The equation for nonrenewable resources NR (from Figure D-1) is an example of a level equation:

L NR.K = NR.J + (DT)(−NRUR.JK),

where

NR.K = the value of NR at the present time K
NR.J = the value of NR at the previous time of evaluation J, DT time units before the present
DT = the length of the computation interval
NRUR.JK = the rate of change of NR over the interval DT

```
RESTR

*     NONRENEWABLE RESOURCE SECTOR WITH EXOGENOUS INPUTS
NOTE
129   L     NR.K=NR.J+(DT)(-NRUR.JK)
      N     NR=NRI
      C     NRI=1E12
130   R     NRUR.KL=(POP.K)(PCRUM.K)(NRUF.K)
131   A     NRUF.K=CLIP(NRUF2,NRUF1,TIME.K,PYEAR)
      C     NRUF1=1
      C     NRUF2=1
132   A     PCRUM.K=TABHL(PCRUMT,IOPC.K,0,1600,200)
      T     PCRUMT=0/.85/2.6/4.4/5.4/6.2/6.8/7/7
133   A     NRFR.K=NR.K/NRI
134   A     FCAOR.K=CLIP(FCAOR2.K,FCAOR1.K,TIME.K,PYEAR)
135   A     FCAOR1.K=TABHL(FCAOR1T,NRFR.K,0,1,.1)
      T     FCAOR1T=1/.9/.7/.5/.2/.1/.05/.05/.05/.05
136   A     FCAOR2.K=TABHL(FCAOR2T,NRFR.K,0,1,.1)
      T     FCAOR2T=1/.9/.7/.5/.2/.1/.05/.05/.05/.05
NOTE
NOTE  EXOGENOUS INPUTS TO THE NONRENEWABLE RESOURCE SECTOR
NOTE
NOTE  POPULATION
NOTE
A     POP.K=CLIP(POP2,POP1.K,TIME.K,2PYT)
A     POP1.K=POP1*EXP(GC*(TIME.K-1900))
C     POP1=1.65E9
C     GC=.042
C     POP2=4E9
C     2PYT=2500
NOTE
NOTE  INDUSTRIAL CAPITAL
NOTE
L     IC.K=IC.J+(DT)(ICIR.JK-ICDR.JK)
N     IC=ICI
C     ICI=2.1E11
R     ICIR.KL=(IO.K)(1-FIOAA-FIOAS-FIOAC)
C     FIOAA=.12
C     FIOAS=.12
C     FIOAC=.43
R     ICDR.KL=IC.K/ALIC
C     ALIC=14
NOTE
NOTE  INDUSTRIAL OUTPUT
NOTE
A     IO.K=(IC.K)(1-FCAOR.K)/ICOR
C     ICOR=3
A     IOPC.K=IO.K/POP.K
NOTE
NOTE  CONTROL CARDS
NOTE
J     TIME=1900
C     PYEAR=1975
SPEC  DT=1/PLTPER=5/LENGTH=2100
PLOT  NRFR=*,FCAOR=F(0,1)/IC=C(0,4E13)/
X     IO=D(0,1E13)/POP=P(0,1.6E10)
```

Figure D-1 Example of DYNAMO equations (nonrenewable resource sector equations)

In the simple numerical integration scheme used by DYNAMO, the rate of change is assumed to be constant during the small time interval DT.

Rate Equation

A rate equation describes how the rate of flow to or from a level changes, depending on other conditions in the system. The expression in the rate equation may contain constants, auxiliaries, and levels. The auxiliaries and levels used in rate equations are written in terms of their values at the present time, represented by the subscript .K. For example, in Figure D-1:

R NRUR.KL = (POP.K)(PCRUM.K) (NRUF.K).

In this example the rate, NRUR.KL, is defined as the product of a level, POP.K, and two auxiliaries, NRUF.K and PCRUM.K.

Auxiliary Equation

An auxiliary equation defines a component of a rate. Rates are separated algebraically into auxiliaries to clarify their structure. All auxiliary variables could be substituted back into rate equations, making them dependent exclusively on levels and constants. Auxiliaries are separated from rate equations only if they represent real-world quantities or concepts. The expression in an auxiliary equation can contain constants, functions (including table functions), levels, and other auxiliaries.

Initial-Value Equation

An initial-value equation defines the value of a level at the beginning of the simulated time period. The variable name in such an equation is the name of the level without subscripts. Its expression can be a number, the variable name of a constant, or a combination of other model variables specified without time subscripts.

Constant Equation

A constant equation defines the numerical value of a constant. The value must be given explicitly by the programmer.

Table Equation

A table equation lists the numerical values of a dependent variable as a function of an independent variable over a specified range. The independent variable and its range are specified in an auxiliary equation preceding the table, as in the following example:

A PCRUM.K = TABHL(PCRUMT,IOPC.K,0,1600,200)
T PCRUMT = 0/.85/2.6/4.4/5.4/6.2/6.8/7/7

The auxiliary equation defines a variable PCRUM as a table function of IOPC. It further specifies that the table PCRUMT gives the values of PCRUM for corresponding values of IOPC between 0 and 1600 units at intervals of 200 units. Since IOPC.K is the value of a continuously variable quantity, its values may not be exact multiples of 200. For values of IOPC.K between the specified points of the table, DYNAMO linearly interpolates the value of PCRUM.K. When IOPC.K is less than