT(1) =  .289437298E-05       TOT(2) =  .888046255E-05
        TOT(3) =             0         TOT(4) =  .127692926E-04       TOT(5) =  .116291772E-05       TOT(6) =  .856886738E-05
        TOT(7) =  .132904882E-05       TOT(8) =  .310816189E-04       PREY(1) =  .289437298E-05      PREY(2) =  .888046255E-05
        PREY(3) =             0        PREY(4) =  .127692926E-04      PREY(5) =  .116291772E-05      PREY(6) =  .856886738E-05
        PREY(7) =  .132904882E-05      PREY(8) =  .310816189E-04      PTOT(1) =  .289437298E-05      PTOT(2) =  .888046255E-05
        PTOT(3) =             0        PTOT(4) =  .127692926E-04      PTOT(5) =  .116291772E-05      PTOT(6) =  .856886738E-05
        PTOT(7) =  .132904882E-05      PTOT(8) =  .310816189E-04

TIME =  130.000000
        X(2) =  56.6810522             X(3) =               0         X(4) =               0         X(5) =               0
        X(6) =              0          ERN(1) =             0         ERF(1) =             0         ERA(1) =  .194995752E-02
        TEI(1) =  .194995752E-02       BMN(1) =             0         BMF(1) =             0         BMA(1) =  .164375051E-02
        TBM(1) =  .164375051E-02       A1 =  34.4022816               FA1(1) =  38.1371441           MA1(1) =  28.7999878
        JA1(1) =  34.4022816           TEITO =  .194995752E-02        EC1(1) =             0         EC2(1) =             0
        CAER(1) =  .824688363E-02      CTEI(1) =  .824688363E-02      CEC(1) =             0         CTHER(1) =  .612906490E-03
        EEATM(1) =  5.40489052         EEATM(2) =  4.73446206         EEATM(3) =  4.92008339         EEATM(4) =  2.23863794
        EEATM(5) =  .290732200         EEATM(6) =  .969107335E-01     EEATM(7) =             0       EEATF(1) =  8.31289090
        EEATF(2) =             0       EEATF(3) =  12.5685767         EEATF(4) =  3.33372923         EEATF(5) =             0
        EEATF(6) =             0       EEATF(7) =             0       TEDM(1) =  17.6857168          TEDF(1) =  24.2151968
        THERM(1) =  2.45413478         THERF(1) =             0       GPREY(1) =  .152830155E-04     GPREY(2) =  .468910703E-04
        GPREY(3) =             0       GPREY(4) =  .674250684E-04     GPREY(5) =  .614049730E-05     GPREY(6) =  .452457696E-04
        GPREY(7) =  .701771120E-05     GPREY(8) =  .164118746E-03     TOT(1) =  .559726766E-04       TOT(2) =  .171734349E-03
        TOT(3) =             0         TOT(4) =  .246938279E-03       TOT(5) =  .224890218E-04       TOT(6) =  .165708582E-03
        TOT(7) =  .257017392E-04       TOT(8) =  .601070220E-03       PREY(1) =  .152830155E-04      PREY(2) =  .468910703E-04
        PREY(3) =             0        PREY(4) =  .674250684E-04      PREY(5) =  .614049730E-05      PREY(6) =  .452457696E-04
        PREY(7) =  .701771120E-05      PREY(8) =  .164118746E-03      PTOT(1) =  .559726766E-04      PTOT(2) =  .171734349E-03
        PTOT(3) =             0        PTOT(4) =  .246938279E-03      PTOT(5) =  .224890218E-04      PTOT(6) =  .165708582E-03
        PTOT(7) =  .257017392E-04      PTOT(8) =  .601070220E-03

TIME =  135.000000
        X(2) =  80.9084333             X(3) =               0         X(4) =               0         X(5) =               0
        X(6) =              0          ERN(1) =             0         ERF(1) =             0         ERA(1) =  .238947527E-02
        TEI(1) =  .238947527E-02       BMN(1) =             0         BMF(1) =             0         BMA(1) =  .229577680E-02
        TBM(1) =  .229577680E-02       A1 =  29.5330804               FA1(1) =  31.8980333           MA1(1) =  25.9856511
        JA1(1) =  29.5330804           TEITO =  .238947527E-02        EC1(1) =             0         EC2(1) =             0
        CAER(1) =  .201819760E-01      CTEI(1) =  .201819760E-01      CEC(1) =             0         CTHER(1) =  .140087711E-02
        EEATM(1) =  5.60983573         EEATM(2) =  4.51235836         EEATM(3) =  3.53217875         EEATM(4) =  2.29591619
        EEATM(5) =  .191326349         EEATM(6) =  .191326349         EEATM(7) =             0       EEATF(1) =  8.56991927
        EEATF(2) =             0       EEATF(3) =  8.30062007         EEATF(4) =  3.59693537         EEATF(5) =             0
        EEATF(6) =             0       EEATF(7) =             0       TEDM(1) =  16.3329417          TEDF(1) =  20.4674747
        THERM(1) =  1.83884227         THERF(1) =             0       GPREY(1) =  .219425808E-04     GPREY(2) =  .673238274E-04
        GPREY(3) =             0       GPREY(4) =  .968055035E-04     GPREY(5) =  .881621549E-05     GPREY(6) =  .649615879E-04
        GPREY(7) =  .100756749E-04     GPREY(8) =  .235633396E-03     TOT(1) =  .158155562E-03       TOT(2) =  .485250020E-03
        TOT(3) =             0         TOT(4) =  .697745126E-03       TOT(5) =  .635446454E-04       TOT(6) =  .468223703E-03
        TOT(7) =  .726224519E-04       TOT(8) =  .169837507E-02       PREY(1) =  .219425808E-04      PREY(2) =  .673238274E-04
        PREY(3) =             0        PREY(4) =  .968055035E-04      PREY(5) =  .881621549E-05      PREY(6) =  .649615879E-04
        PREY(7) =  .100756749E-04      PREY(8) =  .235633396E-03      PTOT(1) =  .158155562E-03      PTOT(2) =  .485250020E-03
        PTOT(3) =             0        PTOT(4) =  .697745126E-03      PTOT(5) =  .635446454E-04      PTOT(6) =  .468223703E-03
        PTOT(7) =  .726224519E-04      PTOT(8) =  .169837507E-02

TIME =  140.000000
        X(2) =  80.7507849             X(3) =               0         X(4) =               0         X(5) =               0
        X(6) =              0          ERN(1) =             0         ERF(1) =             0         ERA(1) =  .237906708E-02
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         TEI(1) =  .237906708E-02    BMN(1) =              0    BMF(1) =              0    BMA(1) =  .224083428E-02
         TBM(1) =  .224083428E-02    A1 =  29.4618447           FA1(1) =  30.3589810       MA1(1) =  28.1161402
         JA1(1) =  29.4618447        TEITO =  .237906708E-02    EC1(1) =              0    EC2(1) =              0
         CAER(1) =  .320497196E-01   CTEI(1) =  .320497196E-01  CEC(1) =              0    CTHER(1) =  .206509982E-02
         EEATM(1) =  5.32989687      EEATM(2) =  4.33371148     EEATM(3) =  5.66427037     EEATM(4) =  2.22440618
         EEATM(5) =  .206509857      EEATM(6) =  .247811829     EEATM(7) =             0   EEATF(1) =  8.02281991
         EEATF(2) =             0    EEATF(3) =  8.19140638     EEATF(4) =  3.36080042     EEATF(5) =             0
         EEATF(6) =             0    EEATF(7) =             0   TEDM(1) =  18.0066066      TEDF(1) =  19.5750267
         THERM(1) =  1.65502992      THERF(1) =             0   GPREY(1) =  .197016131E-04 GPREY(2) =  .613116758E-04
         GPREY(3) =  .179226265E-05  GPREY(4) =  .102440110E-03 GPREY(5) =  .791582669E-05 GPREY(6) =  .597158855E-04
         GPREY(7) =  .904665907E-05  GPREY(8) =  .224521630E-03 TOT(1) =  .260225130E-03   TOT(2) =  .800574332E-03
         TOT(3) =  .447538185E-05    TOT(4) =  .118680943E-02   TOT(5) =  .104554740E-03   TOT(6) =  .773871111E-03
         TOT(7) =  .119491131E-03    TOT(8) =  .282680785E-02   PREY(1) =  .197016131E-04  PREY(2) =  .613116758E-04
         PREY(3) =  .179226265E-05   PREY(4) =  .102440110E-03  PREY(5) =  .791582669E-05  PREY(6) =  .597158855E-04
         PREY(7) =  .904665907E-05   PREY(8) =  .224521630E-03  PTOT(1) =  .260225130E-03  PTOT(2) =  .800574332E-03
         PTOT(3) =  .447538185E-05   PTOT(4) =  .118680943E-02  PTOT(5) =  .104554740E-03  PTOT(6) =  .773871111E-03
         PTOT(7) =  .119491131E-03   PTOT(8) =  .282680785E-02
TIME =   145.000000
         X(2) =  80.5934436          X(3) =              0      X(4) =              0      X(5) =              0
         X(6) =              0       ERN(1) =              0    ERF(1) =              0    ERA(1) =  .239956307E-02
         TEI(1) =  .239956307E-02    BMN(1) =              0    BMF(1) =              0    BMA(1) =  .218609716E-02
         TBM(1) =  .218609716E-02    A1 =  29.7736758           FA1(1) =  29.2413713       MA1(1) =  30.5721326
         JA1(1) =  29.7736758        TEITO =  .239956307E-02    EC1(1) =              0    EC2(1) =              0
         CAER(1) =  .440072778E-01   CTEI(1) =  .440072778E-01  CEC(1) =              0    CTHER(1) =  .275598983E-02
         EEATM(1) =  5.05483236      EEATM(2) =  4.15773341     EEATM(3) =  7.73731728     EEATM(4) =  2.15373241
         EEATM(5) =  .221194140      EEATM(6) =  .302686718     EEATM(7) =             0   EEATF(1) =  7.48638104
         EEATF(2) =             0    EEATF(3) =  8.08119805     EEATF(4) =  3.12931499     EEATF(5) =             0
         EEATF(6) =             0    EEATF(7) =             0   TEDM(1) =  19.6274963      TEDF(1) =  18.6968941
         THERM(1) =  1.75161736      THERF(1) =             0   GPREY(1) =  .181001721E-04 GPREY(2) =  .574946642E-04
         GPREY(3) =  .406801869E-05  GPREY(4) =  .115083274E-03 GPREY(5) =  .727239056E-05 GPREY(6) =  .567381554E-04
         GPREY(7) =  .831130349E-05  GPREY(8) =  .223771846E-03 TOT(1) =  .353947046E-03   TOT(2) =  .109573029E-02
         TOT(3) =  .202491169E-04    TOT(4) =  .173689109E-02   TOT(5) =  .142210867E-03   TOT(6) =  .106355965E-02
         TOT(7) =  .162526705E-03    TOT(8) =  .394725451E-02   PREY(1) =  .181001721E-04  PREY(2) =  .574946642E-04
         PREY(3) =  .406801869E-05   PREY(4) =  .115083274E-03  PREY(5) =  .727239056E-05  PREY(6) =  .567381554E-04
         PREY(7) =  .831130349E-05   PREY(8) =  .223771846E-03  PTOT(1) =  .353947046E-03  PTOT(2) =  .109573029E-02
         PTOT(3) =  .202491169E-04   PTOT(4) =  .173689109E-02  PTOT(5) =  .142210867E-03  PTOT(6) =  .106355965E-02
         PTOT(7) =  .162526705E-03   PTOT(8) =  .394725451E-02
TIME =   150.000000
         X(2) =  80.4364090          X(3) =              0      X(4) =              0      X(5) =              0
         X(6) =              0       ERN(1) =              0    ERF(1) =              0    ERA(1) =  .244182808E-02
         TEI(1) =  .244182808E-02    BMN(1) =              0    BMF(1) =              0    BMA(1) =  .213960848E-02
         TBM(1) =  .213960848E-02    A1 =  30.3572488           FA1(1) =  28.5819107       MA1(1) =  33.0202560
         JA1(1) =  30.1295321        TEITO =  .244182808E-02    EC1(1) =  .159242447       EC2(1) =              0
         CAER(1) =  .561128815E-01   CTEI(1) =  .561128815E-01  CEC(1) =  .379265663E-04   CTHER(1) =  .348440610E-02
         EEATM(1) =  4.79542479      EEATM(2) =  3.99338426     EEATM(3) =  9.77234612     EEATM(4) =  2.08857343
         EEATM(5) =  .235899478      EEATM(6) =  .356726040     EEATM(7) =             0   EEATF(1) =  6.97633803
         EEATF(2) =             0    EEATF(3) =  7.98783074     EEATF(4) =  2.90904332     EEATF(5) =             0
         EEATF(6) =             0    EEATF(7) =             0   TEDM(1) =  21.2423541      TEDF(1) =  17.8732121
         THERM(1) =  1.84873397      THERF(1) =             0   GPREY(1) =  .165670978E-04 GPREY(2) =  .539249212E-04
         GPREY(3) =  .642161913E-05  GPREY(4) =  .128702199E-03 GPREY(5) =  .665642323E-05 GPREY(6) =  .540231451E-04
         GPREY(7) =  .760734084E-05  GPREY(8) =  .224318832E-03 TOT(1) =  .439718986E-03   TOT(2) =  .137206144E-02
         TOT(3) =  .475773673E-04    TOT(4) =  .235196293E-02   TOT(5) =  .176672807E-03   TOT(6) =  .133866513E-02
         TOT(7) =  .201911779E-03    TOT(8) =  .506583691E-02   PREY(1) =  .165670978E-04  PREY(2) =  .539249212E-04
         PREY(3) =  .642161913E-05   PREY(4) =  .128702199E-03  PREY(5) =  .665642323E-05  PREY(6) =  .540231451E-04
         PREY(7) =  .760734084E-05   PREY(8) =  .224318832E-03  PTOT(1) =  .439718986E-03  PTOT(2) =  .137206144E-02
         PTOT(3) =  .475773673E-04   PTOT(4) =  .235196293E-02  PTOT(5) =  .176672807E-03  PTOT(6) =  .133866513E-02
         PTOT(7) =  .201911779E-03   PTOT(8) =  .506583691E-02
TIME =   155.000000
         X(2) =  80.2796803          X(3) =  1.79127450         X(4) =              0      X(5) =              0
         X(6) =              0       ERN(1) =              0    ERF(1) =              0    ERA(1) =  .232655770E-02
         TEI(1) =  .232655770E-02    BMN(1) =              0    BMF(1) =              0    BMA(1) =  .209529965E-02
         TBM(1) =  .209529965E-02    A1 =  28.9806547           FA1(1) =  26.9323528       MA1(1) =  32.0531076
         JA1(1) =  28.3966805        TEITO =  .232655770E-02    EC1(1) =  .408373563       EC2(1) =              0
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         CAER(1) =   .680599650E-01     CTEI(1) =   .680599650E-01     CEC(1) =   .215686001E-03      CTHER(1) =   .425021264E-02
         EEATM(1) =  4.82907650         EEATM(2) =  3.82744250         EEATM(3) =  8.97371925          EEATM(4) =  2.05717752
         EEATM(5) =  .236666441         EEATM(6) =  .546153325         EEATM(7) =           0          EEATF(1) =  6.45996875
         EEATF(2) =           0         EEATF(3) =  6.83952010         EEATF(4) =  2.90917671          EEATF(5) =           0
         EEATF(6) =           0         EEATF(7) =           0         TEDM(1) =  20.4702355           TEDF(1) =  16.2086656
         THERM(1) =  1.94452502         THERF(1) =           0         GPREY(1) =   .143218861E-04     GPREY(2) =   .480148376E-04
         GPREY(3) =  .845274685E-05     GPREY(4) =   .136386684E-03    GPREY(5) =   .575432923E-05     GPREY(6) =   .489499637E-04
         GPREY(7) =  .657637626E-05     GPREY(8) =   .214887833E-03    TOT(1) =   .516594888E-03       TOT(2) =   .162655149E-02
         TOT(3) =  .862243289E-04       TOT(4) =   .302580905E-02      TOT(5) =   .207560446E-03       TOT(6) =   .159620401E-02
         TOT(7) =  .237211938E-03       TOT(8) =   .617069139E-02      PREY(1) =   .143218861E-04      PREY(2) =   .480148376E-04
         PREY(3) =  .845274685E-05      PREY(4) =   .136386684E-03     PREY(5) =   .575432923E-05      PREY(6) =   .489499637E-04
         PREY(7) =  .657637626E-05      PREY(8) =   .214887833E-03     PTOT(1) =   .516594888E-03      PTOT(2) =   .162655149E-02
         PTOT(3) =  .862243289E-04      PTOT(4) =   .302580905E-02     PTOT(5) =   .207560446E-03      PTOT(6) =   .159620401E-02
         PTOT(7) =  .237211938E-03      PTOT(8) =   .617069139E-02
 TIME =  160.000000
         X(2) =   80.1232569            X(3) =   37.5678913            X(4) =            0              X(5) =            0
         X(6) =            0            ERN(1) =           0           ERF(1) =           0            ERA(1) =   .217173105E-02
         TEI(1) =  .217173105E-02       BMN(1) =           0           BMF(1) =           0            BMA(1) =   .205115538E-02
         TBM(1) =  .205115538E-02       A1 =  27.1048773               FA1(1) =  24.9977289             MA1(1) =  30.2656000
         JA1(1) =  26.1782598           TEITO =  .217173105E-02        EC1(1) =  .647984260             EC2(1) =            0
         CAER(1) =  .792271101E-01      CTEI(1) =  .792271101E-01      CEC(1) =  .532658896E-03         CTHER(1) =   .505243401E-02
         EEATM(1) =  4.93104404         EEATM(2) =  3.66240818         EEATM(3) =  7.50057740          EEATM(4) =  2.03365600
         EEATM(5) =  .233960424         EEATM(6) =  .764870619         EEATM(7) =           0          EEATF(1) =  5.94824029
         EEATF(2) =           0         EEATF(3) =  5.45307759         EEATF(4) =  2.96139907          EEATF(5) =           0
         EEATF(6) =           0         EEATF(7) =           0         TEDM(1) =  19.1265167           TEDF(1) =  14.3627169
         THERM(1) =  2.03823858         THERF(1) =           0         GPREY(1) =   .117464722E-04     GPREY(2) =   .408456874E-04
         GPREY(3) =  .997341979E-05     GPREY(4) =   .138193790E-03    GPREY(5) =   .471956472E-05     GPREY(6) =   .425036823E-04
         GPREY(7) =  .539378825E-05     GPREY(8) =   .198221718E-03    TOT(1) =   .580379357E-03       TOT(2) =   .184486958E-02
         TOT(3) =  .133162658E-03       TOT(4) =   .371370319E-02      TOT(5) =   .233188134E-03       TOT(6) =   .182140995E-02
         TOT(7) =  .266500725E-03       TOT(8) =   .719488571E-02      PREY(1) =   .117464722E-04      PREY(2) =   .408456874E-04
         PREY(3) =  .997341979E-05      PREY(4) =   .138193790E-03     PREY(5) =   .471956472E-05      PREY(6) =   .425036823E-04
         PREY(7) =  .539378825E-05      PREY(8) =   .198221718E-03     PTOT(1) =   .580379357E-03      PTOT(2) =   .184486958E-02
         PTOT(3) =  .133162658E-03      PTOT(4) =   .371370319E-02     PTOT(5) =   .233188134E-03      PTOT(6) =   .182140995E-02
         PTOT(7) =  .266500725E-03      PTOT(8) =   .719488571E-02
 TIME =  165.000000
         X(2) =   79.9671384            X(3) =   116.132838            X(4) =            0              X(5) =            0
         X(6) =            0            ERN(1) =           0           ERF(1) =           0            ERA(1) =   .197488814E-02
         TEI(1) =  .197488814E-02       BMN(1) =           0           BMF(1) =           0            BMA(1) =   .200717517E-02
         TBM(1) =  .200717517E-02       A1 =  24.6962462               FA1(1) =  22.1541300             MA1(1) =  28.5094206
         JA1(1) =  24.0025188           TEITO =  .197488814E-02        EC1(1) =  .485124054             EC2(1) =            0
         CAER(1) =  .895146425E-01      CTEI(1) =  .895146425E-01      CEC(1) =  .868626739E-03         CTHER(1) =   .589008492E-02
         EEATM(1) =  5.02891095         EEATM(2) =  3.49985577         EEATM(3) =  6.05857938          EEATM(4) =  2.00994876
         EEATM(5) =  .231233043         EEATM(6) =  .978293644         EEATM(7) =           0          EEATF(1) =  5.44613746
         EEATF(2) =           0         EEATF(3) =  4.09651912         EEATF(4) =  3.01136571          EEATF(5) =           0
         EEATF(6) =           0         EEATF(7) =           0         TEDM(1) =  17.8068216           TEDF(1) =  12.5540223
         THERM(1) =  2.12983621         THERF(1) =           0         GPREY(1) =   .925859413E-05     GPREY(2) =   .337219176E-04
         GPREY(3) =  .110308570E-04     GPREY(4) =   .136375402E-03    GPREY(5) =   .371997086E-05     GPREY(6) =   .359576130E-04
         GPREY(7) =  .425139526E-05     GPREY(8) =   .179147687E-03    TOT(1) =   .631694784E-03       TOT(2) =   .202801313E-02
         TOT(3) =  .186499145E-03       TOT(4) =   .440199573E-02      TOT(5) =   .253805940E-03       TOT(6) =   .201465860E-02
         TOT(7) =  .290063932E-03       TOT(8) =   .813142077E-02      PREY(1) =   .925859413E-05      PREY(2) =   .337219176E-04
         PREY(3) =  .110308570E-04      PREY(4) =   .136375402E-03     PREY(5) =   .371997086E-05      PREY(6) =   .359576130E-04
         PREY(7) =  .425139526E-05      PREY(8) =   .179147687E-03     PTOT(1) =   .631694784E-03      PTOT(2) =   .202801313E-02
         PTOT(3) =  .186499145E-03      PTOT(4) =   .440199573E-02     PTOT(5) =   .253805940E-03      PTOT(6) =   .201465860E-02
         PTOT(7) =  .290063932E-03      PTOT(8) =   .813142077E-02
 TIME =  170.000000
         X(2) =   79.8113241            X(3) =   151.560661            X(4) =   16.2661224            X(5) =            0
         X(6) =            0            ERN(1) =  .794720680E-04       ERF(1) =           0            ERA(1) =   .176797364E-02
         TEI(1) =  .184744571E-02       BMN(1) =  .776515953E-04       BMF(1) =           0            BMA(1) =   .201124537E-02
         TBM(1) =  .208889696E-02       A1 =  22.1519147               FA1(1) =  19.0601431             MA1(1) =  26.7895722
         JA1(1) =  21.8036896           TEITO =  .184744571E-02        EC1(1) =  .243514069             EC2(1) =            0
         CAER(1) =  .987847279E-01      CTEI(1) =  .989515956E-01      CEC(1) =  .106247614E-02         CTHER(1) =   .672558542E-02
         EEATM(1) =  5.19652982         EEATM(2) =  3.38799648         EEATM(3) =  4.71515103          EEATM(4) =  2.01470531
         EEATM(5) =  .231780257         EEATM(6) =  1.20347441         EEATM(7) =           0          EEATF(1) =  5.02524010
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          EEATF(2) =            0        EEATF(3) =  2.81016418       EEATF(4) =  3.10318106       EEATF(5) =            0
          EEATF(6) =            0        EEATF(7) =            0      TEDM(1) =  16.7496373        TEDF(1) =  10.9385853
          THERM(1) =  1.98432925         THERF(1) =            0      GPREY(1) =  .885894746E-05   GPREY(2) =  .316286389E-04
          GPREY(3) =  .109407241E-04     GPREY(4) =  .127909937E-03   GPREY(5) =  .258865348E-05   GPREY(6) =  .317904813E-04
          GPREY(7) =  .591692224E-05     GPREY(8) =  .150730232E-03   TOT(1) =  .675875939E-03     TOT(2) =  .218815051E-02
          TOT(3) =  .241892578E-03       TOT(4) =  .506147141E-02     TOT(5) =  .269072869E-03     TOT(6) =  .218092176E-02
          TOT(7) =  .315083440E-03       TOT(8) =  .894613158E-02     PREY(1) =  .885894746E-05    PREY(2) =  .316286389E-04
          PREY(3) =  .109407241E-04      PREY(4) =  .127909937E-03    PREY(5) =  .258865348E-05    PREY(6) =  .317904813E-04
          PREY(7) =  .591692224E-05      PREY(8) =  .150730232E-03    PTOT(1) =  .675875939E-03    PTOT(2) =  .218815051E-02
          PTOT(3) =  .241892578E-03      PTOT(4) =  .506147141E-02    PTOT(5) =  .269072869E-03    PTOT(6) =  .218092176E-02
          PTOT(7) =  .315083440E-03      PTOT(8) =  .894613158E-02

TIME =    175.000000
          X(2) =  79.6558133             X(3) =  97.5215982           X(4) =  58.5580408           X(5) =  .628956735
          X(6) =            0            ERN(1) =  .420640827E-03     ERF(1) =  .148715473E-04     ERA(1) =  .177475922E-02
          TEI(1) =  .221027159E-02       BMN(1) =  .556088664E-03     BMF(1) =  .144660049E-04     BMA(1) =  .202724045E-02
          TBM(1) =  .259779512E-02       A1 =  22.2803477             FA1(1) =  19.7748771         MA1(1) =  26.0385537
          JA1(1) =  22.2803477           TEITO =  .221027159E-02      EC1(1) =            0        EC2(1) =            0
          CAER(1) =  .107531100          CTEI(1) =  .109014486        CEC(1) =  .111823452E-02     CTHER(1) =  .744141162E-02
          EEATM(1) =  5.30170364         EEATM(2) =  3.40471507       EEATM(3) =  4.40353361       EEATM(4) =  2.01938988
          EEATM(5) =  .225970804         EEATM(6) =  1.18365659       EEATM(7) =            0      EEATF(1) =  5.23755810
          EEATF(2) =            0        EEATF(3) =  3.60339280       EEATF(4) =  3.31782530       EEATF(5) =            0
          EEATF(6) =            0        EEATF(7) =            0      TEDM(1) =  16.5389696        TEDF(1) =  12.1587762
          THERM(1) =  1.66980918         THERF(1) =  1.59634111       GPREY(1) =  .959314430E-05   GPREY(2) =  .331577511E-04
          GPREY(3) =  .114696623E-04     GPREY(4) =  .128695543E-03   GPREY(5) =  .173054170E-05   GPREY(6) =  .309123877E-04
          GPREY(7) =  .845043740E-05     GPREY(8) =  .134553193E-03   TOT(1) =  .721517501E-03     TOT(2) =  .234785027E-02
          TOT(3) =  .297134633E-03       TOT(4) =  .569124232E-02     TOT(5) =  .279215824E-03     TOT(6) =  .233424783E-02
          TOT(7) =  .351651152E-03       TOT(8) =  .963733495E-02     PREY(1) =  .959314430E-05    PREY(2) =  .331577511E-04
          PREY(3) =  .114696623E-04      PREY(4) =  .128695543E-03    PREY(5) =  .173054170E-05    PREY(6) =  .309123877E-04
          PREY(7) =  .845043740E-05      PREY(8) =  .134553193E-03    PTOT(1) =  .721517501E-03    PTOT(2) =  .234785027E-02
          PTOT(3) =  .297134633E-03      PTOT(4) =  .569124232E-02    PTOT(5) =  .279215824E-03    PTOT(6) =  .233424783E-02
          PTOT(7) =  .351651152E-03      PTOT(8) =  .963733495E-02

TIME =    180.000000
          X(2) =  79.5006056             X(3) =  25.7380893           X(4) =  80.2462041           X(5) =  13.2080914
          X(6) =            0            ERN(1) =  .728417379E-03     ERF(1) =  .307634798E-03     ERA(1) =  .186690774E-02
          TEI(1) =  .290295992E-02       BMN(1) =  .108560538E-02     BMF(1) =  .305908832E-03     BMA(1) =  .204316556E-02
          TBM(1) =  .343467977E-02       A1 =  23.4829374             FA1(1) =  22.0954579         MA1(1) =  25.5641566
          JA1(1) =  23.4829374           TEITO =  .290295992E-02      EC1(1) =            0        EC2(1) =            0
          CAER(1) =  .116681064          CTEI(1) =  .122134774        CEC(1) =  .111823452E-02     CTHER(1) =  .807923604E-02
          EEATM(1) =  5.38699496         EEATM(2) =  3.45089533       EEATM(3) =  4.34594315       EEATM(4) =  2.02214015
          EEATM(5) =  .218268473         EEATM(6) =  1.10036172       EEATM(7) =            0      EEATF(1) =  5.60756129
          EEATF(2) =            0        EEATF(3) =  4.92873246       EEATF(4) =  3.56264657       EEATF(5) =            0
          EEATF(6) =            0        EEATF(7) =            0      TEDM(1) =  16.5246038        TEDF(1) =  14.0989403
          THERM(1) =  1.35242883         THERF(1) =  1.28732945       GPREY(1) =  .110905363E-04   GPREY(2) =  .373045312E-04
          GPREY(3) =  .129040831E-04     GPREY(4) =  .139537793E-03   GPREY(5) =  .990226455E-06   GPREY(6) =  .324284687E-04
          GPREY(7) =  .116941029E-04     GPREY(8) =  .128549398E-03   TOT(1) =  .773872012E-03     TOT(2) =  .252576306E-02
          TOT(3) =  .358676795E-03       TOT(4) =  .636622870E-02     TOT(5) =  .285669250E-03     TOT(6) =  .249315689E-02
          TOT(7) =  .403466477E-03       TOT(8) =  .102917169E-01     PREY(1) =  .110905363E-04    PREY(2) =  .373045312E-04
          PREY(3) =  .129040831E-04      PREY(4) =  .139537793E-03    PREY(5) =  .990226455E-06    PREY(6) =  .324284687E-04
          PREY(7) =  .116941029E-04      PREY(8) =  .128549398E-03    PTOT(1) =  .773872012E-03    PTOT(2) =  .252576306E-02
          PTOT(3) =  .358676795E-03      PTOT(4) =  .636622870E-02    PTOT(5) =  .285669250E-03    PTOT(6) =  .249315689E-02
          PTOT(7) =  .403466477E-03      PTOT(8) =  .102917169E-01

TIME =    185.000000
          X(2) =  79.3457003             X(3) =            0          X(4) =  48.7983673           X(5) =  40.8821878
          X(6) =            0            ERN(1) =  .524289039E-03     ERF(1) =  .938526852E-03     ERA(1) =  .195974378E-02
          TEI(1) =  .342255967F-02       BMN(1) =  .845300211E-03     BMF(1) =  .954868637E-03     BMA(1) =  .205902092E-02
          TBM(1) =  .385918977E-02       A1 =  24.6988025             FA1(1) =  24.4424456         MA1(1) =  25.0833379
          JA1(1) =  24.6988025           TEITO =  .342255967E-02      EC1(1) =            0        EC2(1) =            0
          CAER(1) =  .126293838          CTEI(1) =  .138344355        CEC(1) =  .111823452E-02     CTHER(1) =  .870402629E-02
          EEATM(1) =  5.47279338         EEATM(2) =  3.49730204       EEATM(3) =  4.28729128       EEATM(4) =  2.02474030
          EEATM(5) =  .210456877         EEATM(6) =  1.01599872       EEATM(7) =            0      EEATF(1) =  5.98136400
          EEATF(2) =            0        EEATF(3) =  6.26904702       EEATF(4) =  3.80999518       EEATF(5) =            0
          EEATF(6) =            0        EEATF(7) =            0      TEDM(1) =  16.5085826        TEDF(1) =  16.0604062
          THERM(1) =  1.03221312         THERF(1) =  .978317782       GPREY(1) =  .127251335E-04   GPREY(2) =  .418223570E-04
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         GPREY(3) =  .144668531E-04     GPREY(4) =  .151293337E-03     GPREY(5) =  .173314469E-06     GPREY(6) =  .340547729E-04
         GPREY(7) =  .152516733E-04     GPREY(8) =  .121761293E-03     TOT(1) =  .834185567E-03       TOT(2) =  .272573236E-02
         TOT(3) =  .427848564E-03       TOT(4) =  .709898153E-02       TOT(5) =  .288202668E-03       TOT(6) =  .266017334E-02
         TOT(7) =  .472494251E-03       TOT(8) =  .109145871E-01       PREY(1) =  .127251335E-04      PREY(2) =  .418223570E-04
         PREY(3) =  .144668531E-04      PREY(4) =  .151293337E-03      PREY(5) =  .173314469E-06      PREY(6) =  .340547729E-04
         PREY(7) =  .152516733E-04      PREY(8) =  .121761293E-03      PTOT(1) =  .834185567E-03      PTOT(2) =  .272573236E-02
         PTOT(3) =  .427848564E-03      PTOT(4) =  .709898153E-02      PTOT(5) =  .288202668E-03      PTOT(6) =  .266017334E-02
         PTOT(7) =  .472494251E-03      PTOT(8) =  .109145871E-01

TIME =   190.000000
         X(2) =  79.1910968             X(3) =            0            X(4) =  10.8440816             X(5) =  62.8956735
         X(6) =            0            ERN(1) =  .134851914E-03       ERF(1) =  .142836979E-02       ERA(1) =  .205325733E-02
         TEI(1) =  .361647903E-02       BMN(1) =  .232168184E-03       BMF(1) =  .149152597E-02       BMA(1) =  .207480674E-02
         TBM(1) =  .379850089E-02       A1 =  25.9278809               FA1(1) =  26.8157014           MA1(1) =  24.5961501
         JA1(1) =  25.9278809           TEITO =  .361647903E-02        EC1(1) =            0           EC2(1) =            0
         CAER(1) =  .136372829          CTEI(1) =  .156119193          CEC(1) =  .111823452E-02       CTHER(1) =  .927036960E-02
         EEATM(1) =  5.55909688         EEATM(2) =  3.54393449         EEATM(3) =  4.22758494         EEATM(4) =  2.02719154
         EEATM(5) =  .202536689         EEATM(6) =  .930573976         EEATM(7) =            0         EEATF(1) =  6.35894510
         EEATF(2) =            0        EEATF(3) =  7.62425014         EEATF(4) =  4.05985705         EEATF(5) =            0
         EEATF(6) =            0        EEATF(7) =            0        TEDM(1) =  16.4909185          TEDF(1) =  18.0430523
         THERM(1) =  .709186459         THERF(1) =  .669306117         GPREY(1) =  .108506714E-04     GPREY(2) =  .392103808E-04
         GPREY(3) =  .122837790E-04     GPREY(4) =  .157973011E-03     GPREY(5) =            0        GPREY(6) =  .371207180E-04
         GPREY(7) =  .166081706E-04     GPREY(8) =  .137791197E-03     TOT(1) =  .894036131E-03       TOT(2) =  .293076959E-02
         TOT(3) =  .495603920E-03       TOT(4) =  .787820367E-02       TOT(5) =  .288202668E-03       TOT(6) =  .283889361E-02
         TOT(7) =  .554008349E-03       TOT(8) =  .115594016E-01       PREY(1) =  .108506714E-04      PREY(2) =  .392103808E-04
         PREY(3) =  .122837790E-04      PREY(4) =  .157973011E-03      PREY(5) =            0         PREY(6) =  .371207180E-04
         PREY(7) =  .166081706E-04      PREY(8) =  .137791197E-03      PTOT(1) =  .894036131E-03      PTOT(2) =  .293076959E-02
         PTOT(3) =  .495603920E-03      PTOT(4) =  .787820367E-02      PTOT(5) =  .288202668E-03      PTOT(6) =  .283889361E-02
         PTOT(7) =  .554008349E-03      PTOT(8) =  .115594016E-01

TIME =   195.000000
         X(2) =  79.0367946             X(3) =            0            X(4) =            0            X(5) =  69.1852408
         X(6) =            0            ERN(1) =            0          ERF(1) =  .156235884E-02       ERA(1) =  .214743851E-02
         TEI(1) =  .370979735E-02       BMN(1) =            0          BMF(1) =  .168076894E-02       BMA(1) =  .209052322E-02
         TBM(1) =  .377129216E-02       A1 =  27.1701113               FA1(1) =  29.2150887           MA1(1) =  24.1026452
         JA1(1) =  27.1701113           TEITO =  .370979735E-02        EC1(1) =            0           EC2(1) =            0
         CAER(1) =  .146921394          CTEI(1) =  .174488420          CEC(1) =  .111823452E-02       CTHER(1) =  .965839845E-02
         EEATM(1) =  5.64590348         EEATM(2) =  3.59079197         EEATM(3) =  4.16683094         EEATM(4) =  2.02949510
         EEATM(5) =  .194508572         EEATM(6) =  .844093802         EEATM(7) =            0         EEATF(1) =  6.74028380
         EEATF(2) =            0        EEATF(3) =  8.99425703         EEATF(4) =  4.31221833         EEATF(5) =            0
         EEATF(6) =            0        EEATF(7) =            0        TEDM(1) =  16.4716239          TEDF(1) =  20.0467592
         THERM(1) =  .383372795         THERF(1) =  .360294452         GPREY(1) =  .780468087E-05     GPREY(2) =  .342502937E-04
         GPREY(3) =  .883548778E-05     GPREY(4) =  .163188782E-03     GPREY(5) =            0        GPREY(6) =  .407038380E-04
         GPREY(7) =  .173759129E-04     GPREY(8) =  .161092483E-03     TOT(1) =  .939275718E-03       TOT(2) =  .311217593E-02
         TOT(3) =  .546818546E-03       TOT(4) =  .868376929E-02       TOT(5) =  .288202668E-03       TOT(6) =  .303517559E-02
         TOT(7) =  .639350259E-03       TOT(8) =  .123176439E-01       PREY(1) =  .780468087E-05      PREY(2) =  .342502937E-04
         PREY(3) =  .883548778E-05      PREY(4) =  .163188782E-03      PREY(5) =            0         PREY(6) =  .407038380E-04
         PREY(7) =  .173759129E-04      PREY(8) =  .161092483E-03      PTOT(1) =  .939275718E-03      PTOT(2) =  .311217593E-02
         PTOT(3) =  .546818546E-03      PTOT(4) =  .868376929E-02      PTOT(5) =  .288202668E-03      PTOT(6) =  .303517559E-02
         PTOT(7) =  .639350259E-03      PTOT(8) =  .123176439E-01

TIME =   200.000000
         X(2) =  78.8827930             X(3) =            0            X(4) =            0            X(5) =  69.1852408
         X(6) =            0            ERN(1) =            0          ERF(1) =  .157131517E-02       ERA(1) =  .225606614E-02
         TEI(1) =  .382738131E-02       BMN(1) =            0          BMF(1) =  .173296674E-02       BMA(1) =  .210617057E-02
         TBM(1) =  .383913731E-02       A1 =  28.6002315               FA1(1) =  31.8152712           MA1(1) =  23.7776718
         JA1(1) =  28.6002315           TEITO =  .382738131E-02        EC1(1) =            0           EC2(1) =            0
         CAER(1) =  .157970411          CTEI(1) =  .193363709          CEC(1) =  .111823452E-02       CTHER(1) =  .984145520E-02
         EEATM(1) =  5.73321122         EEATM(2) =  3.63787378         EEATM(3) =  4.10503596         EEATM(4) =  2.03165213
         EEATM(5) =  .186373175         EEATM(6) =  .756564372         EEATM(7) =            0         EEATF(1) =  7.12535969
         EEATF(2) =            0        EEATF(3) =  10.3789844         EEATF(4) =  4.56706542         EEATF(5) =            0
         EEATF(6) =            0        EEATF(7) =            0        TEDM(1) =  16.4507106          TEDF(1) =  22.0714095
         THERM(1) =  .177031910         THERF(1) =  .167784535         GPREY(1) =  .446489185E-05     GPREY(2) =  .288188474E-04
         GPREY(3) =  .505459454E-05     GPREY(4) =  .168965515E-03     GPREY(5) =            0        GPREY(6) =  .446489185E-04
         GPREY(7) =  .182240484E-04     GPREY(8) =  .186713659E-03     TOT(1) =  .968379252E-03       TOT(2) =  .326719531E-02
         TOT(3) =  .579765944E-03       TOT(4) =  .951605532E-02       TOT(5) =  .288202668E-03       TOT(6) =  .325018194E-02
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         TOT(7) =  .728659564E-03    TOT(8) =  .131981861E-01    PREY(1) =  .446489185E-05    PREY(2) =  .288188474E-04
         PREY(3) =  .505459454E-05   PREY(4) =  .168965515E-03   PREY(5) =          0         PREY(6) =  .446489185E-04
         PREY(7) =  .182240484E-04   PREY(8) =  .186713659E-03   PTOT(1) =  .968379252E-03    PTOT(2) =  .326719531E-02
         PTOT(3) =  .579765944E-03   PTOT(4) =  .951605532E-02   PTOT(5) =  .288202668E-03    PTOT(6) =  .325018194E-02
         PTOT(7) =  .728659564E-03   PTOT(8) =  .131981861E-01

TIME =   205.000000
         X(2) =  78.7290915          X(3) =          0           X(4) =          0            X(5) =  65.4115004
         X(6) =  2.51998648          ERN(1) =          0         ERF(1) =  .150249722E-02     ERA(1) =  .236369781E-02
         TEI(1) =  .386619503E-02    BMN(1) =          0         BMF(1) =  .169134687E-02     BMA(1) =  .218966265E-02
         TBM(1) =  .388100952E-02    A1 =  29.0919954            FA1(1) =  32.8103243         MA1(1) =  23.5145021
         JA1(1) =  29.0919954        TEITO =  .386619503E-02     EC1(1) =          0          EC2(1) =          0
         CAER(1) =  .169517801       CTEI(1) =  .212678015       CEC(1) =  .111823452E-02     CTHER(1) =  .992277130E-02
         EEATM(1) =  5.82811791      EEATM(2) =  3.66050578      EEATM(3) =  3.98739697       EEATM(4) =  2.06335232
         EEATM(5) =  .170709005      EEATM(6) =  .682836021      EEATM(7) =          0        EEATF(1) =  7.26442695
         EEATF(2) =          0       EEATF(3) =  11.1297704      EEATF(4) =  4.49929561       EEATF(5) =          0
         EEATF(6) =          0       EEATF(7) =          0       TEDM(1) =  16.3929180        TEDF(1) =  22.8934930
         THERM(1) =  .507897801E-01  THERF(1) =  .486082191E-01  GPREY(1) =  .774780887E-06   GPREY(2) =  .226095150E-04
         GPREY(3) =  .877110438E-06  GPREY(4) =  .173642069E-03  GPREY(5) =          0        GPREY(6) =  .485257503E-04
         GPREY(7) =  .189742258E-04  GPREY(8) =  .212888657E-03  TOT(1) =  .979767649E-03     TOT(2) =  .339293460E-02
         TOT(3) =  .592658468E-03    TOT(4) =  .103751286E-01    TOT(5) =  .288202668E-03     TOT(6) =  .348502507E-02
         TOT(7) =  .822045349E-03    TOT(8) =  .142098099E-01    PREY(1) =  .774780887E-06    PREY(2) =  .226095150E-04
         PREY(3) =  .877110438E-06   PREY(4) =  .173642069E-03   PREY(5) =          0         PREY(6) =  .485257503E-04
         PREY(7) =  .189742258E-04   PREY(8) =  .212888657E-03   PTOT(1) =  .979767649E-03    PTOT(2) =  .339293460E-02
         PTOT(3) =  .592658468E-03   PTOT(4) =  .103751286E-01   PTOT(5) =  .288202668E-03    PTOT(6) =  .348502507E-02
         PTOT(7) =  .822045349E-03   PTOT(8) =  .142098099E-01

TIME =   210.000000
         X(2) =  78.5756895          X(3) =          0           X(4) =          0            X(5) =  46.5427984
         X(6) =  15.0696533          ERN(1) =          0         ERF(1) =  .108668565E-02     ERA(1) =  .276780742E-02
         TEI(1) =  .385449307E-02    BMN(1) =          0         BMF(1) =  .124325220E-02     BMA(1) =  .256588239E-02
         TBM(1) =  .380913460E-02    A1 =  29.5562741            FA1(1) =  33.6300408         MA1(1) =  23.4456239
         JA1(1) =  29.5562741        TEITO =  .385449307E-02     EC1(1) =          0          EC2(1) =          0
         CAER(1) =  .182407118       CTEI(1) =  .231976326       CEC(1) =  .111823452E-02     CTHER(1) =  .992939183E-02
         EEATM(1) =  5.95125296      EEATM(2) =  3.69293874      EEATM(3) =  3.87117540       EEATM(4) =  2.11187782
         EEATM(5) =  .153659256      EEATM(6) =  .614637024      EEATM(7) =          0        EEATF(1) =  7.37371792
         EEATF(2) =          0       EEATF(3) =  11.7761225      EEATF(4) =  4.36767065       EEATF(5) =          0
         EEATF(6) =          0       EEATF(7) =          0       TEDM(1) =  16.3955412        TEDF(1) =  23.5175111
         THERM(1) =          0       THERF(1) =          0       GPREY(1) =          0        GPREY(2) =  .246505509E-04
         GPREY(3) =          0       GPREY(4) =  .202037849E-03  GPREY(5) =          0        GPREY(6) =  .570854864E-04
         GPREY(7) =  .221351886E-04  GPREY(8) =  .252668147E-03  TOT(1) =  .979767649E-03     TOT(2) =  .350757668E-02
         TOT(3) =  .592658468E-03    TOT(4) =  .113147440E-01    TOT(5) =  .288202668E-03     TOT(6) =  .375051199E-02
         TOT(7) =  .924989254E-03    TOT(8) =  .153848911E-01    PREY(1) =          0         PREY(2) =  .246505509E-04
         PREY(3) =          0        PREY(4) =  .202037849E-03   PREY(5) =          0         PREY(6) =  .570854864E-04
         PREY(7) =  .221351886E-04   PREY(8) =  .252668147E-03   PTOT(1) =  .979767649E-03    PTOT(2) =  .350757668E-02
         PTOT(3) =  .592658468E-03   PTOT(4) =  .113147440E-01   PTOT(5) =  .288202668E-03    PTOT(6) =  .375051199E-02
         PTOT(7) =  .924989254E-03   PTOT(8) =  .153848911E-01

TIME =   215.000000
         X(2) =  78.4225863          X(3) =          0           X(4) =          0            X(5) =  17.6107886
         X(6) =  34.1854880          ERN(1) =          0         ERF(1) =  .418281335E-03     ERA(1) =  .339268655E-02
         TEI(1) =  .381096788E-02    BMN(1) =          0         BMF(1) =  .484149929E-03     BMA(1) =  .314176527E-02
         TBM(1) =  .362591520E-02    A1 =  30.1282707            FA1(1) =  34.5681693         MA1(1) =  23.4684229
         JA1(1) =  30.1282707        TEITO =  .381096788E-02     EC1(1) =          0          EC2(1) =          0
         CAER(1) =  .198152141       CTEI(1) =  .251115358       CEC(1) =  .111823452E-02     CTHER(1) =  .992939183E-02
         EEATM(1) =  6.08176599      EEATM(2) =  3.72903467      EEATM(3) =  3.75566703       EEATM(4) =  2.16312200
         EEATM(5) =  .136378971      EEATM(6) =  .545515882      EEATM(7) =          0        EEATF(1) =  7.49124964
         EEATF(2) =          0       EEATF(3) =  12.4454553      EEATF(4) =  4.23684002       EEATF(5) =          0
         EEATF(6) =          0       EEATF(7) =          0       TEDM(1) =  16.4114845        TEDF(1) =  24.1735449
         THERM(1) =          0       THERF(1) =          0       GPREY(1) =          0        GPREY(2) =  .311421622E-04
         GPREY(3) =          0       GPREY(4) =  .255243604E-03  GPREY(5) =          0        GPREY(6) =  .721186915E-04
         GPREY(7) =  .279643906E-04  GPREY(8) =  .319207163E-03  TOT(1) =  .979767649E-03     TOT(2) =  .364978366E-02
         TOT(3) =  .592658468E-03    TOT(4) =  .124802836E-01    TOT(5) =  .288202668E-03     TOT(6) =  .407983342E-02
         TOT(7) =  .105268532E-02    TOT(8) =  .168425127E-01    PREY(1) =          0         PREY(2) =  .311421622E-04
         PREY(3) =          0        PREY(4) =  .255243604E-03   PREY(5) =          0         PREY(6) =  .721186915E-04
         PREY(7) =  .279643906E-04   PREY(8) =  .319207163E-03   PTOT(1) =  .979767649E-03    PTOT(2) =  .364978366E-02
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       PTOT(3) =  .592658468E-03     PTOT(4) =  .124802836E-01     PTOT(5) =  .288202668E-03     PTOT(6) =  .407983342E-02
       PTOT(7) =  .105268532E-02     PTOT(8) =  .168425127E-01

TIME = 220.000800
       X(2) =  78.2697815            X(3) =             0          X(4) =             0          X(5) =  1.88687020
       X(6) =  44.3085953            ERN(1) =            0          ERF(1) =  .455681691E-04     ERA(1) =  .376356463E-02
       TFI(1) =  .380913280E-02      BMN(1) =            0          BMF(1) =  .533445162E-04     BMA(1) =  .348122590E-02
       TBM(1) =  .353457042E-02      AI =  30.7033322               FAI(1) =  35.5158863          MAI(1) =  23.4845011
       JAI(1) =  30.7033322          TEITO =  .380913280E-02        EC1(1) =             0          EC2(1) =             0
       CAER(1) =  .216352748         CTEI(1) =  .270143524          CEC(1) =  .111823452E-02      CTHER(1) =  .992939183E-02
       EEATM(1) =  6.21322190        EEATM(2) =  3.76476232         EEATM(3) =  3.63651594        EEATM(4) =  2.21480548
       EEATM(5) =  .118684477        EEATM(6) =  .474737908         EEATM(7) =            0        EEATF(1) =  7.60901143
       EEATF(2) =            0        EEATF(3) =  13.1253841         EEATF(4) =  4.10188867        EEATF(5) =            0
       EEATF(6) =            0        EEATF(7) =            0        TEDM(1) =  16.4227280         TEDF(1) =  24.8362842
       THERM(1) =            0        THERF(1) =            0        GPREY(1) =            0        GPREY(2) =  .360734969E-04
       GPREY(3) =            0        GPREY(4) =  .295661210E-03     GPREY(5) =            0        GPREY(6) =  .835386244E-04
       GPREY(7) =  .323925278E-04     GPREY(8) =  .369753343E-03     TOT(1) =  .979767649E-03      TOT(2) =  .382139589E-02
       TOT(3) =  .592658468E-03      TOT(4) =  .138868309E-01       TOT(5) =  .288202668E-03      TOT(6) =  .447725121E-02
       TOT(7) =  .120678609E-02      TOT(8) =  .186015380E-01       PREY(1) =            0        PREY(2) =  .360734969E-04
       PREY(3) =            0         PREY(4) =  .295661210E-03      PREY(5) =            0        PREY(6) =  .835386244E-04
       PREY(7) =  .323925278E-04     PREY(8) =  .369753343E-03      PTOT(1) =  .979767649E-03     PTOT(2) =  .382139589E-02
       PTOT(3) =  .592658468E-03     PTOT(4) =  .138868309E-01      PTOT(5) =  .288202668E-03     PTOT(6) =  .447725121E-02
       PTOT(7) =  .120678609E-02     PTOT(8) =  .186015380E-01

TIME = 225.000000
       X(2) =  78.1172745            X(3) =             0          X(4) =             0          X(5) =             0
       X(6) =  45.1197257            ERN(1) =            0          ERF(1) =            0        ERA(1) =  .388667710E-02
       TFI(1) =  .388667710E-02      BMN(1) =            0          BMF(1) =            0        BMA(1) =  .361084410E-02
       TBM(1) =  .361084410E-02      AI =  31.5382320               FAI(1) =  36.7725165          MAI(1) =  23.6868052
       JAI(1) =  31.5382320          TEITO =  .388667710E-02        EC1(1) =             0          EC2(1) =             0
       CAER(1) =  .235588963         CTEI(1) =  .289394981          CEC(1) =  .111823452E-02      CTHER(1) =  .992939183E-02
       EEATM(1) =  6.39770516        EEATM(2) =  3.83132295         EEATM(3) =  3.54260763        EEATM(4) =  2.28553395
       EEATM(5) =  .101405943        EEATM(6) =  .405623773         EEATM(7) =            0        EEATF(1) =  7.79043599
       EEATF(2) =            0        EEATF(3) =  13.9292164         EEATF(4) =  3.99539417        EEATF(5) =            0
       EEATF(6) =            0        EEATF(7) =            0        TEDM(1) =  16.5641994         TEDF(1) =  25.7150465
       THERM(1) =            0        THERF(1) =            0        GPREY(1) =            0        GPREY(2) =  .384255649E-04
       GPREY(3) =            0        GPREY(4) =  .314938943E-03     GPREY(5) =            0        GPREY(6) =  .889855186E-04
       GPREY(7) =  .345045889E-04     GPREY(8) =  .393862040E-03     TOT(1) =  .979767649E-03      TOT(2) =  .400957186E-02
       TOT(3) =  .592658468E-03      TOT(4) =  .154291359E-01       TOT(5) =  .288202668E-03      TOT(6) =  .491302713E-02
       TOT(7) =  .137576043E-02      TOT(8) =  .205303417E-01       PREY(1) =            0        PREY(2) =  .384255649E-04
       PREY(3) =            0         PREY(4) =  .314938943E-03      PREY(5) =            0        PREY(6) =  .889855186E-04
       PREY(7) =  .345045889E-04     PREY(8) =  .393862040E-03      PTOT(1) =  .979767649E-03     PTOT(2) =  .400957186E-02
       PTOT(3) =  .592658468E-03     PTOT(4) =  .154291359E-01      PTOT(5) =  .288202668E-03     PTOT(6) =  .491302713E-02
       PTOT(7) =  .137576043E-02     PTOT(8) =  .205303417E-01

TIME = 230.000000
       X(2) =  77.9650645            X(3) =             0          X(4) =             0          X(5) =             0
       X(6) =  44.6703296            ERN(1) =            0          ERF(1) =            0        ERA(1) =  .431949647E-02
       TFI(1) =  .431949647E-02      BMN(1) =            0          BMF(1) =            0        BMA(1) =  .371585244E-02
       TBM(1) =  .371585244E-02      AI =  35.2222660               FAI(1) =  40.9003691          MAI(1) =  26.7051114
       JAI(1) =  35.2222660          TEITO =  .431949647E-02        EC1(1) =             0          EC2(1) =             0
       CAER(1) =  .256116431         CTEI(1) =  .309922449          CEC(1) =  .111823452E-02      CTHER(1) =  .992939183E-02
       EEATM(1) =  6.59618970        EEATM(2) =  3.90454388         EEATM(3) =  3.44875379        EEATM(4) =  2.36145366
       EEATM(5) =  .835560689E-01    EEATM(6) =  .334224276         EEATM(7) =            0        EEATF(1) =  7.98721277
       EEATF(2) =            0        EEATF(3) =  14.7793240         EEATF(4) =  3.88893818        EEATF(5) =            0
       EEATF(6) =            0        EEATF(7) =            0        TEDM(1) =  16.7287214         TEDF(1) =  26.6554750
       THERM(1) =            0        THERF(1) =            0        GPREY(1) =            0        GPREY(2) =  .424343631E-04
       GPREY(3) =            0        GPREY(4) =  .347795369E-03     GPREY(5) =            0        GPREY(6) =  .982690515E-04
       GPREY(7) =  .381043261E-04     GPREY(8) =  .434952222E-03     TOT(1) =  .979767649E-03      TOT(2) =  .421188649E-02
       TOT(3) =  .592658468E-03      TOT(4) =  .170873225E-01       TOT(5) =  .288202668E-03      TOT(6) =  .538154524E-02
       TOT(7) =  .155743072E-02      TOT(8) =  .226040668E-01       PREY(1) =            0        PREY(2) =  .424343631E-04
       PREY(3) =            0         PREY(4) =  .347795369E-03      PREY(5) =            0        PREY(6) =  .982690515E-04
       PREY(7) =  .381043261E-04     PREY(8) =  .434952222E-03      PTOT(1) =  .979767649E-03     PTOT(2) =  .421188649E-02
       PTOT(3) =  .592658468E-03     PTOT(4) =  .170873225E-01      PTOT(5) =  .288202668E-03     PTOT(6) =  .538154524E-02
       PTOT(7) =  .155743072E-02     PTOT(8) =  .226040668E-01
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```
TIME =  235.000000
        X(2) =  77.8131512          X(3) =              0           X(4) =              0           X(5) =              0
        X(6) =  44.2254095          ERN(1) =            0           ERF(1) =            0           ERA(1) =  .576925947E-02
        TEI(1) =  .576925947E-02    BMN(1) =            0           BMF(1) =            0           BMA(1) =  .378690960E-02
        TBM(1) =  .378690960E-02    A1 =  47.2740700                FA1(1) =  53.3763161            MA1(1) =  38.1207009
        JA1(1) =  47.2740700        TEITO =  .576925947E-02         EC1(1) =            0           EC2(1) =            0
        CAEP(1) =  .281563395       CTEI(1) =  .335369413           CEC(1) =  .111823452E-02        CTHER(1) =  .992939183E-02
        EEATM(1) =  6.76080848      EEATM(2) =  3.95618137          EEATM(3) =  3.33033222          EEATM(4) =  2.42541813
        EEATM(5) =  .645701997E-01  EEATM(6) =  .258280799          EEATM(7) =          0           EEATF(1) =  8.14146960
        EEATF(2) =          0       EEATF(3) =  15.5676268          EEATF(4) =  3.75475711          EEATF(5) =          0
        EEATF(6) =          0       EEATF(7) =          0           TEDM(1) =  16.7955912           TEDF(1) =  27.4638535
        THERM(1) =          0       THERF(1) =          0           GPREY(1) =          0           GPREY(2) =  .558784910E-04
        GPREY(3) =          0       GPREY(4) =  .457984495E-03      GPREY(5) =          0           GPREY(6) =  .129402821E-03
        GPREY(7) =  .501766041E-04  GPREY(8) =  .572754532E-03      TOT(1) =  .979767649E-03        TOT(2) =  .445889369E-02
        TOT(3) =  .592658468E-03    TOT(4) =  .191118128E-01        TOT(5) =  .288202668E-03        TOT(6) =  .595356190E-02
        TOT(7) =  .177923310E-02    TOT(8) =  .251358905E-01        PREY(1) =           0           PREY(2) =  .558784910E-04
        PREY(3) =           0       PREY(4) =  .457984495E-03       PREY(5) =           0           PREY(6) =  .129402821E-03
        PREY(7) =  .501766041E-04   PREY(8) =  .572754532E-03       PTOT(1) =  .979767649E-03       PTOT(2) =  .445889369E-02
        PTOT(3) =  .592658468E-03   PTOT(4) =  .191118128E-01       PTOT(5) =  .288202668E-03       PTOT(6) =  .595356190E-02
        PTOT(7) =  .177923310E-02   PTOT(8) =  .251358905E-01

TIME =  240.000000
        X(2) =  26.6768479          X(3) =              0           X(4) =              0           X(5) =              0
        X(6) =  15.0103900          ERN(1) =            0           ERF(1) =            0           ERA(1) =  .250485769E-02
        TEI(1) =  .250485769E-02    BMN(1) =            0           BMF(1) =            0           BMA(1) =  .132121357E-02
        TBM(1) =  .132121357E-02    A1 =  60.0869190                FA1(1) =  66.6138555            MA1(1) =  50.2965142
        JA1(1) =  60.0869190        TEITO =  .250485769E-02         EC1(1) =            0           EC2(1) =            0
        CAER(1) =  .303393784       CTEI(1) =  .357199801           CEC(1) =  .111823452E-02        CTHER(1) =  .992939183E-02
        EEATM(1) =  6.91775834      EEATM(2) =  4.00211986          EEATM(3) =  3.20272499          EEATM(4) =  2.48676443
        EEATM(5) =  .449538352E-01  EEATM(6) =  .179815341          EEATM(7) =          0           EEATF(1) =  8.28529928
        EEATF(2) =          0       EEATF(3) =  16.3493641          EEATF(4) =  3.61020164          EEATF(5) =          0
        EEATF(6) =          0       EEATF(7) =          0           TEDM(1) =  16.8341368           TEDF(1) =  28.2448650
        THERM(1) =          0       THERF(1) =          0           GPREY(1) =          0           GPREY(2) =  .378540243E-04
        GPREY(3) =          0       GPREY(4) =  .310254552E-03      GPREY(5) =          0           GPREY(6) =  .876619509E-04
        GPREY(7) =  .339913687E-04  GPREY(8) =  .388003749E-03      TOT(1) =  .979767649E-03        TOT(2) =  .472239166E-02
        TOT(3) =  .592658468E-03    TOT(4) =  .212714628E-01        TOT(5) =  .288202668E-03        TOT(6) =  .656376772E-02
        TOT(7) =  .201584352E-02    TOT(8) =  .278367447E-01        PREY(1) =           0           PREY(2) =  .378540243E-04
        PREY(3) =           0       PREY(4) =  .310254552E-03       PREY(5) =           0           PREY(6) =  .876619509E-04
        PREY(7) =  .339913687E-04   PREY(8) =  .388003749E-03       PTOT(1) =  .979767649E-03       PTOT(2) =  .472239166E-02
        PTOT(3) =  .592658468E-03   PTOT(4) =  .212714628E-01       PTOT(5) =  .288202668E-03       PTOT(6) =  .656376772E-02
        PTOT(7) =  .201584352E-02   PTOT(8) =  .278367447E-01

TIME =  245.000000
        X(2) =  .766242063          X(3) =              0           X(4) =              0           X(5) =              0
        X(6) =  .424015734          ERN(1) =            0           ERF(1) =            0           ERA(1) =  .624759145E-04
        TEI(1) =  .624759145E-04    BMN(1) =            0           BMF(1) =            0           BMA(1) =  .385126023E-04
        TBM(1) =  .385126023E-04    A1 =  52.4893974                FA1(1) =  59.4489893            MA1(1) =  42.0500096
        JA1(1) =  52.4893974        TEITO =  .624759145E-04         EC1(1) =            0           EC2(1) =            0
        CAER(1) =  .306493145       CTEI(1) =  .360299162           CEC(1) =  .111823452E-02        CTHER(1) =  .992939183E-02
        EEATM(1) =  7.07576041      EEATM(2) =  4.04753632          EEATM(3) =  3.07055691          EEATM(4) =  2.54861316
        EEATM(5) =  .248241541E-01  EEATM(6) =  .992966165E-01      EEATM(7) =          0           EEATF(1) =  8.42927641
        EEATF(2) =          0       EEATF(3) =  17.1439428          EEATF(4) =  3.46048709          EEATF(5) =          0
        EEATF(6) =          0       EEATF(7) =          0           TEDM(1) =  16.8665876           TEDF(1) =  29.0337063
        THERM(1) =          0       THERF(1) =          0           GPREY(1) =          0           GPREY(2) =  .190683766E-05
        GPREY(3) =          0       GPREY(4) =  .156285910E-04      GPREY(5) =          0           GPREY(6) =  .441583457E-05
        GPREY(7) =  .171226238E-05  GPREY(8) =  .195450860E-04      TOT(1) =  .979767649E-03        TOT(2) =  .478160658E-02
        TOT(3) =  .592658468E-03    TOT(4) =  .217567930E-01        TOT(5) =  .288202668E-03        TOT(6) =  .670089702E-02
        TOT(7) =  .206901610E-02    TOT(8) =  .284436976E-01        PREY(1) =           0           PREY(2) =  .190683766E-05
        PREY(3) =           0       PREY(4) =  .156285910E-04       PREY(5) =           0           PREY(6) =  .441583457E-05
        PREY(7) =  .171226238E-05   PREY(8) =  .195450860E-04       PTOT(1) =  .979767649E-03       PTOT(2) =  .478160658E-02
        PTOT(3) =  .592658468E-03   PTOT(4) =  .217567930E-01       PTOT(5) =  .288202668E-03       PTOT(6) =  .670089702E-02
        PTOT(7) =  .206901610E-02   PTOT(8) =  .284436976E-01

TIME =  250.000000
        X(2) =  .864464328E-04      X(3) =              0           X(4) =              0           X(5) =              0
        X(6) =  .450712557E-04      ERN(1) =            0           ERF(1) =            0           ERA(1) =  .522990353E-08
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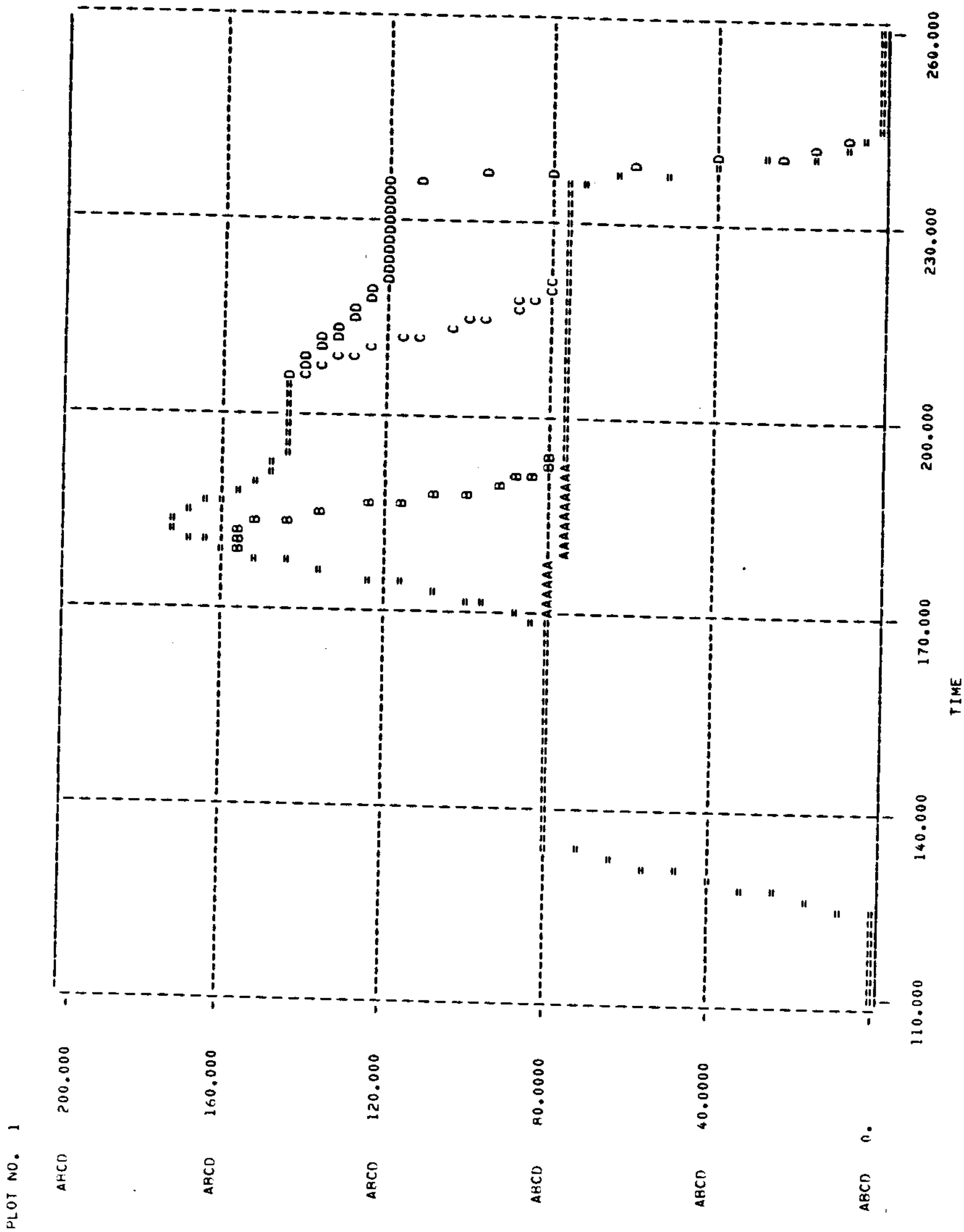
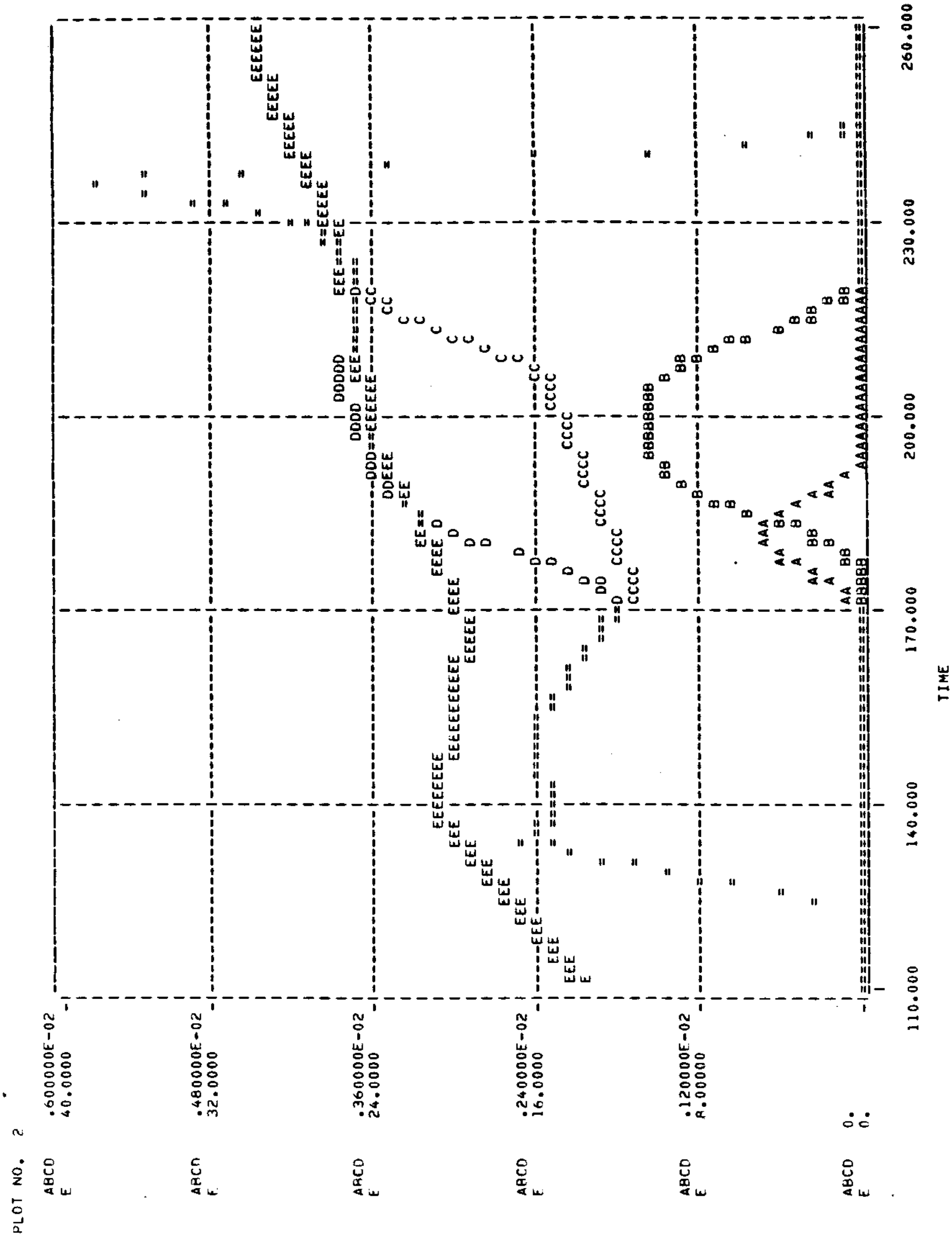
```
          TEI(1) =  .522990353E-08     BMN(1) =           0      BMF(1) =            0     BMA(1) =  .434265689E-08
          TBM(1) =  .434265689E-08     A1 =  39.7657805          FA1(1) =  47.1659052      MA1(1) =  28.6655935
          JA1(1) =  39.7657805         TEITO =  .522990353E-08   EC1(1) =            0     EC2(1) =            0
          CAER(1) =  .306516617        CTEI(1) =  .360322634     CEC(1) =  .111823452E-02  CTHER(1) =  .992939183E-02
          EEATM(1) =  7.23481349       EEATM(2) =  4.09244405    EEATM(3) =  2.93388995    EEATM(4) =  2.61096234
          EEATM(5) =  .418758996E-02   EEATM(6) =  .167503598E-01 EEATM(7) =           0   EEATF(1) =  8.57341334
          EEATF(2) =            0      EEATF(3) =  17.9512318    EEATF(4) =  3.30568351    EEATF(5) =            0
          EEATF(6) =            0      EEATF(7) =            0   TEDM(1) =  16.8930478     TEDF(1) =  29.8303286
          THERM(1) =            0      THERF(1) =            0   GPREY(1) =            0   GPREY(2) =  .980476291E-09
          GPREY(3) =            0      GPREY(4) =  .803606058E-08 GPREY(5) =           0   GPREY(6) =  .227057667E-08
          GPREY(7) =  .880427690E-09   GPREY(8) =  .100498820E-07 TOT(1) =  .979767649E-03 TOT(2) =  .478254163E-02
          TOT(3) =  .592658468E-03     TOT(4) =  .217644568E-01  TOT(5) =  .288202668E-03  TOT(6) =  .670306241E-02
          TOT(7) =  .206985574E-02     TOT(8) =  .284532819E-01  PREY(1) =            0    PREY(2) =  .980476291E-09
          PREY(3) =            0       PREY(4) =  .803606058E-08 PREY(5) =            0    PREY(6) =  .227057667E-08
          PREY(7) =  .880427690E-09    PREY(8) =  .100498820E-07 PTOT(1) =  .979767649E-03 PTOT(2) =  .478254163E-02
          PTOT(3) =  .592658468E-03    PTOT(4) =  .217644568E-01 PTOT(5) =  .288202668E-03 PTOT(6) =  .670306241E-02
          PTOT(7) =  .206985574E-02    PTOT(8) =  .284532819E-01

 TIME =   255.000000
          X(2) =  .862779937E-04       X(3) =              0     X(4) =              0     X(5) =              0
          X(6) =            0          ERN(1) =            0     ERF(1) =            0     ERA(1) =  .359674050E-10
          TEI(1) =  .359674050E-10     BMN(1) =            0     BMF(1) =            0     BMA(1) =  .290606790E-08
          TBM(1) =  .290606790E-08     A1 =  .416878088          FA1(1) =  .416878088      MA1(1) =  .416878088
          JA1(1) =  .416878088         TEITO =  .359674050E-10   EC1(1) =            0     EC2(1) =            0
          CAER(1) =  .306516617        CTEI(1) =  .360322635     CEC(1) =  .111823452E-02  CTHER(1) =  .992939183E-02
          EEATM(1) =            0      EEATM(2) =            0   EEATM(3) =            0   EEATM(4) =            0
          EEATM(5) =            0      EEATM(6) =            0   EEATM(7) =            0   EEATF(1) =            0
          EEATF(2) =            0      EEATF(3) =            0   EEATF(4) =            0   EEATF(5) =            0
          EEATF(6) =            0      EEATF(7) =            0   TEDM(1) =            0    TEDF(1) =            0
          THERM(1) =            0      THERF(1) =            0   GPREY(1) =            0   GPREY(2) =  .706850613E-12
          GPREY(3) =            0      GPREY(4) =  .579340307E-11 GPREY(5) =           0   GPREY(6) =  .163691721E-11
          GPREY(7) =  .634723000E-12   GPREY(8) =  .724521879E-11 TOT(1) =  .979767649E-03 TOT(2) =  .478254170E-02
          TOT(3) =  .592658468E-03     TOT(4) =  .217644573E-01  TOT(5) =  .288202668E-03  TOT(6) =  .670306256E-02
          TOT(7) =  .206985580E-02     TOT(8) =  .284532826E-01  PREY(1) =            0    PREY(2) =  .706850613E-12
          PREY(3) =            0       PREY(4) =  .579340307E-11 PREY(5) =            0    PREY(6) =  .163691721E-11
          PREY(7) =  .634723000E-12    PREY(8) =  .724521879E-11 PTOT(1) =  .979767649E-03 PTOT(2) =  .478254170E-02
          PTOT(3) =  .592658468E-03    PTOT(4) =  .217644573E-01 PTOT(5) =  .288202668E-03 PTOT(6) =  .670306256E-02
          PTOT(7) =  .206985580E-02    PTOT(8) =  .284532826E-01

 TIME =   260.000000
          X(2) =  .861098828E-04       X(3) =              0     X(4) =              0     X(5) =              0
          X(6) =            0          ERN(1) =            0     ERF(1) =            0     ERA(1) =            0
          TEI(1) =            0        BMN(1) =            0     BMF(1) =            0     BMA(1) =  .295750008E-08
          TBM(1) =  .295750008E-08     A1 =            0         FA1(1) =            0     MA1(1) =            0
          JA1(1) =            0        TEITO =            0      EC1(1) =            0     EC2(1) =            0
          CAER(1) =  .306516617        CTEI(1) =  .360322635     CEC(1) =  .111823452E-02  CTHER(1) =  .992939183E-02
          EEATM(1) =            0      EEATM(2) =            0   EEATM(3) =            0   EEATM(4) =            0
          EEATM(5) =            0      EEATM(6) =            0   EEATM(7) =            0   EEATF(1) =            0
          EEATF(2) =            0      EEATF(3) =            0   EEATF(4) =            0   EEATF(5) =            0
          EEATF(6) =            0      EEATF(7) =            0   TEDM(1) =            0    TEDF(1) =            0
          THERM(1) =            0      THERF(1) =            0   GPREY(1) =            0   GPREY(2) =            0
          GPREY(3) =            0      GPREY(4) =            0   GPREY(5) =            0   GPREY(6) =            0
          GPREY(7) =            0      GPREY(8) =            0   TOT(1) =  .979767649E-03  TOT(2) =  .478254170E-02
          TOT(3) =  .592658468E-03     TOT(4) =  .217644573E-01  TOT(5) =  .288202668E-03  TOT(6) =  .670306256E-02
          TOT(7) =  .206985580E-02     TOT(8) =  .284532826E-01  PREY(1) =            0    PREY(2) =            0
          PREY(3) =            0       PREY(4) =            0    PREY(5) =            0    PREY(6) =            0
          PREY(7) =            0       PREY(8) =            0    PTOT(1) =  .979767649E-03 PTOT(2) =  .478254170E-02
          PTOT(3) =  .592658468E-03    PTOT(4) =  .217644573E-01 PTOT(5) =  .288202668E-03 PTOT(6) =  .670306256E-02
          PTOT(7) =  .206985580E-02    PTOT(8) =  .284532826E-01
                 CUMULATIVE ENERGY REQUIREMENTS

                 NSP          NESTLINGS          FLEDGLINGS           ADULTS
                  1      .9431316477E-02    .4437470093E-01    .3065166172E+00
                 PEAK ADULT ENERGY REQUIREMENT =      .5783796127E-02          SPECIES NO. =    1
```

GRAPHICAL SIMULATION RESULTS 03/07/74 10.43.57.

GRAPH NO.	GROUP	GROUP RANGE DECLARATION	DEPENDENT VARIABLE(S)	PLOTTED CHARACTER	INDEPENDENT VARIABLE	INDEPENDENT VARIABLE RANGE DECLARATION
1	1		X(2) AN ANF ANFJ	A B C D	TIME	
2	1		ERN(1) ERF(1) ERA(1) TEI(1)	A B C D	TIME	
	2		AVDEG	E		
3	1		A1	A	TIME	
4	1		FA1(1)	A	TIME	
5	1		MA1(1)	A	TIME	
6	1		JA1(1)	A	TIME	
7	1		TEITO	A	TIME	
8	1		EEATM(1) EEATF(1)	A B	TIME	
9	1		EEATM(2) EEATF(2)	A B	TIME	
10	1		EEATM(3) EEATF(3)	A B	TIME	

11	1	EEATM(4) EEATF(4)	A B	TIME
12	1	EEATM(5) EEATF(5)	A B	TIME
13	1	EEATM(6) EEATF(6)	A B	TIME
14	1	EEATM(7) EEATF(7)	A B	TIME
15	1	AMW(1)	A	TIME
16	1	EC1(1) EC2(1)	A B	TIME
17	1	THERM(1) THERF(1)	A B	TIME
18	1	GPREY(1) GPREY(2) GPREY(3) GPREY(4)	A B C D	TIME
19	1	GPREY(5) GPREY(6) GPREY(7) GPREY(8)	A B C D	TIME


PLOT NO. 1
ABCD 200.000
ABCD 160.000
ABCD 120.000
ABCD 80.0000
ABCD 40.0000
ABCD 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 2
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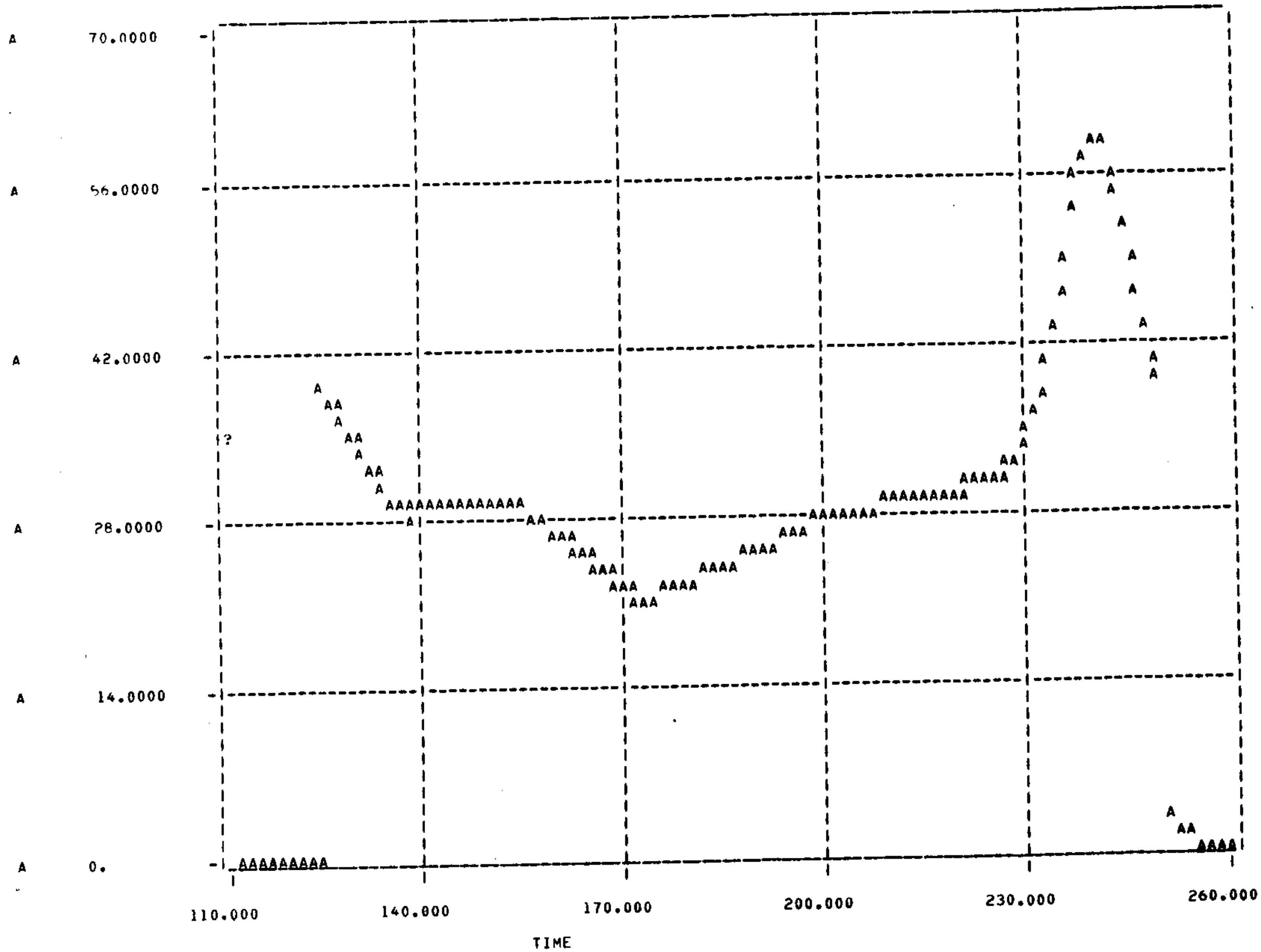
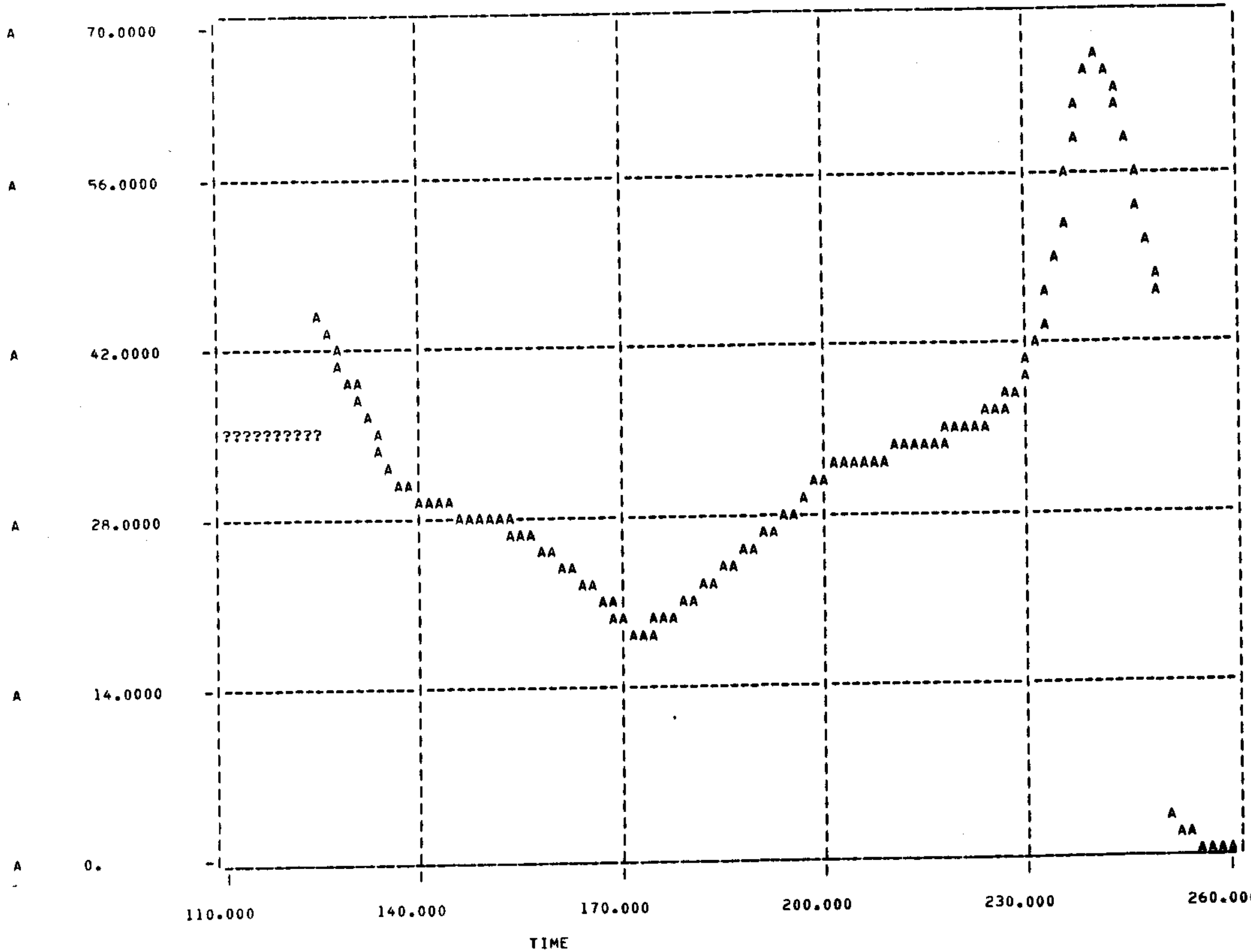
E 40.0000
ABCD .480000E-02
E 32.0000
ABCD .360000E-02
E 24.0000
ABCD .240000E-02
E 16.0000
ABCD .120000E-02
E 8.00000
ABCD 0.
E 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME

PLOT NO. 3



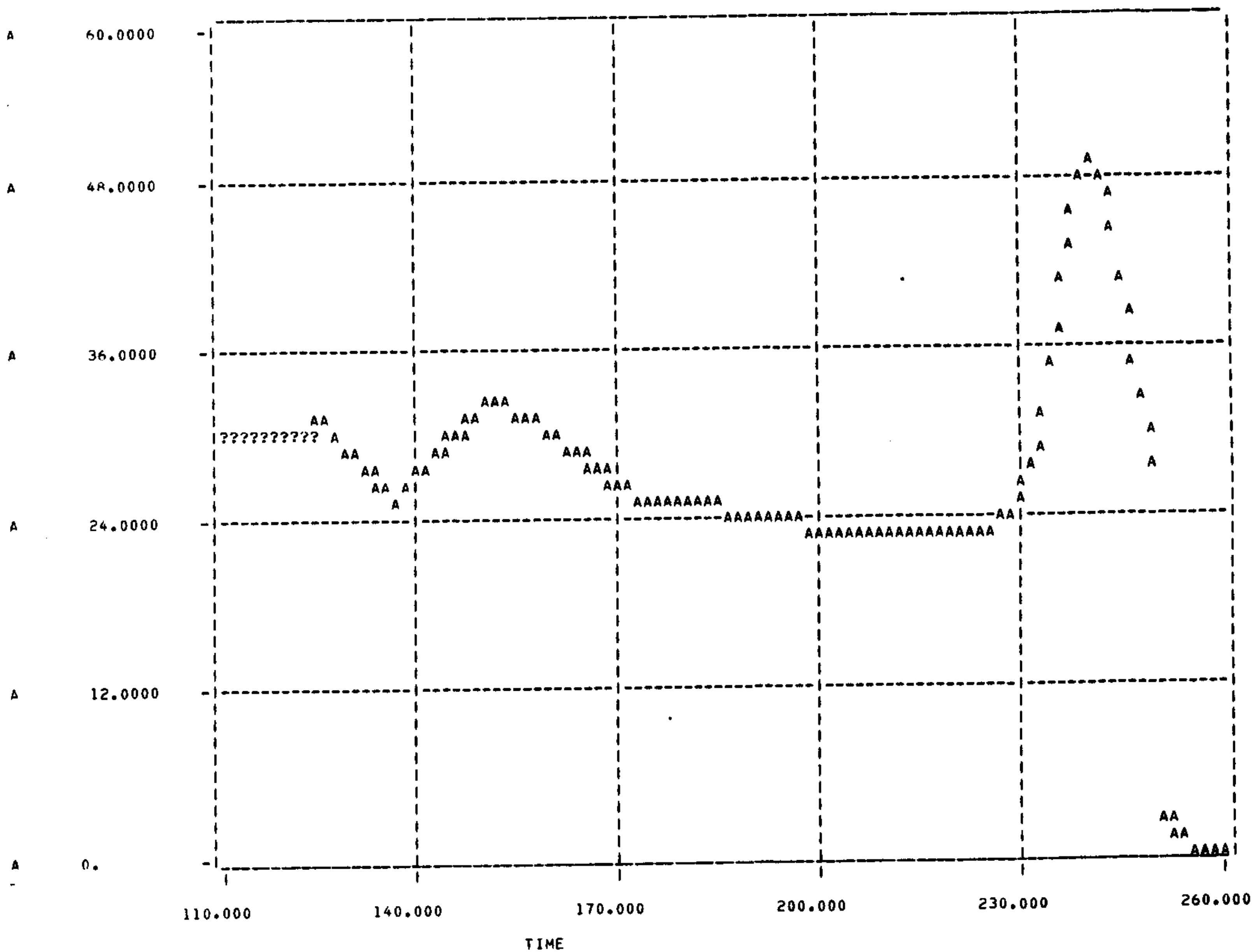
*****NOTE--IN PRECEDING PLOT, EITHER INFINITE OR INDEFINITE VALUES WERE ENCOUNTERED FOR DEPENDENT VARIABLES
CHECK PLOT FOR FOLLOWING INDICATORS--?(INDEFINITE), >(+ INFINITE), OR <(- INFINITE)

PLOT NO. 4



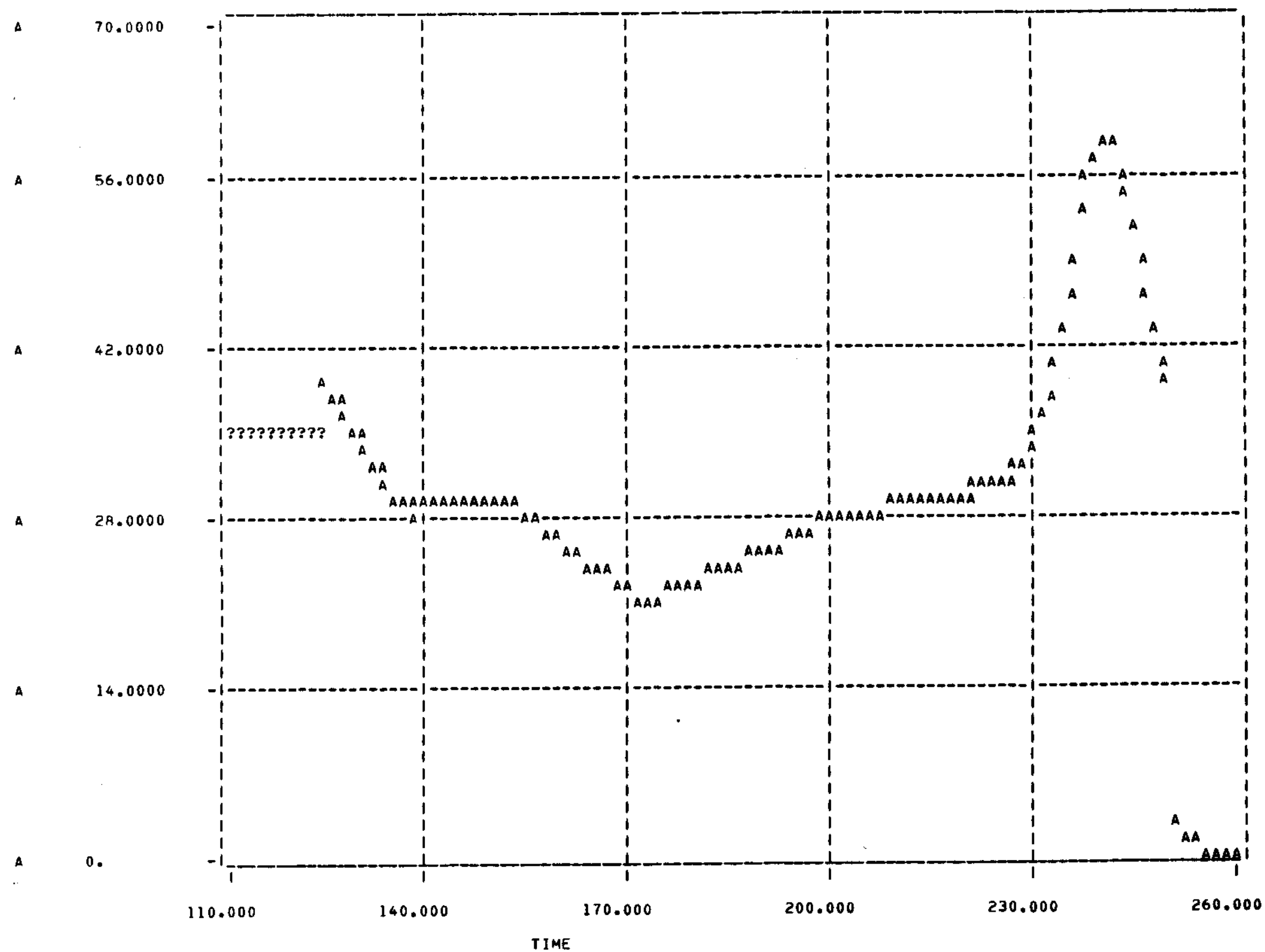
*****NOTE--IN PRECEDING PLOT, EITHER INFINITE OR INDEFINITE VALUES WERE ENCOUNTERED FOR DEPENDENT VARIABLES
CHECK PLOT FOR FOLLOWING INDICATORS--?(INDEFINITE), >(+ INFINITE), OR <(- INFINITE)

PLOT NO. 5



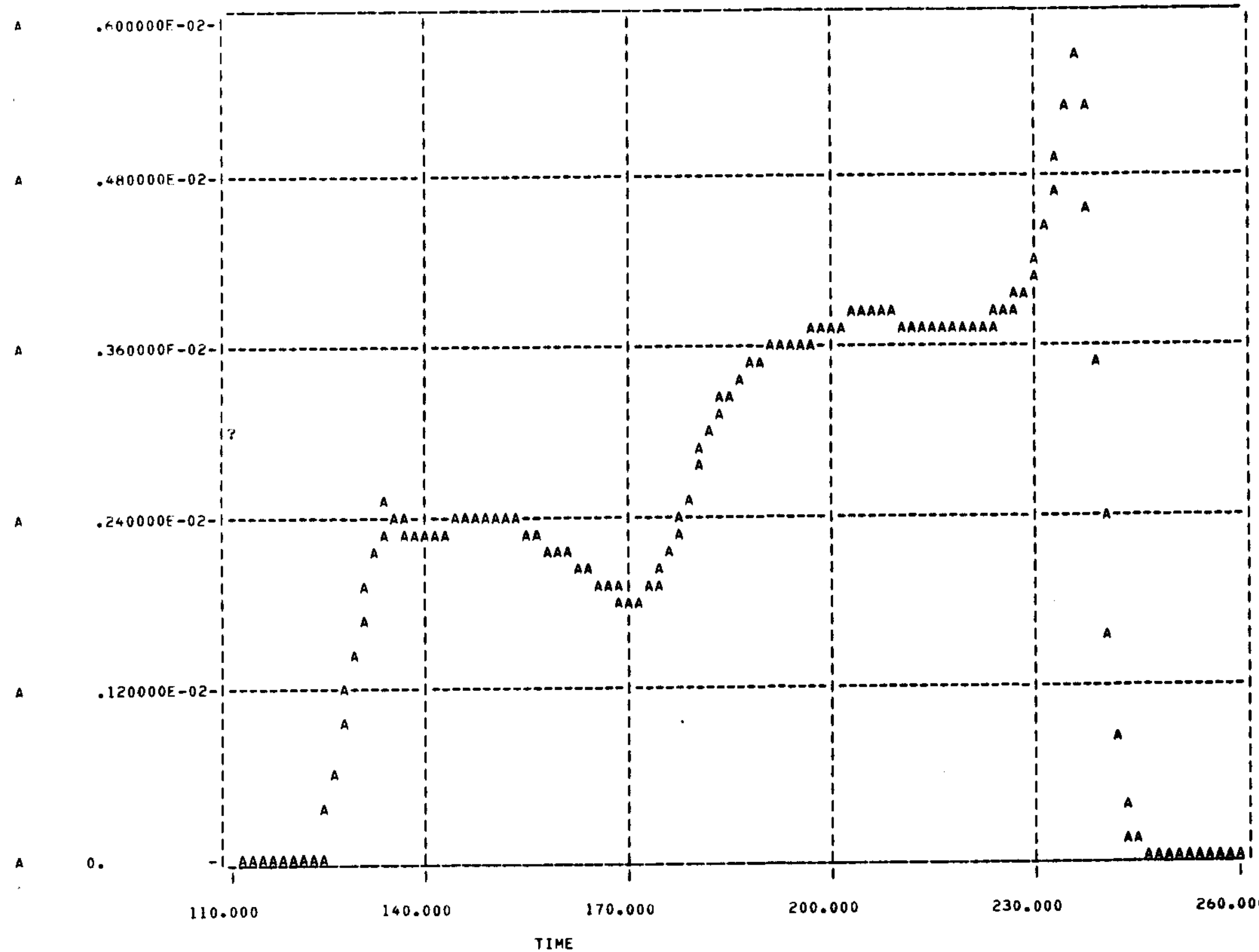
*****NOTE--IN PRECEDING PLOT, EITHER INFINITE OR INDEFINITE VALUES WERE ENCOUNTERED FOR DEPENDENT VARIABLES
CHECK PLOT FOR FOLLOWING INDICATORS--?(INDEFINITE), >(+ INFINITE), OR <(- INFINITE)

PLOT NO. 6



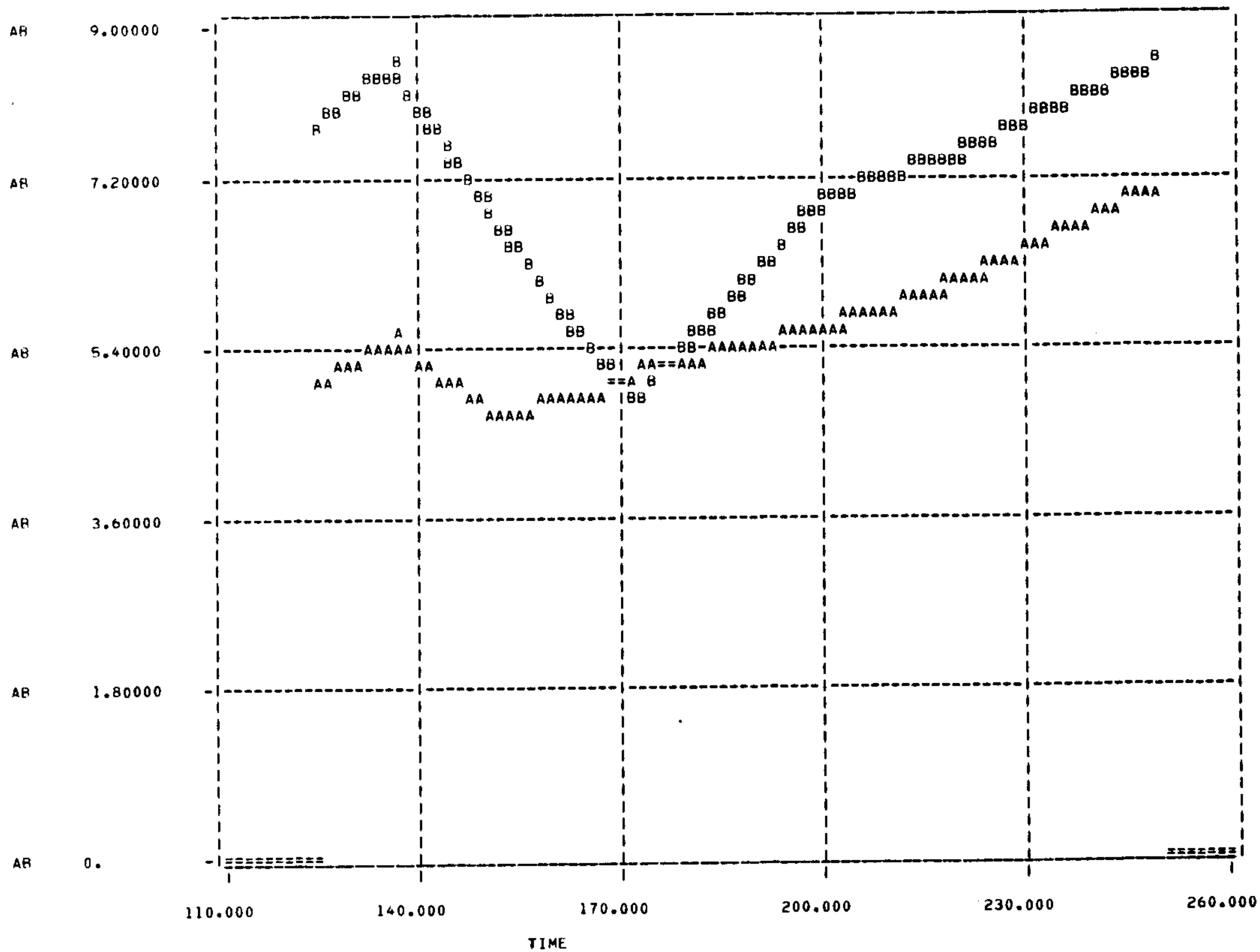
*****NOTE--IN PRECEDING PLOT, EITHER INFINITE OR INDEFINITE VALUES WERE ENCOUNTERED FOR DEPENDENT VARIABLES
CHECK PLOT FOR FOLLOWING INDICATORS--?(INDEFINITE), >(+ INFINITE), OR <(- INFINITE)

PLOT NO. 7

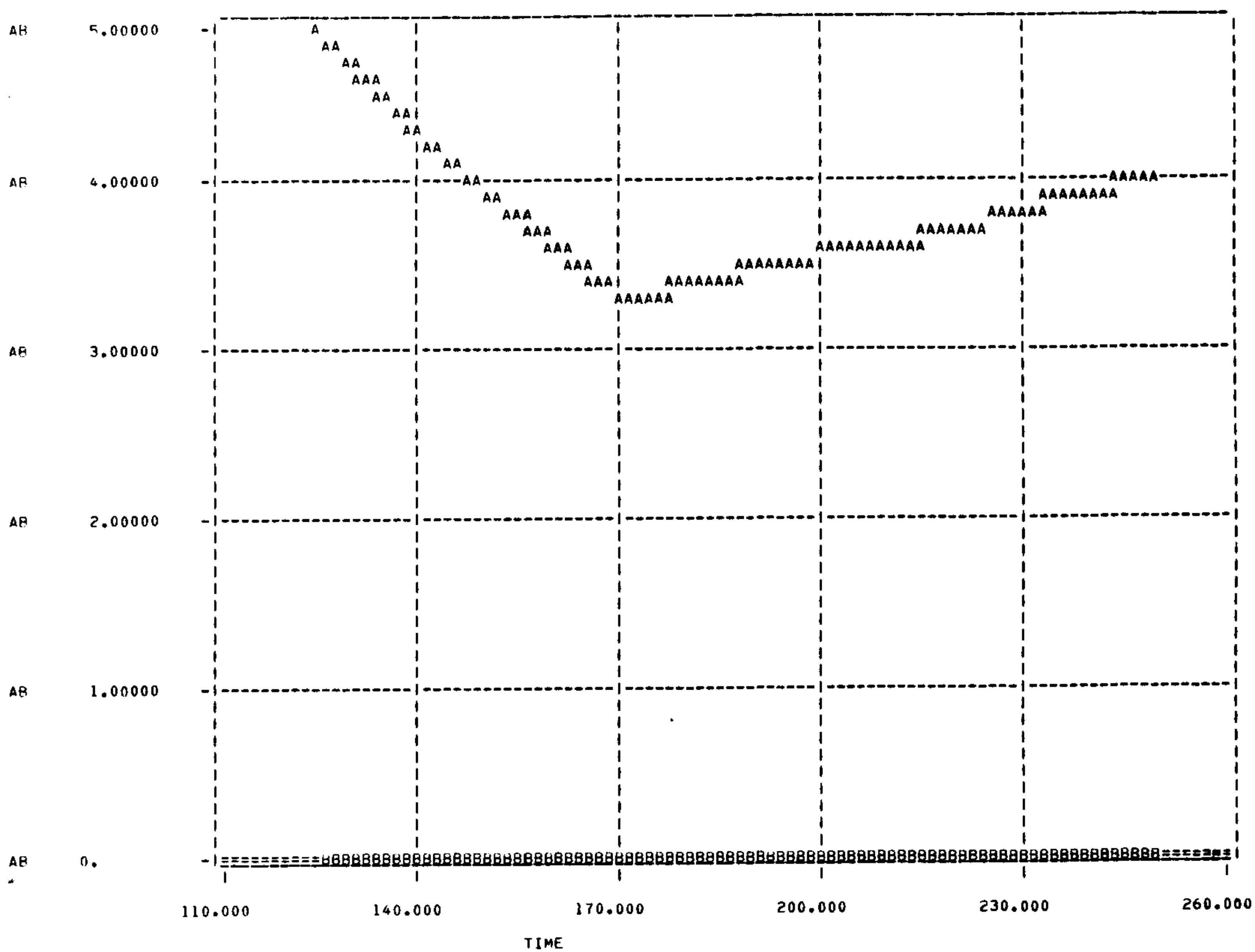


*****NOTE--IN PRECEDING PLOT, EITHER INFINITE OR INDEFINITE VALUES WERE ENCOUNTERED FOR DEPENDENT VARIABLES
CHECK PLOT FOR FOLLOWING INDICATORS--?(INDEFINITE), >(+ INFINITE), OR <(- INFINITE)

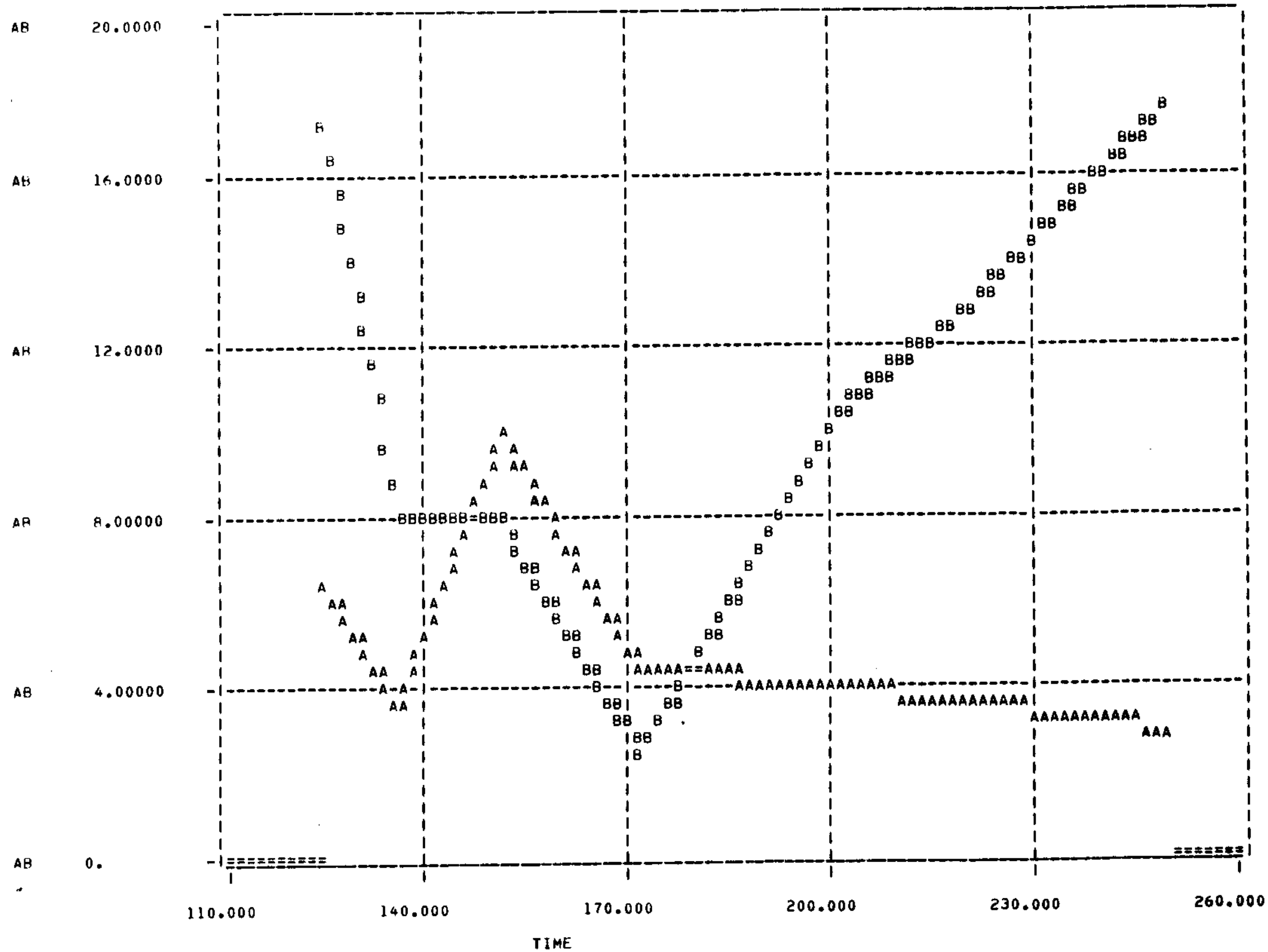
PLOT NO. 8

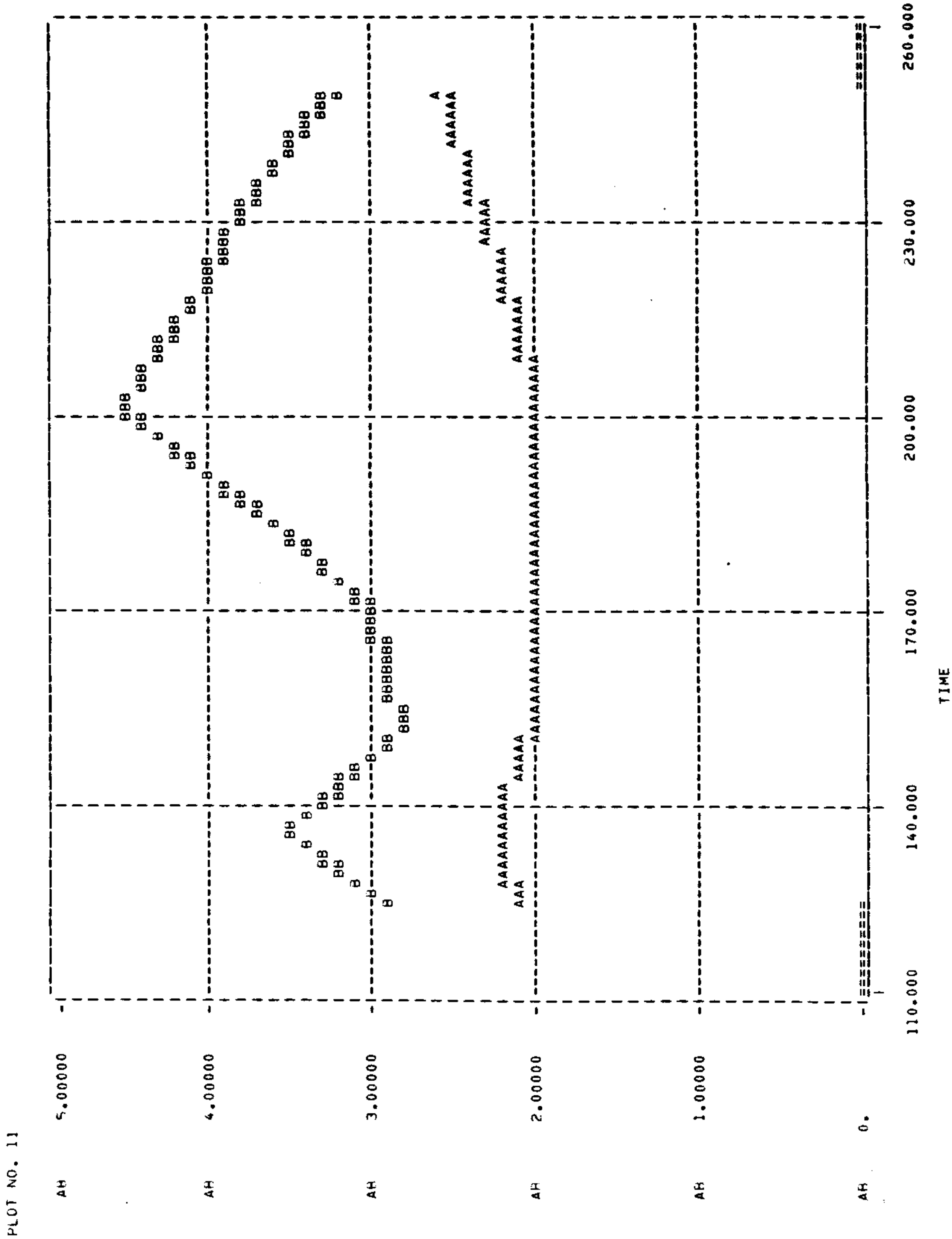

AB 9.00000
AB 7.20000
AB 5.40000
AB 3.60000
AB 1.80000
AB 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME

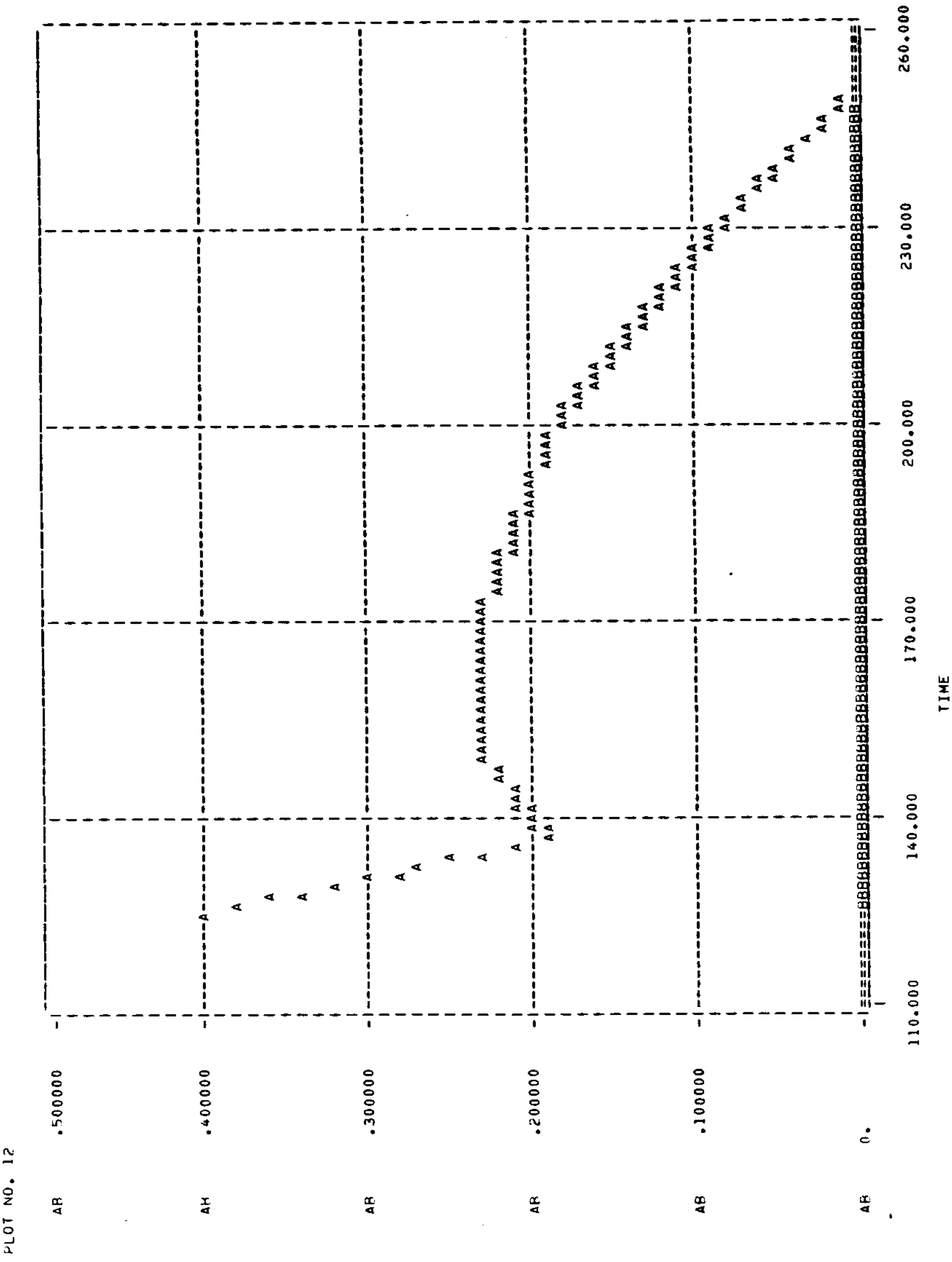
PLOT NO. 9

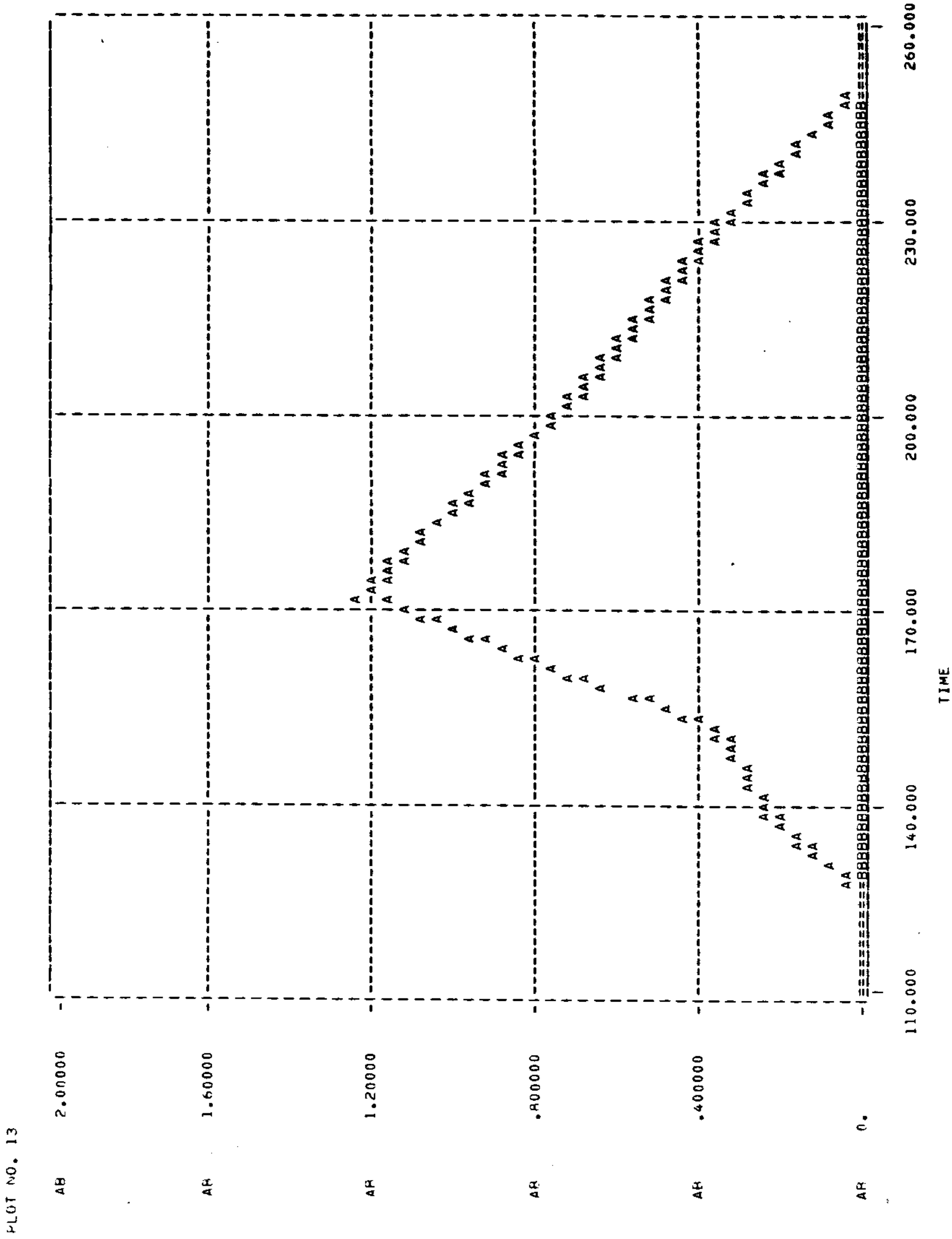

AB 5.00000
AB 4.00000
AB 3.00000
AB 2.00000
AB 1.00000
AB 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME

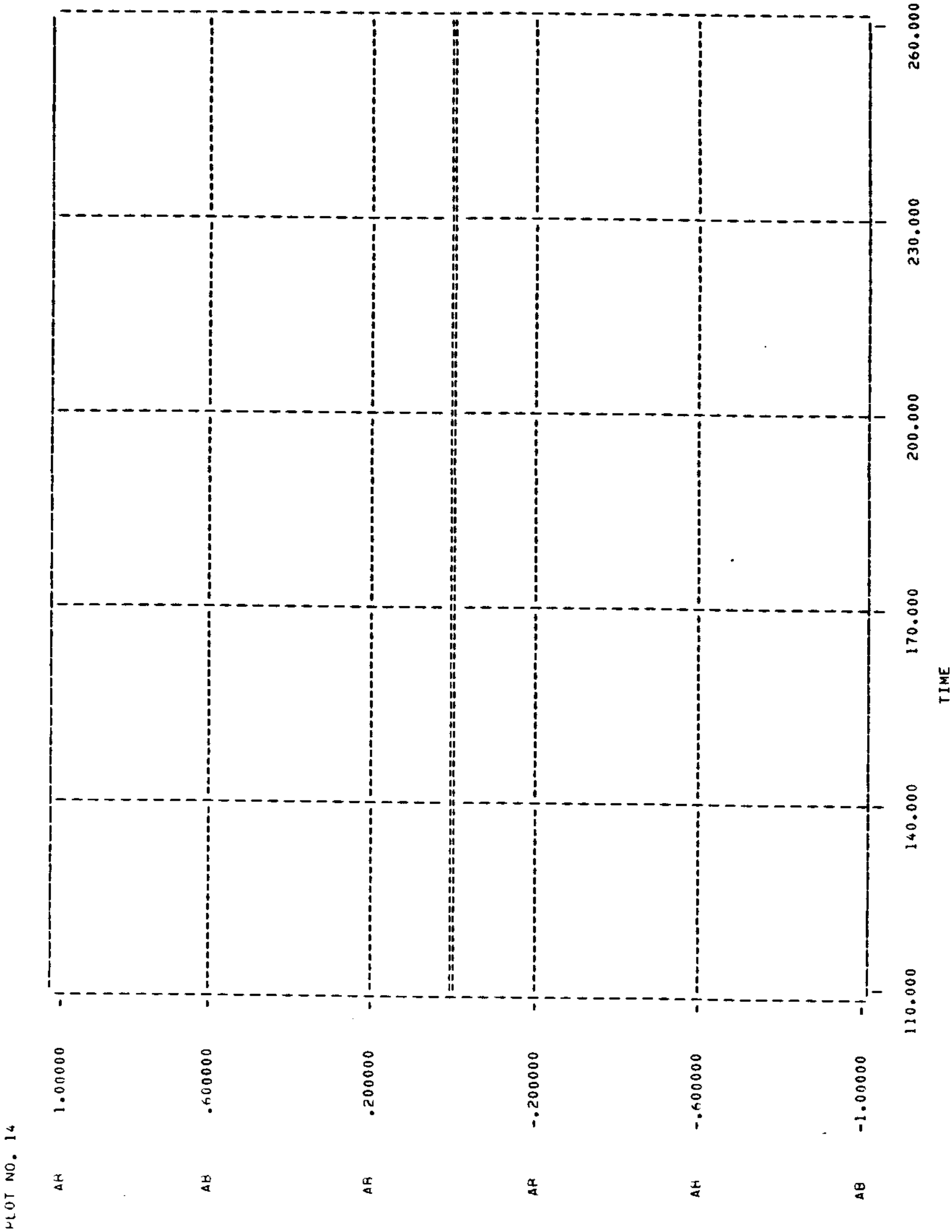
PLOT NO. 10


AB 20.0000
AB 16.0000
AB 12.0000
AB 8.00000
AB 4.00000
AB 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 11
AH 5.00000
AH 4.00000
AH 3.00000
AH 2.00000
AH 1.00000
AH 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 12
AB
.500000
.400000
.300000
.200000
.100000
0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 13
AB 2.00000
AB 1.60000
AB 1.20000
AB .800000
AB .400000
AB 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 14
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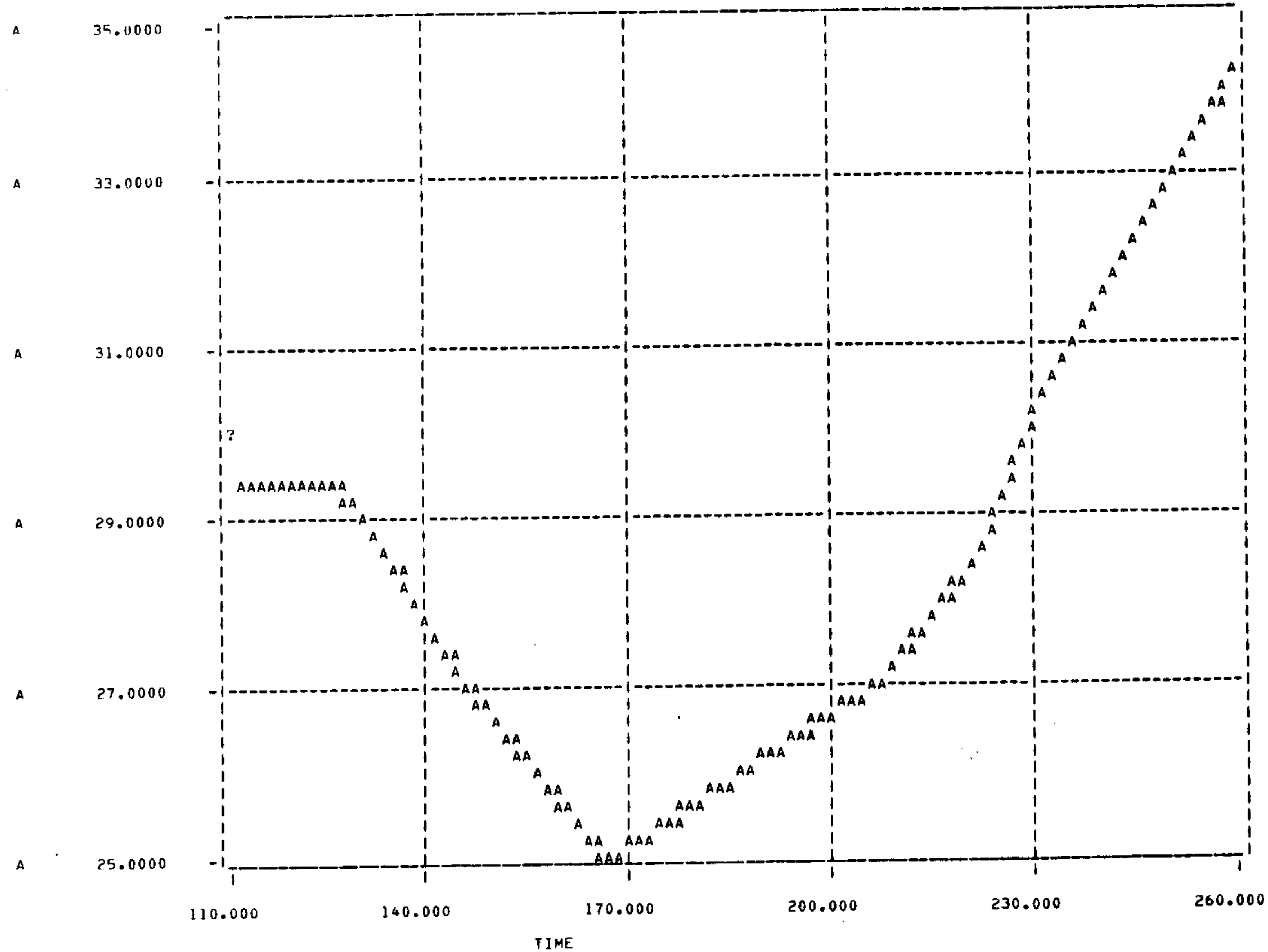
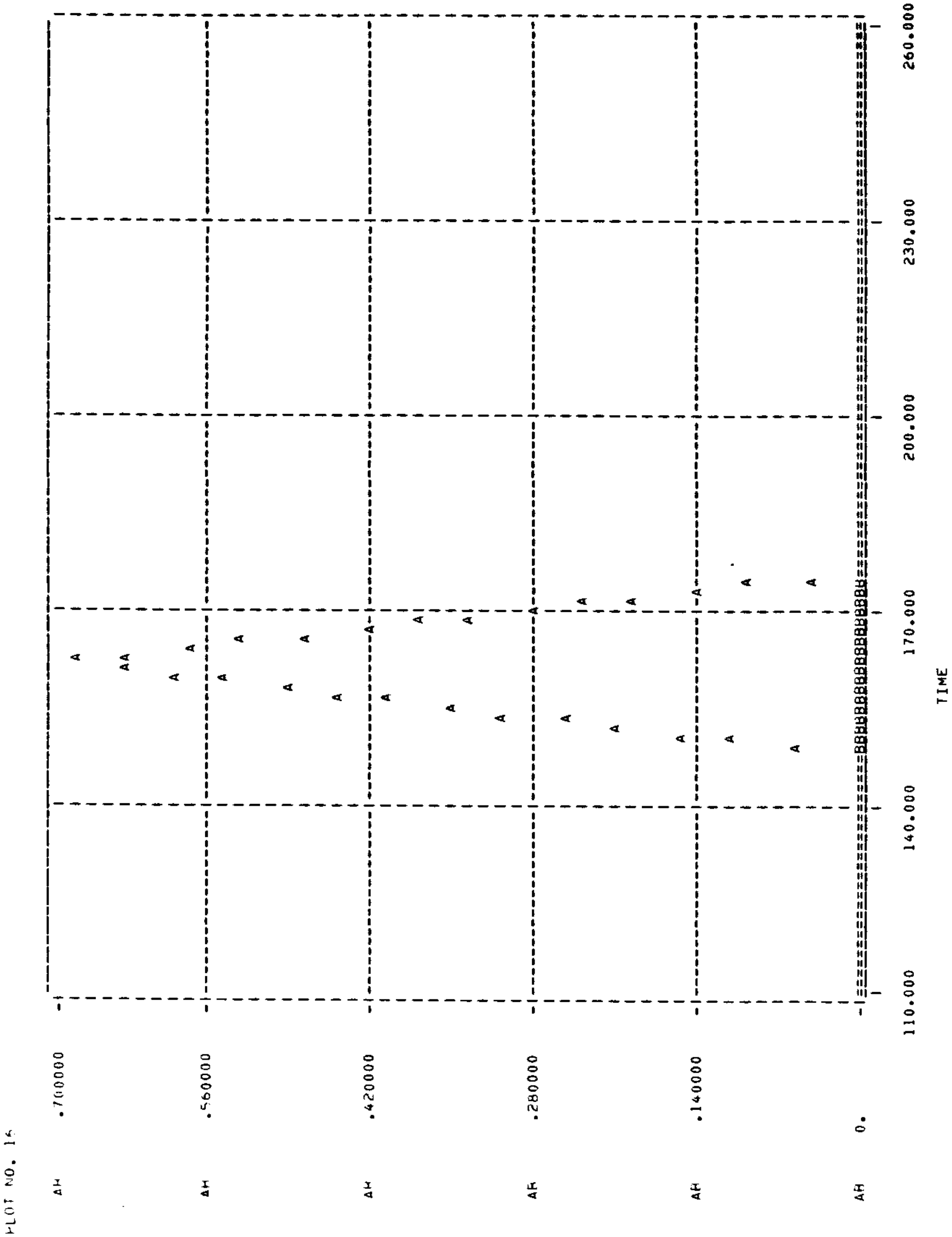
AB .600000
AB .200000
AB -.200000
AB -.600000
AB -1.00000
110.000
140.000
170.000
200.000
230.000
260.000
TIME

PLOT NO. 15



*****NOTE--IN PRECEDING PLOT, EITHER INFINITE OR INDEFINITE VALUES WERE ENCOUNTERED FOR DEPENDENT VARIABLES
CHECK PLOT FOR FOLLOWING INDICATORS--?(INDEFINITE), >(+ INFINITE), OR <(- INFINITE)


PLOT NO. 14
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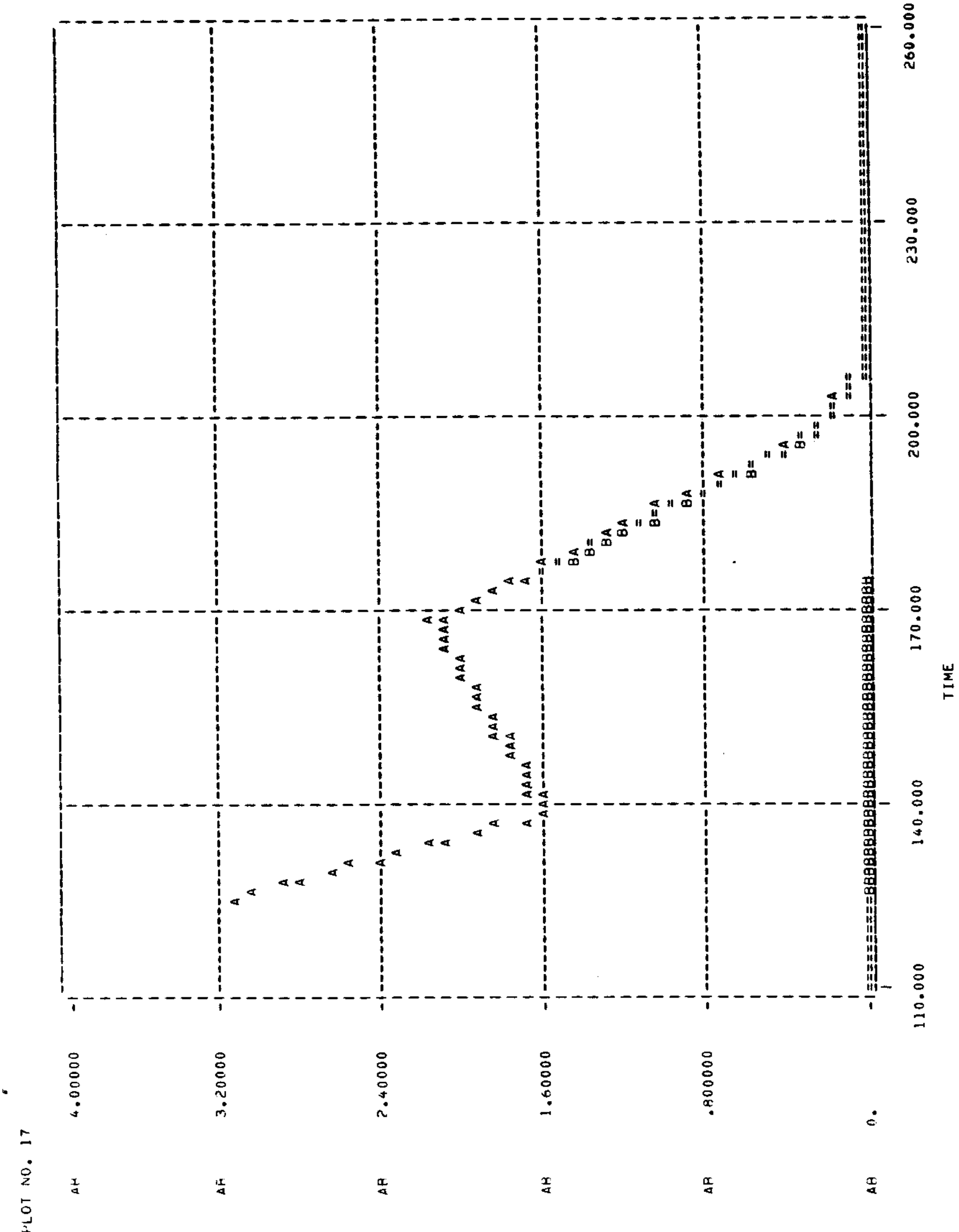
AH .560000
AH .420000
AH .280000
AH .140000
AH 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 17
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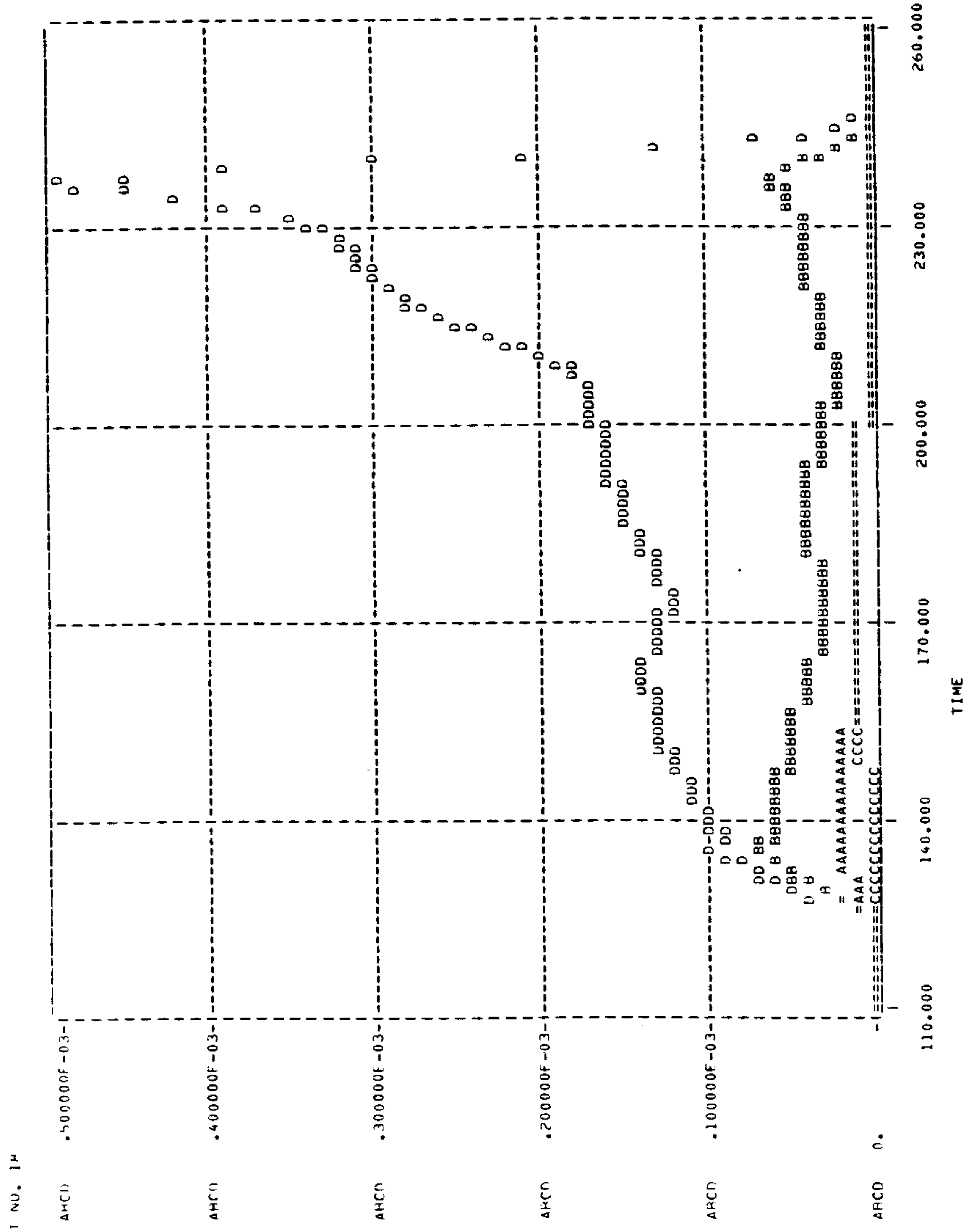
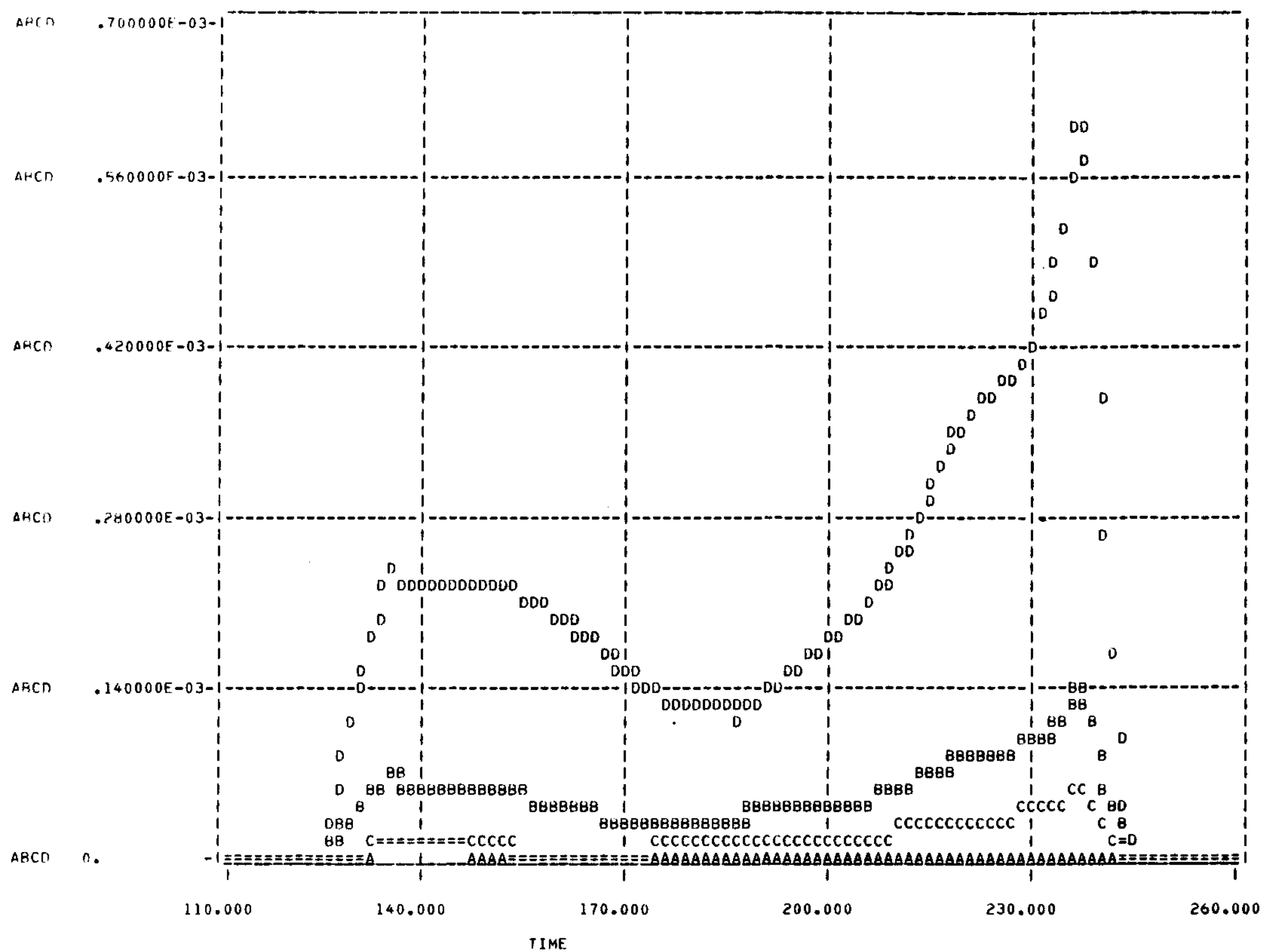
AB 3.20000
AB 2.40000
AB 1.60000
AB .800000
AB 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME


PLOT NO. 18
ARCD .500000E-03
ARCD .400000E-03
ARCD .300000E-03
ARCD .200000E-03
ARCD .100000E-03
ARCD 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME

PLOT NO. 19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ABCD .280000E-03
ABCD .140000E-03
ABCD 0.
110.000
140.000
170.000
200.000
230.000
260.000
TIME

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